LITHUANIA'S NATIONAL INVENTORY REPORT 2015

GREENHOUSE GAS EMISSIONS 1990-2013

VILNIUS, 2015

PREFACE

Lithuania's GHG inventory submission under the United Nations Framework Convention on Climate Change (UNFCCC) and Regulation No 525/2013 of the European Parliament and of the Council of 21 May 2013 repealing Decision No 280/2004/EC contains:

- National Inventory Report (NIR);
- CRF (Common Reporting Format) data tables for years 1990-2013);
- SEF (Standard Electronic Format) tables for reporting of Kyoto units (AAUs, ERUs, CERs, tCERs, lCERs, RMUs) in the National registry during the year 2014 (CP1).

According to Decision 13/CP.20 of the Conference of the Parties to the UNFCCC, CRF Reporter version 5.0.0 was not functioning in order to enable Annex I Parties to submit their CRF tables for the year 2015. In the same Decision, the Conference of the Parties reiterated that Annex I Parties in 2015 may submit their CRF tables after 15/April, but no longer than the corresponding delay in the CRF Reporter availability. "Functioning" software means that the data on the greenhouse emissions/removals are reported accurately both in terms of reporting format tables and XML format.

CRF reporter version 5.10 still contains issues in the reporting format tables and XML format in relation to Kyoto Protocol requirements, and it is therefore not yet functioning to allow submission of all the information required under Kyoto Protocol.

Recalling the Conference of Parties invitation to submit as soon as practically possible, and considering that CRF reporter 5.10 allows sufficiently accurate reporting under the UNFCCC (even if minor inconsistencies may still exist in the reporting tables, as per the Release Note accompanying CRF Reporter 5.10), the present report is the official submission for the year 2015 under the UNFCCC. The present report is not an official submission under the Kyoto Protocol, even though some of the information included may relate to the requirements under the Kyoto Protocol.

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Abbreviations

AAU	Assigned Amount Unit
AB	Stock company (SC)
AIRBC	Agricultural Information and Rural Business Centre
ARD	Afforestation, Reforestation and Deforestation
BOD	Biochemical Oxygen Demand
CC	Cropland remaining cropland
CC	Cropland remaining Cropland
CER	Certified Emission Reduction units
CFC	Chlorofluorocarbon
CH_4	Methane
CHP	Combined Heat and Power
CM	Cropland management
CO_2	Carbon dioxide
CO_2 eqv.	Carbon dioxide equivalent
COD	Chemical Oxygen Demand
COP	Conference of the Parties
CR	CORINAIR emission factor
CRF	Common Reporting Format
CS	Country Specific emission factor
D	Default emission factors
DGSF	Directorate General of Sate Forests
DOC	Degradable Organic Carbon
EF	Emission Factor
EPA	Lithuanian Environmental Protection Agency
ERT	Expert Review Team
ERU	Emission Reduction Units
FAO	Food and Agriculture Organization of the United Nations
FF	Forest Land remaining Forest Land
FM	Forest Management
FOD	First Order Decay
FRA	Forest Resources Assessment
GCV	Gross Calorific Value
GDP	Gross Domestic Product
GG	Grassland remaining Grassland
GHG	Greenhouse gases
GIS	Geographic Information System
GLM	Grazing land management
GPG	Good Practice Guidance
GSV	Growing Stock Volume
GWCS	Green Waste Composting Sites
HFC	Hydrofluorocarbon
HSPP	Hydro Storage Power Plant
HWP	Harvested Wood Products
IE	Included Elsewhere
IFA	International Fertilizer Industry Association
IPCC	Intergovernmental Panel on Climate Change
Kt	Thousand tonnes

L	Level
LF	Land converted to Forest Land
LSFC	Lithuanian State Forest Cadaster
LULUCF	Land Use, Land-Use Change and Forestry
l-CER	long term Certified Emission Reduction units
MCF	Methane correction factor
MMS	Manure Management System
MoE	Ministry of Environment
MSW	Municipal Solid Waste
Mtoe	Million Tonnes of Oil Equivalent
N_2O	Nitrous oxide
NA	Not Applicable
NCV	Net Calorific Value
NE	Not Estimated
NF_3	Nitrogen trifluoride
NFI	National Forest Inventory
NGO	Non-governmental organization
NHF	Nature Heritage Fund
NIR	National Inventory Report
NLS	National Land Service
NMVOC	Non-methane volatile organic compounds
NO	Not Occurring
NPP	Nuclear Power Plant
PFC	Perfluorocarbon
PP	Power Plant
QA/QC	Quality Assurance/Quality Control
REPD	Regional Environmental Protection Departments
RES	Renewable Energy Source
REV	Revegetation
RMU	Removal Units
RWMC	Regional Waste Management Centers
SAPS	Single Area Payment Scheme
SEF	Standard Electronic Format
SF_6	Sulphur hexafluoride
SFE	State Forest Enterprises
SFI	Standwise Forest Inventory
SFS	State Forest Service
SPD	Single Programming Document
SWDS	Solid Waste Disposal Sites
T	Trend
TOE	Tonne of Oil Equivalent
TPP	Thermal Power Plant
t-CER	temporary Certified Emission Reduction units
UAB	Joint-stock company (JSC)
UNFCCC	United Nations Framework Convention on Climate Change
WD	Wood Density

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EXECUTIVE SUMMARY

ES.1 Background information on greenhouse gas inventories and Climate Change

Lithuania takes part in the global climate change mitigation process and is one of the 195 countries of the world that have ratified the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC entered into force on 21st of March, 1994. The Seimas of the Republic of Lithuania ratified the UNFCCC in 1995. The Kyoto Protocol (KP) was signed in 1998 and ratified in 2002. In accordance with Kyoto Protocol Lithuania has undertaken to reduce its greenhouse gas (GHG) emissions by 8% below 1990 level during the first commitment period 2008-2012 and has fulfilled its obligation reducing more than 55% it‘s GHG emissions over this period.

At the Doha Climate Change Conference in December 2012, Lithuania as a European Union (EU) Member State together with other parties to the Kyoto Protocol to the UNFCCC adopted the Doha Amendment, establishing a second commitment period of the Kyoto Protocol, starting on 1st January 2013 and ending on 31st December 2020. The Doha Amendment amends Annex B to the Kyoto Protocol, setting out further legally binding mitigation commitments for parties listed in that Annex for the second commitment period, and amending and further laying down provisions on the implementation of parties' mitigation commitments during the second commitment period. The Union and its Member States agreed at the Doha Climate Change Conference to a quantified emission reduction commitment that limits their average annual emissions of GHGs during the second commitment period to 80% of the sum of their base year emissions.

As a Party to the UNFCCC and in accordance with Article 5, paragraph 2 of the Kyoto Protocol, Lithuania is required to develop and regularly update national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not regulated by Montreal Protocol. As a member of the European Union, Lithuania also has reporting obligations under the EU Regulation No 525/2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC.

The GHG inventory is prepared in accordance with the Updated UNFCCC reporting guidelines on annual inventories following incorporation of the provisions of decision 14/CP.11 (FCCC/SBSTA/2006/9). GHG inventory is compiled in accordance with the methodology recommended by the Intergovernmental Panel on Climate Change (IPCC) in its 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006), 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (IPCC, 2014), 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (IPCC, 2014) and taking into account recommendations by the UNFCCC expert review teams, provided in the Reports of the individual review of the annual submissions of Lithuania and remarks received during EU annual GHG inventory quality checks and GHG inventory technical reviews under EU Decision 406/2009/EC (Effort sharing decision).

The first national GHG inventory data was submitted in 1996 for the first National Communication under the UNFCCC. In 2004 first National Inventory Report (NIR) and Common reporting format (CRF) tables have been developed. In 2006 for the first time complete time series for the period 1990-2004 of the GHG inventory has been developed and submitted to European Commission and the UNFCCC Secretariat together with Lithuania's Initial Report under the Kyoto Protocol.

In accordance with the Order of the Minister of Environment of 22nd of December 2010 (as repealed on 23-01-2014 by MoE Order No D1-61), Lithuanian Environmental Protection Agency (EPA) under the Ministry of Environment was nominated as an institution responsible for the GHG inventory preparation starting from 2011. EPA responsibilities inter alia include monitoring of environmental quality, collection and storage of environmental data and information as well as assessment and forecasting of environmental quality. Permanent GHG inventory preparation working group was established in 2011 by the Governmental Resolution No 683. The working group for GHG inventory preparation include members from Lithuanian Energy Institute, Institute of Physics of the Centre for Physical Sciences and Technology, Institute of Animal Science of the Lithuanian University of Health Sciences, Centre for Environmental Policy, University of Applied Sciences and, The State Forest Service (SFS). External experts, independent specialists providing data for the GHG inventory, may also be involved during the inventory process upon request. The Ministry of Environment is a supervisor and coordinator for preparation of GHG inventory and nominated as the National Focal Point to the UNFCCC.

The GHG inventory presented here is the tenth national GHG inventory report and contains information on anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by Montreal Protocol:

- Carbon dioxide CO_2,
- Methane CH_4,
- Nitrous oxide N_2O,
- Hydrofluorocarbons HFCs,
- Perfluorocarbons PFCs,
- Sulphur hexafluoride SF_6,
- Nitrogen trifluoride NF_3.

In addition, the inventory includes emission estimates of the precursors: nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOCs), carbon monoxide (CO), as well as sulfur dioxide (SO_2).

The national GHG inventory report contains detailed information about Lithuania's emissions by sources and removals by sinks for the period 1990-2013.

For the preparation of the inventory upgraded CRF Reporter inventory software (v5.8.13) has been used. The NIR includes trends of GHG emissions, description of each emission category relevant to CRF, key sources, uncertainty estimates, planned improvements and description of performed procedures of quality assurance and quality control (QA/QC).

This report also includes supplementary information in accordance with Article 7, paragraph 1 of the Kyoto Protocol:

- information on emissions and removals from the land use, land use change and forestry (LULUCF) sector under Article 3 paragraphs 3 and 4 of the Kyoto Protocol (see Chapter 11),
- information of accounting of Kyoto units (see Chapter 12),
- information on changes that have occurred in the national system comparing with the information reported in the last submission (see Chapter 13),
- information on changes that have occurred in the national registry compared with information reported in the last submission (see Chapter 14), and
- information on the minimization of adverse impacts in accordance with Article 3, paragraph 14 of the Kyoto Protocol (see Chapter 15).

ES.2 Summary of national emission and removal-related trends

The summary of Lithuania's GHG emissions and removals for the period 1990-2013 is presented in Table 1.

Table 1. Greenhouse gas emissions/removals by sectors during the period 1990-2013, kt CO_2 eqv.

GHG source and sink categories	Energy	Industrial Processes and Product Use	Agriculture	LULUCUF	Waste	Total (including LULUCF)	Total (excluding LULUCF)
1990	33,022.87	4,518.17	8,622.28	-3,876.39	1,648.30	43,935.23	47,811.63
1991	35,104.43	4,551.40	8,469.72	-4,028.23	1,674.07	45,771.39	49,799.63
1992	19,824.57	2,706.15	5,966.90	-4,074.18	1,642.72	26,066.15	30,140.33
1993	15,950.43	1,775.57	5,046.60	-5,221.72	1,664.16	19,215.05	24,436.77
1994	15,002.24	1,973.08	4,556.04	-4,460.77	1,620.14	18,690.73	23,151.50
1995	14,041.02	2,257.59	4,404.02	-2,910.22	1,648.79	19,441.20	22,351.42
1996	14,522.82	2,647.67	4,645.90	2,561.76	1,647.14	26,025.30	23,463.54
1997	14,065.05	2,610.10	4,662.75	898.34	1,648.74	23,884.98	22,986.63
1998	14,771.45	3,016.94	4,453.27	-7,293.11	1,634.06	16,582.61	23,875.72
1999	12,412.24	2,951.76	4,268.82	-7,329.94	1,607.64	13,910.52	21,240.46
2000	10,855.37	3,104.89	4,006.46	-9,145.41	1,604.56	10,425.88	19,571.28
2001	11,489.17	3,351.79	4,128.41	-12,141.14	1,645.67	8,473.89	20,615.03
2002	11,567.35	3,524.65	4,291.67	-4,300.90	1,633.68	16,716.45	21,017.35
2003	11,571.58	3,607.02	4,551.76	-9,852.76	1,617.12	11,494.72	21,347.48
2004	12,191.03	3,797.33	4,517.30	-7,017.77	1,586.25	15,074.14	22,091.90
2005	12,887.70	4,139.81	4,592.18	-5,155.03	1,547.56	18,012.23	23,167.26
2006	13,042.45	4,380.98	4,544.83	-5,819.89	1,505.99	17,654.37	23,474.25
2007	13,270.24	6,164.42	4,590.88	-4,837.54	1,480.32	20,668.32	25,505.85
2008	13,137.31	5,505.31	4,441.35	-9,406.02	1,469.89	15,147.84	24,553.87
2009	11,920.26	2,314.21	4,493.23	-11,154.58	1,420.72	8,993.84	20,148.42
2010	12,809.31	2,246.22	4,473.41	-11,208.30	1,377.40	9,698.05	20,906.34
2011	11,963.20	3,707.07	4,461.87	-11,153.81	1,286.09	10,264.41	21,418.22
2012	11,967.48	3,529.86	4,482.30	-8,919.70	1,262.13	12,322.09	21,241.78
2013	11,388.75	2,938.11	4,429.44	-9,963.98	1,189.80	9,982.12	19,946.10
2013/1990, %	-65.51	-34.97	-48.63	157.04	-27.82	-77.28	-58.28

The most significant source of GHG emissions in Lithuania is energy sector with 57.1% share of the total emissions in 2013. Agriculture is the second most significant source and accounted for 22.2% of the total emissions. Emissions from industrial processes contributed 14.7% of the total GHG emissions, waste sector – 6.0%.

Main contributors in energy sector are Energy industries and Transport sectors. In 2013 these sectors composed 34.0% and 40.3% of the total GHG emissions from Energy sector respectively.

The composition of greenhouse gas emissions by sectors in 2013 is presented in Figure 1.

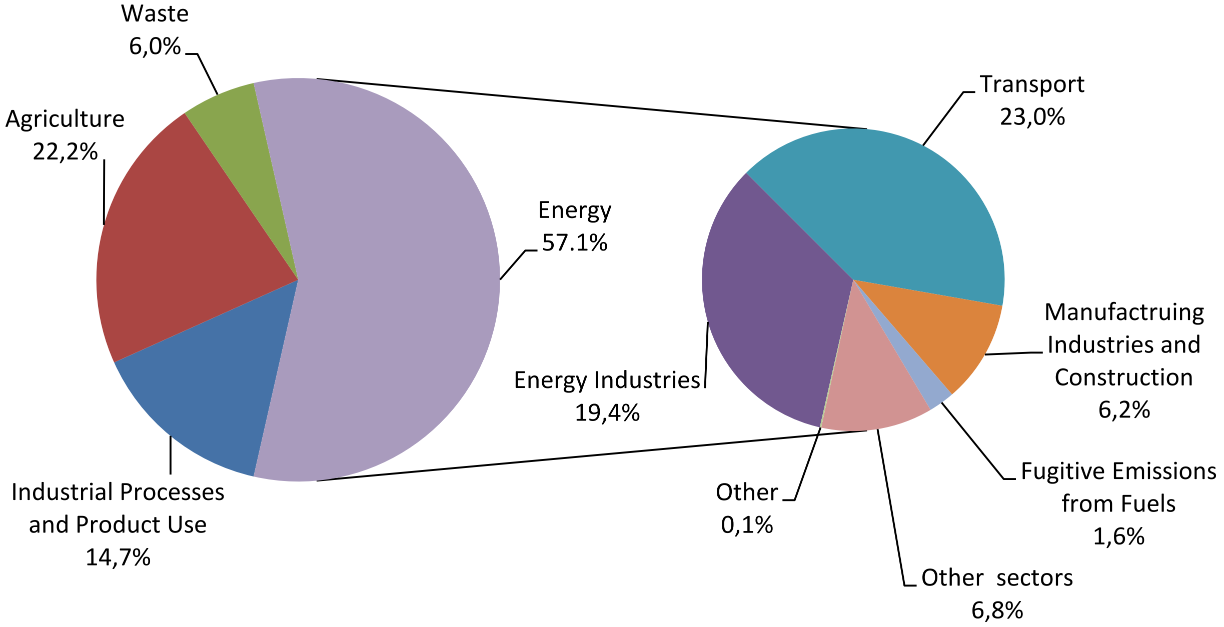


Figure 1. The composition of Lithuanian GHG emissions (CO_2 eqv.) by sectors (excl. LULUCF) in 2013

The total GHG emission (excl. LULUCF) amounted to 19,946.10 kt CO_2 eqv. in 2013. The emissions have decreased by 58.3% comparing with the base year. The base year is 1990 for the greenhouse gases CO_2, CH_4, N_2O and 1995 for the F-gases HFC, PFC, SF_6 and NF_3.

The largest source of CO_2 emission is the energy sector that accounted 82.3% of the total national CO_2 emission (excl. LULUCF) in 2013. The energy industries contribute 35.7% and the transport sector accounts for 41.9% of the CO_2 emission in energy section.

Comparing with 2012 CO_2 emission from energy sector in 2013 have slightly changed with a decrease of 5.2% wherein CO_2 emission from the energy industries decreased by 12.5% and emissions from transport stayed the same with a very minors decrease of 0.01%.

The most important GHG in 2013 was CO_2 it contributed 65.3% of the total national GHG emissions expressed in CO_2 eqv. followed by N_2O (15.8%) and CH_4 (17.5%). HFCs, SF_6 and NF_3 together amounted 1.6% of the total GHG emissions (excl. LULUCF) in Lithuania.

Between 1990 and 2000 GHG emissions decreased significantly as a consequence of the decline in industrial production and associated fuel consumption. Once the economy started to grow again, emission rose but this was partly compensated by reductions achieved through energy efficiency and measures taken to reduce emissions.

Comparing with 2012 the total GHG emissions in 2013 decreased by 6.1% (excl. LULUCF).

An overview of estimated GHG emissions is presented in Figure 2, which shows GHG emissions by gases, expressed in CO_2 eqv. (excl. LULUCF) for the period 1990-2013.

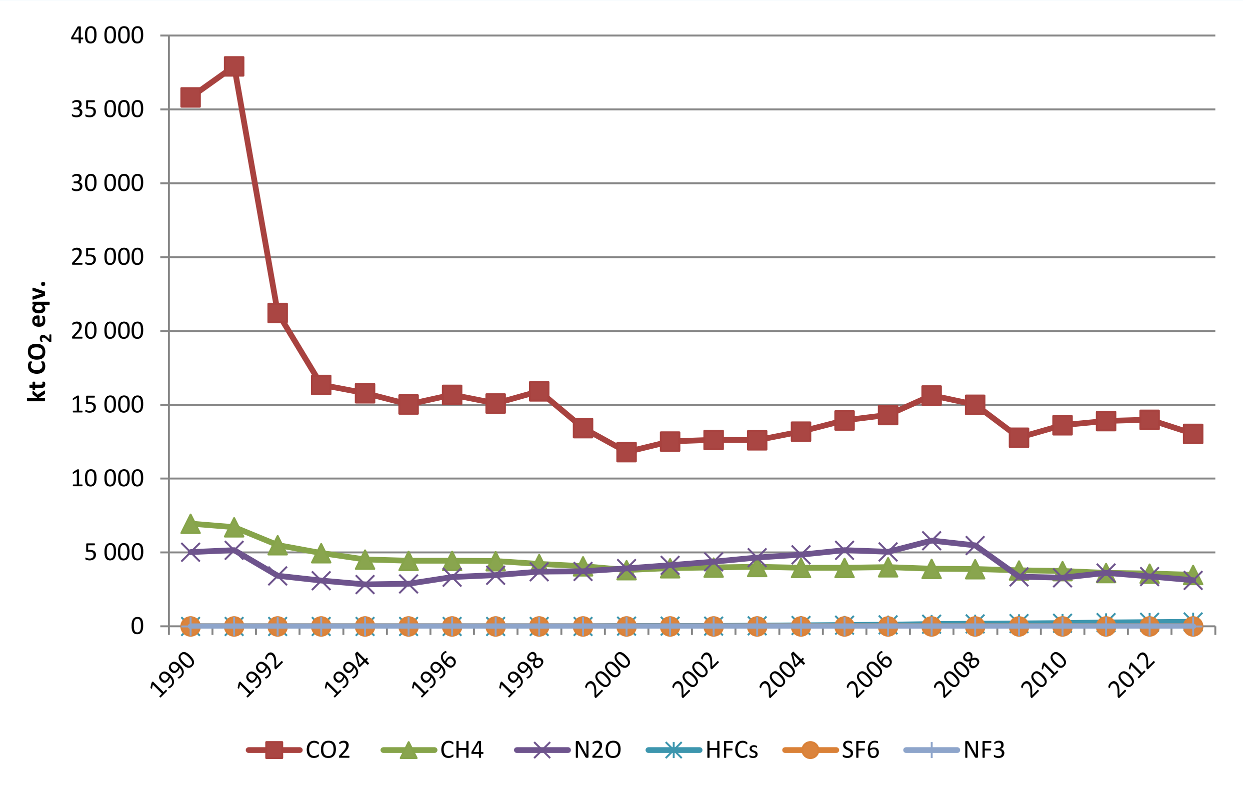


Figure 2. Trends of GHG emissions by gas in kt CO_2 eqv. (excl. LULUCF)

ES.3 Overview of source and sink category emission estimates and trends

Energy sector is the most significant source of GHG emissions in Lithuania with 57.1% share of the total emissions (excl. LULUCF) in 2013. Emissions from energy include CO_2, CH_4 and N_2O GHG.

CO_2 emission from energy sector contained 82.3% of the total national CO_2 emissions (excl. LULUCF) in 2013. The main categories are energy industries and transport which contribute 29.4% and 34.5% to the total national CO_2 emission (excl. LULUCF) respectively. Comparing with 2012 CO_2 emissions from energy sector have decreased by 5.2% in 2013. The emissions of CH_4 have increased by 1.3% and N_2O emissions increased by 0.02%.

The second most important source of GHG emissions is agriculture sector accounting for 22.2% of the total national GHG emissions (excl. LULUCF). This sector is the most significant source of CH_4 and N_2O emissions accounting for 52.2% and 82.0% of the total CH_4 and N_2O emissions, respectively. The main source of CH_4 emissions is enteric fermentation contributing 84.9% to the total agricultural CH_4 emissions. Agricultural soils are the most significant source of N_2O emissions accounting for 93.5% of the total agricultural N_2O emissions. Comparing with 2012 GHG emissions in agriculture sector decreased by 1.2% in 2013

Emissions from industrial processes and product use amounted to 14.7% of the total GHG emissions (excl. LULUCF) in 2013. The main categories are: ammonia production, nitric acid production and cement production. Ammonia production is the largest source of CO_2 emissions in industrial processes and product use sector contributing 12.9% to the total national CO_2 emissions (excl. LULUCF) in 2013. Nitric acid production is the single source of N_2O emissions in industrial processes sector and accounts for 10.7% in the total national N_2O emissions (excl.

LULUCF) in 2013. GHG emissions in 2012 from industrial processes and product use sector have decreased by 13.2% comparing with 2013.

Waste sector accounted for 6.0% of the total GHG emissions in 2013 (excl. LULUCF). The solid waste disposal on land is the second important source of CH_4 emissions. It contributes 25.9% to the total CH_4 emissions (excl. LULUCF). There was 6.0% reduction in CH_4 emission from waste sector in 2013.

PART 1:

ANNUAL INVENTORY SUBMISSION

1 INTRODUCTION

1.1 Background information on GHG inventories and climate change

1.1.1 Background information on climate change in Lithuania

Lithuanian climate is formed affected by global factors and local geographical circumstances. Key features of the climate depend on the country's geographical location. The territory of Lithuania lies in the northern part of the temperate climate zone. The distance from the equator (6100 km) and from the North Pole (3900 km) determines general solar radiation flux and atmospheric circulation patterns over the country. According to the general classification of climate, almost the entire territory of Lithuania is assigned to the south-western sub-region of the continental forest region of the middle latitudes of the Atlantic Ocean, because its climate is close to that of Western Europe; while the Baltic coast is assigned to the South Baltic sub-region.

The character of climate variations in Lithuania greatly depends on the processes of atmospheric circulation, i.e., cyclonic and anticyclone formations and air mass advection of a different nature. It was observed that a number of deep cyclones visiting Lithuania in cold seasons (November - March) was increasing, whereas a number of anticyclone formations decreasing. The changing patterns of atmospheric circulation entailed changes in other climatic indices: changes in thermal season duration, decrease in seasonal differences of air temperature and precipitation amount, decline in snow cover indices.

Rapid increase in average annual temperature in Vilnius observed in the last 30 years (Figure 1-1).

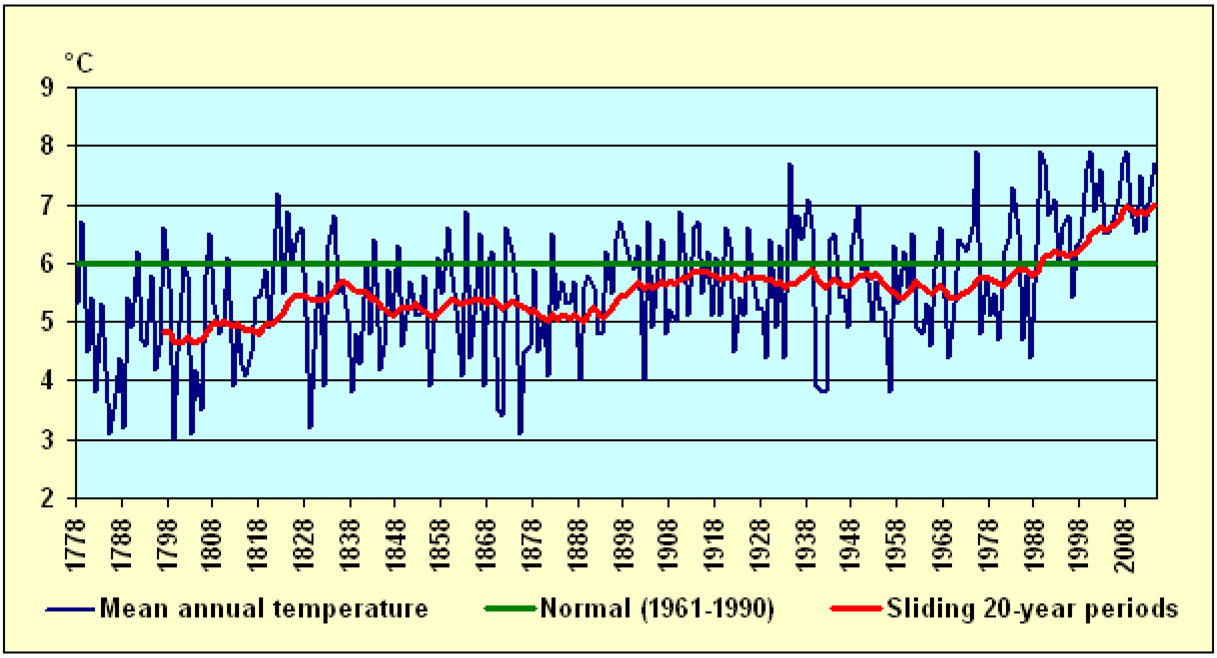


Figure 1-1. Average annual temperature in Vilnius, 1778-2014[1]

Average annual temperature, compared with the beginning of 20th century, has increased 0.7-0.9°C which leads to more frequent droughts (for example 1992, 1994, 2002, 2006 summer seasons). Changes in precipitation patterns are not homogenous – in some parts of Lithuania it is increasing, in other – decreasing. However, these changes are not very significant. There is an

[1] Lithuanian Hydrometeorological Service under the Ministry of Environment. Available from: *http://www.meteo.lt/english/*

observed tendency of precipitation increase during cold season and decrease during warm season. Liquid precipitation is becoming more frequent in cold season.

In Lithuania climate predictions are made by downscaling COSMO-CLM, HadCM3, ECHAM5 models output data. According to the modelling results, average maximum and minimal temperature in 21st century in Lithuania should increase. Highest changes are predicted during cold season. In Vilnius, average maximum and minimum temperature could increase by 4°C in year 2100. During different months, however, this increase could be up to 7°C.

In 21st century heat waves (days when maximum temperature ≥ 30°C) will become more frequent. In 2061-2100 there could be 7 heat wave days per year more compared to 1971-2000. Cold spells, on the contrary, will become less frequent with most significant changes in January. Modelling experiments suggest that at the end of 21st century cold spells (days when minimal temperature ≤ -15°C) will occur only during January-February.

In 21st century sunshine hours will increase during August – October, and will decrease during rest of the year. This will be caused by the higher cyclonic activity during cold season.

Studies made in Lithuania assume that biggest changes in precipitation patterns will be during winter season and will not be so explicit in summer. Precipitation can double in Klaipėda – by the end of century precipitation amount can increase 16-22% compared to the end of 20th century. In Vilnius changes will be not so significant – projected increase is about 9-10%. Severe thundershowers will be more frequent on the coast (> 30%).

Changes in temperature and precipitation patterns will affect different economical activities and natural ecosystems. Coastal region is one of the most vulnerable regions in Lithuania. Lithuanian coast is in the south-eastern region of Baltic Sea which will undergo biggest changes in 21st century, due to the sink of terrain and sea level rise. Pessimistic scenario suggests that water level in this region can rise by 0.5-1.0 m. In that case, there would be high risk of flooding urban areas in Klaipėda and Palanga. Also wind surge could disturb the port activities in Klaipėda more frequently.

All information about climate condition in Lithuania is observed from Lithuanian Hydrometeorological Service.

1.1.2 Background information on greenhouse gas inventories

This National Inventory Report (NIR) covering the inventory of GHG emissions in Lithuania is being submitted to the secretariat of the UNFCCC, in compliance with the decision 24/CP.19 of the Conference of the Parties. NIR is also submitted to the European Commission and complies with EU Regulation 525/2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC. NIR submitted to European Commission is also in compliance with decision No 529/2013/EU of the European Parliament and of the Council of 21 May 2013.

Since 2004, inventory is prepared using common reporting format (CRF). From 2006 inventory was being prepared using CRF Reporter software, developed by UNFCCC secretariat. In 2006 for the first time complete time series 1990-2004 has been developed and submitted to the European Commission and the UNFCCC secretariat together with Lithuania's Initial Report under the Kyoto protocol.

The GHG inventory presented here contains information on anthropogenic emissions by sources and removals by sinks for the direct (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3) and indirect (CO, NOx, SO_2, NMVOCs,) greenhouse gases. This report contains detailed information about Lithuania's GHG inventory for the period 1990-2013. NIR includes description of the methodologies and data sources used for emissions estimation by sources and removals by sinks, also description of the trends, key categories analysis, uncertainty estimates, planned improvements and description of performed procedures of QA/QC. The purpose of the report is to ensure the transparency, consistency, comparability, completeness and accuracy of GHG inventory. For the preparation of inventory upgraded CRF Reporter v.5.8.13 available as online application has been used.

The GHG inventory is prepared in accordance with the updated UNFCCC guidelines on annual inventories following incorporation of the provisions of decision 14/CP.11 (FCCC/SBSTA/2006/9). Greenhouse gas inventory is compiled in accordance with IPCC methodology: Guidelines for National Greenhouse Gas Inventories (IPCC, 2006); 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (IPCC, 2014), 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (IPCC, 2014), and also in accordance with decision No 529/2013/EU of the European Parliament and of the Council of 21 May 2013 when NIR is being submitted to EC.

1.2 A description of the national inventory arrangements

1.2.1 Institutional, legal and procedural arrangements

National system for Lithuanian GHG inventory preparation has been changing over the time. Until the year 2011, GHG inventory preparation process was performed by contracting GHG compilers on the annual basis. Aiming to increase institutional capacity for inventory preparation and continuity of the inventory preparation process in compliance with Guidelines for National systems under Article 5 paragraph 1 of the Kyoto Protocol (decision 19/CMP.1) the Government of Lithuania and the Minister of Environment have issued a number of key regulatory legal acts and assigned responsible institutions for GHG inventory preparation. The main entities participating in GHG inventory preparation process are:

- Ministry of Environment
- Environmental Protection Agency
- State Forest Service
- National Climate Change Committee
- Permanent GHG inventory working group
- Data providers
- External consultants

The principle scheme showing institutions responsibility in preparation of the GHG inventory in Lithuania and their interaction is shown in Figure 1-2.

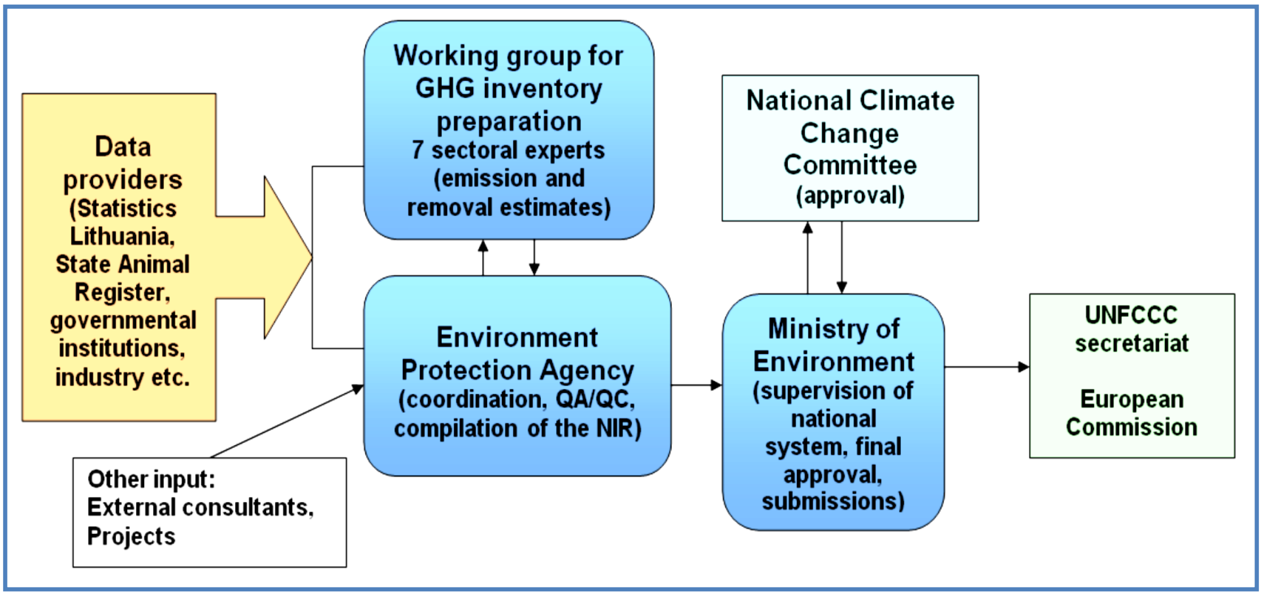


Figure 1-2. Institutional arrangement for GHG inventory

Ministry of Environment

Ministry of Environment of the Republic of Lithuania is a National Focal Point to the UNFCCC. The Ministry of Environment is designated as single national entity responsible for the national GHG inventory. It has overall responsibility for the national system of GHG inventory and is in charge of the legal, institutional and procedural arrangements for the national system and the strategic development of the national inventory. Within the ministry, the Climate Change Policy Division of the Pollution Prevention Department administers this responsibility by supervising the national system. The Division will continue to supervise and coordinate the preparation of the National Inventory Report, including the final review of the draft NIR. Among its responsibilities are the following:

- Overall coordination of GHG inventory process;
- Preparation of legal basis necessary for national system functioning;
- Official consideration and approval of GHG inventory;
- Approval of QA/QC plan and procedures;
- Timely submission of GHG inventory to UNFCCC Secretariat and European Commission;
- Coordination of the UNFCCC inventory reviews in Lithuania;
- Keeping of archive of official submissions to UNFCCC and European Commission;
- Informing the inventory compilers about relevant requirements for the national system.

Environmental Protection Agency

Lithuanian Environmental Protection Agency (EPA) under the Ministry of Environment starting from 2011 was nominated as an entity responsible for GHG inventory preparation by the Order of the Minister of Environment No D1-1017 (repealed by the Order of the Minister of Environment No D1-61, 23-01-2014). Before this assignment EPA was one of the main activity data and other relevant information providers for GHG inventory‘s Waste sector and data on F-gases.

At present EPA collects data on the use of water resources, discharges of wastewater, waste generation and treatment, pollution of ambient air and surface water, chemicals and fluorinated gases; manages the available registers, e.g. the Ambient Air Quality, the European Pollutants

Releases and Transfer Register and various databases. In 2012 Climate change division for GHG inventory preparation was established within the EPA.

As the coordinator of the GHG inventory preparation process, EPA has the following functions and responsibilities:

- Development and implementation of QA/QC plan and specific QA/QC procedures;
- Identification of data providers for specific information and collection of activity data and emission factors used to calculate emissions;
- Collaboration with sectoral experts while selecting best available methods that complying with IPCC methodology giving the priority to key categories and categories with high uncertainty;
- Documenting and archiving data related to GHG inventory and its preparation process;
- Accomplishment of cross-cutting issues: key categories analysis, overall uncertainty assessment, analysis of GHG trends;
- Preparation of CRF tables and compilation of NIR;
- Evaluation of requirements for new data, based on recommendations received during internal and external reviews.

Since 2014 submission personnel of EPA is also responsible for calculation of emissions and preparation of NIR part of the industrial processes, solvents and other products use sectors and agricultural soils part of the agriculture sector.

EPA establishes and operates GHG inventory archive, where GHG inventory submissions and all supporting reference material is stored and maintained. Backups are prepared on regular basis following the EPA's information management procedures. The archive is managed according to the EPA Director's Order No AV-152 concerning the approval of the National GHG inventory data archiving procedures (26^{th} June 2012). The main QA/QC procedures under responsibility of EPA are performed according to the EPA Director's Order No AV-191 concerning the approval of the National GHG inventory data quality assurance and quality control procedures (23^{th} July 2012).

State Forest Service

The State Forest Service (SFS) compiles the National Forest Inventory (NFI) and the forest information system, carries out monitoring of the status of the Lithuanian forests, collects and manages statistical data etc. The Service functions under the Ministry of Environment.

Since 2010 SFS in the GHG inventory preparation process is responsible for calculations of emissions and removals of LULUCF (forestry part) sector and Kyoto Protocol activities under Art. 3 para. 3 and 4 following the Order of the Minister of Environment 29 of July, 2010 No D1-666 (repealed by the Order of the Minister of Environment No D1-61, 23-01-2014). SFS representative is also a member of permanent working group for GHG inventory preparation under the Government Resolution No 683. In this framework, the SFS has the following responsibilities:

- Collection of activity data and emission factors used to calculate emissions and removals for LULUCF and KP-LULUCF sectors;
- Selection of methods (complying with IPCC Good Practice Guidance for LULUCF) for calculation of emissions and removals giving the priority to key categories and categories with a high uncertainty;
- Emission and removals estimates for LULUCF and KP-LULUCF sectors, preparation of CRF tables and NIR parts for LULUCF and KP-LULUCF and providing the final estimates for the EPA;

- Uncertainty assessment for LULUCF and KP-LULUCF sector;
- Checking and archiving of input data, prepared estimates and used materials;
- Implementation of QA/QC plan and specific QA/QC procedures related to LULUCF and KP-LULUCF;
- Evaluation of requirements for new data, based on recommendations received during internal and external reviews.

In 2012 Climate Change group responsible for LULUCF sector GHG emission and removals estimates was established within National Forest Inventory division at SFS.

Permanent GHG Inventory working group

Permanent GHG Inventory preparation working group is established by the Governmental Resolution No 683 (as amended on 18-12-2013 by Governmental Resolution No 1221) and MoE Order No D1-538 (as amended on 09-01-2014 by the Minister of Environment Order No D1-25). According to the Governmental Resolution No 683, working group (commission) for the preparation of a GHG inventory report consists of representatives from:

- Ministry of Environment (Chairman of the Commission);
- Environmental Protection Agency (Deputy Chairman of the Commission);
- Institute of Physics of the Centre for Physical Sciences and Technology (energy, transport);
- Lithuanian Energy Institute (energy, except transport);
- Institute of Animal Science of the Lithuanian University of Health Sciences (agriculture);
- University of Applied Sciences (LULUCF, except forestry);
- State Forest Service (LULUCF, forestry; KP-LULUCF);
- Public body Centre for Environmental Policy (waste).

Institutions, listed in the Governmental Resolution No 683, nominated experts, who have experience in areas related to GHG emissions accounting, and the personal composition of the permanent GHG inventory working group was approved by the MoE Order No D1-538.

Functions and responsibilities of the working group for GHG inventory preparation as a whole are defined as follows:

- Evaluation of requirements for new data based on internal and external reviews;
- Search and identification of specific data providers;
- Preparation of requests for new data;
- Identification, on the basis of the IPCC 2006 Guidelines, of methodologies for calculation of GHG emissions setting priority to the key categories and categories with high uncertainty level;
- Determination of activity data and appropriate emission factors, calculation of emissions;
- Filling in CRF tables for corresponding sectors, drafting relevant NIR sectoral chapters;
- Application of sector specific QA/QC procedures;
- Preparation of comments and answers to the questions and comments received during the EC and UNFCCC reviews;
- Collaboration with NIR compiler and QA/QC manager (EPA).

The composition of the Working group for GHG inventory preparation (as approved by MoE Order No D1-538 and amended on 09-01-2014 by the MoE Order No D1-25) is as follows:

- Mr. Vitalijus Auglys (Ministry of Environment) – Chairman of the working group;

- Dr. Mindaugas Gudas (Environment Protection Agency) – Deputy Chairman of the working group;
- Dr. Inga Konstantinavičiūtė (Lithuanian Energy Institute) – energy sector (except transport);
- Dr. Steigvilė Byčenkienė (Institute of Physics) – energy sector (transport);
- Dr. Remigijus Juška (Institute of Animal Science) – agriculture sector;
- Dr. Saulius Marcinkonis (University of Applied Sciences) – LULUCF (land use other than forestry);
- Dr. Ričardas Beniušis (State Forest Service) – LULUCF (forestry), KP-LULUCF;
- Dr. Romualdas Lenkaitis (Centre for Environmental Policy) – waste sector.

National Climate Change Committee

Before final submission to the UNFCCC Secretariat and the European Commission, National Inventory Report is forwarded to the National Climate Change Committee for the comments and final approval. The National Committee on Climate Change was set up in 2001 in the first instance and renewed in January 2013. It consists of experts from government, academia and non-governmental organizations (NGOs) and has an advisory role. The main objective of the Committee is to ensure attainment of the goals related to the restriction of GHG emissions as set in the National Sustainable Development Strategy and implementation of the measures for attaining such goals. Also, the Committee has to coordinate the issues related to formulation and implementation of the national policy on climate change management, to advise on the implementation of the provisions of the UNFCCC and coordinate compliance with the requirements of the Kyoto Protocol and the EU legal acts related to the UNFCCC. Also, the Committee submits proposals regarding the annual priorities for the financing of climate change management measures under the Special Program for Climate Change, which is set up by the Law on Financial Instruments for Climate Change Management adopted on 7th July 2009.

Data providers

Data providers are responsible for:

- collection of activity data;
- applying QC procedures (references in the documentation QC protocols to be provided to EPA);
- evaluation of uncertainties of the initial data.

The main providers of the data for the Lithuania's GHG inventory are:

- Statistics Lithuania publishes Lithuanian annual statistical publications (annual statistical data on energy balance, agriculture, production and commodities);
- State Forest Service under the Ministry of Environment publishes annual statistical data on forestry (Lithuanian Statistical Yearbook of Forestry (2001-2014); Lithuanian Country Report on Global Forest Resources Assessment (2005, 2010));
- The National Land Service under the Ministry of Agriculture provides data of the Lithuanian Land Fund including data on forest land area;
- The Geological Survey of Lithuania provides data on peat extraction areas;
- Environmental Protection Agency collects data and maintains database on wastewater and waste, F-gases;
- Industrial companies (AB Achema (ammonia, nitric acid production data and natural gas consumption data), AB Orlen Lietuva (CO2 EFs for fuel combustion), AB Akmenes cementas (activity data and CaO/MgO content), AB Naujasis Kalcitas (limestone composition data),

glass production companies (data on dolomite, soda ash, potash and chalk use), UAB Paroc (rock wool production data, etc.));
- Institute of Physics annually calculates precursors (NOx, SO_2, CO, NMVOC) emissions under the UNECE Convention on Long-range Transboundary Air Pollution;
- Agricultural Information and Rural Business Centre of Ministry of Agriculture (data on livestock population);
- State Medicines Control Agency (data on metered dose inhalers, N_2O use in medicine);
- Annual EU Emissions Trading System (ETS) data reports by the operators.

Aiming to set up the system to ensure a better data collection for the preparation of NIR the amendment No 1540 of the Government Resolution No 388 of 7th April 2004 was adopted on 3rd November 2010. The Government Resolution determines responsibilities of other ministries and their subordinated institutions, as well as other institutions and the state science research institutes to provide data which they collect and possess and are required for the inventory compilation (Table 1-1). In the Government Resolution each ministry is assigned to collect more precise information from institutions and agencies within their jurisdiction and provide all this information to Ministry of Environment and its authorized institution – Environmental Protection Agency. The state science research institutes are authorized to perform new scientific researches, necessary for the improvement of data collection in the sectors where lack of data is identified, and to provide information required for the preparation of the NIR.

Table 1-1. Summary of institutions responsibilities to provide data under the amendment No 1540 to the Government Resolution No 388

Institution	**Data**
Ministry of Agriculture and it's subordinates	Information on land use and land use change areas and other relevant information Information on cattle population, age and other relevant information required for inventory's Agriculture sector's estimates preparation
Ministry of Energy and it's subordinates	All the available information required for GHG inventory's Energy sector's estimates preparation
Statistics Lithuania	All the available information required for GHG inventory preparation, including energy and fuel balance, economic development indicators, e.g. GDP, etc.
State science research institutes	All the available information required for GHG inventory preparation possessed by the Lithuanian Energy Institute, Agriculture Institute, Institute of Agrarian Economics, Institute of Animal Science, Institute of Physics, etc.
State Road Transport Inspectorate under the Ministry of Transport and Communications	Information on average CO_2 emission from different type of vehicles
Ministry of Interior and it's subordinates	Information on annually registered number of vehicles, their models, types, engine capacity and fuels used

External consultants

External experts, independent specialists providing data for the GHG inventory (data providers) may also be involved during the inventory process in preparation and upgrading of methodologies, data review and evaluation they can also perform expertise of the whole inventory or of its separate parts. External experts can be contracted annually in the areas where specific expertise is needed and the experience and knowledge of the working group member's is not enough.

One of the sources for external consultation is Wiki forum that was initiated and launched by European Commission in 2013. This is a helpful tool for EU Member States helping to implement *IPCC 2006*.

Norway Grants partnership project "Cooperation on GHG inventory" between Lithuania and Norway under the program No 25 „Capacity-building and institutional cooperation between beneficiary state and Norwegian public institutions, local and regional authorities" has been started in 2015. In 2014 the documentation phase of the project was completed by providing main documents and contracts. The partner of this program is Norwegian Environment Agency, which is the national entity responsible for GHG inventory preparation in Norway.

The objective of this partnership project is capacity building and improvement of the Lithuania's National system for the preparation of GHG inventory to comply with the relevant UNFCCC and Kyoto protocol reporting requirements. The main purpose of this project is to share experiences of implementation the new guidelines (*IPCC 2006*) in GHG inventory. Expected outcomes of the project are:

- A training program for Lithuanian inventory experts to raise the technical competence in the GHG inventory and GHG emissions projections development process.
- The improvement of Quality assurance/Quality control (QA/QC) procedures as well as documenting, archiving system.
- Implementation of studies to fill in the reporting gaps in several LULUCF sector's areas:
  - Study for evaluation of carbon stocks in forest and non-forest land in soil and forest litter. This study will cover the sampling of soil and litter on the national forest inventory sample plots and analysis of these samples.
  - Study for evaluation of carbon stocks in soil and forest litter of forests that were afforested on non-forest land. The study will include determination of sample plots and sampling, analysis of samples.
  - Study for evaluation of carbon stock in dead organic matter (dead wood) analyzing various degrees of dead wood decomposition rates. The study will cover determination of sample plots and sampling, analysis of samples.
  - Study for development of the harvested wood products (HWP) accounting system and preparation of accounting methodology. This study should cover analysis of legal regulation, practices of neighboring countries and accounting principles of harvested wood products in Lithuania.
  - National emission factors for energy sector development and revision study.
- Assistance in improvement of national system for GHG projections reporting. Development of proposals for fulfillment of relevant EU and UNFCCC GHG projections reporting requirements and support in modeling tools and methodologies use.

Project activities will be implemented during the period 2015-2016. As project activities just started, project results will be reported in the next NIR.

1.2.2 Overview of inventory planning, preparation and management

Lithuania prepares National Inventory Report and fills in CRF tables according to requirements of the UNFCCC, the Kyoto Protocol and the EU greenhouse gas monitoring mechanism Regulation

No 525/2013. The organization of the preparation and reporting of Lithuania's GHG inventory and the responsibilities of its different institutions are described in previous section.

The annual GHG inventory preparation follows the Work schedule for reporting. Work schedule for preparation and submission of National GHG inventory 2015 is presented in Table 1-2. Lithuania has to submit GHG inventory to the European Commission by 15th January and update estimates by 15th March annually. GHG inventory to the UNFCCC shall be submitted by 15th April annually.

Table 1-2. Work plan for preparation and submission of National GHG inventory in 2015

Activity	Responsible institutions	Deadlines
Updated QA/QC plan 2014-2015	EPA, MoE	August 2014
Data collection - sending of official letters to data providers; Methods development; QC procedures, data archiving	EPA, WG sectoral experts	September-October 2014
Meetings of all involved institutions for defining specific areas for improvements and recalculations	MoE, EPA, SFS, WG sectoral experts	September 2014
Sectoral experts input results to EPA	WG sectoral experts	October-November 2014
Filling in CRF Reporter, QC procedures, data archiving	EPA	November 2014
Filling in CRF and prepare NIR part on LULUCF and KP-LULUCF and sending to EPA, data archiving	SFS	November 2014
Prepare draft NIR and send to MoE and other institutions for comments	EPA	By December 2014
Comments from MoE and others to EPA	MoE	By 15 December 2014
Submission of CRF tables, xml file and draft NIR to European Commission	MoE	By 15 January 2015
Possible CRF and NIR updates and final approval by MoE	EPA, WG sectoral experts, MoE	By March 2015
Sending NIR to NCCC for comments and final approval, QA procedures	MoE	By 15 March 2015
Submission of GHG inventory to European Commission	MoE	By 15 March 2015
Submission of GHG inventory to UNFCCC secretariat	MoE	By 15 April 2015

This schedule does not include timeframe for the EU inventory consistency checks, UNFCCC reviews and Lithuania's responses though the Work Plan may be updated during the year. Possible legislation improvements for a proper National System functioning are also not included in this scheme, but will be considered during the year and will be drafted by the Ministry of Environment, if necessary.

1.2.3 Quality assurance, quality control and verification plan

1.2.3.1 Quality assurance and quality control procedures

General Quality Control procedures applied

As a GHG inventory compiler and QA/QC manager EPA performs general QC procedures presented in the Figure below.

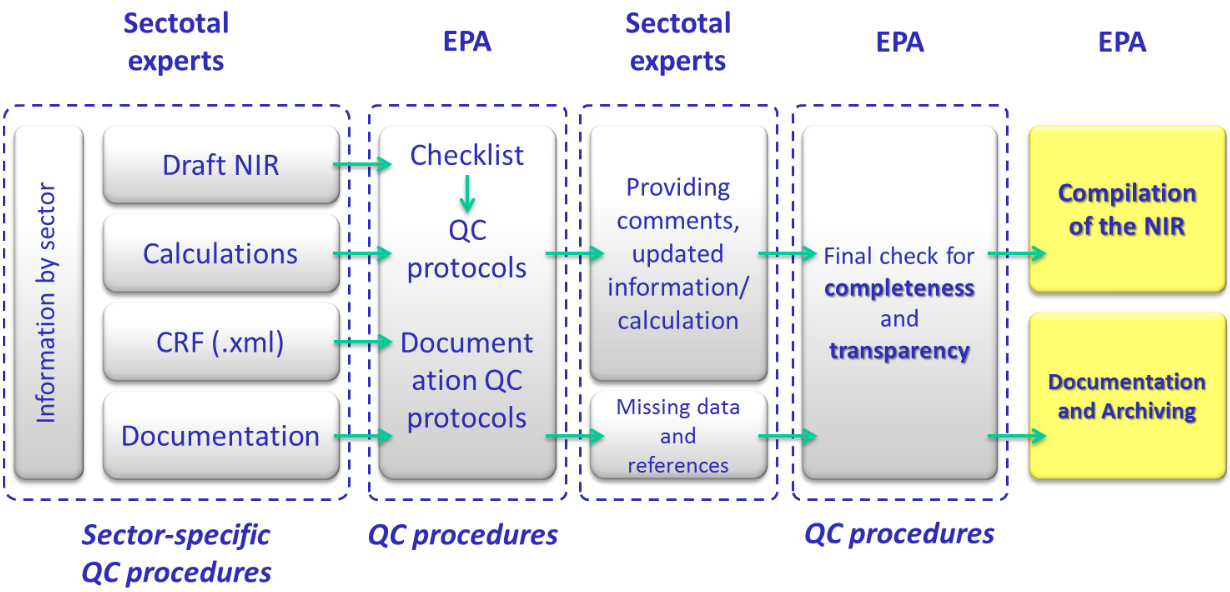


Figure 1-3. General QC procedures performed by EPA

As shown in the Figure above general procedures of the QC involves check of all the input data, assumptions and data criteria, references provided, emission calculations, units and conversion, consistency between source categories, aggregation and transcription. Besides of general check EPA fills in the Checklist for primer data check and QC protocols which record all the corrective actions taken. General control procedures also involve QC of documentation and archiving system.

QC procedures involve the **evaluation of the data collection procedure**. This covers evaluation of the following checks: if all the necessary methods, activity data and emission factors have been used; if calculations have been made correctly; if all-time series data has been provided and calculated; if comparison of current year data and calculation to the results of the previous years have been made; if the notes and comments contain all necessary information on the data sources, calculation methods, etc. Procedure also includes **evaluation of the emission calculation** by assessing the consistency of emission factors (EF) used, correctness of parameters and units, conversion factors used; correctness of data upload to CRF. Finally **general evaluation of the respective sectors** are made to establish: integrity of the inventory data structures, completeness of the inventory, consistency of the time-series, general comparison with the previous year, full correspondence of the calculations to the NIR text, all necessary information on methodology, assumptions, data sources and references are provided.

Results of the checks are recorded in the Checklists and QC protocols. After the check, the QC protocols are given back to the sectoral experts who respond to the comments of the QC Manager and, if necessary, correct the data, calculation methodology or the text in the NIR accordingly.

In addition to routine quality checks (Tier 1), source specific quality control procedures are applied, focusing on key categories and categories with high uncertainty. Source-specific QA/QC is discussed in detail in the relevant sections of the NIR.

Quality Assurance

The aim of Quality Assurance (QA) procedures is to review the complete GHG inventory by the third party which is not directly involved in preparation of inventory to assess its quality i.e. assure that best available data and methods are used. The objective of QA implementation is to involve reviewers that can conduct an unbiased review of the inventory. Review for QA can be applied either for the whole inventory either for a certain sector. QA procedures for Lithuania's GHG inventory can be applied by performing scheduled international review (UNFCCC review, EU review) or performing national QA procedures.

National QA procedures

As QA/QC procedures are coordinated by EPA it is also under responsibility of EPA to establish a QA system comprising the procedure of the review. This procedure includes:

- Identification and prioritization of data sets for review based on key category, uncertainty analysis, conducted QC procedures, etc.;
- Identification of reviewers;
- Conclusion of findings and corrective actions based on the review results.

National review of the draft GHG inventory report takes place before the final submissions to the EC and UNFCCC secretariat (January to March) by institutions that are not directly involved to inventory preparation process. If not planned otherwise the final draft of the NIR is reviewed by Ministry of Environment, National Climate Change Committee members and, if possible, by additional institutions that are not directly involved in the preparation process.

International reviews

On the annual basis European Commission (EC) conducts quality checks of the EU member states GHG inventories. EC uses QA/QC communication tool what is a convenient way of providing questions and answers. After these procedures corrections are elaborated in Lithuania's GHG inventory responding to EC quality checks and comments. Starting from 2015, EU Members states GHG inventories will also be subject to review under EU Decision 406/2009/EC to check Member states' compliance with EU Effort Sharing Decision (ESD) targets.

UNFCCC reviews performed by the external review team (ERT) help fulfilling requirements of the Quality Assurance. By conducting annual reviews ERT indicate issues and provides recommendations where inventory needs improvements. These recommendations are taken into account in the subsequent submission by providing detailed explanation how each of the recommendation was or will be applied.

1.2.3.2 QA/QC plan

The overall aim of the quality system is to maintain and improve the quality in all stages of the inventory work, in accordance with decision 24/CP.19. The quality objectives of the QA/QC plan and its application are an essential requirement in the GHG inventory and submission processes in order to ensure and improve the inventory principles: transparency, consistency, comparability, completeness, accuracy, timeliness and confidence in the national emissions and removals estimates for the purposes of meeting Lithuania's reporting commitments under the

UNFCCC and the Kyoto protocol. In addition, one of the objectives of the quality system is to determine short-term and long-term activities for the GHG inventory improvement plan.

QA/QC plan was updated in 2014. EPA was responsible for the update of QA/QC plan which was approved by the MoE. EPA is responsible for the coordination and implementation of the Plan with a supervision performed by the MoE.

The QA/QC Plan describes the quality objectives of the GHG inventory, the national system for inventory preparation, tasks and responsibilities. A description is provided of various formal procedures already implemented in the development of the GHG inventory and planned improvements for the period 2014-2015.

1.2.3.3 Verification activities

According to the obligations under the EU Regulation No 525/2013 on a mechanism for monitoring and reporting GHG emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC Lithuania has to evaluate and report on consistency of the reported data in GHG inventory to submitted information under other Directives, statistical databases, etc. This information includes:

- a brief assessment whether the emissions estimates of carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen oxides (NOx) and volatile organic compounds, in inventories submitted by the Member State under Directive 2001/81/EC of the European Parliament and of the Council and under the UNECE Convention on Long-range Transboundary Air Pollution are consistent with the corresponding emission estimates in greenhouse gas inventories under Regulation (EU) No 525/2013;
- comparison between the reference approach calculated on the basis of the data included in the greenhouse gas inventory and the reference approach calculated on the basis of the data reported pursuant to Article 4 of Regulation (EC) No 1099/2008 of the European Parliament and of the Council and Annex B to that Regulation (EU) No 525/2013;
- consistency check of the data reported on fluorinated greenhouse gases in the greenhouse gas inventory with the data reported pursuant to Article 6(1) of Regulation (EC) No 842/2006 (referred to in Article 7(1)(m)(ii) of Regulation (EU) No 525/2013);
- consistency check of reported emissions in the greenhouse gas inventory with data of the actual or estimated allocation of the verified emissions reported by installations and operators under Directive 2003/87/EC (referred to in Article 7(1)(k) of Regulation (EU) No 525/2013);
- Lithuania also conducts annual consistency checks of activity data (mainly livestock population) provided in the greenhouse gas inventory with those reported by FAO statistics.

1.2.3.4 Treatment of confidential information

There is no information in CRF reporter that would be identified as confidential.

1.2.4 Changes in the national inventory arrangements since previous annual GHG inventory submission

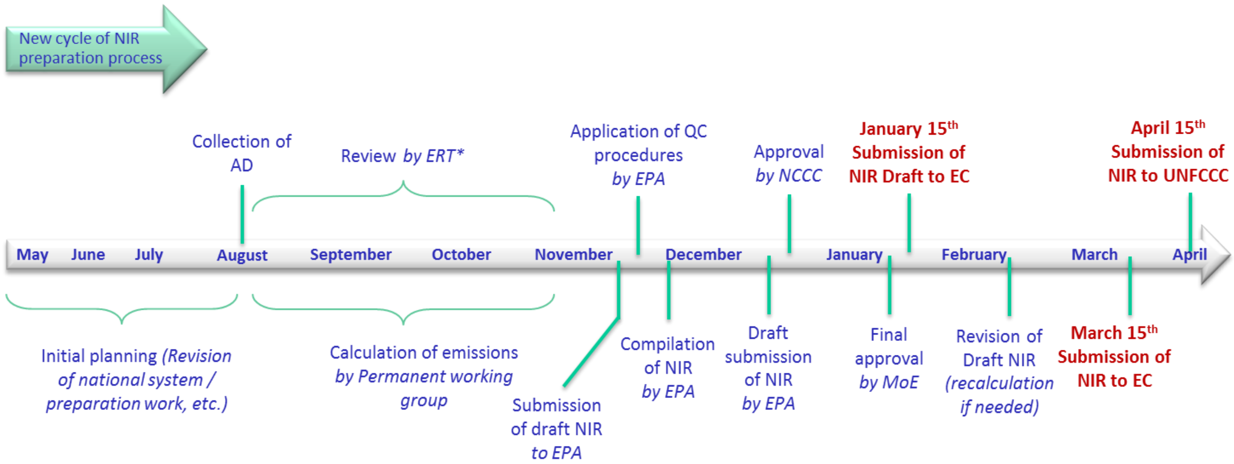
No changes in the national inventory arrangements were made since the previous submission.

1.3 Inventory preparation, and data collection, processing and storage

1.3.1 Inventory preparation process

Lithuania prepares NIR and CRF tables annually according to requirements of the UNFCCC, the Kyoto Protocol and the EU greenhouse gas monitoring mechanism Regulation No 525/2013. The annual GHG inventory preparation follows the Work schedule for reporting.

Work process of preparation and submission of National GHG inventory in Lithuania is organized by performing planned activities. The Figure below shows a general overview of the NIR preparation and submission process cycle.



igure 1-4. General Timeline of NIR preparation and submission process

Lithuania has to submit GHG inventory to the European Commission by 15th January and update estimates by 15th March annually. GHG inventory to the UNFCCC shall be submitted by 15th April annually.

This timeline shows only general activities overview and might be modified according to the reviews scheduled, planned projects, etc.

1.3.2 Data collection, processing and storage

Data is being collected annually from the main data sources. All data sources and data providers are described in Chapter 1.1.2 (Data providers).

Processing of data and its storage (archiving) is one of the main QC procedures. Proper documentation and archiving system is an essential part of inventory compilation and assurance of inventory transparency. Inventory documentation must be sufficiently comprehensive, clear and adequate for all present and future experts to be able to obtain and review the references used and reproduce the inventory calculations.

The main archive of the GHG inventory is placed within the Environmental Protection Agency (EPA). In 2011 GHG inventory archive was transmitted to EPA from the Ministry of Environment (MoP) for the further enhancement and completion. In 2011 EPA prepared GHG inventory archive improvement plan. The main tasks outlined in the plan are:

- to develop documentation checklists for each CRF category;
- to complete GHG inventory archive with the documentation provided by the sectoral experts;

– to develop a manual describing common archiving procedures (archive data structure, timing, data security etc.).

The manual describing common archiving procedures of Lithuania's GHG inventory (archive data structure, timing, data security etc.) was approved on 26th of June 2012 and published as EPA Director's Order No. AV-152 *Concerning the approval of the National GHG inventory data archiving procedures*. The document describes general archiving principles, timing and outlines the structure of the Lithuania's GHG inventory archive. Figure 1-5 outlines Lithuania's GHG inventory archive structure.

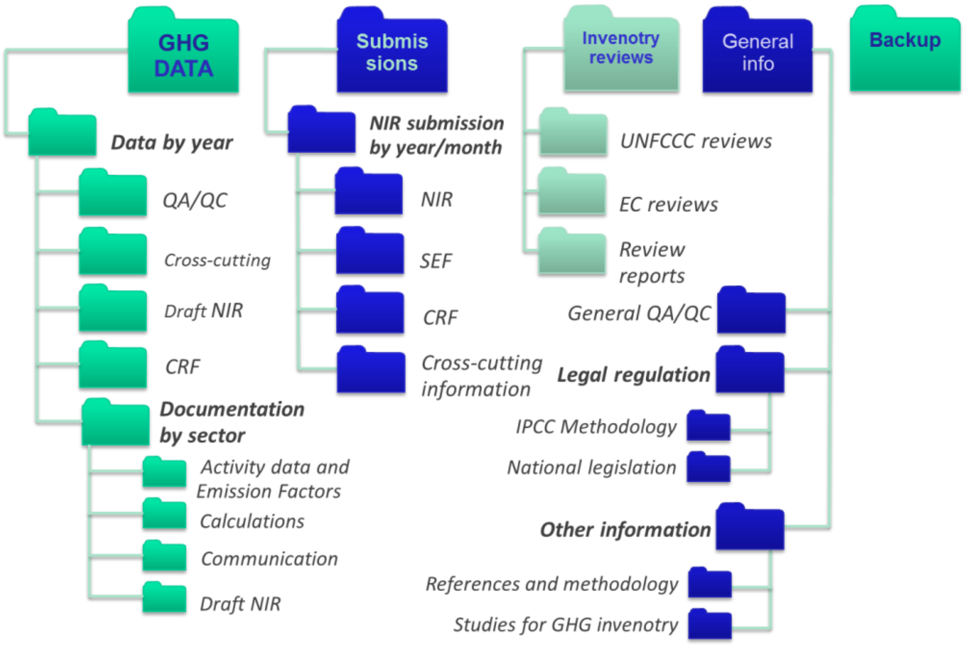


Figure 1-5. Lithuania's GHG inventory archive structure

As shown in Figure x archive is organized by locating information in 5 main folders: 1) **General information** contains all related legislation (national, EU and UNFCCC decisions), IPCC methodologies and other methodological information provided by UNFCCC, all information related to QA/QC system (QA/QC plans and templates for protocols and checklists while performing QC procedures), other relevant information e.g. important sources and references, conducted studies and projects, etc. 2) **GHG data** – this is the folder were all activity data used for calculations are stored. Data in this section is stored by year of submission further allocating it by sectors. Each CRF sector contains the following information – activity data and emission factors, calculations (excel spread sheets), communication (data or other relevant information obtained through communication with external experts, companies etc.), draft versions of text part with comments and tracked changes. Besides the information on each sector each folder by year contains information on cross-cutting issues (key categories and uncertainty analysis, GHG trends), draft CRF xml files, draft versions of NIR with comments and tracked changes, quality control protocols, documentation protocols and checklists for each sector. As submission of NIR is scheduled in January, March and Aprils information located in GHG data might be further stored by month of submission if major recalculations are applied. 3) Folder **Submissions** stores information by date of submission (NIR, its annexes and cross-cutting information, SEF tables, CRF tables and xml file). 4) **Inventory Reviews** stores information of EU and UNFCCC review process (centralized and in-country review questions and answers and review reports) 5) Folder **Backups** stores the backup files of CRF storing them by date.

In order to assure quality of archiving system EPA performs quality control procedures for documentation and archiving system. Figure 1-6 provides main QC procedures applied for documentation placed in archive.

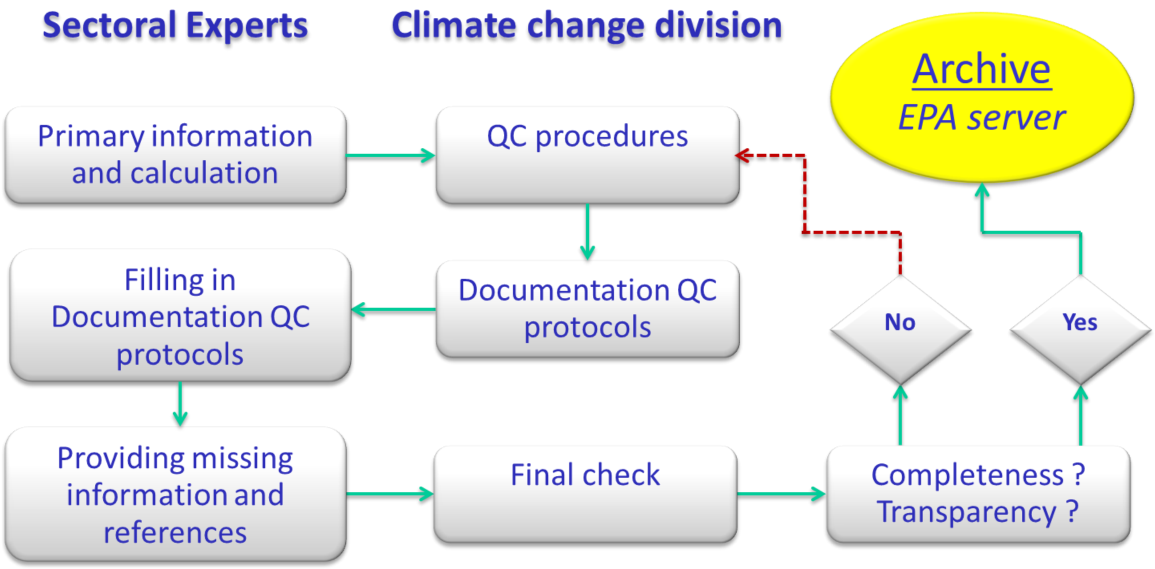


Figure 1-6. Quality control procedures applied for data archiving system

In order to assure transparency and completeness of data archived EPA developed documentation quality control protocols for each sector. Prior to each submission of NIR comprehensive quality checks are performed over each sector to identify missing references and documentation. Taking into consideration check results, sectoral experts provide missing references, documentation and/or additional explanation to the EPA. This procedure also allows EPA experts to assess the rationale for methods choice and availability of activity data. Further all relevant GHG inventory information is collected, systematized, compiled and arranged according to the established archiving system.

In addition to the main archive, sectoral experts have archives located in their own facilities. Original National Forest Inventory data is archived in the SFS as this data contains GIS maps and other sizeable data.

1.4 Brief general description of methodologies and data sources used

1.4.1 Methodologies used for preparation of GHG inventory

GHG inventory contains information on the following greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). Information is provided on the following indirect greenhouse gases: carbon monoxide (CO), nitrogen oxides (NOx) and non-methane volatile organic compounds (NMVOCs), as well as sulphur oxides (SOx). Information on indirect GHG emissions is provided in detail in Chapter 9.

The GHG inventory is prepared in accordance with IPCC methodology:

- 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPPC, 2006);
- Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPPC, 2003).

GHG inventory is prepared also taking into account requirements, provided in Regulation (EU) No 525/2013 of the European Parliament and of the Council on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC.

Simple equations that combine activity data with emission factors are used. Different sources in the transport, agriculture, waste and LULUCF sectors necessitate the use of more complicated equations and models. Table 1-3 summarizes the most important data sources used in the inventory.

Table 1-3. Main data sources used in the greenhouse gas inventory

Sector	**Main data sources**
1.A Energy: Fuel Combustion	Energy Statistics database (Statistics Lithuania) EU ETS emission data
1.B Energy: Fugitive Emissions	Energy Statistics database (Statistics Lithuania) Lithuanian Geological Service Individual companies
2. Industrial Processes and Product Use	Individual production plants EU ETS emission data Industrial statistics database (Statistics Lithuania) F-gases database (EPA) Published literature
3. Agriculture	The Register of Agricultural Information and Rural Business Centre of Ministry of Agriculture Agricultural Statistics database (Statistics Lithuania) Published literature
4. LULUCF	NFI (National Forest Inventory) State Forest inventory Lithuanian Statistical Yearbook of Forestry Published literature
5. Waste	Waste database (EPA) Water and wastewater database (EPA) Regional Waste Management Centres

A detailed description of methodologies and data sources used in the preparation of the emission inventory for each sector is outlined in the relevant chapters.

1.5 Brief description of key categories

Key categories analyses for the GHG inventory were performed according to the *2006 IPCC* Approach 1 and Approach 2 level and trend assessment of the key categories. Level assessment with uncertainty (LU_{xt}) and trend assessment with uncertainty (TU_{xt}) were calculated using Approach 1 uncertainty analysis (Annex II).

The base year for the analysis is 1990 for the greenhouse gases CO_2, CH_4, N_2O and 1995 for the F-gases HFC, PFC, SF_6 and NF_3. The categories identified by Approach 2 that are different from categories identified by Approach 1 were treated as key categories.

The level of disaggregation used for the key category analysis was performed by taking into account country-specific issues, specifically, in energy and agriculture sectors key categories were broken down into sub-source categories in order to reflect the level at which the EFs were applied and in order to focus efforts towards methodological improvements on these most significant sub-source categories.

Approach 1 key category with a highest contribution to national total emission in 2013 and 1990 is 4.A.1 Forest land remaining forest land - carbon stock change in biomass (CO_2). Its contribution to national total is 25% in 2013 and 10% in the base year. The second most important source of greenhouse gas emissions in 2013 is 1.A.3.b Road transportation accounting for 10% of the total emissions whereas in the base year was 1.AA.1.A Public electricity and heat production - liquid fuel (CO_2) accounting for 9% of the total emissions.

Key category analysis using a subset of inventory estimates was conducted. The LULUCF sector has been excluded from the analyses. Level and trend assessment of the subset identified additional categories when compared to Approach 1 analysis of total inventory. Additional categories identified by level assessment: 1.A.1. Energy industries-Other fossil fuels (CO_2), 1.A.4 Other sectors-Peat (CO_2), 3.B.1.3 Manure Management – Swine (CH4), 3.D.2.1 Indirect N2O Emissions From Managed Soils - Atmospheric deposition (N_2O) and by trend assessment: 1.A.1. Energy industries-Other fossil fuels (CO_2), 1.A.4 Other sectors-Peat (CO_2), 1.A.4 Other sectors-Biomass (CH_4), 3.D.1.1 Direct N_2O Emissions From Managed Soils - Inorganic N Fertilizers (N_2O), 3.D.2.2 Indirect N_2O Emissions From Managed Soils - Nitrogen leaching and run-off (N_2O).

Approach 2 key category with a highest contribution to national total emission in 2013 is 4.A.1 Forest land remaining forest land - carbon stock change in biomass (CO_2) accounting for 20% of the total emissions whereas in the base year was 4.B.2 Land converted to cropland - net carbon stock change in mineral soils (CO_2) accounting for 21% of the total emissions.

The following categories were identified by Approach 2 that was different from categories identified by Approach 1:

– 3.B.1 Manure Management – Other (N_2O);
– 3.B.2 Manure Management – Cattle (N_2O);
– 3.B.2 Manure Management – Indirect N_2O Emissions (N_2O);
– 3.D.2.1 Indirect N2O Emissions From Managed Soils – Atmospheric deposition (N_2O).

Results of the Approach 1 and Approach 2 Level and Trend key categories analysis are provided in Table 1-4. More detailed information on key categories calculations is provided in the Annex I.

Table 1-4. Key category analysis by Level and by Trend

IPCC Category	***Greenhouse gas***	***Identification criteria****	***Comments***
1.A.1. Energy industries-Other fossil fuels	CO_2	T1	
1.A.1. Energy industries-Solid fuels	CO_2	T1	
1.A.1. Energy industries-Biomass	N_2O		T2sub
1.A.1. Energy industries-Peat	CO_2		T1sub
1.A.1.a Public electricity and heat production - Gaseous Fuels	CO_2	L1,T1, T2	
1.A.1.a Public electricity and heat production - Liquid Fuels	CO_2	L1,T1, T2	
1.A.1.b Petroleum refining - Liquid Fuels	CO_2	L1,T1	
1.A.2 Manufacturing industries and construction-Gaseous fuels	CO_2	L1,T1	
1.A.2 Manufacturing industries and construction-Liquid fuels	CO_2	T1,T2	
1.A.2 Manufacturing industries and construction-Solid fuels	CO_2	L1,T1	
1.A.3.b Road transportation	CO_2	L1,T1	
1.A.3.c Railways	CO_2	L1	

1.A.3.e Other transportation	CO_2	L1,T1, T2	
1.A.3.e Other transportation	N_2O	T1,T2	
1.A.4 Other sectors-Biomass	CH_4	L1,L2,T1,T2	
1.A.4 Other sectors-Gaseous fuels	CO_2	L1,T1	
1.A.4 Other sectors-Liquid fuels	CO_2	L1,T1	
1.A.4 Other sectors-Peat	CO_2	L1	
1.A.4 Other sectors-Solid fuels	CO_2	L1,T1,T2	
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	L1, L2, T1,T2	
2.A.1 Cement Production	CO_2	L1,T1	
2.A.2 Lime Production	CO_2	T1	
2.A.4 Other process use of carbonates	CO_2	T1	
2.B.1 Ammonia Production	CO_2	L1,T1	
2.B.2 Nitric Acid Production	N_2O	L1,T1	
2.F.1 Refrigeration and Air Conditioning Equipment	HFCs	L1,T1	
3.A.1 Enteric Fermentation - Cattle	CH_4	L1,L2,T1,T2	
3.B.1.1 Manure Management - Cattle	CH_4	L1	
3.B.1.3 Manure Management - Swine	CH_4	T1	
3.B.1 Manure Management - Other	N_2O	T2	
3.B.2 Manure Management - Cattle	N_2O	T2	
3.B.2 Manure Management - Indirect N_2O Emissions	N_2O	L2, T2	
3.D.1.1 Direct N_2O Emissions From Managed Soils - Inorganic N Fertilizers	N_2O	L1, L2, T2	
3.D.1.2 Direct N_2O Emissions From Managed Soils - Organic N Fertilizers	N_2O	L1,T1,T2	
3.D.1.3 Direct N_2O Emissions From Managed Soils - Urine and dung deposited by grazing animals	N_2O	L1,T1,T2	
3.D.1.4 Direct N_2O Emissions From Managed Soils - Crop Residues	N_2O	L1,L2,T1,T2	
3.D.1.6 Direct N_2O Emissions From Managed Soils - Cultivation of organic soils	N_2O	L1,L2,T1,T2	
3.D.2.1 Indirect N_2O Emissions From Managed Soils - Atmospheric deposition	N_2O	L1,L2	
3.D.2.2 Indirect N_2O Emissions From Managed Soils - Nitrogen leaching and run-off	N_2O	L1, L2	
4.A Forest land-4(II) organic soils	CO_2	L1,L2,T1,T2	
4.A.1 Forest land remaining forest land - carbon stock change in biomass	CO_2	L1,L2,T1,T2	
4.A.1 Forest land remaining forest land - net carbon stock change in dead wood	CO_2	T1,T2	
4.A.2 Land converted to forest land - carbon stock change in biomass	CO_2	L1,L2,T1,T2	
4.A.2 Land converted to forest land - net carbon stock change in litter	CO_2	L1,L2,T1,T2	
4.B.1 Cropland remaining cropland - net carbon stock change in mineral soils	CO_2	T1,T2	
4.B.1 Cropland remaining cropland - net carbon stock change in organic soils	CO_2	L1,L2, T2	
4.B.2 Land converted to cropland - net carbon stock change in mineral soils	CO_2	L1, L2,T2	
4.B.2 Land converted to cropland- carbon stock change in biomass	CO_2	L1,L2,T1,T2	

4.C.2 Land converted to grassland - net carbon stock change in mineral soils	CO_2	L1,L2,T1,T2	
4.D.1 Wetlands remaining wetlands -net carbon stock change in organic soils	CO_2	L1, L2,T1,T2	
4.E.2 Land converted to settlements	CO_2	L1,L2,T1,T2	
4.G Harvested wood products	CO_2	L1,L2,T1,T2	
5.A Solid Waste Disposal	CH_4	L1,L2,T1,T2	
5.D Wastewater Treatment and Discharge	CH_4	L1,L2,T1,T2	

** Tsub denote the categories that were identified by level and trend assessment for a subset without LULUCF*

1.6 General uncertainty evaluation, including data on the overall uncertainty for the inventory totals

Uncertainty estimation was performed using Approach 1 of *IPCC 2006*. Quantitative uncertainties assessment was carried out for the emission level 2013 and for 1990-2013 (1995-2013 for F-gases) trend in emissions for all source categories comprising emissions of CO_2, CH_4, N_2O, HFC and SF_6 gases (in CO_2 equivalents). The GHG uncertainty estimates do not take into account the uncertainty of the Global Warming Potential (GWP) factors. The sources included in the uncertainty estimate cover 99.9% of the total greenhouse gas emission.

Uncertainties were estimated using combination of available default factors proposed in *IPCC 2006* with uncertainties based on expert judgment, consultation with statistical office. Approach 1 uncertainty evaluation analysis (including and excluding LULUCF) is presented in Annex II Tables 2-1, 2-2.

Uncertainty categories are reported in line with key categories analysis and they are used for *Tier 2* key categories analysis.

The uncertainty analysis was performed for each sector for all gases combined on purpose to have more detailed information for inventory improvements planning. Uncertainties of activity data of different gases and uncertainties of emission factor from the same sectors were combined using *IPCC 2006* equation 3.2.

$$U_{total} = \frac{\sqrt{(U_1 \cdot x_1)^2 + (U_2 \cdot x_2)^2 + \cdots + (U_n \cdot x_n)^2}}{|x_1 + x_2 + \ldots + x_n|}$$

Detailed information about uncertainty assessment is described under each sub-sector in the relevant NIR chapters.

Overall uncertainty

The total national GHG emission including LULUCF in the year 2013 is estimated with an uncertainty of ±62.6% and the trend of GHG emission 1990-2013 has been estimated to be ±11.4%.

The total national GHG emission excluding LULUCF in the year 2013 is estimated with an uncertainty of ±11.0% and the trend of GHG emission 1990-2013 has been estimated to be ±2.5%.

1.7 General assessment of the completeness

Lithuania's GHG emission inventory includes all the major emission/removal sources identified by the IPCC 2006 with some exceptions reported as "not estimated" (NE) (see Table 1-6), which have a minor effect on the total GHG emissions. Emissions/removals are not estimated mainly due to lack of available IPCC methodologies and/or lack of activity data.

Activity data and emission factors/parameters used for estimations are consistent and adequate through the 1990-2013.

Table 1-6. Summary of GHG inventory completeness

IPCC source and sink categories	CO_2	CH_4	N_2O	HFCs	PFC	SF_6	NF_3
1 Energy							
A Fuel combustion	√	√	√				
1 Energy industries	√	√	√				
2 Manufacturing industries and construction	√	√	√				
3 Transport	√	√	√				
4 Other sectors	√	√	√				
5 Other	√	√	√				
B Fugitive emissions from fuels	√	√	√				
1 Solid fuels	NO	NO	NO				
2 Oil and natural gas	√	√	√				
C CO_2 Transport and storage	NO						
D Memo items							
1 International Bunkers	√	√	√				
2 Multilateral Operations	NO	NO	NO				
3 CO_2 emissions from biomass	√						
4 CO_2 Captured	NO						
2 Industrial processes and product use							
A Mineral products	√						
B Chemical industry	√	√/NO	√	NO	NO	NO	NO
C Metal production	√	NO	NO	NO	NO	NO	NO
D Non-energy products from fuels and solvent use	√						
E Electronics industry				NO	NO	√	√
F Product uses as substitutes for ODS				√	NA/NO	NO	NO
G Other product manufacture and use	NO	NO	√	NO	NO	√	NO
H Other	√	NO	NO	NO	NO	NO	NO
3 Agriculture							
A Enteric fermentation		√					
B Manure management		√	√				
C Rice cultivation		NO					
D Agricultural soils		NA	√				
E Prescribed burning of savannahs		NO	NO				

	F	Field burning of agricultural residues		NO	NO				
	G	Liming	√						
	H	Urea application	√						
	I	Other carbon-containing fertilizers	NO						
	J	Other	NO	NO	NO				
4	**Land use, land use change and forestry**								
	A	Forest land	√	√	√				
	B	Cropland	√	√	√				
	C	Grassland	√	√	√				
	D	Wetlands	√	NO/NE	√				
	E	Settlements	√/NO/NE	NO/NE	NO/NE				
	F	Other land	√/NO/NE	NE	NO/NE				
	G	Harvested Wood Products	√						
	H	Other land	NO	NO	NO				
5	**Waste**								
	A	Solid waste disposal on land	NO	√					
	B	Biological treatment of solid waste		√	√				
	C	Incineration and open burning of waste	√	√	√				
	D	Wastewater treatment and discharge		√	√				
	E	Other	NO	NO	NO				
	F	Memo item	√						
6	**Other**		NO	NO	NO	NO	NO	NO	NO

√ – Emissions of the gas are covered under the source category
NA – Emissions of the gas are not applicable to the source category
NO – Emissions of the gas does not occur in Lithuania for the source category
NE – Emissions on the gas are not estimated for the source category
IE – Included elsewhere

2 TRENDS IN GREENHOUSE GAS EMISSIONS

2.1 Description and interpretation of emission trends for aggregated GHG emissions

Total GHG emissions amounted to 19946.1 kt CO_2 eqv. excluding LULUCF and 9982.12 kt CO_2 eqv. including LULUCF in 2013. GHG include CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3. The emissions of GHG expressed in kt CO_2 eqv. in 2013 have decreased by 58.3% comparing to the base year excluding LULUCF and by 77.3% including LULUCF. Figure 2-1 shows the estimated total GHG emissions in CO_2 eqv. from 1990 to 2013.

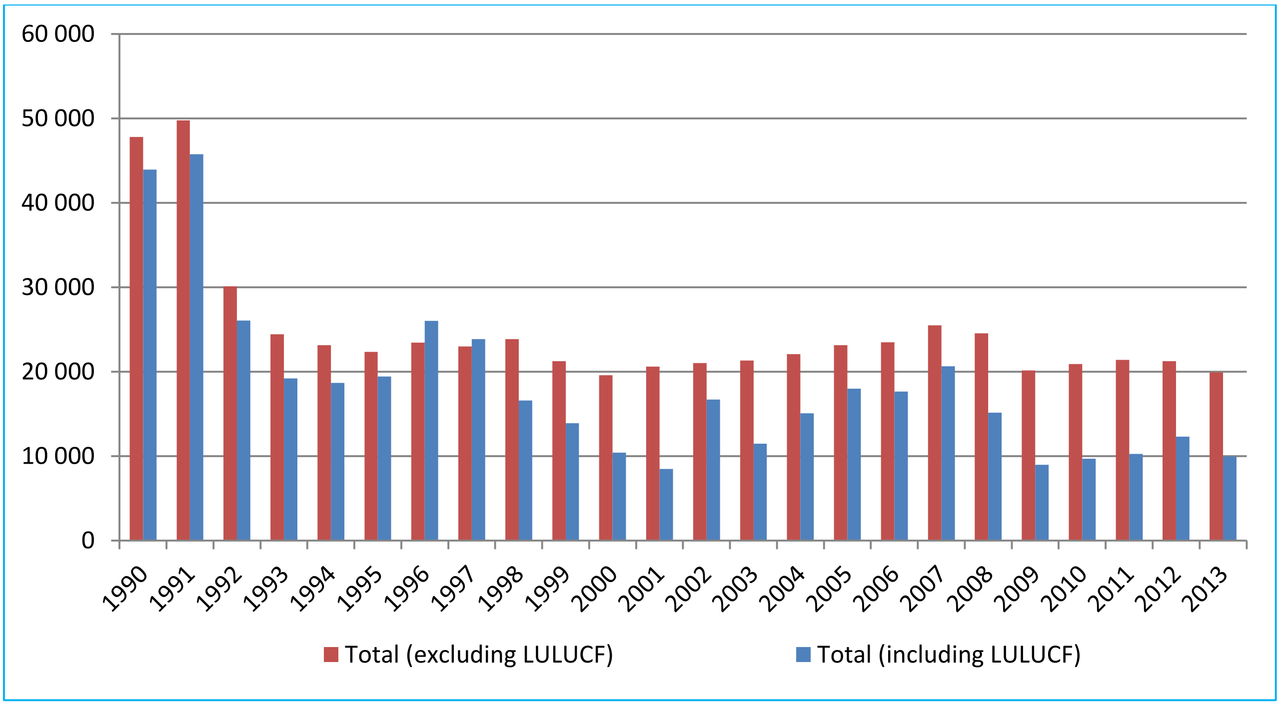


Figure 2-1. Emission trends for aggregated GHG in 1990-2013, kt CO_2 eqv.

The most important greenhouse gas is CO_2 as it contributed 65.2% to the total national GHG emissions expressed in CO_2 eqv. in 2013, followed by N_2O (15.8%) and CH_4 (17.5%). PFCs, HFCs, SF_6 and NF_3 amounted together to 1.6% of the total GHG emissions (excl. LULUCF) in Lithuania.

Upon its independence from the Soviet Union in 1990, after 50 years of annexation, Lithuania inherited an economy with high energy intensity. A blockade of resources, imposed by USSR during 1991–1993 led to a sharp fall in economic activity, as reflected by the decrease of the Gross Domestic Product (GDP) in the beginning of nineties. The economic situation improved in the middle of the last decade and GDP has been increasing until 1999 (during 1999-2000, GDP decreased due to the economic crisis in Russia) and GDP continued increasing from 2001 to 2008. In 2009 GDP decreased due to the world economic crisis and the slight growth of GDP in 2011 was observed 6.1%, in 2012 – 3.8% and in 2013 – 3.3%. These fluctuations were reflected in the country's emissions of greenhouse gases.

2.2 Description and interpretation of emission trends by sector

The trends of greenhouse gas emissions by sectors are presented in Table 1 showing greenhouse gas emissions by sectors, expressed in CO_2 equivalent and taking into account greenhouse gas emissions/removals from LULUCF sector.

Energy

Energy sector is the most significant source of GHG emissions in Lithuania with 57.1% share of the total emissions (excl. LULUCF) in 2013. Emissions from energy include CO_2, CH_4 and N_2O GHG.

Emissions of total GHG from energy sector have decreased almost 3 times from 33022.87 kt CO_2 eqv. in 1990 to 11388.75 kt CO_2 eqv. in 2013 (Figure 2-2). Significant decrease of emissions was mainly due to economic slump in the period 1991-1995. During the fast economic growth over the period 2000-2008 GHG emission in energy sector was increasing about 2.5% per annum. The global economic recession had impact on GHG reduction in energy sector by 9.5% in 2009. The closure of Ignalina NPP and GDP increase had impact on greenhouse gas increase by 7.5% in 2010.

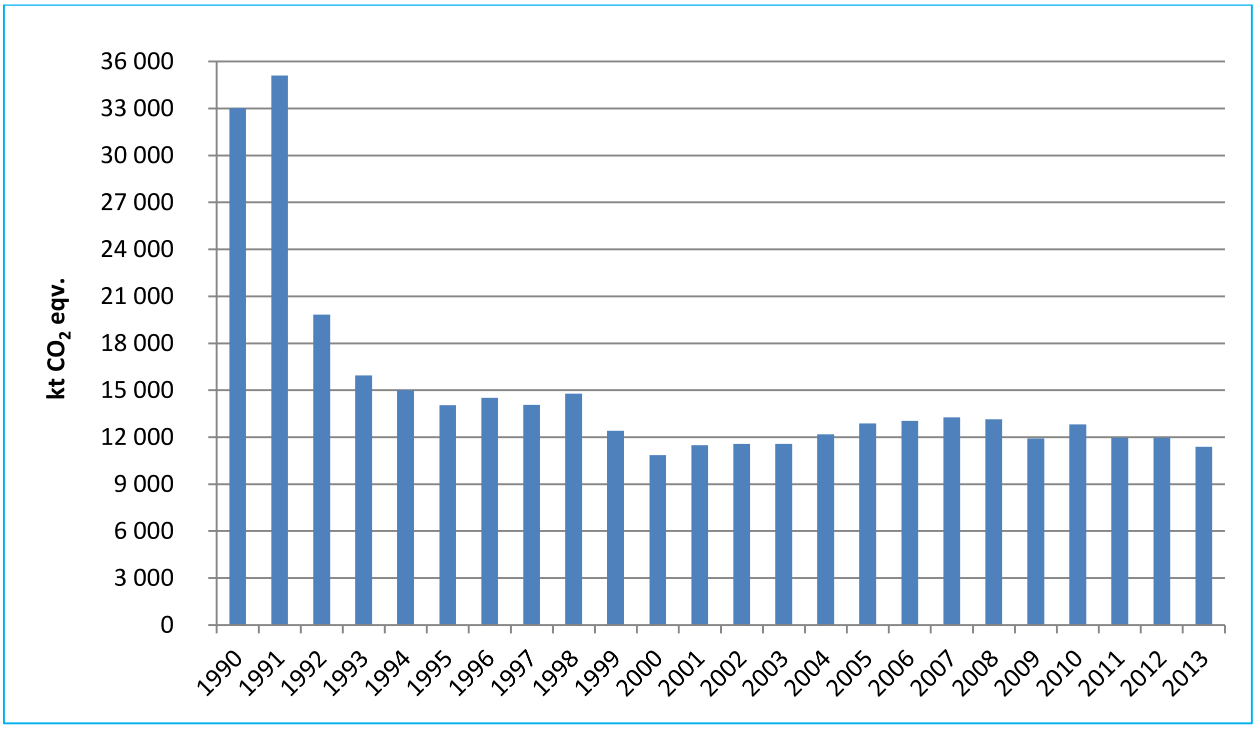


Figure 2-2. Trend of GHG emissions in energy sector during the period 1990-2013, kt CO_2 eqv.

During the period 1990-2013 the share of transport sector significantly increased. In 1990 transport sector accounted for 23.3% of total GHG emission in energy sector whereas in 2013 – 40.3%. This growth is influenced by the rapid increase of the density of transport routes and the number of road vehicles.

The increase of GHG emissions from fugitive is mainly caused by the increase of CH_4 emissions from natural gas distribution, reflecting the increase of the length of natural gas pipelines. Since 1990 GHG emissions from this subsector was increasing by average 3% per annum.

Industrial Processes and Product Use

Emissions from industrial processes and product use (referred to as non-energy related ones) amount to 14.7% of the total emissions (excl. LULUCF) in 2013. Emissions from industrial processes and product use include CO_2, N_2O and F-gases emissions. Emissions of total GHG from the industrial processes and product use sector have decreased by 1.5 times from 4518.17 kt CO_2 eqv. in 1990 to 2938.11 kt CO_2 eqv. in 2013 (Figure 2-3).

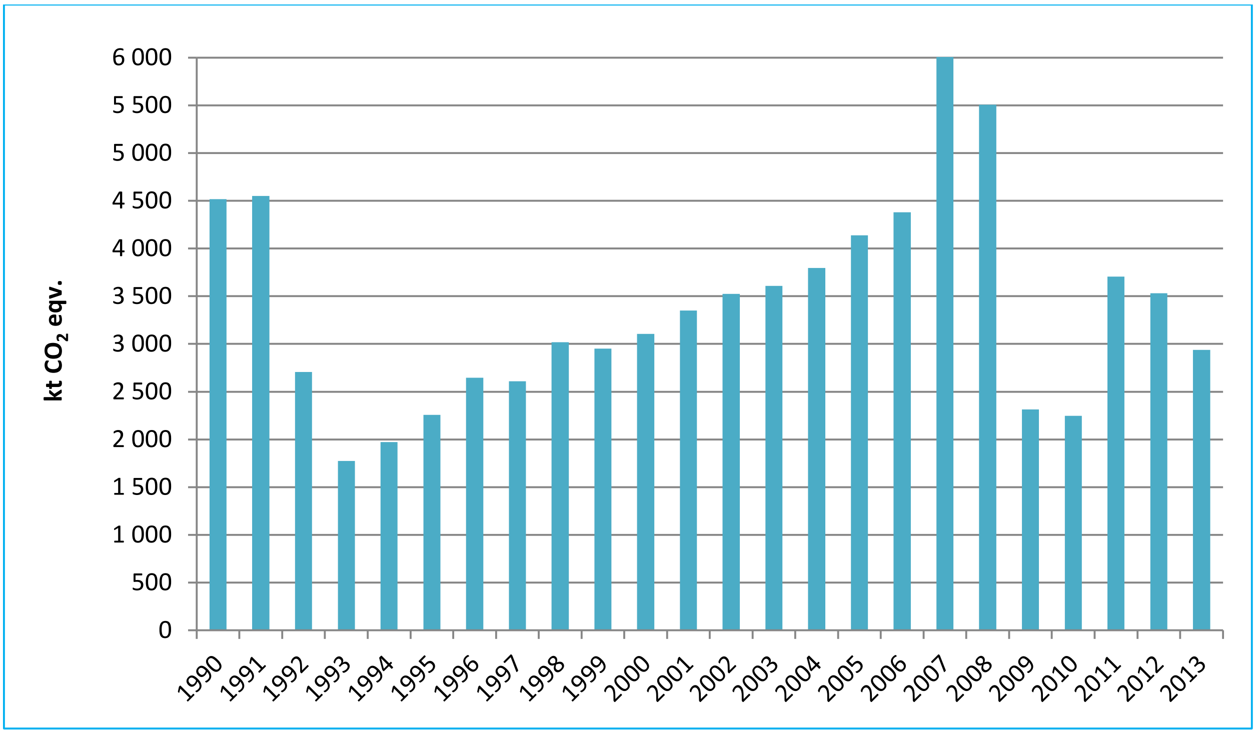


Figure 2-3. Trend of GHG emissions in industrial processes and product use sector during the period 1990-2013, kt CO_2 eqv.

CO_2 emissions from ammonia production contributed 12.9% to the total national CO_2 emissions (excl. LULUCF) in 2013. The lowest emission of CO_2 was in 1993 due to decrease of the ammonia production and the peak of CO_2 emissions were in 2007 when the ammonia production increased. Comparing with 2012 CO_2 emissions decreased by 21%.

Nitric acid production is the single source of N_2O emissions in industrial processes sector and accounts for 10.7% in the total national N_2O emissions (excl. LULUCF) in 2013. N_2O emissions had been increasing since 1995 and reached its peak in 2007. After the installation of the secondary catalyst in nitric acid production enterprise in 2008 the emissions of N_2O dropped drastically till 2010 and started to increase because of the increase of production capacity. After 2011 emissions began to decrease because the project ("Nitrous Oxide Emission Reduction Project at GP Nitric Acid Plant in AB Achema Fertiliser Factory) of catalyst installation has been finished. Comparing with 2012 N_2O emissions decreased by 41.4%.

Agriculture

Agriculture sector is the second most important source of greenhouse gas emissions in Lithuania contributing 22.2% to the total GHG emission (excl. LULUCF). The emissions from agriculture sector in 2013 include CH_4, N_2O and CO_2 emissions. Emissions of total greenhouse gases from agriculture sector have decreased twice from 8622.28 kt CO_2 eqv. in 1990 to 4429.44 kt CO_2 eqv. in 2013.

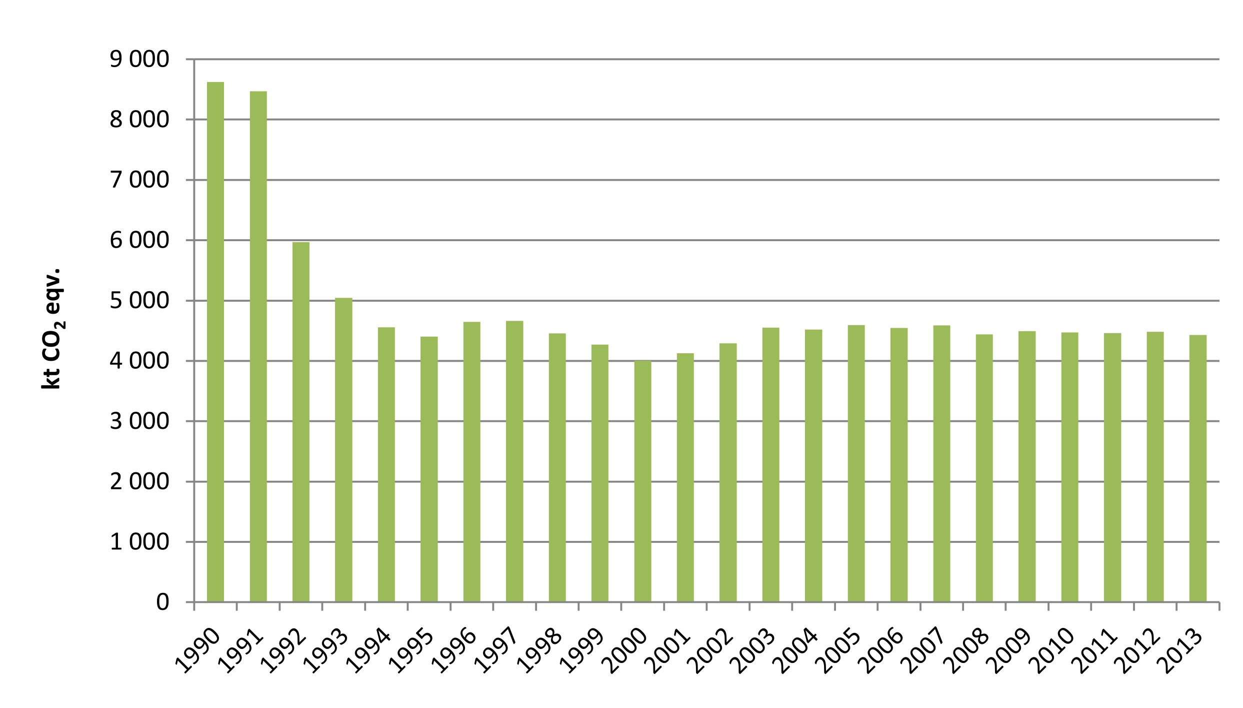


Figure 2-4. Trend of GHG emissions in agriculture sector during the period 1990-2013, kt CO_2 eqv.

Agriculture sector is the most significant source of the CH_4 and N_2O emissions accounting for 52.2% and 82.0% in the total CH_4 and N_2O emissions, respectively. The emissions of CH_4 and N_2O from agriculture sector decreased by 63.1% and 29.2% compare to the base year, respectively. The reduction of CH_4 emissions is caused by the decrease in total number of livestock population.

The major part of the agricultural CH_4 emission originates from digestive processes. Enteric fermentation contributes 44.3%, manure management – 7.9% to the total national CH_4 emissions.

Agricultural soils are the most significant source of N_2O emissions accounting for 76.7% in the total national N_2O emissions.

LULUCF

The Land Use, Land-Use Change and Forestry (LULUCF) sector for 1990-2013 as a whole acted as a CO_2 sink except in 1996 and 1997 when emission constituted to 2561.76 and 898.34 kt CO_2 eqv. (Figure 2-5). That is explained by sudden spruce dieback that caused huge losses in trees volume, in Lithuania`s spruce stands, which has direct impact on biomass calculations and on CO2 balance from this sector.

LULUCF sector during the period 2008-2013 removed from 38.7% to 55.4% of the total CO_2 emissions in Lithuania. Largely this should be contributed to forest land.

Increased removals from LULUCF sector in 2013 comparing with 2012 has been mainly caused by increased mean annual volume change from forest land (from 8.0 mill. m^3 in 2012 up to 9.4 mill. m^3 in 2013). As a result of such mean annual volume increment total removals in forest land raised up to 11179.96 kt CO_2 in 2013 comparing with 9447.85 kt CO_2 removed in the previous year.

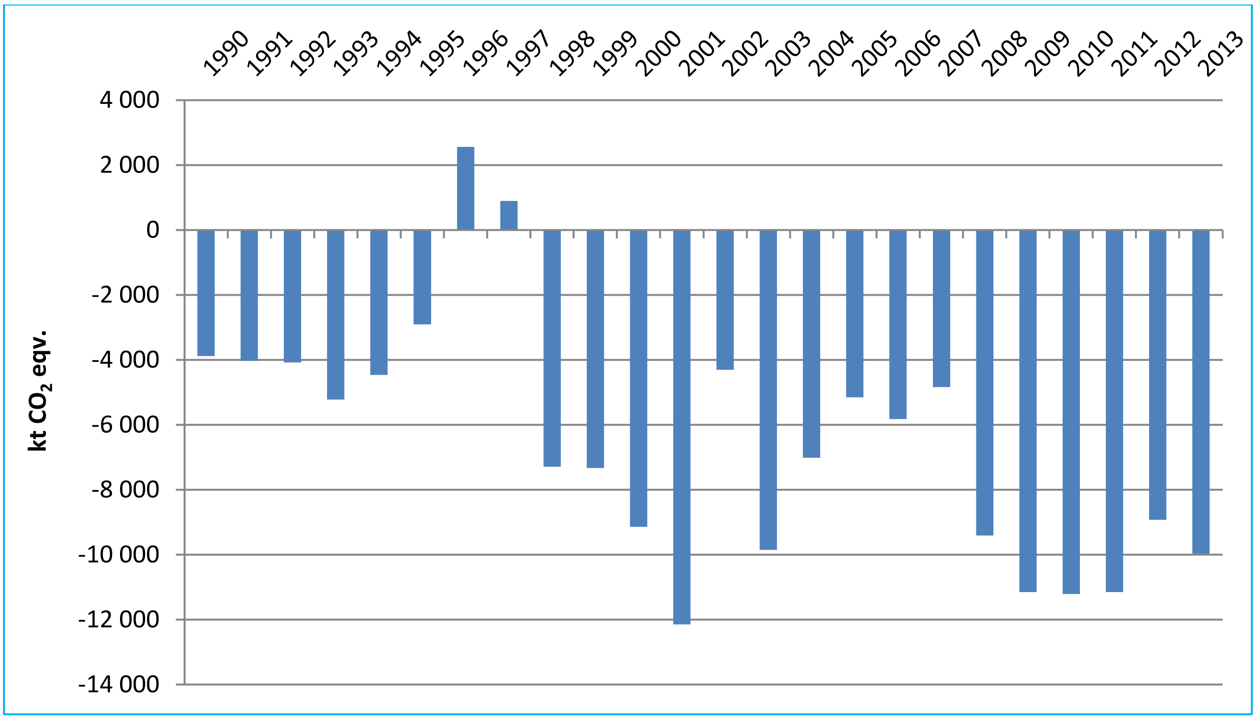


Figure 2-5. Total GHG emissions/removals from LULUCF sector for the period 1990-2013, kt CO_2 eqv.

Waste

The waste sector accounted for 6% of the total greenhouse gas emissions in 2013 (excl. LULUCF). The emissions from waste sector in 2013 included CO_2, CH_4 and N_2O emissions. Emissions of the total GHG from waste sector have decreased from 1648.3 kt CO_2 eqv. in 1990 to 1189.8 kt CO_2 eqv. in 2013 (Figure 2-6).

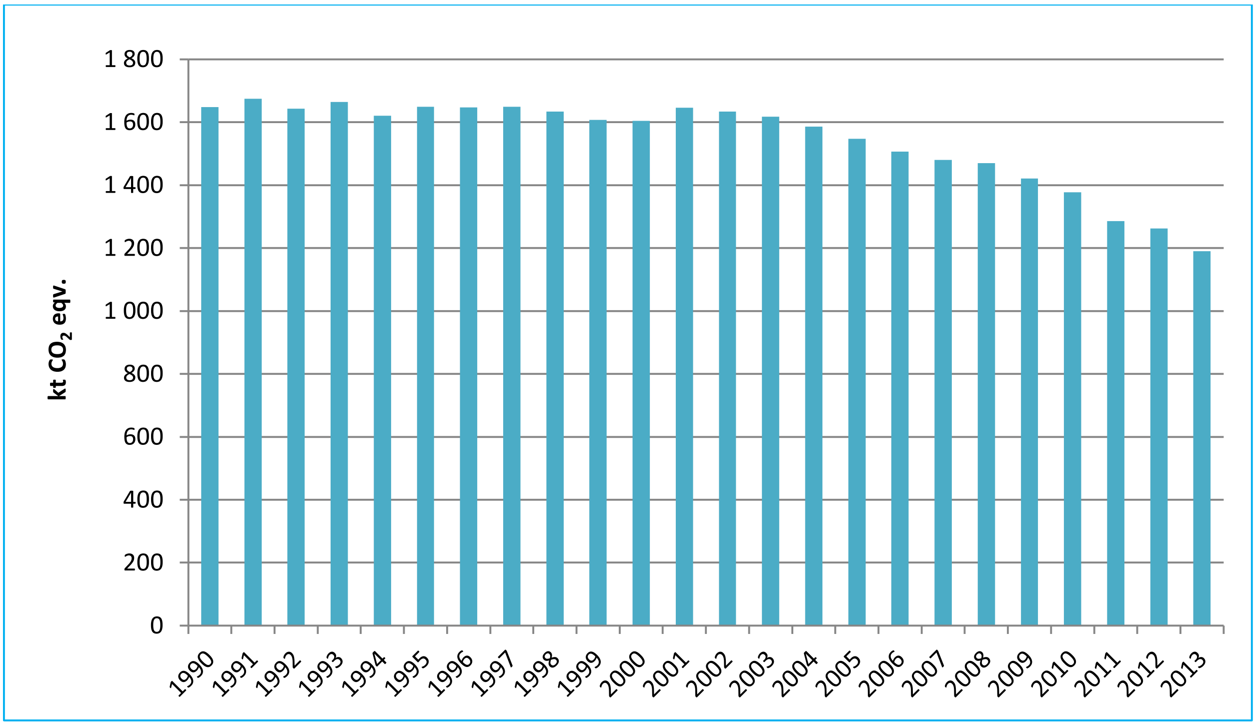


Figure 2-6. Trend of GHG emissions in waste sector during the period 1990-2013, kt CO_2 eqv.

Solid waste disposal on land including disposal of sewage sludge is the largest GHG emission source from waste sector. It contributed around 75.7% of the total GHG emission from waste sector in 2013 (72.3% excluding disposal of sewage sludge). GHG emissions occurring due to solid waste and sewage sludge disposal on land were increasing slightly from 1990 to 2001 and then started to decrease due to reduction of disposed waste, extraction of landfill gas, anaerobic digestion of sewage sludge.

Certain increase of emissions was observed from 2001 to 2004 and was caused mainly by disposal of large amounts of organic sugar production waste. In later years the producers managed to hand this waste over to farmers for use in agriculture and GHG emissions declined.

Wastewater treatment and discharge contributed around 22.3% of GHG emissions from waste sector in 2013. Wastewater in Lithuania is treated in aerobic treatment systems with minimum CH_4 generation. However, significant part of population still does not have connection to public sewerage systems and emissions from sewage collected from septic tanks are significant.

3 ENERGY (CRF 1)

3.1 Overview of the sector

Sudden political upheaval, after the collapse of the Former Soviet Union, was followed by deep and complicated changes in all sectors of the Lithuanian economy, including Energy sector. Economic slump in Lithuania was comparatively large: at the end of 1994 Lithuanian Gross Domestic Product (GDP) dropped to 56,1% of the 1990 level. Since 1995 country's economy has been gradually recovering (Figure 3-1). Lithuanian GDP decreased by 1,0% in 1999 due to the financial and economic crisis in Russia. The year 2000 was a turning point because since this year the national economy has been recovering very fast. During the period 2000-2007 the average growth rate of GDP was 8,0% per annum (Statistics Lithuania, Statistical Yearbook of Lithuania, 2008). The impact of global economic recession was dramatic in Lithuania. The global economic crisis had an effect on Lithuanian GDP already in 2008, but GDP growth rate in 2008 was still positive (2,6%). In 2009, GDP decreased by 14,8%. Since 2010 Lithuania's GDP has grown slightly by 1,6% in 2010, 6,1% in 2011 and 3,8% in 2012. In 2013, GDP growth rates slightly slowdown and accounted 3,3%. Increased by 9,4% import volume of goods and services and by 0,5% reduced gross capital formation were the key drivers of slacken rate of GDP growth. However, increased governmental (by 1,8%) and consumption (by 4,2%) expenditure, as well increased export volume of goods and services (by 9,4%) contributed to GDP growth in 2013 (Statistics Lithuania, Database of gross domestic product, 2014).

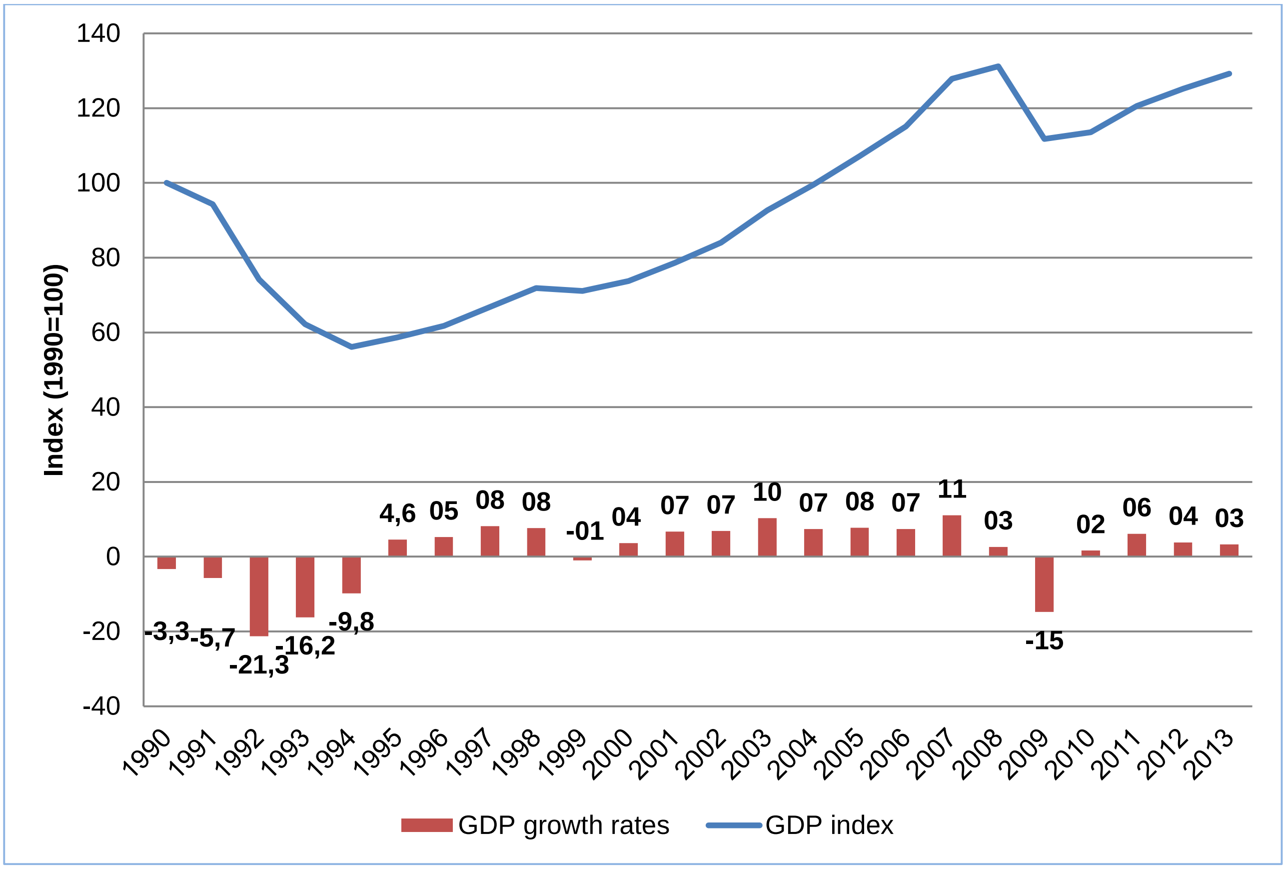


Figure 3-1. Changes of GDP annual growth rates and index in Lithuania

Dynamics of primary energy consumption in Lithuania during 1990-2013 is presented in Figure 3-2. Total primary energy consumption in 1990 amounted to 675,26 PJ (16,14 Mtoe) and in 2013 – 291,31 PJ (6,96 Mtoe). Oil and oil products were the most important fuel in Lithuania over the previous decade. Since 2000 their share in the primary energy balance has been fluctuating about 32% with the smallest portion of 23,7% in 2003 and the largest share of 39,2% in 2013. The major factors influencing changes in the role of oil products were decreasing consumption of heavy oil products for production of electricity and district heat and growing consumption of motor fuels in the transport sector. In 2009, due to significant reduction of motor fuel consumption, share of oil products decreased to 28,0%, but in 2010 due to the closure of Ignalina Nuclear Power Plant (NPP) the share of oil products increased to 36,3%. With reference to data of 2013, the share of oil and oil products was 35,8%.

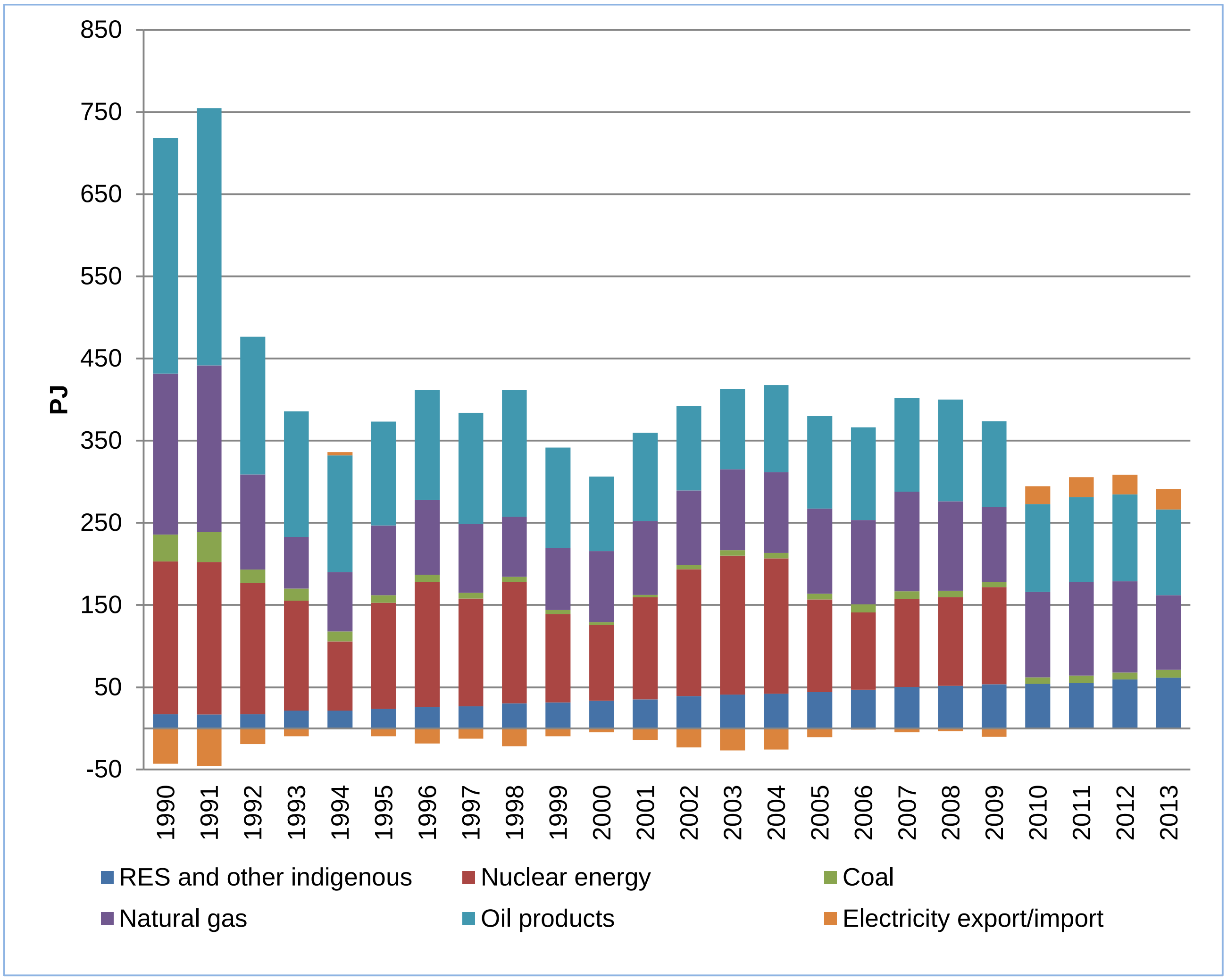


Figure 3-2. Primary energy consumption in Lithuania

At present natural gas is the most important fuel in the Lithuanian primary energy balance. The share of natural gas was fluctuating about 26% over the period 2000-2009 with the lowest contribution of 23,2% in 2002 and the largest share of 30,1% in 2007. Total consumption of natural gas decreased owing to reduction of its use for non-energy needs in 2008 and 2009. Consumption of gas for production of mineral fertilizers in 2009 was by 1,9 times less than in 2007. Since the beginning of

Lithuanian economy recovery after the global crisis, the share of natural gas increased by 9,6 percentage points, i.e. from 24,4% in 2009 till 31,1% in 2013.

During the period 1990-2009 the share of nuclear energy was very high and fluctuated about 32% with the lowest value of 25,8% in 2006 and the highest value of 40,9% in 2003. The role of nuclear fuel was very important in Lithuania. Nuclear fuel helped to increase the security of the primary energy supply, especially in the power sector. During the process of accession into the EU, one of the country's obligations was a decision on the early closure of Ignalina Nuclear Power Plant (NPP). It was agreed that Unit 1 of this power plant would be closed before 2005 and Unit 2 in 2009. Ignalina NPP was the main source of electricity generation during the period 1988-2009, and even after the closure of Unit 1 it was producing more than 70% of electricity generated by Lithuanian power plants. The share of nuclear energy in the primary energy balance in the year 2009 (year of final closure of Ignalina NPP) was 31,7%. It is important to note that a large portion of electricity generated by this power plant was exported. Lithuania during the last decade was a net exporter of electricity and for instance in 2004 more than 37% of electricity generated by Ignalina NPP was exported to neighbouring countries. In 2013, the share of electricity generated by all Lithuanian power plants was about 40,7% in the balance of gross electricity consumption and 59,3% of electricity necessary to meet internal requirements was covered by electricity import. Electricity import in the primary energy balance accounted 8,6% in 2013.
Over the period 2000-2013 the share of coal in the primary energy balance was fluctuating about 2,0%, and in 2013 contribution of this fuel was 3,3%.

Comparison of the primary energy consumption structure in 1990 and in 2013 is presented in Figure 3-3.

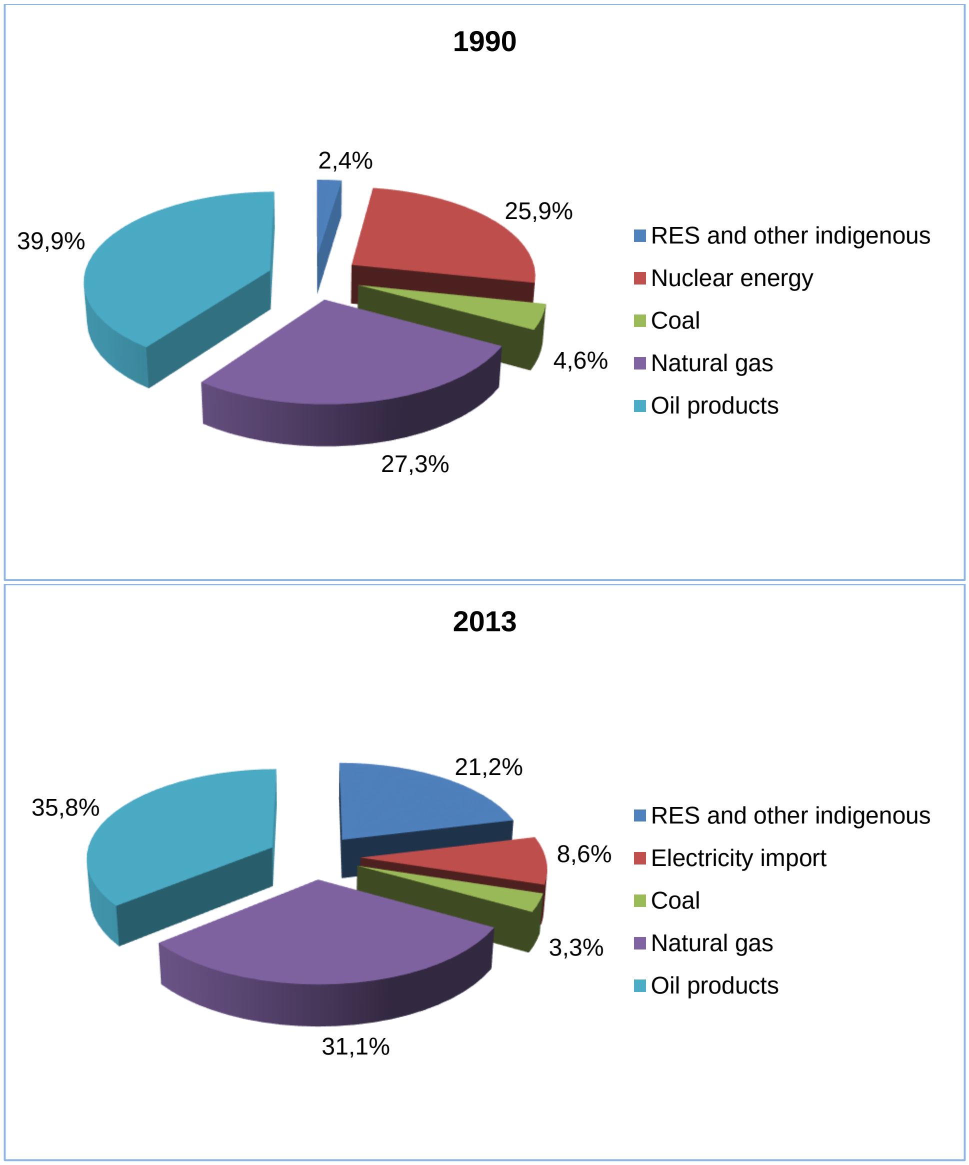


Figure 3-3. Structure of primary energy consumption in Lithuania

Indigenous energy resources in Lithuania are rather scarce. Certain contribution into balance of indigenous resources is originated from local oil, peat and energy of chemical processes. Contribution of renewable energy sources into the country's primary energy balance during the period 1990-2013 was increasing (Statistics Lithuania, Energy balances). During the period 1990-2013 primary energy supply from renewable sources increased by 3,8 times with an average annual growth of 5,6%.

The consumption of renewable energy sources by energy forms are presented in Figure 3-4. Currently the main domestic energy resource is solid biomass. Solid biomass accounted for 85,1% in the balance of renewable energy sources in 2013. The second largest renewable energy source is liquid biomass. In 2013, a share of bioethanol and biodiesel was 5,1%. Wind energy accounted 4,3% of total renewable energy. Hydro power is fluctuating and currently provides 3,7% in the balance of renewable energy sources. The shares of biogas, solar energy and geothermal energy were 1,3%, 0,3% and 0,1% in 2013, respectively.

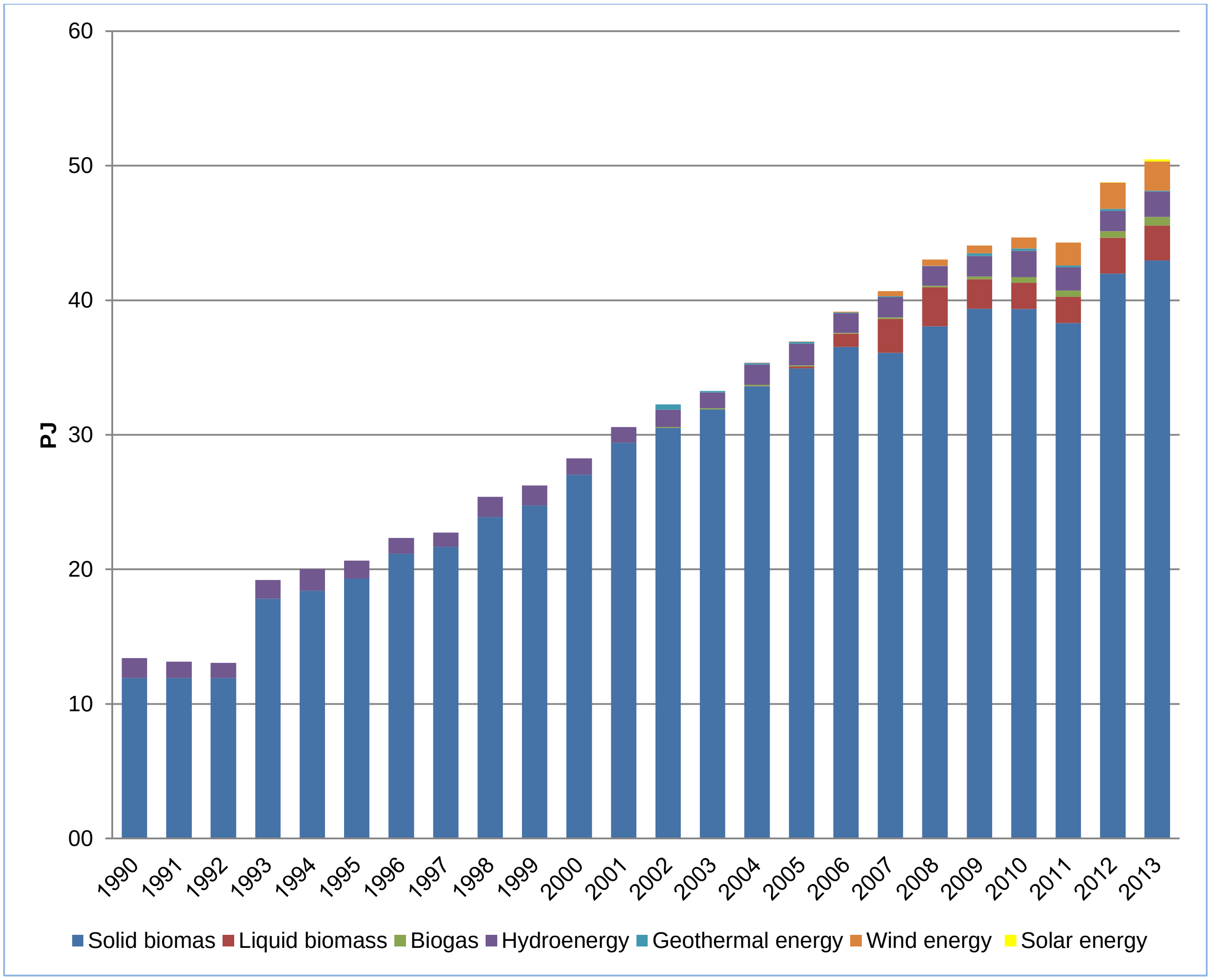


Figure 3-4. Consumption of renewable energy sources in Lithuania

Ignalina NPP played a key role in the Lithuanian energy sector producing up to 70-80% of the electricity. Even after the closure of Unit 1 at the end of 2004 this power plant was dominating in the electricity market – its share in the balance of gross electricity generation in 2009 has been almost 70,7%. Therefore the most important internal changes in the Lithuanian energy sector in 2010 are related with the final closure of Ignalina NPP (Figure 3-5). After the closure of Ignalina NPP Lithuanian Thermal Power Plant (Lithuanian TPP) is the major electricity generation source. Lithuanian TPP can cover up to 50-60% of the gross internal consumption. But in this case the country's dependence on primary energy import is very high. After closure of Ignalina NPP energy sector dependent very much on supply of primary energy sources from one country (the country depends on Russia for 100% of its natural gas, and for more than 90% of its crude oil and almost 100% of coal requirements). In addition cost of electricity production at this power plant is high due to high price of natural gas. Thus, currently more than half of required electricity is imported from neighbouring countries.

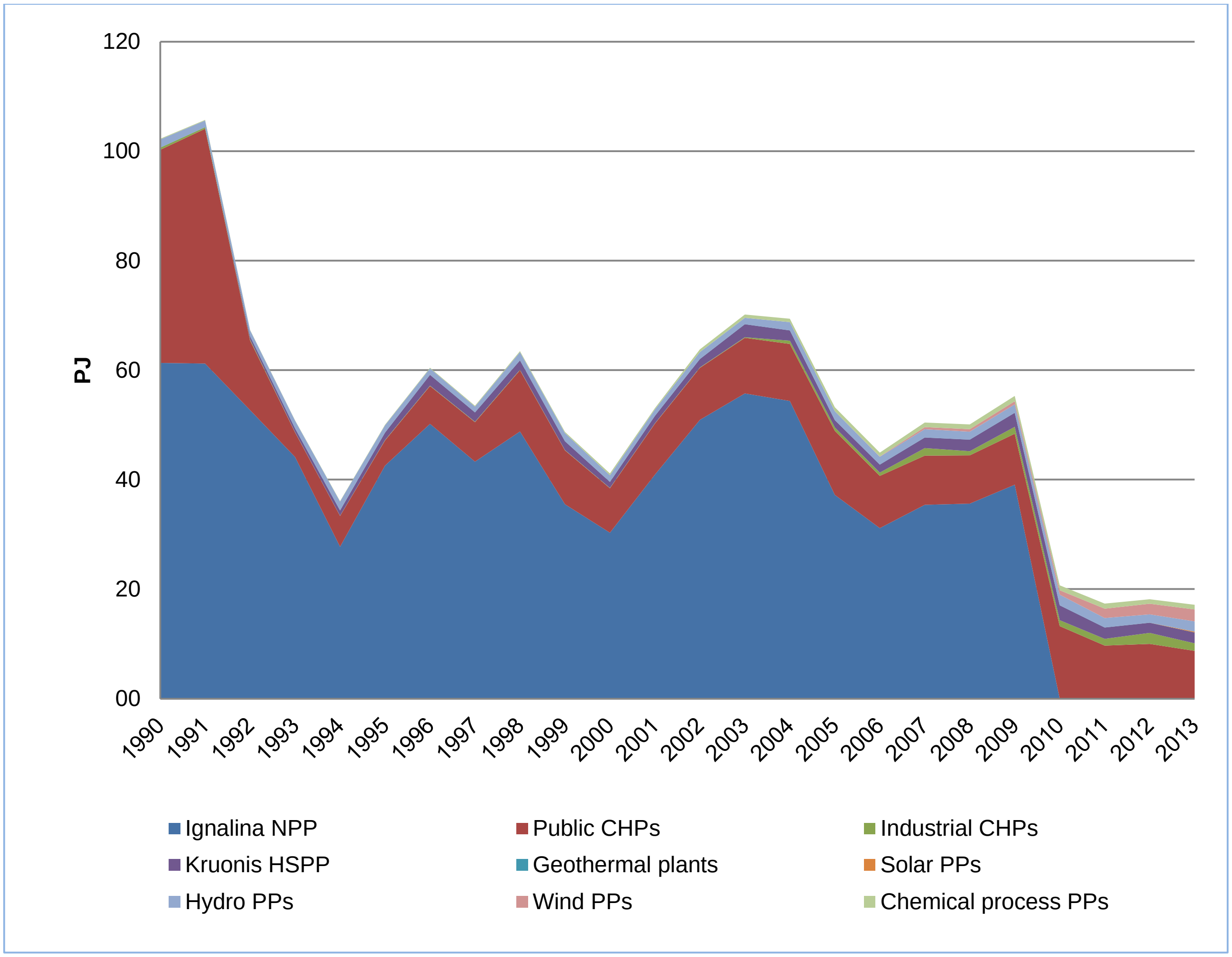


Figure 3-5. Structure of electricity generation in Lithuania

Baltic Energy Market Interconnection Plan (BEMIP) was signed in 2009 seeking to diverse and ensure the electricity supply to the Baltic States. Connecting the Lithuania, Latvia and Estonia to neighbouring EU countries and the internal market is the main priority of the BEMIP Action Plan. This priority requires the full implementation of the internal market rules in order to enable the three Baltic States to participate into the EU electricity market. Interconnection between Lithuania and Poland (project LitPol Link) is fully in line with the EU energy policies and National energy strategies in the region. The 500 MW power link connecting Lithuania and Poland will be put into operation in December 2015. By 2020, the LitPol Link will start operating at a 1000 MW capacity.

The European Commission through the European Energy Programme for Recovery provides funding for the construction electricity interconnection between the Lithuania and Sweden (NordBalt). NordBalt is a planned submarine power cable between Klaipeda in Lithuania and Nybro in Sweden. The aim of the project is to promote trading between Baltic and Nordic electricity markets, as also to increase the security of power supply in both markets. Submarine cable laying started in 11 April 2014. This interconnection will be high voltage direct current cable. The length of the cable will be 450 kilometres. Its capacity will be 700 MW. The cable is expected to be commissioned in 2016.

Taking into consideration current absence of interconnections with the Western energy systems, the country’s energy policy is focused on gradual increase of consumption of renewable energy resources and increase of energy efficiency.

Green electricity generation has been almost stable and fully dominated by hydropower in Lithuania during the period 1990-2000 (Figure 3-6). Since 2000 green electricity generation was increasing on average by 10,8% per year. Current electricity generation from renewable energy sources is dominated by wind power, generating about 42,1%, and hydro power, producing 36,3% of green electricity in 2013.

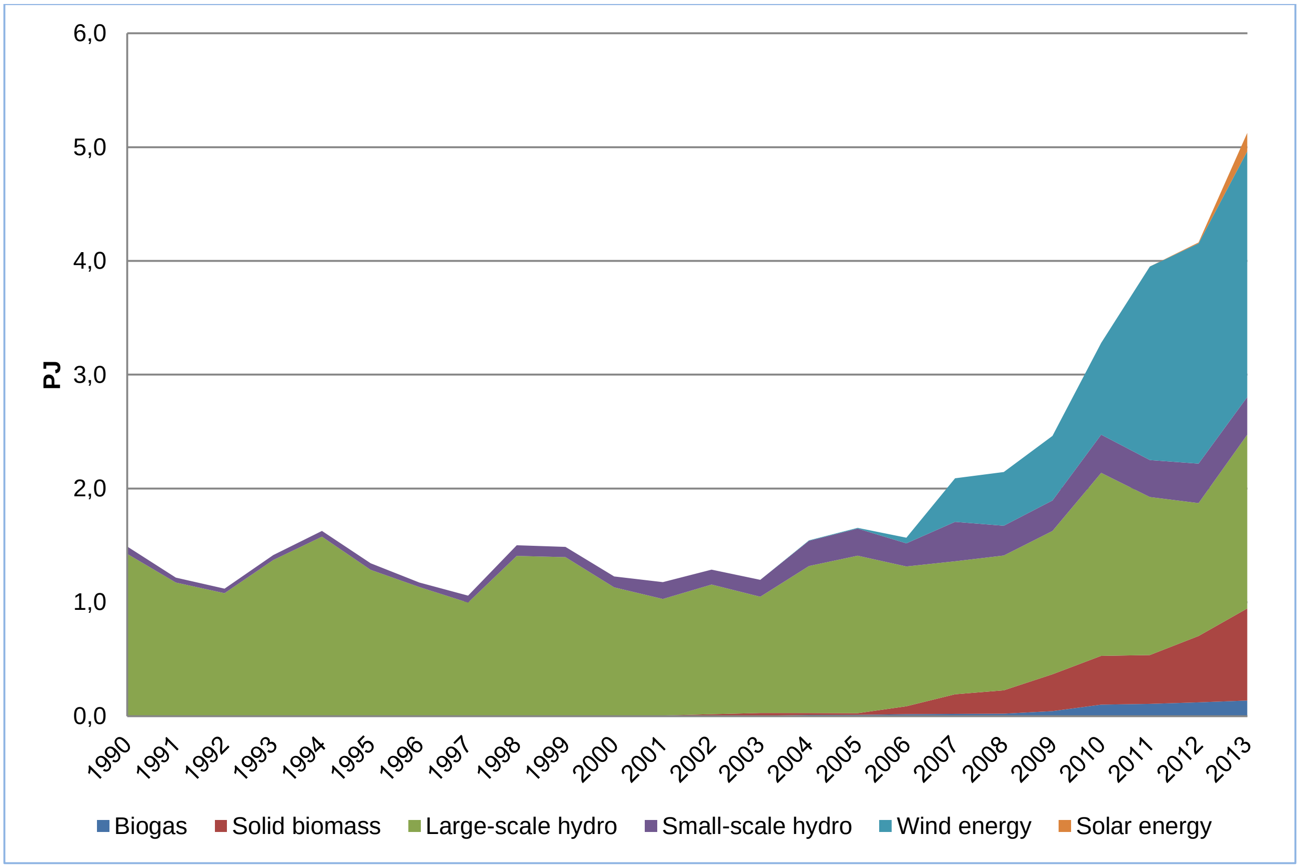


Figure 3-6. Green electricity production in Lithuania

Since 2006 the role of new renewable energy sources is growing rapidly in the Lithuanian electricity market. In 2013, about 42,1% of green electricity was covered by wind energy, 15,8% by biomass and about 2,7% by biogas. With reference of data 2013, there was produced 161,3 TJ (44,8 GWh) of solar electricity. Solar electricity contribution to the structure of RES-E was 3,1% in 2013 (LITGRID, 2013).

Many factors had influence on changes of energy consumption: deep economic slump in 1991-1994, fast economic growth over the period 2000-2008, dramatic reduction of economic activities in all branches of the national economy and the closure of Ignalina NPP in 2009, a significant increase of energy prices, an increase of energy efficiency and other reasons.

Total final energy consumption (excluding non-energy use) in 1990 amounted to 405,28 PJ (9,68 Mtoe). In 1991-1994 final energy consumption decreased approximately by 2,1 times (Figure 3-7). The final energy consumption was increasing during the period 2000-2003 by 3.8% per annum, and in 2008 it was 212.1 PJ (5.1 Mtoe) (Statistics Lithuania, Energy balances). During this period the final energy consumption was increasing in all sectors of the national economy.

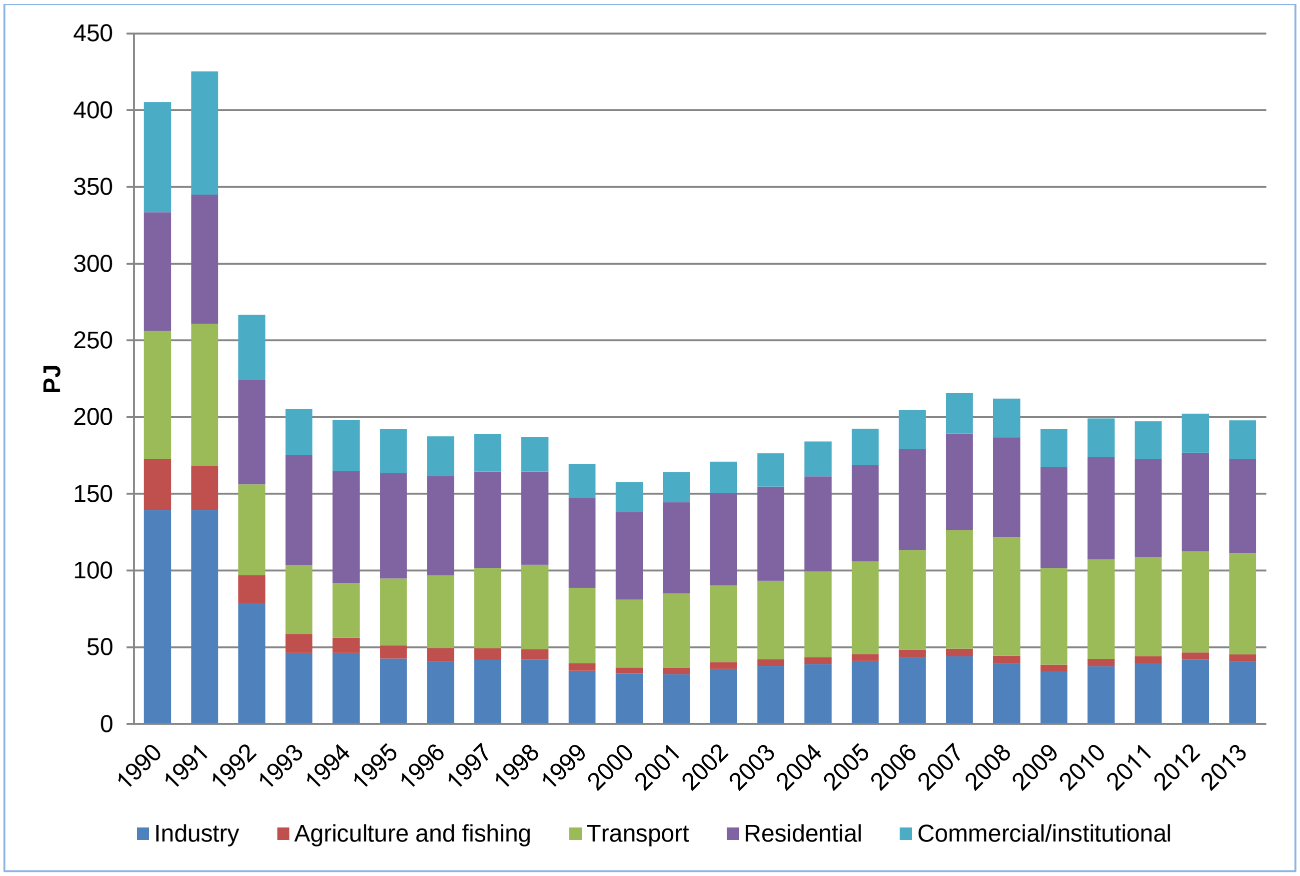


Figure 3-7. Final energy consumption in Lithuania

In 2009, total final energy consumption was by 9,4% less than in the previous year, and the most severe impact of the economic recession was in the construction sector where energy consumption decreased by 35%. Energy consumption decreased in the transport sector by 18,5%. As a result of recovering Lithuanian economy, final energy consumption increased by 3,6% in 2010. However, in 2011 the final energy consumption reduced by 0,93% and amounted to 197,3 PJ (4,71 Mtoe). This decrease was mainly caused by reduced energy consumption in transport, residential and commercial/institutional sectors. Final energy consumption in industry increased by 4,6% in 2011 due to growing activities of Lithuanian manufacturing sector. During 2012-2013 the final energy consumption was further decreasing by 1,1% and in 2013 it amounted to 197,8 PJ (4,73 Mtoe).

During the transition to a market economy period significant improvements in the energy efficiency has been achieved due to replacement of the old energy intensive technologies by the new innovative technologies in the industry and implementation of various energy efficiency improvement measures in other sectors of the economy. During 2000-2013 period the final energy consumption and final electricity consumption grew more slowly than the GDP (Figure 3-8).

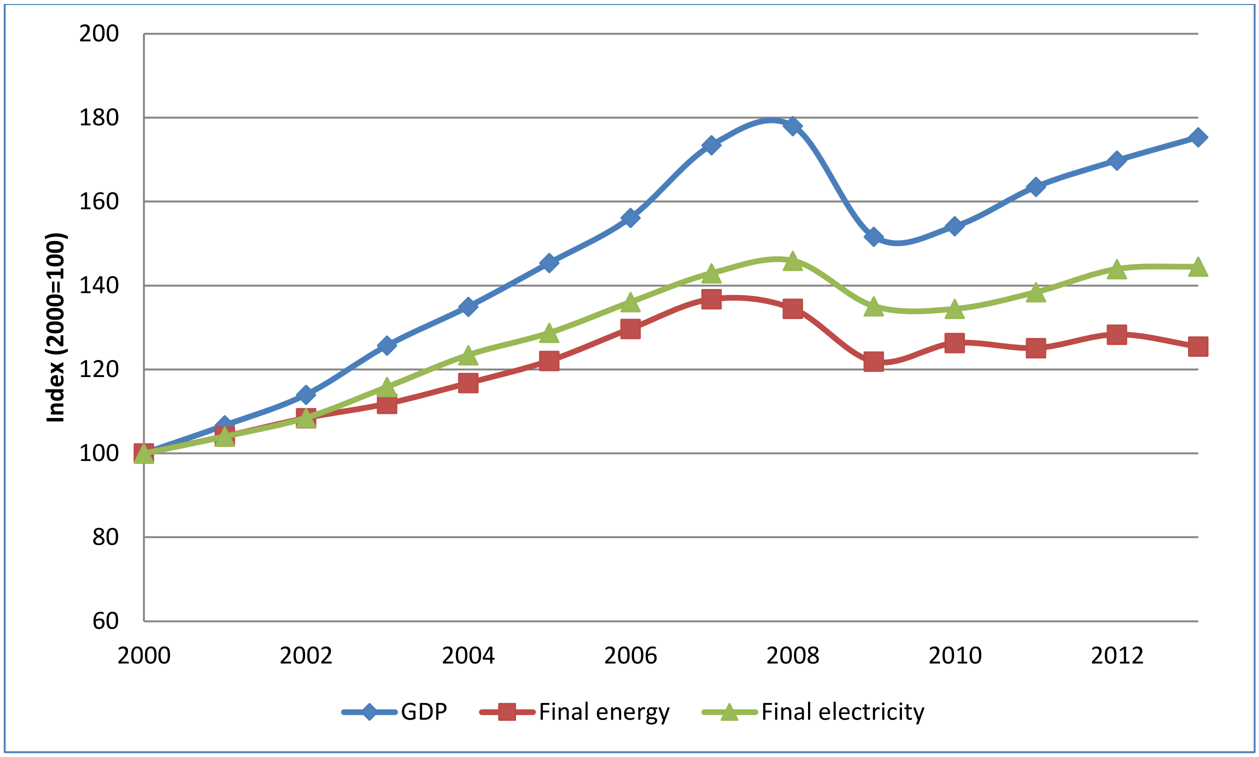


Figure 3-8. GDP, final energy and final electricity growth index

Energy intensity indicator mainly is used for characterization of energy efficiency within the country and for respective branch of economy. Energy intensity is defined as the primary (final) energy consumption (measured in units of energy) with the performance indicators (calculated in national currency or a common currency), which is characterized by gross domestic product. Changes in primary and final energy intensity in Lithuania is presented in Figure 3-9.

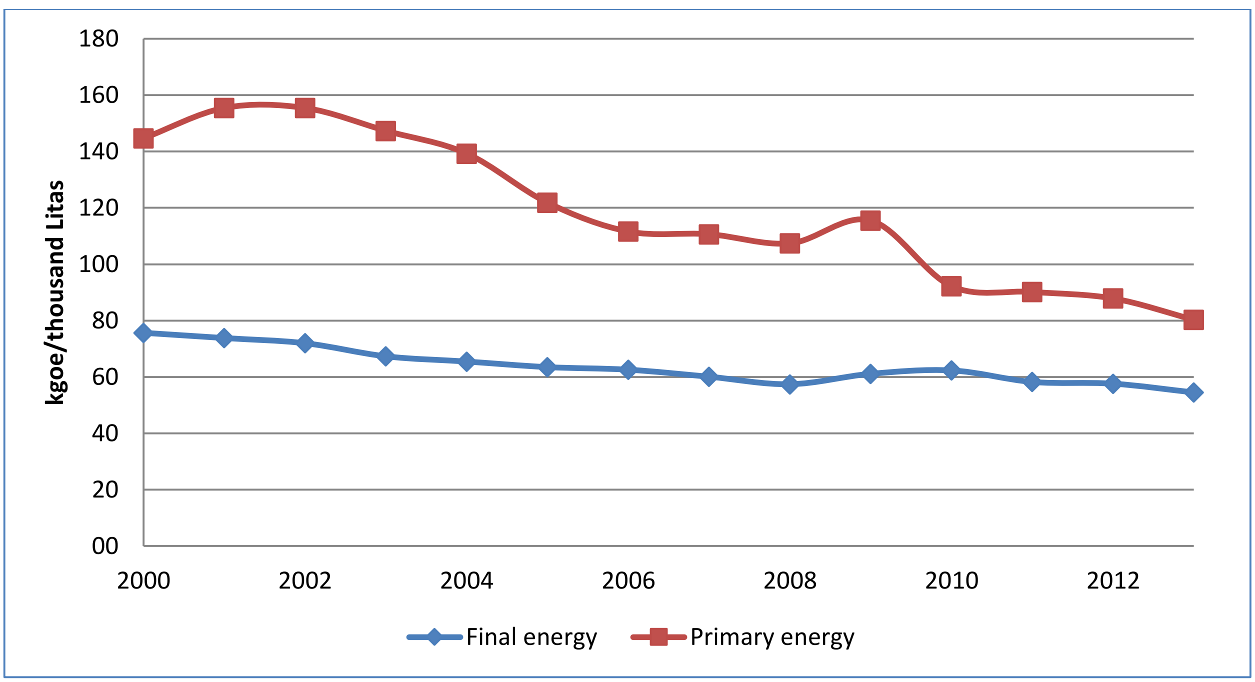


Figure 3-9. Changes in primary and final energy intensity

Substantial changes in the power sector and the above mentioned changes in primary energy balance has led to a very significant reduction in primary energy intensity. In 2013 primary energy intensity was 56% less than in 2000. Final energy intensity decreased by 28% - from 75.7 kgoe/thous.Lt in 2000 to 54.5 kgoe/thous.Lt in 2013. A further reduction in primary energy intensity depends very much on the efforts to reduce the final energy intensity, i.e. on successful implementation of energy efficiency measures in respective economy branches.

Several emission sources in the Energy Sector are key categories. Key categories in 2013 by level (L) and trend (T), excluding LULUCF are listed in Table 3-1.

Table 3-1. Key category from Energy Sector in 2013

IPCC Category	***Greenhouse gas***	***Identification criteria****	***Comments***
1.A.1. Energy industries-Other fossil fuels	CO2	T1	
1.A.1. Energy industries-Solid fuels	CO2	T1	
1.A.1. Energy industries-Biomass	N2O		T2sub
1.A.1. Energy industries-Peat	CO2		T1sub
1.A.1.a Public electricity and heat production - Gaseous Fuels	CO2	L1,T1, T2	
1.A.1.a Public electricity and heat production - Liquid Fuels	CO2	L1,T1, T2	
1.A.1.b Petroleum refining - Liquid Fuels	CO2	L1,T1	
1.A.2 Manufacturing industries and construction-Gaseous fuels	CO2	L1,T1	
1.A.2 Manufacturing industries and construction-Liquid fuels	CO2	T1,T2	
1.A.2 Manufacturing industries and construction-Solid fuels	CO2	L1,T1	
1.A.3.b Road transportation	CO2	L1,T1	
1.A.3.c Railways	CO2	L1	
1.A.3.e Other transportation	CO2	L1,T1, T2	
1.A.3.e Other transportation	N2O	T1,T2	
1.A.4 Other sectors-Biomass	CH4	L1,L2,T1,T2	
1.A.4 Other sectors-Gaseous fuels	CO2	L1,T1	
1.A.4 Other sectors-Liquid fuels	CO2	L1,T1	
1.A.4 Other sectors-Peat	CO2	L1	
1.A.4 Other sectors-Solid fuels	CO2	L1,T1,T2	
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH4	L1, L2, T1,T2	

**Lsub, Tsub denote the categories that were identified by level and trend assessment for a subset without LULUCF*

In the Energy sector emissions of CO_2 contribute about 94% of total greenhouse gas emissions CO_2 eqv. in 2013. Trends of total GHG emissions calculated as CO_2 equivalents from the energy sector are presented in Figure 3-10. Total greenhouse gases (GHG) from the energy sector have decreased by almost 2,9 times from 33022,9 kt CO_2 eqv. in 1990 to 11388,8 kt CO_2 eqv. in 2013. Significant decrease of emissions was mainly due to economic slump in 1991-1994 period. During the fast economic growth over the period 2000-2008 GHG emission in Energy sector was increasing about 2,1% per annum. The global economic recession had impact on GHG reduction in energy sector by 9,3% in 2009. The closure of Ignalina NPP and GDP increase had impact on GHG increase by 7,5% in 2010. In 2011, total GHG emissions in Energy sector decreased by 6,6%. This trend was stipulated by almost 16,4% decrease of GHG emissions in public electricity and heat production sector due to increased share of electricity import from neighbouring countries, increased use of renewable energy sources and natural gas. The level of total GHG emissions in Energy sectors in 2012 remain almost the same as in 2011. In 2013, total GHG emissions in Energy sector decreased by 4,8% due to high share of electricity import from and increased use of renewable energy sources.

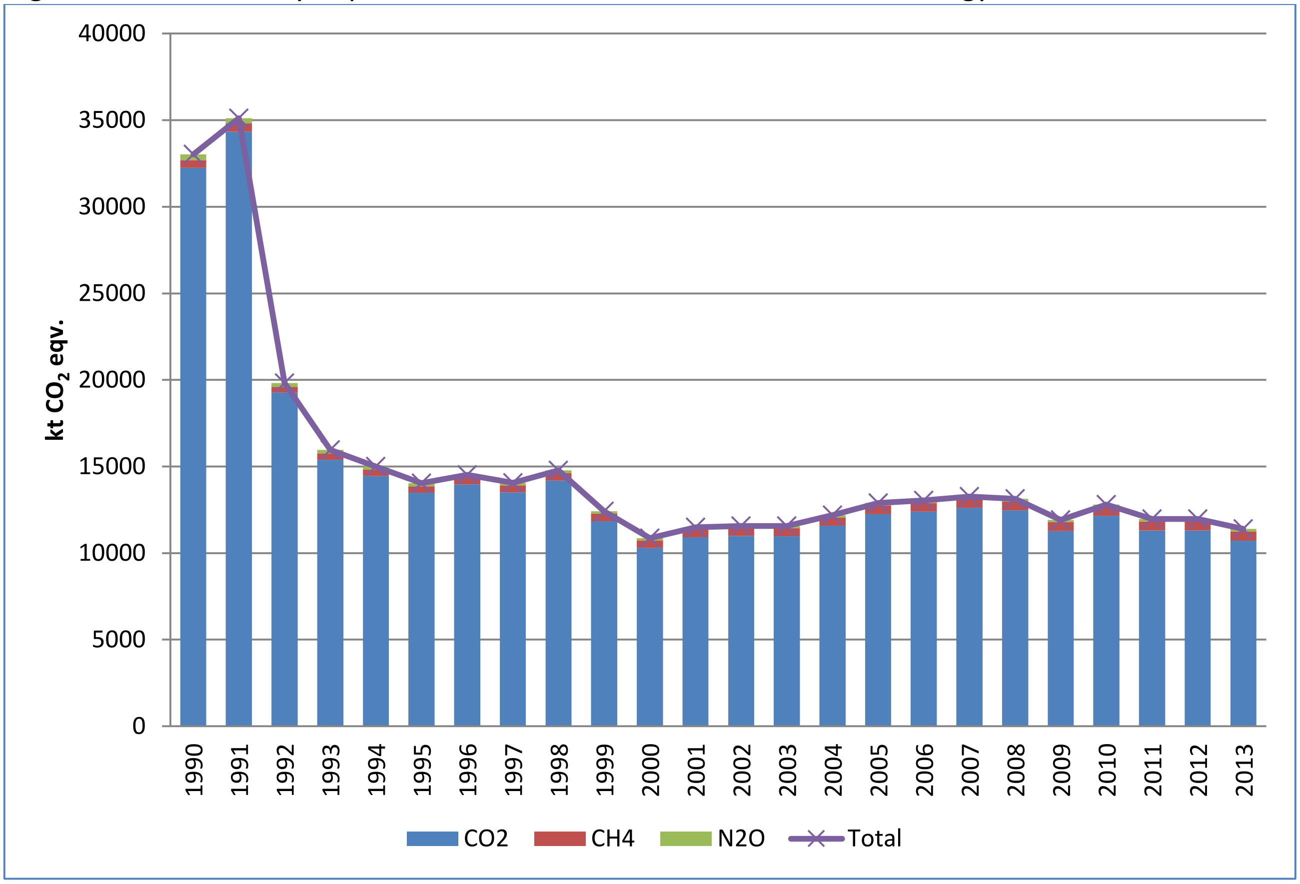


Figure 3-10. Total GHG emission from the Energy Sector (CRF 1), kt CO_2 eqv.

Changes in structure of GHG emissions in energy sector showed in Figure 3-11. Historically the 1.A.1 Energy industries accounted for the largest share of GHG emission from Energy Sector. In 2013 this source category amounted about 33,95% of total GHG emission from energy sector. During the period 1990-2013 the share of transport sector increased significantly. In 1990 transport sector accounted for 23,33% of total GHG emission from Energy Sector and in 2013 - 40,25%. In 2013 transport accounted the largest share of GHG emission from Energy sector.

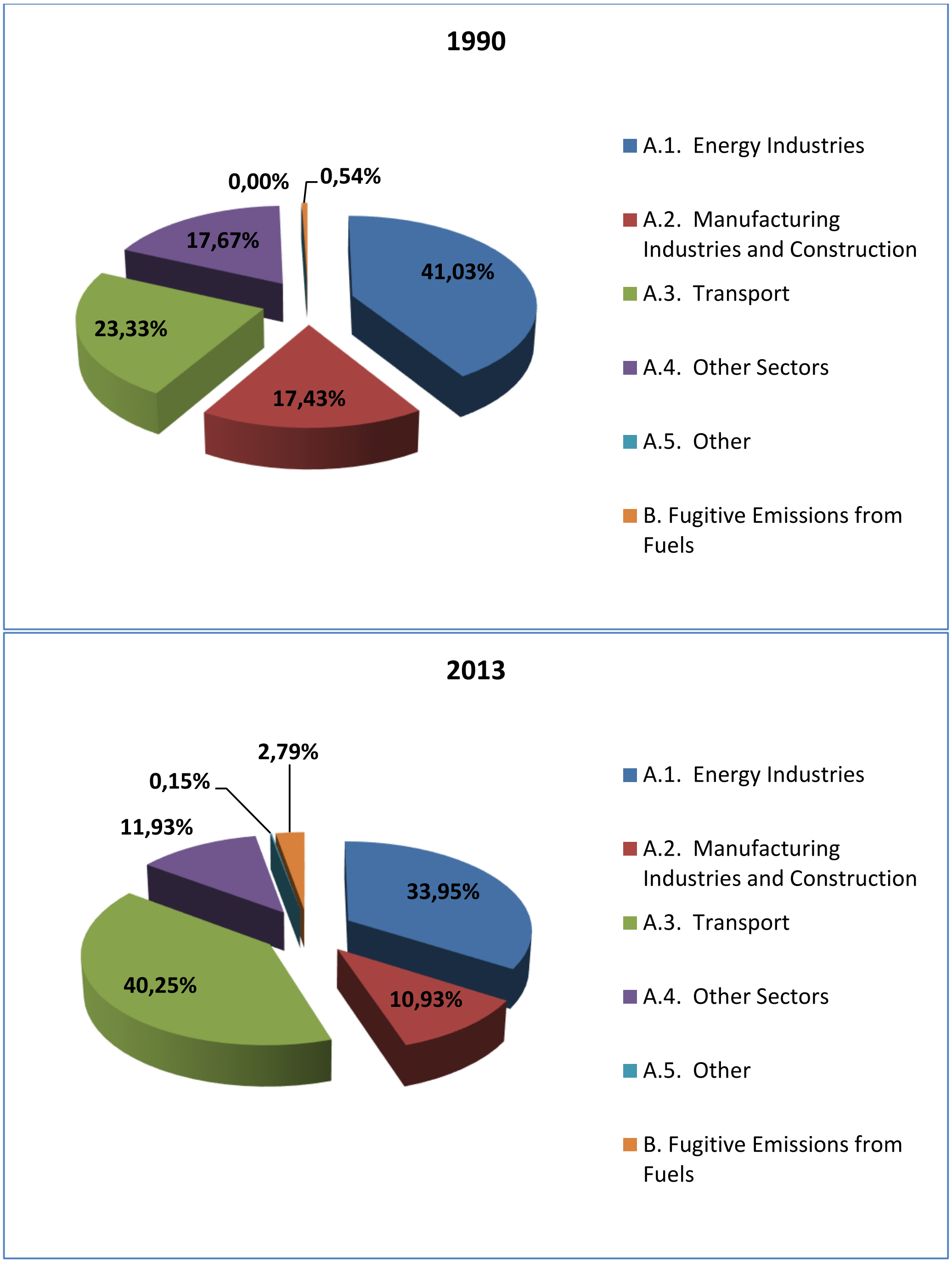


Figure 3-11. Structure of GHG emission from Energy Sector in 1990 and 2012

The trends of GHG emissions calculated as CO_2 equivalent from different subsectors within the Energy Sector are presented in Figure 3-10. The most important subsector regarding total emission in the base year was Energy industries (1.A.1) and it remains to be one of the most important. The closure of Ignalina NPP in 2010 had impact on GHG emission increase in this subsector. In 2010 GHG emissions increased by approximately 10,5% in energy industries. In 2011 GHG emissions in energy industries reduced by almost 16,4%, in 2012 - by 0,9%, in 2013 - 12,3%. Growing activities in the Manufacturing industries and construction sector stipulated increase in GHG emissions during 2009-2013. GHG emissions from Transport sector in 2012 increased by 0,5% and in 2013 remain at the same level. An increase took place in Other sectors (1.A.4). Since 2000 GHG emissions in this subsector was growing about 2,5% per annum. Such increase was mainly stipulated by significant growth of natural gas and coal consumption in residential and commercial/institutional subsectors. In 2012 GHG emissions in Other Sectors (1.A.4) reduced by 5,3%, in 2013 by - 2,0% due to implemented energy efficiency measures and increased share of biomass consumption.

Increase of GHG emissions from 1.B Fugitive emissions from fuels is mainly caused by the increase of CH_4 emissions from natural gas distribution, reflecting the increase of the length of natural gas pipelines. Since 1990 GHG emissions from this subsector was increasing by 2,4% per annum. In 2013 fugitive emissions accounted 317,2 kt CO_2 eqv.

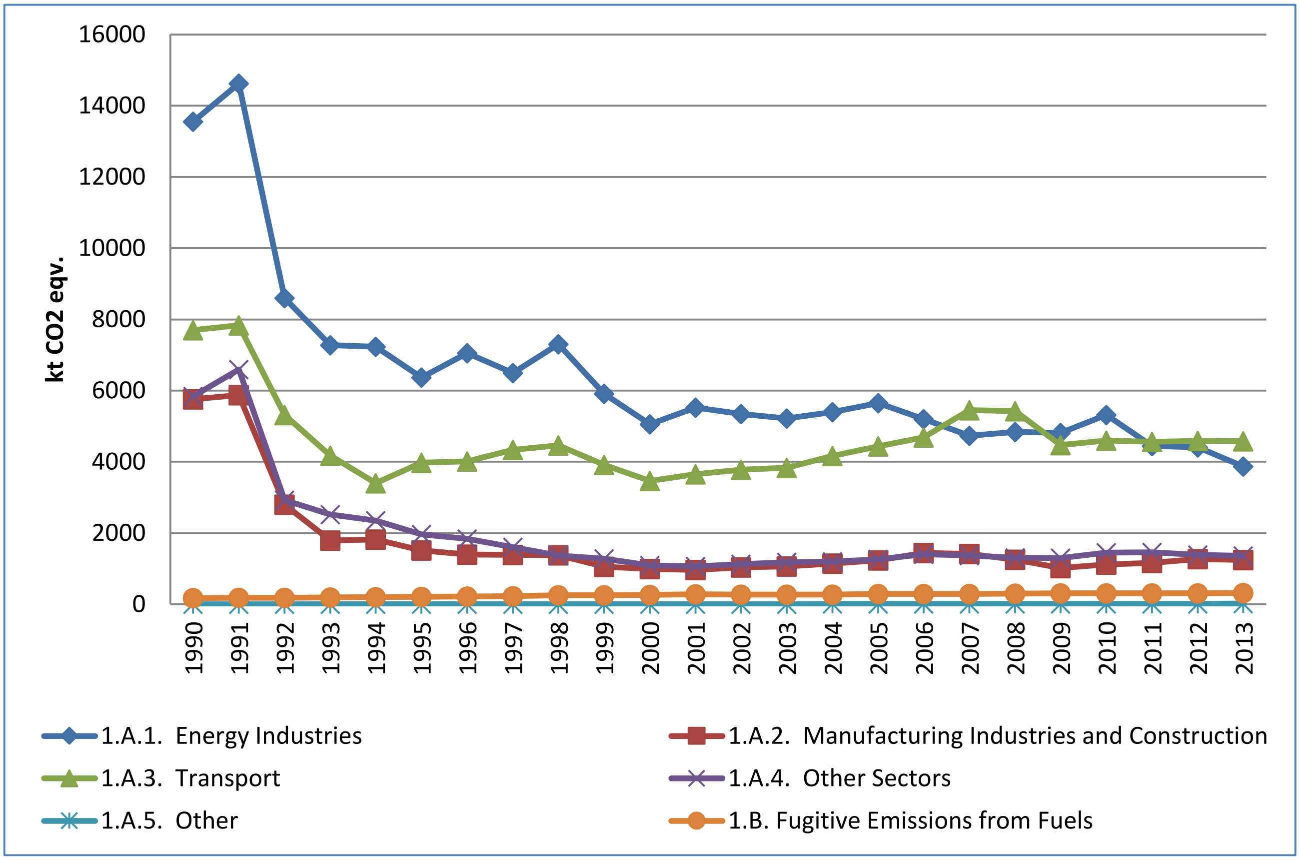


Figure 3-12. Total GHG emissions from the different subsectors within the Energy Sector, (CRF 1), kt CO_2 eqv.

3.2 Fuel combustion (CRF 1.A)

- Fuel Combustion category (CRF 1.A) comprises following sources:
  - Fuel Combustion – Sectoral Approach (CRF 1.A.A)
  - Energy Industries (CRF 1.A.A.1)
  - Manufacturing Industries and Construction (CRF 1.A.A.2)
  - Transport (CRF 1.A.A.3)
  - Other Sectors (CRF 1.A.A.4)
  - Non-Specified (CRF 1.A.A.5)

- Fuel Combustion – Reference Approach (CRF 1.A.B.)
- Difference - Reference and Sectoral Approach (CRF 1.A.C)
- Feedstocks and non-energy use of fuels (CRF 1.A.D)

This chapter gives an overview of emissions and key sources of fuel combustion activities, includes information on completeness, QA/QC, planned improvements as well as on emissions, emission trends and methodologies applied (including emission factors). Furthermore, information on sectoral/reference approach and feedstocks/non-energy use of fuels is given in this sector. Additionally to information provided in this Chapter, Annex III includes information on the activity data used for emissions estimation, i.e. national energy balance data are presented and Annex IV includes summary of study on "Determination of national GHG emission factors for energy sectors" (fuel combustion) performed by Lithuanian Energy Institute in August 2012.

3.2.1 Comparison of sectoral approach with the reference approach

CO_2 emissions from energy sector were calculated using both sectoral and reference approaches. Reference approach is accounting for carbon, based mainly on supply of primary fuels and the net quantities of secondary fuels brought into the country. The reference approach is a top-down approach, using a country's energy supply data to calculate the CO_2 emissions from combustion of fuels.

Differences between sectoral and reference approach were estimated for fuel consumption and CO_2 emissions. Figure 3-13 shows comparison of CO_2 emissions estimates for the two approaches for the period 1990–2013.

Table 3-2 presents CO_2 emissions of sectoral and reference approach.

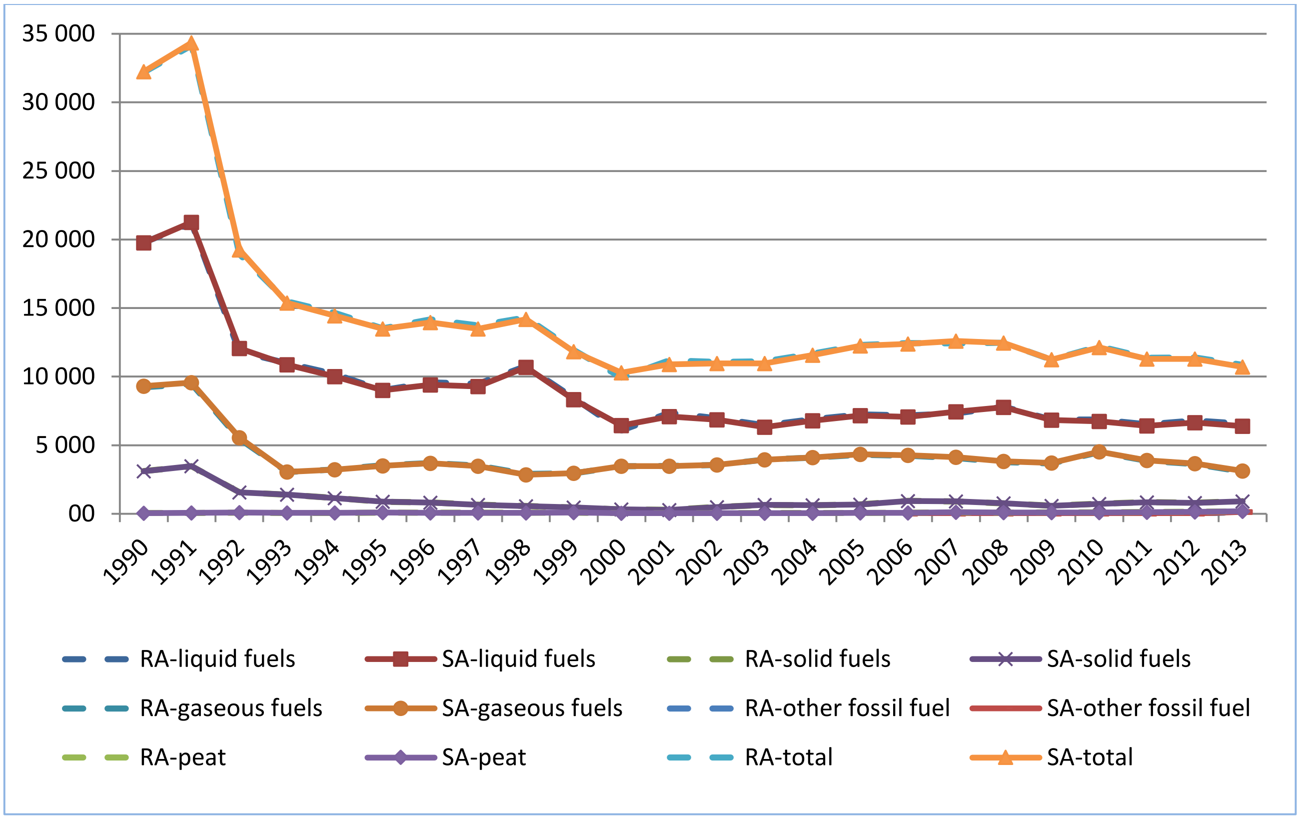


Figure 3-13. Comparison of CO_2 emissions between sectoral and reference approach

Figure 3-13 shows that the differences for CO_2 emissions are very closely correlated.

Table 3-2. Values of CO_2 emissions from sectoral and reference approach

	Reference approach						Sectoral approach					
Year	**Liquid,** kt CO_2	**Solid,** kt CO_2	**Ga-seous,** kt CO_2	**Other fossil fuel,** kt CO_2	**Peat,** kt CO_2	**Total,** kt CO_2	**Liquid,** kt CO_2	**Solid,** kt CO_2	**Ga-seous,** kt CO_2	**Other fossil fuel,** kt CO_2	**Peat,** kt CO_2	**Total,** kt CO_2
1990	19783	3106	9236	-	57	32182	19759	3106	9322	-	56	32242
1991	21171	3473	9451	-	60	34155	21251	3473	9557	-	59	34340
1992	11817	1566	5461	-	88	18933	12061	1564	5548	-	86	19259
1993	10984	1397	3036	-	64	15481	10870	1397	3053	-	62	15382
1994	10188	1147	3232	-	69	14636	10020	1144	3214	-	68	14447
1995	9018	884	3541	-	90	13533	9007	882	3504	-	89	13481
1996	9581	823	3709	-	74	14187	9395	815	3677	-	73	13961
1997	9488	654	3504	-	79	13726	9284	652	3480	-	78	13494
1998	10777	568	2895	-	73	14314	10679	568	2857	-	72	14176
1999	8430	458	2960	-	85	11933	8333	458	2959	-	84	11834
2000	6089	326	3466	-	46	9928	6433	325	3478	-	46	10282
2001	7354	287	3499	-	46	11186	7085	286	3477	-	46	10893
2002	6972	496	3559	-	46	11073	6867	492	3560	-	46	10965
2003	6457	649	3957	-	61	11124	6315	645	3942	-	58	10960

2004	6887	622	4106	-	58	11673	6799	621	4098	-	56	11574
2005	7247	683	4312	-	70	12313	7158	682	4333	-	70	12243
2006	7181	946	4228	19	74	12449	7078	944	4267	19	74	12382
2007	7305	905	4080	22	112	12424	7451	904	4120	22	110	12606
2008	7807	767	3779	19	91	12463	7763	766	3817	19	91	12457
2009	6873	589	3667	17	96	11242	6846	588	3707	17	96	11255
2010	6883	736	4484	18	103	12224	6751	735	4535	18	103	12142
2011	6525	845	3852	21	125	11367	6416	844	3897	21	125	11303
2012	6809	804	3628	23	144	11408	6661	803	3672	23	144	11303
2013	6572	913	3076	130	177	10868	6383	912	3116	130	177	10718

Table 3-3 presents percentage differences of CO_2 emissions between reference and sectoral approach. Statistical differences of energy balances contribute to some share of differences between these two methods especially for liquid fuels. The differences of CO_2 emissions between these two methods arise also due to fuel transformation and distribution losses, which are not considered in the sectoral approach. In reference approach CO_2 emissions from diesel are fully accounted as fossil emissions while in sectoral the share of biofuels is accounted under liquid biomass (as biofuel).

Table 3-3. Difference of CO_2 emissions by fuel type, %

Year	Liquid fuels, %	Solid fuels, %	Gaseous fuels, %	Other fossil fuel, %	Peat, %	Total, %
1990	0.12	0.00	-0.92	-	1.69	-0.19
1991	-0.38	0.00	-1.11	-	1.76	-0.54
1992	-2.02	0.16	-1.56	-	2.30	-1.69
1993	1.05	0.00	-0.56	-	3.14	0.65
1994	1.68	0.21	0.54	-	1.54	1.31
1995	0.13	0.27	1.07	-	1.17	0.39
1996	1.98	0.88	0.87	-	1.43	1.62
1997	2.20	0.36	0.69	-	1.33	1.71
1998	0.92	0.01	1.34	-	1.80	0.97
1999	1.16	0.00	0.03	-	1.47	0.84
2000	-5.35	0.34	-0.33	-	1.51	-3.44
2001	3.81	0.23	0.63	-	0.42	2.68
2002	1.52	0.80	-0.02	-	0.09	0.98
2003	2.26	0.54	0.38	-	6.46	1.50
2004	1.30	0.15	0.18	-	4.09	0.85
2005	1.24	0.10	-0.47	-	0.99	0.57
2006	1.46	0.19	-0.91	0.01	0.14	0.54
2007	-1.96	0.13	-0.96	0.01	2.19	-1.45
2008	0.56	0.09	-1.00	0.01	0.00	0.05
2009	0.39	0.17	-1.08	0.01	0.00	-0.11
2010	1.95	0.12	-1.11	0.01	0.00	0.68
2011	1.69	0.09	-1.17	0.01	0.00	0.57
2012	2.22	0.11	-1.18	0.01	0.00	0.93

2013	2.96	0.10	-1.29	-0.02	0.00	1.40

In reference approach emissions are estimated by excluding carbon stored in the final products from the total carbon content calculated from the apparent consumption. Feedstocks and non energy consumption has been accounted according to the energy balances based on information provided in the Lithuanian Statistics database (http://www.stat.gov.lt/lt/).

During the review ERT noticed differences between the IAE data and the reference approach data which are provided by the Lithuanian Statistics and recommended explain these differences in the NIR. Following this recommendation Lithuania investigated that the differences in natural gas consumption between the IEA data and the reference approach are due to the use of different types of calorific values: Lithuanian Statistics uses a net calorific value whereas the IAE data are based on a gross calorific value. The difference between net calorific value (NCV) and gross calorific value (GCV) is: 1 NCV = 0.9 GCV (IEA, 2005).

Representatives of Lithuanian Statistics explained that differences of refinery feedstock imports and refinery stocks between the IAE data and the reference approach are due to different aggregation level. The Lithuanian Statistics for refinery feedstock aggregates: refinery feedstock, semi-finished products of oil refining and additives/oxygenates. In the IEA database, refinery feedstock aggregates: refinery feedstock and semi-finished products of oil refining. Additives/oxygenates is provided separately in the IEA database.

It was investigated that crude oil import data for 1991-1994, 2000 and crude oil stock for 1990 between the IAE data and the Lithuanian statistics differ only in TJ, but are the same in specific unit (tons). This shows that these differences are due to the use of different types of calorific values.

It is necessary to mentioned, that GHG emission estimates in the sectoral approach and in the reference approach are based on activity data which are provided by the Lithuanian Statistics using the same NCV. Following to the 2006 IPCC Guidelines "fuel statistics collected by an officially recognised national body are usually the most appropriate and accessible activity data".

3.2.2 International bunker fuels

The Statistics Lithuania provides data on marine bunkers in Energy Balances (see Annex III). Emissions factors used to estimate CO_2, CH_4 and N_2O emissions are presented in Table 3-4. Country specific CO_2 emission factor and 2006 IPCC default values of CH_4 and N_2O has been used.

Table 3-4. Emission factors used for International bunkers

	CO_2**, t/TJ**	**EF**	CH_4**, t/TJ**	**EF**	N_2O**, t/TJ**	**EF**
International navigation						
Gas/diesel oil	72,89	CS	0,007	D	0,002	D
Residual fuel oil	77,60	CS	0,007	D	0,002	D
International aviation						
Jet kerosene	72,24	CS	0,0005	D	0,002	D

CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute (values of country specific CO_2 EFs for gas/diesel oil, jet kerosene, residual fuel oil were determined in the basis of measurements performed by the accredited Laboratory of Quality Research Centre of JSC ORLEN Lietuva); D - default emission factors (2006 IPCC).

Tier 2 is used for CO_2 emissions estimates and Tier 1 for CH_4 and N_2O for International bunkers. GHG emissions and activity data from navigation assigned to international bunkers are presented in the following Table 3-5.

Table 3-5. GHG emissions and activity from 1.D International bunkers-navigation 1990-2013

Year	Activity data, TJ	CO_2, kt	CH_4, kt	N_2O, kt
1990	3894	302,2	0,027	0,008
1991	6422	498,3	0,045	0,013
1992	11921	925,1	0,083	0,024
1993	6583	510,8	0,046	0,013
1994	6222	482,8	0,044	0,012
1995	5780	448,5	0,040	0,012
1996	5379	417,4	0,038	0,011
1997	2496	192,3	0,017	0,005
1998	2094	158,1	0,015	0,004
1999	3019	229,5	0,021	0,006
2000	3828	292,6	0,027	0,008
2001	4112	314,9	0,029	0,008
2002	4554	348,9	0,032	0,009
2003	4532	348,2	0,032	0,009
2004	4692	360,1	0,033	0,009
2005	5933	456,8	0,042	0,012
2006	5681	437,8	0,040	0,011
2007	4944	380,7	0,035	0,010
2008	3722	285,9	0,026	0,007
2009	5285	406,9	0,037	0,011
2010	5781	445,0	0,040	0,012
2011	5883	452,4	0,041	0,012
2012	5006	384,5	0,035	0,010
2013	3626	278,7	0,025	0,007

GHG emissions and activity data from aviation assigned to international bunkers are presented in the following Table 3-6.

Table 3-6. GHG emissions and activity from 1.D International bunkers-aviation 1990–2013

Year	Activity data, TJ	CO_2, kt	CH_4, kt	N_2O, kt
1990	5527	399,3	0,003	0,011
1991	6652	480,5	0,003	0,013
1992	2695	194,7	0,001	0,005
1993	1494	107,9	0,001	0,003
1994	1586	114,6	0,001	0,003
1995	1634	118,0	0,001	0,003

1996	1338	96,7	0,001	0,003
1997	1257	90,8	0,001	0,003
1998	1133	81,8	0,001	0,002
1999	1053	76,1	0,001	0,002
2000	972	70,2	0,000	0,002
2001	1295	93,6	0,001	0,003
2002	1155	83,4	0,001	0,002
2003	1294	93,5	0,001	0,003
2004	1445	104,4	0,001	0,003
2005	1923	138,9	0,001	0,004
2006	2189	158,1	0,001	0,004
2007	2742	198,1	0,001	0,005
2008	3176	229,4	0,002	0,006
2009	1522	109,9	0,001	0,003
2010	2012	145,3	0,001	0,004
2011	2311	166,9	0,001	0,005
2012	2634	190,3	0,001	0,005
2013	2922	211,1	0,001	0,006

Statistical data on use of three types of aviation fuel are collected by the Statistics Lithuania: aviation gasoline, gasoline type jet fuel and kerosene type jet fuel since 2000. Since 2000 Statistics Lithuania distinguishes aviation fuel consumption between domestic and international flights, however for 1990-1999 period only total fuel consumption data are available. Taking into consideration IPCC good practise guidelines activity data were extrapolated and following advice from experts during 2004 review it was distinguished in such a way that all aviation gasoline and part of kerosene type jet fuel is used for domestic purposes and the rest kerosene type jet fuel is used for international flights – the latter could therefore be considered as aviation bunkers. More information on AD extrapolation is provided in chapter 3.4.1. Emissions factors used to estimate CO_2, CH_4 and N_2O emissions for international aviation are presented in Table 3-4.

3.2.3 Feedstocks and non-energy use of fuels

Feedstocks and non-energy use of fuel are included in national Energy balances (see Annex III). Use of fuels for feedstocks and non-energy use is dominated by natural gas (Figure 3-14). In 2013, natural gas amounted about 81,5% in the structure of feedstocks and non-energy use of fuels.

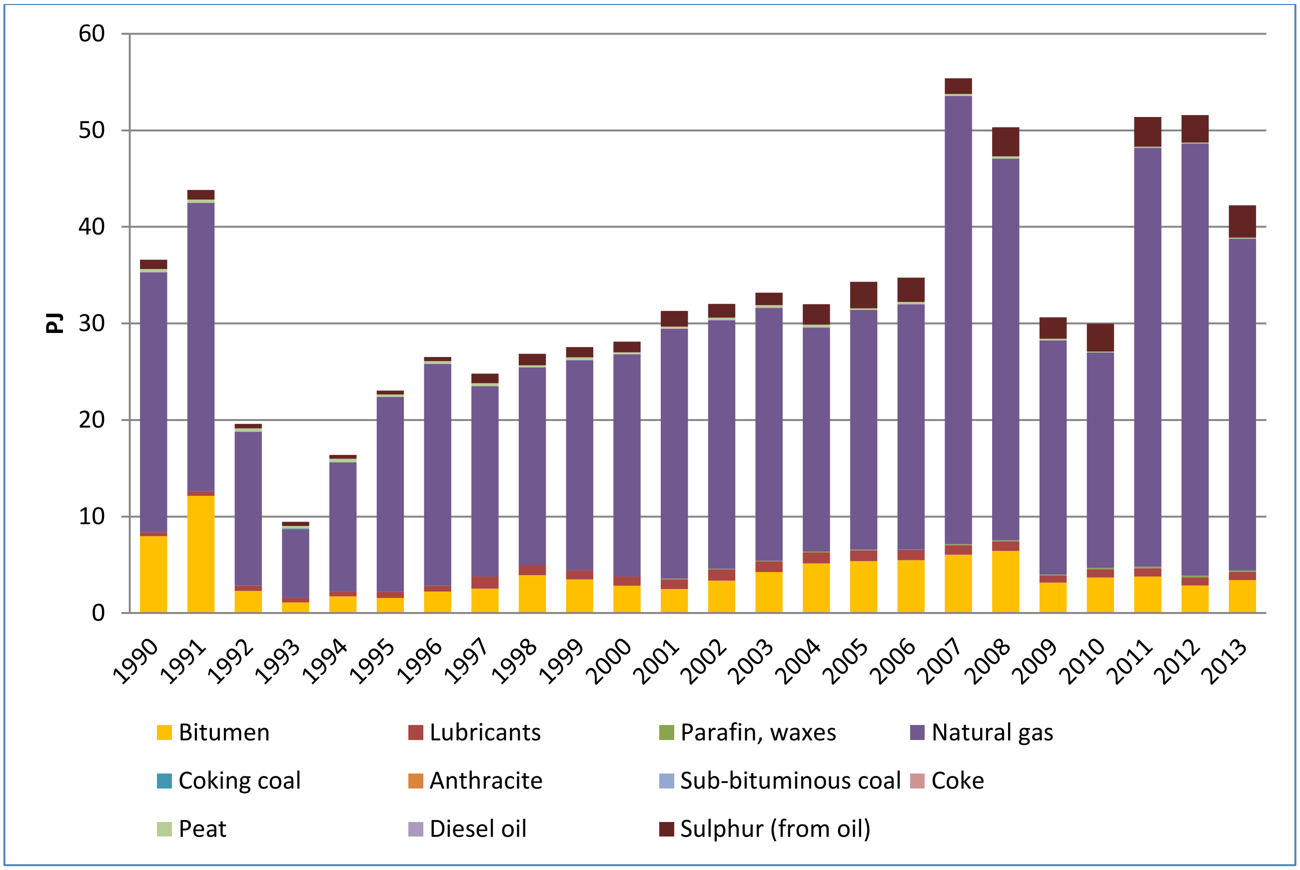


Figure 3-14. Feedstocks and non-energy use of fuels in Lithuania

The natural gas is used for ammonia, calcium ammonium nitrate, organic products and nitric acid production in the JSC Achema. JSC Achema is a leading manufacturer of nitrogen fertilizers and chemical products in Lithuania and the Baltic states. The previous ERT recommended to cross-check the data reported as non-energy use in the energy sector and the data reported under the industrial processes as the calculated CO_2 non-emitted from the use of natural gas for non-energy purpose differs from CO_2 emissions from ammonia production. A cross-check between the natural gas data used in industrial processes and the data reported as non-energy use in the energy sector showed that difference occur due to the use of different calorific values for the natural gas. In the industrial processes sector a specific calorific value is based on average annual lower calorific value of natural gas which is calculated on the basis of reports from the natural gas supplier AB Lietuvos dujos, which measure the calorific value twice a month. In the energy sector calculations are based on the data provided by the Lithuanian Statistics where fuel consumption is calculated in terms of tonnes of oil equivalent and terajoules using the net calorific value. The data reported as non-energy use in the energy sector and the data reported under the industrial processes also differs because the data reported as non-energy use in the energy sector accounts not only feedstocks for ammonia production, but also feedstocks for calcium ammonium nitrate, organic products and nitric acid production.

The amounts of excluded carbon were calculated in accordance with the methodology provided in 2006 IPCC Guidelines (page 6.7). The amounts of excluded carbon are reported in CRF 1.AD

Feedstocks, reductants and other non-energy use of fuels and linked to the CRF 1.AB Fuel Combustion - Reference Approach as excluded carbon.

3.2.4 CO_2 capture from flue gases and subsequent CO_2 storage

CO_2 capture from flue gases and subsequent CO_2 storage is not occurring in Lithuania.

3.2.5 Country-specific issues

All country specific issues are explained in details under relevant chapters of source categories.

Table 3-7 provides information on the status of emission estimates of all subcategories of Category 1.A Fuel Combustion. Symbol "+" indicates that emissions from this subcategory have been estimated. "NO" indicates that the respective sector and fuel category is not relevant for Lithuanian energy balance.

Table 3-7. Overview on the status of emission estimation of Category 1.A Fuel Combustion (CRF 1.A)

IPCC Category	CO_2	CH_4	N_2O
1.A.1.a Public electricity and heat production			
1.A.1.a Liquid fuels	+	+	+
1.A.1.a Solid fuels	+	+	+
1.A.1.a Gaseous fuels	+	+	+
1.A.1.a Other fossil fuels	+	+	+
1.A.1.a Peat	+	+	+
1.A.1.a Biomass	+	+	+
1.A.1.b Petroleum refining			
1.A.1.b Liquid fuels	+	+	+
1.A.1.b Solid fuels	NO	NO	NO
1.A.1.b Gaseous fuels	+	+	+
1.A.1.b Other fossil fuels	NO	NO	NO
1.A.1.b Peat	NO	NO	NO
1.A.1.b Biomass	+	+	+
1.A.1.c Manufacture of solid fuels and other energy industries			
1.A.1.c Liquid fuels	+	+	+
1.A.1.c Solid fuels	+	+	+
1.A.1.c Gaseous fuels	+	+	+
1.A.1.c Other fossil fuels	NO	NO	NO
1.A.1.c Peat	+	+	+
1.A.1.c Biomass	+	+	+
1.A.2.a Iron and steel			
1.A.2.a Liquid fuels	NO	NO	NO
1.A.2.a Solid fuels	NO	NO	NO
1.A.2.a Gaseous fuels	NO	NO	NO
1.A.2.a Other fossil fuels	NO	NO	NO
1.A.2.a Peat	NO	NO	NO
1.A.2.a Biomass	NO	NO	NO

1.A.2.b Non-ferrous metals			
1.A.2.b Liquid fuels	NO	NO	NO
1.A.2.b Solid fuels	NO	NO	NO
1.A.2.b Gaseous fuels	NO	NO	NO
1.A.2.b Other fossil fuels	NO	NO	NO
1.A.2.b Peat	NO	NO	NO
1.A.2.b Biomass	NO	NO	NO
1.A.2.c Chemicals			
1.A.2.c Liquid fuels	+	+	+
1.A.2.c Solid fuels	+	+	+
1.A.2.c Gaseous fuels	+	+	+
1.A.2.c Other fossil fuels	NO	NO	NO
1.A.2.c Peat	NO	NO	NO
1.A.2.c Biomass	+	+	+
1.A.2.d Pulp, Paper and Print			
1.A.2.d Liquid fuels	+	+	+
1.A.2.d Solid fuels	+	+	+
1.A.2.d Gaseous fuels	+	+	+
1.A.2.d Other fossil fuels	NO	NO	NO
1.A.2.d Peat	NO	NO	NO
1.A.2.d Biomass	+	+	+
1.A.2.e Food processing, beverages and tobacco			
1.A.2.e Liquid fuels	+	+	+
1.A.2.e Solid fuels	+	+	+
1.A.2.e Gaseous fuels	+	+	+
1.A.2.e Other fossil fuels	NO	NO	NO
1.A.2.e Peat	+	+	+
1.A.2.e Biomass	+	+	+
1.A.2.f Non-metallic minerals			
1.A.2.f Liquid fuels	+	+	+
1.A.2.f Solid fuels	+	+	+
1.A.2.f Gaseous fuels	+	+	+
1.A.2.f Other fossil fuels	NO	NO	NO
1.A.2.f Peat	+	+	+
1.A.2.f Biomass	+	+	+
1.A.2.g Transport equipment			
1.A.2.g Liquid fuels	+	+	+
1.A.2.g Solid fuels	+	+	+
1.A.2.g Gaseous fuels	+	+	+
1.A.2.g Other fossil fuels	NO	NO	NO
1.A.2.g Peat	NO	NO	NO
1.A.2.g Biomass	+	+	+
1.A.2.h Machinery			
1.A.2.h Liquid fuels	+	+	+

1.A.2.h Solid fuels	+	+	+
1.A.2.h Gaseous fuels	+	+	+
1.A.2.h Other fossil fuels	NO	NO	NO
1.A.2.h Peat	+	+	+
1.A.2.h Biomass	+	+	+
1.A.2.i Mining and quarrying			
1.A.2.i Liquid fuels	+	+	+
1.A.2.i Solid fuels	+	+	+
1.A.2.i Gaseous fuels	+	+	+
1.A.2.i Other fossil fuels	NO	NO	NO
1.A.2.i Peat	+	+	+
1.A.2.i Biomass	+	+	+
1.A.2.j Wood and wood products			
1.A.2.j Liquid fuels	+	+	+
1.A.2.j Solid fuels	+	+	+
1.A.2.j Gaseous fuels	+	+	+
1.A.2.j Other fossil fuels	NO	NO	NO
1.A.2.j Peat	+	+	+
1.A.2.j Biomass	+	+	+
1.A.2.k Construction			
1.A.2.k Liquid fuels	+	+	+
1.A.2.k Solid fuels	+	+	+
1.A.2.k Gaseous fuels	+	+	+
1.A.2.k Other fossil fuels	NO	NO	NO
1.A.2.k Peat	+	+	+
1.A.2.k Biomass	+	+	+
1.A.2.l Textile and leather			
1.A.2.l Liquid fuels	+	+	+
1.A.2.l Solid fuels	+	+	+
1.A.2.l Gaseous fuels	+	+	+
1.A.2.l Other fossil fuels	NO	NO	NO
1.A.2.l Peat	+	+	+
1.A.2.l Biomass	+	+	+
1.A.2.m Non-specified industry			
1.A.2.m Liquid fuels	+	+	+
1.A.2.m Solid fuels	+	+	+
1.A.2.m Gaseous fuels	+	+	+
1.A.2.m Other fossil fuels	+	+	+
1.A.2.m Peat	+	+	+
1.A.2.m Biomass	+	+	+
1.A.3.a Domestic aviation			
1.A.3.a Liquid fuels	+	+	+
1.A.3.a Biomass	NO	NO	NO
1.A.3.b Road Transport			

1.A.3.b Liquid fuels	+	+	+
1.A.3.b Gaseous fuels	+	+	+
1.A.3.b Biomass	+	+	+
1.A.3.b Other fossil fuels	NO	NO	NO
1.A.3.c Railways			
1.A.3.c Liquid fuels	+	+	+
1.A.3.c Solid fuels	NO	NO	NO
1.A.3.c Gaseous fuels	NO	NO	NO
1.A.3.c Other fossil fuels	NO	NO	NO
1.A.3.c Biomass	NO	NO	NO
1.A.3.d Domestic Navigation			
1.A.3.d Liquid fuels	+	+	+
1.A.3.d Gaseous fuels	NO	NO	NO
1.A.3.d Biomass	NO	NO	NO
1.A.3.d Other fossil fuels	NO	NO	NO
1.A.3.e Other Transportation			
1.A.3.c Liquid fuels	+	+	+
1.A.3.c Solid fuels	NO	NO	NO
1.A.3.c Gaseous fuels	+	+	+
1.A.3.c Other fossil fuels	NO	NO	NO
1.A.3.c Biomass	NO	NO	NO
1.A.4.a Commercial/Institutional			
1.A.4.a Liquid fuels	+	+	+
1.A.4.a Solid fuels	+	+	+
1.A.4.a Gaseous fuels	+	+	+
1.A.4.a Other fossil fuels	NO	NO	NO
1.A.4.a Peat	+	+	+
1.A.4.a Biomass	+	+	+
1.A.4.b Residential			
1.A.4.b Liquid fuels	+	+	+
1.A.4.b Solid fuels	+	+	+
1.A.4.b Gaseous fuels	+	+	+
1.A.4.b Other fossil fuels	NO	NO	NO
1.A.4.b Peat	+	+	+
1.A.4.b Biomass	+	+	+
1.A.4.c Agriculture/Forestry/Fisheries			
1.A.4.c Liquid fuels	+	+	+
1.A.4.c Solid fuels	+	+	+
1.A.4.c Gaseous fuels	+	+	+
1.A.4.c Other fossil fuels	NO	NO	NO
1.A.4.c Peat	+	+	+
1.A.4.c Biomass	+	+	+
1.A.5 Non-specified			
1.A.5 Liquid fuels	+	+	+

1.A.5 Solid fuels	NO	NO	NO
1.A.5 Gaseous fuels	NO	NO	NO
1.A.5 Other fossil fuels	NO	NO	NO
1.A.5 Peat	NO	NO	NO
1.A.5 Biomass	NO	NO	NO

3.2.6 Main Activity Electricity and Heat Production (CRF 1.A.1.a)

3.2.6.1 Source category description

During 1990-2010 Ignalina NPP was dominating in the internal electricity market - its share in the structure of electricity generation was fluctuating at around 80%. At the beginning of 2009 the total installed capacity of the Lithuanian power plants was 5029 MW, including Ignalina NPP with 1300 MW and Lithuanian TPP with 1800 MW of electrical capacity. After the decommissioning of Ignalina NPP (Unit 1 was closed in 2004 and Unit 2 in 2009) total available capacity of Lithuanian power plants was 3605 MW in 2010. Currently Lithuanian TPP is dominating in the structure of capacities. Almost 40% of the overall available electrical capacity is covered by this power plant. Currently more than half of required electricity is imported as the cost of electricity production at Lithuanian TPP is high due to high price of natural gas.

In 2010-2013, almost a third of the electricity was produced by the Lithuanian TPP, about 20% was produced by the Vilnius CHP and Kaunas CHP. The share of green electricity is increasing - in 2013 this share reached 24%. The key trend in public electricity and heat production sector - power generation becoming more geographically distributed due to the installation of a relatively small power plants based on biomass.

Characteristics of the Lithuanian power plants in January 2013 are presented in Table 3-8.

Table 3-8. Characteristics of the Lithuanian power plants in January 2013 (Energy in Lithuania, 2013)

Power plant	Fuel	Available capacity, MW
Lithuanian TPP	Residual fuel oil, natural gas, orimulsion	1304 (1884*)
Vilnius CHP	Residual fuel oil, natural gas	333
Kaunas CHP	Residual fuel oil, natural gas	155
Petrasiunai CHP	Natural gas	3
Klaipeda CHP	Residual fuel oil, natural gas	10
ORLEN Lietuva CHP	Residual fuel oil	144
Panevezys CHP	Natural gas	33
Kaunas hydro PP	-	90
Kruonis hydro pumped storage PP	-	760
Small hydro PP	-	27
Wind PP	-	274
Biofuel PP	Biomass, biogas	54

Solar PP	-	8
Industrial PP	Residual fuel oil, natural gas, energy from chemical processes	129
Total	**-**	**3324 (3904*)**

* – including 580 MW mothballed capacity that could be commissioned in two months

Lithuania is a country, where living space heating season (when outside temperature is less than +10ºC) is on average 219 days per year (6-7 months). Lithuanian district heating systems are playing very important role in heat production sector. About 75% of residential buildings in Lithuania's towns are supplied with heat from district heating systems.

In 2013, 43.1% of heat supplied to district heating systems was produced at Combined Heat and Power plants (CHP) and 35.0% - at heat only boilers, and 21.9% - at geothermal and other plants.

Natural gas is the main fuel used in the district heating sector. In 2013, natural gas covered about 63.7% of fuel consumption. Since 2000 the share of renewable energy increased significantly from 2% to 27.5% (2013) in Lithuanian district heating sector. Relevant share of residual fuel oil used for heat production in district heating systems was replaced by renewable energy sources mainly by biomass.

Category 1.A.1.a Public Electricity and Heat Production covers emissions from fuel combustion for electricity generation, combined heat and power generation and fuel combustion in heat plants.

3.2.6.2 Electricity Generation (1.A.1.a.i)

All emissions are reported as "included elsewhere". Emissions for this activity are estimated and included in the inventory under Combined Heat and Power Generation (1.A.1.a.ii).

3.2.6.3 Combined Heat and Power Generation (1.A.1.a.ii)

3.2.6.3.1 Methodological issues

GHG emissions were calculated on the basis of the amount and type of fuel combusted and its carbon content. The following equation has been used:

$$Emission_{GHG,\,fuel} = Fuel\ consumption_{fuel} \cdot Emission\ factor_{GHG,\,fuel} \quad (1)$$

where:

$Emission_{GHG,\,fuel}$ - emissions of GHG by type of fuel, kg GHG;

$Fuel\ consumption_{fuel}$ - amount of fuel combusted, TJ;

$Emission\ factor_{GHG,\,fuel}$ - emission factor of a given GHG by type of fuel, kg/TJ.

CO_2 emissions were calculated applying Tier 2 or Tier 3, except industrial and municipal waste (Tier 1 based on 2006 IPCC default emission factor); CH_4 and N_2O were calculated applying Tier 1 or Tier 2 (as presented in Table 3-9).

Emission factors and methods

Emission factors and methods used in the calculations of emissions from Combined Heat and Power Generation (1.A.1.a.ii) are presented in Table 3-9.

Table 3-9. Emission factors and methods for category Combined Heat and Power Generation (1.A.1.a.ii)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Residual fuel oil	77.60	CS	T2	3.0	D	T1	0.6	D	T1
LPG	65.42	CS	T2	1.0	D	T1	0.1	D	T1
Not liquefied petroleum gas	56.54	PS	T3	1.0	D	T1	0.1	D	T1
Orimulsion	81.74	PS	T3	3.0	D	T1	0.6	D	T1
Emulsified vacuum residue	79.41	PS	T3	3.0	D	T1	0.6	D	T1
Natural gas	55.23	CS	T2	1.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	1.0	CS	T2	1.5	CS	T2
Wood/ wood waste	109.90	CS	T2	30.0	D	T1	4.0	D	T1
Other solid biomass	109.90	CS	T2	30.0	D	T1	4.0	D	T1
Biogas	58.45	CS	T2	1.0	CS	T2	0.1	CS	T2
Industrial waste	143.0	D	T1	30.0	D	T1	4.0	D	T1
Municipal waste	91.70	D	T1	30.0	D	T1	4.0	D	T1

Abbreviations: CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute;

PS - plant specific emission factors are based on EU ETS data and considering to the Tier 3 reliability that ensures the lowest uncertainty of emission factor. PS EFs are applied for orimulsion and emulsified vacuum residue for category Combined Heat and Power Generation (1.A.1.a.ii). Orimulsion was combusted in Lithuania TPP and emulsified vacuum residue was combusted in CHP of the JSC "ORLEN Lietuva". Linear regression analysis was performed using EU ETS data and taking into accoun than R^2 is small the averaged (over time) value was asumed to be valid for all year. D - default emission factors (2006 IPCC); T1 - Tier 1; T2 - Tier 2; T3 - Tier 3.

Country specific CO_2 emission factors were applied based on the results of study "Determination of national GHG emission factors for energy sector", which was prepared by Lithuanian Energy Institute in 2012. Summary of this study is provided in the Annex IV. Plant specific CO_2 emission factors based on EU ETS data used for emulsified vacuum residue, not liquefied petroleum gas and orimulsion.

Emulsified vacuum residue and not liquefied petroleum gas are combusted at the ORLEN Lietuva CHP. Orimulsion was combusted at the Lithuanian TPP during 1995-2008 period.

2006 IPCC default emission factors were used for CH_4 and N_2O emissions estimation, except biogas, peat and used tires (combusted in the non-specifed industry). CH_4 and N_2O emission factors for biogas, peat and used tires were based on the results of study "Determination of national GHG emission factors for energy sector".

Activity data

In the Energy Sector all activity data for calculation of GHG emissions has been obtained from the Lithuanian Statistics database and yearly publications "Energy balance".

Fuel and energy balance has been compiled based on the data provided by legal entities (enterprises) consuming, producing or supplying fuel and energy. The data presented in the Energy balances shows domestic fuel and energy resources of the Republic of Lithuania, including their extraction, production, exports and imports, fuel consumption for generating electricity and heat, as well as final fuel and energy consumption by main economic activity and in households.

All heat generated in public power plants (CHP), public heat plants (heat only boilers), as well as energy (heat) from chemical processes, generated in chemical industry enterprises, is subsumed under the energy balance. Fuel is calculated in terms of tonnes of oil equivalent and terajoules using the net calorific value. The net calorific value (NCV) is the amount of heat which is actually available from the combustion process, i.e. excluding the latent heat of water formed during combustion.

Following the recommendation of expert review team (ERT) in 2010 in the individual review report, net calorific values (NCVs) used to convert fuel consumption in natural units into energy units are provided in the tables below.

Table 3-10. Specific net calorific values (Statistics Lithuania)

Type of fuel	**Tonne**	**Tonne of oil equivalent (TOE)**	**TJ/tonne**
Hard coal	1.0	0.600	0.02512
Coke	1.0	0.700	0.02930
Peat	1.0	0.280	0.01172
Peat briquettes	1.0	0.360	0.01500
Firewood (m^3)	1.0	0.196	0.00820
Biogas (1000 m^3)	1.0	0.480	0.02000
Natural gas (1000 m^3)	1.0	0.800	0.03349
Liquefied petroleum gases	1.0	1.109	0.04642
Motor gasoline	1.0	1.070	0.04479
Gasoline type jet fuel	1.0	1.070	0.04479
Kerosene type jet fuel	1.0	1.031	0.04316
Transport diesel	1.0	1.029	0.04307
Heating and other gasoil	1.0	1.029	0.04307
Fuel oil	1.0	0.957	0.04006

Crude oil	1.0	1.022	0.04278
Bioethanol	1.0	0.645	0.02700
Biodiesel (methyl ester)	1.0	0.884	0.03700

Table 3-11. Conversion factors (Statistics Lithuania)

Factor	TOE	GJ	Gcal	MWh
TOE	1.000	41.861	10.000	11.628
GJ	0.024	1.000	0.239	0.278
Gcal	0.100	4.186	1.000	1.163
MWh	0.086	3.600	0.860	1.000

Brief overview of the Lithuania's Energy balance is presented below:

- *Consumption in the energy sector* refers to the quantities consumed by the energy industry to support extraction (mining, oil and gas production) or plant operations of transformation activities, as well as for pumped water storage in hydropower stations. The quantities of fuels transformed into another form of energy are excluded. Energy enterprises are those which under the international methodology of energy are subsumed under the following kinds of activity according to the national version (EVRK Rev. 2) of the Statistical Classification of Economic Activities in the European Community (NACE Rev. 2):
  - Extraction of crude petroleum;
  - Extraction of peat;
  - Support activities for petroleum and natural gas mining;
  - Manufacture of refined petroleum products;
  - Electricity, gas, steam and air conditioning supply.
- *Non-energy use* covers energy resources used as raw materials, i.e. energy resources which are neither used as fuel nor converted into other kind of fuel.
- *Consumption in industry* refers to fuel quantities consumed by an industrial undertaking in support of its primary activities. Industrial enterprises are those which under the international methodology of energy are subsumed under the following kinds of activity according to EVRK Rev. 2 (excluding enterprises which are subsumed under the energy sector):
  - Mining and quarrying;
  - Manufacturing.
- *Consumption in the transport sector* includes fuel and energy consumed by all means of transport: railways, inland waterways (excluding fishing), air (international, domestic and military aviation), road (fuel used in road vehicles including fuel used by agricultural vehicles on highways), pipeline system and other transport, irrespective of the kind of enterprise industrial, construction, transport, agricultural, commercial or public) the transport facility belongs to. Moreover, fuel consumed by personal transport facilities is included. Fuel with which vehicles (cars, aircraft, ships, etc.) were fuelled abroad is not recorded.
- *Consumption in agriculture* encompasses fuel and energy consumption by enterprises whose economic activity is related to agriculture, hunting and forestry.

- *Consumption in fishing* encompasses fuels delivered to inland, coastal and deep-sea fishing vessels of all flags that are refuelled in the country (including international fishing) and fuel and energy used in the fishing industry.
- *Consumption in the service sector* encompasses fuel and energy consumed in other economic activities not mentioned above, i.e. for heating and lighting premises meant for trade, education, health, commercial services, administration, etc.
- *Consumption in households* encompasses fuel and energy sold to the population for heating, lighting, cooking. Fuel consumed for individual transport is subsumed under the item "Consumption in transport".
- *International marine bunkers* are defined as quantities of fuels delivered to ships of all flags that are engaged in international navigation. Consumption by ships engaged in fishing and domestic navigation vessels is excluded.

To improve transparency of the reporting in energy sector in the NIR the energy balance data for 1990, 1995, 2000 and 2005-2013 are provided in the Annex III. The entire time series (1990-2013) are publically available at the databases of the Statistics of Lithuania[2]. In the Annex III the energy balance data are provided in Terajoule (TJ).

Tendencies of fuel consumed and total GHG emissions in Combined Heat and Power Generation (including Electricity Generation) is provided in Figure 3-15.

As it is seen from Figure 3-15, during the latter ten years the consumption of fuels in Combined Heat and Power Generation was rather stable – about 45 PJ a year. However, in 2013 fuel consumption reduced by 13.3% in comparison to 2012. This is mainly due to reduction of liquid fuels and natural gas consumption. CHPs based on municipal and industrial waste started operation in 2013 and combusted 1.1 PJ of waste. Consumption of fuels in Combined Heat and Power Generation (including Electricity Generation) amounted 38.1 PJ in 2013.

[2] Available from: *http://www.stat.gov.lt/lt/*

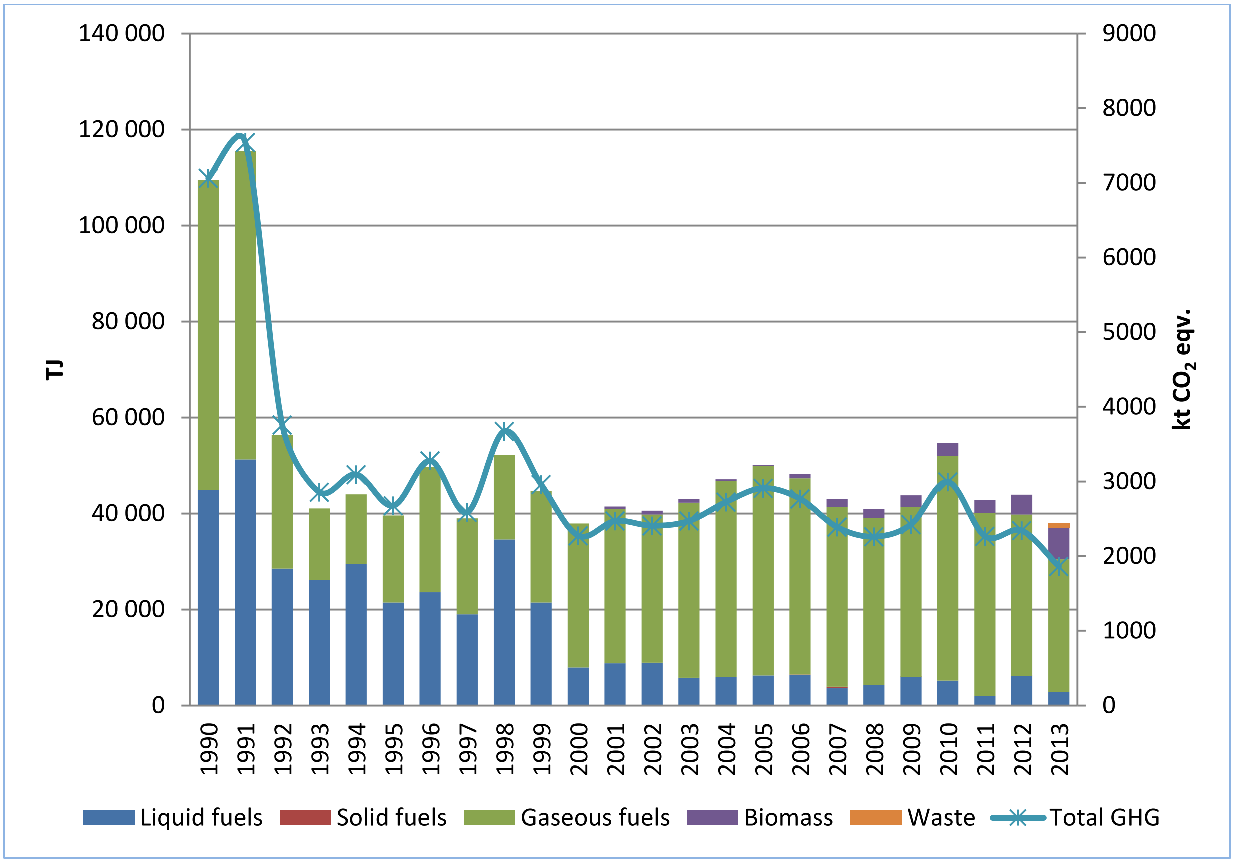


Figure 3-15. Tendencies of fuel consumed and GHG emissions in Combined Heat and Power Generation (1.A.1.a.ii)

Natural gas dominates in the structure of total fuel combusted for Combined Heat and Power Generation. In 2013 natural gas accounted 72.7%. The share and volume of liquid fuels drastically reduced since 1990s and in 2013 accounted only 7.2% in structure of fuel combusted. Since 2001 wood/wood waste started to be used for Combined Heat and Power Generation. During a last decade the share of biomass increased from 1.1% (2001) till 17.2% (2013). Municipal and industrial waste in the structure of total fuel combusted accounted 2.9% in 2013.

Total GHG emissions from Combined Heat and Power Generation reduced by almost 4 times since 1990 and amounted 1862.0 kt CO_2 eqv.

3.2.6.3.2 Uncertainties and time-series consistency

Uncertainty in activity data in Combined Heat and Power Generation is ±2% taking into consideration recommendations provided by IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000 and IPCC 2006 Guidelines for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by 2006 IPCC.

Uncertainties of CO_2 emission factors for liquid fuels (residual fuel oil, LPG, non-liquefied petroleum gas, orimulsion and emulsified vacuum residue) and gaseous fuels (natural gas) are ±2.5% in Combined Heat and Power Generation. Uncertainties of CO_2 emission factors for solid fuels (peat) are ±7%. Estimated uncertainties of CO_2 emission factors for biomass are ±50%. Uncertainties of all country specific CO_2 emission factors are derived in the study "Determination of national GHG emission factors for Lithuanian energy sector" (see Annex IV).

Uncertainties of CH_4 and N_2O emission factors for liquid, solid and gaseous fuels were assigned as very high about ±50%. Uncertainties of emission factors for biomass were assumed ±150%. Uncertainties were derived considering IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in the time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.2.6.3.3 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

The consumption of every type of fuel has been checked and compared with other available data sources (IEA, EUROSTAT). The time series for all data have been studied carefully in search for outliers.

The results are verified by calculating CO_2 emissions with the reference approach, and comparing results with the sectoral approach.

3.2.6.3.4 Source-specific planned improvements

The following improvement are foreseen:

- further investigate the possibility of using data provided in the EU ETS, reported by the operators for the energy sector emission estimates.

3.2.6.4 Heat plants (1.A.1.a.iii)

3.2.6.4.1 Methodological issues

CO_2 emissions were calculated applying Tier 2 or Tier 3, CH_4 and N_2O were calculated applying Tier 1 or Tier 2 (as presented in Table 3-12).

Emission factors and methods

Emission factors and methods used in the calculations of emissions from Heat Plants (1.A.1.a.iii) are presented in Table 3-12.

Table 3-12. Emission factors and methods for category Heat Plants (1.A.1.a.iii)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method

Crude oil	77.74	CS	T2	3.0	D	T1	0.6	D	T1
Shale oil	77.40	CS	T2	3.0	D	T1	0.6	D	T1
Residual fuel oil	77.60	CS	T2	3.0	D	T1	0.6	D	T1
LPG	65.42	CS	T2	1.0	D	T1	0.1	D	T1
Not liquefied petroleum gas	56.54	PS	T3	1.0	D	T1	0.1	D	T1
Gasoil	72.89	CS	T2	3.0	D	T1	0.6	D	T1
Diesel oil	72.89	CS	T2	3.0	D	T1	0.6	D	T1
Coking coal	94.90	CS	T2	1.0	D	T1	1.5	D	T1
Sub-bituminous coal	95.70	PS	T3	1.0	D	T1	1.5	D	T1
Anthracite	106.55	PS	T3	1.0	D	T1	1.5	D	T1
Natural gas	55.23	CS	T2	1.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	1.0	CS	T2	1.5	CS	T2
Wood/ wood waste	109.90	CS	T2	30.0	D	T1	4.0	D	T1
Other solid biomass	109.90	CS	T2	30.0	D	T1	4.0	D	T1
Biogas	58.45	CS	T2	1.0	CS	T2	0.1	CS	T2

Abbreviations: CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute;

PS - plant specific emission factors are based on EU ETS data and considering to the Tier 3 reliability that ensures the lowest uncertainty of emission factor. PS EFs are applied for not liquefied petroleum gas, sub-bituminous coal and anthracite for category Heat Plants (1.A.1.a.iii). Linear regression analysis was performed using EU ETS data and taking into accoun than R2 is small the averaged (over time) value was asumed to be valid for all year. D - default emission factors (2006 IPCC); T1 - Tier 1; T2 - Tier 2; T3 - Tier 3.

Activity data

For calculation of GHG emissions in category Heat Plants (1.A.1.a.iii) activity data had been obtained from the Lithuanian Statistics database (http://www.stat.gov.lt/lt/). Activity data is provided in the Annex III.

Tendencies of fuel consumed and total GHG emissions in Heat Plants is provided in Figure 3-16.

Total fuel consumption in Heat Plants reduced by 4 times since 1990 (Figure 3-16). During the 2004-2012 the consumption of fuels in Heat Plants was rather stable – about 20 PJ a year. In 2013 fuel consumption reduced by 11.0% in comparison to 2012. Consumption of fuels in Heat plants amounted 17.7 PJ in 2013.

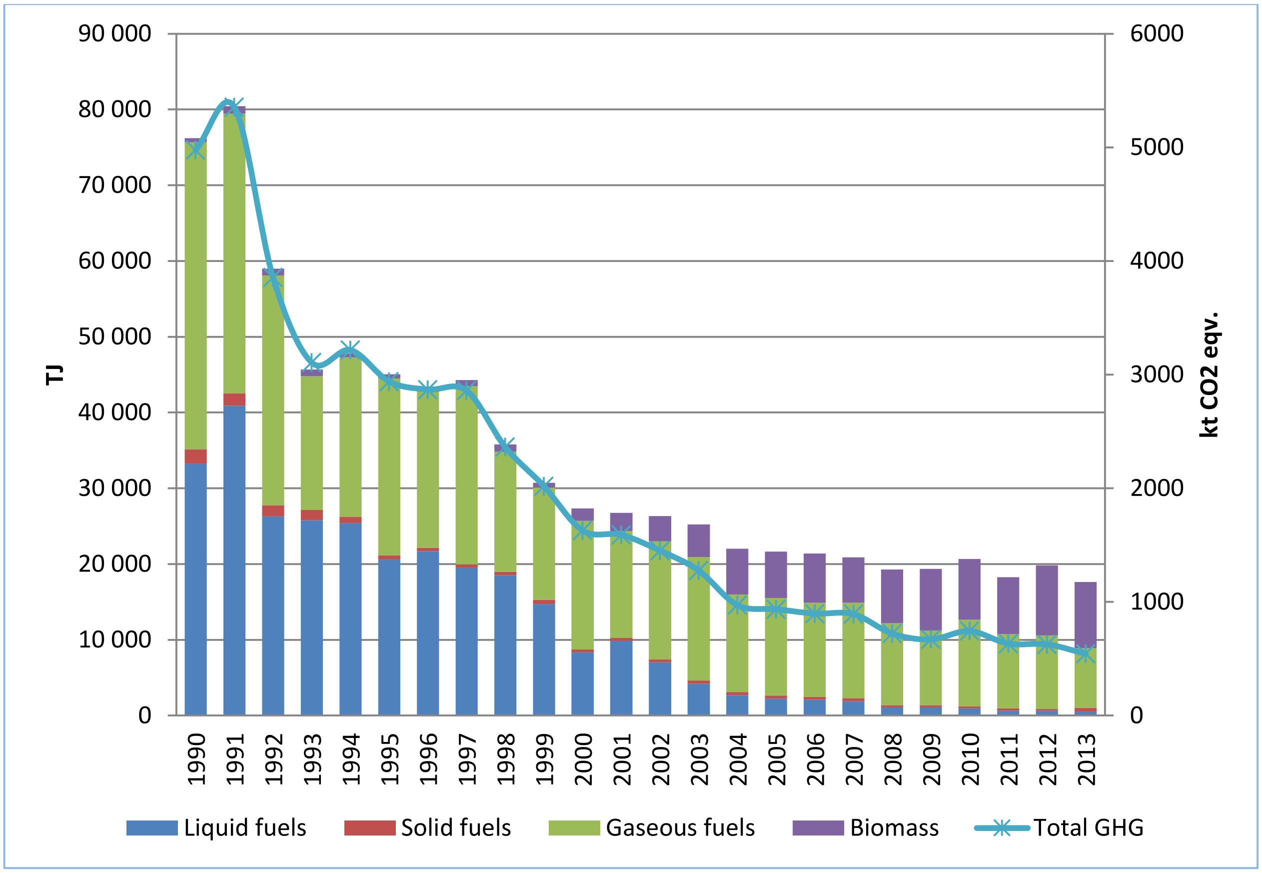


Figure 3-16. Tendencies of fuel consumed and GHG emissions in Heat Plants (1.A.1.a.iii)

Curentlly natural gas and biomass dominates in the structure of total fuel combusted in Heat Plants. In 2013 natural gas accounted 44.4% and biomass 49.7%. Since 2000 wood/wood waste started to be widely used for heat generation in Heat Plants. During a last decade the share of biomass increased from 6.0% (2000) till 49.7% (2013).The share and volume of liquid fuels drastically reduced since 1990s and in 2011 accounted only 2.8% in structure of fuel combusted. Solid fuels accounted 3.1 % in 2013.

Total GHG emissions from Heat Plants reduced by 9 times since 1990 and amounted 543.5 kt CO_2 eqv.

3.2.6.4.2 Uncertainties and time-series consistency

Uncertainty in activity data in public electricity and heat production is ±2% taking into consideration recommendations provided by IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000 and IPCC 2006 Guidelines for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by 2006 IPCC.

Uncertainties of CO_2 emission factors for liquid fuels (crude oil, shale oil, residual fuel oil, LPG, non liquefied petroleum gas, orimulsion, gasoil, diesel oil and emulsified vacuum residue) and gaseous fuels (natural gas) are ±2.5% in Public electricity and heat production. Uncertainties of CO_2 emission factors for solid fuels (peat and coking coal) are ±7%. Estimated uncertainties of CO_2 emission factors for biomass are ±50%. Uncertainties of all country specific CO_2 emission factors are derived in the study "Determination of national GHG emission factors for Lithuanian energy sector" (see Annex IV).

Uncertainties of CH_4 and N_2O emission factors for liquid, solid and gaseous fuels were assigned as very high about ±50%. Uncertainties of emission factors for biomass were assumed ±150%. Uncertainties were derived considering IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in the time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.2.6.4.3 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

The consumption of every type of fuel has been checked and compared with other available data sources (IEA, EUROSTAT). The time series for all data have been studied carefully in search for outliers.

The results are verified by calculating CO_2 emissions with the reference approach, and comparing results with the sectoral approach.

3.2.6.4.4 Source-specific planned improvements

Source-specific improvements are not planned currently but will be decided after finalization of the national QA/QC plan.

3.2.6.5 CO_2 emission from carbonates use in flue gas desulphurisation

In this submission CO_2 emission from carbonates use in flue gas desulphurisation was calculated for the first time. There is one power plant in Lithuania which has flue gas desulphurisation facility since 2008. CO_2 emissions were calculated using Tier 1 method based on mass of carbonates used (equation 2.14, page 2.34) described in IPCC 2006 Guidelines:

$$CO_2\ Emissions = M_c \bullet (0.85EF_{ls} + 0.15EF_d)$$

Where:
M_c = mass of carbonate consumed, tonnes
EF_{ls} or EF_d = emission factor for limestone or dolomite calcination, tonnes CO_2/tonne carbonate

Activity data (limestone use) was supplied by power plant, default emission factor (0.43971 tonnes CO_2/tonne carbonate) suggested in IPCC 2006 Guidelines table 2.1 (page 2.7) was used. Results are provided in Table 3-14.

According to IPCC 2006 Guidelines: "It is good practice to report emissions from the consumption of carbonates in the source category where the carbonates are consumed and the CO_2 emitted. (…) Where carbonates are used as fluxes or slagging agents (e.g., in iron and steel, chemicals, or for environmental pollution control etc.) emissions should be reported in the respective source categories where the carbonate is consumed." (page 2.33), therefore information on emissions calculated was provided under Energy sector (CRF 1.A.1.a) of the NIR, however, due to lack of CRF Reporter functionality emissions in CRF Reporter were reported under CRF 2.H.3 "Other" category in Industrial processes and product use sector.

Table 3-14. CO_2 emission from limestone use in flue gas desulphurisation

	2008	**2009**	**2010**	**2011**	**2012**	**2013**
Limestone use, tonnes	4138	2237	3647	49	10028	2703
CO_2 emission, kt	1,55	0,84	1,37	0,02	3,75	1,01

3.2.7 Petroleum Refining (CRF 1.A.1.b)

3.2.7.1 Source category description

Refineries process crude oil into a variety of hydrocarbon products such as gasoline, kerosene and etc. UAB ORLEN Lietuva[3] 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 kerosene, 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.

3.2.7.2 Methodological issues

CO_2 emissions were calculated applying Tier 2 or Tier 3, CH_4 and N_2O were calculated applying Tier 1 (as presented in Table 3-13) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Petroleum Refinery (1.A.1.b) are presented in the Table 3-13.

Table 3-13. Emission factors and methods for category Petroleum Refinery (1.A.1.b)

Fuel	**CO_2**			**CH_4**			**N_2O**		
	CO_2, kg/GJ	**EF**	**Method**	**CH_4, kg/TJ**	**EF**	**Method**	**N_2O, kg/TJ**	**EF**	**Method**
Crude oil	77.74	CS	T2	3.0	D	T1	0.6	D	T1

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

Residual fuel oil	80.97	PS	T3	3.0	D	T1	0.6	D	T1
LPG	65.42	CS	T2	1.0	D	T1	0.1	D	T1
Petroleum coke	94.06	CS	T2	3.0	D	T1	0.6	D	T1
Diesel oil	72.89	CS	T2	3.0	D	T1	0.6	D	T1
Not liquefied petroleum gas	56.54	PS	T3	1.0	D	T1	0.1	D	T1
Natural gas	55.23	CS	T2	1.0	D	T1	0.1	D	T1
Wood / wood waste	109.9	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations: CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute; PS - plant specific emission factors are based on EU ETS data and considering to the Tier 3 reliability that ensures the lowest uncertainty of emission factor. PS EFs are applied for residual fuel oil and not liquefied petroleum gas for category Petroleum Refinery (1.A.1.b). Linear regression analysis was performed using EU ETS data and taking into accoun than R2 is small the averaged (over time) value was asumed to be valid for all year; D - default emission factors (2006 IPCC); T1 - Tier 1; T2 - Tier 2; T3 - Tier 3.

Activity data

For calculation of GHG emissions in category Petroleum Refinery (1.A.1.b) activity data had been obtained from the Lithuanian Statistics database (http://www.stat.gov.lt/lt/). Activity data is provided in the Annex III.

Tendencies of fuel consumed and total GHG emissions in Petroleum Refinery is presented in Figure 3-17.

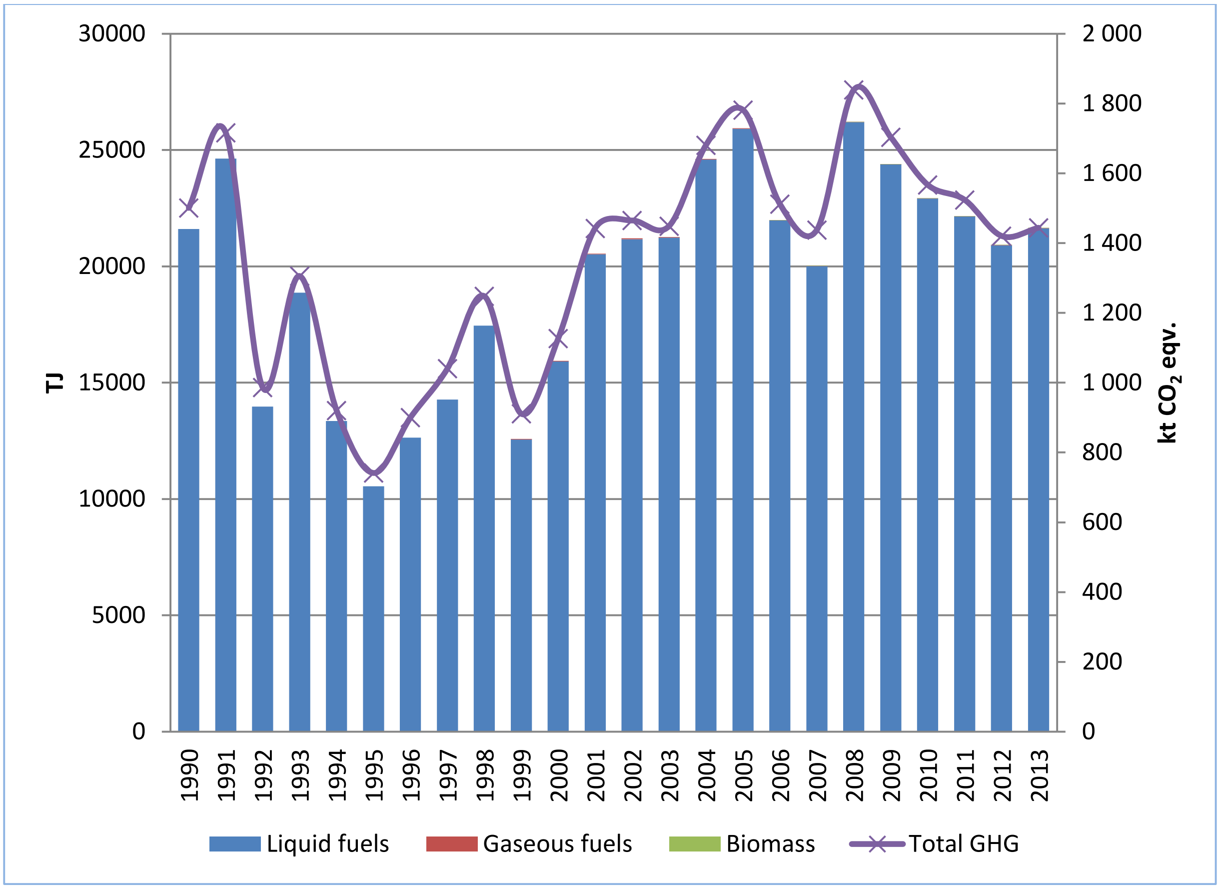


Figure 3-17. Tendencies of fuel consumed and total GHG emissions in Petroleum Refinery (1.A.1.b)

As it is seen from Figure 3-17, liquid fuels are mainly used in Lithuanian Petroleum Refinery industry. Liquid fuels accounted 99.9% of fuel structure in 2013. Historically, non liquefied petroleum gas made more than 50% of total fuel consumed in petroleum refinery. With reference to data of 2013, there was consumed 21.6 PJ, from which non liquefied petroleum gas accounted 68.2%, petroleum coke – 14.5%, residual fuel oil – 17.3%.

Total GHG emissions from Petroleum Refinery in 2013 were below 1990 level by 4% and amounted 1444.1 kt CO_2 eqv.

3.2.7.3 Uncertainties and time-series consistency

Uncertainty in activity data in Petroleum Refinery is ±2% taking into consideration recommendations provided by IPCC GPG 2000 and IPCC 2006 Guidelines for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by 2006 IPCC.

Uncertainties of CO_2 emission factors for liquid fuels (crude oil, residual fuel oil, LPG, non liquefied petroleum gas, diesel oil and petroleum coke) and gaseous fuels (natural gas) are ±2.5% in Petroleum refinery. Estimated uncertainties of CO_2 emission factors for biomass are ±50%. Uncertainties of all country specific CO_2 emission factors are derived in the study "Determination of national GHG emission factors for Lithuanian energy sector" (see Annex IV).

Uncertainties of CH_4 and N_2O emission factors for liquid and gaseous fuels were assigned as very high about ±50%. Uncertainties of emission factors for biomass were assumed ±150%. Uncertainties were derived considering IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.2.7.4 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

The results are verified by calculating CO_2 emissions with the reference approach, and comparing results with the sectoral approach.

3.2.7.5 Source-specific planned improvements

Source-specific improvements are not planned.

3.2.8 Manufacture of Solid Fuels and Other Energy Industries (CRF 1.A.1.c)

3.2.8.1 Source category description

Emissions in this sector arise from fuel combustion in Manufacturing of Solid Fuels and other Energy Industries.

3.2.9 Manufacture of solid fuels (1.A.1.c.i)

3.2.9.1 Methodological issues

CO_2 emissions were calculated applying Tier 2, CH_4 and N_2O were calculated applying Tier 1 or Tier 2 (as presented in Table 3-14) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculations of emissions from Manufacture of Solid Fuels (1.A.1.c.i) are presented in Table 3-14.

Table 3-14. Emission factors and methods for category Manufacture of Solid Fuels (1.A.1.c.i)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Motor gasoline	72.97	CS	T2	3.0	D	T1	0.6	D	T1
Gasoil	72.89	CS	T2	3.0	D	T1	0.6	D	T1
Diesel oil	72.89	CS	T2	3.0	D	T1	0.6	D	T1

Peat	104.34	CS	T2	1.0	CS	T2	1.5	CS	T2
Wood/wood waste	109.90	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations: CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute; D - default emission factors (2006 IPCC); T1 - Tier 1; T2 - Tier 2.

Activity data

For calculation of GHG emissions in category Manufacture of Solid Fuels (1.A.1.c.i) activity data had been obtained from the Lithuanian Statistics database (http://www.stat.gov.lt/lt/). Activity data are provided in the Annex III.

Tendencies of fuel consumption and total GHG emissions in Manufacture of Solid Fuels are presented in Figure 3-18.

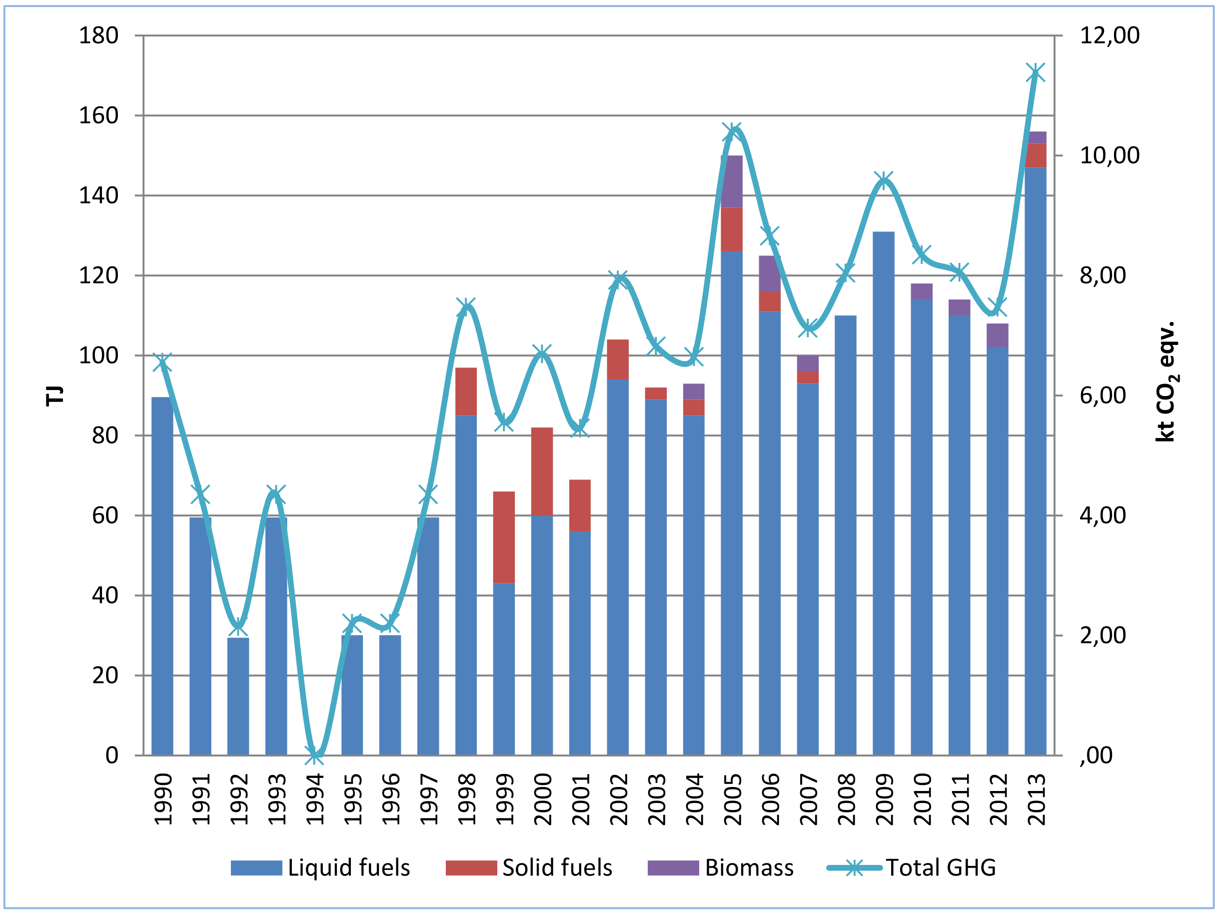


Figure 3-18. Tendencies of fuel consumption and total GHG emissions in Manufacture of Solid Fuels (1.A.1.c.i)

As it is seen from Figure 3-18, fuel consumption in Manufacture of Solid Fuels increased by 44.4% in comparison to 2012 and accounted 156 TJ in 2013. With reference to data of 2013, liquid fuels accounted 94.2%, solid fuels 3.8% and biomass – 2.0% of structure.

In 2013, total GHG emissions from Manufacture of Solid Fuels were about 2 times higher than in 1990 and amounted 11.4 kt CO_2 eqv.

3.2.9.1.1 Uncertainties and time-series consistency

Uncertainty in activity data in Manufacture of Solid Fuels is ±2% taking into consideration recommendations provided by IPCC GPG 2000 and IPCC 2006 Guidelines for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by 2006 IPCC.

Uncertainties of CO_2 emission factors for liquid fuels (motor gasoline, gasoil, LPG, diesel oil) and gaseous fuels (natural gas) are ±2.5% in Manufacture of solid fuels. Estimated uncertainties of CO_2 emission factors for biomass are ±50%. Uncertainties of all country specific CO_2 emission factors are derived in the study "Determination of national GHG emission factors for Lithuanian energy sector" (see Annex IV).

Uncertainties of CH_4 and N_2O emission factors for liquid and gaseous fuels were assigned as very high about ±50%. Uncertainties of emission factors for biomass were assumed ±150%. Uncertainties were derived considering IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.2.9.1.2 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

The results are verified by calculating CO_2 emissions with the reference approach, and comparing results with the sectoral approach.

3.2.9.1.3 Source-specific planned improvements

Source-specific improvements are not planned.

3.2.9.2 Other Energy Industries (1.A.1.c.ii)

3.2.9.2.1 Methodological issues

CO_2 emissions were calculated applying Tier 2, CH_4 and N_2O were calculated applying Tier 1 or Tier 2 (as presented in Table 3-15) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculations of emissions from Other Energy Industries (1.A.1.c.ii) are presented in Table 3-15.

Table 3-15. Emission factors and methods for category Other Energy Industries (1.A.1.c.ii)

Fuel	CO_2	CH_4	N_2O

	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Motor gasoline	72.97	CS	T2	3.0	D	T1	0.6	D	T1
LPG	65.42	CS	T2	1.0	D	T1	0.1	D	T1
Diesel oil	72.89	CS	T2	3.0	D	T1	0.6	D	T1
Natural gas	55.23	CS	T2	1.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	1.0	CS	T2	1.5	CS	T2
Wood/wood waste	109.90	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations: CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute; D - default emission factors (2006 IPCC); T1 - Tier 1; T2 - Tier 2.

Activity data

For calculation of GHG emissions in category Other Energy Industries (1.A.1.c.ii) activity data had been obtained from the Lithuanian Statistics database (http://www.stat.gov.lt/lt/). Activity data are provided in the Annex III.

Tendencies of fuel consumption and total GHG emissions in Other Energy Industries are presented in Figure 3-19.

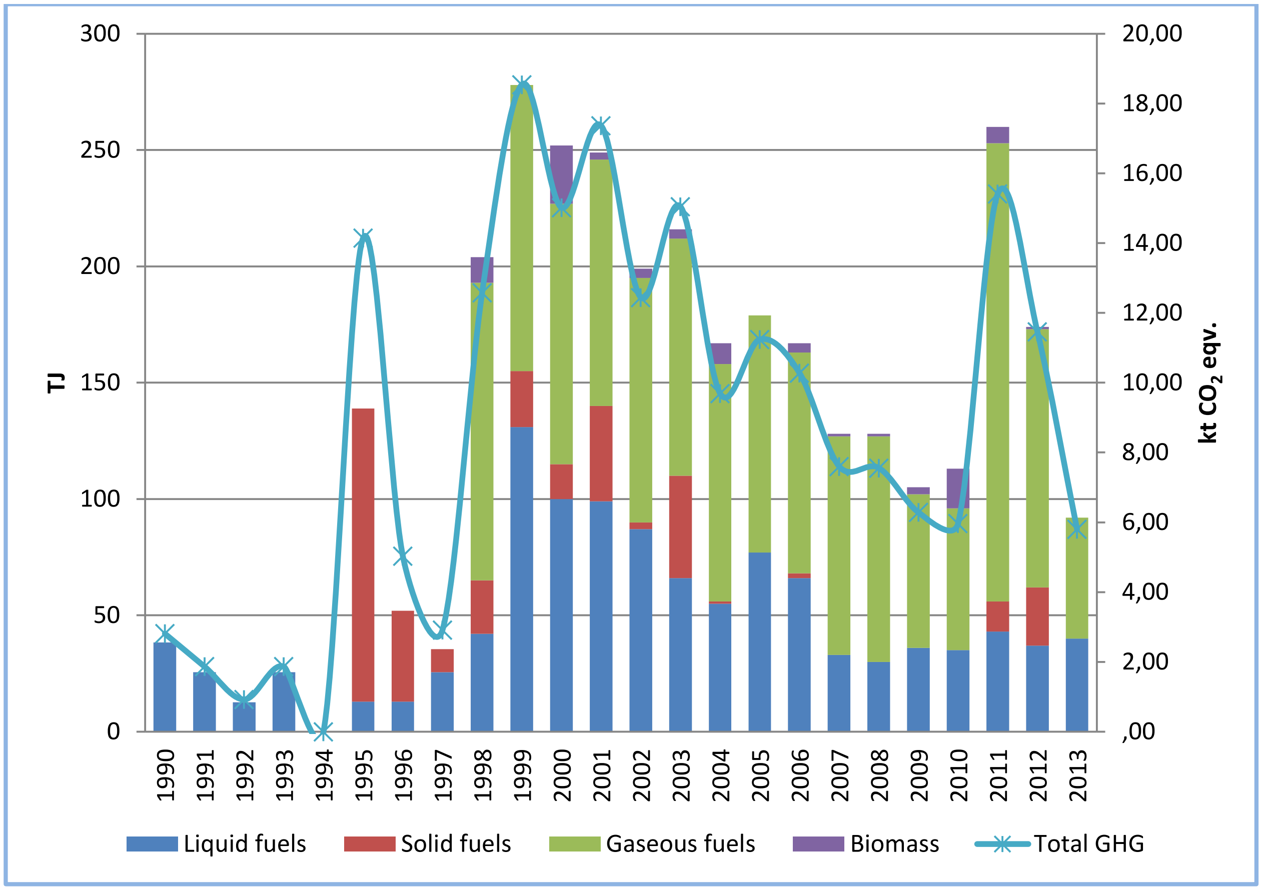


Figure 3-19. Tendencies of fuel consumption and total GHG emissions in Other Energy Industries (1.A.1.c.ii)

As it is seen from Figure 3-19, fuel consumption in Other Energy Industries reduced by 47.1% and accounted 92 TJ in 2013. With reference to data of 2013, natural gas accounted 56.5%, liquid fuels – 43.5% of structure.

In 2013, total GHG emissions from Manufacture of Solid Fuels were about 2 times higher than in 1990 and amounted 5.8 kt CO_2 eqv.

3.2.9.2.2 Uncertainties and time-series consistency

Uncertainty in activity data in Other Energy Industries is ±2% taking into consideration recommendations provided by IPCC GPG 2000 and IPCC 2006 Guidelines for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by 2006 IPCC.

Uncertainties of CO_2 emission factors for liquid fuels (motor gasoline, gasoil, LPG, diesel oil) and gaseous fuels (natural gas) are ±2.5% in Other Energy Industries. Estimated uncertainties of CO_2 emission factors for biomass are ±50%. Uncertainties of all country specific CO_2 emission factors are derived in the study "Determination of national GHG emission factors for Lithuanian energy sector" (see Annex IV).

Uncertainties of CH_4 and N_2O emission factors for liquid and gaseous fuels were assigned as very high about ±50%. Uncertainties of emission factors for biomass were assumed ±150%. Uncertainties were derived considering IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.2.9.2.3 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

The results are verified by calculating CO_2 emissions with the reference approach, and comparing results with the sectoral approach.

3.2.9.2.4 Source-specific planned improvements

Source-specific improvements are not planned.

3.3 Manufacturing Industries and Construction (CRF 1.A.2)

3.3.1 Iron and Steel (CRF 1.A.2.a)

There is no Iron and Steel industries in Lithuania. All emissions are reported as not occurring/not applicable therefore there are no “not estimated” sectors.

3.3.2 Non-Ferrous Metals (CRF 1.A.2.b)

There is no Non-Ferrous Metals industries in Lithuania. All emissions are reported as not occurring/not applicable therefore there are no “not estimated” sectors.

3.3.3 Chemicals (CRF 1.A.2.c)

3.3.3.1 Source category description

The Chemicals industry is one of the largest manufacturing industries in Lithuania. It produces a number of different products among which the most important are the following: sulphur acid (SO_2), ethyl alcohol, fermented preparations, ammonium nitrate, urea, diammonium phosphate, amino resins, phenolic resins and polyurethanes in primary form, toilet and washing soap, preparations for use on hair and yarn of cellulose acetate. During the latter decade it has been noticed an intensive development of this industry. According to the data of 2013, chemicals industry produced 6172 thousand tons of ethyl alcohol, 1078 thousand tons of preparations for use on hair, 789.6 thousand tons of diammonium phosphate, 752.3 thousand tons of sulphur acid and other chemicals in smaller numbers. As a result this allowed to achieve 10.0% of the total value added created in a manufacturing industry. During the latter economic crisis, when the price of fertilizer has been decreasing and natural gas price has been increasing, the value added of the industry has decreased by 8.7% in 2008 (compared to value in 2007). It is worth noting that labour productivity and new technology implementation in Lithuanian chemical industry is rather above the country’s average (Kaunas Technology University, 2009).

3.3.3.2 Methodological issues

CO_2 emissions were calculated applying Tier 2, CH_4 and N_2O were calculated applying Tier 1 or Tier 2 (as presented in Table 3-16) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Chemical industries (1.A.2.c) are presented in table 3-16.

Table 3-16. Emission factors and methods for category Chemical industries (1.A.2.c)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Residual fuel oil	77.60	CS	T2	3.0	D	T1	0.6	D	T1
LPG	65.42	CS	T2	1.0	D	T1	0.1	D	T1

Gasoil	72.89	CS	T2	3.0	D	T1	0.6	D	T1
Sub-bituminous coal	96.00	CS	T2	10.0	D	T1	1.5	D	T1
Natural gas	55.23	CS	T2	1.0	D	T1	0.1	D	T1
Wood/ wood waste	109.9	CS	T2	30.0	D	T1	4.0	D	T1
Biogas	58.45	CS	T2	1.0	CS	T2	0.1	CS	T2

Abbreviations: CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute; D - default emission factors (2006 IPCC); T1 - Tier 1; T2 - Tier 2.

Activity data

For calculation of GHG emissions in category Chemical industries (1.A.2.c) activity data had been obtained from the Lithuanian Statistics. The Lithuanian Statistics provided data on energy consumption in manufacturing industries and construction according to the type of economic activity based on special request. Activity data are provided below in the Table 3-17.

Table 3-17. Energy consumption by fuel type in Chemicals industries, TJ

Year	**RFO**	**LPG**	**Gasoil**	**Sub-bitu-minous coal**	**Natural gas**	**Wood/ wood waste**	**Biogas**	**Total**
1990	883.1	0.0	0.0	0.0	6001.0	0.0	0.0	**6884.1**
1995	281.0	0.0	0.0	0.0	1563.0	0.0	0.0	**1844.0**
2000	20.0	0.0	0.0	0.0	190.9	3.0	0.0	**213.9**
2001	72.4	0.0	0.0	2.5	190.9	1.6	0.0	**267.4**
2002	66.7	0.7	0.0	2.0	250.5	0.7	0.0	**320.5**
2003	17.0	4.0	0.0	0.0	351.6	0.8	0.0	**373.5**
2004	4.0	0.0	5.0	0.0	1852.0	0.0	0.0	**1861.0**
2005	0.0	6.9	0.0	0.4	2019.6	0.4	0.0	**2027.3**
2006	23.0	8.0	0.0	0.0	3419.3	2.5	0.0	**3452.8**
2007	0.0	21.3	0.0	0.3	2399.4	0.3	0.0	**2421.2**
2008	0.0	22.0	0.0	0.0	2468.0	0.0	0.0	**2490.0**
2009	0.0	16.0	0.0	0.0	3493.0	2.0	0.0	**3511.0**
2010	47.0	17.0	0.0	0.0	3306.0	0.0	94.0	**3464.0**
2011	0.0	4.0	0.0	0.0	2781.0	0.0	31.0	**2816.0**
2012	0.0	27.4	0.0	0.0	3721.0	0.0	52.0	**3800.4**
2013	0.0	26.0	0.0	0.0	2713.0	0.0	66.0	**2805.0**

Tendencies of fuel consumption and total GHG emissions in Chemical industries are presented in Figure 3-20.

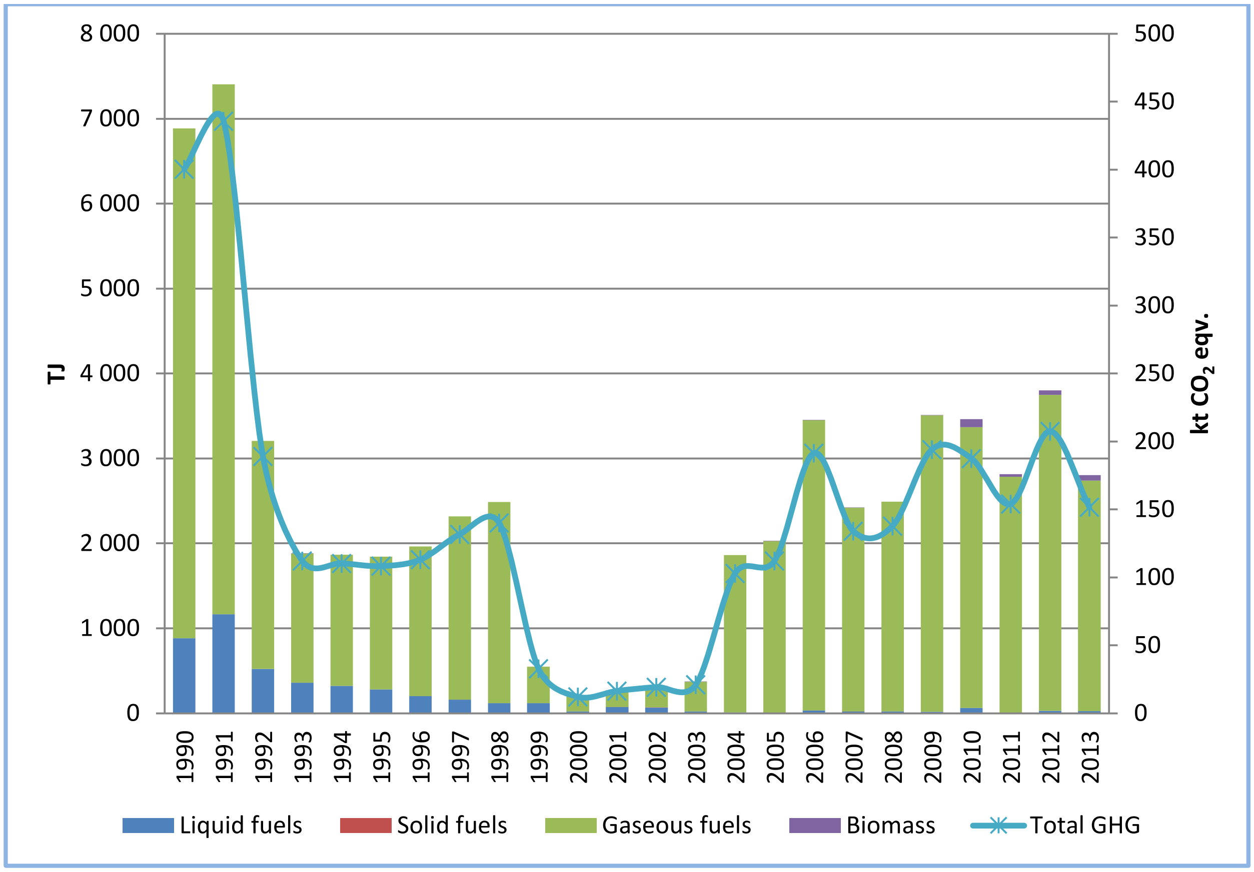


Figure 3-20. Tendencies of fuel consumption and total GHG emissions in Chemical industries (1.A.2.c)

Natural gas is the main fuel used in chemical industry in Lithuania. During 1990-2012 period it has contained 71-99% of total fuel used in industry. During economic recession and "recovery" period (1990-2002) fuel consumption in Lithuania's chemical industry has had a tendency to decrease by 22.5% a year with a large decrease of natural gas consumption (Figure 3-20). Since 2003, when economy has started to grow at very fast rates, energy consumption in Chemical industries began to increase. In 2013, energy consumption in Chemical industries reduced by 26.2% (in comparison to 2012) and amounted 2.8 PJ. With reference to data of 2013, natural gas accounted 96.7% in the structure of total fuel consumption in Chemical industry, biomass - 2.3% and solid fuels - 1.0%.

In 2013, total GHG emissions from Chemical industries were about 2.5 times lower than in 1990 and amounted 151.7 kt CO_2 eqv.

3.3.3.3 Uncertainties and time-series consistency

Uncertainty of activity data in Chemical industries is ±2% taking into consideration recommendations provided by IPCC GPG 2000 and IPCC 2006 Guidelines for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by 2006 IPCC.

Uncertainties of CO_2 emission factors for liquid fuels (residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.5% in Chemical industries. Uncertainties of CO_2 emission factors for solid fuels (coking coal) are ±7%. Estimated uncertainties of CO_2 emission factors for biomass are ±50%.

Uncertainties of all country specific CO_2 emission factors are derived in the study "Determination of national GHG emission factors for Lithuanian energy sector" (see Annex IV).

Uncertainties of CH_4 and N_2O emission factors for liquid, solid and gaseous fuels were assigned as very high about ±50%. Uncertainties were derived considering IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.3.3.4 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

The consumption of every type of fuel has been checked and compared with other available data sources. The time series for all data have been studied carefully and compared with economic activity of the sector in order to search for outliers.

The results are verified by calculating CO_2 emissions with the reference approach, and comparing results with the sectoral approach.

3.3.3.5 Source-specific planned improvements

Source-specific improvements are not planned.

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

3.3.4.1 Source category description

The Pulp, Paper and Print industries is a small branch of manufacturing industry in Lithuania. With reference to data of 2012, value added created by Pulp, Paper and Print industries made 4.5% in the structure of manufacturing industry. This is by 0.1 percentage points more than in 2011. The Pulp, Paper and Print industries has been growing by 7.0% during 2005-2008, and the growth rates have been by 3.4 percentage points higher than the average growth rate of manufacturing industry in Lithuania. However, in 2009 when economic crisis pick up the steam and the average value added created in Lithuanian manufacturing industry went down by 16.0%, the Pulp, Paper and Print industries has remained the third sector (after chemicals and non-metallic minerals production) with the lowest decline rates. In 2012, Pulp, Paper and Print industry produced 123.5 thousand tons of paper and paperboard (i.e. this is by 14.3% less than in 2011), as well 94.5 thousand tons of corrugated paper and paperboard, cartons, boxes and cases of corrugated paper or paperboard (i.e. this is by 9.6% more than in 2011).

3.3.4.2 Methodological issues

CO_2 emissions were calculated applying Tier 2, CH_4 and N_2O were calculated applying Tier 1 or Tier 2 (as presented in Table 3-18) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Pulp, Paper and Print industries (1.A.2.d) is presented in Table 3-18.

Table 3-18. Emission factors and methods for category Pulp, Paper and Print industries (1.A.2.d)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Gasoil	72.89	CS	T2	3.0	D	T1	0.6	D	T1
Residual fuel oil	77.60	CS	T2	3.0	D	T1	0.6	D	T1
LPG	65.42	CS	T2	1.0	D	T1	0.1	D	T1
Coke	109.11	CS	T2	10.0	D	T1	1.5	D	T1
Coking coal	94.90	CS	T2	10.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00	CS	T2	10.0	D	T1	1.5	D	T1
Natural gas	55.23	CS	T2	1.0	D	T1	0.1	D	T1
Wood/ wood waste	109.90	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations: CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute; D - default emission factors (2006 IPCC); T1 - Tier 1; T2 - Tier 2.

Activity data

For calculation of GHG emissions in category Pulp, paper and print industries (1.A.2.d) activity data had been obtained from the Lithuanian Statistics. The Lithuanian Statistics provided data on energy consumption in manufacturing industries and construction according to the type of economic activity based on special request. Activity data are provided in the Table 3-19.

Table 3-19. Energy consumption by fuel type in Pulp, paper and print industries, TJ

Year	Gas-oil	RFO	LPG	Coke	Coking coal	Sub-bitumi-nous coal	Na-tural gas	Wood/ wood waste	Total
1990	0.0	883.1	0.0	0.0	0.0	0.0	3388.0	3.0	**4274.1**
1995	0.0	401.4	0.0	0.0	75.4	0.0	749.0	5.0	**1230.8**
2000	4.0	64.0	42.0	0.0	17.5	0.0	1162.1	1.0	**1290.6**
2001	6.0	16.4	9.0	0.0	0.0	12.0	1235.8	30.3	**1309.5**
2002	0.0	7.2	10.9	0.0	0.0	0.0	918.7	25.5	**962.3**
2003	0.0	20.0	4.6	0.0	0.0	0.0	415.3	7.4	**447.3**
2004	0.0	0.0	9.0	0.0	0.0	0.0	53.6	0.0	**62.6**

2005	0.0	0.0	3.9	0.0	0.0	0.1	64.4	0.4	**68.9**
2006	0.0	0.0	9.3	0.0	0.0	0.0	43.5	0.0	**52.8**
2007	0.0	0.0	4.0	0.0	0.0	0.0	70.0	1.0	**75.0**
2008	0.0	0.0	3.0	0.0	0.0	0.0	603.0	0.0	**606.0**
2009	0.0	0.0	2.0	0.0	0.0	0.0	893.0	85.0	**980.0**
2010	0.0	0.0	3.0	0.0	0.0	0.0	1172.0	128.0	**1303.0**
2011	20.0	0.0	4.0	0.0	0.0	0.0	921.0	140.0	**1085.0**
2012	15.0	0.0	4.4	0.0	0.0	0.0	778.0	86.0	**883.4**
2013	0.0	0.0	5.0	0.0	0.0	0.0	780.0	217.0	**1002.0**

Tendencies of fuel consumption and total GHG emissions in Pulp, Paper and Print industries are presented in Figure 3-21.

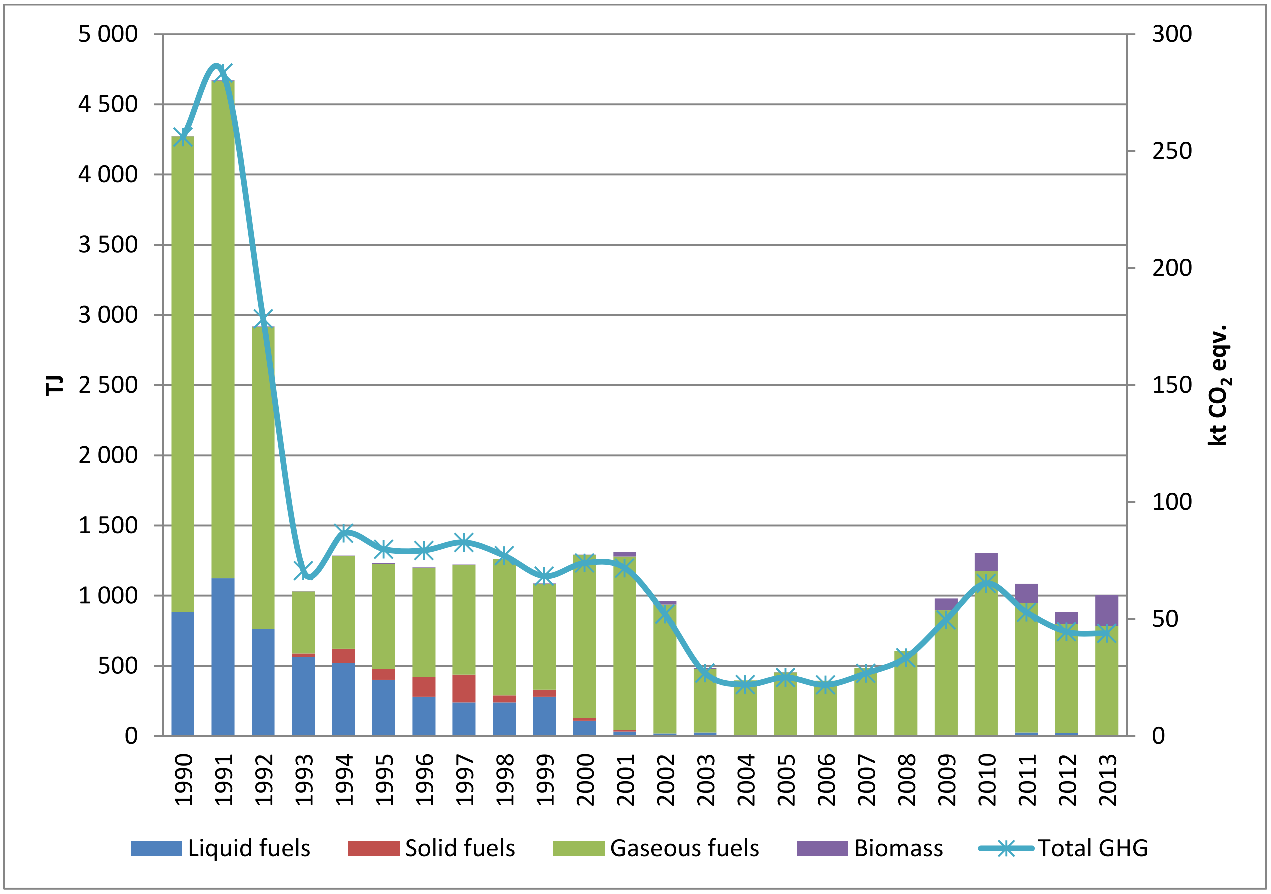


Figure 3-21. Tendencies of fuel consumption and total GHG emissions in Pulp, Paper and Print industries (1.A.2.d)

Historically natural gas was the main fuel used in Pulp, Paper and Print industries. In 2013, the share of natural gas was 77.8%. During 2000-2013 biomass consumption increased by almost 7 times. Thus, in 2013, the share of biomass accounted 21.7%, natural gas - 77.8%, liquid fuels - only 0.5% in the structure of fuel used in Pulp, Paper and Print industries.

In 2013, total GHG emissions from Pulp, Paper and Print industries were even 5.8 times lower than in 1990 and amounted 43.9 kt CO_2 eqv.

3.3.4.3 Uncertainties and time-series consistency

Uncertainty in activity data in Pulp, Paper and Print industries is ±2% taking into consideration recommendations provided by IPCC GPG 2000 and IPCC 2006 Guidelines for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by 2006 IPCC.

Uncertainties of CO_2 emission factors for liquid fuels (residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.5% in Pulp, Paper and Print industries. Uncertainties of CO_2 emission factors for solid fuels (coke, coking coal) are ±7%. Estimated uncertainties of CO_2 emission factors for biomass are ±50%. Uncertainties of all country specific CO_2 emission factors are derived in the study "Determination of national GHG emission factors for Lithuanian energy sector".

Uncertainties of CH_4 and N_2O emission factors for liquid, solid and gaseous fuels were assigned as very high about ±50%. Uncertainties were derived considering IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.3.4.4 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

The consumption of every type of fuel has been checked and compared with other available data sources. The time series for all data have been studied carefully and compared with economic activity of the sector in order to search for outliers.

The results are verified by calculating CO_2 emissions with the reference approach, and comparing results with the sectoral approach.

3.3.4.5 Source-specific planned improvements

Source-specific improvements are not planned.

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

3.3.5.1 Source category description

Food Processing, Beverages and Tobacco industries 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. Till the beginning of last economic crisis Food Processing, Beverages and Tobacco industries meet a slow decrease in the structure of value added created, i.e. from 31.5% (1995) till 23.7% (2008), but remained the largest manufacturing industry in Lithuania. 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. Food processing industry has kept a stable share in terms of value added in the structure of national economy and rapid growth rates in the export structure (Kaunas Technology University, 2009). Currently, the share of value added in Food Processing, Beverages and Tobacco industry accounts 23.1% of total value added in manufacturing industry. In 2013, industry produced 210.3 thousand tons of meat and meat sub-products, 82.9 thousand tons of food fish, 27.6 thousand tons of prepared preserved vegetables, fruits and nuts, 11.7 thousand tons of fruits and vegetables, 101.6 thousand tons of milk, 365.5 thousand tons of flour, 144.6 thousand tons of bread and pastry products, 28863 thousand dal of beer, 17829 thousand dal of natural mineral and aerated waters without sugar and non-flavoured, 18035 thousand dal of non-alcoholic beverages and other.

3.3.5.2 Methodological issues

CO_2 emissions were calculated applying Tier 2, CH_4 and N_2O were calculated applying Tier 1 or Tier 2 (as presented in Table 3-20) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Food Processing, Beverages and Tobacco industries (1.A.2.e) are presented in Table 3-20.

Table 3-20. Emission factors and methods for category Food Processing, Beverages and Tobacco industries (1.A.2.e)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Shale oil	77.40	CS	T2	3.0	D	T1	0.6	D	T1
Residual fuel oil	77.60	CS	T2	3.0	D	T1	0.6	D	T1
LPG	65.42	CS	T2	1.0	D	T1	0.1	D	T1
Gasoil	72.89	CS	T2	3.0	D	T1	0.6	D	T1
Coking coal	94.90	CS	T2	10.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00	CS	T2	10.0	D	T1	1.5	D	T1
Anthracite	106.55	CS	T2	10.0	D	T1	1.5	D	T1
Coke	109.11	CS	T2	10.0	D	T1	1.5	D	T1

Peat	104.34	CS	T2	2.0	CS	T2	1.5	CS	T2
Natural gas	55.23	CS	T2	1.0	D	T1	0.1	D	T1
Wood/ wood waste	109.90	CS	T2	30.0	D	T1	4.0	D	T1
Other solid biomass	109.90	CS	T2	30.0	D	T1	4.0	D	T1
Biogas	58.45	CS	T2	1.0	CS	T2	0.1	CS	T2

Abbreviations: CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute; D - default emission factors (2006 IPCC); T1 - Tier 1; T2 - Tier 2.

Activity data

For calculation of GHG emissions in category Food Processing, Beverages and Tobacco industries (1.A.2.e) activity data had been obtained from the Lithuanian Statistics. The Lithuanian Statistics provided data on energy consumption in manufacturing industries and construction according to the type of economic activity based on special request. Activity data are provided in the Table 3-21.

Table 3-21. Energy consumption by fuel type in Food Processing, Beverages and Tobacco industries, TJ

Year	Shale oil	RFO	LPG	Gasoil	Peat	Coking coal	Anthracite	Sub-bituminous coal	Coke	Natural gas	Wood and wood waste	Biogas	Other solid biomass	Total
1990	0.0	2247.8	0.0	0.0	0.0	351.7	0.0	0.0	0.0	8498.0	36.0	0.0	0.0	**11133.5**
1995	0.0	1605.6	0.0	0.0	0.0	150.7	0.0	0.0	0.0	2077.0	57.0	0.0	0.0	**3890.3**
2000	0.0	1567.2	121.0	3.0	0.0	67.5	0.0	0.0	105.0	2890.2	77.1	0.0	0.0	**4831.0**
2001	0.0	1120.0	60.0	0.0	0.0	0.0	0.0	37.7	99.5	2987.3	42.6	0.0	0.0	**4347.1**
2002	0.0	875.6	64.0	4.3	0.8	0.0	0.0	61.3	98.0	3792.1	49.4	0.0	0.0	**4945.4**
2003	0.0	677.0	74.3	29.5	1.5	0.0	0.0	40.9	105.5	4025.5	71.3	0.0	0.0	**5025.6**
2004	5.0	588.0	102.0	47.0	1.5	0.0	0.0	34.1	76.0	3710.7	112.0	0.0	0.0	**4676.2**
2005	13.0	334.2	157.5	148.4	5.5	0.0	0.0	49.6	63.5	3695.4	297.3	0.0	0.0	**4764.5**
2006	40.0	292.0	210.0	89.8	1.5	0.0	0.0	41.0	62.0	3868.1	140.0	5.0	0.0	**4749.4**
2007	22.0	379.2	237.3	51.7	2.0	0.0	0.0	36.0	60.0	4213.3	82.2	13.0	0.0	**5096.7**
2008	27.0	274.0	205.0	92.0	2.0	0.0	0.0	32.0	29.0	3933.0	102.0	10.0	0.0	**4706.0**
2009	0.0	233.0	186.0	73.0	1.0	36.0	0.0	7.0	45.0	3645.0	78.0	18.0	0.0	**4322.0**
2010	0.0	212.0	192.0	94.0	15.0	3.0	0.0	38.0	54.0	4005.0	93.0	10.0	0.0	**4716.0**
2011	0.0	268.0	194.0	86.0	9.0	29.0	18.0	9.0	49.0	4295.0	87.5	10.0	0.0	**5054.5**
2012	0.0	243.0	221.0	121.0	11.0	29.0	24.0	2.0	44.0	4422.0	63.0	0.0	0.0	**5180.0**
2013	0.0	213.0	215.0	93.0	9.0	28.5	38.0	0.0	41.0	4178.0	190.0	20.0	3.0	**5028.5**

Tendencies of fuel consumption and total GHG emissions in Food processing, beverages and tobacco industries are presented in Figure 3-22.

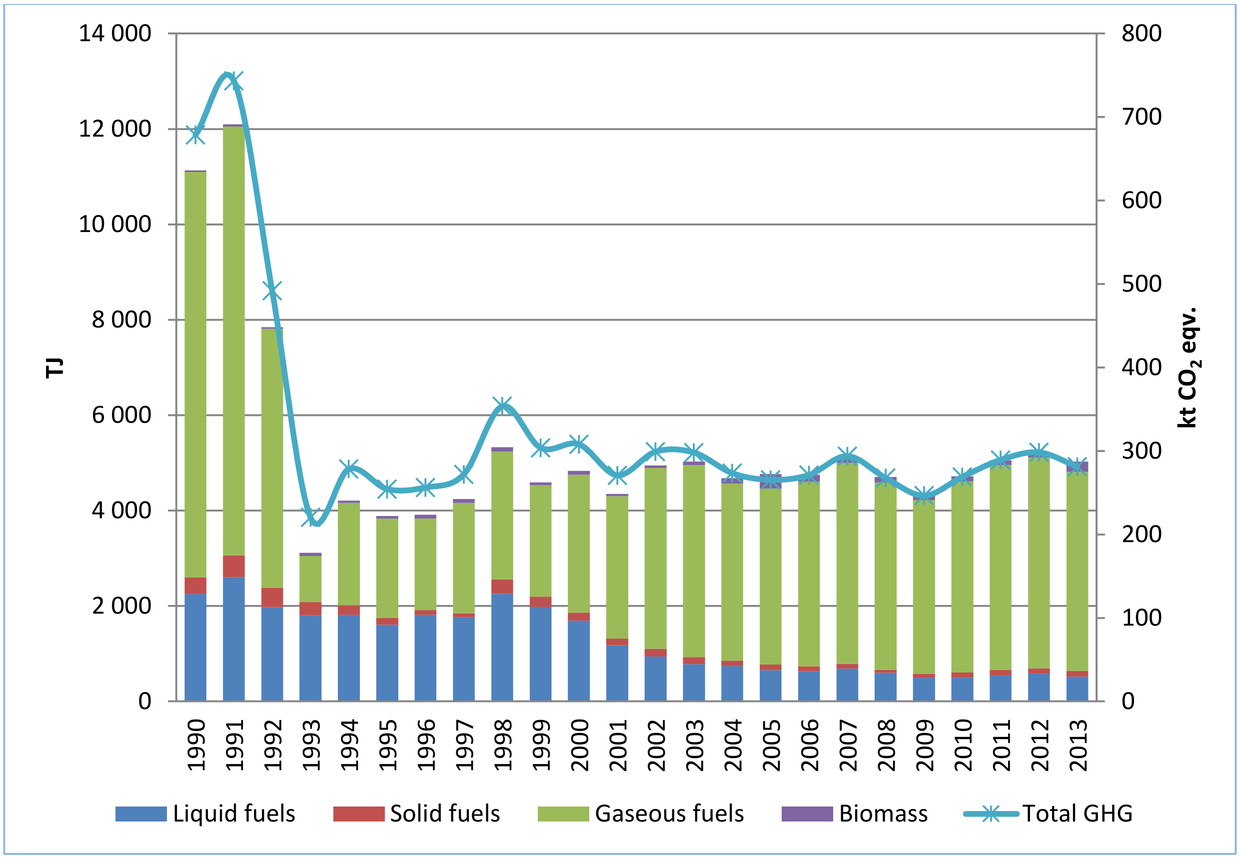


Figure 3-22. Tendencies of fuel consumption and total GHG emissions in Food Processing, Beverages and Tobacco industries (1.A.2.e)

Fuel consumed in Food Processing, Beverages and Tobacco industries has become more diversified in 2013 compared to the structure that have existed in 1990. Instead of three fuels (residual fuel oil, coking coal and natural gas) that have been widely used in industry in early 1990s, currently LPG, gasoil, peat, wood/wood waste and biogas penetrate the market (Figure 3-22). The share of residual fuel oil in the structure of energy consumed in industry has reduced from 41.3% (1995) till 4.2% (2013). The share of natural gas has a tendency to increase. In 2013, natural gas accounted 83.1%, liquid fuels - 10.4%, biomass - 4.2% and solid fuels - 2.3% in the total structure of fuel combusted Food Processing, Beverages and Tobacco industries.

In 2013, total GHG emissions from Food Processing, Beverages and Tobacco industries were 2.4 times lower than in 1990 and amounted 281.1 kt CO_2 eqv.

3.3.5.3 Uncertainties and time-series consistency

Uncertainty in activity data in Food Processing, Beverages and Tobacco industries is ±2% taking into consideration recommendations provided by IPCC GPG 2000 and IPCC 2006 Guidelines for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by 2006 IPCC.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.5% in Food Processing, Beverages and Tobacco industries. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and coke) are ±7%. Estimated uncertainties of CO_2 emission factors for biomass are ±50%. Uncertainties of all country specific CO_2 emission factors are derived in the study "Determination of national GHG emission factors for Lithuanian energy sector".

Uncertainties of CH_4 and N_2O emission factors for liquid, solid and gaseous fuels were assigned as very high about ±50%. Uncertainties were derived considering IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.3.5.4 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

The consumption of every type of fuel has been checked and compared with other available data sources. The time series for all data have been studied carefully and compared with economic activity of the sector in order to search for outliers.

The results are verified by calculating CO_2 emissions with the reference approach, and comparing results with the sectoral approach.

3.3.5.5 Source-specific planned improvements

Source-specific improvements are not planned.

3.3.6 Non-Metallic Minerals (CRF 1.A.2.f)

3.3.6.1 Source category description

The category of Non-Metallic Minerals takes into account production and processing of glass, building material from clay (mole), pottery, cement and their products. In 2012, value added created in the Non-Metallic Minerals industry accounted 3.0% of total value added of the manufacturing industry. There were produced 1061.7 thous. m^2 of multiple-walled insulating units of glass, 177.5 millions of bottles of colourless and coloured glass, 64.9 thous. m^3 of clay building bricks, 233.4 , thous. t of silicate bricks and blocks, 1015.0 thous. t of cement, 6.1 mill. m^2 of sheets from non-asbestos cement and 539.3 thous. t of prefabricated structural components for building or civil engineering in 2012. The economic crisis hitted the Non-Metallic Minerals industry the most within all other manufacturing industries. In 2009, value added created in the industry reduced by 46% and the structural share from 4.8% (2008) till 3.1% (2009). Production of all types of products significantly reduced. During 2009-2012 annual growth rates of value added were 8.5%, however, thus far the pre-crisis level is not reached, i.e. in 2012, value added made only 66.4% of 2007 level.

3.3.6.2 Methodological issues

CO_2 emissions were calculated applying Tier 2, CH_4 and N_2O were calculated applying Tier 1 or Tier 2 (as presented in Table 3-22) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Non-Metallic Minerals industries (1.A.2.f) are presented in Table 3-22.

Table 3-22. Emission factors and methods for category Non-Metallic Minerals industries (1.A.2.f)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Residual fuel oil	77.60	CS	T2	3.0	D	T1	0.6	D	T1
LPG	65.42	CS	T2	1.0	D	T1	0.1	D	T1
Gasoil	72.89	CS	T2	3.0	D	T1	0.6	D	T1
Petroleum coke	94.06	CS	T2	3.0	D	T1	0.6	D	T1
Coking coal	94.90	CS	T2	10.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00	CS	T2	10.0	D	T1	1.5	D	T1
Anthracite	106.55	CS	T2	10.0	D	T1	1.5	D	T1
Coke	109.11	CS	T2	10.0	D	T1	1.5	D	T1
Natural gas	55.23	CS	T2	1.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	2.0	CS	T2	1.5	CS	T2
Wood/ wood waste	109.90	CS	T2	30.0	D	T1	4.0	D	T1
Other solid biomass	109.90	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations: CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute; D - default emission factors (2006 IPCC); T1 - Tier 1; T2 - Tier 2.

Activity data

For calculation of GHG emissions in category Non-Metallic Minerals (1.A.2.f) activity data had been obtained from the Lithuanian Statistics. The Lithuanian Statistics provided data on energy consumption in manufacturing industries and construction according to the type of economic activity based on special request. Activity data are provided in the Table 3-23.

Table 3-23. Energy consumption by fuel type in Non-Metallic Minerals industries, TJ

Year	**RFO**	**LPG**	**Gasoil**	**Petro-leum coke**	**Peat**	**Coking coal**	**Anthra-cite**	**Sub-bitumi-nous coal**	**Coke**	**Natural gas**	**Wood / wood waste**	**Other solid biomass**	**Total**
1990	35443.6	0.0	0.0	0.0	168.0	628.0	0.0	0.0	0.0	6934.0	19.0	0.0	**43192.6**
1995	7787.2	0.0	0.0	0.0	227.0	326.6	0.0	0.0	0.0	1833.0	63.0	0.0	**10236.7**
2000	3522.2	5.0	0.0	0.0	43.4	7.5	0.0	0.0	190.0	1775.0	151.7	0.0	**5694.8**
2001	3534.0	4.6	0.0	0.0	35.2	0.0	0.0	0.0	190.0	1845.3	159.1	0.0	**5768.2**
2002	1872.3	5.9	0.4	0.0	11.0	102.0	0.0	1580.0	187.0	1280.5	367.4	0.0	**5406.4**
2003	543.0	4.6	38.0	0.0	12.9	414.5	690.0	1816.0	231.5	1282.7	606.8	0.0	**5640.0**
2004	996.0	4.6	30.0	17.0	1.2	580.3	95.0	2233.7	255.0	1185.5	581.0	0.0	**5979.3**
2005	1180.3	5.2	148.2	46.2	7.0	0.0	0.0	2924.1	401.5	1615.3	565.8	0.0	**6893.6**
2006	815.0	4.6	98.4	325.0	3.0	125.6	0.0	4202.0	586.0	1691.2	469.0	0.0	**8319.9**
2007	4.0	6.1	104.3	793.3	4.0	0.0	0.0	4526.4	585.0	1785.0	528.2	0.0	**8336.4**
2008	82.0	7.0	83.0	218.0	6.0	301.0	75.0	3665.0	411.0	1538.0	501.0	0.0	**6887.0**
2009	20.0	3.0	69.0	685.0	6.0	1184.0	370.0	679.0	240.0	813.0	360.0	0.0	**4429.0**
2010	1.0	2.0	65.0	111.0	11.0	2847.0	0.0	153.0	387.0	909.0	345.0	0.0	**4831.0**
2011	14.0	5.0	69.0	0.0	36.0	3701.0	73.0	5.0	440.0	1005.0	501.5	0.0	**5849.5**
2012	145.0	3.0	56.0	13.0	38.0	4307.0	0.0	9.0	481.0	1007.0	460.0	3.0	**6522.0**
2013	112.0	3.0	66.0	1.0	40.0	5033.5	0.0	0.0	498.0	947.0	451.0	4.0	**7155.5**

Tendencies of fuel consumption and total GHG emissions in Non-Metallic Minerals industries are presented in Figure 3-23.

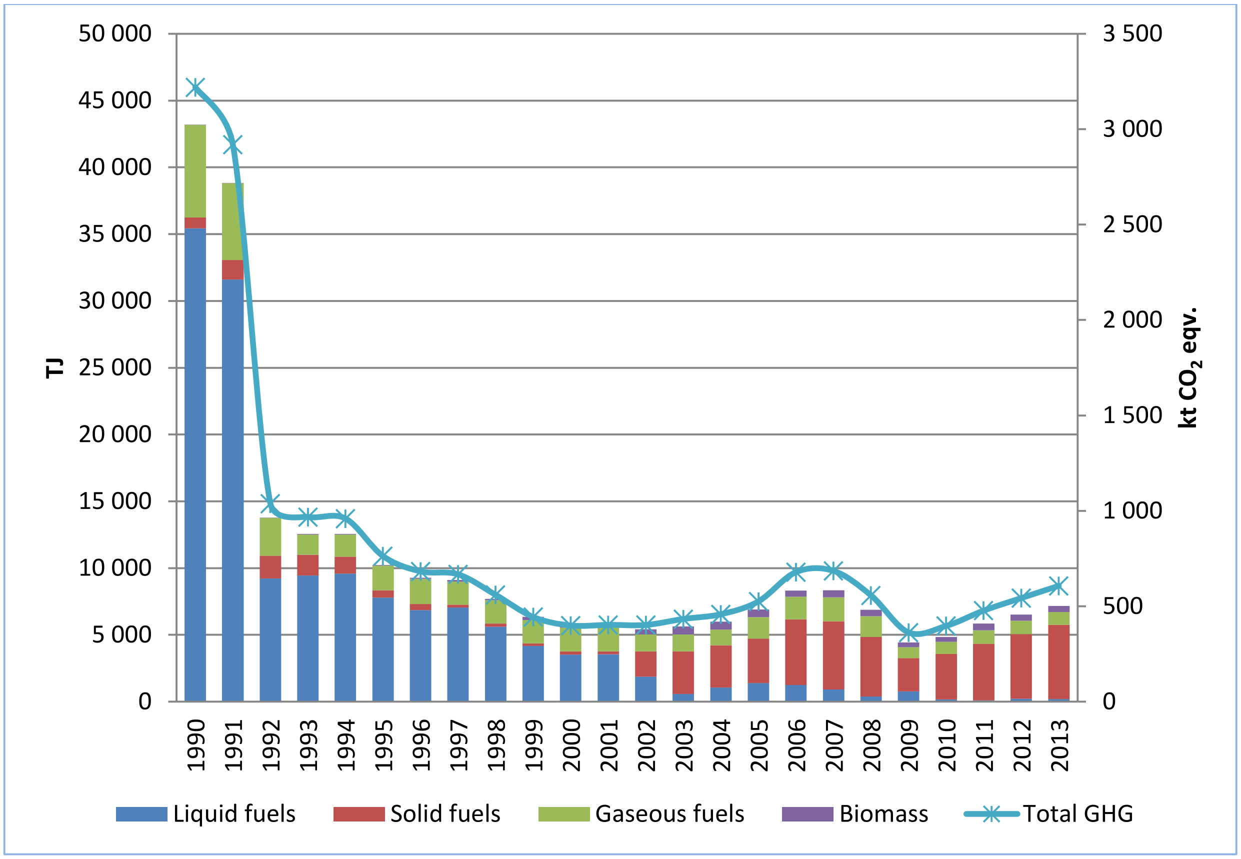


Figure 3-23. Tendencies of fuel consumption and total GHG emissions in Non-Metallic Minerals (1.A.2.f)

Due to significant economic slump after restoration of independence fuel consumption in Non-Metallic Minerals industries reduced by almost 7.6 times during 1990-2000. In 1990 liquid fuels dominated in the structure of total fuel consumed in Non-Metallic Minerals industries and since 2003 solid fuels started to dominate. In 2013, the share of solid fuels was 77.8%, natural gas - 13.2%, biomass - 6.4% and liquid fuels - 2.5%.

In 2013, total GHG emissions from Non-Metallic Minerals industries were 5.3 times lower than in 1990 and amounted 607.1 kt CO_2 eqv.

3.3.6.3 Uncertainties and time-series consistency

Uncertainty in activity data in Non-Metallic Minerals industries is ±2% taking into consideration recommendations provided by IPCC GPG 2000 and IPCC 2006 Guidelines for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by 2006 IPCC.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.5% in Non-Metallic Minerals industries. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and coke) are ±7%. Estimated uncertainties of CO_2 emission factors for biomass are ±50%. Uncertainties of all country specific CO_2 emission factors are derived in the study "Determination of national GHG emission factors for Lithuanian energy sector".

Uncertainties of CH_4 and N_2O emission factors for liquid, solid and gaseous fuels were assigned as very high about ±50%. Uncertainties were derived considering IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.3.6.4 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

The consumption of every type of fuel has been checked and compared with other available data sources. The time series for all data have been studied carefully and compared with economic activity of the sector in order to search for outliers.

The results are verified by calculating CO_2 emissions with the reference approach, and comparing results with the sectoral approach.

3.3.6.5 Source-specific planned improvements

Source-specific improvements are not planned.

3.3.7 Transport Equipment (CRF 1.A.2.g)

3.3.7.1 Source category description

The category of Transport Equipment takes into account manufacture of motor-vehicles, trailers and semi-trailers, as well manufacture of other transport equipment. In 2013, there were manufactured 2.2 thousand of trailers and semi-trailers, 2.5 thousand tons of insulated ignition wiring sets and 294.1 thousand of bicycles. This influenced on the creation of 578 million LTL (167.4 million EUR) of value added. Since 2007 manufacturing volume of aforementioned goods was reducing. Especially manufacturing of bicycles decreased. In 2013, volume of manufactured bicycles made 73% of 2007 level. Today Transport Equipment industry is one of the smallest in the country. In 2013, value added created made 2.9% of total value added of the manufacturing industry.

3.3.7.2 Methodological issues

CO_2 emissions were calculated applying Tier 2, CH_4 and N_2O were calculated applying Tier 1 or Tier 2 (as presented in Table 3-24) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Transport Equipment industries (1.A.2.g) are presented in Table 3-24.

Table 3-24. Emission factors and methods for category Transport Equipment industries (1.A.2.g)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Residual fuel oil	77.60	CS	T2	3.0	D	T1	0.6	D	T1
LPG	65.42	CS	T2	1.0	D	T1	0.1	D	T1
Gasoil	72.89	CS	T2	3.0	D	T1	0.6	D	T1
Coking coal	94.90	CS	T2	10.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00	CS	T2	10.0	D	T1	1.5	D	T1
Natural gas	55.23	CS	T2	1.0	D	T1	0.1	D	T1
Wood/ wood waste	109.90	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations: CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute; D - default emission factors (2006 IPCC); T1 - Tier 1; T2 - Tier 2.

Activity data

For calculation of GHG emissions in category Transport Equipment (1.A.2.g) activity data had been obtained from the Lithuanian Statistics. The Lithuanian Statistics provided data on energy consumption in manufacturing industries and construction according to the type of economic activity based on special request. Activity data are provided in the Table 3-25.

Table 3-25. Energy consumption by fuel type in Transport Equipment industries, TJ

Year	Gasoil	Residual fuel oil	LPG	Coking coal	Sub-bituminous coal	Natural gas	Wood/ wood waste	Total
1990	0.0	0.0	0.0	0.0	0.0	189.0	0.0	**189.0**
1995	0.0	0.0	0.0	0.0	0.0	102.0	0.0	**102.0**
2000	0.0	0.0	9.3	0.0	0.0	170.8	0.0	**180.1**
2001	0.0	40.0	83.0	0.0	2.5	177.5	4.9	**307.9**
2002	0.2	27.1	49.5	0.0	2.3	232.0	3.0	**314.0**
2003	0.0	0.0	27.9	0.0	0.0	207.6	4.1	**239.6**
2004	0.0	0.0	13.9	0.0	0.0	204.3	0.0	**218.2**
2005	0.7	0.0	8.1	0.0	4.1	238.4	0.6	**251.9**
2006	0.0	0.0	4.6	0.0	4.5	214.3	1.0	**224.5**
2007	1.5	0.0	6.3	0.0	4.4	214.3	1.1	**227.6**
2008	0.0	0.0	4.4	0.0	3.0	142.0	0.0	**149.4**

2009	0.0	0.0	4.0	0.0	1.0	131.0	0.0	**136.0**
2010	1.0	0.0	1.0	1.0	1.0	105.0	1.0	**110.0**
2011	0.0	0.0	2.0	1.0	0.0	48.0	0.0	**51.0**
2012	1.0	0.0	3.0	1.0	1.0	59.0	0.0	**65.0**
2013	1.0	0.0	1.0	2.0	0.0	54.0	0.0	**58.0**

Tendencies of fuel consumption and total GHG emissions in Transport Equipment industries are presented in Figure 3-24.

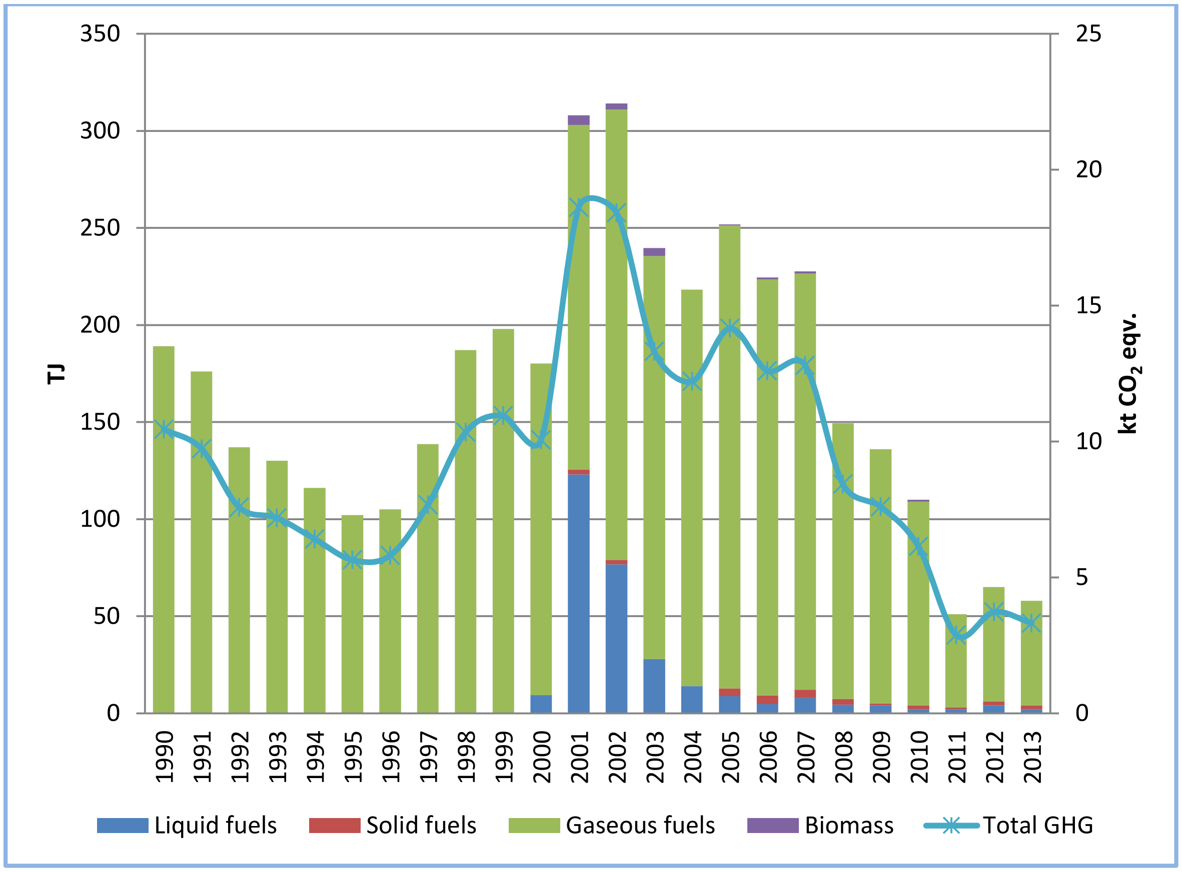


Figure 3-24. Tendencies of fuel consumption and total GHG emissions in Transport Equipment industries (1.A.2.g)

Historically natural gas was the main fuel used in Transport Equipment industries. In 2013, the share of natural gas was 93.1%, liquid and solid fuels accounted only by 3.4% in the structure of fuel used in Transport Equipment industries.

In 2013, total GHG emissions from Transport Equipment industries were 3 times lower than in 1990 and amounted 3.3 kt CO_2 eqv.

3.3.7.3 Uncertainties and time-series consistency

Uncertainty in activity data in Transport Equipment industries is ±2% taking into consideration recommendations provided by IPCC GPG 2000 and IPCC 2006 Guidelines for National GHG

Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by 2006 IPCC.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.5% in Transport Equipment industries. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and coke) are ±7%. Estimated uncertainties of CO_2 emission factors for biomass are ±50%. Uncertainties of all country specific CO_2 emission factors are derived in the study "Determination of national GHG emission factors for Lithuanian energy sector".

Uncertainties of CH_4 and N_2O emission factors for liquid, solid and gaseous fuels were assigned as very high about ±50%. Uncertainties were derived considering IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.3.7.4 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

The consumption of every type of fuel has been checked and compared with other available data sources. The time series for all data have been studied carefully and compared with economic activity of the sector in order to search for outliers.

The results are verified by calculating CO_2 emissions with the reference approach, and comparing results with the sectoral approach.

3.3.7.5 Source-specific planned improvements

Source-specific improvements are not planned.

3.3.8 Machinery (CRF 1.A.2.h)

3.3.8.1 Source category description

The category of Machinery takes into account manufacture of fabricated metal products, except machinery and equipment, manufacture of computer, electronic and optical products, manufacture of electrical equipment and manufacture of machinery and equipment. The most important goods produced within the Machinery industry in Lithuania are as follows: windows, doors, their frames and thresholds from iron, metallic containers (less than 50 l), liquid supply meters, electricity supply meters, TV sets, electric wires and cables, chandeliers and other electric ceiling or wall lighting fittings, refrigerators and freezers. In 2012, value added created in Machinery industry made 12.1% of total value added of manufacturing industry. In 2009 value added decreased by 38.6% (compared to 2008). However, it recovered faster compared to other industries. Already in 2011 the pre-crisis value added level has been achieved.

3.3.8.2 Methodological issues

CO_2 emissions were calculated applying Tier 2, CH_4 and N_2O were calculated applying Tier 1 or Tier 2 (as presented in Table 3-26) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Machinery industries (1.A.2.h) are presented in Table 3-26.

Table 3-26. Emission factors and methods for category Machinery industries (1.A.2.h)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Residual fuel oil	77.60	CS	T2	3.0	D	T1	0.6	D	T1
LPG	65.42	CS	T2	1.0	D	T1	0.1	D	T1
Gasoil	72.89	CS	T2	3.0	D	T1	0.6	D	T1
Coking coal	94.90	CS	T2	10.0	D	T1	1.5	D	T1
Anthracite	106.55	CS	T2	10.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00	CS	T2	10.0	D	T1	1.5	D	T1
Coke	109.11	CS	T2	10.0	D	T1	1.5	D	T1
Natural gas	55.23	CS	T2	1.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	2.0	CS	T2	1.5	CS	T2
Wood/ wood waste	109.90	CS	T2	30.0	D	T1	4.0	D	T1
Other solid biomass	109.90	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations: CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute; D - default emission factors (2006 IPCC); T1 - Tier 1; T2 - Tier 2.

Activity data

For calculation of GHG emissions in category Machinery (1.A.2.h) activity data had been obtained from the Lithuanian Statistics. The Lithuanian Statistics provided data on energy consumption in manufacturing industries and construction according to the type of economic activity based on special request. Activity data are provided in the Table 3-27.

Table 3-27. Energy consumption by fuel type in Machinery industries, TJ

Year	RFO	LPG	Gasoil	Peat	Coking coal	Anthra-cite	Sub-bituminous coal	Coke	Natural gas	Wood/ wood waste	Other solid biomass	Total
1990	1565.5	0.0	0.0	0.0	50.2	0.0	0.0	0.0	2923.0	14.0	0.0	**4552.7**
1995	481.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1036.0	68.0	0.0	**1585.7**
2000	48.0	4.6	0.0	0.0	7.5	0.0	0.0	23.0	924.3	108.2	0.0	**1115.7**
2001	12.0	9.0	0.0	0.0	0.0	0.0	10.0	14.5	780.3	187.0	0.0	**1012.8**
2002	0.0	18.0	0.1	0.2	0.0	0.0	12.0	17.0	918.2	263.8	0.1	**1229.4**
2003	0.0	13.9	0.0	1.5	0.0	0.0	13.6	23.0	1044.9	191.9	0.0	**1288.8**
2004	0.0	9.3	0.0	10.0	0.0	0.0	9.1	18.0	1178.8	276.0	0.0	**1501.2**
2005	0.1	15.4	3.6	0.5	0.0	0.0	13.2	17.0	1098.8	373.1	0.0	**1521.6**
2006	0.0	18.6	0.0	0.0	0.0	0.0	18.2	18.0	532.5	279.0	0.0	**866.2**
2007	0.0	10.4	3.1	1.5	0.0	0.0	16.1	19.0	266.3	134.1	0.0	**450.6**
2008	0.0	8.4	4.0	0.0	0.0	0.0	12.0	14.0	236.0	96.0	6.0	**376.4**
2009	0.0	8.0	5.0	0.0	3.0	0.0	0.0	5.0	177.0	38.0	3.5	**239.5**
2010	0.0	9.0	8.0	3.0	0.0	3.0	2.0	3.0	262.0	36.0	9.0	**335.0**
2011	0.0	5.0	7.0	3.0	5.0	0.0	1.0	5.0	284.0	35.0	6.0	**351.0**
2012	0.0	4.0	11.0	5.0	6.0	0.0	0.0	0.0	267.0	99.0	3.0	**395.0**
2013	0.0	5.0	9.0	3.0	6.0	2.0	0.0	0.0	214.0	48.0	0.0	**287.0**

Tendencies of fuel consumption and total GHG emissions in Machinery industries are presented in Figure 3-25.

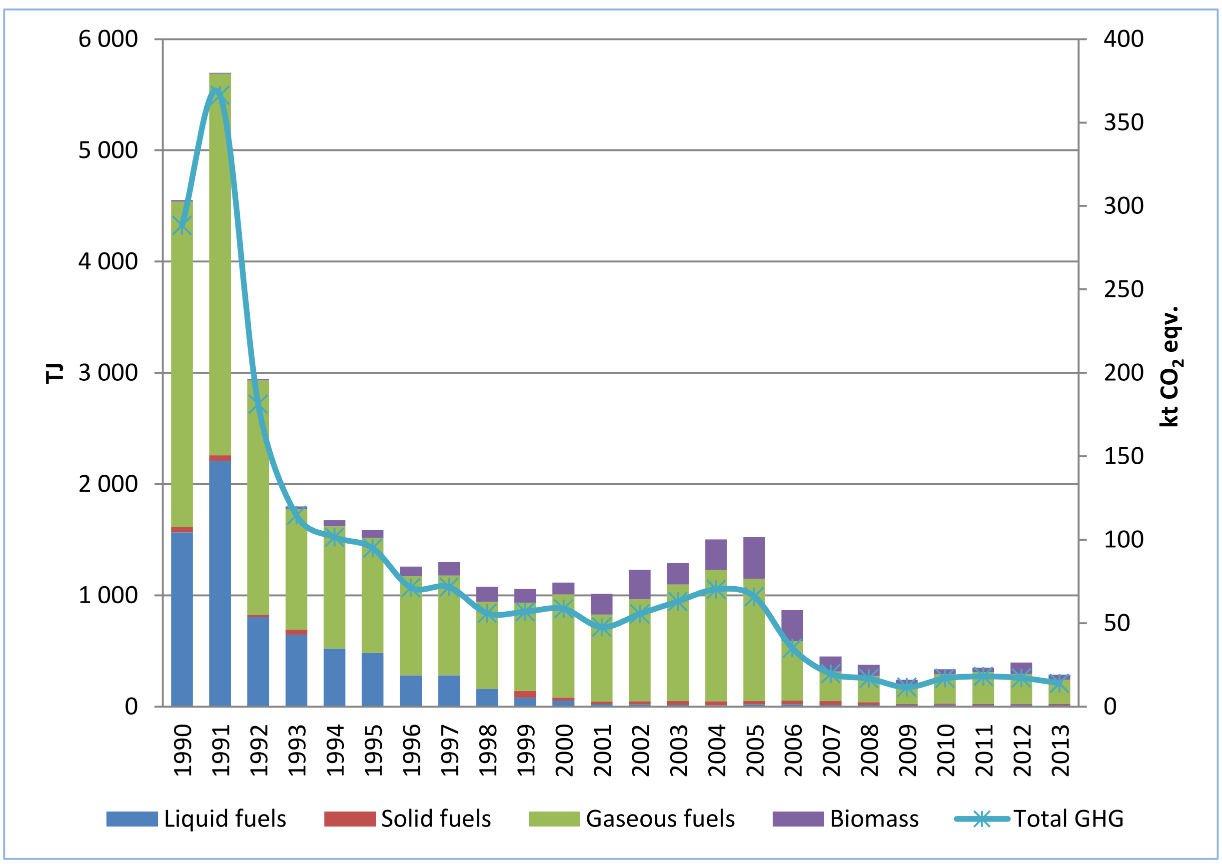


Figure 3-25. Tendencies of fuel consumption and total GHG emissions in Machinery industries (1.A.2.h)

Since 1990 fuel consumption in Machinery industries reduced by 16 times from 4553 TJ in 1990 till 287 TJ in 2013. The share and volume of liquid fuels drastically reduced and in 2013 accounted only 4.9% in structure of fuel combusted. In 2013, the share of natural gas was 74.6%, solid fuels accounted 3.8% and biomass - 16.7% in the structure of fuel used in Machinery industries.

In 2013, total GHG emissions from Machinery industries were 20 times lower than in 1990 and amounted 14.0 kt CO_2 eqv.

3.3.8.3 Uncertainties and time-series consistency

Uncertainty in activity data in Machinery industries is ±2% taking into consideration recommendations provided by IPCC GPG 2000 and IPCC 2006 Guidelines for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by 2006 IPCC.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.5% in Machinery industries. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and coke) are ±7%. Estimated uncertainties of CO_2 emission factors for biomass are ±50%. Uncertainties of all country specific CO_2 emission factors are derived in the study "Determination of national GHG emission factors for Lithuanian energy sector".

Uncertainties of CH_4 and N_2O emission factors for liquid, solid and gaseous fuels were assigned as very high about ±50%. Uncertainties were derived considering IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.3.8.4 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

The consumption of every type of fuel has been checked and compared with other available data sources. The time series for all data have been studied carefully and compared with economic activity of the sector in order to search for outliers.

The results are verified by calculating CO_2 emissions with the reference approach, and comparing results with the sectoral approach.

3.3.8.5 Source-specific planned improvements

Source-specific improvements are not planned.

3.3.9 Mining and Quarrying (CRF 1.A.2.i)

3.3.9.1 Source category description

The category of Mining and Quarrying takes into account mining and quarrying of silica sand, construction sand, gravel, pebbles, shingle and silica, crushed dolomite, crushed granite and extraction of peat in Lithuania. In 2013, there were mined 10670.6 thousand tons of aforementioned resources (39.5% of construction sand, 25.2% of crushed dolomite, 25.6% of gravel, pebbles, shingle and silica). This is by 31.7% more than in 2012. Value added created in the industry was 349 million LTL (101 million EUR) and this made 0.4% of total value added created in the economy.

3.3.9.2 Methodological issues

CO_2 emissions were calculated applying Tier 2, CH_4 and N_2O were calculated applying Tier 1 or Tier 2 (as presented in Table 3-28) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Mining and Quarrying industries (1.A.2.i) are presented in Table 3-28.

Table 3-28. Emission factors and methods for category Mining and Quarrying industries (1.A.2.i)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Residual fuel oil	77.60	CS	T2	3.0	D	T1	0.6	D	T1
Gasoil	72.89	CS	T2	3.0	D	T1	0.6	D	T1
Coking coal	94.90	CS	T2	10.0	D	T1	1.5	D	T1
Anthracite	106.55	CS	T2	10.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00	CS	T2	10.0	D	T1	1.5	D	T1
Natural gas	55.23	CS	T2	1.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	2.0	CS	T2	1.5	CS	T2
Wood/ wood waste	109.90	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations: CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute; D - default emission factors (2006 IPCC); T1 - Tier 1; T2 - Tier 2.

Activity data

For calculation of GHG emissions in category Mining and Quarrying (1.A.2.i) activity data had been obtained from the Lithuanian Statistics. The Lithuanian Statistics provided data on energy consumption in manufacturing industries and construction according to the type of economic activity based on special request. Activity data are provided in the Table 3-29.

Table 3-29. Energy consumption by fuel type in Mining and Quarrying industries, TJ

Year	RFO	Gasoil	Peat	Coking coal	Anthra-cite	Sub-bituminous coal	Natural gas	Wood/ wood waste	Total
1990	80.3	0.0	0.0	0.0	0.0	0.0	270.0	0.0	**350.3**
1995	40.1	0.0	0.0	0.0	0.0	0.0	264.0	0.0	**304.1**
2000	56.0	0.0	0.0	2.5	0.0	0.0	20.1	1.6	**80.2**
2001	80.0	0.0	0.0	0.0	0.0	2.5	3.3	1.6	**87.5**
2002	64.0	0.0	0.0	0.0	0.0	2.3	1.9	4.3	**72.4**
2003	52.0	0.0	0.0	0.0	0.0	2.3	3.3	2.5	**60.1**
2004	24.0	5.0	0.0	0.0	0.0	2.3	16.7	4.0	**52.0**
2005	0.0	4.9	0.0	0.0	0.0	2.0	41.1	4.9	**52.9**
2006	0.0	8.6	0.0	0.0	0.0	2.3	30.1	5.0	**46.0**
2007	0.0	3.9	0.0	0.0	0.0	1.2	33.7	3.0	**41.8**
2008	0.0	1.0	0.0	0.0	0.0	1.0	26.0	5.0	**33.0**
2009	0.0	1.0	0.0	0.0	0.0	1.0	9.0	5.0	**16.0**
2010	0.0	0.0	1.0	0.0	0.0	0.0	17.0	4.0	**22.0**
2011	0.0	1.0	0.0	0.0	0.0	0.0	2.0	4.0	**7.0**
2012	0.0	1.0	0.0	1.0	0.0	0.0	11.0	1.0	**14.0**
2013	0.0	1.0	0.0	0.0	1.0	0.0	11.0	11.0	**24.0**

Tendencies of fuel consumption and total GHG emissions in Mining and Quarrying industries are presented in Figure 3-26.

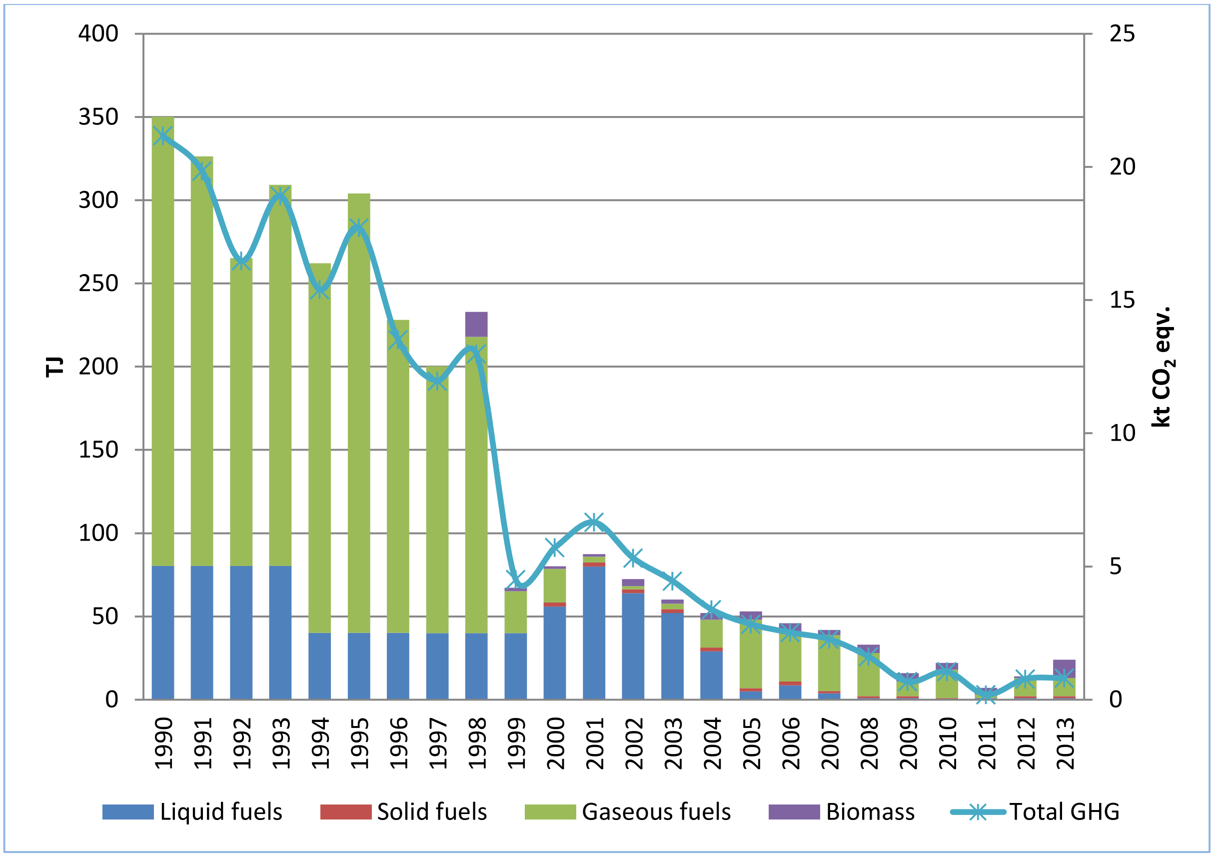


Figure 3-26. Tendencies of fuel consumption and total GHG emissions in Mining and Quarrying industries (1.A.2.i)

Since 1990 fuel consumption in Mining and Quarrying industries reduced significantly from 350.3 TJ in 1990 till 24.0TJ in 2013. In 2013, the share of natural gas and biomass accounted about 45.8%, liquid and solid fuels - about 4.2 in the structure of fuel used in Mining and Quarrying industries.

In 2013, total GHG emissions from Mining and Quarrying industries were 26 times lower than in 1990 and amounted 0.8 kt CO_2 eqv.

3.3.9.3 Uncertainties and time-series consistency

Uncertainty in activity data in Mining and Quarrying industries is ±2% taking into consideration recommendations provided by IPCC GPG 2000 and IPCC 2006 Guidelines for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by 2006 IPCC.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.5% in Mining and Quarrying industries. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and coke) are ±7%. Estimated uncertainties of CO_2 emission factors for biomass are ±50%. Uncertainties of all country specific CO_2 emission factors are derived in the study "Determination of national GHG emission factors for Lithuanian energy sector".

Uncertainties of CH_4 and N_2O emission factors for liquid, solid and gaseous fuels were assigned as very high about ±50%. Uncertainties were derived considering IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.3.9.4 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

The consumption of every type of fuel has been checked and compared with other available data sources. The time series for all data have been studied carefully and compared with economic activity of the sector in order to search for outliers.

The results are verified by calculating CO_2 emissions with the reference approach, and comparing results with the sectoral approach.

3.3.9.5 Source-specific planned improvements

Source-specific improvements are not planned.

3.3.10 Wood and Wood Products (CRF 1.A.2.j)

3.3.10.1 Source category description

The category of Wood and Wood Products takes into account manufacture of plywood and similar laminated wood, particle board of wood, fibre board, windows and their frames and doors and their frames of wood in Lithuania. In 2012, Wood and Wood Products industry created value added of 1179 million LTL (341.5 million EUR). This made 6.2% of total value added created in the manufacturing industry. The structural share of value added was rather stable during 2008-2012. In 2012, Wood and Wood Products industry manufactured 44 thousand m3 of plywood and similar laminated wood, 664.4 thousand m^3 of particle board of wood, 17.4 million m^2 of fibre board, 121.1 thousand of windows and their frames and 698.3 thousand of doors and their frames of wood.

3.3.10.2 Methodological issues

CO_2 emissions were calculated applying Tier 2, CH_4 and N_2O were calculated applying Tier 1 or Tier 2 (as presented in Table 3-30) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Wood and Wood Products industries (1.A.2.j) are presented in Table 3-30.

Table 3-30. Emission factors and methods for category Wood and Wood Products industries (1.A.2.j)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
LPG	65.42	CS	T2	1.0	D	T1	0.1	D	T1
Residual fuel oil	77.60	CS	T2	3.0	D	T1	0.6	D	T1
Gasoil	72.89	CS	T2	3.0	D	T1	0.6	D	T1
Peat	104.34	CS	T2	2.0	CS	T2	1.5	CS	T2
Anthracite	106.55	CS	T2	10.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00	CS	T2	10.0	D	T1	1.5	D	T1
Natural gas	55.23	CS	T2	1.0	D	T1	0.1	D	T1
Wood/ wood waste	109.90	CS	T2	30.0	D	T1	4.0	D	T1
Other solid biomass	109.90	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations: CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute; D - default emission factors (2006 IPCC); T1 - Tier 1; T2 - Tier 2.

Activity data

For calculation of GHG emissions in category Wood and Wood Products (1.A.2.j) activity data had been obtained from the Lithuanian Statistics. The Lithuanian Statistics provided data on energy consumption in manufacturing industries and construction according to the type of economic activity based on special request. Activity data are provided in the Table 3-31.

Table 3-31. Energy consumption by fuel type in Wood and Wood Products industries, TJ

Year	Gasoil	RFO	LPG	Anthra-cite	Sub-bituminous coal	Peat	Natural gas	Other solid biomass	Wood / wood waste	Total
1990	0.0	1204.2	0.0	0.0	0.0	0.0	1167.0	0.0	240.0	**2611.2**
1995	0.0	321.1	0.0	0.0	0.0	0.0	451.0	0.0	284.0	**1056.1**
2000	0.0	147.9	4.6	0.0	0.0	0.0	288.0	0.0	465.8	**906.3**
2001	0.0	112.0	0.0	0.0	0.0	0.0	358.3	0.0	965.1	**1435.5**
2002	1.0	133.2	2.0	0.0	0.0	0.0	954.9	0.0	1888.8	**2980.1**
2003	0.0	100.0	5.0	0.0	0.0	0.0	1091.8	0.0	2257.5	**3454.2**
2004	0.0	139.9	4.6	0.0	0.0	0.0	1235.8	0.0	2258.0	**3638.4**
2005	2.6	147.5	3.5	0.0	11.8	1.2	1430.0	0.0	2081.1	**3677.8**

2006	0.0	119.0	4.6	0.0	9.1	4.0	1239.1	0.0	2016.0	**3391.9**
2007	0.6	68.4	15.3	0.0	2.9	11.0	1528.9	0.0	2203.7	**3830.8**
2008	0.0	18.0	14.0	0.0	3.0	10.0	1605.0	0.0	2104.0	**3754.0**
2009	1.0	23.0	8.0	2.0	0.0	5.0	757.0	3.5	1616.0	**2415.5**
2010	0.0	31.0	19.0	0.0	0.0	1.0	944.0	0.0	1905.0	**2900.0**
2011	0.0	0.0	5.0	0.0	0.0	0.0	650.0	1.0	1804.0	**2460.0**
2012	2.0	0.0	3.0	0.0	0.0	0.0	396.0	0.0	2252.0	**2653.0**
2013	0.0	0.0	5.0	0.0	0.0	0.0	399.0	0.0	2052.0	**2456.0**

Tendencies of fuel consumption and total GHG emissions in Wood and Wood Products industries are presented in Figure 3-27.

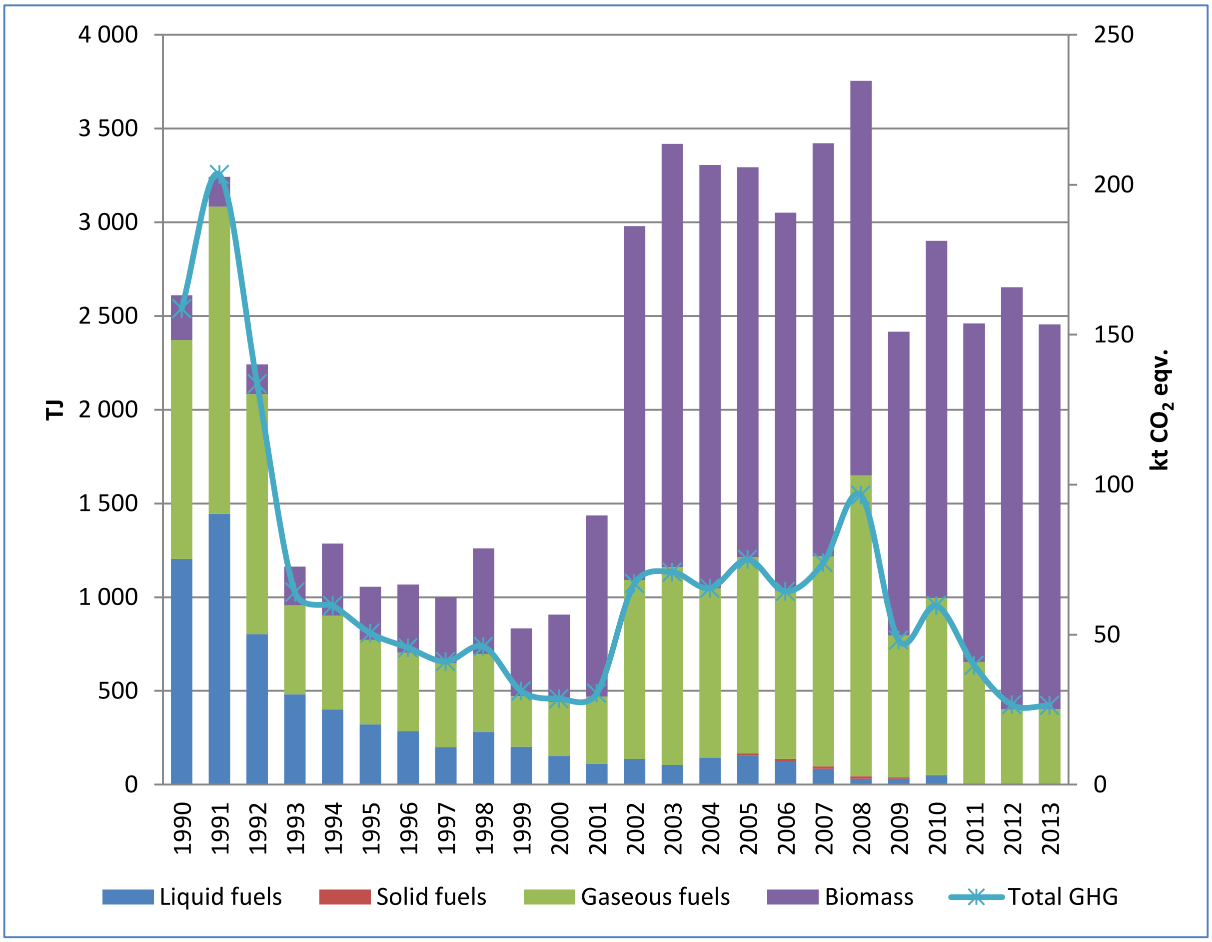


Figure 3-27. Tendencies of fuel consumption and total GHG emissions in Wood and Wood Products industries (1.A.2.j)

The share of liquid fuels has reduced from 46.1% (1990) till 0.2% (2013) in the structure of fuel consumed in Wood and Wood Products industries. In general liquid fuels were replaced by biomass. Since 2000 the share of biomass increased from 51.4% till 83.6% in 2013. In 2013 the share of natural gas accounted 16.2%.

In 2013, total GHG emissions from Wood and Wood Products industries were 6 times lower than in 1990 and amounted 26.4 kt CO_2 eqv.

3.3.10.3 Uncertainties and time-series consistency

Uncertainty in activity data in Wood and Wood Products industries is ±2% taking into consideration recommendations provided by IPCC GPG 2000 and IPCC 2006 Guidelines for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by 2006 IPCC.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.5% in Wood and Wood Products industries. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and coke) are ±7%. Estimated uncertainties of CO_2 emission factors for biomass are ±50%. Uncertainties of all country specific CO_2 emission factors are derived in the study "Determination of national GHG emission factors for Lithuanian energy sector".

Uncertainties of CH_4 and N_2O emission factors for liquid, solid and gaseous fuels were assigned as very high about ±50%. Uncertainties were derived considering IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.3.10.4 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

The consumption of every type of fuel has been checked and compared with other available data sources. The time series for all data have been studied carefully and compared with economic activity of the sector in order to search for outliers.

The results are verified by calculating CO_2 emissions with the reference approach, and comparing results with the sectoral approach.

3.3.10.5 Source-specific planned improvements

Source-specific improvements are not planned.

3.3.11 Construction (CRF 1.A.2.k)

3.3.11.1 Source category description

Construction sector of Lithuania has approximately 5 thousand of enterprises of which 39% are specialized in constructing buildings and their parts. Small enterprises (the personnel is less than 49) are prevailing in this sector. The largest concentration of construction enterprises is in Vilnius and Kaunas counties. This situation was mainly caused by unequal distribution of investments within the territory of Lithuania. Till the last crisis, construction sector was one of the most developing industry branches in Lithuania. It created 7.3% (2005) - 9.9% (2008) of total value added in the country. This was mainly caused by the growth of national industry, good credit terms, possibilities given by EU Structural Funds, a larger demand for residential, commercial and industrial buildings, increasing selection of new building materials and technologies (Analysis of Lithuanian Construction Market, 2011). However, already in 2009 value added significantly reduced and in 2010 it made only 51% of 2008 level. In 2013, Construction sector created 6.4% of total value added.

3.3.11.2 Methodological issues

CO_2 emissions were calculated applying Tier 2, CH_4 and N_2O were calculated applying Tier 1 or Tier 2 (as presented in Table 3-32) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Construction (1.A.2.k) are presented in Table 3-32.

Table 3-32. Emission factors and methods for category Construction (1.A.2.k)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
LPG	65.42	CS	T2	1.0	D	T1	0.1	D	T1
Residual fuel oil	77.60	CS	T2	3.0	D	T1	0.6	D	T1
Gasoil	72.89	CS	T2	3.0	D	T1	0.6	D	T1
Coking coal	94.90	CS	T2	10.0	D	T1	1.5	D	T1
Anthracite	106.55	CS	T2	10.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00	CS	T2	10.0	D	T1	1.5	D	T1
Natural gas	55.23	CS	T2	1.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	2.0	CS	T2	1.5	CS	T2
Wood/ wood waste	109.90	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations: CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute; D - default emission factors (2006 IPCC); T1 - Tier 1; T2 - Tier 2.

Activity data

For calculation of GHG emissions in category Construction (1.A.2.k) activity data had been obtained from the Lithuanian Statistics. The Lithuanian Statistics provided data on energy consumption in manufacturing industries and construction according to the type of economic activity based on special request. Activity data are provided in the Table 3-33.

Table 3-33. Energy consumption by fuel type in Construction industries, TJ

Year	Gasoil	RFO	LPG	Coking coal	Anthra-cite	Sub-bituminous coal	Peat	Natural gas	Wood/ wood waste	Total
1990	0.0	1044.0	92.0	226.0	0.0	0.0	0.0	1030.0	51.0	**2443.0**
1995	0.0	201.0	46.0	25.0	0.0	0.0	0.0	219.0	105.0	**596.0**
2000	7.0	58.0	74.0	14.0	0.0	0.0	0.0	266.0	100.0	**519.0**
2001	0.0	66.0	64.0	0.0	0.0	11.0	0.0	279.0	119.0	**539.0**
2002	5.0	93.0	79.0	0.0	0.0	13.0	0.0	366.0	196.0	**752.0**
2003	15.0	93.0	82.0	0.0	0.0	23.0	0.0	410.0	233.0	**856.0**
2004	30.0	79.0	95.0	0.0	0.0	13.0	0.0	493.0	238.0	**948.0**
2005	25.0	110.0	77.0	0.0	0.0	18.0	0.0	513.0	185.0	**928.0**
2006	22.0	52.0	93.0	0.0	0.0	23.0	0.0	611.0	232.0	**1033.0**
2007	31.0	96.0	94.0	0.0	0.0	17.0	1.0	655.0	217.0	**1111.0**
2008	33.0	109.0	133.0	0.0	0.0	11.0	0.0	677.0	177.0	**1140.0**
2009	26.0	54.0	98.0	0.0	0.0	5.0	0.0	424.0	125.0	**732.0**
2010	47.0	75.0	122.0	0.0	2.0	2.0	0.0	501.0	143.0	**892.0**
2011	49.0	72.0	48.0	11.0	0.0	1.0	0.0	459.0	145.0	**785.0**
2012	63.0	35.0	32.0	7.0	0.0	1.0	0.0	490.0	157.0	**785.0**
2013	60.0	37.0	35.0	7.0	0.0	0.0	0.0	509.0	125.0	**773.0**

Tendencies of fuel consumption and total GHG emissions in Construction are presented in Figure 3-28.

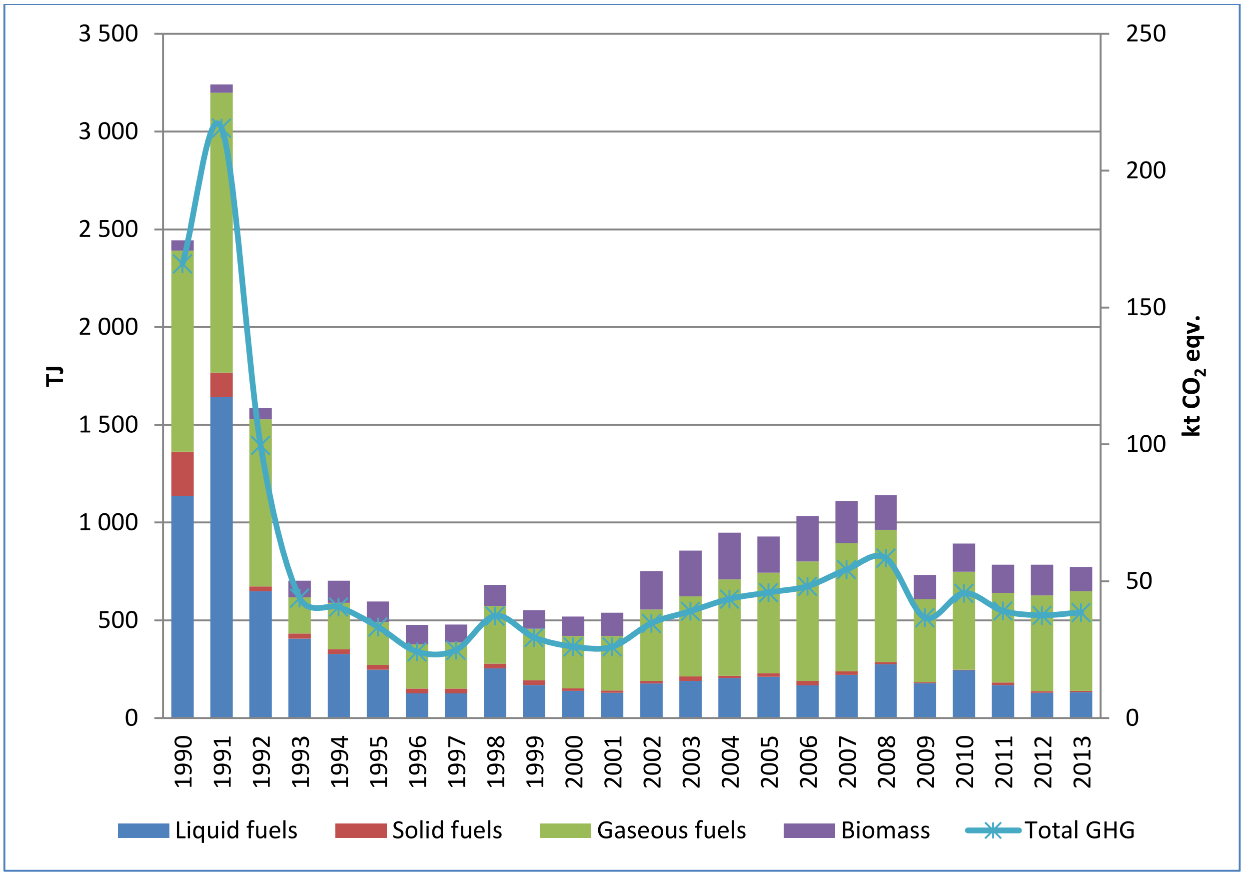


Figure 3-28. Tendencies of fuel consumption and total GHG emissions in Construction (1.A.2.k)

The final energy consumption was increasing during the period 2000-2008 by 10.0% per annum in Construction, but the most severe impact of the economic recession was in this sector where energy consumption decreased by 35% in 2009. In 2003, the share of natural gas accounted 65.8%, liquid fuels - 17.0%, biomass - 16.2% and solid fuels -1.0% in the total fuel structure used for the Construction.

In 2013, total GHG emissions from Construction industries were 4 times lower than in 1990 and amounted 38.6 kt CO_2 eqv.

3.3.11.3 Uncertainties and time-series consistency

Uncertainty in activity data in Construction industries is ±2% taking into consideration recommendations provided by IPCC GPG 2000 and IPCC 2006 Guidelines for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by 2006 IPCC.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.5% in Construction industries. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and coke) are ±7%. Estimated uncertainties of CO_2 emission factors for biomass are ±50%. Uncertainties of all country specific CO_2 emission factors are derived in the study "Determination of national GHG emission factors for Lithuanian energy sector".

Uncertainties of CH_4 and N_2O emission factors for liquid, solid and gaseous fuels were assigned as very high about ±50%. Uncertainties were derived considering IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.3.11.4 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

The consumption of every type of fuel has been checked and compared with other available data sources. The time series for all data have been studied carefully and compared with economic activity of the sector in order to search for outliers.

The results are verified by calculating CO_2 emissions with the reference approach, and comparing results with the sectoral approach.

3.3.11.5 Source-specific planned improvements

Source-specific improvements are not planned.

3.3.12 Textile and Leather (CRF 1.A.2.l)

3.3.12.1 Source category description

Textile and Leather industry in Lithuania integrates 3 branches of the industry, i.e. production of textile products, sewing of clothes and manufacture of leather and leather articles. The industry is considered as one of the most important industries in the country. In 2013, the Textile and Leather industry created 8.4% of total value added created in the manufacturing industry, which remained stable during the latter three years. The following below is presented the most important products and their production volumes in 2013: 2484.5 thous. of trousers, overalls, breeches and shorts, 1724.5 thous. of women and girls' blouses, 1804.7 thous. of dresses, 1157.0 thous of jackets and blousers and other.

3.3.12.2 Methodological issues

CO_2 emissions were calculated applying Tier 2, CH_4 and N_2O were calculated applying Tier 1 or Tier 2 (as presented in Table 3-34) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Textile and Leather industries (1.A.2.l) are presented in Table 3-34.

Table 3-34. Emission factors and methods for category Textile and Leather industries (1.A.2.l)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
LPG	65.42	CS	T2	1.0	D	T1	0.1	D	T1
Residual fuel oil	77.60	CS	T2	3.0	D	T1	0.6	D	T1
Gasoil	72.89	CS	T2	3.0	D	T1	0.6	D	T1
Coking coal	94.90	CS	T2	10.0	D	T1	1.5	D	T1
Anthracite	106.55	CS	T2	10.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00	CS	T2	10.0	D	T1	1.5	D	T1
Natural gas	55.23	CS	T2	1.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	2.0	CS	T2	1.5	CS	T2
Wood/ wood waste	109.90	CS	T2	30.0	D	T1	4.0	D	T1
Other solid biomass	109.90	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations: CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute; D - default emission factors (2006 IPCC); T1 - Tier 1; T2 - Tier 2.

Activity data

For calculation of GHG emissions in category Textile and Leather (1.A.2.l) activity data had been obtained from the Lithuanian Statistics. The Lithuanian Statistics provided data on energy consumption in manufacturing industries and construction according to the type of economic activity based on special request. Activity data are provided in the Table 3-35.

Table 3-35. Energy consumption by fuel type in Textile and Leather industries, TJ

Year	Gasoil	RFO	LPG	Coking coal	Anthra-cite	Sub-bituminous coal	Peat	Natural gas	Other solid biomass	Wood / wood waste	Total
1990	0.0	1364.8	0.0	527.5	0.0	0.0	0.0	2467.0	0.0	20.0	**4379.3**
1995	0.0	441.5	0.0	100.5	0.0	0.0	0.0	646.0	0.0	50.0	**1238.0**
2000	0.0	139.9	4.6	34.5	0.0	0.0	0.0	810.5	0.0	109.1	**1098.6**
2001	0.0	28.0	0.0	0.0	0.0	32.7	0.0	1118.6	0.0	40.2	**1219.4**
2002	3.8	27.8	3.5	0.0	0.0	27.2	0.5	1292.9	47.0	55.0	**1457.8**
2003	25.5	23.0	0.0	0.0	0.0	27.2	0.0	1409.9	84.0	37.7	**1607.4**
2004	35.0	56.0	0.0	0.0	0.0	36.3	1.5	1309.5	91.0	42.6	**1571.9**

2005	76.2	40.5	2.1	0.0	0.0	48.6	0.6	1228.0	41.0	37.0	**1474.0**
2006	29.9	25.0	4.6	0.0	0.0	34.1	4.0	1282.7	10.0	59.0	**1449.3**
2007	19.5	27.5	7.8	0.0	0.0	19.0	1.0	1097.5	76.0	28.1	**1276.3**
2008	40.0	33.0	5.0	0.0	0.0	12.0	1.0	584.0	13.0	16.0	**704.0**
2009	29.0	16.0	8.0	14.0	0.0	0.0	0.0	499.0	1.0	16.0	**583.0**
2010	41.0	4.0	12.0	7.0	2.0	8.0	1.0	591.0	2.0	18.0	**686.0**
2011	19.0	6.0	10.0	11.0	0.0	1.0	3.0	608.0	0.0	15.0	**673.0**
2012	20.0	4.0	13.0	7.0	0.0	7.0	4.0	551.0	0.0	19.0	**625.0**
2013	19.0	3.0	13.0	9.0	0.0	4.0	4.0	553.0	0.0	6.0	**611.0**

Tendencies of fuel consumption and total GHG emissions in Textile and Leather industries are presented in Figure 3-29.

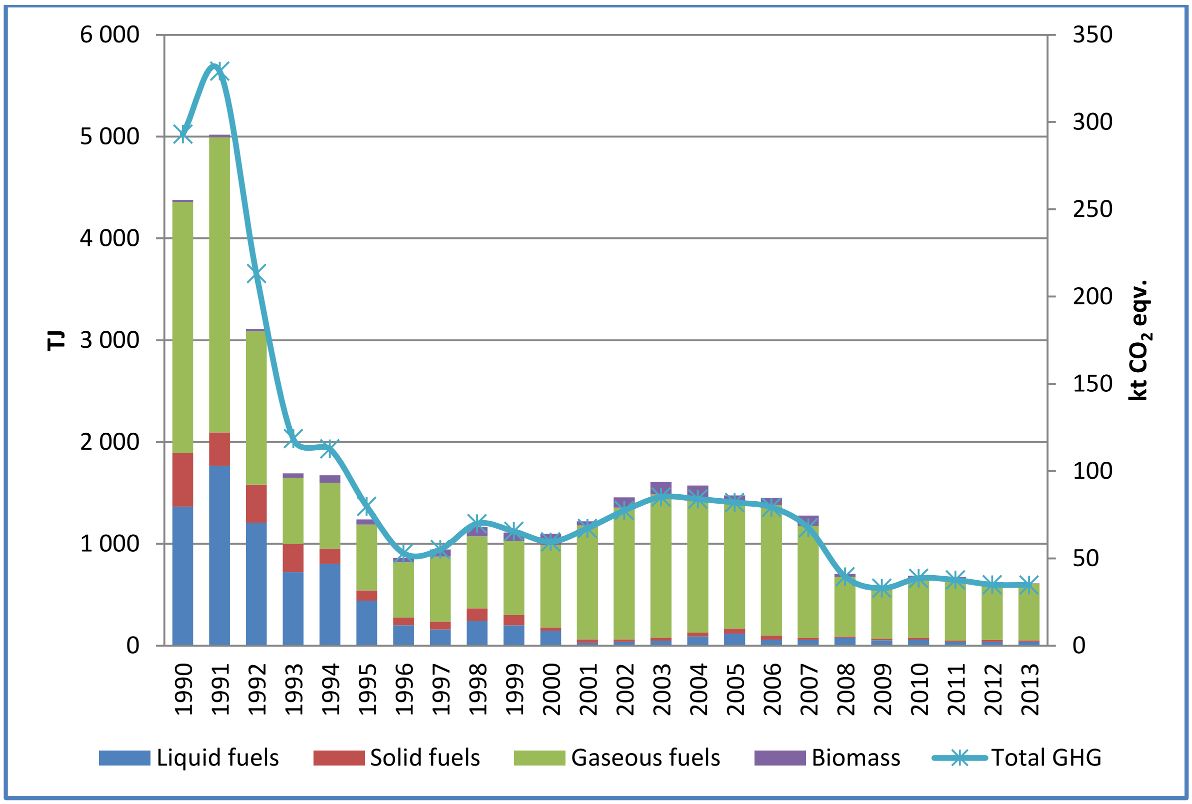


Figure 3-29. Tendencies of fuel consumption and total GHG emissions in Textile and Leather industries (1.A.2.l)

The fuel consumption in Textile and Leather industries reduced by almost 7 times since 1990. In 2013, the natural gas accounted 90.5%, liquid fuels - 5.7%, solid fuels - 2.8% and biomass about 1% in the structure of fuel used in Textile and Leather industries.

In 2013, total GHG emissions from Textile and Leather industries were 8.4 times lower than in 1990 and amounted 34.7 kt CO_2 eqv.

3.3.12.3 Uncertainties and time-series consistency

Uncertainty in activity data in Textile and Leather industries is ±2% taking into consideration recommendations provided by IPCC GPG 2000 and IPCC 2006 Guidelines for National GHG

Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by 2006 IPCC.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.5% in Textile and Leather industries. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and coke) are ±7%. Estimated uncertainties of CO_2 emission factors for biomass are ±50%. Uncertainties of all country specific CO_2 emission factors are derived in the study "Determination of national GHG emission factors for Lithuanian energy sector".

Uncertainties of CH_4 and N_2O emission factors for liquid, solid and gaseous fuels were assigned as very high about ±50%. Uncertainties were derived considering IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.3.12.4 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

The consumption of every type of fuel has been checked and compared with other available data sources. The time series for all data have been studied carefully and compared with economic activity of the sector in order to search for outliers.

The results are verified by calculating CO_2 emissions with the reference approach, and comparing results with the sectoral approach.

3.3.12.5 Source-specific planned improvements

Source-specific improvements are not planned.

3.3.13 Non-Specified Industry (CRF 1.A.2.m)

3.3.13.1 Source category description

Non-Specified Industries in Lithuania include the following activities:

- manufacturing of rubber and plastic goods;
- manufacturing of furniture;
- manufacturing of other goods.

Non-specified industries in Lithuania have accounted 17.4% of value added in 2012. The share of value added increased by 2.8 percentage points since 2009. There were produced 1226.9 thous. m^3 of polystyrene, 3369.8 million of plastic bottles including those of large capacity, 415.5 thous. of doors, windows and their frames of plastics, 8089 thous. units of various type of furniture in 2013.

3.3.13.2 Methodological issues

CO_2 emissions were calculated applying Tier 2, CH_4 and N_2O were calculated applying Tier 1 or Tier 2 (as presented in Table 3-36) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Non-Specified Industry (1.A.2.m) are presented in Table 3-36.

Table 3-36. Emission factors and methods for category Non-Specified Industry (1.A.2.m)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
LPG	65.42	CS	T2	1.0	D	T1	0.1	D	T1
Residual fuel oil	77.60	CS	T2	3.0	D	T1	0.6	D	T1
Gasoil	72.89	CS	T2	3.0	D	T1	0.6	D	T1
Coking coal	94.90	CS	T2	10.0	D	T1	1.5	D	T1
Anthracite	106.55	CS	T2	10.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00	CS	T2	10.0	D	T1	1.5	D	T1
Coke	109.11	CS	T2	10.0	D	T1	1.5	D	T1
Natural gas	55.23	CS	T2	1.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	2.0	CS	T2	1.5	CS	T2
Wood/ wood waste	109.90	CS	T2	30.0	D	T1	4.0	D	T1
Other solid biomass	109.90	CS	T2	30.0	D	T1	4.0	D	T1
Biogas	58.45	CS	T2	1.0	CS	T2	0.1	CS	T2
Industrial waste (used tires)	85.13	PS	T3	30.0	D	T1	4.0	D	T1

Abbreviations: CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute; D - default emission factors (2006 IPCC); T1 - Tier 1; T2 - Tier 2.

Activity data

For calculation of GHG emissions in category Non-Specified Industry (1.A.2.m) activity data had been obtained from the Lithuanian Statistics. The Lithuanian Statistics provided data on energy consumption in manufacturing industries and construction according to the type of economic activity based on special request. Activity data are provided in the Table 3-37.

Table 3-37. Energy consumption by fuel type in Non-Specified Industry, TJ

Year	RFO	LPG	Gasoil	Peat	Coking coal	An-thra-cite	Sub-bitu-mi-nous coal	Coke	Natu-ral gas	Wood / wood waste	Other solid biomass	Biogas	In-dus-trial waste - used tires (rubber)	Total
1990	321.1	0.0	0.0	0.0	25.1	0.0	0.0	0.0	4228.0	121.0	0.0	0.0	0.0	**4695.2**
1995	160.6	0.0	0.0	0.0	50.2	0.0	0.0	0.0	195.0	229.0	0.0	0.0	0.0	**634.8**
2000	0.0	9.3	0.0	0.0	0.0	0.0	5.0	28.0	53.6	300.1	0.0	0.0	0.0	**396.0**
2001	0.0	13.0	0.0	0.0	0.0	0.0	0.0	0.0	113.9	379.7	0.0	0.0	0.0	**506.5**
2002	0.0	14.3	3.2	0.1	0.0	0.0	2.3	0.0	152.1	482.4	0.0	0.0	0.0	**654.4**
2003	0.0	23.2	4.5	1.5	0.0	0.0	0.0	0.0	150.7	669.1	0.0	0.0	0.0	**849.1**
2004	0.0	32.5	5.0	0.0	0.0	0.0	2.3	10.0	127.3	712.6	0.0	0.0	0.0	**889.6**
2005	3.4	26.4	19.9	0.5	0.0	0.0	5.0	52.0	189.1	646.5	0.0	0.0	0.0	**942.9**
2006	4.0	27.9	12.8	1.5	0.0	0.0	4.5	51.0	134.0	615.0	0.0	1.0	218.2	**1069.9**
2007	2.6	15.1	13.9	4.5	0.0	0.0	4.0	46.0	211.0	498.5	0.0	0.0	254.0	**1049.6**
2008	0.0	23.0	13.0	3.0	0.0	0.0	8.0	33.0	191.0	449.0	0.0	0.0	227.0	**947.0**
2009	1.0	15.0	10.0	0.0	3.0	0.0	0.0	31.0	123.0	431.0	0.0	0.0	197.4	**811.4**
2010	0.0	18.0	11.0	4.0	2.0	0.0	5.0	29.0	189.0	390.0	0.0	0.0	209.4	**857.4**
2011	1.0	30.0	12.0	13.0	3.0	0.0	0.0	28.0	461.0	440.0	0.0	0.0	248.8	**1236.8**
2012	0.0	41.0	13.0	16.0	2.0	0.0	0.0	29.0	436.0	420.0	0.0	0.0	264.8	**1221.8**
2013	0.0	52.0	11.0	12.0	4.0	1.0	0.0	22.0	204.0	405.0	6.0	2.0	263.8	**982.8**

Tendencies of fuel consumption and total GHG emissions in Non-Specified industry are presented in Figure 3-30.

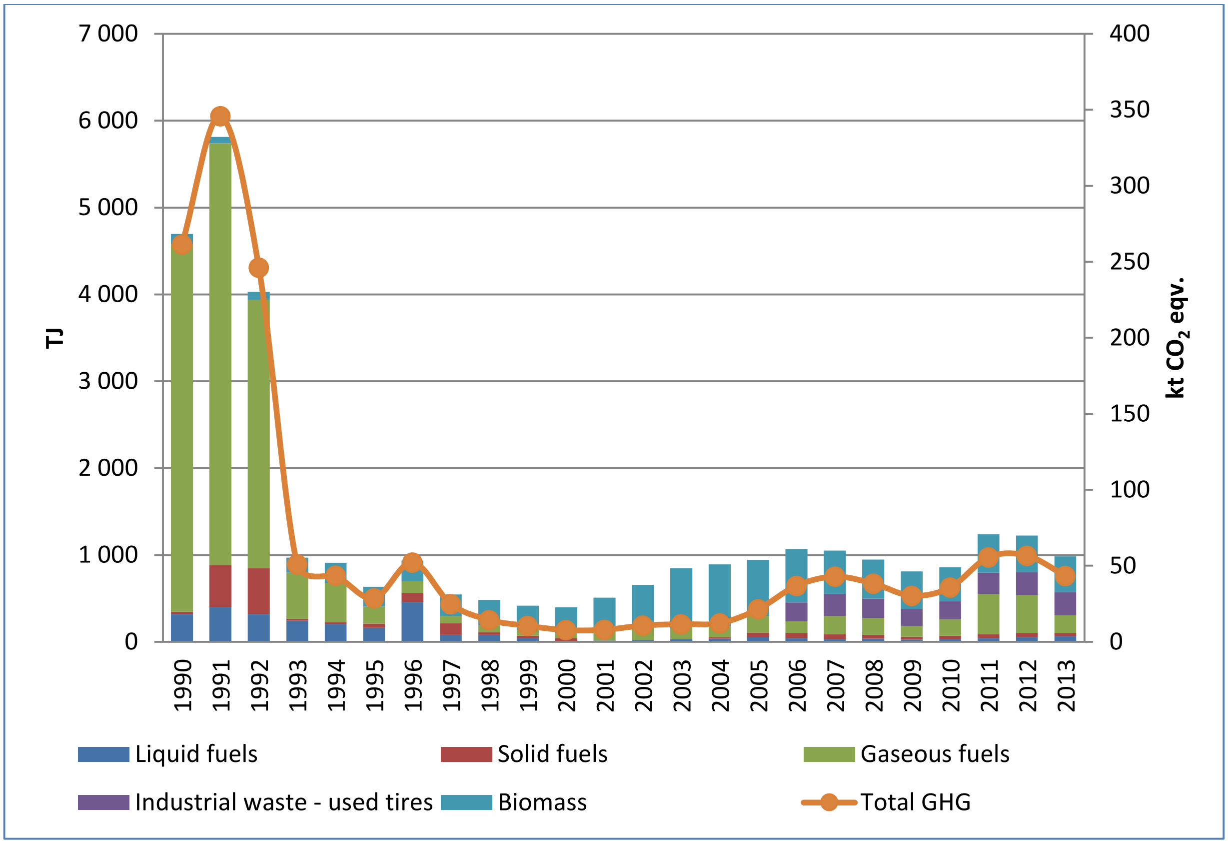


Figure 3-30. Tendencies of fuel consumption and total GHG emissions in Non-Specified Industry (1.A.2.m)

Fuel consumed in the Non-Specified industry has become more diversified in 2013 compared to the structure that have existed in 1990. In 2013, biomass accounted 42.0%, industrial waste (used tires) - 26.8%, natural gas - 20.8%, liquid fuels - 6.4% and solid fuels - 4.0% in the total structure of fuel combusted in the Non-Specified industry.

In 2013, total GHG emissions from Non-Specified industry were 6 times lower than in 1990 and amounted 43.4 kt CO_2 eqv.

3.3.13.3 Uncertainties and time-series consistency

Uncertainty in activity data in Non-Specified industry is ±2% taking into consideration recommendations provided by IPCC GPG 2000 and IPCC 2006 Guidelines for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by 2006 IPCC.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.5% in Non-Specified industry. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and coke) are ±7%. Estimated uncertainties of CO_2 emission factors for biomass are ±50%. Uncertainties of all country specific CO_2 emission factors are derived in the study "Determination of national GHG emission factors for Lithuanian energy sector".

Uncertainties of CH_4 and N_2O emission factors for liquid, solid and gaseous fuels were assigned as very high about ±50%. Uncertainties were derived considering IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.3.13.4 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

The consumption of every type of fuel has been checked and compared with other available data sources. The time series for all data have been studied carefully and compared with economic activity of the sector in order to search for outliers.

The results are verified by calculating CO_2 emissions with the reference approach, and comparing results with the sectoral approach.

3.3.13.5 Source-specific planned improvements

Source-specific improvements are not planned.

3.4 Transport (1.A.3)

The source category 1.A.3 comprises the sources presented on Table 3-38. The source category Civil Aviation only includes emissions from domestic civil aviation, i.e., civil aviation with departure and arrival in the Lithuania. In the same manner, the source category Water-borne Navigation only includes emissions from domestic inland navigation.

Table 3-38. Description of categories in the 1.A.3 Transport sector

CRF source category	Description	Remarks
CRF 1.A.3		
1.A.3.a *Civil Aviation*	Jet and turboprop powered aircraft (turbine engine fleet) and piston engine aircraft	Combustion of jet fuel (jet kerosene and jet gasoline). Emissions from helicopters are not calculated separately. Emissions caused by fuel consumption by military aviation are included in 1.A.5.b – Other (military mobile combustion).
1.A.3.b *Road Transportation*	Transportation on roads by vehicles with combustion engines: Passenger Cars, Light Duty Vehicles, Heavy Duty Vehicles and Buses, Mopeds and Motorcycles. Farm and forest tractors are included in CRF 1.A.4.c Agriculture/Forestry/Fishery. Fuel consumption and emissions from off-road vehicles and pipelines are included in category 1.A.3e Other transportation.	
1.A.3.b	Cars	Emissions from automobiles so designated in the vehicle registering country primarily for transport of persons and normally having a capacity of 12 persons or fewer.
1.A.3.b.i	Passenger cars	Emissions from passenger car
1.A.3.b.ii	Light duty trucks	Emissions from vehicles so designated in the vehicle registering country primarily for transportation of light -weight cargo or which are equipped with special features such as four-wheel drive for off-road operation. The gross vehicle weight normally ranges up to 3500 kg or less.
1.A.3.b.iii	Heavy duty trucks and buses	Emissions from any vehicles so designated in the vehicle registering country. Normally the gross vehicle weight ranges from 3500 kg and more for heavy duty trucks and the buses are rated to carry more than 12 persons.
1.A.3.b.iv	Motorcycles	Emissions from any motor vehicle designed to travel with not more than three wheels in contact with the ground and weighing less than 680 kg.
2.D.3	Urea-based catalysts	CO_2 emissions from use of urea-based additives in catalytic converters (non-combustive emissions)

1.A.3.c *Railways*	Railway transport operated by diesel locomotives	Emissions from railway transport for both freight and passenger traffic routes.
1.A.3.d *Water-borne Navigation*	Merchant ships, passenger ships, container ships, cargo ships, technical ships, tourism ships and other inland vessels.	Fishing emissions are included in the CRF 1.A(a).4.c
1.A.5.b; 1.A.3.e *Other*	Transport of gases via pipelines, military activity and off-road transport.	

Emissions from motorized mobile road traffic in Lithuania includes traffic on public roads within country, except for agricultural and forestry transports. The source category Civil Aviation only includes emissions from national aviation. The source category Water-borne Navigation includes emissions only from inland navigation. The source categories Road transportation and Railways include all emissions from fuel sold to road transport and railways in the Lithuania. CO_2 emissions from 1.A.3.b Road transportation are dominant in this source category (Table 3-39).

Table 3-39. GHG emissions (kt) by subcategories from 1.A.3 Transport sector in 1990 – 2013

Year	1.A.3.A *Civil Aviation*			1.A.3.B *Road Transportation*			1.A.3.C *Railways*			1.A.3.D *Water-borne navigation*			1.AA.3.E *Transprt via pipelines*			1.AA.3.E *Off-road*			1.A Militar	
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CH4	N
1990	8.2	0.00006	0.00023	5247.2	1.9	0.1	350.0	0.02	0.14	15.5	0.0011	0.0001	85.5	0.0015	0.00015	1678.6	0.17	0.63	0.4	0.000
1991	7.9	0.00005	0.00022	5818.7	2.2	0.1	371.7	0.02	0.15	9.3	0.0011	0.0001	82.3	0.0015	0.00015	1260.7	0.15	0.46	0.4	0.000
1992	7.4	0.00005	0.00021	3713.6	1.3	0.1	359.3	0.02	0.14	3.1	0.0002	0.00003	47.2	0.0009	0.00009	962.4	0.11	0.35	0.5	0.000
1993	7.3	0.00005	0.00020	2763.1	1.0	0.1	353.1	0.02	0.14	3.1	0.0002	0.00003	26.5	0.0005	0.00005	834.9	0.09	0.31	0.6	0.000
1994	6.8	0.00005	0.00019	2071.3	0.8	0.1	374.8	0.02	0.15	3.1	0.0002	0.00003	28.9	0.0005	0.00005	751.3	0.09	0.28	0.7	0.000
1995	6.5	0.00005	0.00018	2769.7	1.0	0.1	241.6	0.01	0.09	3.1	0.0002	0.00003	33.7	0.0006	0.00006	757.2	0.08	0.28	0.9	0.000
1996	6.2	0.00004	0.00017	3050.4	1.0	0.1	251.5	0.01	0.1	15.5	0.0011	0.0001	37.8	0.0007	0.00007	506.5	0.07	0.18	1.1	0.000
1997	6.1	0.00004	0.00017	3444.7	1.1	0.1	241.0	0.01	0.09	15.6	0.0011	0.0001	35.5	0.0006	0.00006	459.8	0.06	0.17	1.2	0.000
1998	5.8	0.00004	0.00016	3645.3	1.1	0.1	233.2	0.01	0.09	10.9	0.0007	0.0001	27.5	0.0005	0.00005	407.3	0.06	0.14	1.5	0.000
1999	5.6	0.00004	0.00015	3243.8	1.0	0.1	206.6	0.01	0.08	9.3	0.0006	0.0001	31.3	0.0006	0.00006	298.7	0.05	0.10	1.8	0.000
2000	5.8	0.00004	0.00016	2860.0	0.8	0.1	217.9	0.01	0.09	9.0	0.0006	0.0001	38.3	0.0007	0.00007	229.3	0.04	0.08	3.5	0.000
2001	6.0	0.00004	0.00017	3137.6	0.8	0.1	191.5	0.01	0.08	10.4	0.0007	0.0001	18.7	0.0003	0.00003	192.2	0.02	0.07	0.7	0.000
2002	8.1	0.00006	0.00022	3238.4	0.8	0.1	206.7	0.01	0.08	11.9	0.0008	0.0001	20.7	0.0004	0.00004	191.7	0.02	0.07	1.1	0.000
2003	2.7	0.00002	0.00007	3282.4	0.9	0.1	226.7	0.01	0.09	13.1	0.0009	0.0001	17.8	0.0003	0.00003	181.7	0.02	0.07	3.5	0.000
2004	4.0	0.00003	0.00011	3610.3	0.9	0.1	225.7	0.01	0.09	17.0	0.0012	0.0001	17.8	0.0003	0.00003	184.6	0.02	0.07	9.3	0.000
2005	1.8	0.00001	0.00005	3832.0	1.0	0.1	228.4	0.01	0.09	16.8	0.0012	0.0001	35.7	0.0006	0.00006	204.7	0.02	0.08	12.4	0.000
2006	2.1	0.00005	0.00006	4081.6	0.9	0.2	217.6	0.01	0.09	19.1	0.0013	0.0002	60.3	0.0011	0.00011	193.1	0.02	0.07	12.1	0.000
2007	3.9	0.00011	0.00012	4817.9	1.0	0.2	226.0	0.01	0.09	17.8	0.0012	0.0001	63.2	0.0011	0.00011	192.1	0.02	0.07	15.8	0.000
2008	4.4	0.00011	0.00013	4793.1	0.9	0.2	228.4	0.01	0.09	18.9	0.0013	0.0002	55.5	0.001	0.0001	197	0.02	0.07	12.3	0.000
2009	2.6	0.00006	0.00008	3968.1	0.7	0.1	175.0	0.01	0.07	16.5	0.0011	0.0001	56.1	0.001	0.0001	151.2	0.01	0.06	11.3	0.000
2010	1.7	0.00002	0.00005	4075.6	0.7	0.1	185.1	0.01	0.07	19.8	0.0014	0.0002	56.8	0.001	0.0001	156.6	0.01	0.06	15.9	0.000
2011	1.9	0.00003	0.00005	4045.1	0.6	0.1	193.0	0.01	0.08	16.3	0.0011	0.0001	47.6	0.0009	0.00009	164.8	0.02	0.06	12.8	0.000
2012	1.7	0.00003	0.00005	4049.5	0.6	0.1	180.8	0.01	0.07	14.9	0.0010	0.0001	73.5	0.0013	0.00013	173.3	0.01	0.07	9.0	0.000
2013	1.7	0.00003	0.00005	4077.9	0.6	0.1	166.3	0.01	0.07	14.3	0.0014	0.0004	69.0	0.0013	0.00013	165	0.01	0.06	17.3	0.000

Fuel combustion emissions in 1.A.3 Transport sector accounted for 60384 and 62619 TJ in 2005 and 2013, respectively. The sectors emissions increased from 4435.96 in 2005 to 4583.07 kt CO_2 in 2013. In 2013 the most important source of transportation GHGs was transport, with a share of 90% (Figure 3-20). Lithuania's railway system is mainly driven by diesel oil (4% of total fuel consumption in transport sector). Fuels used by ships on inland waterways have a share of 0.3% in transport fuel consumption. In 2013 about 0.04% of transportation fuel consumption arose from civil aviation sector. However, emissions from international transport at inland waterways are excluded from the national total and reported as marine bunkers.

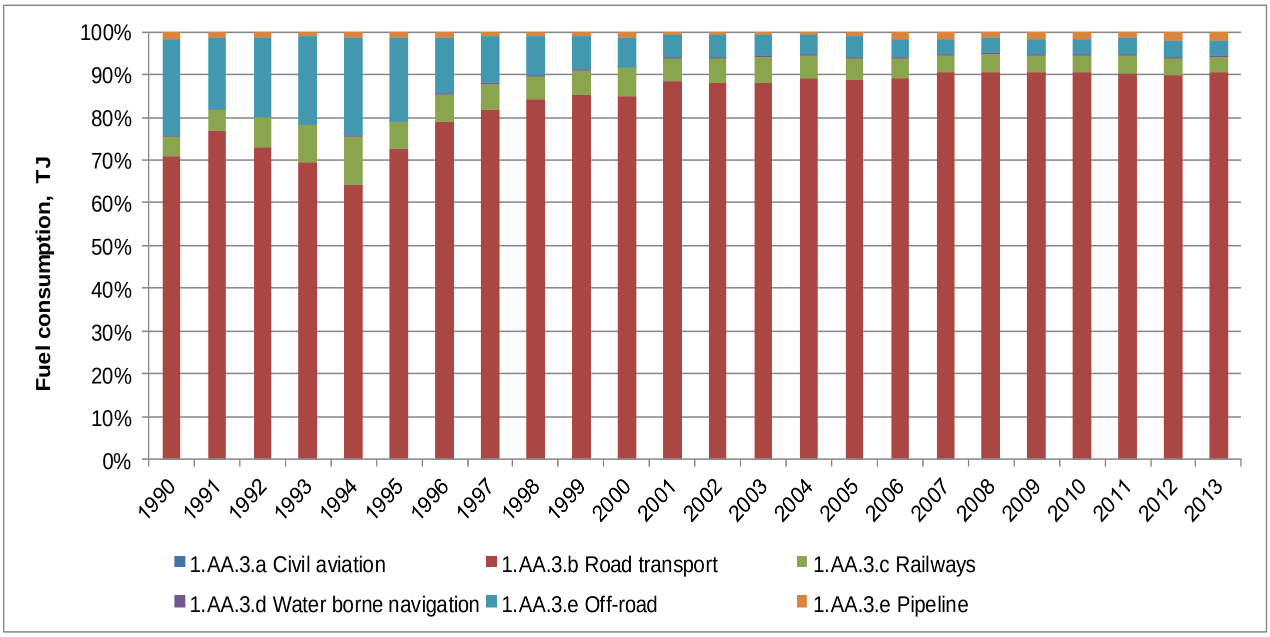


Figure 3-20. Fuel consumption distribution in Transport sector in 1990-2013

Activity Data

Calculations demand speed mode of vehicles and fuel consumption are supplied by The Lithuanian Road Administration under the Ministry of Transport and Communications of the Republic of Lithuania, and the Lithuanian Statistics yearly publications "Energy balance" (Statistics Lithuania, 2013). Meteorological data is obtained from Lithuanian Hydrometeorological Service under the Ministry of Environment of the Republic of Lithuania (LHMS). The number of registered cars in Lithuania from 2004 through 2012 was obtained on the basis of the officially published ownership provided by State Enterprises Regitra and before 2003 Ministry of Interior data.

According to the information provided by Lithuanian Statistics, fuel use in road transport data collection methodology is part of the annual energy and fuel statistics survey. Functional enterprises are surveyed irrespective to their kind and ownership form. Statistical survey covers enterprises producing, supplying and consuming fuel and (or) energy.

Statistical information about oil products (motor gasoline, diesel, liquefied petroleum gas (LPG)) consumption in road transport is reported by the following enterprises:

- Enterprises producing oil products;
- Enterprises importing and exporting oil products;
- Oil products wholesale trade enterprises;
- Enterprises, which according to Law on State's oil and oil products reserve are obliged to store and manage State's oil and oil products reserve;
- Enterprises consuming fuel and energy belonging to the following economical activities: agricultural (with 10 and more employees), forestry and fishing, mining and quarrying, manufacturing industry, construction, transport and storage (except for road transportation) (with 20 and more employees).

Energy balance statistical report EN-01 and Oil/ Oil products balance statistical report EN-06 are the sources for statistical data.

In the statistical reports respondents are providing statistical data about each fuel and energy type: changes in stocks at the beginning and end of the year, production, inter-product transfer processes, import and export, purchase and sale in the internal market, consumption allocated by consumption purposes.

Statistical indicator "Consumption in road transport" is based on the territorial principle, not on the resident, i.e. the fuel sold (purchased) in Lithuania's territory is accounted, regardless of the country the vehicle originates.

In the balance row "Consumption in road transport" fuel used by all commercial and passenger vehicle's engines, i.e. consumed in industry, construction, transportation, service and other sectors is included. Fuel used by agricultural vehicles used on highways is accounted as well.

For fuels in common circulation, the carbon content of the fuel and net calorific values were obtain from fuel suppliers in accordance with the IPCC GPG 2000.

3.4.1 Civil aviation (1.A.3.a)

3.4.1.1 Source category description

Civil International airports in Lithuania (Vilnius, Kaunas and Palanga) are operated by State owned assets of the enterprises under the supervision of the Ministry of Transport and Communications. The Resolution No 1355 dated 28 October 2004 of the Government of the Republic of Lithuania approved the Šiauliai Airport as military, granting the right to use it for international civil air transport. Vilnius International Airport is the main airport in Lithuania handling around 1.37 million passengers every year; more than 70% of passenger and aircraft movements in Lithuania are operated through Vilnius International Airport (Figure 3-21).

Domestic civil aviation is essentially narrow (0.01%) in Lithuania. Aviation gasoline (avgas) is used for piston-type powered aircraft engines, while the jet fuel used in turbine engines for aircraft and diesel engines. The corresponding figure was 1.8 kt (CO_2 equivalent) in 2005 (Figure 3-22 and Table 3-33).

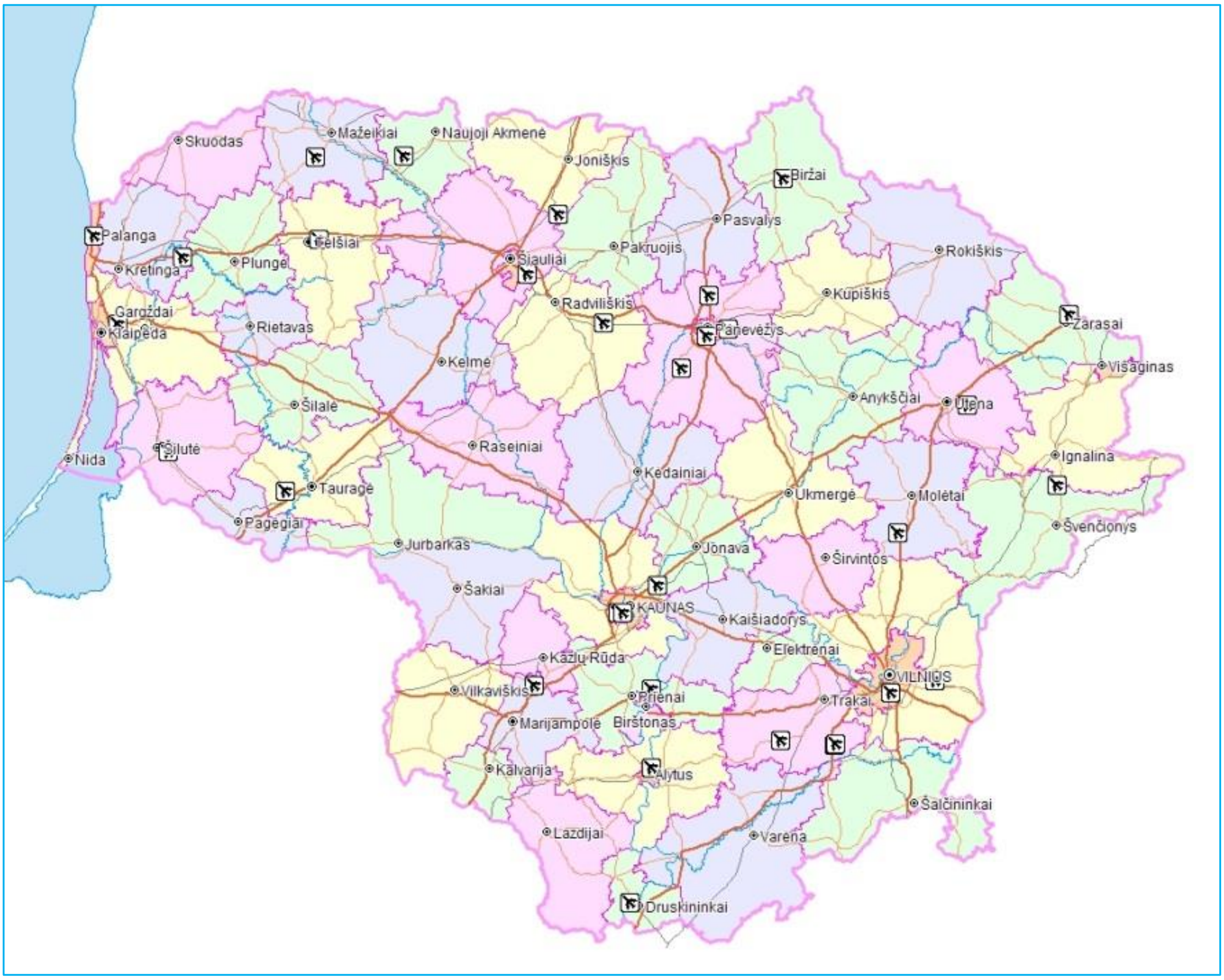


Figure 3-31. Map of aerodromes in Lithuania

Aviation gasoline is more common as fuel for private aircraft, while the jet fuel used in aircraft, airlines, military aircraft and other large aircraft. Following the recommendation of ERT in 2010 in the individual review report, net calorific values (NCVs) used to convert fuel consumption in natural units into energy units are provided in the Table 3-40[4].

Table 3-40. Specific net calorific values (conversion factors)

Type of fuel	Tonne	Tonne of oil equivalent (TOE)	TJ/tonne
Gasoline type jet fuel	1.0	1.070	0.04479
Kerosene type jet fuel	1.0	1.031	0.04316

[4] IPCC 2006 Guidelines. Energy. Mobile Combustion. P. 3.16

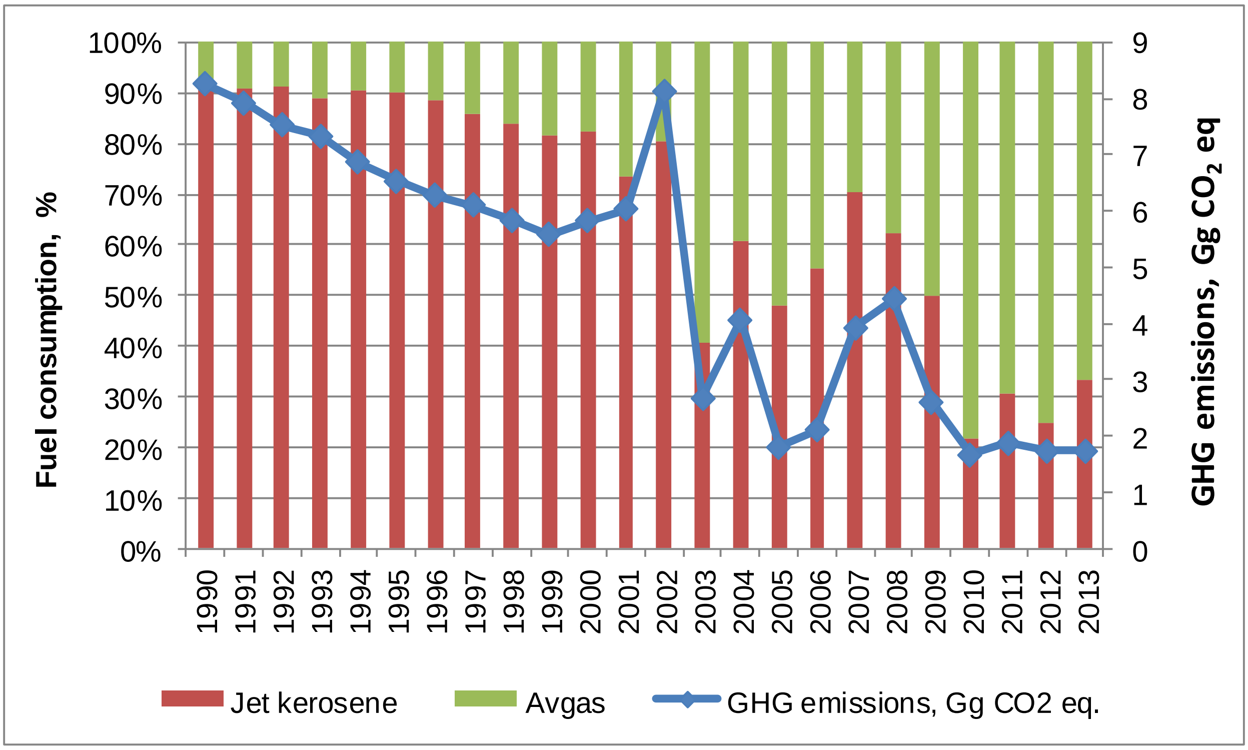


Figure 3-32. Trend of GHG emissions in Civil Aviation sector

3.4.1.2 Methodological issues

The aviation gasoline consumption and GHG emissions were based on Tier 1 approach as this method should be used to estimate emissions from aircraft that use aviation gasoline which is only used in small aircraft and generally represents less than 1 % of fuel consumption from aviation. The jet kerosene fuel consumption and emissions within Lithuania associated with sub-category 1.A.3(a) Civil Aviation was estimated using a Tier 2 approach (2006 IPCC) based on aircraft type and LTO data for domestic and international air travel, the fuel consumption rates given by the EMEP/EEA emission inventory guidebook (2009) appropriate to the type of aircraft. This approach was used for all years from 2005 to 2013 where data is available.

For the purpose of these guidelines, operations of aircraft were divided into *Landing/Take-Off (LTO) cycle* and *Cruise*. Generally, about 10 percent of aircraft emissions of all types (except hydrocarbons and CO) are produced during airport ground level operations and during the LTO cycle[5]. The bulk of aircraft emissions (90 percent) occur at higher altitudes.

In Tier 2 the emissions for the LTO and cruise phases are estimated separately (Fig. 3-23), in order to harmonise with methods that were developed for air pollution programmes that cover only emissions below 914 meters (3000 feet). Emissions depend on the number and type of aircraft operations, the types and efficiency of the aircraft engines, the length of flight, the power setting, and the time spent at each stage of flight.

The level of detail necessary for this methodology is the aircraft types used for both domestic and international aviation, together with the number of LTOs carried out by the various aircraft

[5] LTO cycle is defined in ICAO, 1993. If countries have more specific data on times in mode these can be used to refine computations in higher tier methods.

types. Apart from this level of further detail according to aircraft type, the algorithms are the same as for the Tier 1 approach:

$$E_{pollutant} = \sum AR_{fuel\ consumption,\ aircraft\ type} \times EF_{pollutant,\ aircraft\ type}, \quad (1)$$

where:

$E_{pollutant}$ – annual emission of pollutant for each of the LTO and cruise phases of domestic and international flights;

$AR_{fuel\ consumption,\ aircraft\ type}$ – activity rate by fuel consumption for each of the flight phases and trip types, for each aircraft type;

$EF_{pollution,\ aircraft\ type}$ – emission factor of pollutant for the respective flight phase and trip type, for each aircraft type.

Activity data

Following advice from experts[6] it was decided to distinguish GHG emissions from aviation bunkers in such a way that all aviation gasoline and part of kerosene type jet fuel is used for domestic purposes and the rest kerosene type jet fuel is used for international flights – the latter could therefore be considered as aviation bunkers. Activity data on aviation gasoline split between domestic and international aviation is available only from 2000. Following the recommendation of ERT in 2011 the estimates of aviation gasoline consumption were linearly interpolated for the period 1996-1999 since effect of annual fluctuations was considered negligible. Emissions were estimated by assuming a constant annual rate of growth in fuel consumption from 1995 to 2000 (*IPCC 2006, Vol. 1. General Guidance and Reporting*). Trend extrapolation of GHG from jet kerosene for 1990-was evaluated in combination with surrogate data. To improve the accuracy of estimates changes in total jet kerosene consumption during 1990-2010 were used underlying activity for simulation of trend in GHG emissions (*IPCC 2006, Vol. 1. General Guidance and Reporting*).

[6]ICR Lithuania 17-21 May, 2004, Branca Americano (Brazil); consultant Domas Balandis (Lithuania).

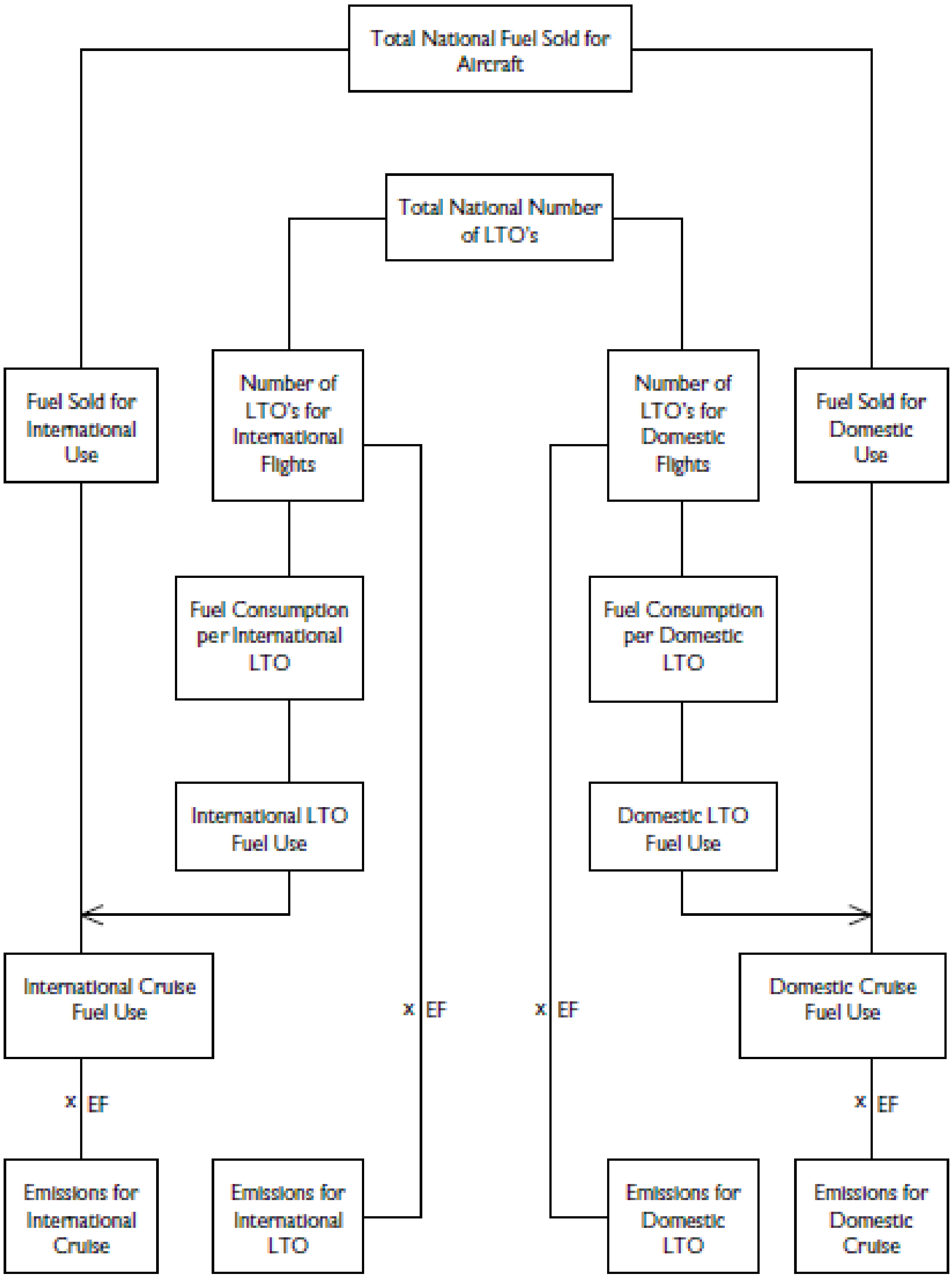


Figure 3-32. Estimation of Aircraft Emissions with the Tier 2 Method

Following the recommendation of ERT in 2012[7] the extrapolation procedure was explained. In a case when we have very sharp annual fluctuations in time-series the partial correlation can be done. Bearing in mind that the relationship between emissions and surrogate can be developed on the basis of data for a single year, the use of multiple years might provide a better estimate. Two underlying activities for surrogate data were used: average length of carriage per tonne, km and international fuel consumed, TJ. The extrapolation was made using it's own extrapolation

[7] ICR Lithuania 1-6 October, 2012, Tomas Gustafsson (Sweden)

alghoritm and surrogate data was used as parameters for comparison (for example Average length of carriage per tonne, km) (Fig. 3-33).

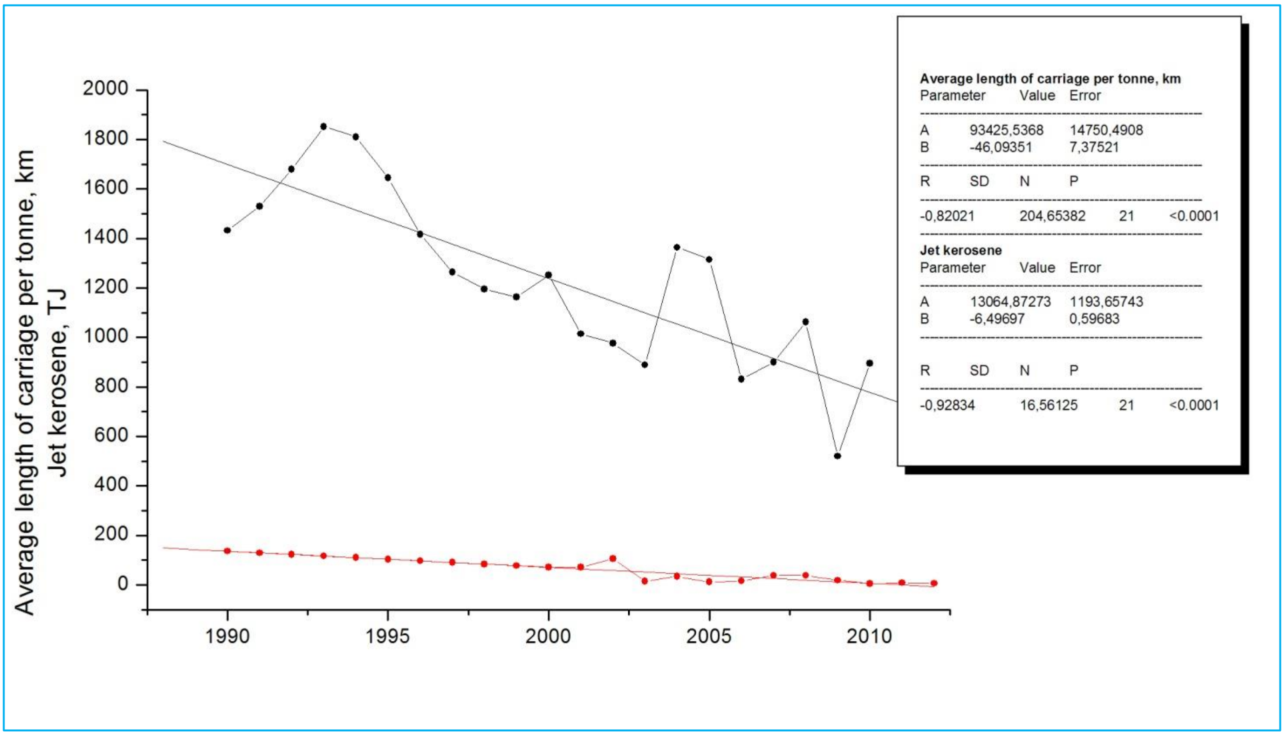


Figure 3-33. The intercomparison between surrogate data and trend of civil aviation emissions

The underlying algorithm used in the SLOPE functions is different than the underlying algorithm used in the EXTRAPOLATION function. The difference between these algorithms can lead to different results when data is undetermined and collinear. In this reason the tendency of surrogate data was compared to tendency of time-series after extrapolation was applied.

Data on jet kerosene used for military in Lithuania is available starting from 2001. Data for 1990-2000 were extrapolated.

Additionally expert asks the data by special inquiry data on consumption of aviation fuels for international bunkering and inland consumption every year because this data is not published in the National Energy Balances and Annual Yearbooks, i.e. data of aviation fuels is given in total and is not splitted into national and international use. For 2006-2013 the air flight statistics is provided by the statistical data from Vilnius International Airport and SE "Oro navigacija".

Emission factors

Emission factors for *Civil aviation* sources used in the Lithuanian national GHG inventory are provided in Table 3-41. Country specific CO_2 EF was developed based on research data from the Lithuanian oil refinery (research protocols of UAB ORLEN Lietuva Quality Research Center) in 2010. Jet kerosene used in the country is produced by oil refinery UAB ORLEN Lietuva.

Table 3-41. Emission factors for Civil aviation sector used in the Lithuanian GHG inventory

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	**EF**	**Method**	**CH_4, kg/TJ**	**EF**	**Method**	**N_2O, kg/TJ**	**EF**	**Method**
Aviation gasoline	71.62	CS	T2	0.5	D	T1, T2	2	D	T1, T2
Jet kerosene	72.24	CS	T2	0.5	D	T1, T2	2	D	T1, T2

It should be noted that the reporting of emissions from military aircraft is under CRF code 1.A.5, not 1.A.3.a. Military activity is defined in this report as those activities using fuel purchased by or supplied to the military authorities of the country.

3.4.1.3 Uncertainties and time-series consistency

Uncertainty in activity data of aviation fuel consumption in civil aviation is ±10 % influenced mainly by domestic and international fuel split and extrapolation procedure. In fuel combustion activity, the CO_2 emission factor mainly depends on the carbon content of the fuel instead of on combustion technology. CO_2 emission factor (uncertainty 2.5%) was estimated according physical characterization of used fuels in country based on average NCV and emission factors of jet kerosene reported by ORLEN Lietuva. Uncertainty in activity data of fuel consumption for 1990-2000 in civil aviation is influenced by data based on extrapolation (jet kerosene).

The current limited knowledge of CH_4 and N_2O emission factors, more detailed methods not significantly reduce uncertainties for CH_4 and N_2O emissions, so uncertainty was assigned about 57%/+100% and -70%/+150%, respectively. The time series for all data have been studied carefully in search for outliers.

3.4.1.4 Source-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

3.4.1.5 Source-specific recalculations

No source specific recalculations.

3.4.1.6 Source-specific planned improvements

No improvements are planned.

3.4.2 Road transportation (1.A.3.b)

3.4.2.1 Source category description

Lithuania has a fairly well-developed road network provided with a dense road (1.294 km/km^2) network (2013). At the end of 2013, the length of roads amounted to 84.5 thousand kilometres and, compared to 2012, increased by 0.4 %; the length of E-roads amounted to 1639 kilometres, that of motorways – 309 km (Statistics Lithuania, 2013).

Road transportation is the most important emission source in the Transport sector. This sector includes all types of vehicles on roads (passenger cars (PC), light duty vehicles (LD), heavy duty trucks and buses (HD), motorcycles and mopeds (2-wheels)) (Table 3-42). The source category does not cover farm and forest tractors driving occasionally on the roads because they are included in other sectors as off-roads.

67.3 % mopeds, 22.7 % of motorcycles, 15.2 % of passenger cars, 18.6 % of buses, 43.6 % of lorries and 67.6 % of road tractors were produced up to 10 years ago.

Table 3-42. Number of vehicles in road transport sector by UNECE classification (thousands) (Passenger Cars-M1, Light Duty Vehicles-N1, Heavy Duty Vehicles-N2, N3, Urban Buses & Coaches-M2, M3, Two Wheelers-L1, L2, L3, L4, L5)

Year	L1, L2, L3, L4, L5	M1	N1, N2, N3, M2, M3	Total
1990	192.1	493.0	105.9	791.0
1991	181.2	530.8	114.0	826.0
1992	177.5	565.3	129.5	872.3
1993	180.5	609.1	106.4	896.0
1994	162.8	652.8	111.2	926.8
1995	19.2*	718.5	125.9	844.4
1996	19.4	785.1	104.8	909.3
1997	19.1	882.1	108.6	1009.8
1998	19.3	980.9	114.6	1114.8
1999	19.5	1089.3	112.2	1221.0
2000	19.8	1172.4	113.7	1305.9
2001	20.2	1133.5	115.6	1269.3
2002	21.0	1180.9	120.9	1322.8
2003	21.9	1256.9	126.1	1404.9
2004	22.9	1315.9	130.1	1468.9
2005	24.0	1455.3	137.3	1616.6
2006	25.5	1592.2	150.7	1768.4
2007	35.3	1587.9	161.6	1784.8
2008	40.6	1621.1	163.9	1825.6
2009	41.4	1595.3	159.7	1796.4
2010	36.3	1541.9	147.2	1725.4
2011	33.8	1577.6	193.6	1805.0
2012	26.8	1617.7	196.2	1840.7
2013	25.1	1630.0	194.2	1849.3

*Number of re-registered motorcycles

Greenhouse gas emissions from road transport increased by 5.9% from 3.9 to 4.1 Tg CO_2 eq. during 2005-2013, that was 86% and 89% of the sector's emissions, respectively. GHG emissions from road transport comparing with 2012 increased by 0.7 % in 2013. This increase is primarily caused by a 4.7% increase (1493 TJ) in diesel oil fuel consumption by road transportation, while consumption of motor gasoline decreased by 907 TJ. The lowest emission level in the road transportation was achieved in 1994 (2.1 Tg) because of the economic depression in Lithuania.

Greenhouse gas emissions from transport sector amounted to 5.3 Tg CO_2 equivalent in 1990. The greenhouse gas emissions from the transport sector are summarised in Fig. 3-43.

Table 3-43. Fuel consumption, [TJ]

Year	Motor gasoline	Transport diesel	LPG	Bioethanol*	Biodiesel*
1990	41840	29275.61	920	-	-
1991	47290	31867.5	690	-	-
1992	28568	22308	46	-	-
1993	22722	14872	322	-	-
1994	18547	9560.25	322	-	-
1995	25887	11133	1058	-	-
1996	28347	12398	1196	-	-
1997	28347	17725	1288	-	-
1998	27117	21254	1794	-	-
1999	21140	20450	3220	-	-
2000	16337	18366	5032	-	-
2001	16169	22127	5272	-	-
2002	15710	22977	6378	-	-
2003	15662	22772	7332	-	-
2004	14970	26595	8857	2	29
2005	14685	29262	9593	26	119
2006	15433	31753	9810	72	589
2007	18577	38798	9708	200	1762
2008	18309	39697	8615	334	1916
2009	15358	32128	7681	584	1581
2010	12405	36892	7275	436	1454
2011	10804	38491	6790	397	1481
2012	9656	40053	6400	365	2168
2013	8749	41546	6147	284	2173

Following the recommendation of ERT in 2010 of the individual review report, net calorific values (NCVs) used to convert fuel consumption in natural units into energy units are provided in the Table 3-44[8].

Table 3-44. Specific net calorific values for Road transportation (conversion factors)

Type of fuel	Tonne	Tonne of oil equivalent (TOE)	TJ/tonne
Liquefied petroleum gases	1.0	1.109	0.04642
Motor gasoline	1.0	1.070	0.04479
Transport diesel	1.0	1.029	0.04307
Bioethanol	1.0	0.645	0.02700
Biodiesel (methyl ester)	1.0	0.884	0.03700

*Carbon from biofuel is reported as a memo item but not included in national CO_2 totals, as required by the IPCC Gudelines.

[8] IPCC 2006 Guidelines. Energy. Mobile Combustion. P. 3.16.

CO_2 emissions depend directly on fuel consumption[9]. From 2000-2007, these emissions increased, since growth in mileage travelled outweighed improvements in vehicle fuel consumption. Road traffic is an important source of N_2O from fuel combustion and from 1994-2007 emissions has increased in line with the increasing share of catalyst-controlled vehicles in the national fleet (exception 2000 when the consumption of motor gasoline was noticeably decreased). The use of liquefied petroleum gas is strongly influenced by the fluctuation of fuel prices.

Since 1990 the density of transport routes as well as the number of road vehicles has increased rapidly. Since 1995, the number of personal cars more than doubled (Table 3-40). 90% of the fuel in transportation sector is consumed by road transport.

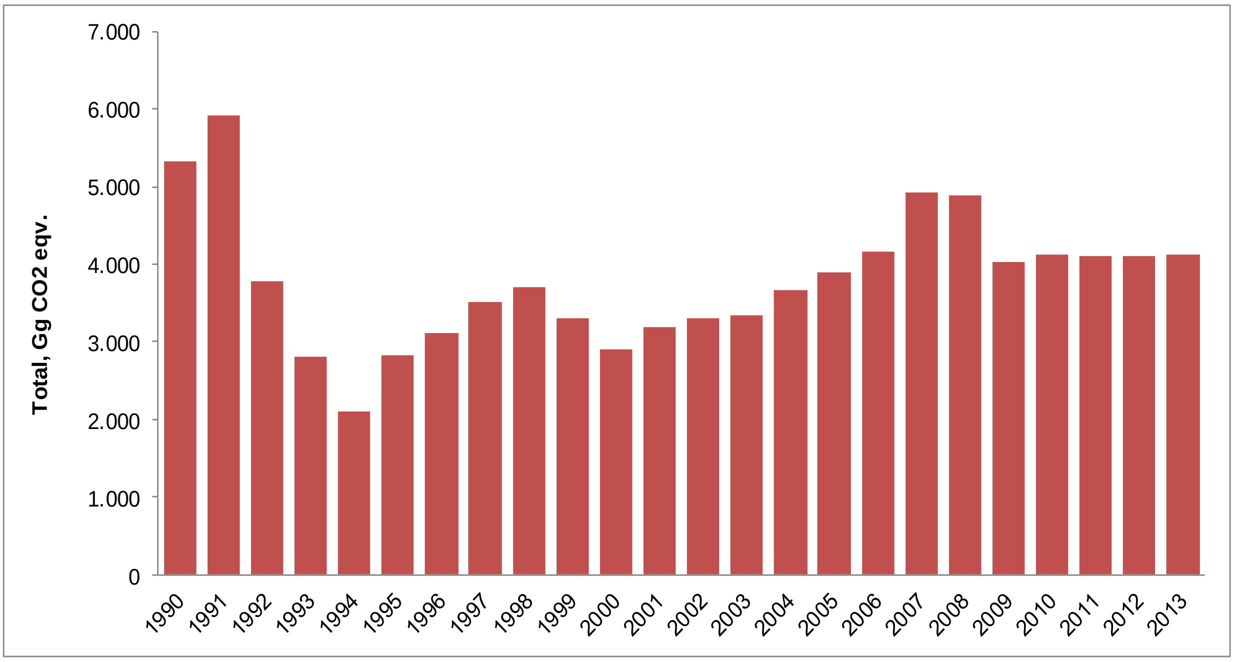


Figure 3-34. Development of greenhouse-gas emissions from road transport, kt CO_2 eq. in 1990-2013

Bigger amount of passenger cars with petrol engines have catalysers installed. N_2O emissions result primarily from incomplete reduction of NO to N_2 in 3-way catalytic converters. N_2O emissions are dependent on driving cycle variables, catalyst composition, catalyst age, catalyst exposure to variable levels of sulfur compounds. They are not limited by law. Initially, growth in numbers of cars with catalytic converters caused increases in N_2O emissions in comparison to the 1990 level. Newer catalytic converters are optimized to produce only small amounts of N_2O. For this reason, the increasing trend in N_2O emissions that have been observed since 2000 (Fig. 4-35).

[9] CO_2 emissions can be estimated from the mileage, however, it is usually best to estimate the total emissions from the fuel consumption (as this is the more reliable data) and then allocate this emission to the vehicle types by vehicle mileage data and relative fuel effiencies.

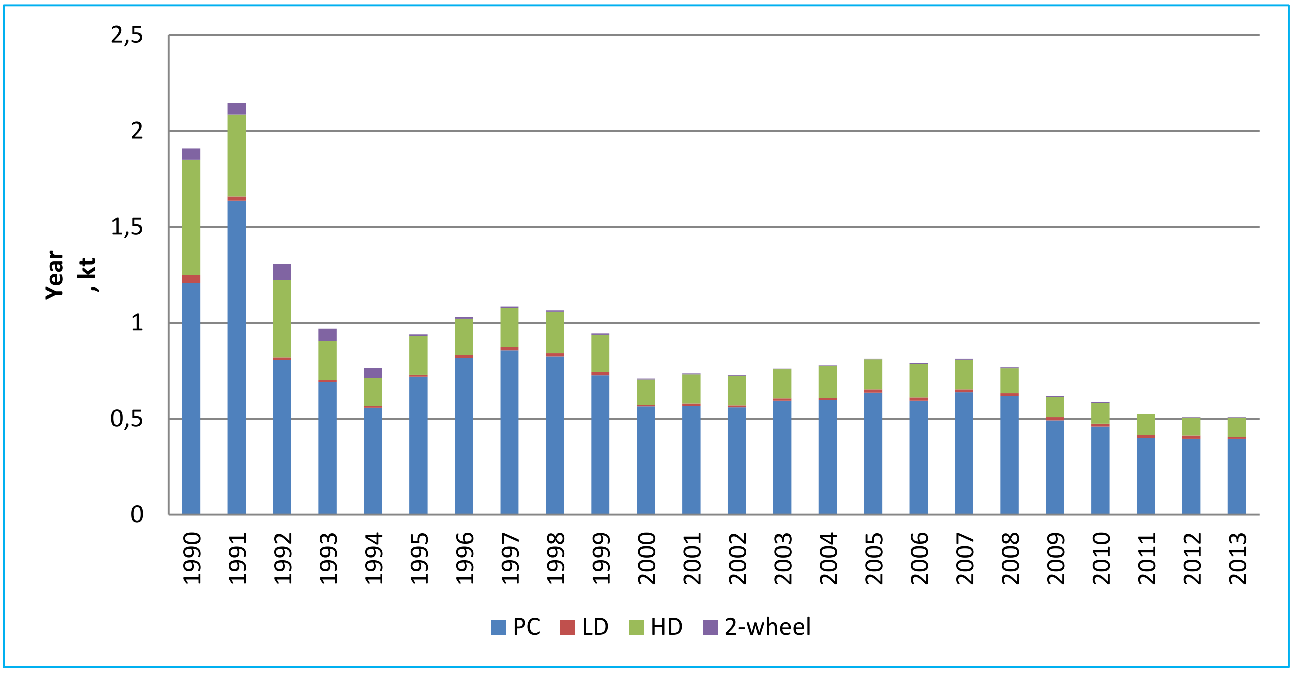


Figure 3-34. CH_4 emissions in Road transport during 1990-2013

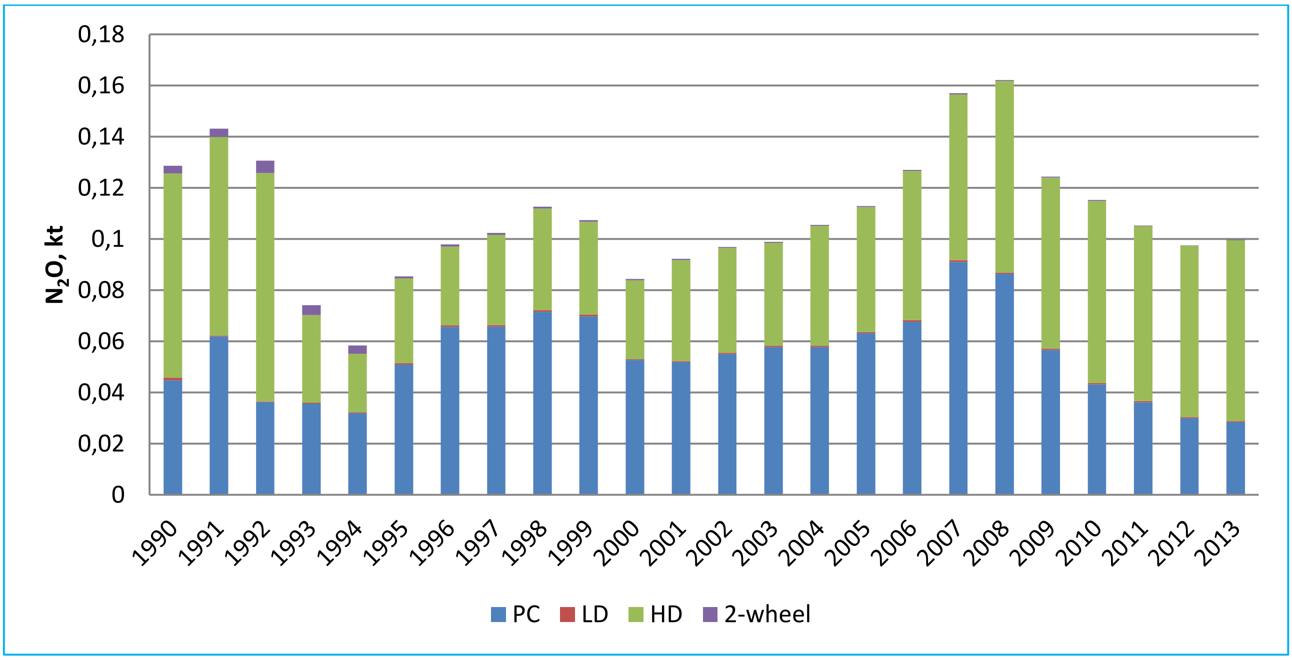


Figure 3-35. N_2O emissions in Road transport during 1990-2013

The last two years, 2008 and 2009, emissions of N_2O have decreased. The effect of fuel sulfur is another important factor that can influence the formation of N_2O over the catalyst (Baronick *et al.*, 2000). This is primarily due to a decrease in consumption of motor gasoline, but also because emission factors for petrol-driven vehicles have decreased substantially, reflecting the improved control of N_2O emissions (TNO, 2002; Riemersma et al., 2003) in more modern vehicles.

There is a marked switch from petrol engines to diesel (Table 3-41). The number of petrol engines (all vehicles) has dropped between 1990 and 2013 (-55%), while the number of diesel engines has more than doubled from ~116 to 736 thousand for the same period.

Within sub-sectors, passenger cars represent the most fuel-consuming vehicle category, followed by heavy-duty vehicles, light duty vehicles and 2-wheelers, in decreasing order (Figs 3-36 – 3-37).

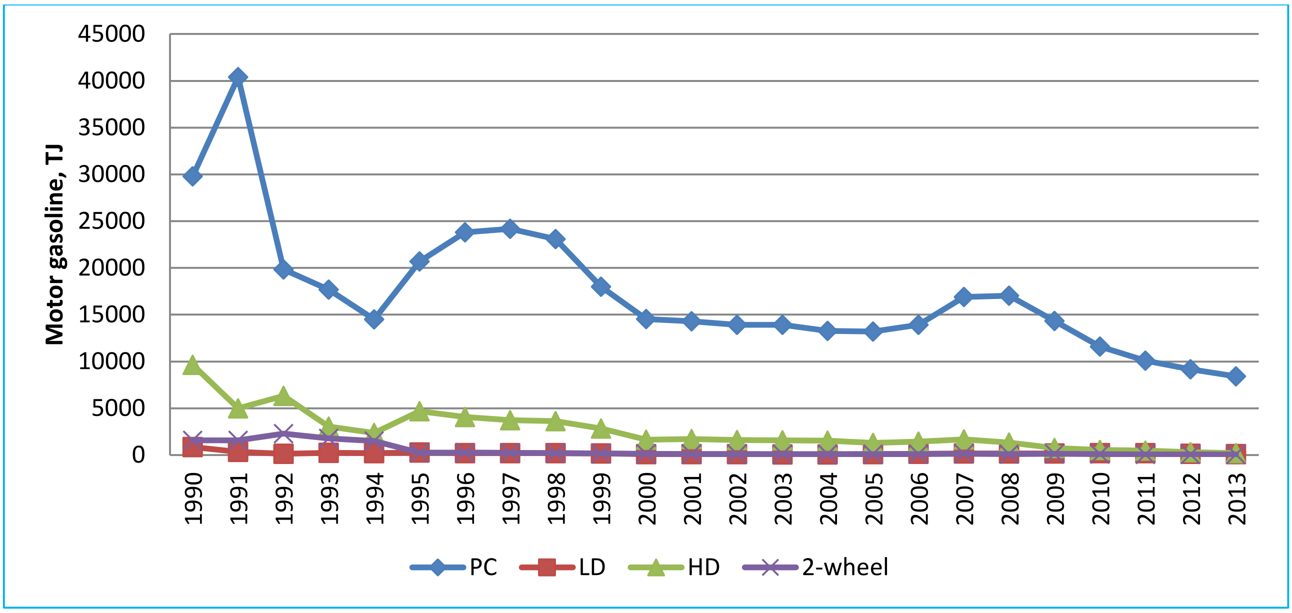


Figure 3-36. Gasoline fuel consumption per vehicle type for road transport 1990-2013

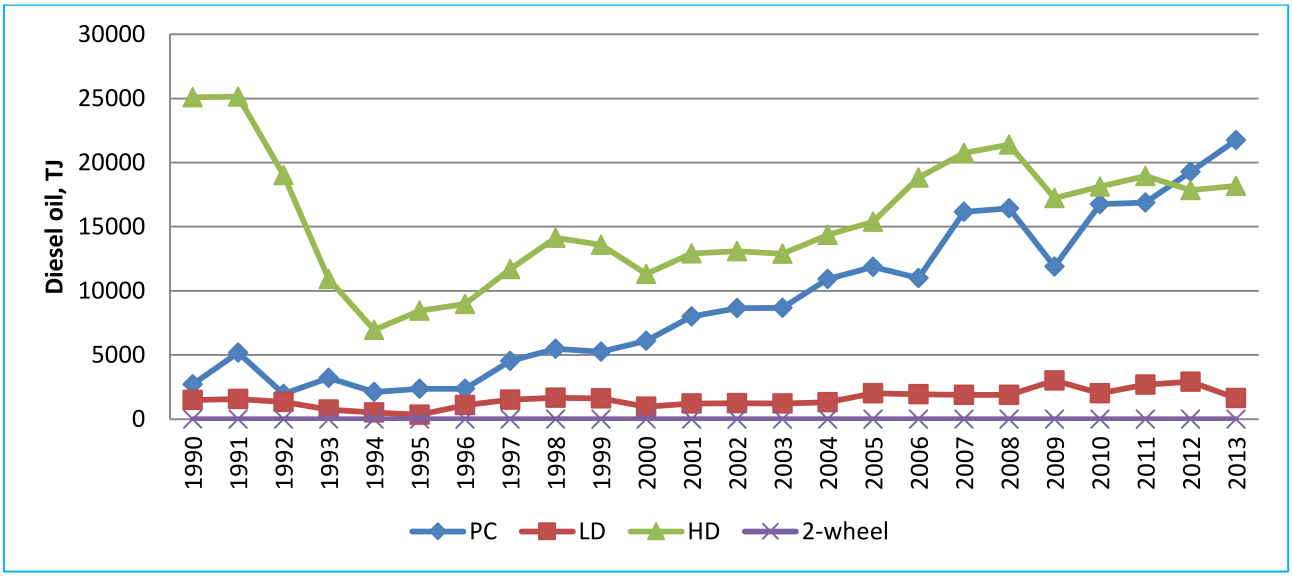


Figure 3-37. Diesel oil consumption per vehicle type for road transport 1990-2013

In 2013, fuel consumption shares for gasoline passenger cars, heavy-duty vehicles, diesel passenger cars, diesel light duty vehicles and gasoline light duty vehicles were 34, 26, 25, 14 and 1 %, respectively (Figure 3-38).

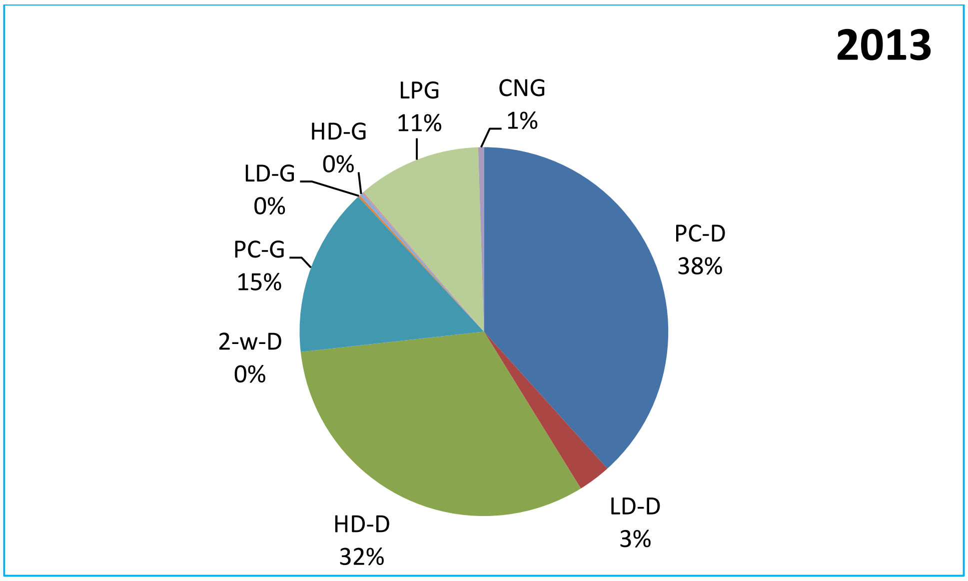


Figure 3-38. Fuel consumption share (TJ) per vehicle type and fuel type for road transport in 2013.

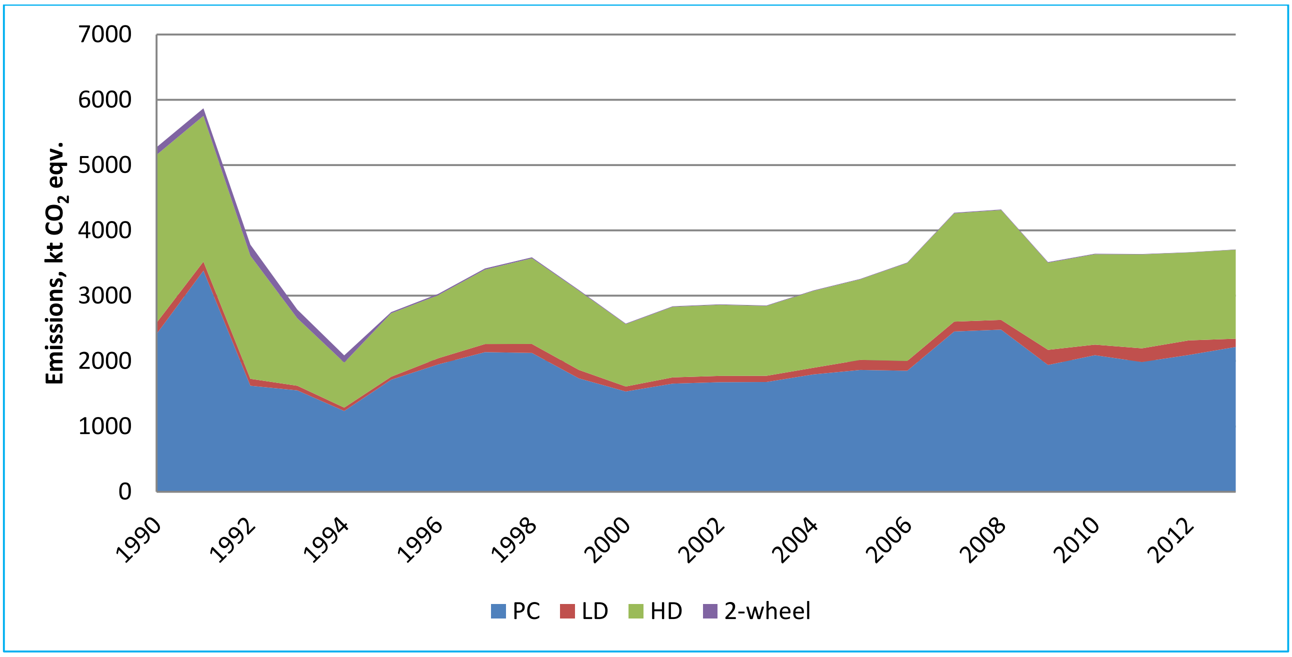


Figure 3-39. Emissions from road transportation by types of vehicle (kt CO_2 eq.)

3.4.2.2 Methodological issues

Emission estimations from road transportation are made using the *IPCC Guidance* 2006 Tier 2 method (for CO_2 emissions) and for CH_4 and N_2O emissions based on the COPERT IV (v11.0) model (best practice) which corresponds to the *IPCC Guidance* Tier 3 method. The country-specific and default emission factors of LPG were used for emission evaluation.

In order to apply the CORINAIR methodology the vehicle categories were broken down into so-called *vehicle layers* with the same emissions technology behavior, by type of fuel used, vehicle size (heavy duty trucks and buses by weight class, passenger cars and motorcycles by engine displacement) and pollution control equipment used, as defined by EU directives for emissions control ("EURO norms"), and by regional traffic distribution (urban, rural and highways). The classification of vehicles was done according to the UN-ECE. The main vehicle categories were allocated to the UNECE classification as follows:

Passenger Cars	M1
Light Duty Vehicles	N1
Heavy Duty Vehicles	N2, N3
Urban Buses & Coaches	M2, M3
Two Wheelers	L1, L2, L3, L4, L5

In the Tier 3 method, emissions are calculated using a combination of firm technical data and activity data. The activity data of road transport was split and filled in for a range of parameters including:

- Fuel consumed, quality of each fuel type;

- Emission controls fitted to vehicle in the fleet;

- Operating characteristics (e.g. average speed per vehicle type and per road)

- Types of roads;

- Maintenance;

- Fleet age distribution;

- Distance driven (mean trip distance), and

- Climate

The program calculates vehicle mileages, fuel consumption, exhaust gas emissions, evaporative emissions of the road traffic. The balances use the vehicle stock and functions of the km driven per vehicle and year to assess the total traffic volume of each vehicle category. The production year of vehicles in this category has been taken into account by introducing different classes, which either reflects legislative steps ('ECE', 'Euro') applicable to vehicles registered in each Member State. The technology mix in each particular year depends on the vehicle category and the activity dataset considered.

For the period between 1990 and 2006, it was necessary to estimate the figures with the aid of numerous assumptions. The total emissions were calculated by summing emissions from different sources, namely the thermally stabilized engine operation (hot) and the warming-up phase (cold start) (EEA 2000; MEET, 1999). For Tier 3 approaches cold start emissions were estimated:

$$E_{COLD;i,j} = \beta_{i,k} \times N_k \times M_k \times E_{HOT;i,k} \times (e_{COLD} / e_{HOT}\big|_{i,k} - 1) \quad (1)$$

Where:

$E_{COLD;i,k}$ - cold start emissions of pollutant *i*(for the reference year), produced by vehicle technology *k*,

$\beta_{i,k}$ - fraction of mileage driven with a cold engine or the catalyst operated below the light-off temperature for pollutant *i* and vehicle [veh] technology *k*,

N_k - number of vehicle of technology *k* in circulation,

M_k - total mileage per vehicle [km veh^{-1}] in vehicle technology *k*,

e_{COLD}/e_{HOT} - cold/hot emission quotient for pollutant *i* and vehicle of *k* technology.

$$E_{TOTAL} = E_{HOT} + E_{COLD}. \quad (2)$$

where,

E_{TOTAL} - total emissions (g) of compound for the spatial and temporal resolution of the application,

E_{HOT} - emissions (g) during stabilized (hot) engine operation,

E_{COLD} - emissions (g) during transient thermal engine operation (cold start).

The *β*-parameter depends upon ambient temperature *ta* (for practical reasons the average monthly temperature was used).Since information on average trip length is not available for all vehicle classes, simplifications have been introduced for some vehicle categories. According to the available statistical data (André *et al.*, 1998), a European value of 12.4 km has been established for the l_{trip} value and used in estimations in Lithuania.

Due to the fact that concentrations of some pollutants during the warming-up period are many times higher than during hot operation. In this respect, a distinction is made between urban, rural and highway driving modes. Cold-start emissions are attributed mainly to urban driving (and secondarily to rural driving), as it is expected that a limited number of trips start at highway conditions. Therefore, as far as driving conditions are concerned, total emissions were calculated by means of the equation:

$$E_{TOTAL} = E_{URBAN} + E_{RURAL} + E_{HIGHWAY}. \quad (3)$$

where:

E_{URBAN}, E_{RURAL} and $E_{HIGHWAY}$ - the total emissions (g) of any pollutant for the respective driving situations.

Fuel was distributed to transport categories, types, ecology standards and driving modes according to data taken from State Enterprise Transport and Road Research Institute under the Ministry of Transport and Communications of the Republic of Lithuania.

Emissions was estimated from the fuel consumed (represented by fuel sold) and the distance travelled by the vehicles. The first approach (fuel sold) was applied for CO_2 and the second (distance travelled by vehicle type and road type) for CH_4 and N_2O.

Emissions of CO_2 was calculated on the basis of the amount and type of fuel combusted (equal to the fuel sold) and its carbon content (*IPCC Guidance* 2006. Energy. Mobile Combustion. P. 3-10):

$$Emission = \sum [Fuel_a \cdot EF_a] \quad (4)$$

where:

Emission - emissions of CO_2, kg;

Fuel$_a$ -fuel sold, TJ;

EF$_a$ - emission factor, kg/TJ. This is equal to the carbon content of the fuel multiplied by44/12;

a -type of fuel (petrol, diesel, natural gas).

Emission factor assumes full oxidation of the fuel. Emission equation for CH_4 and N_2O for Tier 3 is:

$$Emission = \sum_{a,b,c,d} \left[Distance_{a,b,c,d} \cdot EF_{a,b,c,d}\right] + \sum_{a,b,c,d} C_{a,b,c,d} \ . \quad (5)$$

where:

Emission - emission of CH_4 or N_2O;

EF$_{a,b,c,d}$ - emission factor, kg/km;

Distance$_{a,b,c,d}$ - distance travelled during termally stabilized engine operation phase, km;

C$_{a,b,c,d}$ - emission during (g) during transient thermal engine operation (cold start), kg;

b – vehicle type;

c – emission control technology;

d – driving situation (urban, rural, highway).

Mileage data

The annual mileage driven by the stock of vehicle per year is an important parameter in emission calculation as it affects both the total emissions calculated but also the relative contributions of the vehicle types considered. Calculations demand annual mileage per vehicle technology and the number of vehicles was supplied by the Lithuanuan Road Administration and study funded by the European Commission – DG Environment and executed in collaboration with, KTI, Renault, E3M-Lab/NTUA, Oekopol, and EnviCon. The source for these data is various European measurement programmes. Fuel consumption was calculated on the basis of appropriate assumptions for annual mileage of the different vehicle categories can be balanced with available fuel statistics (Ntziachristos et al., 2008). In general the COPERT IV v.11 data are transformed into trip-speed dependent fuel consumption and emission factors for all vehicle categories and layers. The calculated fuel consumption in COPERT IV must equal the statistical fuel sale totals according to the UNFCCC and UNECE emissions reporting format. The statistical fuel sales for road transport are derived from the Statistics Lithuania.

For example, if a country has bulk fuel sold but does not have fuel use by vehicle type, they may allocate total fuel consumption across vehicle types based on the consumption patterns of their fleet (TRB's National Cooperative Highway Research Program (NCHRP) project report, Greenhouse Gas Emission Inventory Methodologies for State Transportation Departments). By applying a trial-and-error approach, it was possible to reach acceptable estimates of mileage. For each group, the emissions was estimated by combining vehicle type and annual mileage with hot emission factors, cold/hot ratios and evaporation factors.

Emission factors

Country specific CO_2 EF was developed in 2010 based on research data from the Lithuanian oil refinery (research protocols of UAB ORLEN Lietuva Quality Research Center). Motor gasolines, diesel oil, LPG used in the country are produced by the oil refinery UAB ORLEN Lietuva. Imports of the fuels listed above comprise only a minor fraction of the fuels used in Lithuania.

All mileage depend emission factors for diesel and motor gasoline are listed in the EMEP/EEA Guidebook, 2009. Correction factors were applied to the baseline emission factors for gasoline cars and light-duty vehicles to account for different vehicle age (COPERT IV v11.0). It is assumed that emissions do not further degrade above 120 000 km for Euro 1 and Euro 2 vehicles, and above 160 000 km for Euro 3 and Euro 4 vehicles.

Following the remarks of the ERT, a review of emission factors for mobile sources was undertaken in 2010 (discussion and comparison with EF provided in the literature was presented in National Greenhouse Gas Emission Inventory Report 2010, covering the period 1990-2008). Emission factors for Road transportation used in the Lithuanian national GHG inventory are provided in Tables 3-45.

Table 3-45. Emission factors for Road transportation sector used in the Lithuanian GHG inventory

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Motor gasoline	72.97	CS	T2	-	CR	T3	-	CR	T3
Gas/Diesel oil	72.89	CS	T2	-	CR	T3	-	CR	T3
LPG	65.42	CS	T2	-	CR	T3	-	CR	T3
Biodiesel	70.8	D	T1	10.0	D	T1	0.6	D	T1
Bioethanol	70.8	D	T1	10.0	D	T1	0.6	D	T1

*CR – values modelled using COPERT4

Because fuel prices in Lithuania are higher – significantly, in some cases – than in almost all of neighbours, for some time the fuels used in Lithuania have included fuels purchased in other countries and brought into the country as "grey" imports. At present, no precise data are available on this phenomenon, which is significant for truck and automobile traffic in country border regions and which is referred to as "refuelling tourism".

3.4.2.3 Uncertainties and time-series consistency

The activity data for fuels used in road transportation are very accurate due to accurate total fuel sales statistics. Uncertainty in the activity data is 2%. The uncertainty on activity data for CO_2 emissions from road transport is given in *IPCC GPG* 2000[10], where mentions that this is the main source of uncertainty for CO_2. The uncertainty in road transport CO_2 emission factor is estimated to be ±2.5%. The uncertainty in annual N_2O emissions from road transport is estimated to be ±50%. The estimated uncertainty of the CH_4 emissions from road transport is estimated to be ± 40%. The time series for all data have been studied carefully in search for outliers.

The Tier 3 CH_4 and N_2O emission factors have been derived from experimental (measured) data collected in a range of scientific programmes. The emission factors for old-technology passenger cars and light commercial vehicles were taken from earlier COPERT/CORINAIR activities (Eggleston et al., 1989), whilst the emissions from more recent vehicles are calculated on the basis of data from the Artemis project. (Boulter and Barlow, 2005; Boulter and McCrae, 2007). The emission factors for mopeds and motorcycles are derived from the study on impact assessment of two-wheel emissions (Ntziachristos et al., 2004). Also, the emission factors of Euro 4 diesel passenger cars originate from an ad-hoc analysis of the Artemis dataset, enriched with more measurements (Ntziachristos et al., 2007).

Emission factors proposed for the Tier 3 methodology are functions of the vehicle type (emission standard, fuel, capacity or weight) and travelling speed. These have been deduced on the basis of a large number of experimental data, i.e. individual vehicles which have been measured over different laboratories in Europe and their emission performance has been summarised in a database. Emission factors per speed class are average emission levels of the individual vehicles. As a result, the uncertainty of the emission factor depends on the variability of the individual vehicle measurements for the particular speed class. This uncertainty has been characterized in the report of Kouridis et al. (2009) for each type of vehicle, pollutant, and speed classes. In general, the variability of the emission factors depends on the pollutant, the vehicle type, and the speed class considered. The standard deviations range from a few percentage units of the mean value to more than two times the emission factor value for some speed classes with limited emission information.

The distribution of individual values around the mean emission factor for a particular speed class is considered to follow a log-normal size distribution. This is because negative emission factor values are not possible and the log-normal distribution can only lead to positive values. Also, the lognormal distribution is highly skewed with a much higher probability allocated to values lower than the mean and a long tail that reaches high emission values.

Emissions of N_2O are a function of many complex aspects of combustion and mileage dynamics as well as the type of emission control systems used. During the last decades the stock of Lithuanian diesel passenger cars and heavy-duty vehicles has intensively grown. In the period from 1990 to 2000 the number of diesel-powered vehicles was increased by about 13% per year. As was expected, the linear regression analysis did not provide statistically significant linear

[10]IPCC GPG 2000. Energy. P. 2-49.

relationship between total diesel fuel consumption and N_2O IEF values for the reason that the variation from year to year between sub-sectors and technology differ due to changes in abatement technologies and mileage. For the period between 1990 and 2000, it was necessary to estimate the figures with the aid of numerous scientific assumptions regarding mileage distribution between subsectors. In conjunction with decreasing fuel consumption 1990-1994 the number of diesel powered vehicles was increased (for example, in 1992 the fuel consumption was sharply decreased by 26% while the number of diesel powered vehicles was increased by 13%). We had to make fuel correction by reduce/increase mileage from our initial calculations to match the statistical fuel consumption. The correction for fuel consumption within ± one standard deviation of the official value is very critical as it reduces the uncertainty of the calculation N_2O, conversely good knowledge of the statistical fuel consumption and comparison with the calculated fuel consumption was necessary to improve the quality of the inventory. The uncertainty in annual N_2O emissions from road transport is estimated to be ±50%.

Developing emission factors for CH_4 and N_2O is more difficult because these pollutants require technology-based emission factors rather than aggregate default emission factors. Following in-country review ERT 2012 recommended providing justification of gasoline N_2O IEF fluctuation 2006-2008. Over 1990-2013 period the number of passenger cars (dominant gasoline consumers) increased despite the fact of economic crisis. Therefore, decreasing fuel consumption was balanced by mileage, although N_2O emission exceptionally differ according to the fuel sulphur level (Fig. 3-40) since a regression line of nitrous oxide emission factors against mileage for passenger vehicles yielded a slight not significant slope (Barton and Simpson, 1994):

$$EFN_2O = (a \times Mj,k + b) \times EF_{BASE,} \qquad (2)$$

where,

a, b, EF_{BASE} depend on technology level for gasoline PCs & LCVs

a, b depend on fuel sulfur content

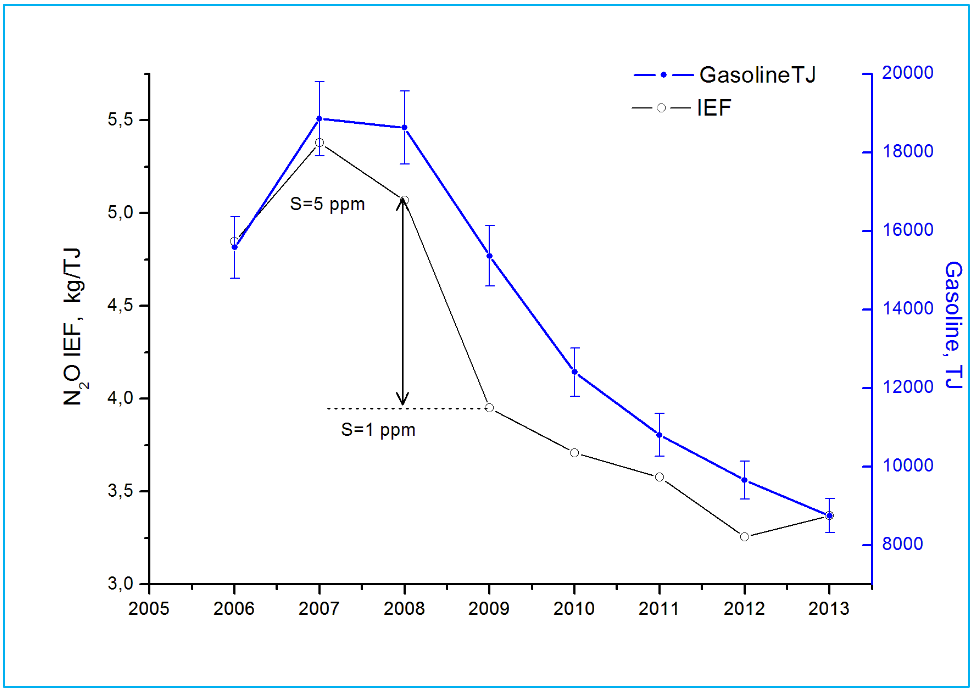


Figure 3-40. Dynamic of Implied Emission Factors of N_2O for gasoline

The fuel consumption slightly decreased in 2007-2013, however the amount of vehicles remain increasing. Lithuanian car fleet consists mainly of 16-20 year old cars (31.3 %) and younger than 10 years – 23.1 %. This means that one of the determining factors is the large proportion of petrol cars fitted with a three-way catalyst. The effect of fuel sulfur is another significant factor that influences the formation of N_2O over the catalyst (Baronick et al., 2000). Since January 2008, Lietuva group's company ORLEN started producing and supplying gasoline which already meets the EU requirements to be effective on January 1st, 2009 with sulfur content less than 10 ppm. The implementation of regulations reducing fuel sulfur levels across the EU in 2008 also reduced N_2O emissions for vehicles of all technology categories[11] .

3.4.2.4 Source-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

3.4.2.5 Source-specific recalculations

No source specific recalculations.

3.4.2.6 Source-specific planned improvements

Fuel consumption factors for road transport vehicles will be updated by the time when new data becomes available from COPERT model updates. Implementation of COPERT 4 11.0 version with a new subsector for very small (<0.8 l) gasoline and (<1.4 l) diesel passenger cars of Euro 4-6 technologies.

[11]TNO, 2002; Riemersma et al., 2003

3.4.3 CO_2 emissions from urea-based catalysts (CRF 2.D.3)

3.4.3.1 Source category description

"AdBlue" urea solution reduces nitrogen oxide emission from auto exhaust system (fitted with SCR technology). The solution is injected to diesel engine exhaust systems before selective reduction catalyst, consequently due to the solution reaction with nitrogen oxide gasses emissions are converted to water vapor and nitrogen. This technology optimizes engine performance by reducing particle emission and maximizing fuel energy generation. Another significant effect of the process is reduced fuel consumption (on average 5 %).

AdBlue is produced according to the German standard DIN 70070 and European standard ISO/PAS 22241-1. Only the product meeting the aforementioned standards may be marked with the AdBlue trademark. AdBlue produced by AB "Achema" and distributed by "Gaschema", the branch of "Achema", is the only certified product of such type in Baltic region.

The Euro V step was introduced in 2008 October and the Euro VI step in 2013 September. Euro V introduced SCR to the majority of heavy duty engines.

3.4.3.2 Methodological issues

Tier 3 category specific method assuming 1-3% of diesel consumption for vehicles using urea as a selective catalytic reduction agent (SCR) supplemented by guidance for ammonia emissions from the EMEP-EEA Guidebook 2013. This requires detailed knowledge of the diesel fleet to estimate the number of SCR vehicles and their fuel use. COPERT and TREMOVE provided defaults for the necessary detail of fleet make-up for European fleets. The 2006 GL suggest urea consumption can be estimated as 1-3% of diesel consumed by vehicles using urea (as an SCR agent).

$$E_{CO2} = Activity \cdot \frac{12}{60} \cdot Purity \cdot \frac{44}{12}. \quad (3)$$

Where:

ECO_2 = CO_2 emissions from urea-based additive in catalytic converters (kt CO_2),

Activity = amount of urea-based additive consumed for use in catalytic converters (kt),

Purity = the mass fraction (= percentage divided by 100) of urea in the urea-based additive.

The factor (12/60) captures the stochiometric conversion from urea ($CO(NH_2)_2$) to carbon, while factor (44/12) converts carbon to CO_2. On the average, the activity level is 1 to 3 percent of diesel consumption by the vehicle. Thirty two and half percent can be taken as default purity in case country-specific values are not available (Peckham, 2003). As this is based on the properties of the materials used, there are no tiers for this source.

Tier 3 category specific method assuming 3% of diesel consumption for vehicles using urea as a SCR (EMEP-EEA Guidebook). This share was obtained by COPERT model in the diesel consumption for Euro V and VI catalysts equipped cars (cars, trucks, buses, mobile machinery).

3.4.3.3 Uncertainties and time-series consistency

Expert judgement suggests that the uncertainty of the CO_2 estimate is approximately ±10 %, based on studies with reliable fuel statistics. The primary source of uncertainty is the activity data rather than emission factors.

3.4.4 Railways (CRF 1.A.3.c)

3.4.4.1 Source category description

In 2013, the operational length of railways amounted to 1767.6 km. The length of electrified lines remained unchanged (122 km).

In 2013, compared to 2012, the number of railway vehicles increased: that of locomotives by 5.5, wagons – 1, coaches (including diesel and electric railcars) – 2.2 %. 66 % of locomotives, 77 % of coaches (including diesel and electric railcars) and 87 % of wagons were produced 15 and more years ago.

Emissions of railway transportation comprise railway transport operated by diesel locomotives. In 2011 electric locomotives run only 0.7 % of railway transportation in Lithuania. Most locomotives (70 %), 81 % of coaches and 91 % of wagons were produced 15 and more years ago. Emissions from producing electricity used in electric trains are not included this category, but in category 1.A 1.

Lithuanian Railways (*Lithuanian*: "Lietuvos Geležinkeliai") is the national, state-owned railway company of Lithuania. Lithuanian's trains operate frequent services across the whole of Lithuania (Fig. 3-41).

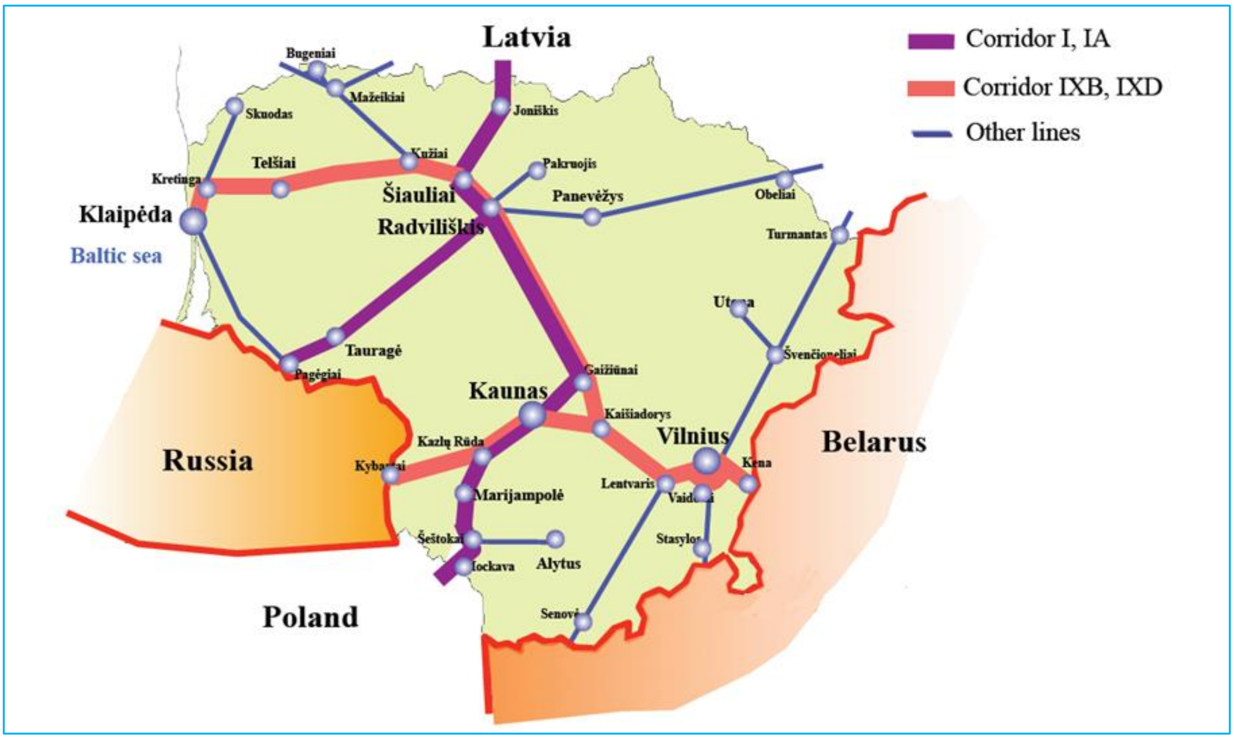


Figure 3-41. Lithuanian railways network

In 2013, goods transport by rail amounted to 48 million tonnes, which is by 2.7 % less than in 2012. National goods transport by rail amounted to 15.1 million tonnes, which is by 1.6 % more than in 2012; international goods transport by rail amounted to 32.9 million tonnes, which is by 4.6 % less than in 2012. In 2013, 32.3 % of all the goods carried by rail (15.5 million tonnes) were coke and refined petroleum products; compared to 2012, their carriage decreased by 7.1 %.

Chemicals, chemical products and man-made fibres, rubber and plastic products carried by rail amounted to 11.2 million tonnes, or 23.4 % of all the goods carried; compared to 2012, their carriage decreased by 15.6 %. Metal ores and other mining and quarrying products, peat, uranium and thorium amounted to 5.8 million tonnes, or 12.1 % of all the goods carried by rail; compared to 2012, their carriage increased by 30.4 %.

The major proportion of goods was carried from Belarus (62.1 %) and Russia (26.4 %). Most goods from Lithuania were carried to Latvia (22.2 %), Belarus (19.8 %), and Ukraine (17.5 %). In 2013, the number of passengers carried by rail totalled 4.8 million, which is by 0.9 % more than in 2012. In 2013, passenger-kilometres amounted to 391 million, which is by 3 % less than in 2012. In 2013, compared to 2012, national passenger transport increased by 0.7, international transport – by 1.6 %. In 2013, compared to 2012, the number of arriving passengers increased by 12.9 %, that of departing passengers by 16.6 %. The majority of passengers departed to (70.1 %) and arrived from (68.3 %) Belarus. Fuel consumption 1990-2013 for railways, based on energy statistics from Statistics Lithuania is shown in Figure 3-42.

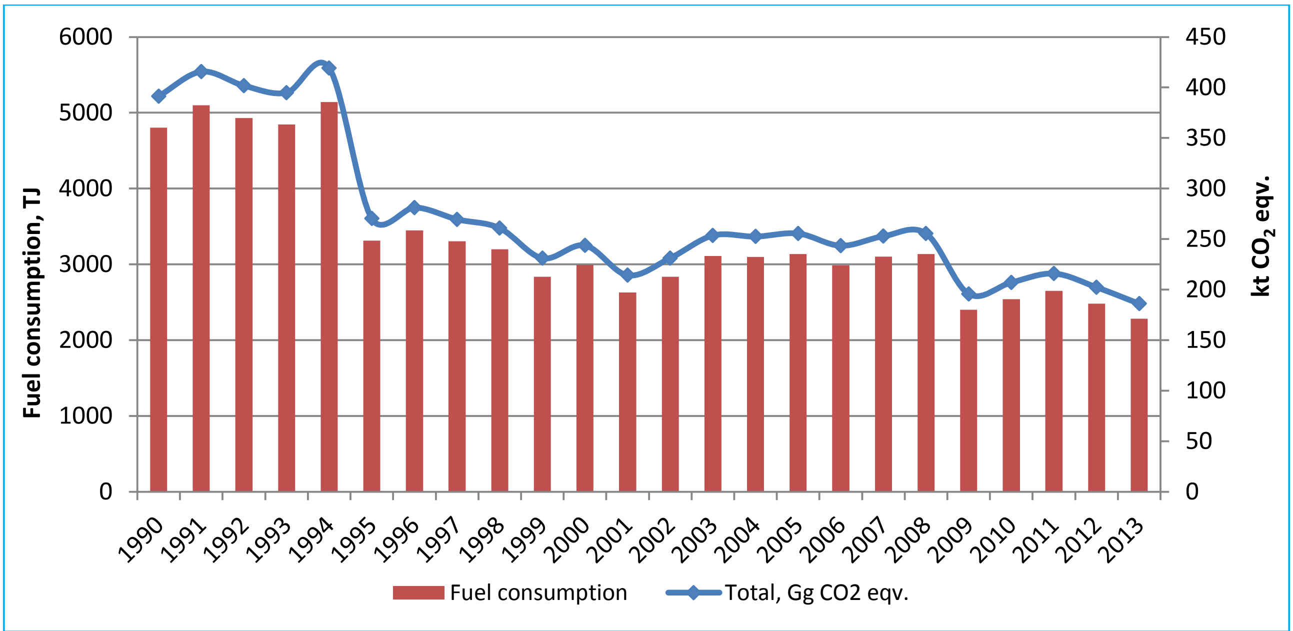


Figure 3-42. Trend of GHG emissions in Railways sector

The trend of kt CO_2 eq. emissions follows in general the fuel consumption trend in the railway transportation sector. The Lithuanian railway transport has suffered two obvious downturns within the last two decades, the first relating to Lithuania's separation from the Soviet Union and the second one – to the global financial and economic crisis.

3.4.4.2 Methodological issues

CO_2 emission calculations are based on the Tier 2 methodology with country specific emission factors and CH_4 and N_2O on default Tier 1 methodology (2006 IPCC Guidelines for National Greenhouse Gas Inventories: Mobile Combustion). Currently, the Tier 2 methodology for CH_4 and N_2O emissions will not be used throughout the lack of activity data. Emissions of railway transport sector are calculated by multiplying the statistical fuel consumption by respective emission factors assuming that for each fuel type the total fuel is consumed by a single locomotive type.

Tier 2 uses equation (5) with country-specific data on the carbon content of the fuel (*IPCC Guidance* 2006. Energy. Mobile Combustion. P. 3.41):

$$Emission = \sum_{j} (Fuel_j \cdot EF_j). \tag{4}$$

where:

Emission - emissions, kg;

$Fuel_j$ - fuel type *j* consumed (as represent by fuel sold), TJ;

EF_j - emission factor for fuel type *j*, kg TJ^{-1};

j - fuel type.

Activity data

The data about fuel consumption of diesel are obtained from official statistics (Statistics Lithuania).

Emission factor

The emission factors used in the calculation of emissions from Railway transportation are presented in Table 3-46

Table 3-46. Emission factors for Railways sector used in the Lithuanian GHG inventory

Fuel	**CO_2**			**CH_4**			**N_2O**		
	CO_2, kg/GJ	**EF**	**Method**	**CH_4, kg/TJ**	**EF**	**Method**	**N_2O, kg/TJ**	**EF**	**Method**
Diesel oil	72.89	CS	T2	4.15	D	T1	28.6	D	T1

Emissions from electricity used in electric trains are not included in this category, but in category 1.A 1. Emissions of railway transportation were 0.19 Tg (CO_2 eq.) in 2011, it was only 4.3% of the *Transport* sector emissions. The emissions were 0.35 Tg (CO_2 eq.) in 1990. Substantial decrease from the year 2008 is caused by the ongoing economic depression.

3.4.4.3 Uncertainties and time-series consistency

The uncertainty in activity data (fuel use) is 5%. Uncertainties in CH_4 and N_2O emission factors are larger than those in CO_2 (±5%). *IPCC Guidance* 2006 refers that the uncertainty range for the default factors for Tier 1 method is estimated to be +50%/-100%. The time series for all data have been studied carefully in search for outliers.

3.4.4.4 Source-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

3.4.4.5 Source-specific recalculations

N_2O and CH_4 emissions were recalculated according to default emission factor by 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Mobile Combustion 3.43. TABLE 3.4.1.

3.4.4.6 Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

3.4.5 Water borne navigation (CRF 1.A.3.d)

Lithuania has ~900 km of inland waterways. Inland waterways are navigable rivers, canals, lakes, man-made water bodies, and part of the Curonian Lagoon belonging to the Republic of Lithuania. Lenght of inland waterways regularly used for transport in Lithuania equalled 452 km in 2013. In 2013, transport of goods by inland waterways amounted to 1076.7 thousand tonnes, which is by 2.6 % more than in 2012. In 2013, compared to 2012, passenger transport by inland waterways increased by 7.8 %.

As seen in Figure 3-43 fuel consumption decreased by 14.9% between 2005 and 2013. This decrease is obviously due to the impact of the decreased fuel consumption in inland waterways.

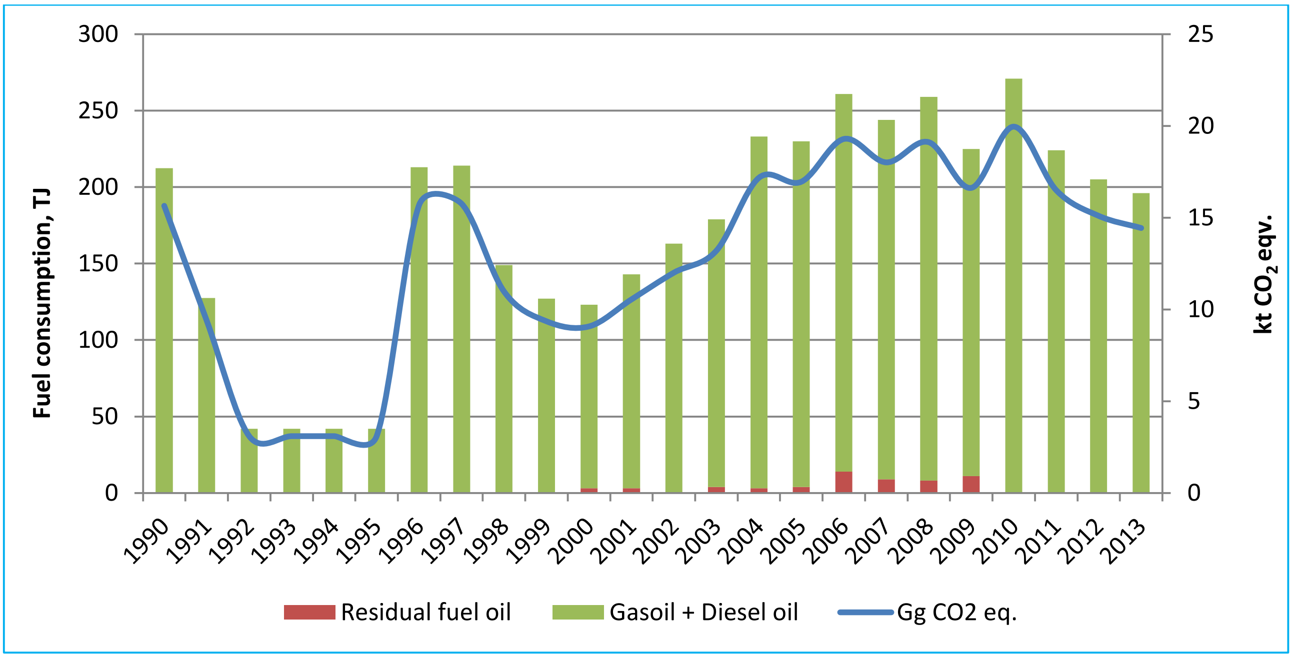


Figure 3-43. Trend of GHG emissions in Water navigation sector

3.4.5.1 Source category description

Inland waterways are navigable rivers, canals, lakes, man-made water bodies, and part of the Curonian Lagoon belonging to the Republic of Lithuania. Emissions of domestic navigation were 0.014 Tg (CO_2 eq.) in 2013, it was ~0.4% of the sector's emissions. Emissions were 0.017 Tg (CO_2 eq.) in 2005.

3.4.5.2 Methodological issues

Tier 1 method was applied with default and country specific (for CO_2 and CH_4) values (Tables 3-23-24). The existing default Tier 2 approach provided in the *IPCC Guidelines* provides only limited benefits over the Tier 1 approach:

$$Emission = \sum (FuelConsumed_{ab} \cdot EF_{ab}) \, . \quad (7)$$

where:

Emission - emissions, kg;

EF_j - emission factor for fuel type, kg TJ^{-1};

a - fuel type;

b - water-borne navigation type. At Tier 1 fuel used differentiation by type of vessel can be ignored) (*IPCC Guidelines* 2006. Energy. Mobile Combustion. P. 3.47).

Activity data

Data of fuel consumption are obtained from official statistics (Statistics Lithuania) excluding fishing vessels.

Emission factors

Emission factors used in the calculation of emissions from *Water-borne navigation* are presented in Tables 3-47.

Table 3-47. Emission factors for Water-borne navigation sector used in the Lithuanian GHG inventory

Fuel	**CO_2**			**CH_4**			**N_2O**		
	CO_2, kg/GJ	**EF**	**Method**	**CH_4, kg/TJ**	**EF**	**Method**	**N_2O, kg/TJ**	**EF**	**Method**
Residual Fuel Oil	77.60	CS	T2	7.0	D	T1	2.0	D	T1
Gasoil and Diesel oil	72.89	CS	T2	7.0	D	T1	2.0	D	T1

3.4.5.3 Uncertainties and time-series consistency

The uncertainty in activity data (fuel use) is 5%. The uncertainty value of CO_2 is ± 3%. The uncertainty of the N_2O emission factor -40 – +140% and CH_4± 50% (2006 *IPCC Guidelines*).

3.4.5.4 Source-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

3.4.5.5 Source-specific recalculations

No source specific recalculations

3.4.5.6 Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

3.4.6 Other (CRF 1.A.3.e; 1.A.5.b)

3.4.6.1 Natural gas transportation in pipelines (1.A.3.e)

In Lithuania, natural gas is transported via gas transmission and distribution systems (Fig. 3-44) Statistics Lithuania started collecting data on consummption of natural gas used for gas transportation in pipeline compressor staitions from 2001.

AB "Lietuvos Dujos" is the operator of Lithuania's natural gas transmission system in charge of the safe operation, maintenance and development of the system. The transmission system is comprised of gas transmission pipelines, gas compressor stations, gas metering and distribution stations (Table 3-48).

Table 3-48. Lithuanian natural gas transmission system

Gas transmission pipelines	**Gas distribution stations**	**Gas metering stations**	**Gas compressor stations**
1.9 thous. km	65 stations	3 stations	2 stations

Figure 3-44. Gas distribution network in Lithuania

3.4.6.1.1 Source category description (1.A.3.e)

Transport via pipelines includes transport of gases via pipelines.

3.4.6.1.2 Methodological issues (1.A.3.e)

Activity Data

Statistics Lithuania has started collecting data on consumption of natural gas used for gas transportation in pipeline compressor stations from 2001. For the period prior to 2001 data on use of natural gas for transmission are not available.

The surrogate method to estimate unavailable data during 1990-2000 was used since the extrapolation approaches should not be done to long periods and inconsistent trend. To evaluate more accurate relationships the regression analysis was developed by relating emissions to more than one statistical parameter. The relationship between gas pipeline emissions and surrogate data was developed on the basis of underlying activity data during multiple years.

Emission factors

Emission factors used in the calculation of emissions from *Natural gas transportation in pipelines* are presented in Table 3-49.

Table 3-49. Emission factor for Natural gas transportation in pipelines sector used in the Lithuanian national GHG inventory

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Natural gas	55.23	CS	T	1.0	D	T2	0.1	D	T1

3.4.6.1.3 Uncertainties and time-series consistency

The uncertainty in activity data (fuel use) is 5%. CO_2 emission factor uncertainty is ±7% based on *IPCC 1996* Guidelines. The uncertainty of the N_2O and CH_4 emission factor is± 50% (2006 *IPCC Guidelines*).

3.4.6.1.4 Source-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

3.4.6.1.5 Source-specific recalculations

No source specific recalculations

3.4.6.1.6 Source-specific planned improvements

No improvements are planned.

3.4.6.2 Off-road vehicles and other machinery (1.A.3.E)

3.4.6.2.1 Source category description (1.A.3.e)

The off-road category includes vehicles and mobile machinery used within the agriculture, forestry, industry (including construction and maintenance), residential, and sectors, such as agricultural tractors, chain saws, forklifts, snowmobiles (2006 *IPCC Guidelines*).

3.4.6.2.2 Methodological issues

IPCC 2006 Guidelines for National Greenhouse Gas Inventories Tier1 Sectoral approach was used to calculate GHG emissions from the 1.A.3.e sector.

Activity Data

Data on fuel consumption by off-road vehicles and machinery in industry, construction, agriculture, fishery and forestry are not collected separately and provided in statistical reports but included in overall fuel consumption by separate sectors (industry, construction, agriculture). Consumption of motor gasoline and diesel oil in these sectors as shown in energy balances provided by the Statistics Lithuania actually should be assigned to consumption by off-road machinery. Therefore consumption of motor gasoline and diesel oil can be separated from other fuels and emissions caused by off-road vehicles can be calculated from these data.

Emission factors

Emission factors for off-road vehicles and machinery sector used in the Lithuanian GHG inventory are provided in tables 3-50.

Table 3-50. Emission factors for Off-road vehicles and other machinery sector used in the Lithuanian national GHG inventory

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Motor gasoline	72.97	CS		65	D		4.15	D	
Diesel oil	72.89	CS		2	D		28	D	

3.4.6.2.3 Uncertainties and time-series consistency

GHG emissions from off-road sources are typically much smaller than those from road transportation, but activities in this category are diverse and are thus typically associated with higher uncertainties because of the additional uncertainty in activity data. Uncertainty in activity data is determined by the accuracy of the surveys 10%. The uncertainty estimate is likely to be dominated by the activity data. The uncertainty on CO_2 emission factor from off-road transport is given in *IPCC GPG* 2000 ±5%). The uncertainty in N_2O emission factor from off-road transport is estimated to be ±50% and CH_4 is estimated to be ±40%. The time series for all data have been studied carefully in search for outliers.

3.4.6.2.4 Source-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

3.4.6.2.5 Source-specific recalculation

No source specific recalculations

3.4.6.2.6 Source-specific planned improvements

No improvements are planned.

3.4.6.3 Military aviation (1.A.5.b)

3.4.6.3.1 Source category description

Military activity is defined here as those activities using fuel purchased by or supplied to the military authorities of the country.

3.4.6.3.2 Methodological issues

The 2006 *IPCC Guidelines* Tier 1 approach has been applied. Emission factors for aviation sources used in the Lithuanian national GHG inventory are provided in Table 3-36, 3-37, 3-38. Country specific CO_2 EF was developed in 2010 based on research data from the Lithuanian oil refinery (research protocols of UAB ORLEN Lietuva Quality Research Center). Jet kerosene used in the country is produced by the oil refinery UAB ORLEN Lietuva.

Activity data

Statistical reports are based on information provided by the fuel suppliers. No statistical data are available for fuel consumption for military mobile sources. Data on jet kerosene used for military in Lithuania is available starting from 2001. Data for 1990-2000 were extrapolated.

Emission factors

Emission factors used in the calculation of emissions from *Military aviation* transportation are presented in Tables 3-41 (chapter 3.4.1).

3.4.6.3.3 Uncertainties and time-series consistency

Uncertainty in activity data of aviation fuel consumption in military aviation is ±2%. According to expert judgment, CO_2 emission factors for fuels are generally well determined as they are primarily dependent on the carbon content of the fuel (EPA, 2004). CO_2 emission factor (uncertainty 2%) was estimated according physical characterization of used fuels in country based on average NCV and emission factors of jet kerosene reported by ORLEN Lietuva. CH_4 emission factor used in estimation of emissions was taken from IPCC (2006) so uncertainty was assigned about ±100% and 150% for N_2O. The time series for all data have been studied carefully in search for outliers.

3.4.6.3.4 Source-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

3.4.6.3.5 Source-specific recalculation

Country specific EF based on "Greenhouse gas emissions characteristics of national energy sector" study, 2012 for avgas CO_2 was applied. The default emission factor for CH_4 and N_2O was applied and new activity data from Statistics Lithuania was revised.

3.4.6.3.6 Source-specific planned improvements

No improvements are planned.

3.5 Other sectors (CRF 1.A.4)

3.5.1 Commercial/institutional (CRF 1.A.4.a)

3.5.1.1 Source category description

Commercial and institutional sector encompasses the following activities in Lithuania: wholesale and retail trade, maintenance of motor vehicle and motorbikes, repairing of household equipments, hotels and restaurants, financial intermediation, real estate management and rent, public management and defence, mandatory social security, education, health treatment and social work, other public, social and individual services, as well private households related activities. Analysis of the structure of value added has showed that commercial and institutional sector creates more than half of the total value added created in the country. Since 1995 the share has been annually increasing from 57.6% (1995) till 67.6% (2009). In 2013 the share of value added in commercial / institutional sector reduced till 66.7%. Retail, wholesale trade, transport, accommodation and catering services' sector is the largest sector prescribed to this category. With reference to data of 2013, it created 32.8% of total value added in the country.

3.5.1.2 Methodological issues

CO_2 emissions were calculated applying Tier 2, CH_4 and N_2O were calculated applying Tier 1 or Tier 2 (as presented in Table 3-38) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Commercial/institutional sector (1.A.4.a) are presented in Table 3-51.

Table 3-51. Emission factors and methods for category Commercial/institutional sector (1.A.4.a)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Shale oil	77,40	CS	T2	10,0	D	T1	0,6	D	T1
Residual fuel oil	77,60	CS	T2	10,0	D	T1	0,6	D	T1
LPG	65,42	CS	T2	5,0	D	T1	0,1	D	T1
Gasoil	72,89	CS	T2	10,0	D	T1	0,6	D	T1
Charcoal	109,90	CS	T2	200,0	D	T1	1,0	D	T1
Coking coal	94,90	CS	T2	10,0	D	T1	1,5	D	T1
Anthracite	106,55	CS	T2	10,0	D	T1	1,5	D	T1
Sub-bituminous coal	96,00	CS	T2	10,0	D	T1	1,5	D	T1
Lignite	101,20	CS	T2	10,0	D	T1	1,5	D	T1
Natural gas	55,23	CS	T2	5,0	D	T1	0,1	D	T1
Peat	104,34	CS	T2	10,0	CS	T2	1,4	CS	T2

Wood/ wood waste	109,90	CS	T2	250,0	CS*	T2	4,0	D	T1
Other solid biomass	109,90	CS	T2	250,0	CS*	T2	4,0	D	T1
Biogas	58,45	CS	T2	5,0	CS	T2	0,1	CS	T2

Abbreviations: CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute; D - default emission factors (2006 IPCC); T1 - Tier 1; T2 - Tier 2. CS* - country specific emission factors are based on internationally referenced sources and EFs from neighbouring countries appropriate to Lithuania's national circumstances. These EFs were estimated following recommendation provided by ERT in 2013 (Report of the individual review of the annual submission of Lithuania submitted in 2013, paragraph 31).

Activity data

For calculation of GHG emissions in category Commercial/ institutional sector (1.A.4.a) activity data had been obtained from the Lithuanian Statistics database (http://www.stat.gov.lt/lt/). Activity data are provided in the Annex III.

Tendencies of fuel consumption and total GHG emissions in Commercial / institutional sector is presented in Figure 3-45.

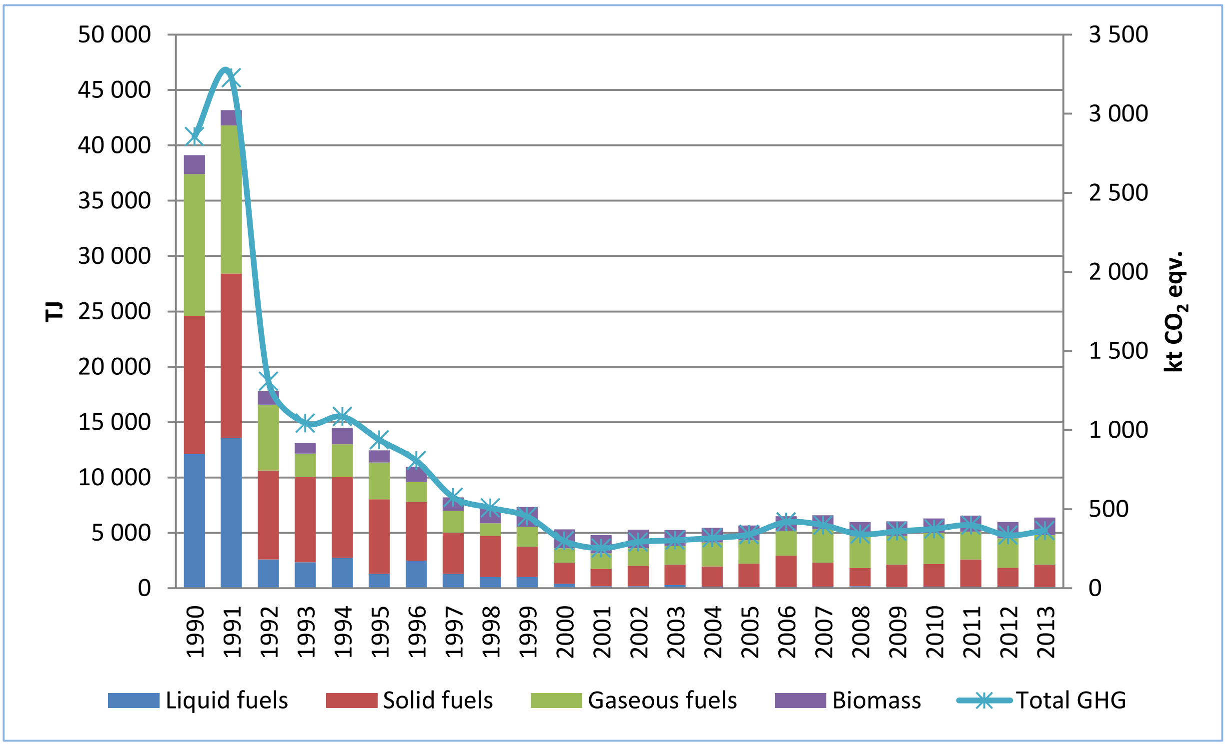


Figure 3-45. Tendencies of fuel consumption and total GHG emissions in Commercial / institutional sector (1.A.4.a)

After the drastically reduced fuel consumption volume in Commercial / institutional sector during 1990-2000, later (2001-2007) fuel consumption volumes was increasing by 5,5% a year. However, during the time of global economic crisis fuel consumption volumes was further reduced by 4,8%. In 2013 there was consumed 6,37 PJ of fuel in Commercial / institutional sector. This was by 6,7% more than in 2012. In 2013, natural gas accounted 41,7% in the fuel structure, solid fuels – 31,6%, biomass – 24,7% and liquid fuels – 2,0%.

In 2013, total GHG emissions from Commercial / institutional sector were even 7,8 times lower than in 1990 and amounted 364,1 kt CO_2 eqv.

3.5.1.3 Uncertainties and time-series consistency

Uncertainty in activity data in Commercial/ institutional sector is ±3% taking into consideration recommendations provided by IPCC 2006 Guidelines for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±50% as recommended by 2006 IPCC.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.5% in Commercial / institutional sector. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and lignite) are ±7%. Estimated uncertainties of CO_2 emission factors for biomass are ±50%. Uncertainties of all country specific CO_2 emission factors are derived in the study "Determination of national GHG emission factors for Lithuanian energy sector".

Uncertainties of CH_4 and N_2O emission factors for liquid, solid and gaseous fuels were assigned as very high about ±50%. Uncertainties were derived considering IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.5.1.4 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

The consumption of every type of fuel has been checked and compared with other available data sources (EUROSTAT). The time series for all data have been studied carefully and compared with economic activity of the sector in order to search for outliers.

The results are verified by calculating CO_2 emissions with the reference approach, and comparing results with the sectoral approach.

3.5.1.5 Source-specific planned improvements

Source-specific improvements are not planned.

3.5.2 Residential sector (CRF 1.A.4.b)

3.5.2.1 Source category description

The number of dwellings remains quite stable during last decade and on average there are 1.3 million dwellings in Lithuania. Increase of the number of dwellings in Lithuania depends very much on demographical situation in the country. Since 1992 the number of inhabitants has decreased in Lithuania. The average floor area per each dwelling increases annually: in 2004, the average area of useful floor for each dwelling was 60.8 m^2, in 2013 – 66.9 m^2. With reference to data of 2013, 70% of all dwellings are situated in Lithuanian cities, where large multifamily buildings dominate in urban areas.

Taking into account actual heat consumption, Lithuanian District Heating Association grouped Lithuanian multifamily houses according to kWh/m^2 during a month into four categories:

- Multifamily houses of new construction and with high thermal isolation - 8 kWh/m^2/month
- Multifamily houses of old construction after full renovation - 15 kWh/m^2/month
- Multifamily houses of old construction and still not renovated - 25 kWh/m^2/month
- Multifamily houses of old construction and with poor thermal isolation - 35 kWh/m^2/month

90.8% of dwellings located in urban areas had central heating systems in 2009, while only 42.8% of Lithuanian dwellings set in rural territories can take advantage of this service. On average in 77% of Lithuanian dwellings piped water is installed, but only 62% can profit from convenience which hot water provides (Lithuanian Statistics, 2010).

3.5.2.2 Methodological issues

CO_2 emissions were calculated applying Tier 2, CH_4 and N_2O were calculated applying Tier 1 or Tier 2 (as presented in Table 3-39) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Residential sector (1.A.4.b) are presented in Table 3-52.

Table 3-52. Emission factors and methods for category Residential sector (1.A.4.b)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Residual fuel oil	77,60	CS	T2	10,0	D	T1	0,6	D	T1
LPG	65,42	CS	T2	5,0	D	T1	0,1	D	T1
Gasoil	72,89	CS	T2	10,0	D	T1	0,6	D	T1
Coking coal	94,40	CS	T2	300,0	D	T1	1,5	D	T1
Anthracite	106,55	CS	T2	300,0	D	T1	1,5	D	T1
Sub-bituminous coal	96,00	CS	T2	300,0	D	T1	1,5	D	T1
Lignite	101,20	CS	T2	300,0	D	T1	1,5	D	T1
Natural gas	55,23	CS	T2	5,0	D	T1	0,1	D	T1
Peat	104,34	CS	T2	300,0	CS	T2	1,4	CS	T2
Wood/ wood waste	109,90	CS	T2	260,0	CS*	T2	4,0	D	T1

Other solid biomass	109,90	CS	T2	260,0	CS*	T2	4,0	D	T1

Abbreviations: CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute; D - default emission factors (2006 IPCC); T1 - Tier 1; T2 - Tier 2. CS* - country specific emission factors are based on internationally referenced sources and EFs from neighbouring countries appropriate to Lithuania's national circumstances. These EFs were estimated following recommendation provided by ERT in 2013 (Report of the individual review of the annual submission of Lithuania submitted in 2013, paragraph 31).

Activity data

For calculation of GHG emissions in category Residential sector (1.A.4.b) activity data had been obtained from the Lithuanian Statistics database (http://www.stat.gov.lt/lt/). Activity data are provided in the Annex III.

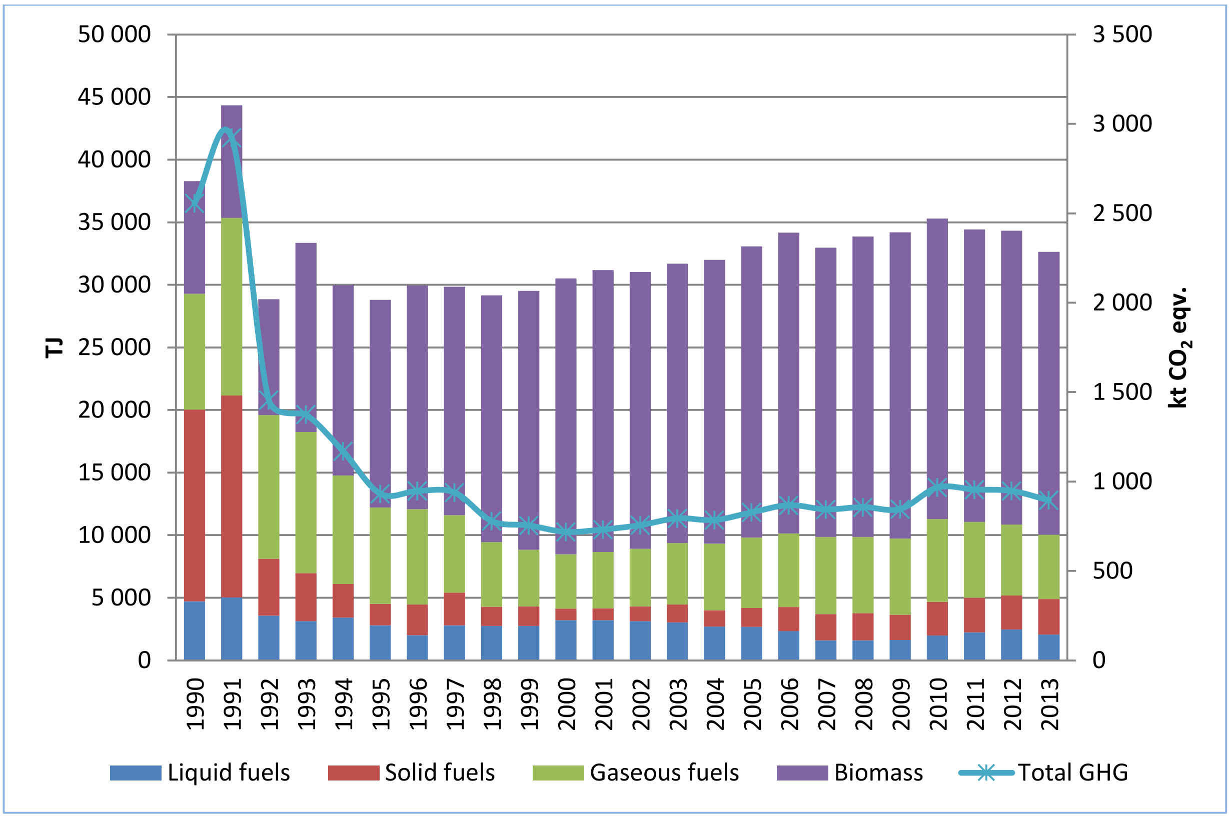


Figure 3-46. Tendencies of fuel consumption and total GHG emissions in Residential sector (1.A.4.b)

As it is seen from Figure 3-46, biomass dominates in the structure of fuel consumed in Residential sector. Biomass accounted 69,2%, natural gas - 15,8%, solid fuels - 8,6%, liquid fuels - 6,3% of fuel structure in 2013.

In 2013, total GHG emissions from Residential sector were 2,8 times lower than in 1990 and amounted 895,4 Kt CO_2 eqv.

3.5.2.3 Uncertainties and time-series consistency

Uncertainty in activity data in Residential sector is ±3% taking into consideration recommendations provided by IPCC 2006 Guidelines for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±50% as recommended by 2006 IPCC.

Uncertainties of CO_2 emission factors for liquid fuels (residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.5% in Residential sector. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and lignite) are ±7%. Estimated uncertainties of CO_2 emission factors for biomass are ±50%. Uncertainties of all country specific CO_2 emission factors are derived in the study "Determination of national GHG emission factors for Lithuanian energy sector".

Uncertainties of CH_4 and N_2O emission factors for liquid, solid and gaseous fuels were assigned as very high about ±50%. Uncertainties were derived considering IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.5.2.4 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

The consumption of every type of fuel has been checked and compared with other available data sources (EUROSTAT). The time series for all data have been studied carefully in order to search for outliers.

The results are verified by calculating CO_2 emissions with the reference approach, and comparing results with the sectoral approach.

3.5.2.5 Source-specific planned improvements

Source-specific improvements are not planned.

3.5.3 Agriculture/forestry/fisheries sector (CRF 1.A.4.c)

3.5.3.1 Source category description

Agricultural, forestry and fisheries sector has developed at very moderate rates in Lithuania during 1995-2008. Value added created has been increasing by 1.0% a year. The global economic crisis adjusted growth rates at a negative direction. i.e. value added has decreased by 6.8% in 2010. Value added in agricultural, forestry and fisheries sector increased by 8.2% in 2011. With reference to data of 2013, this sector created 3.4% of total GDP. This is by 0.2 percentage points less than in 2012.

3.5.3.2 Agriculture/forestry/fishing sector - Stationary (CRF 1.A.4.c.i)

3.5.3.2.1 Methodological issues

CO_2 emissions were calculated applying Tier 2, CH_4 and N_2O were calculated applying Tier 1 or Tier 2 (as presented in Table 3-40) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Agriculture/forestry/fishing sector - Stationary (1.A.4.c.i) are presented in Table 3-53.

Table 3-53. Emission factors and methods for category Agriculture/forestry/fishing sector - Stationary (1.A.4.c.i)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Shale oil	77,40	CS	T2	10,0	D	T1	0,6	D	T1
Residual fuel oil	77,60	CS	T2	10,0	D	T1	0,6	D	T1
LPG	65,42	CS	T2	5,0	D	T1	0,1	D	T1
Gasoil	72,89	CS	T2	10,0	D	T1	0,6	D	T1
Coking coal	94,90	CS	T2	300,0	D	T1	1,5	D	T1
Anthracite	106,55	CS	T2	300,0	D	T1	1,5	D	T1
Sub-bituminous coal	96,00	CS	T2	300,0	D	T1	1,5	D	T1
Natural gas	55,23	CS	T2	5,0	D	T1	0,1	D	T1
Peat	104,34	CS	T2	300,0	CS	T2	1,4	CS	T2
Wood/ wood waste	109,90	CS	T2	250,0	CS*	T2	4,0	D	T1
Other solid biomass	109,90	CS	T2	250,0	CS*	T2	4,0	D	T1
Biogas	58,45	CS	T2	5,0	CS	T2	0,1	CS	T2

Abbreviations: CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute; D - default emission factors (2006 IPCC); T1 - Tier 1; T2 - Tier 2.CS* - country specific emission factors are based on internationally referenced sources and EFs from neighbouring countries appropriate to Lithuania's national circumstances. These EFs were estimated following recommendation provided by ERT in 2013 (Report of the individual review of the annual submission of Lithuania submitted in 2013, paragraph 31).

Activity data

For calculation of GHG emissions in category Agriculture/forestry/fishing sector - Stationary (1.A.4.c.i) activity data had been obtained from the Lithuanian Statistics database (http://www.stat.gov.lt/lt/). Activity data are provided in the Annex III.

Tendencies of fuel consumed and total GHG emission in Agriculture/forestry/fishing sector - Stationary are presented in Figure 3-33.

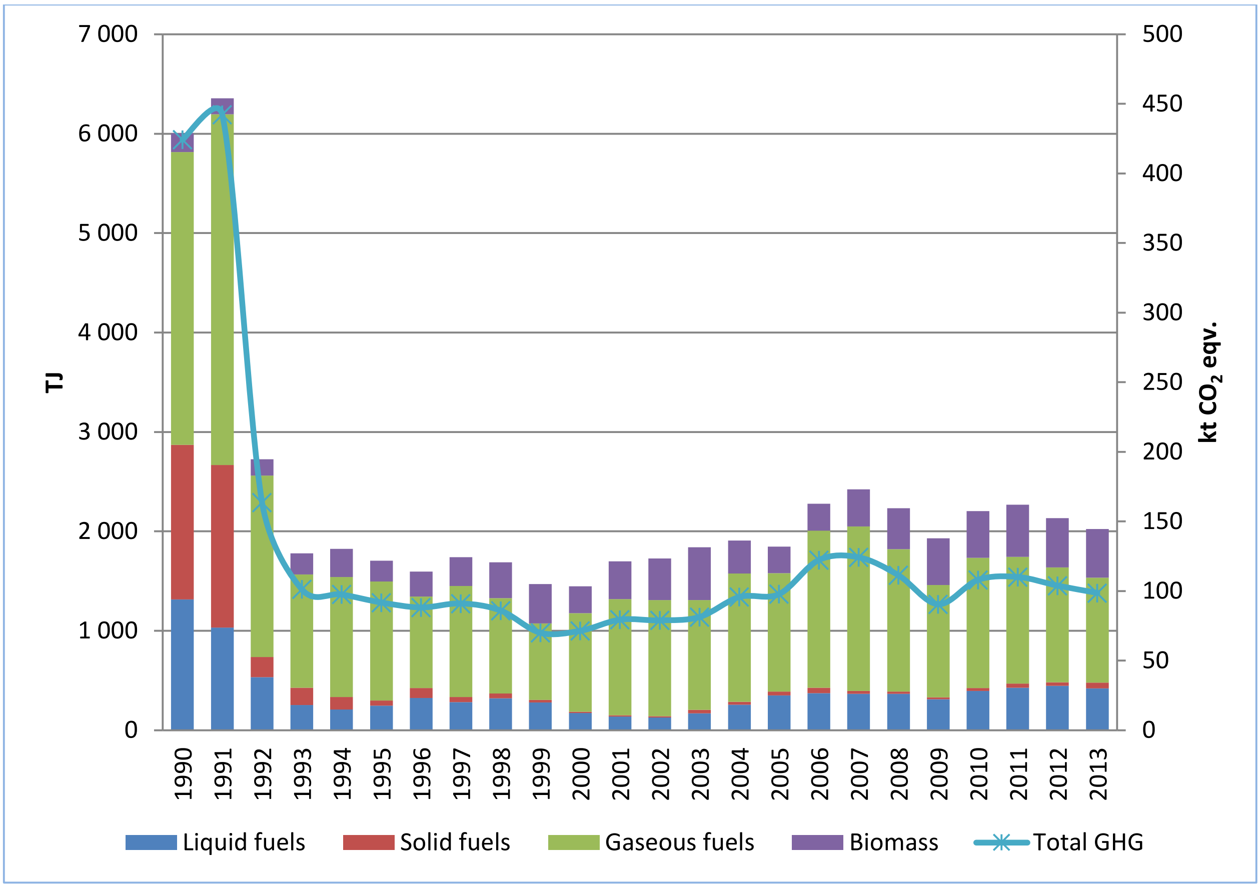


Figure 3-47. Tendencies of fuel consumed and total GHG emissions in Agriculture/forestry/fishing sector - Stationary (1.A.4.c.i)

Figure 3-47 showed that during the rapid economy development period (2000-2007) fuel consumption had a tendency to increase by 4,2% a year. During the time of global economic crisis (2008-2009) fuel consumption in Agriculture/forestry/fishing sector (1.A.4.c.i) reduced by 11,7%. In 2010 fuel consumption increased by 9,4%. In 2013, natural gas made the largest share in the structure of fuel – 52,3%. The share of biomass was 24,1%, liquid fuel – 20,8% and solid fuel – 2,8%.

In 2013, total GHG emissions from Agriculture/forestry/fishing sector (1.A.4.c.i) were 4,3 times lower than in 1990 and amounted 98,6 kt CO_2 eqv.

3.5.3.2.2 Uncertainties and time-series consistency

Uncertainty in activity data in Agriculture/forestry/fishing sector is ±2% taking into consideration recommendations provided by IPCC GPG 2000 and IPCC 2006 Guidelines for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±50% as recommended by 2006 IPCC.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.5% in Agriculture/forestry/fishing sector. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal) are ±7%. Estimated uncertainties of CO_2 emission factors for biomass are ±50%. Uncertainties of all country specific CO_2 emission factors are derived in the study "Determination of national GHG emission factors for Lithuanian energy sector".

Uncertainties of CH_4 and N_2O emission factors for liquid, solid and gaseous fuels were assigned as very high about ±50%. Uncertainties were derived considering IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.5.3.2.3 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

The consumption of every type of fuel has been checked and compared with other available data sources (EUROSTAT). The time series for all data have been studied carefully in order to search for outliers.

The results are verified by calculating CO_2 emissions with the reference approach, and comparing results with the sectoral approach.

3.5.3.2.4 Source-specific planned improvements

Source-specific improvements are not planned.

3.5.3.3 Agriculture/forestry/fishing sector - Off-road Vehicles and Other Machinery (CRF 1.A.4.c.ii)

3.5.3.3.1 Methodological issues

CO_2 emissions were calculated applying Tier 2, CH_4 and N_2O were calculated applying Tier 1 or Tier 2 (as presented in Table 3-41) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Agriculture/forestry/fishing sector - Off-road Vehicles and Other Machinery (1.A.4.c.ii) are presented in Table 3-54.

Table 3-54. Emission factors and methods for category Agriculture/forestry/fishing sector - Off-road Vehicles and Other Machinery sector (1.A.4.c.ii)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Motor gasoline	72,97	CS	T2	10,0	D	T1	0,6	D	T1
Diesel oil	72,89	CS	T2	10,0	D	T1	0,6	D	T1

Abbreviations: CS - country specific emission factors were developed in August 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute; D - default emission factors (2006 IPCC); T1 - Tier 1; T2 - Tier 2.

Activity data

For calculation of GHG emissions in category Agriculture/forestry/fishing sector - Off-road Vehicles and Other Machinery (1.A.4.c.ii) activity data had been obtained from the Lithuanian Statistics database (http://www.stat.gov.lt/lt/). Activity data are provided in the Annex III.

Tendencies of fuel consumed and total GHG emission in Agriculture/forestry/fishing sector Off-road Vehicles and Other Machinery (1.A.4.c.ii) are presented in Figure 3-48.

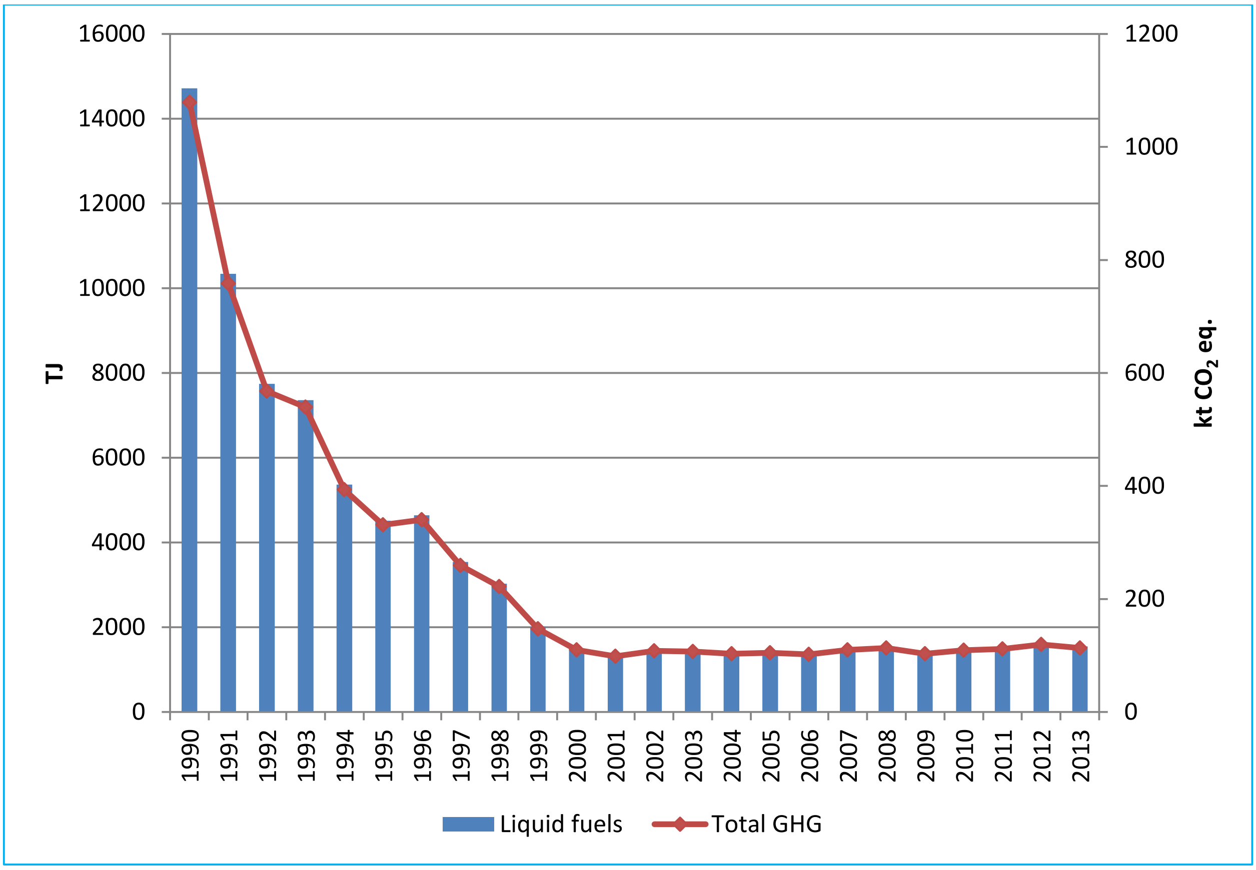


Figure 3-48. Tendencies of fuel consumed and total GHG emissions in Agriculture/forestry/fishing - Off-road Vehicles and Other Machinery sector (1.A.4.c.ii)

After the drastically reduced fuel consumption volume in Agriculture/forestry/fishing - Off-road Vehicles and Other Machinery sector during 1990-2000, later fuel consumption volumes was very stable. In 201,3 total fuel consumption amounted 1,55 PJ of liquid fuels.

In 2013, total GHG emissions from Agriculture/forestry/fisheries sector - Off-road Vehicles and Other Machinery sector (1.A.4.c.ii) were 9,5 times lower than in 1990 and amounted 113,3 kt CO_2 eqv.

3.5.3.3.2 Uncertainties and time-series consistency

Uncertainty in activity data in Agriculture/forestry/fishing sector - Off-road Vehicles and Other Machinery sector is ±3% taking into consideration recommendations provided by IPCC GPG 2000 and IPCC 2006 Guidelines for National GHG Inventories.

Uncertainties of CO_2 emission factors for liquid fuels (motor gasoline, diesel oil) are ±2,5% in Agriculture/forestry/fishing sector - Off-road Vehicles and Other Machinery sector. Uncertainties of all country specific CO_2 emission factors are derived in the study "Determination of national GHG emission factors for Lithuanian energy sector".

Uncertainties of CH_4 and N_2O emission factors for liquid were assigned as very high about ±50%. Uncertainties were derived considering IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories 2000.

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.5.3.3.3 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

The time series for all activity data have been studied carefully in search for outliers and to make sure that levels are reasonable.

The results are verified by calculating CO_2 emissions with the reference approach, and comparing results with the sectoral approach.

3.5.3.3.4 Source-specific planned improvements

Source-specific improvements are not planned.

3.5.4 Non-Specified (CRF 1.A.5.a)

Data on fuel consumption for military stationary combustion are not available. The statistical reports are based on information provided by the fuel suppliers therefore data on fuel used for military stationary combustion is included in Commercial/institutional category. Emissions are reported as "IE", i.e. emissions from military stationary combustion (1.A.5.a) are included in Commercial/institutional category (1.A.4.a).

3.6 Fugitive emissions (CRF 1.B)

3.6.1 Fugitive emissions from solid fuels (CRF 1.B.1)

There are no mining activities in Lithuania and hence no fugitive emissions from coal mines occur. All emissions are reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.6.2 Oil and natural gas (CRF 1.B.2)

3.6.2.1 Source category description

Fugitive emissions from oil and natural gas activities include all emissions from the exploration, production, processing, transport, and use of oil and natural gas and from non-productive combustion. Fugitive emissions consist mainly of emissions of methane, carbon dioxide and nitrous oxide.

3.6.2.2 Methodological issues

GHG emissions were calculated applying a Tier 1. The application of a Tier 1 is done using equation presented below:

$$E_{oil,gas\,industry\,segment} = A_{industry\,segment} \cdot EF_{industry\,segmentl}$$

where:

$E_{oil,gas\,industry\,segment}$ - annual emissions, kt;

$A_{industry\,segment}$ - activity value, units of activity;

$EF_{industry\,segmentl}$ - emission factor, kt/unit of activity.

Emission factors

Emission factors used in the calculation of fugitive emissions from oil and natural gas systems (1.B.2) are presented in Table 3-55.

Emissions from oil were calculated by using emission factors provided in the IPCC 2006 guidelines (table 4.2.5) and in the IPCC GPG table 2.16 (page 2.86)

Emissions from natural gas distribution were calculated by using emission factors provided in the IPCC GPG table 2.16 (page 2.86) and based on pipeline length. As noted in the IPCC GPG (p. 2.84), "fugitive emissions from gas transmission and distribution systems do not correlate well with throughput, and are better related to lengths of pipeline". It should be assumed that emissions from natural gas distribution cover emissions at residential and commercial sectors and in industrial plants and power stations. Therefore these emissions were not calculated separately and marked with notation key "IE" (included in 1.B.2.iii.5).

Emission from natural gas storage was not estimated due to there are no natural gas storage facilities in Lithuania. Lithuania uses storage facilities located in Latvia.

Table 3-55. Emission factors for fugitive emissions from oil and natural gas systems (1.B.2)

Category	Subcategory	Emission type	Emission factors			Units of measure
			CH_4	CO_2	N_2O	
Wells	Drilling	All	4,3E-07	2,8E-08	0	Gg per number of wells drilled
	Testing	All	2,7E-04	5,7E-03	6,8E-08	Gg per number of wells drilled
	Servicing	All	6,4E-05	4,8E-07	0	Gg/yr per number of producing and capable wells
Oil production	Conventional oil	Fugitives	1,5E-06	1,1E-07	0	Gg per 10^3 m^3 conventional oil production
		Venting	7,2E-04	9,2E-05	0	Gg per 10^3 m^3 conventional oil production
		Flaring	2,5E-05	4,1E-02	6,4E-07	Gg per 10^3 m^3 conventional oil production
Oil transport	Pipelines	All	5,4E-06	4,9E-07	0	Gg per 10^3 m^3 oil transported by pipeline
Crude oil refining	All	All	745	0	0	kg per PJ oil refined
Gas transmission	All	Fugitive	2,5E-03	1,6E-05	0	Gg per year per km of transmission pipeline
		Venting	1,0E-03	8,5E-06	0	Gg per year per km of transmission pipeline
Gas distribution	All	All	6,15E-04	0	0	Gg per year per km of transmission pipeline

Activity data

Activity data have been obtained from various sources: oil production and refining data from the Lithuanian Statistics database (see Annex III), number of drilling, testing, servicing wells from the Lithuanian Geological Survey, length of natural gas transmission and distribution pipelines from UAB Lietuvos dujos (http://www.dujos.lt/) and UAB Ambergrid (http://www.ambergrid.lt). In addition to energy balance the data on transportation of crude oil and oil products in pipelines from database of the Lithuanian Statistics[12] have been used.

3.6.2.3 Uncertainties and time-series consistency

Uncertainty in activity data for fugitive emissions is ±5% taking into consideration recommendations provided by IPCC 2006 Guidelines for National GHG Inventories.

Uncertainty in CO_2, CH_4 and N_2O emission factors for fugitive emissions from oil and natural gas systems are provided in the table 3-56.

[12] http://www.stat.gov.lt

Table 3-56. Uncertainties of emission factors for fugitive emissions from oil and natural gas systems

Category	Subcategory	Emission type	Uncertainty of emission factors, %		
			CH_4	CO_2	N_2O
Oil production	Conventional oil	Fugitives	±50	±50	NA
		Venting	±75	±75	NA
		Flaring	±75	±75	±75
Wells	Drilling	All	±50	±50	NA
	Testing	All	±50	±50	±50
	Servicing	All	±50	±50	NA
Oil transport	Pipelines	All	±50	±50	NA
Crude oil refining	All	All	±50	NA	NA
Gas transmission	All		±50	±50	NA
Gas distribution	All	All	±50	NA	NA

Time series of the estimated emissions are consistent and complete because the same methodology, emission factors and data sources are used for sectors for all years in time series. All emissions are estimated or reported as not occurring/not applicable therefore there are no "not estimated" sectors.

3.6.2.4 Source-specific QA/QC and verifications

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

3.6.2.5 Source-specific planned improvements

The following improvements are foreseen:

- investigate the possibility to apply Tier 2 for estimation fugitive emissions from natural gas systems.

3.7 Comparison of the verified CO_2 emission in GHG Registry and NIR

The Lithuanian Greenhouse Gas Emission Allowance Registry was established in 2005 and re-established as the State Greenhouse Gas Registry by the Government Resolution No 1072 On the establishing Greenhouse Gas Registry and approval of the regulation of the Greenhouse Gas Registry, adopted on 14 July 2010. The managing institution (competent authority) of the Registry is the Ministry of Environment and administrating institution - the Lithuanian Environment Investment Fund.

In 2013 the Fund provided information on verified CO_2 emissions for 95 fuel combustion installations[13] (see Annex V). CO_2 emissions from fuel combustion and production process are included in the registry for the installations, covered by activities, listed in Annex 1 of the EU Directive 2003/87/EC (mineral oil refinery, production of cement clinker, manufacture of glass, ceramic and paper, rockwool).

For the purpose of comparison of verified emissions of the Greenhouse Gas Registry with the CO_2 emissions in the NIR, installations were allocated to a certain CRF sector (sectoral approach). Comparison of the verified CO_2 emissions and NIR is provided in Table 3-57.

Table 3-57. Comparison of the verified CO_2 emissions and NIR (sectoral approach), 2013

Sources category	Verified CO_2 emissions, kt	Calculated CO_2 emissions, kt	Absolute difference, kt	Relative difference, %
1.A.1.A Public Electricity and Heat Production	2367,47	2371,58	4,1	0,2
1.A.1.B Petroleum Refining	1518,57	1441,53	-77,0	-5,3
1.A.2.C Chemicals	194,31	151,54	-42,8	-28,2
1.A.2.D Pulp, Paper and Print	33,83	43,41	9,6	22,1
1.A.2.E Food Processing, Beverages and Tobacco	73,34	280,29	207,0	73,8
1.A.2.F Non-Metallic Minerals	605,09	602,28	-2,8	-0,5
1.A.2.J Wood and Wood Products	21,99	22,36	0,4	1,7
Total	4814,59	4912,99	98,4	2,0

Total CO_2 emissions calculated in NIR sectoral approach are by 2% higher as compared to verified fuel combustion emissions in the Greenhouse Gas Registry. The differences mainly occur due to accuracy of emission factors and due to different coverage and thresholds in EU ETS.

[13] http://www.laaif.lt/index.php?-130096284

4 INDUSTRIAL PROCESSES AND PRODUCT USE (CRF 2)

4.1 Overview of the Sector

After the economic recession in early 1990's, Lithuania's industrial production and economy started to grow, as reflected by the growth of the GDP. Lithuania was struck by the global economic crisis causing significant reduction in industrial production in 2009. Dominating industry in Lithuania is manufacturing. Manufacturing constituted 88% of the total industrial production (excluding construction) in 2013 (Figure 4-1).

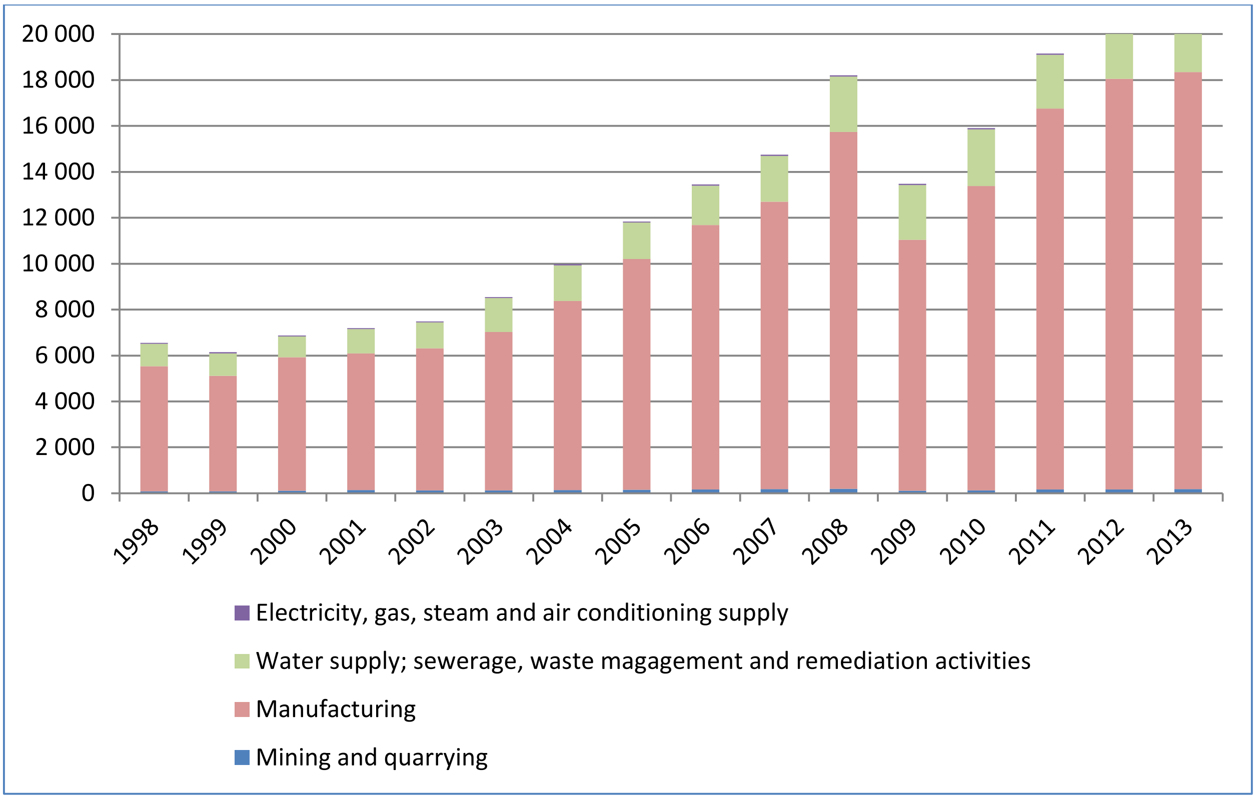


Figure 4-1. Industrial production at constant prices (except construction) in millions EUR

Four most important sectors within manufacturing cumulatively produced 72% of production:

- manufacture of refined petroleum products (33%);
- manufacture of food products and beverages (19%);
- manufacture of wood products and furniture (10%);
- manufacture of chemicals and chemical products (10%).

Share of the main sectors in production of manufacturing products in Lithuania is presented in Figure 4-2.

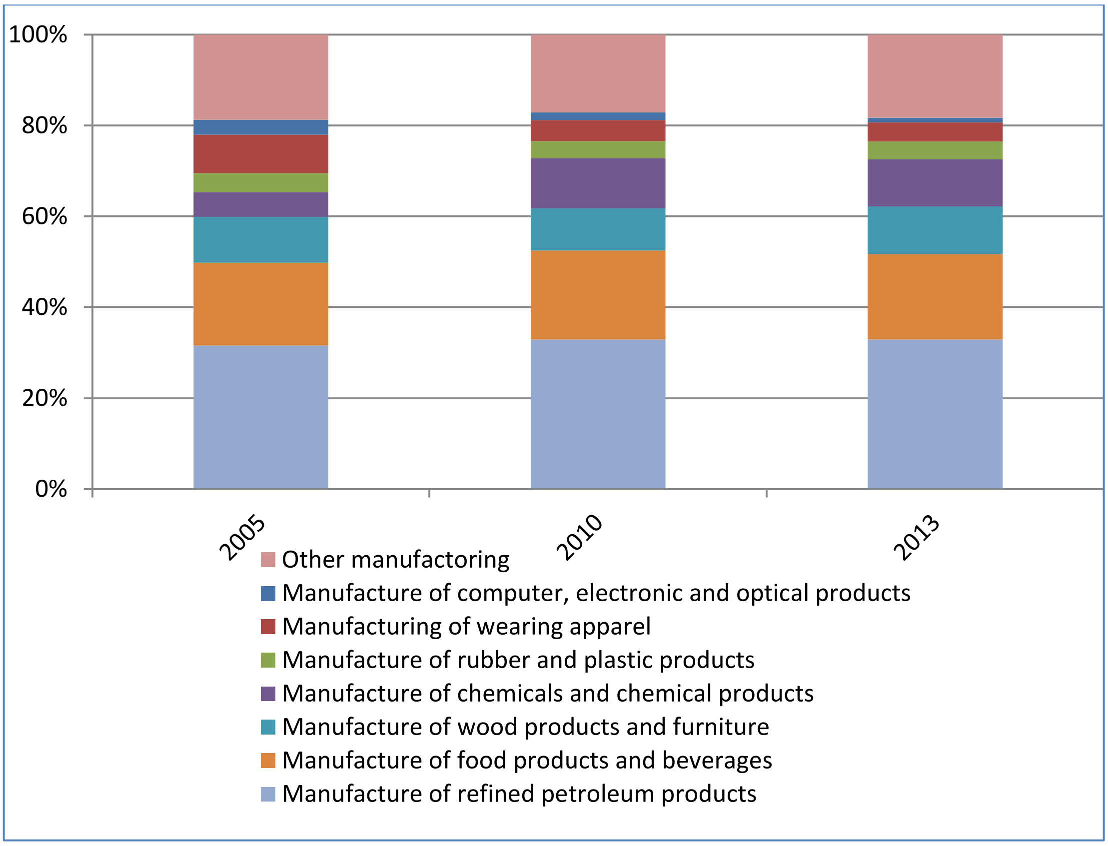


Figure 4-2. Share of the main sectors in production of manufacturing products in Lithuania

Greenhouse gas emissions from industrial processes contributed 14.7% to the total anthropogenic greenhouse gas emissions in Lithuania in 2013, totaling 2938.4 kt CO_2 eqv. (Figure 4-3.).

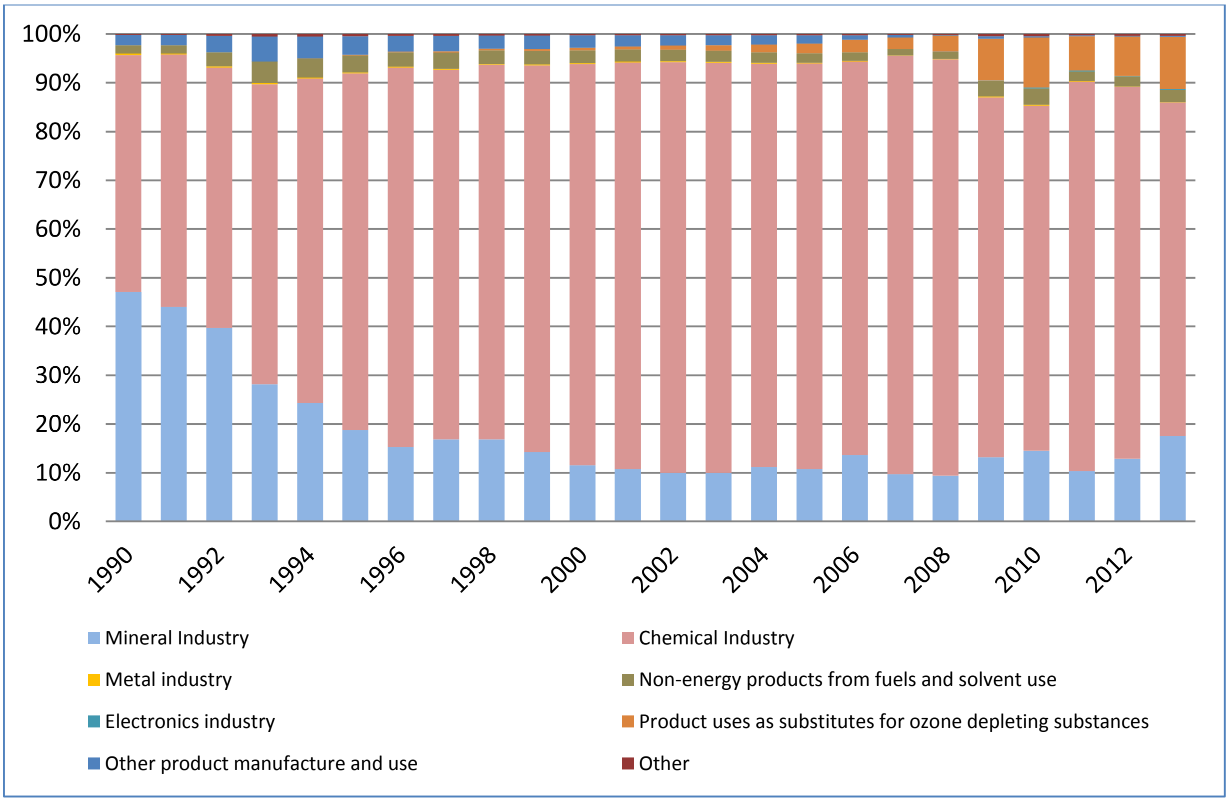


Figure 4-3. GHG emissions from industrial processes in 1990-2013, kt CO_2 eqv.

Lithuanian greenhouse gas emissions from industrial processes consist from the following emission categories:

- Mineral Industry (CRF 2.A) include CO_2 emissions from:
  - cement production (CRF 2.A.1);
  - lime production (CRF 2.A.2);
  - glass production (CRF 2.A.3);
  - ceramics (CRF 2.A.4.a);
  - other uses of soda ash (CRF 2.A.4.b);
  - mineral wool production (CRF 2.A.4.d).
- Chemical industry (CRF 2.B) include:
  - CO_2 emissions from ammonia production (CRF 2.B.1) and methanol production (CRF 2.B.8.a);
  - N_2O emissions from nitric acid production (CRF 2.B.2);
  - CH_4 emissions from methanol production (CRF 2.B.8.a).
- Metal industry (CRF 2.C) include CO_2 emissions from the cast iron production (CRF 2.C.1).
- Non-energy products from fuels and solvent use (CRF 2.D) include CO_2 emissions from:
  - lubricant use (CRF 2.D.1);
  - paraffin wax use (CRF 2.D.2);
  - solvent use (CRF 2.D.3);
  - asphalt production and use (CRF 2.D.3);
  - urea-based catalyst (CRF 2.D.3).
- Electronics industry (CRF 2.E) include NH_3 and SF_6 emissions from:
  - semiconductor (2.E.1);
  - photovoltaic (2.E.3).
- Product uses as substitutes for ozone depleting substances (CRF 2.F) include F-gases emissions from:
  - refrigeration and air conditioning (2.F.1);
  - foam blowing agents (2.F.2);
  - fire protection (2.F.3);
  - metered dose inhalers (2.F.4.a).
- Other product manufacture and use (CRF 2.G) include emissions from:
  - SF_6 emissions from electrical equipment (2.G.1);
  - SF_6 emissions from accelerators (2.G.2.b);
  - N_2O emissions from medical applications (CRF 2.G.3.a)
  - N_2O emissions from propellant for pressure and aerosol products (CRF 2.G.3.b).
- Other (CRF 2.H) include:
  - SO_2, NOx, NMVOC and CO_2 emissions from pulp and paper industry (CRF 2.H.1);
  - NMVOC and CO_2 emissions from food and beverages industry (CRF 2.H.2);
  - CO_2 emissions from consumption of carbonates in flue gas desulphurisation (CRF 2.H.3).

Several emission sources in the industrial processes sector are key categories. The key categories in 2013 by level and trend, excluding LULUCF are listed in Table 4-1.

Table 4-1. Key category from industrial processes and product use in 2013

IPCC Category	***Greenhouse gas***	***Identification criteria****

2.A.1 Cement Production	CO_2	L1,T1
2.A.2 Lime Production	CO_2	T1
2.A.4 Other process use of carbonates	CO_2	T1
2.B.1 Ammonia Production	CO_2	L1,T1
2.B.2 Nitric Acid Production	N_2O	L1,T1
2.F.1 Refrigeration and Air Conditioning Equipment	HFCs	L1,T1

4.2 Mineral Industry (CRF 2.A)

This category includes emissions from cement production, lime production, glass production, ceramics (bricks and tiles), other uses of soda ash and mineral wool production (Table 4-2). Cement production is a key source category in Lithuanian GHG inventory.

Table 4-2. Reported emissions under the subcategory mineral products

CRF	Source	Emissions reported
2.A.1	Cement production	CO_2
2.A.2	Lime production	CO_2
2.A.3	Glass production	CO_2
2.A.4.a	Ceramics	CO_2
2.A.4.b	Other uses of soda ash	CO_2
2.A.4.d	Mineral wool production	CO_2

Emissions of the category mineral industry were 47.0% of the emissions of the industrial processes sector in 1990 and 17.6% in 2013. Amount of emissions were 2,142.0 kt CO_2 eqv. in 1990 and 516.6 kt CO_2 eqv. in 2013 (Figure 4-4, 4-5).

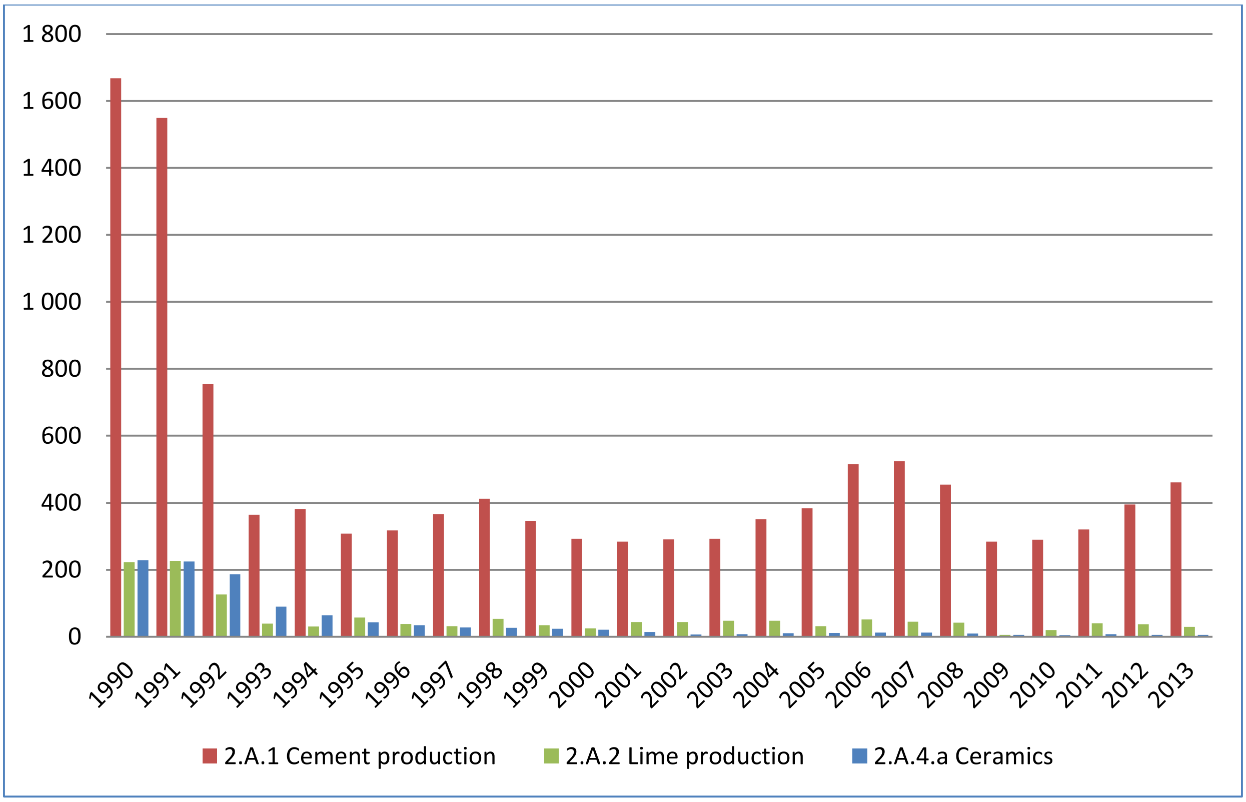


Figure 4-4. Greenhouse gas emission from mineral industry, kt CO_2 eqv. in 1990-2013: cement production, lime production and ceramics

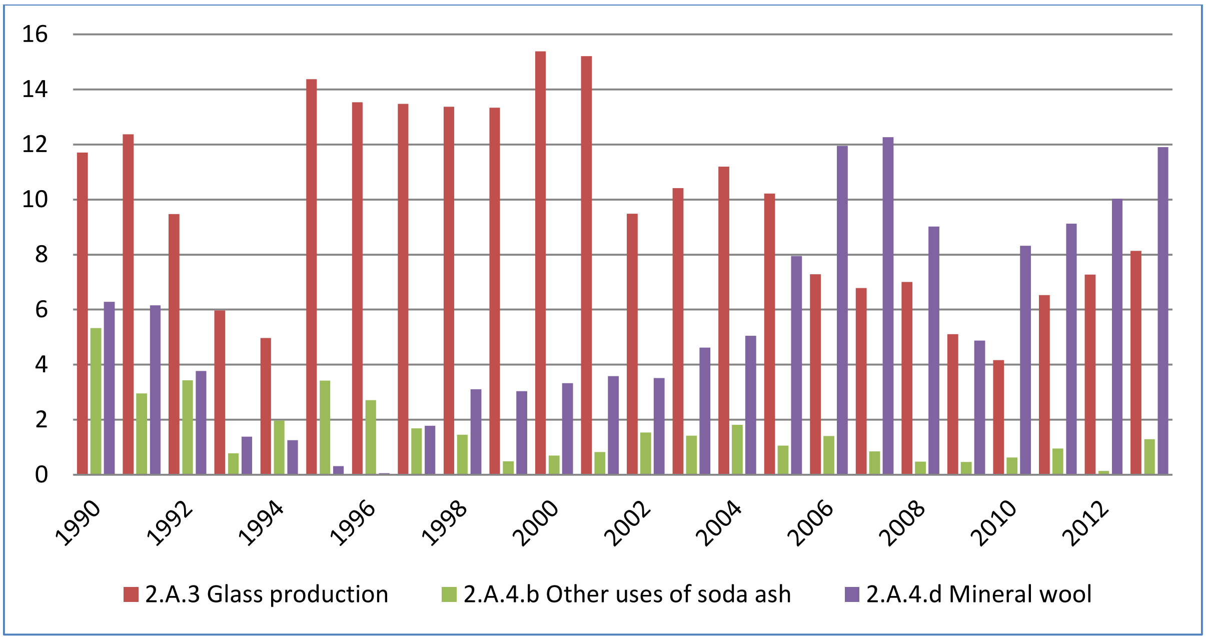


Figure 4-5. Greenhouse gas emission from mineral industry, kt CO_2 eqv. in 1990-2013: glass production, soda ash use and mineral wool production

Cement production is the biggest source of greenhouse gas emissions in the mineral industry category, being 460.8 kt in 2013 (89.2%). Emissions from cement production were 36.6% in 1990 and 15.7 % in 2013 of the emissions in the industrial processes sector. There was a rapid decrease in the production volume in 1990-1993 after gaining independence from Soviet Union. The output has had a slight growing trend in 2003-2007 fuelled by the boost in construction industry. Emissions from other mineral processes are a minor source in the category mineral products.

4.2.1 Cement Production (CRF 2.A.1)

4.2.1.1 Category Description

Category covers CO_2 emissions from cement production. Emissions of CO_2 occur during the production of clinker that is an intermediate component in the cement manufacturing process. High temperatures in cement kilns chemically change calcium carbonate into lime and CO_2. During the production of clinker, limestone, which is mainly calcium carbonate ($CaCO_3$), is heated, or calcinated, to produce lime (CaO) and CO_2 as a by-product. Portland cement is produced in a single company, which is situated in the North Western part of Lithuania. The plant was constructed in Soviet times (1947-1974), cement produced in the factory was exported to other Republics of USSR, Hungary, Cuba and Yugoslavia. The company produces more than 1 million tonnes of portland cement per year. The data on clinker production and composition were provided by the plant. Activity data is collected on company level.

Since the opening of the plant cement has been produced using wet production technology. In 2006 the company has made a strong innovation step and decided to build new 4.500 t/d dry process clinker production line. The construction and installation of new dry clinker production line was completed at the end of 2013.

Clinker production has fallen sharply after the declaration of independence from more than 3 million tonnes annually in 1990 to about 500 to 600 kt in 2000 (Figure 4-6). Sharp decline in cement production in 1990-1993 is mainly due to loss of market in former USSR. Demand of the cement in the local market has also dropped due to structural changes in industry and economy.

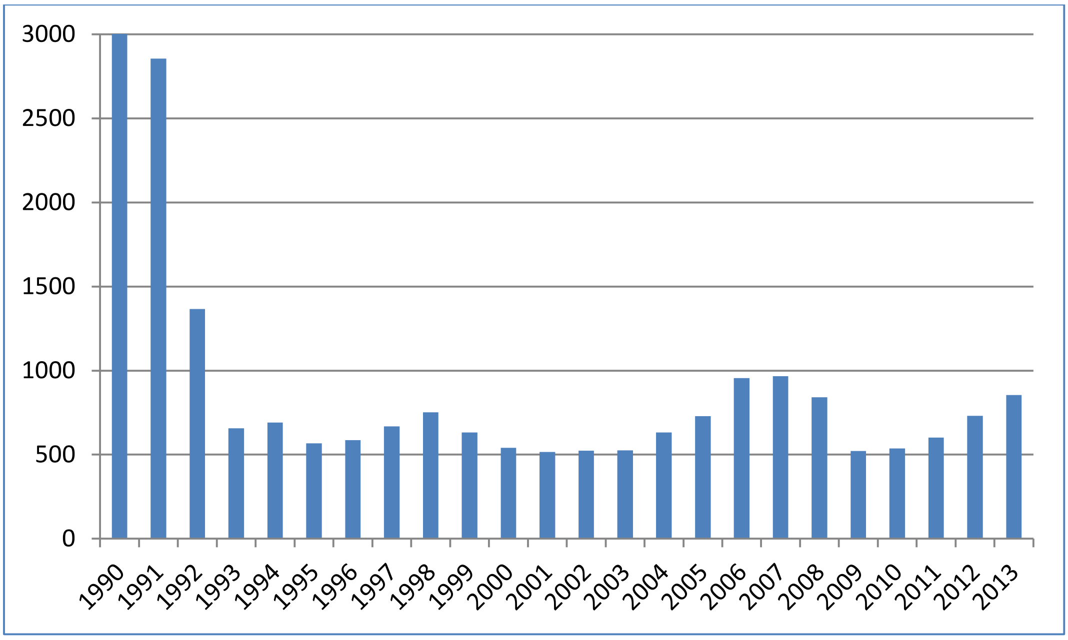


Figure 4-6. Clinker production, kt in 1990-2013

4.2.1.2 Methodological issues

For the period 1990-2004 CO_2 emission was calculated using Tier 2 method using specific production data provided by the production company. CO_2 emissions were calculated from material mass balance assuming that all carbon contained in raw materials (limestone) was released to the atmosphere as CO_2. Actual CO_2 emission was calculated from the data on clinker production and composition. In addition, it was assumed that CO_2 was released from calcinated fraction of kiln dust. According to the company, only about 5% of the CKD is calcinated.

CO_2 emission was calculated using the following equation:

$$Emission = CP \times (C_{CaO} \times (MCO_2/M_{CaO}) + C_{MgO} \times (MCO_2/M_{MgO})) +$$

$$+ CKD \times CF \times (C_{CaO} \times (MCO_2/M_{CaO}) + C_{MgO} \times (MCO_2/M_{MgO})),$$

where:
CP – clinker production, kt;
CKD – cement kiln dust generation, kt;
CF – calcinated fraction of the CKD, the time-series of the CKD correction factor is provided in Table 4-3;
C_{CaO} and C_{MgO} – CaO and MgO fractions in clinker;
MCO_2, M_{CaO}, M_{MgO} – molecular weights of CO_2, CaO and MgO.

For the period 2005-2013 CO_2 emission data have been accessed via the verified EU ETS reports of the production plant. CO_2 emissions were calculated using plant specific data on production of clinker and CKD, and plant specific emission factors (t CO_2/t clinker, t CO_2/t CKD).

Estimated CO_2 emissions from cement production are shown in Table 4-3.

Table 4-3. Estimated CO_2 emissions (kt/year) from Cement production

Year	Emission	CKD fraction
1990	1,668.1	1.3 %

1991	1,550.0	1.3 %
1992	755.0	1.3 %
1993	363.9	1.3 %
1994	381.6	1.3 %
1995	308.0	1.3 %
1996	317.5	1.3 %
1997	366.1	1.3 %
1998	411.7	1.3 %
1999	345.8	1.3 %
2000	292.5	1.3 %
2001	283.4	1.3 %
2002	290.5	1.3 %
2003	292.5	1.3 %
2004	351.0	1.3 %
2005	383.3	2.3 %
2006	515.3	0.5 %
2007	524.1	1.0 %
2008	453.8	1.4 %
2009	284.0	0.8 %
2010	289.0	0.2 %
2011	319.8	0.3 %
2012	395.2	0.3 %
2013	460.8	0.4 %

4.2.1.3 Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- Activity data uncertainty is assumed to be 2%. Data on clinker production provided by the single production company is considered reliable;
- Emission factor uncertainty is assumed to be 5%;
- Combined uncertainty is 5.4%.

CaO content in clinker fluctuated from 62.3% to 65.3% (from 1990 to 2013), the average value being 64.2%, standard deviation 0.8%.

Data on MgO content in clinker were available for the periods 2000 to 2009 and 2012 to 2013 (provided by the producer). MgO content fluctuated in the range from 3.33% to 4.13%, average value was 3.82%, standard deviation 0.26%. For GHG calculation for the period 1990 to 1999 average MgO content value was used.

Data on generation of cement kiln dust (CKD) (fraction not recycled to the kiln) were available for period 2005-2013. 2005-2007 average value was used for period 1990-2004 when the data were not available (CKD fluctuated from 0.5% to 2.3% of clinker production (average value 1.3%)).

4.2.1.4 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

As the producer reports CO_2 emissions for EU ETS, it was decided to perform a quality control by comparing the two estimates (2006 IPCC Tier 2 versus EU ETS). Comparison of CO_2 emissions (Tier 2 versus EU ETS) for 2005-2009 is provided below:

Table 4-4. Comparison of CO_2 emissions from cement production 2005-2009 (Tier 2 versus EU ETS)

	2005	2006	2007	2008	2009
CO_2 emissions TIER 2, kt	383.4	516.4	523.8	454.1	283.7
CO_2 emissions EU ETS, kt	383.3	515.3	524.1	453.8	284.0
ETS share, %	99.97%	99.78%	100.04%	99.94%	100.11%

The difference between the Tier 2 estimations based on plant-specific data (annual clinker and CKD data, CaO and MgO content in clinker) and EU ETS data was less than 1%. Therefore, it is concluded that the estimates for the period 1990-2004 and 2005-2013 are consistent.

4.2.1.5 Category-specific planned improvements

No source-specific improvements have been planned.

4.2.2 Lime Production (CRF 2.A.2)

4.2.2.1 Category Description

After restoration of independence lime production decreased from approximately 300 thous tonnes annually to 50 thous tonnes in 1993 and is fluctuating about this value. Exceptionally low production of lime – only 5.6 kilo tonnes was observed in 2009. (Figure 4-7). Data on lime production were provided by Statistics Lithuania[14] covering the whole reporting period.

Data on hydrated lime production are provided by Statistics Lithuania for the period 1999-2013. The fraction of hydrated lime fluctuated from 0% to 4%.

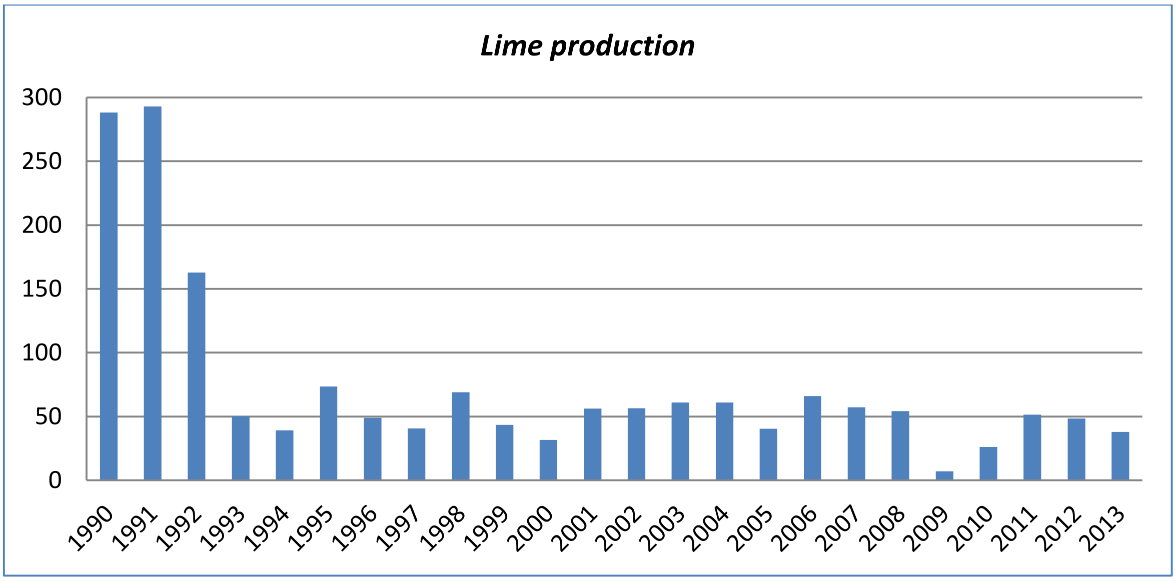


Figure 4-7. Lime production, kt in 1990-2013 in Lithuania

Lime production in sugar industry

For the completeness of the activity data, the data on non-marketed lime production was collected. Lime auto produced by the sugar producing companies is not covered by the national

[14] Database of Statistics Lithuania

statistics therefore the quantities of the lime produced were obtained directly from the sugar producing companies for the years 1990-2013.

4.2.2.2 Methodological issues

CO_2 emission from lime production was calculated using production data provided by Statistics Lithuania and limestone composition data provided by the lime production company. According to the data provided by the lime production company, which is the main lime producer in Lithuania, limestone used for lime production contains 90% to 92% of $CaCO_3$ and 4% to 5% of $MgCO_3$. Based on these data it was assumed that products contain 91.1% of CaO, 3.9% of MgO and 5% of impurities. Actual hydrated lime production data were used for emission calculation in 1999-2013 and it was assumed that during 1990-2001 there was no hydrated lime production. CO_2 emissions were calculated by Tier 2 method using following equation (2006 IPCC, Volume 3, Part 1, p. 2.21):

$$Emission=\sum(EF_{lime} \times M_l \times CF_{lkd} \times C_h)$$

where:
EF_{lime} – emission factors for quick and hydrated lime, tonnes CO_2/tonne lime (EFs calculated using eq. 2.9 from 2006 IPCC, Volume 3, Part 1, p. 2.23);
M_l – quick and hydrated lime production, tonnes;
CF_{lkd} – correction factor for LKD (default 1.02 (2006 IPCC, Volume 3, Part 1, p. 2.24));
C_h – correction factor for hydrated lime (default 0.97 (2006 IPCC, Volume 3, Part 1, p. 2.24));

Lime production in sugar industry

For determining activity data and emissions of CO_2 within the sugar industry, the amounts of limestone for the production of quicklime are used. The quantities were obtained directly from the sugar producing companies for the years 1990-2013.

According to the producers the used limestone consists to 97% of $CaCO_3$. In the production of sugar, lime is used for purification of the juice. Lime is added to the raw juice and some impurities are precipitated. In the carbonization step CO_2 is bubbled through the juice and most of the remaining lime is precipitated as $CaCO_3$. The precipitated "limestone" is sold and used within agricultural activities.

Lithuania calculated CO_2 emissions from lime production in sugar refining plants assuming that 86% of CaO is recovered as $CaCO_3$. This assumption is based on the data provided by the sugar producing companies:

$CaCO_3$ content of the limestone used in sugar refineries is on average 97%;

$CaCO_3$ content of the lime after the saturation/carbonation process is on average 83.9%.

Based on this data we assume that 14% of CaO is not recovered as $CaCO_3$. Only the part of CaO which is not recovered as $CaCO_3$ is reported as activity data.

In Table 4-5 the used amounts of limestone, the amounts of produced lime and emitted CO_2, the precipitated $CaCO_3$, and the reported activity data and CO_2 emissions from lime production within the sugar industry is presented.

Table 4-5. Lime production and estimated CO_2 emissions from sugar industry

Year	Used amount of limestone, kt	Amount of lime produced, kt	CO_2 from lime production, kt	Precipitated share of lime, %	Precipitated amount of lime, kt	Reported activity data (lime), kt	Reported CO_2 emissions, kt
1990	34.2	17.6	13.8	86%	15.1	2.5	1.9
1991	29.0	14.9	11.7	86%	12.8	2.1	1.6
1992	25.6	13.2	10.3	86%	11.3	1.8	1.4
1993	27.5	14.1	11.1	86%	12.2	2.0	1.6
1994	21.5	11.0	8.7	86%	9.5	1.5	0.2
1995	24.2	12.4	9.7	86%	10.7	1.7	1.4
1996	24.8	12.7	10.0	86%	11.0	1.8	1.4
1997	21.5	11.0	8.7	86%	9.5	1.5	1.2
1998	23.7	12.2	9.6	86%	10.5	1.7	1.3
1999	21.7	11.2	8.8	86%	9.6	1.6	1.2
2000	17.3	8.9	7.0	86%	7.7	1.2	1.0
2001	15.1	7.8	6.1	86%	6.7	1.1	0.9
2002	17.7	9.1	7.1	86%	7.8	1.3	1.0
2003	15.7	8.1	6.3	86%	6.9	1.1	0.9
2004	15.4	7.9	6.2	86%	6.8	1.1	0.9
2005	14.7	7.6	5.9	86%	6.5	1.1	0.8
2006	12.6	6.5	5.1	86%	5.6	0.9	0.7
2007	14.1	7.2	5.7	86%	6.2	1.0	0.8
2008	9.1	4.7	3.7	86%	4.0	0.7	0.5
2009	18.8	9.7	7.6	86%	8.3	1.4	1.1
2010	19.2	9.9	7.8	86%	8.5	1.4	1.1
2011	22.4	11.5	9.0	86%	9.9	1.6	1.3
2012	29.2	15.0	11.8	86%	12.9	2.1	1.6
2013	31.3	16.4	12.9	86%	14.1	2.3	1.8

Estimated CO_2 emissions from lime production are provided in Table 4-6 (total, including sugar industry).

Table 4-6. Estimated CO_2 emissions from lime production, kt/year

Year	Reported CO_2 emissions from lime production	Reported CO_2 emissions from sugar industry	Total CO_2 emissions
1990	220.7	1.9	222.7
1991	224.8	1.6	226.4
1992	124.3	1.4	125.8
1993	37.2	1.6	38.7
1994	29.1	1.2	30.3
1995	55.4	1.4	56.8
1996	36.3	1.4	37.7
1997	30.2	1.2	31.4
1998	52.0	1.3	53.3
1999	32.3	1.2	33.6
2000	23.5	1.0	24.4
2001	42.6	0.9	43.5
2002	42.6	1.0	43.6

2003	46.2	0.9	47.1
2004	46.2	0.9	47.1
2005	30.3	0.8	31.1
2006	50.2	0.7	50.9
2007	43.3	0.8	44.1
2008	41.3	0.5	41.8
2009	4.4	1.1	5.4
2010	19.0	1.1	20.1
2011	38.4	1.3	39.7
2012	35.7	1.6	37.4
2013	27.5	1.8	29.3

4.2.2.3 Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- Activity data uncertainty is assumed to be 5%. Data on lime production was taken from Statistics Lithuania publications;
- Emission factor uncertainty is assumed to be 30%;
- Combined uncertainty is 30.9%.

CO_2 emission was calculated using production data provided by Statistics Lithuania and limestone composition data provided by lime production company. Quantities of the lime produced in sugar production were obtained from the sugar producing companies. Data is consistent over the time series.

4.2.2.4 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

In addition, source category-specific quality control procedures have been carried out in this submission. Emission data for years 2011-2013 have been verified with EU ETS data. The calculated emissions are slightly higher than reported in EU ETS 1.2 % in 2013. This difference in estimated CO_2 emission is due to:

- activity data: GHG inventory also covers CO_2 emissions from lime production in sugar industry;
- methodology: in GHG inventory CO_2 emissions from lime production were calculated by Tier 2 method using plant specific limestone composition data. In EU ETS emissions were estimated using Tier 1 method and correction factor for LKD was not taken into account.

4.2.2.5 Category-specific planned improvements

No source-specific improvements have been planned.

4.2.3 Glass Production (CRF 2.A.3)

4.2.3.1 Category Description

There were three glass production plants in Lithuania. One of them (producing cathode ray tubes) got bankrupt in 2006 and currently there are only two plants in operation.

AB Klar Glass produces both sheet glass and container glass. Its production has fallen down substantially in early nineties following the declaration of independence, but increased again later even exceeding pre-independence level. However, sheet glass production was stopped in 2002 causing again substantial reduction in production to approximately 40 thousand tonnes per year.

UAB Kauno stiklas is the oldest glass production plant in Lithuania and produces container glass. In the period 1990 to 2011, its production was comparatively stable averaging about 20 thousand tonnes annually. Due to modernization of container glass production line in 2012 (the company installed a new more powerful and more economical glass melting furnace and purchased equipment to produce thin-walled bottles) the production of glass increased by more than 60% in 2012 and continues to increase (6% in 2013).

Glass production in CRT manufacturer AB Ekranas decreased slightly in the very beginning of the period, but then was increasing continuously from 1993 to 2004. However, changing market conditions and sharp reduction of demand for CRTs caused sudden bankruptcy of the company and production was stopped completely in 2006.

Glass production in 1990-2013 is shown in Figure 4-8.

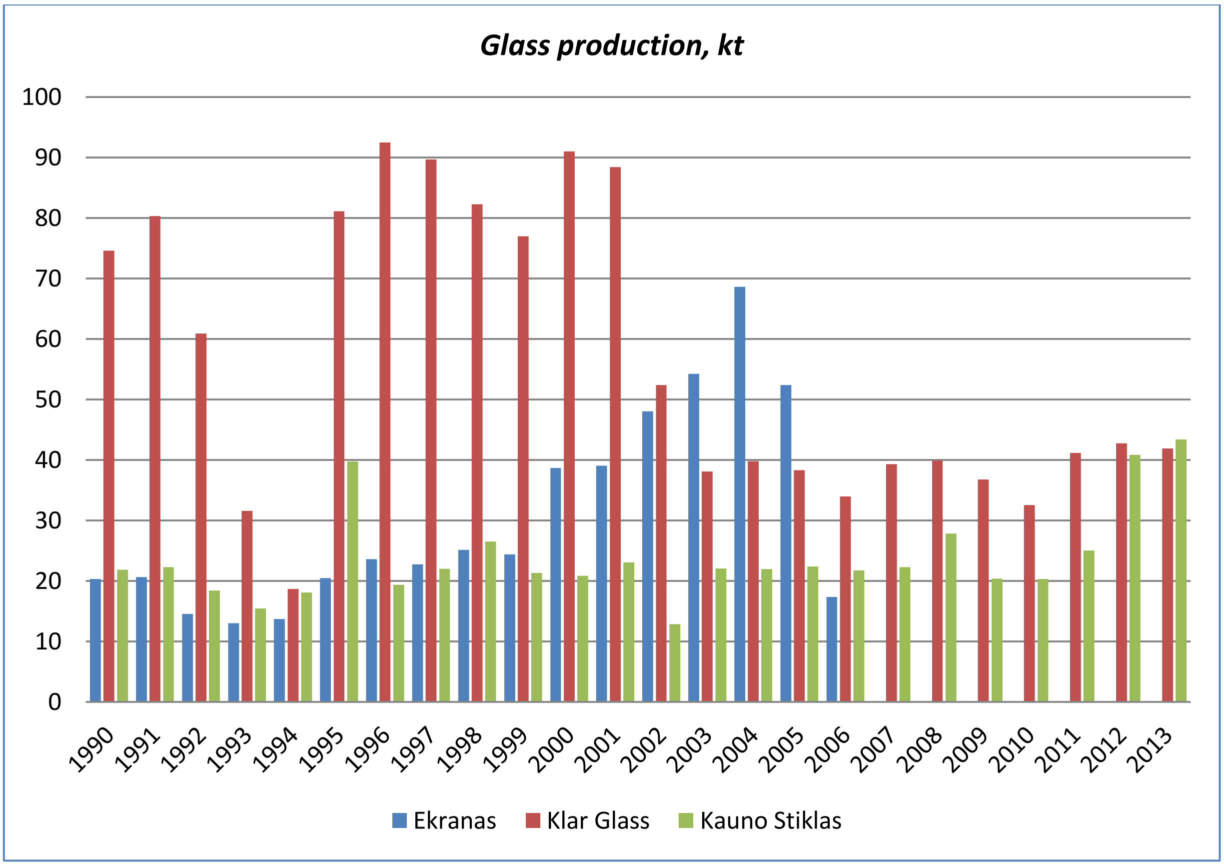


Figure 4-8. Glass production

4.2.3.2 Methodological issues

CO_2 emissions were calculated using the following equation (2006 IPCC, Volume 3, Part 1, p. 2.28):

$$CO_2\ Emissions = \sum(M_i \times EF_i \times F_i) + M_c \times EF_c$$

where:

CO_2 Emissions - emissions of CO_2 from glass production, tonnes;
EF_i - emissions factor for the particular carbonate i, tonnes CO_2/tonne carbonate
M_i - mass of the carbonate i consumed, tonnes;
F_i - fraction calcination achieved for the carbonate i, fraction. It was assumed that the fraction calcination is equal to 1.00 for all carbonate types;
EF_c - emissions factor for carbon oxydised in glass furnace, tonnes CO_2/tonne carbon;
M_c - mass of the carbon oxydised in glass furnace, tonnes.

Default emission factors for the particular carbonate (tonnes CO_2/tonne carbonate) were used, as provided in 2006 IPCC (Volume 3, Part 1, table 2.1, page 2.7). According to EU ETS report of Kauno stiklas, small quantity of carbon is oxidised directly in glass furnace. The factory uses natural gas as a fuel.

CO_2 emissions were calculated for each production plant based on plant specific data on use of particular carbonates. Summary for each production plant is provided below.

AB Ekranas

The production plant produced cathode ray tubes, but got bankrupt in 2006. Production data (number of cathode ray tubes produced) is available for 1990-2006. EU ETS reports provide data on consumption of particular carbonates: Na_2CO_3, $K2CO_3$, $BaCO_3$, $CaCO_3$, $SrCO_3$ and dolomite in 2005 and 2006. Average plant specific emission factor (t CO_2/t glass produced, excluding cullet) was calculated based on available 2005-2006 data. The emission factor was used for extrapolation of emissions in 1990-2004.

AB Klar Glass

CO_2 emissions were calculated using plant specific data provided by the production company:

- Glass production data is available for 1990-2013 (tonnes of glass produced).
- Data on cullet use is available for the period 1999-2013.
- Data on consumption of particular carbonates: dolomite, soda ash and chalk are available for 1999-2009. In 1999-2002 company has also used small quantities of potash and carbon.
- Data on composition of dolomite and chalk is available for the period 2005-2009.
- Since 2005 the company is reporting under EU ETS, thus data on consumption of $MgCO_3$, $CaCO_3$ and Na_2CO_3 is available for the period 2005-2013.

Plant specific emission factor (t CO_2/t glass produced, excluding cullet) was calculated based on available data outlined above. The emission factor was used for extrapolation of emissions in 1990-1998.

UAB Kauno stiklas

CO_2 emissions were calculated using plant specific data provided by the production company:

- Glass production data is available for 1990-2013 (tonnes of glass produced).
- Data on cullet use is available for the period 2004-2013;
- Data on consumption of particular carbonates: dolomite and soda ash is available for 2004-2006;
- Data on composition of dolomite is available for 2004-2009;

- Since 2007 the company is reporting under EU ETS, thus data on consumption of $MgCO_3$, $CaCO_3$, Na_2CO_3 and Carbon oxidised directly in glass furnace is available for the period 2007-2013.

Plant specific emission factor (t CO_2/t glass produced, excluding cullet) was calculated based on available data outlined above. The emission factor was used for extrapolation of emissions in 1990-2003.

Estimated CO_2 emissions (excluding cullet) from glass production are provided in Table 4-7.

Table 4-7. Estimated CO_2 emissions from glass production, kt/year

Year	CO_2 emission, kt
1990	11.7
1991	12.4
1992	9.5
1993	6.0
1994	5.0
1995	14.4
1996	13.5
1997	13.5
1998	13.4
1999	13.3
2000	15.4
2001	15.2
2002	9.5
2003	10.4
2004	11.2
2005	10.2
2006	7.3
2007	6.8
2008	7.0
2009	5.1
2010	4.2
2011	6.5
2012	7.3
2013	8.1

4.2.3.3 Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- CO_2 emissions in glass production were calculated from the data on use of raw materials containing carbonates. Data were obtained from the production companies, but only for the second half of the period under consideration (1999-2013). Detailed data on composition of raw materials were available only for the last 6 years. In addition, only very limited data were obtained from cathode ray tubes producer AB Ekranas which got bankrupt in 2006. In view of these considerations, it was assumed that activity data uncertainty for glass production is 7%.
- Emission factor uncertainty is assumed to be 5%;
- Combined uncertainty is 8.6%.

Activity data is not fully consistent over the time-series. Starting from 2005 data is fully consistent and reliable.

4.2.3.4 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

Source category-specific quality control procedures have been carried out in this submission. Emission data for years 2010-2013 have been verified with EU ETS data. The difference between the GHG inventory and the EU ETS data is less than 0.5%, as illustrated in the Table 4-8 below:

Table 4-8. Estimated CO_2 emissions (kt/year) from glass production. Comparison of GHG inventory and EU ETS data.

EU ETS, kt CO_2	**2010**	**2011**	**2012**	**2013**
Kauno stiklas	1.26	2.45	3.43	3.98
Klar Glass	2.90	4.10	3.84	4.15
Glass production, total	4.16	6.55	7.27	8.13
CRF, kt CO_2				
Kauno stiklas	1.26	2.45	3.43	3.98
Klar Glass	2.90	4.08	3.84	4.15
Glass production, total	4.16	6.53	7.27	8.13
EU ETS/ CRF				
Kauno stiklas	100.13%	100.03%	99.99%	99.99%
Klar Glass	99.95%	100.48%	100.00%	100.00%
Glass production, total	100.00%	100.31%	100.00%	99.99%

4.2.3.5 Category-specific planned improvements

No source-specific improvements have been planned.

4.2.4 Other process uses of carbonates (CRF 2.A.4)

Category of other process uses of carbonates (CRF 2.A.4) are divided into four sub-categories: ceramics (CRF 2.A.4.a), other uses of soda ash (CRF 2.A.4.b), non-metallurgical magnesia production (CRF 2.A.4.c) and other (please specify) (CRF 2.A.4.d).

4.2.4.1 Category Description

Ceramics (CRF 2.A.4.a)

This category includes CO_2 emissions from bricks and tiles production. Data on ceramic bricks, tiles and vitrified clay pipes production were taken from Statistics Lithuania publications[15]. Production of bricks, tiles and clay pipes has fallen down dramatically from 1990. Tiles are not produced since 2004 and vitrified clay pipes are not produced since 2007.

Ceramic bricks production data from Statistics Lithuania publications for various periods are provided in different units. The data for 1990-2001 are provided in millions of bricks, while the data for the following years are in thousands cubic meters. Recalculation of data to mass units was made by applying average conversion factors based on information provided by the largest

[15] Database of Statistics Lithuania

ceramic bricks and pipes producer in Lithuania[16]. It was assumed that average brick mass is 2.7 kg and average volume weight of bricks is 1.6 t/m^3.

Vitrified clay pipes production data from Statistics Lithuania publications are provided in thousands of kilometers for the period 1990-2001 and in tonnes for the remaining period. Production of vitrified clay pipes were converted to mass units using conversion factor 3.0 tonnes per km.

Ceramic tiles production data were provided in square meters from 1990 to 2001 and in tile units from 2002. These data were converted to weight units assuming that average tile area is 350×200 mm and average weight is 2.8 kg (information by ceramic bricks producer). Ceramics production in Lithuania in 1990-2013 is provided in Figure 4-9.

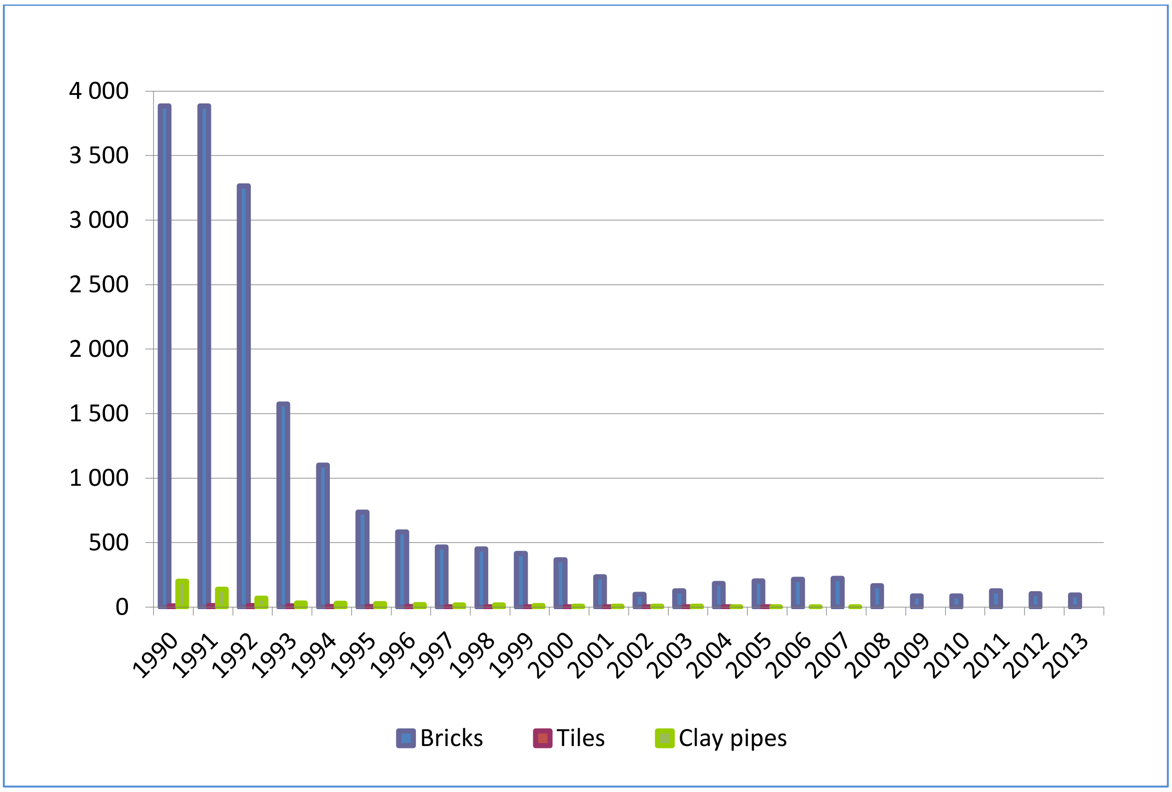


Figure 4-9. Production of ceramic products in 1990-2013

Other Uses of Soda Ash (CRF 2.A.4.b)

CO_2 emissions from soda ash consumed in glass production is covered under CRF 2.A.3. This chapter covers other uses of soda ash. The data on overall use of soda ash were obtained from the publications of Statistics Lithuania17. In 2010 the Statistics Lithuania has stopped the collection of statistical data on the overall use of soda ash. Therefore for the years 2010-2013 overall soda ash use is determined via balancing (import minus export). The relevant import and export quantities are taken from the foreign-trade statistics of the Statistics Lithuania. Soda ash consumed in the glass production industry was subtracted from the overall use of soda ash.

Soda ash consumption by the glass companies was calculated based on the data on consumption of carbonates by the production companies:

[16] http://www.palemonokeramika.lt/
[17] Statistic Lithuania publication "Raw Materials"

Karr Glass 1999-2013. For the period 1990-1998 average soda ash consumption (1990-1998) per tonne of glass was used. Cullet was excluded from the calculation.

Kauno stiklas 2004-2013. For the period 1990-2003 average soda ash consumption (1990-2002) per tonne of glass was used. Cullet was excluded from the calculation.

Ekranas 2005-2006. The plant got bankrupt in 2006. For the period 1990-2004 average soda ash consumption (1990-2003) per tonne of glass was used. Cullet was excluded from the calculation.

Variations of soda ash use are shown in Figure 4-10.

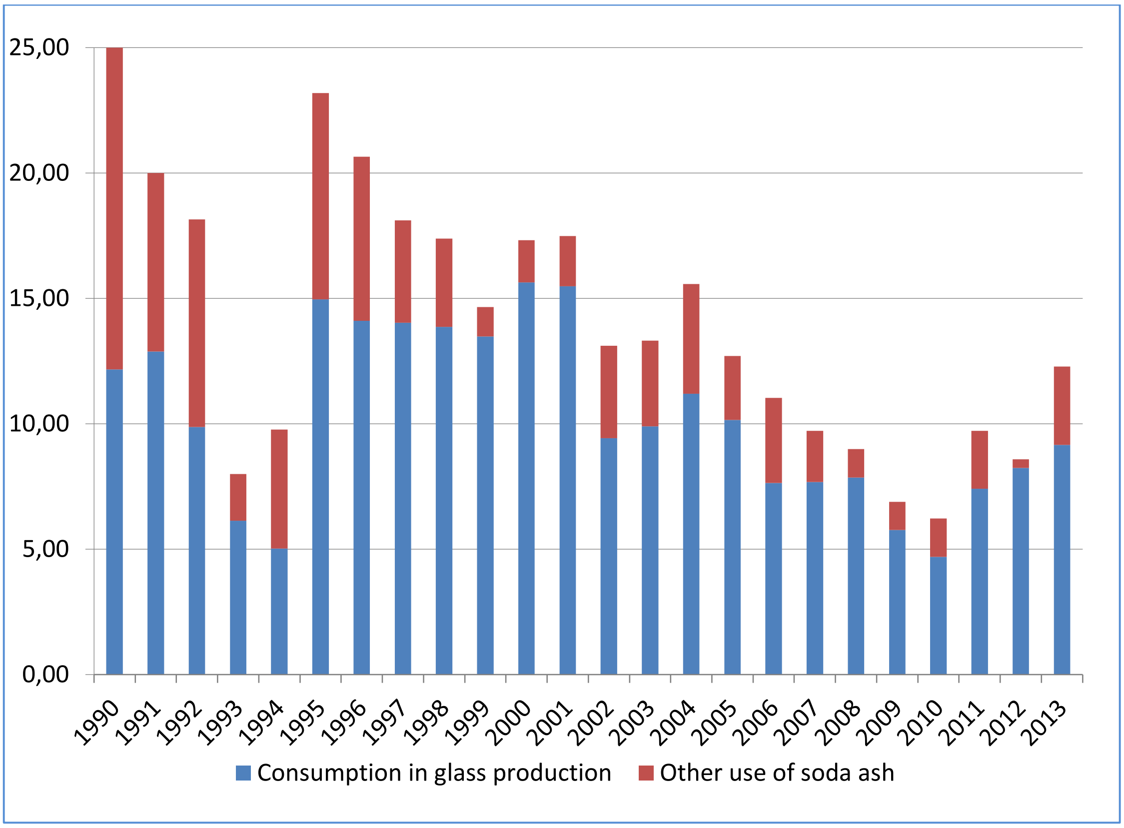


Figure 4-10. Evaluated use of soda ash in 1990-2013

<u>*Non Metallurgical Magnesia Production (CRF 2.A.4.c)*</u>

Emissions from non-metallurgical magnesia production are not occurring in Lithuania so for the category "CRF 2.A.4.c Non Metallurgical Magnesia Production" notation key "NO" is used.

<u>*Mineral wool (CRF 2.A.4.d)*</u>

Two mineral wool plants were in operation in Lithuania in 1990. The Alytus plant was closed soon after independence. AB Silikatas continued operation, but production was constantly decreasing. Finally it was bought by the Finnish company Paroc which performed major upgrading of the plant in 1996 when production fell down actually to zero.

It was not possible to find actual data on mineral wool production from 1990 to 1997. Evaluation of production figures for that period based on remaining data was performed by prof. A. Kaminskas who was the director of the Institute of Thermal Insulation in Vilnius in eighties and nineties. Production data for the period 1998-2013 were provided by the UAB Paroc company.

Mineral wool production during 1990-2013 is shown in Figure 4-11.

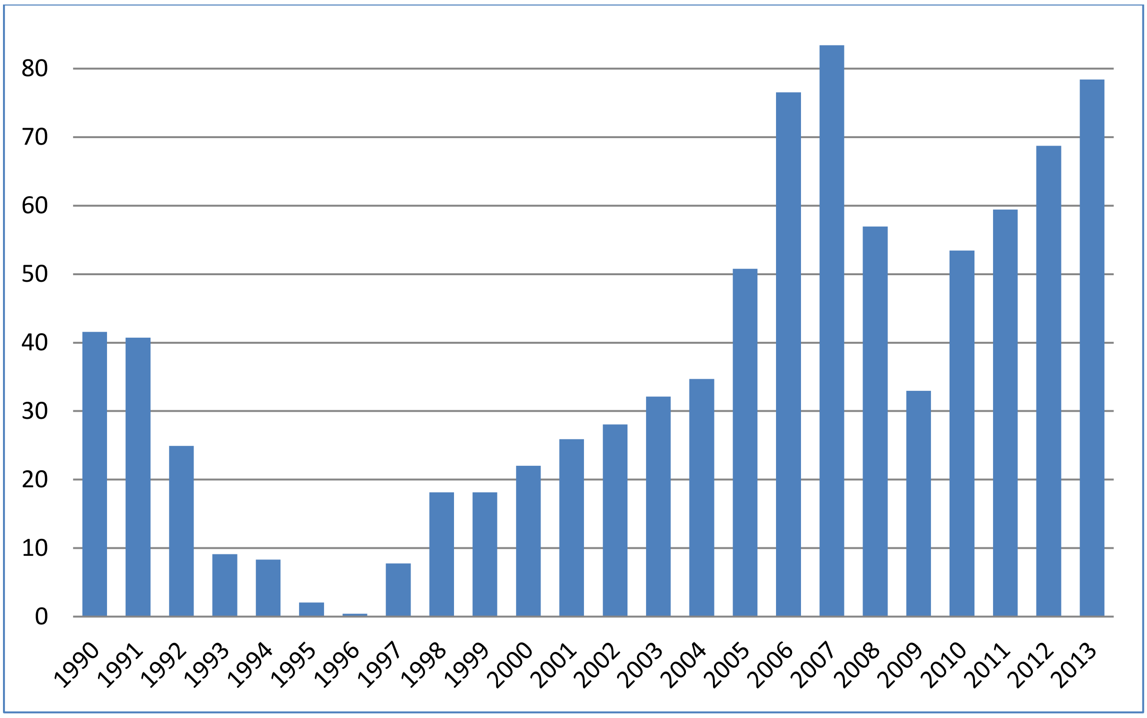


Figure 4-11. Mineral wool production in 1990-2013

In mineral wool production CO_2 is formed by decomposition of dolomite. Data on consumption of dolomite for production of the mineral wool was provided by the Paroc company (1997-2013).

4.2.4.2 Methodological issues

Ceramics (CRF 2.A.4.a)

CO_2 emissions from ceramics production were calculated from material balance based on CaO and MgO contents in the product provided by the ceramic bricks producer. According to the company, CaO content in bricks is fluctuating from 3.5% to 4.7% and MgO content is varying from 1.65% to 2.65%. Average values of 4.1% CaO and 2.15% MgO were taken as emission factors for calculation of emissions.

CO_2 emissions were calculated using the following equation:

$$Emission = CP\times (C_{CaO}\times (MCO_2/M_{CaO}) + C_{MgO}\times (MCO_2/M_{MgO}).$$

where:
CP - ceramics production, kt;
C_{CaO} and C_{MgO} - CaO and MgO fractions in ceramics products;
MCO_2, M_{CaO}, M_{MgO} - molecular weights of CO_2, CaO and MgO.

Estimated CO_2 emissions from ceramics production are provided in Table 4-9.

Table 4-9. Estimated CO_2 emissions from briks and tiles production, kt/year

Year	Emission
1990	228.1
1991	224.8
1992	186.3
1993	90.0

1994	63.3
1995	42.8
1996	33.9
1997	27.1
1998	26.2
1999	23.9
2000	20.9
2001	13.6
2002	6.0
2003	7.4
2004	10.3
2005	11.4
2006	12.1
2007	12.4
2008	9.2
2009	4.9
2010	4.8
2011	7.0
2012	5.8
2013	5.2

4.2.4.3 Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- Activity data uncertainty is assumed to be 5%;
- Emission factor uncertainty is assumed to be 5%;
- Combined uncertainty is 7.1%.

Data on ceramic bricks, tiles and vitrified clay pipes production were taken from Statistics Lithuania publications[18]. Ceramic bricks production data in Statistics Lithuania publications for various periods are provided in different units. Data for 1990-2001 are provided in millions of bricks, while the data for the following years are in thousands cubic meters. Recalculation of data to mass units was made. Vitrified clay pipes production data in Statistics Lithuania publications are provided in thousands of kilometers for the period 1990-2001 and in tonnes for the remaining period. Production of vitrified clay pipes were converted to mass units. Ceramic tiles production data were provided in square meters from 1990 to 2001 and in tile units from 2002. These data were converted to weight units.

Other uses of soda ash (CRF 2.A.4.b)

CO_2 emissions were calculated from mass balance assuming that all carbon contained in soda ash was released to the atmosphere after use as CO_2. The following equation was used:

$$Emission = M \times EF,$$

where:
M – mass of soda ash, tonnes;

[18] http://db1.stat.gov.lt/statbank/default.asp?w=1440

EF – emission factor for soda ash, tonnesCO_2/tonne carbonate.

Estimated CO_2 emissions from other use of soda ash are provided in Table 4-10.

Table 4-10. Estimated CO_2 emissions from soda ash use, kt/year

Year	CO_2 emission, kt
1990	5.3
1991	3.0
1992	3.4
1993	0.8
1994	2.0
1995	3.4
1996	2.7
1997	1.7
1998	1.5
1999	0.5
2000	0.7
2001	0.8
2002	1.5
2003	1.4
2004	1.8
2005	1.1
2006	1.4
2007	0.8
2008	0.5
2009	0.5
2010	0.6
2011	1.0
2012	0.1
2013	1.3

Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- Soda ash use was evaluated as difference of data provided by Statistics Lithuania and evaluated other uses (namely glass production). As each of these components contains certain uncertainty, the total uncertainty in soda ash use activity data was assumed to be 15%.
- Emission factor uncertainty is assumed to be 5%;
- Combined uncertainty is 15.8%.

Data on overall use of soda ash were taken from the publications of Statistics Lithuania. Data on overall use of soda ash was not available for 2010-2013 therefore the data on soda ash import and export was taken from Statistics Lithuania. Issues related to time-series consistency of the soda ash use by glass production is covered in section Other (CRF 2.A.3).

Mineral wool (CRF 2.A.4.d)

CO_2 emissions from mineral wool production were calculated using data provided by the production company.

The production company has provided data on:

- total production 1998-2013;
- dolomite consumption 1997-2013;
- CO_2 emission factors (t CO_2/t dolomite) 2008-2013.

Difference in emission factor for dolomite is due to moisture of the raw material.

CO_2 emissions in 1997-2013 were calculated using data on consumption of dolomite and emission factor provided by the production company (for the period 1997-2007 average emission factors was used 0.43 t CO_2/t dolomite).

Based on the results, average emission factor for CO_2 emission from mineral wool production was calculated as 0.15 tonnes CO_2 per tonne mineral wool produced. This emission factor was used for calculation on CO_2 emission in 1990-1996.

Estimated CO_2 emissions from mineral wool production are provided in Table 4-11.

Table 4-11. Estimated CO_2 emissions from mineral wool production, kt/year

Year	Emission
1990	6.3
1991	6.2
1992	3.8
1993	1.4
1994	1.3
1995	0.3
1996	0.1
1997	1.8
1998	3.1
1999	3.0
2000	3.3
2001	3.6
2002	3.5
2003	4.6
2004	5.1
2005	8.0
2006	12.0
2007	12.3
2008	9.0
2009	4.9
2010	8.3
2011	9.1
2012	10.0
2013	11.9

4.2.4.4 Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- The data on mineral wool production and raw materials consumption obtained from the production company are reliable and precise, however, they cover only the period after reconstruction of the plant (from 1997). Historic data for 1990-1996 are expert evaluation and is less reliable. It was assumed that overall uncertainty of mineral wool production activity data is 7%.
- Emission factor uncertainty is assumed to be 5%;
- Combined uncertainty is 8.6%.

Production data for the period 1998-2013 were provided by the producer company. Activity data is not available for the period 1990-1997 and was extrapolated.

4.2.4.5 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

Mineral wool category-specific quality control procedures have been carried out in this submission. The recalculated emission data based on updated activity data and plant-specific emission factors provided by the producer for years 2008-2013 have been verified with ETS data and the correspondence between these data is 100%.

4.2.4.6 Category-specific planned improvements

In order to increase the accuracy of the estimates and improve the time-series consistency, possibility to collect data on soda ash use by end use following ERT encouragement will be explored.

4.3 Chemical Industry (CRF 2.B)

In Lithuanian GHG inventory this category includes non-fuel emissions of CO_2 from ammonia production and methanol production, N_2O from nitric acid production and CH_4 emissions from methanol production (Table 4-12).

Table 4-12. Reported emissions under the subcategory chemical industry

CRF	Source	Emissions reported
2.B.1	Ammonia production	CO_2
2.B.2	Nitric acid production	N_2O
2.B.8.a	Methanol	CO_2, CH_4

Ammonia and nitric acid production are key sources of this source category in Lithuanian inventory. Adipic acid, caprolactam, glyoxal and glyoxylic acid, carbides, titanium dioxide, pertrochemical and carbon black, fluorochemical production dichloroethylene and styrene are not produced in Lithuania.

Emissions of chemical industry in 2013 were 2,008.9 kt CO_2 eqv., and it was 68.4% of industry sector emissions.

Nitric acid and ammonia is nowadays produced in Lithuania in a single company. Emissions of CO_2 from ammonia production were 1,673.0 kt in 2013. Emissions of N_2O from nitric acid production were 1.13 kt in 2013. Ammonia and nitric acid production show recovery after the financial crisis and reached the levels of 2007-2008. Significant decline in N_2O emissions in 2009-2012 are due to installing of secondary catalyst in August 2008.

Emissions of CO_2 and CH_4 from methanol production comprise a small fraction in the emissions of greenhouse gases from chemical industry (emissions of CH_4 did not exceed 0.2% and emissions of CO_2 did not exceed 2.7% during the whole time series 1990-2008). No methanol was produced in 1999 and since 2008 due to economic reasons the production of methanol was stopped.

4.3.1 Ammonia Production (CRF 2.B.1)

4.3.1.1 Category Description

There is a single ammonia production company in Lithuania. In the production plant ammonia is produced at 22.0-24.0 MPa pressure from hydrogen and nitrogen, which are generated at 800-1100 °C temperatures by conversion of natural gas. The converted gas is cleaned from impurities (CO, CO_2, H_2O vapour, etc.).

Capacities of ammonia production:

- AM-70 unit – project (design or primary) capacity was 1,360 t/day; after reconstruction (in 1995) it reached 1,560 t/day or 569,400 t/year.
- AM-80 unit – project capacity is 1,560 t/day or 569,400 t/year.
- Total ammonia capacity is 1,138.800 t/year.

Ammonia production and natural gas consumption data (Figure 4-12) were provided by company. Other fuels are not used in the ammonia production process.

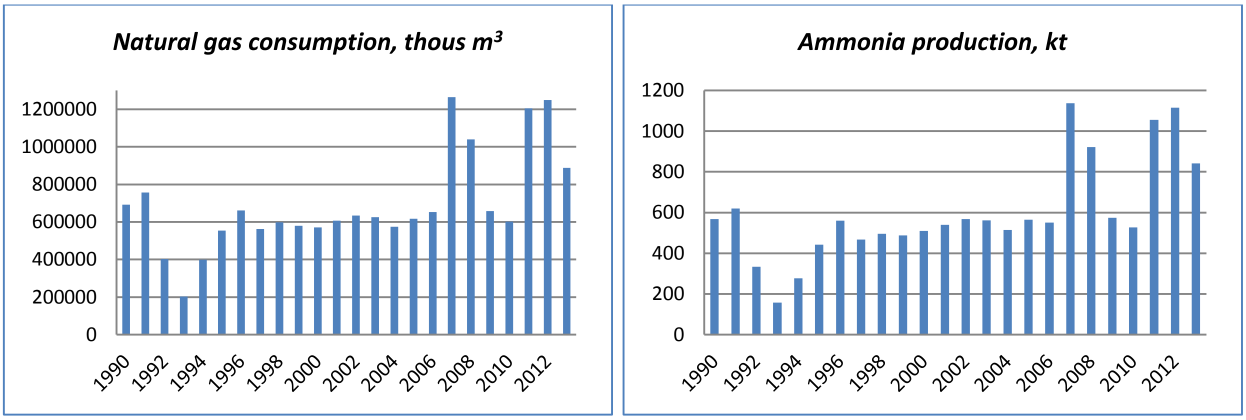


Figure 4-12. Natural gas consumption and ammonia production

Variations in ammonia production closely follow the variations in natural gas consumption. A sharp downwards trend in ammonia production in 2008-2010 was caused by the financial crisis. In 2013 ammonia production were 842 kt, compared to 2012 ammonia production has decreased by 24.5%.

4.3.1.2 Methodological issues

The CO_2 emissions were calculated using Tier 3 method (2006 IPCC, Volume 3, Part 1, p. 3.13) and based on the following data provided by producer:

- annual production of ammonia;
- data on natural gas consumption;
- data on CO_2 recovered for urea production;
- data on amount of exported urea;
- data on CO_2 emitted from urea application on soils;
- data on CO_2 emitted from the use of urea-based catalyst;

- lower calorific values (annual average) of natural gas;
- country specific emission factor.

CO_2 emissions were calculated using the following equation:

$$CO_2\ emitted = (TFR\ x\ Cv\ x\ 4.186\ x\ 10^{-9}\ x\ EF)\text{-}RCO_2$$

Where:

TFR_{NG} – total fuel requirements for ammonia production (= total consumption of natural gas, thousand m^3);

Cv – lower calorific value of the natural gas (kcal/m^3);

$4.186\ x\ 10^{-9}$ – conversion factor TJ/kcal;

EF – country specific CO_2 emission factor for natural gas (t CO_2/TJ). Constant emission factor 55.23 t CO_2/TJ is used over the whole time series. Emission factor was developed in 2012 based on the results of the study "Determination of national GHG emission factors for energy sector" prepared by Lithuanian Energy Institute. Summary of this study is provided in the Annex IV of the NIR 2015. Also this EF is used consistently in energy sector for emissions from combustion of natural gas. Justification of the country specific emission factor for natural gas is provided in NIR Energy chapter;

R_{CO2} – CO_2 recovered for urea production, kg. According to company data about 30 % of urea production is exported. Emissions from urea fertilizer are reported under agriculture sector. The use of urea-based catalyst in transport sector were simulated considering the number of cars, which use urea based catalyst and by mileage data provided by COPERT model. Emissions from the use of urea-based catalyst are reported under Non-energy products from fuels and solvent use.

Data on average annual lower calorific value of natural gas is provided by the producer for the whole time series. Data is calculated on the basis of reports from the natural gas supplier. Calorific value of supplied natural gas is measured twice per month at Lithuania's natural gas supplier laboratory.

Ammonia production, CO_2 recovered for urea production and estimated CO_2 emissions are provided in Table 4-13.

Table 4-13. Ammonia production, CO_2 recovered for urea production, estimated CO_2 emissions, kt/year

Year	**Ammonia production**	**Exported CO_2**	**CO_2 emitted from urea application on soils**	**CO_2 emitted from the use of urea-based catalyst**	**CO_2 emission**
1990	568.4	0.0	35.7	0.0	1,255.8
1991	619.6	0.0	41.7	0.0	1,365.5
1992	334.0	0.0	14.8	0.0	732.4
1993	157.9	0.0	7.2	0.0	370.7
1994	277.2	0.0	7.2	0.0	736.3
1995	442.3	0.0	6.7	0.0	1,010.5
1996	560.6	0.0	13.3	0.0	1,195.1
1997	467.3	0.0	13.6	0.0	1,021.3

1998	495.6	0.0	14.0	0.0	1,088.1
1999	487.3	0.0	15.8	0.0	1,051.3
2000	509.9	0.0	16.5	0.0	1,039.0
2001	540.1	0.0	17.2	0.0	1,114.4
2002	568.6	0.0	19.4	0.0	1,149.5
2003	561.2	0.0	19.5	0.0	1,136.0
2004	515.2	0.0	19.7	0.0	1,043.4
2005	565.5	0.0	31.4	0.0	1,110.4
2006	551.1	0.0	18.9	0.0	1,189.2
2007	1,137.6	28.1	31.4	0.0	2,280.3
2008	921.9	19.5	19.3	0.1	1,886.3
2009	574.4	109.2	36.2	0.2	1,077.7
2010	527.2	65.8	15.7	0.2	1,033.8
2011	1,056.0	105.2	14.1	0.3	2,111.7
2012	1,115.9	185.5	15.7	0.4	2,118.0
2013	842.3	89.2	15.7	1.1	1,673.0

4.3.1.3 Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- Activity data uncertainty is assumed to be 2%;
- Emission factor uncertainty is assumed to be 2.5%;
- Combined uncertainty is 3.2%.

The data is consistent over the time-series. Natural gas consumption data, CO_2 recovered for urea production and annual average lower calorific values of the natural gas were provided by the production company. The same emission factor is used over the time-series.

4.3.1.4 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

4.3.1.5 Category-specific planned improvements

No source-specific improvements have been planned.

4.3.2 Nitric Acid Production (CRF 2.B.2)

4.3.2.1 Category Description

Nitric acid is produced by the single nitric acid producer in Lithuania. According to information provided by company, the nitric acid is produced in UKL-7 units and GP unit by absorbing NO_2 with water. NO_2 is produced by air oxidation of NO with oxygen. Nitric oxide (NO) produced by air oxidation of ammonia with oxygen on Pt mesh catalyst. UKL-7 units are working by single pressure (high pressure) scheme. Gaseous emissions after absorption are cleaned from NO_x in a reactor. Grande Paroisse (GP) unit uses a dual-pressure scheme (medium/high). Gaseous emissions from GP are cleaned from NO_x in the reactor using a $DeNO_x$ technology.

Capacities:

At present company operates 9 UKL-7 units. The biggest capacity of one UKL-7 unit is 120 thous t/year (calculated to 100% HNO_3). Capacity of all UKL-7 units is 1.080 thous t/year. Capacity of GP unit is 360 thous t/year. Total nitric acid production capacity is 1.440 thous t/year. Information on nitric acid production units operated during 1990-2013 period is provided in Table 4-14.

Table 4-14. Nitric acid production units in 1990 - 2013

Nitric acid production unit	**1990-2002**	**2003**	**2004**	**2005-2008**	**2009-2013**
UKL-1	operational	operational	operational	operational	operational
UKL-2	operational	operational	operational	operational	operational
UKL-3	operational	operational	operational	operational	operational
UKL-4	operational	operational	operational	operational	operational
UKL-5	operational	operational	operational	operational	operational
UKL-6	operational	operational	operational	operational	operational
UKL-7		operational	operational	operational	operational
UKL-8				operational	operational
UKL-9					operational
GP unit			operational	operational	operational

The Joint Implementation project "Nitrous Oxide Emission Reduction Project at GP Nitric Acid Plant in AB Achema Fertiliser Factory" was carried out by installing secondary catalyst in August 2008. The baseline campaign was launched from September 2007 to July 2008 during which emissions were monitored to determine the baseline emissions of the plant. After installing of the secondary catalyst, the first project campaign was launched and the Project emissions monitored until the end of the campaign – 26 September 2009.

BASF technology was applied by introducing a new catalyst bed which was installed in a new basket, directly under the Platinum gauze in the nitric acid reactors. The secondary catalyst (on Al_2O_3 basis with active metal oxides CuO and ZnO) was installed underneath the platinum gauze. In order to be able to install a secondary catalyst the reconstruction of a burner basket was performed.

Nitric acid production data (Figure 4-13) were provided by the company.

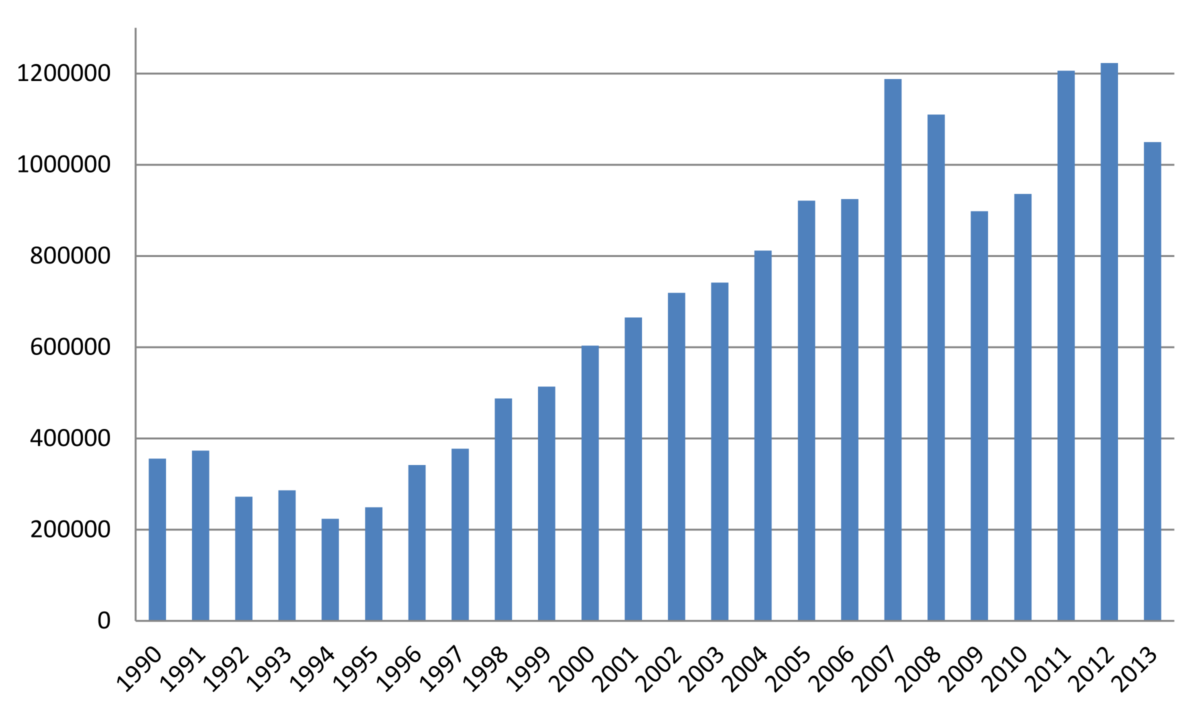


Figure 4-13. Nitric acid production, kt (100% acid) in 1990-2013

4.3.2.2 Methodological issues

The N_2O emissions from the nitric acid production were estimated based on the following data:

- Annual production of nitric acid:
  - Data on the level of production plant (1990-2008);
  - Data on the level of production units (2009-2013).
- Production unit specific N_2O emission factors (Table 4-20):
  - Prior to installation of catalyst (2007-2008 monitoring campaign data);
  - After installation of catalyst (2009-2013).

For the years 2009-2013 production unit specific N_2O emission factors were obtained from the producer (Table 4-15). The emission factors were measured and registered in automated monitoring system (AMS) by AB Achema.

Table 4-15. Production unit specific N_2O emission factors calculated using measured and registered data in automated monitoring system, kg N_2O/t HNO_3 (100%)

Production unit code	2007-2008*	2009	2010	2011	2012	2013
UKL-1	9.63	1.72	1.86	1.87	1.62	1.77
UKL-2	9.51	1.43	1.42	1.65	1.71	1.31
UKL-3	5.45	2.22	2.92	2.16	1.32	1.18
UKL-4	7.73	1.88	2.4	1.68	0.77	0.72
UKL-5	6.61	2.07	1.87	1.69	1.43	1.39
UKL-6	10.34	3.73	3.51	2.65	2.48	0.88
UKL-7	9.09	2.70	1.54	1.16	1.64	0.95
UKL-8	6.96	2.35	1.58	1.50	1.18	0.42
UKL-9	not operational	4.81	4.84	6.65	1.66	0.54

GP	8.83	1.17	0.96	2.32	1.63	1.26

* Data source: Report of the AB Achema for the calculation of EU allowances for the third EU ETS period 2013-2020.

Annual emissions of N_2O from nitric acid production were estimated:

- 1990-2008: based on extrapolated unit specific activity data and the mean value of EFs of the actually operating units;
- 2009-2013: based on unit-specific activity data and unit-specific EFs.

For 1990-2008 emissions calculation production of nitric acid for each operational unit was extrapolated from the data on total annual production of nitric acid in a particular year based on information on unit-specific output (share of each production unit as % of the total production based on 2009-2010 data). Mean value of EFs of the actually operating production units is based on 2007-2008 measurements in automated monitoring system prior to installation of the catalyst (Table 4-20).

For 2009-2013 emissions calculation N_2O emissions were estimated using unit specific emission factors (Table 4-20) and unit specific production data provided by the producer. As already mentioned, in 2008 JI project for N_2O emission reduction from the nitric acid plant in AB Achema has started. During the implementation of the project, substantial emission reduction was achieved as monitored in an automated monitoring system (Table 4-20).

Estimated emissions of N_2O from nitric acid production are provided in Table 4-16.

Table 4-16. Estimated emissions of N_2O from nitric acid production, kt/year

Year	Emission
1990	3.00
1991	3.14
1992	2.30
1993	2.41
1994	1.88
1995	2.10
1996	2.88
1997	3.18
1998	4.11
1999	4.33
2000	5.08
2001	5.61
2002	6.06
2003	6.31
2004	6.99
2005	7.79
2006	7.81
2007	10.04
2008	9.38
2009	2.12
2010	1.86
2011	2.85
2012	1.92

2013	1.13

4.3.2.3 Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- Activity data is provided by a single producer. Uncertainty is assumed to be 2%;
- Emission factor uncertainty is assumed to be 10%;
- Combined uncertainty is 10.2%.

4.3.2.4 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

Plant specific EFs (since 2008 for UKL 1-8, GP and since 2011 for UKL 9) are based on measurements carried out in automated monitoring system by the plant, therefore it is considered that those plant-specific EFs represent the best possible knowledge and are accurate.

4.3.2.5 Category-specific planned improvements

No source-specific improvements have been planned.

4.3.3 Adipic Acid Production (CRF 2.B.3)

Emissions from adipic acid production are not occurring in Lithuania so for the category "CRF 2.B.3 Adipic Acid Production" notation key "NO" is used.

4.3.4 Caprolactum, Glyoxal and Glyoxylic Acid Production (CRF 2.B.4)

Emissions from caprolactum, glyoxal and glyoxylic acid production are not occurring in Lithuania so for the category "CRF 2.B.4 Caprolactum, Glyoxal and Glyoxylic Acid Production" notation key "NO" is used.

4.3.5 Carbide Production (CRF 2.B.5)

Emissions from carbide production are not occurring in Lithuania so for the category "CRF 2.B.5 Carbide Production" notation key "NO" is used.

4.3.6 Titanium Dioxide Production (CRF 2.B.6)

Emissions from titanium dioxide production are not occurring in Lithuania so for the category "CRF 2.B.6 Titanium Dioxide Production" notation key "NO" is used.

4.3.7 Soda Ash Production (CRF 2.B.7)

Emissions from soda ash production are not occurring in Lithuania so for the category "CRF 2.B.7 Soda Ash Production" notation key "NO" is used.

4.3.8 Petrochemical and Carbon Black Production (CRF 2.B.8)

This category is divided into six sub-categories: methanol production (CRF 2.B.8.a), ethylene production (CRF 2.B.8.b), ethylene dichloride and vinyl chloride monomer (CRF 2.B.8.c), ethylene oxide (CRF 2.B.8.d), acrylonitrile (CRF 2.B.8.e) and carbon black (CRF 2.B.8.f).

Methanol Production (CRF 2.B.8.a)

4.3.8.1 Category Description

AB Achema company is a single methanol production company in Lithuania. According to information provided by the company, methanol is produced from the CO, CO_2 and H_2. The medium temperature technological scheme was used in which methanol synthesis reactions are carried out in 8.0 MPa and 180-280°C. Gases required for methanol synthesis are generated by converting natural gas. Project capacity of methanol unit is 74.000 t/year.

Methanol production data (Figure 4-14) 1990-2008 were obtained from Statistics Lithuania publications[19]. According to AB Achema data methanol was not produced in 1999. The company is not producing methanol since 2008 due to economic reasons (high natural gas prices, competitiveness issues) and there are no plans to renew methanol production in the future.

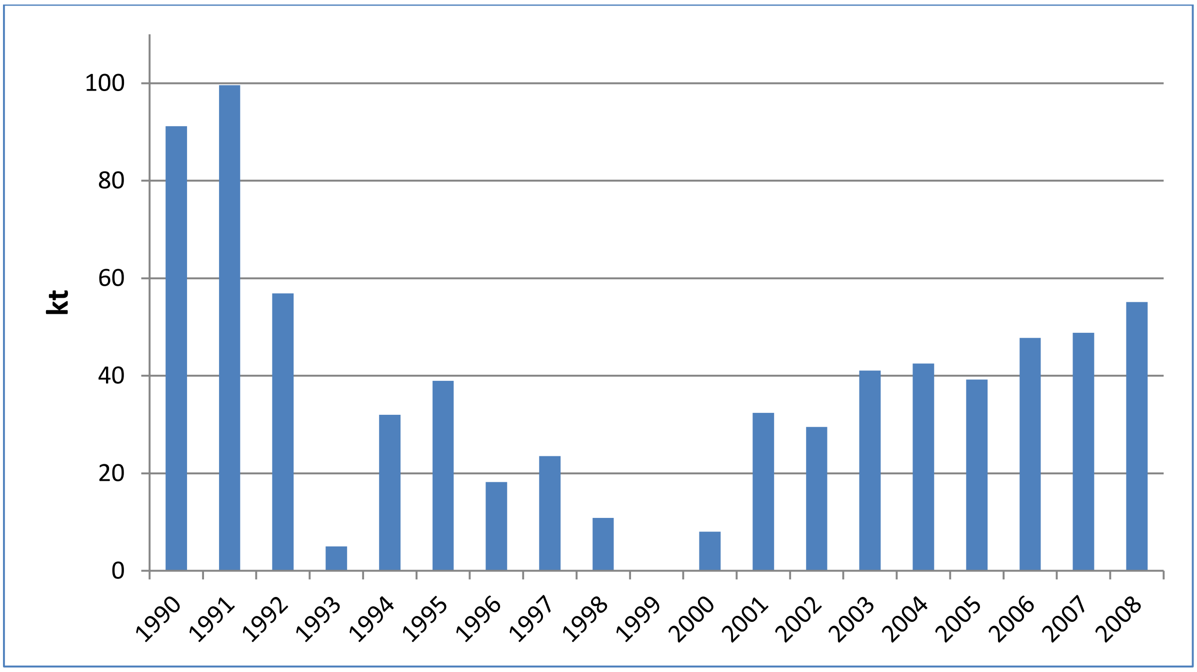


Figure 4-14. Methanol production

Ethylene (CRF 2.B.8.b)

Emissions from ethylene production are not occurring in Lithuania so for the category "CRF 2.B.8.b Ethylene" notation key "NO" is used.

Ethylene Dichloride and Vinyl Chloride Monomer (CRF 2.B.8.c)

Emissions from ethylene dichloride and vinyl chloride monomer production are not occurring in Lithuania so for the category "CRF 2.B.8.b Ethylene Dichloride and Vinyl Chloride Monomer" notation key "NO" is used.

Ethylene Oxide (CRF 2.B.8.d)

Emissions from ethylene oxide production are not occurring in Lithuania so for the category "CRF 2.B.8.d Ethylene Oxide" notation key "NO" is used.

Acrylonitrile (CRF 2.B.8.e)

[19] Database of Statistics Lithuania

Emissions from acrylonitrile production is not occurring in Lithuania so for the category "CRF 2.B.8.e Acrylonitrile" notation key "NO" is used.

Carbon Black (CRF 2.B.8.f)

Emissions from carbon black production is not occurring in Lithuania so for the category "CRF 2.B.8.d Carbon Black" notation key "NO" is used.

4.3.8.2 Methodological issues

Methanol production (CRF 2.B.8.a)

CH_4 emissions were calculated from methanol production data using emission factor 2.3 kg CH_4 per tonne of produced methanol taken from the 2006 IPCC (Volume 3, Part 1, p. 3.74). Estimated emissions of CH_4 (kt/year) from methanol production are provided in Table 4-22.

CO_2 emissions were calculated from methanol production data using default emission factor 0.267 tonne CO_2 per tonne of produced methanol taken from the 2006 IPCC (Volume 3, Part 1, table 3.12, p. 3.73). Estimated emissions of CO_2 (kt/year) from methanol production are provided in Table 4-17.

Table 4-17. Estimated emissions of CH_4 and CO_2 from methanol production

Year	CH_4, kt	CO_2, kt
1990	0.210	24.35
1991	0.229	26.59
1992	0.131	15.19
1993	0.012	1.34
1994	0.074	8.54
1995	0.090	10.41
1996	0.042	4.86
1997	0.054	6.27
1998	0.025	2.90
1999	NO	NO
2000	0.019	2.15
2001	0.075	8.65
2002	0.068	7.88
2003	0.094	10.97
2004	0.098	11.35
2005	0.090	10.47
2006	0.110	12.75
2007	0.112	13.04
2008	0.127	14.72
2009-2013	NO	NO

Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- Activity data was obtained from Statistics Lithuania publications. Uncertainty is assumed to be 5%;
- Emission factor uncertainty is assumed to be 30%;
- Combined uncertainty is 30.4%.

Data is consistent over the time-series. Methanol production activity data 1990-2008 was obtained from Statistics Lithuania publications. According to the production company no methanol was produced in 1999, 2009-2013.

4.3.8.3 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

4.3.8.4 Category-specific planned improvements

No source-specific improvements have been planned.

4.3.9 Fluorochemical Production (CRF 2.B.9)

Fluorochemical production category is divided into two sub-categories: by-product emissions (CRF 2.B.9.a) and fugitive emissions (CRF 2.B.9.b). Emissions from by-product emissions (CRF 2.B.9.a) and fugitive emissions (CRF 2.B.9.b) sub-categories are not occurring in Lithuania so for these sub-categories notation key "NO" is used.

4.3.10 Other (CRF 2.B.10)

Emissions from other production are not occurring in Lithuania so for the category "CRF 2.B.10 Other" notation key "NO" is used.

4.4 Metal industry (CRF 2.C)

In Lithuanian GHG inventory this category includes non-fuel emissions of CO_2 from cast iron production.

There are no key sources in this source category. Steel, sinter, coke, ferroalloys, aluminium, magnesium, lead and zinc are not produced in Lithuania. Emissions from cast iron production in 2013 were 2.4 kt CO_2 eqv., and it was only 0.1% of industry sector's emissions.

4.4.1 Iron and Steel Production (CRF 2.C.1)

4.4.1.1 Category Description

There were three companies producing cast iron until 2009. Only pig iron was used as raw material. The largest company was producing cast iron in induction furnace, but it went bankrupt in 2010. The other two companies are still operating, one is producing cast iron in blast furnace and the other was producing cast iron in blast furnace until 2011, after 2011 it has been using induction furnace.

Estimated CO_2 emissions from the cast iron production are shown in Figure 4-15.

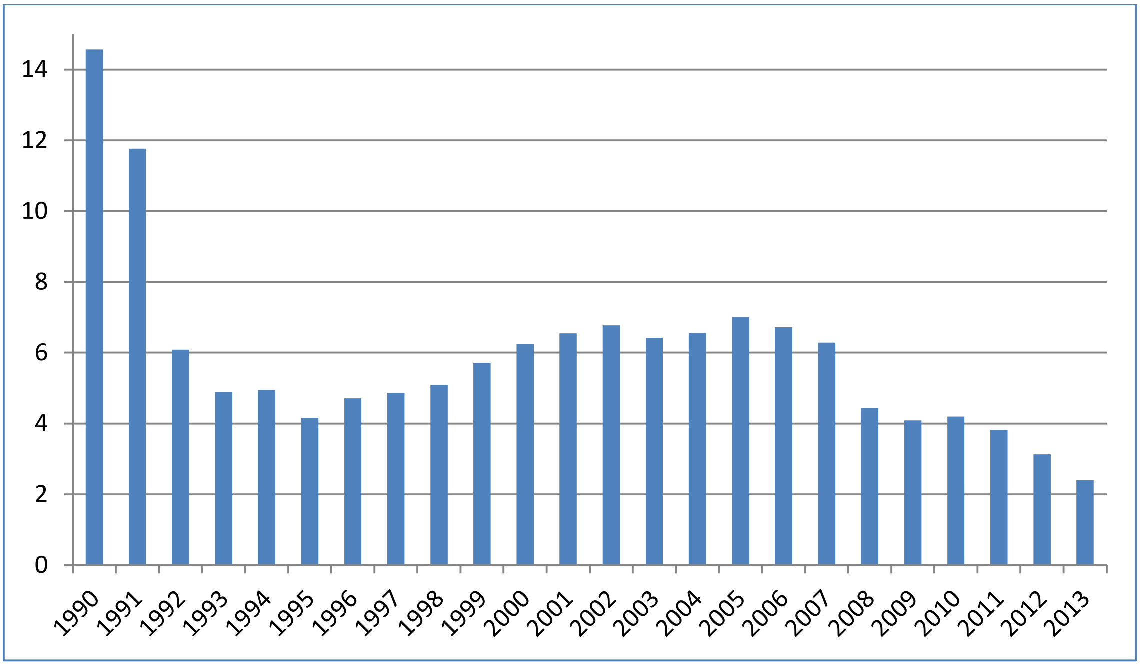


Figure 4-15. CO_2 emissions from the cast iron production, kt

4.4.1.2 Methodological issues

The CO_2 emissions from the cast iron production were estimated based on the following data:

- Annual production of cast iron:
  - total cast iron production (Statistics Lithuania[20] data (1990-2009) and the producing companies data since 2010).
- Coke consumption (the companies data for period 1990-2013).
- Limestone consumption in blast furnace:
  - data on consumed amount of limestone for period 2003-2013 (the company data);
  - amount of limestone consumed for 1 tonne cast iron produced (85 kg/t cast iron, the companies data).
  - Amount of limestone consumption for 1 tonne cast iron produced in induction furnace (10 kg/t cast iron, the company data).

CO_2 emissions from the cast iron production were calculated by Tier 2 method using following modified 2006 IPCC equation (2006 IPCC, Volume 3, Part 1, p. 4.22):

$$E_{CO2,non-energy} = [PC \times C_{PC} + L \times C_L] \times \frac{44}{12}$$

where:

PC – quantity of coke consumed in cast iron production, tonnes;

C_{PC} – carbon content of coke consumed (default – 0.83 tonnes C/tonne);

L – quantity of limestone consumed in cast iron production, tonnes;

C_L –carbon content of limestone consumed (default – 0.12 tonnes C/tonne).

[20] Database of Statistic Lithuania

4.4.1.3 Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- Data on the total cast iron production for period 1990-2009 were taken from Statistics Lithuania and the data were provided by the production companies since 2010. Uncertainty of the activity data is assumed to be 10%;
- Emission factor uncertainty is assumed to be 10%;
- Combined uncertainty is 14.1%.

Data is consistent over the time-series.

4.4.1.4 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

4.4.1.5 Category-specific planned improvements

No source-specific improvements have been planned.

4.4.2 Ferroalloys Production (CRF 2.C.2)

Emissions from ferroalloys production are not occurring in Lithuania so for the category "CRF 2.C.2 Ferroalloys Production" notation key "NO" is used.

4.4.3 Aluminium Production (CRF 2.C.3)

Emissions from aluminium production are not occurring in Lithuania so for the category "CRF 2.C.3 Aluminium Production" notation key "NO" is used.

4.4.4 Magnesium Production (CRF 2.C.4)

Emissions from magnesium production are not occurring in Lithuania so for the category "CRF 2.C.4 Magnesium Production" notation key "NO" is used.

4.4.5 Lead Production (CRF 2.C.5)

Emissions from lead production are not occurring in Lithuania so for the category "CRF 2.C.5 Lead Production" notation key "NO" is used.

4.4.6 Zinc Production (CRF 2.C.6)

Emissions from zinc production are not occurring in Lithuania so for the category "CRF 2.C.6 Zinc Production" notation key "NO" is used.

4.4.7 Other (CRF 2.C.7)

Emissions from other production are not occurring in Lithuania so for the category "CRF 2.C.7 Other" notation key "NO" is used.

4.5 Non-energy products from fuels and solvent use (CRF 2.D)

4.5.1 Lubricant use (CRF 2.D.1)

4.5.1.1 Category Description

The Statistics Lithuania provides data on non-energy use of lubricants in Energy Balance (see Annex III). There is no subdivision of lubricants into oils and greases in Energy Balance. Data on consumption of lubricants is available for 1990-2013 and is shown in Figure 4-16.

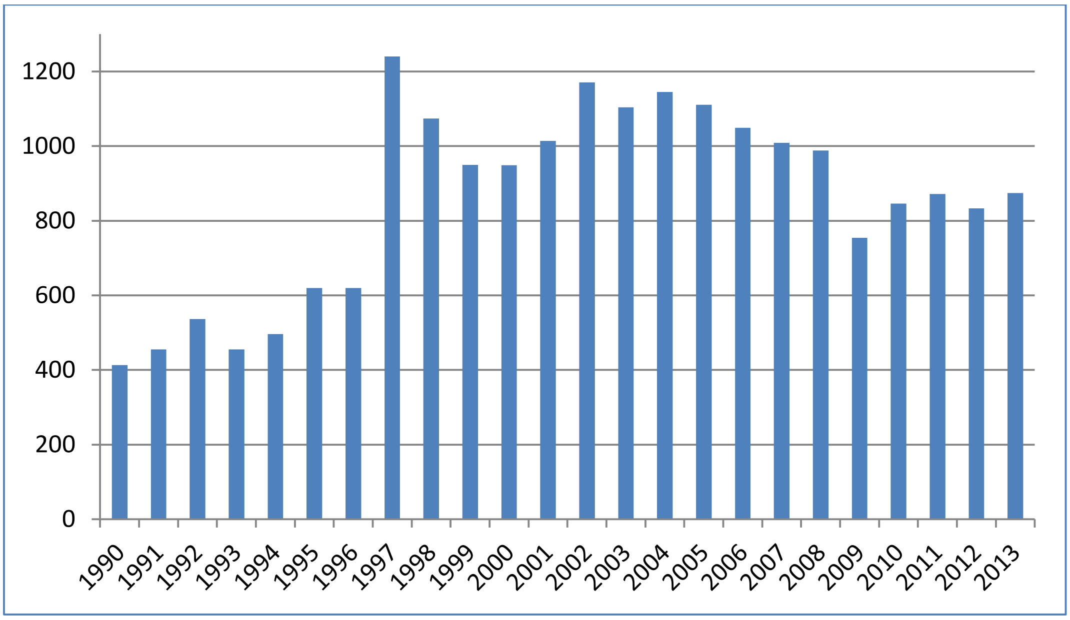


Figure 4-16. Consumption of lubricants for non-energy purposes, TJ

4.5.1.2 Methodological issues

CO_2 emission calculations are based on total consumption of lubricants, the default carbon content and ODU factors. Emissions are calculated according to following equation (2006 IPCC, Volume 3, Part 2, p. 5.7):

$$CO_2 Emissions = LC \times CC_{Lubricant} \times ODU_{Lubricant} \times 44/12$$

where

LC – total lubricant consumption, TJ;

$CC_{Lubricant}$ – carbon content of lubricants (default – 20 C/TJ);

$ODU_{Lubricants}$ – amount of lubricants oxidised during use factor (default – 0.2);

44/12 – mass ratio of CO_2/C.

Estimated CO_2 emissions from use of lubricants are provided in Table 4-18.

Table 4-18. Estimated CO_2 emissions from use of lubricants, kt/year

Year	Emission
1990	6.06
1991	6.67
1992	7.88
1993	6.67

1994	7.27
1995	9.09
1996	9.09
1997	18.19
1998	15.75
1999	13.93
2000	13.92
2001	14.87
2002	17.17
2003	16.19
2004	16.79
2005	16.29
2006	15.39
2007	14.80
2008	14.49
2009	11.06
2010	12.41
2011	12.79
2012	12.22
2013	12.82

4.5.1.3 Uncertainties and time-series consistency

Activity data was obtained from Statistics Lithuania publications. Uncertainty is assumed to be 5%. Emission factor uncertainty is assumed to be 50.1% and combined uncertainty is 50.3%.

Data is consistent over the time-series. Data on consumption of lubricants for all period was obtained from Statistics Lithuania.

4.5.1.4 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

4.5.1.5 Category-specific planned improvements

No source-specific improvements have been planned.

4.5.2 Paraffin wax use (CRF 2.D.2)

4.5.2.1 Category Description

The Statistics Lithuania provides data on non-energy use of paraffin wax in Energy Balance (see Annex). Data on consumption of paraffin wax is available for 2001-2013 and is shown in Figure 4-17.

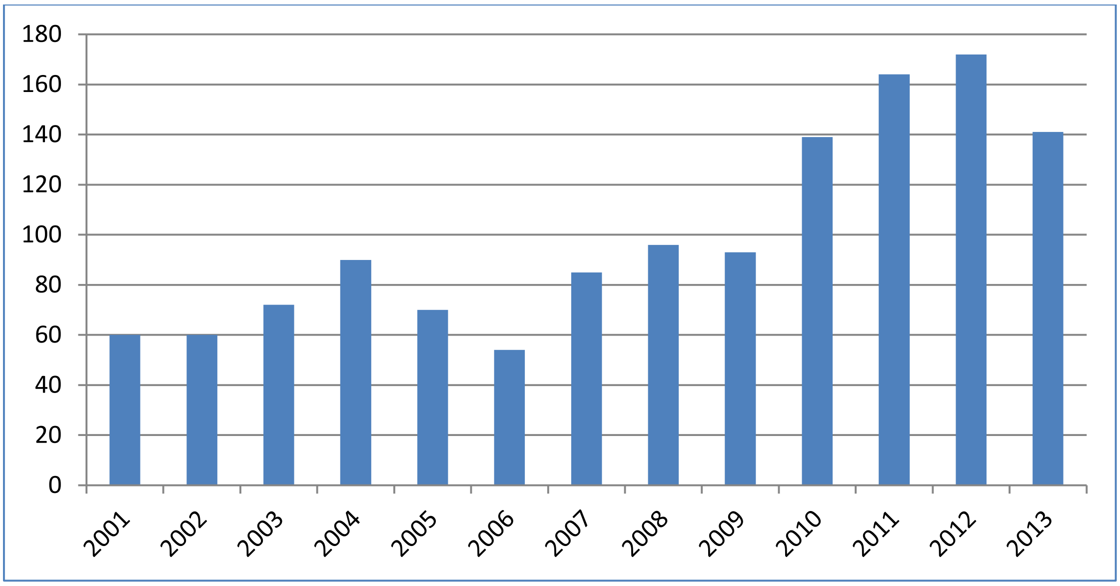


Figure 4-17. Consumption of paraffin wax for non-energy purposes, TJ

4.5.2.2 Methodological issues

CO_2 emission calculations are based on total consumption of paraffin wax, the default carbon content and ODU factors. Emissions are calculated according to following equation (2006 IPCC, Volume 3, Part 2, p. 5.11):

$$CO_2 Emissions = PW \times CC_{Wax} \times ODU_{Wax} \times 44/12$$

where

PW – total wax consumption, TJ;

CC_{Wax} – carbon content of paraffin wax (default – 20 C/TJ);

ODU_{Wax} – amount of paraffin wax oxidised during use factor (default – 0.2);

44/12 – mass ratio of CO_2/C.

Estimated CO_2 emissions from use of paraffin wax are provided in Table 4-19.

Table 4-19. Estimated CO_2 emissions from use of paraffin wax, kt/year

Year	Emission
2001	0.88
2002	0.88
2003	1.06
2004	1.32
2005	1.03
2006	0.79
2007	1.25
2008	1.41
2009	1.36
2010	2.04
2011	2.41
2012	2.52

2013	2.07

4.5.2.3 Uncertainties and time-series consistency

Activity data was obtained from Statistics Lithuania publications. Uncertainty is assumed to be 5%. Emission factor uncertainty is assumed to be 100% and combined uncertainty is 100.2%.

Data is consistent over the time-series. Data on consumption of paraffin wax was obtained from Statistics Lithuania.

4.5.2.4 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

4.5.2.5 Category-specific planned improvements

No source-specific improvements have been planned.

4.5.3 Other (CRF 2.D.3)

4.5.3.1 Category Description

Solvent use

Solvent use contributes a small amount to the total GHG emissions in Lithuania. Share to the total emission was only 0.3% in 2013 (excl. LULUCF). Indirect CO_2 emission from NMVOC for the following subcategories was estimated:

- Domestic solvent use;
- Dry cleaning;
- Degreasing;
- Chemical products;
- Coating applications: paint application.

The inventory of NMVOC emissions from the solvent use sector is performed at Lithuanian Environmental Protection Agency. The NMVOC inventory is carried out to meet the obligations of the UNECE Convention on Long-range Transboundary Air Pollution and EU Directive 2001/81/EC (NEC Directive).

Asphalt roofing

UAB Mida LT is a single company in Lithuania producing asphalt roofing materials. The company started operation in 2001 after reorganization of Soviet construction materials production company. Company produces bitumen tiles as well as roll roofing materials. Data on production of roofing materials was provided by the producer and is available for the period 2001-2013 (Table 4-22). The production of roll roofing materials was almost stopped compared to 2012, this is due to the import of the cheaper production from other countries.

Table 4-22. Production of asphalt roofing materials in Lithuania 2001-2013 (thous m^2)

Year	Bitumen tiles	Roll roofing materials
2001	253	2,087
2002	403	3,352
2003	975	5,526
2004	1,670	6,124
2005	3,157	4,488

2006	2,356	4,322
2007	3,842	5,948
2008	3,451	6,424
2009	367	0
2010	3,681	477
2011	3,265	573
2012	3,737	29
2013	3,743	0.001

According to the producer, asphalt roofing materials were also produced in 1990-2000 prior to reorganization of the company in 2001, but data for this period is not available.

Production of the asphalt roofing materials in 1990-2000 was estimated based on annual average use of bitumen.

Asphalt roofing production is provided in Figure 4-18.

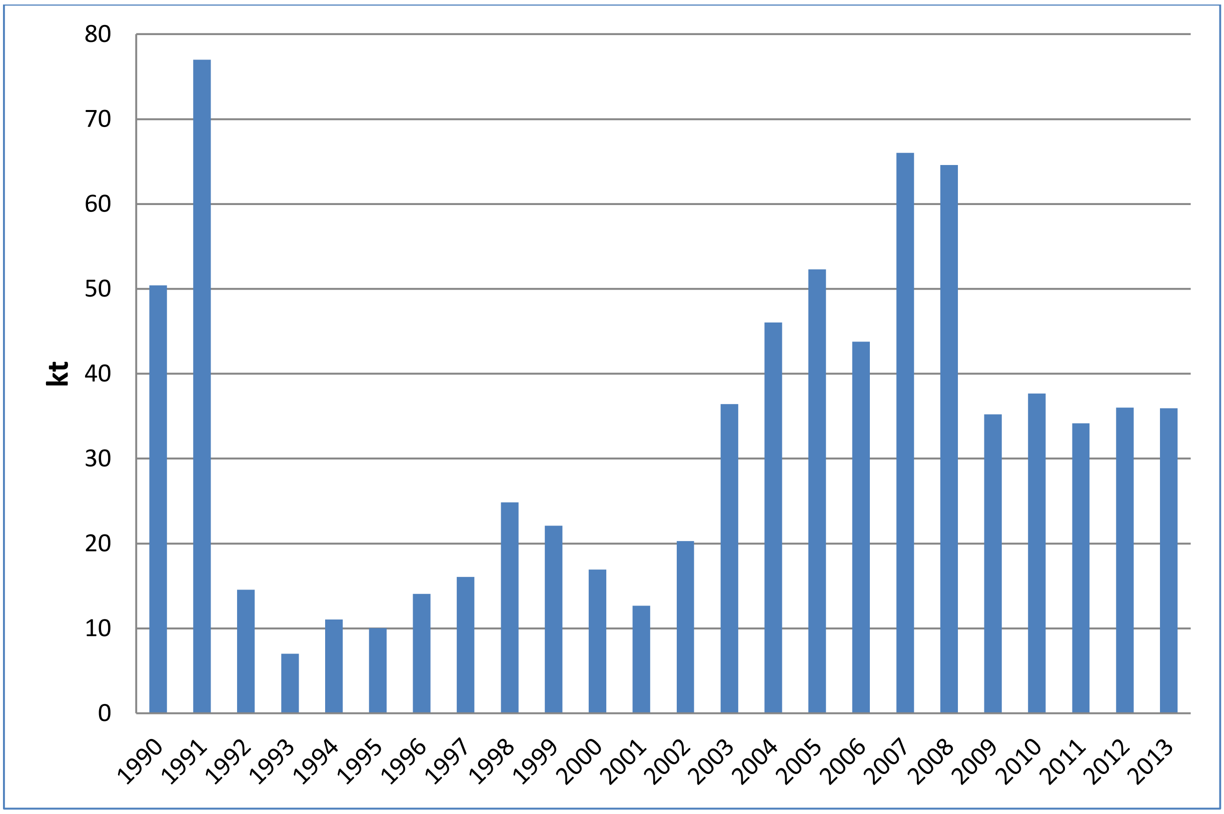


Figure 4-18. Production of asphalt roofing in 1990-2013

Road paving with asphalt

According to the data published in the European Asphalt Pavement Association publication "Asphalt in figures" there were 20 companies in the asphalt industry in 2013 in Lithuania. In the same publication the data on consumption of bitumen in the road industry is also available for the years 2007-2013. Statistics Lithuania collects data on production of bitumen (data available for 2002-2013), but not on consumption of bitumen, therefore data available from Statistics Lithuania, was used to extrapolate consumption of bitumen for the period 2002-2006. To extrapolate data on the consumption of bitumen in 1990-2001 the data on installed, rebuilt and modified asphalt roads (1989-2000) were used. This data was taken from 2002-2015 program on the maintenance and development of the Lithuanian state roads. Consumption of bitumen in road industry is provided in Figure 4-19.

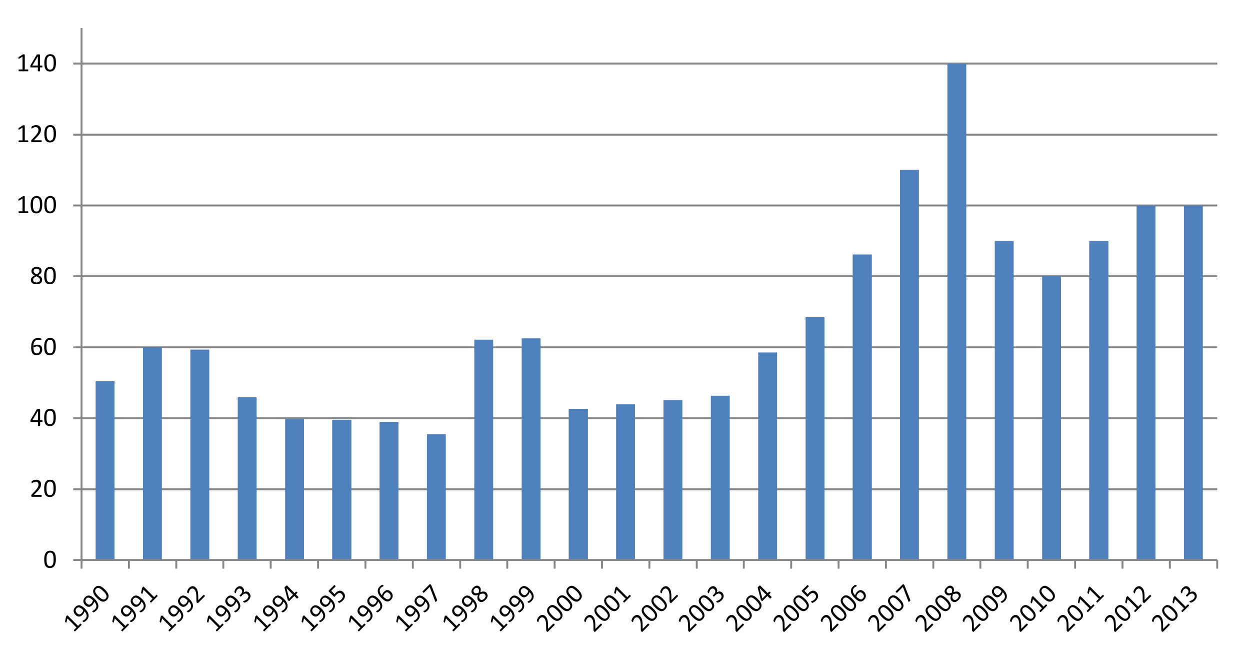


Figure 4-19. Consumption of bitumen in 1990-2013

4.5.3.2 Methodological issues

<u>*Solvent use*</u>

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 (Table 4-20).

Table 4-20. NMVOC emission factors

Sub-sectors	**NMVOC emission factors, kg/cap/year**
Domestic solvent use:	
Household	0.507
Car care products	0.464
Cosmetics and toiletries	1.088
DIY/buildings	0.522
Pharmaceutical products	0.048
Dry cleaning	0.3
Degreasing	0.7
Chemical products	0.65
Coating applications: paint application	4.5

Emissions were calculated using annual average population data provided by the Statistics Lithuania. The default fossil carbon content fraction of NMVOC (2006 IPCC, Volume 3, part 2, p. 5.17) was used for all categories under sector of solvent use. CO_2 emissions from solvent use were calculated using the equation below.

$$\textit{Emission } CO_2 = \textit{Emission NMVOC} \times 0.6 \times 44/12$$

CO_2 and NMVOC emissions from solvent use are presented in Table 4-21.

Table 4-21. CO_2 and NMVOC emissions (kt) from solvent use for the period 1990-2013

Year	CO_2 emission	NMVOC emission
1990	71.42	32.46
1991	71.54	32.52
1992	71.46	32.48
1993	71.12	32.33
1994	70.63	32.11
1995	70.09	31.86
1996	69.56	31.62
1997	69.05	31.39
1998	68.55	31.16
1999	68.07	30.94
2000	67.59	30.72
2001	67.03	30.47
2002	66.50	30.23
2003	65.96	29.98
2004	65.22	29.65
2005	64.17	29.17
2006	63.15	28.71
2007	62.41	28.37
2008	61.77	28.08
2009	61.09	27.77
2010	59.82	27.19
2011	58.48	26.58
2012	57.71	26.23
2013	57.12	25.97

Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- Uncertainty of activity data is assumed to be 30%;
- Emission factor uncertainty is assumed to be 20%;
- Combined uncertainty is 36%.

Asphalt roofing

Weight of the asphalt roofing material was calculated using area to weight ratio provided by the production company: 9.6 kg/m^2 for bitumen tiles and 4.9 kg/m^2 for roll roofing material. Amount of bitumen used for production of asphalt roofing is 2 kg/m^2 for bitumen tiles and 2.6 kg/m^2 for roll roofing.

Production of the asphalt roofing materials in 1990-2000 was estimated based on annual average use of bitumen. During the period between 2001 and 2010 production of asphalt roofing materials annually consumed on average 13% of the bitumen used for non-energy uses. Data on bitumen use for non-energy uses was obtained from energy balance by Statistics Lithuania. It was also assumed that only roll roofing was produced in 1990-2000.

Emissions of non-methane volatile organic compounds (NMVOC) from asphalt roofing were calculated from the national data on the total mass of production. Default emission factor of 0.13 kg NMVOC per tonne product was used (EMEP/CORINAIR, 2.D.3.c Asphalt roofing, Table 3.1, p.7).

Estimated NMVOC emissions form asphalt roofing production were converted to CO_2 equivalent assuming that NMVOC contain 80% carbon by weight (IPCC Guidelines 2006, page 5.16). Estimated NMVOC and CO_2 eqv. emissions from asphalt roofing production are shown in Table 4-23.

Table 4-23. Estimated NMVOC and CO_2 eqv. emissions from asphalt roofing production

Year	NMVOC, kt	CO_2 eqv., kt
1990	0.0066	0.0192
1991	0.0100	0.0294
1992	0.0019	0.0055
1993	0.0009	0.0027
1994	0.0014	0.0042
1995	0.0013	0.0038
1996	0.0018	0.0054
1997	0.0021	0.0061
1998	0.0032	0.0095
1999	0.0029	0.0084
2000	0.0022	0.0065
2011	0.0016	0.0048
2002	0.0026	0.0077
2003	0.0047	0.0139
2004	0.0060	0.0176
2005	0.0068	0.0199
2006	0.0057	0.0167
2007	0.0086	0.0252
2008	0.0084	0.0246
2009	0.0046	0.0134
2010	0.0049	0.0144
2011	0.0044	0.0130
2012	0.0047	0.0137
2013	0.0047	0.0137

Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- The data on production of asphalt roofing materials and raw materials consumption obtained from the production company are reliable and precise. However, they cover only the period after reconstruction of the plant (from 2001). Historic data for 1990-2000 are expert evaluation and may be less reliable. It was assumed that overall uncertainty of asphalt roofing activity data is 5%.
- Emission factor uncertainty is assumed to be 25%.
- Combined uncertainty is 25.4%.

Data on production of roofing materials was provided by the producer and is available for the period 2001-2013. Production of the asphalt roofing materials in 1990-2000 was estimated based on annual average use of bitumen.

Road paving with asphalt

NMVOC emissions from road paving with asphalt are calculated based on annual consumption of bitumen. NMVOC emission was calculated using default emission factor 0.016 kg/tonne of asphalt (EMEP/CORINAIR, 2.D.3.b Road paving with asphalt, Table 3.1, p.8).

Estimated NMVOC emissions from road paving with asphalt were converted to CO_2 equivalent assuming that NMVOC contain 45% carbon by mass (IPCC Guidelines 2006, p. 5.16). Estimated NMVOC and CO_2 eqv. emissions from road paving with asphalt are shown in Table 4-24.

Table 4-24. Estimated NMVOC and CO_2 eqv. emissions from road paving with asphalt

Year	NMVOC, kt	CO_2 eqv., kt
1990	0.001	0.001
1991	0.001	0.002
1992	0.001	0.002
1993	0.001	0.001
1994	0.001	0.001
1995	0.001	0.001
1996	0.001	0.001
1997	0.001	0.001
1998	0.001	0.002
1999	0.001	0.002
2000	0.001	0.001
2001	0.001	0.001
2002	0.001	0.001
2003	0.001	0.001
2004	0.001	0.002
2005	0.001	0.002
2006	0.001	0.002
2007	0.002	0.003
2008	0.002	0.004
2009	0.001	0.002
2010	0.001	0.002
2011	0.001	0.002
2012	0.002	0.003

2013	0.002	0.003

Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- The data on consumption of bitumen obtained from the European Asphalt Pavement Association are reliable. However, it covers only the period 2007-2012. Historic data for 1990-2006 are expert evaluation and may be less reliable. It was assumed that overall uncertainty of road paving with asphalt activity data is 20%.
- Emission factor uncertainty is assumed to be 50%.

Combined uncertainty is 53.8%.

4.5.3.3 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

4.5.3.4 Category-specific planned improvements

No planned improvements are under the consideration.

4.6 Electronic Industry (CRF 2.E)

This section covers emissions of sulphur hexafluoride (SF_6) from semiconductor and nitrogen trifluoride (NF_3) from photovoltaics production. There is one company in Lithuania, which produces semiconductors and there is one company, which is manufacturer of high efficiency solar cells. In 2013 the emissions from electronic industry were estimated at 5.98 kt CO_2 eqv.

4.6.1 Integrated Circuit or Semiconductor (CRF 2.E.1)

4.6.1.1 Category Description

There is one company in Lithuania, which produces semicondutors. The company's authorities informed that in 2008 company started use SF_6 gas, so the emission data are only available for the period 2008-2013. Only 50% of emissions are released into environment. Emissions from semiconductors fluctuation are highly related to economic situation and production demand.

4.6.1.2 Methodological issues

Emissions of SF_6 from semiconductor manufacturing were calculated using the following modified equation (2006 IPCC Guidelines):

$$E_{SF6,\,t} = F_{SF6,\,t} \ x \ C_i$$

where:

F_{SF6}, t - quantity of HFCs used by the company in year t, t;

C_i - emission factor during production.

Estimates of SF_6 emissions from semiconductor manufacture are demonstrated in Figure 4-20 and Table 4-25 below.

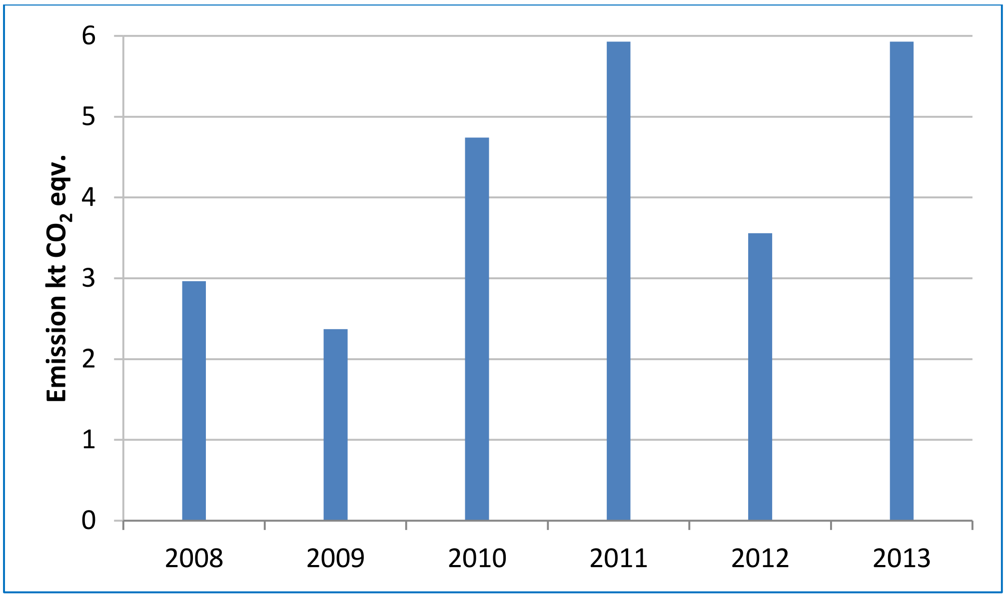


Figure 4-20. SF_6 emissions from semiconductor manufacture for 2008-2013

Table 4-25. SF_6 emissions from semiconductor manufacture for the period 2008-2013

Year	Emissions from semiconductor manufacture, kt CO_2 eqv.
2008	2.96
2009	2.37
2010	4.74
2011	5.93
2012	3.56
2013	5.93

4.6.1.3 Uncertainties and time-series consistency

Emission uncertainty was estimated using Approach 1 of the 2006 IPCC Guidelines (p. 3.27). Uncertainty estimates of activity data and emission factors are presented in Table 4-26.

Table 4-26. Uncertainty (UN) estimates of SF_6 emissions in the sub-category of semiconductor manufacture

Emission source	Input data UN, %	EF during operation UN, %	Total emission UN, %
CRF 2.E.1Integrated Circuit or Semiconductor	5	5	7

4.6.1.4 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

4.6.1.5 Category-specific planned improvements

No source-specific improvements have been planned.

4.6.2 TFT Flat Panel Display (CRF 2.E.2)

Fluorinated compounds (FC) emissions from TFT flat panel display production are not occurring in Lithuania so for the category "CRF 2.E.2TFT Flat Panel Display" notation key "NO" is used.

4.6.3 Photovoltaics (CRF 2.E.3)

4.6.3.1 Category Description

UAB "SoliTek" is the single company in Lithuania producing high efficiency solar cells. The company owns the latest manufacturing equipment and advanced industrial facilities with an annual capacity of 80 MW from PV cells and 50 MW from Glass/Glass modules. 100% of raw materials used in companies PV cell manufacturing are provided by European suppliers. UAB "SoliTek" holds the complete production chain of PV cells of finished Glass/Glass modules[21].

4.6.3.2 Methodological issues

During 2013 325 kg of NF_3 gases has been consumed. One of the solar cell production processes is deposition of antireflective SiNx layer by Plasma Enhanced Chemical Vapour Deposition (PECVD) method. NF_3 is used as cleaning agent for process chambers of PECVD equipment. This equipment is connected to the burner scrubber on the outlet of the vacuum pump. All waste gases generated after chemical vapor deposition process and cleaning step (including NF_3) are diluted in nitrogen and cleaned via burning, wet scrubbing and aerosol retention.

Burning

The gases requiring disposal are called waste gases and they are exposed to a natural gas/compressed air flame. At a temperature of over 1000^0C the reaction products and process gases remaining in the waste gas are either burned or thermally decomposed and converted into products that can be wet scrubbed.

Wet Scrubbing

After leaving the burner unit the waste gases are led to a scrubber column. Components that are soluble or react with the washing liquid are wet scrubbed and neutralized at waste water treatment (WWT) plant. The drain of the scrubber is connected to the waste water treatment plant. Dust particles are retained from the waste gas and are removed with the washing liquid. After burning and wet scrubbing procedure the gas, which is fed into exhaust system is designated clean gas.

Company's authorities informed that the efficiency of the cleaning device is 99%, which means that only 1% of NF_3 is released to the environment. According to the company's authorities NF_3 has been used only since 2013. Total NF_3 emissions from Photovoltaics for the 2013 were 0.06 kt CO_2 eqv.

4.6.3.3 Uncertainties and time-series consistency

Emission uncertainty was estimated using 2006 IPCC Guidelines, Volume 3, p. 6.25. Uncertainty estimates of activity data and emission factors are presented in Table 4-27.

Table 4-27. Uncertainty (UN) estimates of fluorinated gas emissions in the sub-category of photovoltaics

Emission source	Input data UN, %	EF during operation UN, %	Total emission UN, %

[21] http://www.solitek.eu/en/

CRF 2.E.3 Photovoltaics	5	20	21

4.6.3.4 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

4.6.3.5 Category-specific planned improvements

No source-specific improvements have been planned.

4.6.4 Heat Transfer Fluid (CRF 2.E.4)

FC emissions from heat transfer fluid production are not occurring in Lithuania so for the category "CRF 2.E.4 Heat Transfer Fluid" notation key "NO" is used.

4.6.5 Other (CRF 2.E.5)

FC emissions from other production are not occurring in Lithuania so for the category "CRF 2.E.5 Other" notation key "NO" is used.

4.7 Product Uses as Substitutes for Ozone Depleting Substances (CRF 2.F)

Hydrofluorocarbons (HFCs) are used as alternatives to chlorofluorocarbons (CFCs), ozone depleting substances being phased out under the Montreal Protocol. Emissions of HFCs occur as leakage from the charge of equipment, its use and from the destruction of such equipment at the end of life.

The main data source for halocarbons calculations is Environmental Protection Agency (EPA) database, however there are drawbacks in some sub-sectors, this is the reason why studies were carried out for specific sub-sectors and used as a supplementary data source for calculations. A study "Analysis of the Use of Fluorinated Greenhouse Gases in Lithuania in 1990-2011" was carried out in 2012. The project was financed from the national sources. The results of the study were used for the preparation of the present report.

The share of GHG emissions from the consumption of halocarbons is steadily increasing. In 2013 the emissions were estimated at 314.2 kt CO_2 eqv. (or 10.7% from the aggregated emissions from Industrial processes).

Based on the current knowledge, the major source of GHG emissions in the sub-sector "Product Uses as Substitutes for ODS" is mobile air conditioning (CRF 2.F.1.e), which accounts for approximately 40.4% of the emissions (as CO_2 eqv.). Transport Refrigeration (CRF 2.F.1.d) and Commercial Refrigeration (CRF 2.F.1.a) account for 25.7% and 17.4% of the 2013 emissions respectively (as CO_2 eqv.).

Only subcategory Refrigeration and Air Conditioning Equipment (CRF 2.F.1) is the key category in 2013 by level and trend.

Estimated emissions from consumption of halocarbons in 1993-2013 are shown in Figure 4-21.

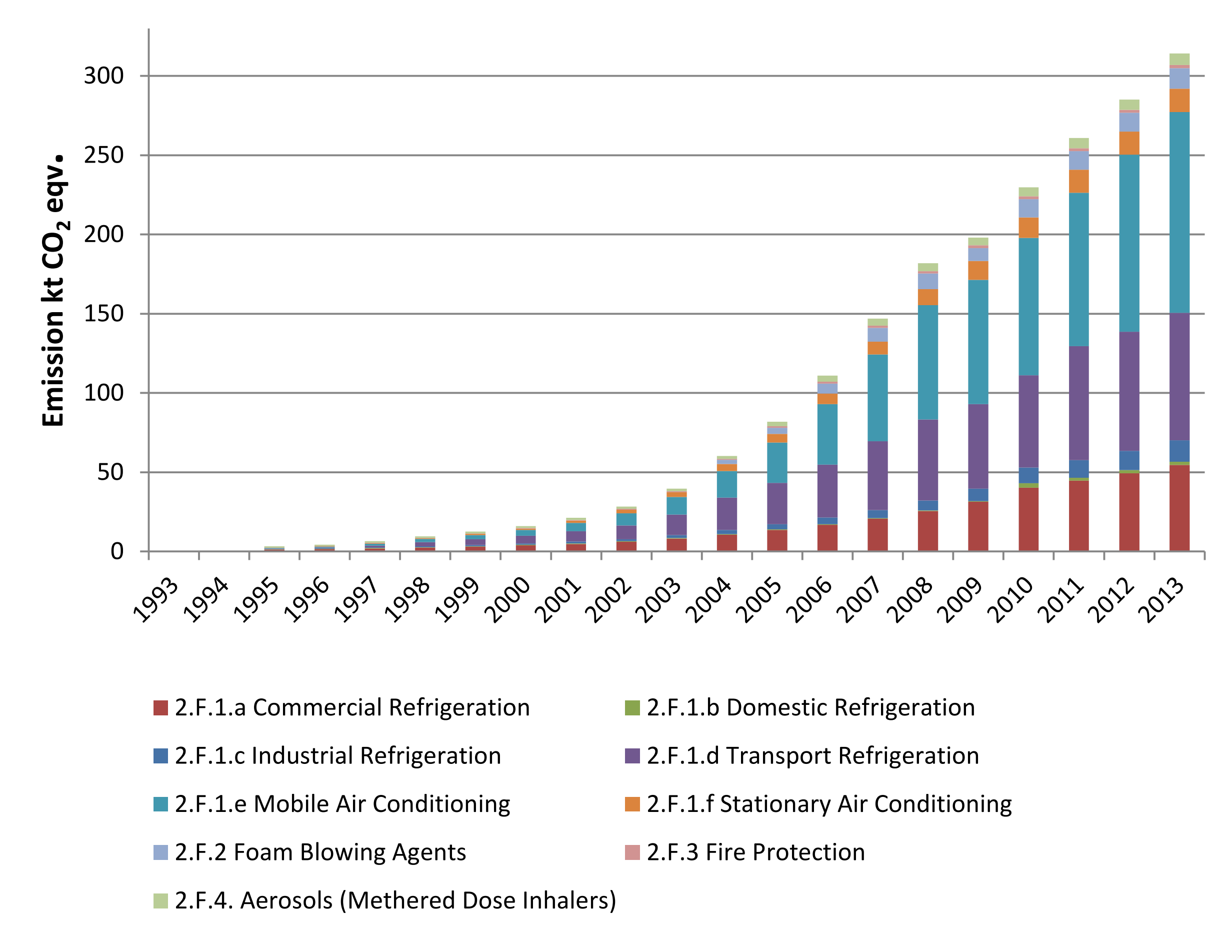


Figure 4-21. Estimated emissions from consumption of Halocarbons in 1993-2013.

4.7.1 Refrigeration and air conditioning (CRF 2.F.1)

This section covers emissions of halocarbons from: commercial refrigeration (CRF 2.F.1.a), domestic refrigeration (CRF 2.F.1.b), industrial refrigeration (CRF 2.F.1.c), transport refrigeration (CRF 2.F.1.d), mobile air-conditioning (CRF 2.F.1.e) and stationary air-conditioning (CRF 2.F.1.f).

4.7.1.1 Category Description

Commercial Refrigeration (CRF 2.F.1.a)

Emission sources in commercial refrigeration category are refrigeration in supermarkets and shops, Drink coolers, Refrigeration in accommodation and catering businesses. The main fluorinated gases in this category are HFC-125 and HFC-143a, also small amounts of HFC-32 and HFC-134a are occurring.

A survey of fluorinated gas use in commercial and industrial refrigeration in Lithuania was conducted in 2008 (2008 Study) and the results of the survey were used as a basis for calculation of emissions. The data on the use of F-gases was collected by interviewing representatives of the most important trade and industry sectors. The representatives were also asked to evaluate the market situation and market share of the company. The estimated use of fluorinated gases is shown in Table 4-28.

Table 4-28. Estimated use of fluorinated gases in Lithuania

	F-gases in surveyed enterprises, t	**Market share %**	**Total F-gases in use, t**

	R404a	R134a	R407c		R404a	R134a	R407c
Skating rinks	0.15	-	-	90%	0.17	-	-
Supermarkets	72.86	1.48	-	65%	112.10	2.27	-
Other retail enterprises*	-	-	-	-	5.61	0.11	-
Meat processing	2.15	-	-	30%	7.17	-	-
Milk processing	0.59	-	-	20%	2.95	-	-
Fish processing	1.01	-	-	20%	5.03	-	-
Fruit and vegetable processing	1.28	-	-	30%	4.27	-	-
Beverage production	0.28	-	-	20%	1.41	-	-
Processing of berries and mushrooms	1.07	-	-	45%	2.38	-	-
Prefabricated food products	0.66	-	-	30%	2.20	-	-
Warehouses	1.15	-	-	30%	3.83	-	-
Poultry processing	1.20	-	-	25%	4.80	-	-
PET production	0.13	0.12	0.39	30%	0.43	0.40	1.28
Other industries**	-	-	-	-	1.72	0.02	0.06
Total				-	154.06	2.81	1.35

**Assumed as 5% of supermarkets, **Assumed 5% of the total*

Historically, ammonia was the most widely used refrigerant in meat, milk and other food product production and storage systems in the eighties. However, these huge systems were not able to survive in the early nineties after the introduction of market economy and were closed or split into smaller production units. Old refrigeration systems were substituted by new smaller systems mainly using chlorinated refrigerants, such as R-12 and R-22, which were also used in refrigeration systems in supermarkets.

Based on Study 2008 and Study 2012 results and the assessment of EPA database in 2013 it was assumed (table 4-29) that annual change of F-gases use was:

Table 4-29. Assumed annual change of F-gases used comparing with previous year

F-gases	2012	2013
HFC-32	5%	5%
HFC-125	10%	10%
HFC-134a	20%	20%
HFC-143a	10%	10%

Estimations were made after assessing the EPA database. This database is made up of companies reports submitted in accordance with Order No. D1-12 of the Minister of Environment of the Republic of Lithuania of 7 January 2010 on the approval of the procedure for the provision, collection and handling of data on fluorinated greenhouse gases and ozone depleting substances and accounting of equipment and systems containing such gases or substances. According the changes made in 2013 every company who submits report marks quantity of substance used in newly installed equipment and quantity of substance used for refill. All used blends are broken into constituent substances by the companies. Furthermore, company marks the sub-category for which substance was used (industrial, commercial, air conditioning etc.).

Domestic Refrigeration (CRF 2.F.1.b)

The predominant refrigerant in domestic refrigeration equipment is R-134a, a small number of the appliances are also filled with the refrigerant R-125. Over the past decade, the use of these refrigerants has been limited, so more and more of new equipment is charged with isobutane R600a which does not contain fluorinated gases.

There is only one company manufacturing domestic refrigerators in Lithuania. According to the company data, all domestic refrigerators manufactured by the company are being filled with the refrigerant R600a since 2011. The company started using isobutane (R600a) in 2000. Over the period 2000-2010, part of refrigerators manufactured by company were charged with the refrigerant R-134a, which resulted in fluorinated gas emissions during their assembly/manufacturing process when refrigerators were being filled with the refrigerant. The company provided annual data on sales/production of domestic refrigerators for 2000-2011, specifying number refrigerators filled with R-134a. The use of the refrigerant R-134a for the charging of new equipment during the said period was continuously going down and was completely discontinued from 2011.

According to the study Analysis of the Use of Fluorinated Greenhouse Gases in Lithuania conducted in 2008, the HFCs were not collected in Lithuania until 2007. The first company to start this activity in 2007 was UAB EMP Recycling. Following the company data, refrigerators collected by UAB EMP Recycling account for up to 50% of the total amount of refrigerators discarded in Lithuania. The remaining refrigerators are collected by various companies, however, part of the collected refrigeration equipment is transferred to UAB EMP Recycling.

Following the afore-mentioned Study Analysis of the Use of Fluorinated Greenhouse Gases in Lithuania (2008) and expert judgement, over the period 1986-2002 the refrigerant R12 in domestic refrigeration compressors was gradually replaced by R-134a. The use of R-134a at the beginning of the said period was very insignificant, meanwhile the period 1994-1995 the use of R-134a increased considerably in domestic refrigeration equipment, as witnessed by the experience of other European countries in the production of these domestic appliances. According to the situation described, fluorinated gas emissions from domestic refrigeration equipment have been estimated since 1995.

Industrial Refrigeration (CRF 2.F.1.c)

HFC-125, HFC-143a and HFC-134a are the main gases which occur in industrial refrigeration category. Small amounts of HFC-32 gases are also released in this sub-sector. Emissions from industrial refrigeration decommissioning were estimated for 2010-2013 and taking into account that HFCs have been used in industrial refrigeration in Lithuania since 1995, end-of-life emissions were estimated for 2010-2013 years. Based on 2012 study „Analysis of the use of fluorinated GHG in Lithuania in 1990-2011“ results, it was considered that the lifetime of the industrial refrigeration equipment is 15 years, which is in the range of lifetime values provided in 2006 IPCC Guidelines (15-30 years).

It was contacted few refrigeration and A/C equipment servicing companies, as well as electronic waste recycling company to get more information on F-gases recovery practices in Lithuania. Refrigeration and A/C equipment servicing companies informed us that F-gases recovery is taking place in accordance with existing legislative acts and experience shows that the recovery of F-gases from refrigeration and air-conditioning equipment is more than 90%, while it is economically beneficial to reuse recovered F-gases in other systems, due to quite high costs of such gases.

Furthermore, F-gases recovery in Lithuania is taking place also in UAB EMP Recycling, which has the single refrigerator recycling unit in Baltic countries since 2007. The company has certificated refrigerator recycling line, where ozone depleting substances (ODS) and F-gases are collected from pipes and walls of refrigerators. According to the company specialists, more than 90% of F-gases are collected during the process. All collected ODS and F-gases are exported for further recycling/destruction to Germany. Amount of intentional destruction is considered to be zero, as F-gases destruction is not taking place in Lithuania.

Transport Refrigeration (CRF 2.F.1.d)

Emission sources in transport refrigeration category are refrigerated road vehicles and refrigerated rail vehicles. It is considered that refrigerated road vehicles are: refrigerated trucks, refrigerated vans and refrigerated semi-trailers. HFC gases in refrigeration units in vehicles have been used since 1993. The refrigerant R-404a is a blend, consisting of HFC-125 (44%), HFC-143a (52%) and HFC-134a (4%).

The following companies were surveyed for the 2012 study on the use of HFCs in Lithuania:

1. State enterprise Regitra – in order to obtain missing data on vehicles with refrigeration units registered in Lithuania by class and year of manufacture;

2. companies servicing vehicles with refrigeration units in order to obtain more specific data on the variety of refrigerants used in refrigeration equipment, average charge of refrigerated vehicles by vehicle class, and factors of emission during equipment operation;

3. joint stock company AB Lietuvos geležinkeliai (Lithuanian Railway) – in order to collect data on refrigerated freight wagons and to assess fluorinated gas emissions from refrigeration on the basis of this information;

4. companies which operate shipping containers and reefers – in order to obtain data for the assessment of fluorinated gas emissions.

The EPA database could not be used for the assessment of fluorinated gas emissions from refrigerated vehicles for the following reasons:

- there is no such category of gas use in the EPA 2009-2010 database (it covers both stationary and mobile equipment classified by refrigerant weight); also, not all companies servicing refrigeration units in vehicles submitted reports in 2013 to the EPA (there are only a few declarations of the gas use in the equipment of this category and in some cases most probably a wrong category was indicated);

- the data collection period (2009-2013) is too short to be able to create an accurate database of the EPA, and assessment of the missing period by way of extrapolation does not show the actual/factual annual consumption and emissions of fluorinated gases (the accuracy would be higher if suppliers and servicing companies provided relevant information);

- information provided by individual companies servicing refrigeration equipment in vehicles does not allow formulating country-specific assumptions and emission factors.

Mobile Air-Conditioning (CRF 2.F.1.e)

Road vehicles with air conditioning are: passenger vehicles, buses and freight vehicles. According to the information provided in the 2012 study on the use of HFCs in Lithuania, the refrigerants R-

134a and R-404a have been used in mobile air-conditioning systems since 1993. The refrigerant R-404a is a blend of fluorinated gases consisting of HFC-125 (44%), HFC-143a (52%), and HFC-134a (4%).

The refrigerant R-134a in passenger carriages equipped with air conditioning has been used since 2006. According to the data provided by joint-stock company AB Lietuvos geležinkeliai, at present this company has 27 passenger carriages equipped with air conditioning, with each carriage having a UKV-type air conditioner. The company performs regular maintenance of air conditioners but does not recycle end-of-life equipment. The lifetime of air conditioners is 28 years.

Stationary Air-Conditioning (CRF 2.F.1.f)

Stationary air-conditioning category is divided to air-conditioning and ventilation equipment sub-category and heat pumps sub-category. Main fluorinates gases in this category are: HCF-32, HFC-125 and HFC-134a. Small amounts of HFC-143a also are occurring in stationary air-conditioning.

Data of other countries demonstrate that stationary air conditioning has been used since approximately 1995, therefore, in the absence of other information source, it is reasonable to assume that Lithuania also started using such systems charged with fluorinated gases not earlier than in 1995.

4.7.1.2 Methodological issues

Commercial Refrigeration (CRF 2.F.1.a)

The following factors and assumptions were used to estimate the emissions from commercial refrigeration in **skating rinks, supermarkets, other retail enterprises and storage facilities**:

- refrigerants charged in the equipment are HFC-134a, HFC-404A, HFC-407A and HFC-410A;
- the average lifetime of equipment is 15 years;
- the emission factor during the operation of the equipment is 3% (according to data provided in 2008 study);
- initial charge remaining – 90%, recovery efficiency – 70% (2006 IPCC Guidelines, Volume 3, part 2,p. 7.52);
- emission factor during the initial charging is 4% (according to data provided in 2008 study);
- there is no data available for the assessment of the emission factor during equipment servicing, therefore this factor was assumed to be included in the emission factor during operation.

The Study 2012 identified that drink coolers are only charged with the refrigerant HFC-134a. Emissions in this sector were estimated on the basis of specific companies data and using the following factors and assumptions:

- the average amount of refrigerant charged in equipment is 250 g, except TUB Rinkuskiai -150 g and AB Kauno Alus draft beer freezers which contains 500 g of refrigerant;
- the emission factor during the operation of the equipment is 8% (data source: drink producers);
- the average lifetime of drink coolers is 10 years (data source: drink producers);
- emissions at system disposal is 10% (data source: waste recycling company);
- emission factor during the initial charging is 3% (2006 IPCC Guidelines, Volume 3, part 2, p. 7.52);

- there is no data available for the assessment of the emission factor during equipment maintenance, therefore this factor is assumed to be included in the emission factor during operation.

Commercial refrigeration equipment in **accommodation and catering businesses** (hotels, cafés, bars, canteens) was assessed using the national statistical data. The data on the number of accommodation and catering businesses provided by Statistics Lithuania covers the period 2006-2013. The following factors and assumptions were used to estimate the emissions:

- refrigerants charged in the equipment are HFC-134a and HFC-404A;
- the average amount of refrigerant charged in the equipment is 750 g;
- the average lifetime of drink coolers is 15 years;
- the emission factor during the operation of the equipment is 15% (2006 IPCC Guidelines, Volume 3, part 2, p. 7.52);
- the data on the use of HFC-134a and HFC-404A in Lithuania is available from 1995;
- the number of accommodation and catering businesses in 1995 was 15% less than in 2006; based on this assumption, the number of the companies was interpolated for the period 1996-2005;
- initial charge remaining – 70%, recovery efficiency – 80% (2006 IPCC Guidelines, Volume 3, part 2, p. 7.52);
- emission factor during the initial charging is 3% (2006 IPCC Guidelines, Volume 3, part 2, p. 7.52);
- there is no data available for the assessment of the emission factor during equipment servicing, therefore this factor was assumed to be included in the emission factor during operation.

Emissions of HFCs from commercial refrigeration (supermarkets, shops and skating rinks), drink coolers and commercial refrigeration equipment in accommodation and catering businesses were calculated using the following equation (2006 IPCC Guidelines, Volume 3, part 2, p. 7.49, Tier 2a):

$$E_{total,\,t} = E_{lifetime,\,t} + E_{enf\text{-}of\text{-}life,\,t}$$

where:

$E_{total,\,t}$ – total HFC emission, t;

$E_{lifetime,\,t}$ – amount of HFCs emitted during system operation in year t, t;

$E_{end\text{-}of\text{-}life,\,t}$ – amount of HFCs emitted at system disposal in year t, t.

Emissions during lifetime:

$$E_{lifetime,\,t} = B_t \;x\, x$$

where:

B_t – amount of HFCs banked in existing systems in year t, t;

x – emission factor of HFCs for each sub-application bank during operation, accounting for average annual leakage and average annual emission during servicing, %.

Emissions at end-of-life:

$$E_{end\text{-}of\text{-}life,\ t} = M_{t\text{-}d} \times p \times (1\text{-}\eta_{rec,\ d})$$

where:

M_{t-d} – amount of HFCs initially charged into new systems installed in year (t-d), t;

p – residual charge of HFCs in equipment being disposed of expressed in percentage of full charge, %;

$\eta_{rec,\ d}$ – recovery efficiency at disposal, which is the ratio of recovered HFCs referred to HFC contained in the system, %.

Estimates of fluorinated gas emission from commercial refrigeration (supermarkets, shops and skating rinks) are demonstrated in Figure 4-22 below.

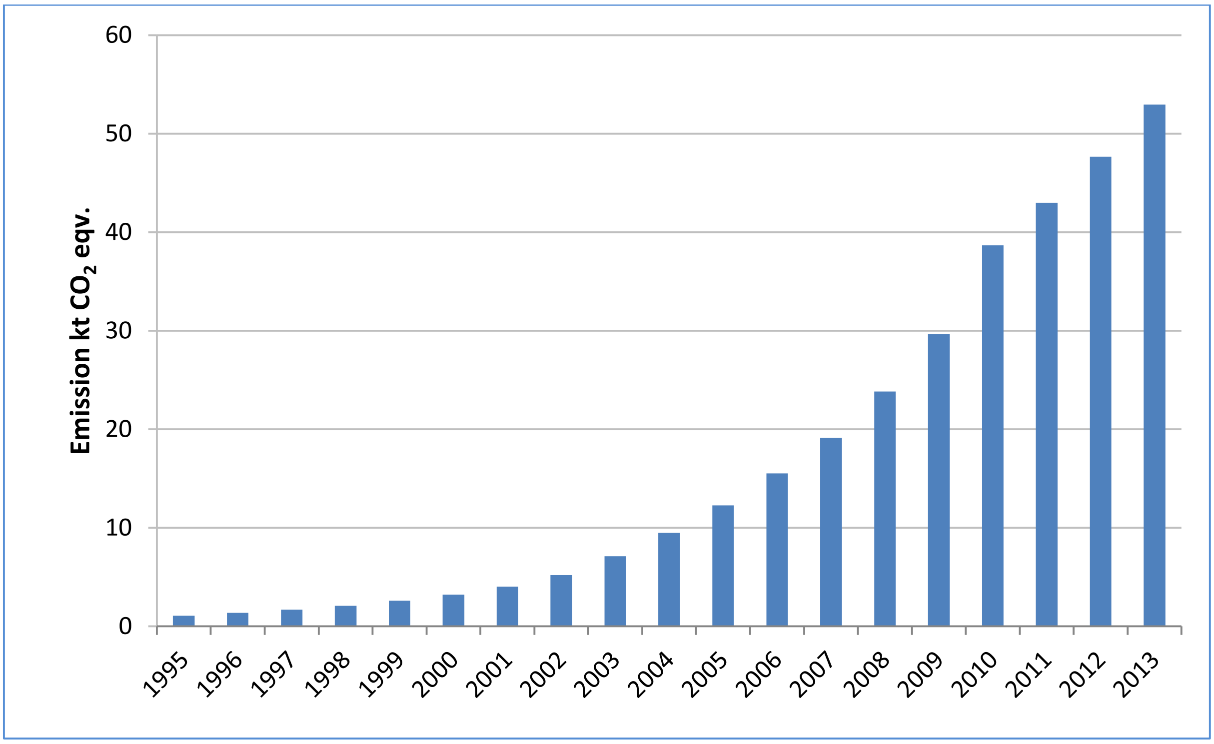


Figure 4-22. Fluorinated gas emissions from commercial refrigeration (supermarkets, shops, skating rinks) for 1995-2013

Estimates of fluorinated gas emissions from drink coolers air-conditioning systems are demonstrated in Figure 4-23 below.

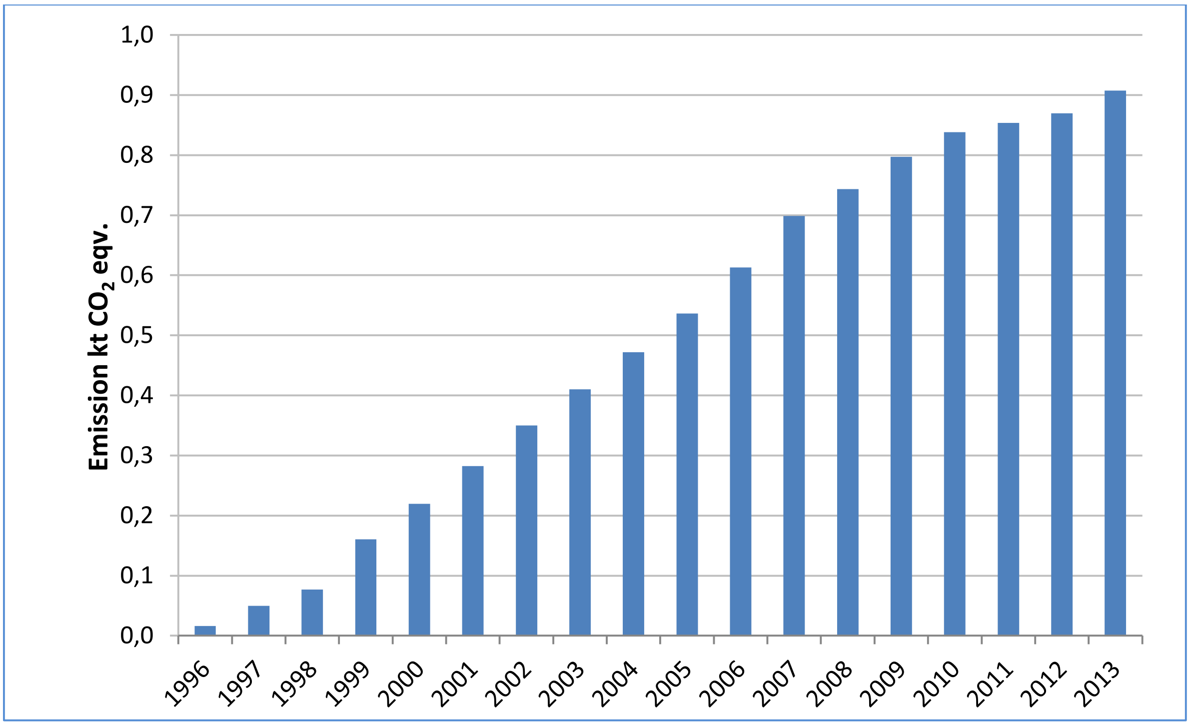


Figure 4-23. Fluorinated gas emissions from drink coolers for 1996-2013

Estimates of fluorinated gas emissions from commercial refrigeration equipment in accommodation and catering businesses are demonstrated in Figure 4-24 below.

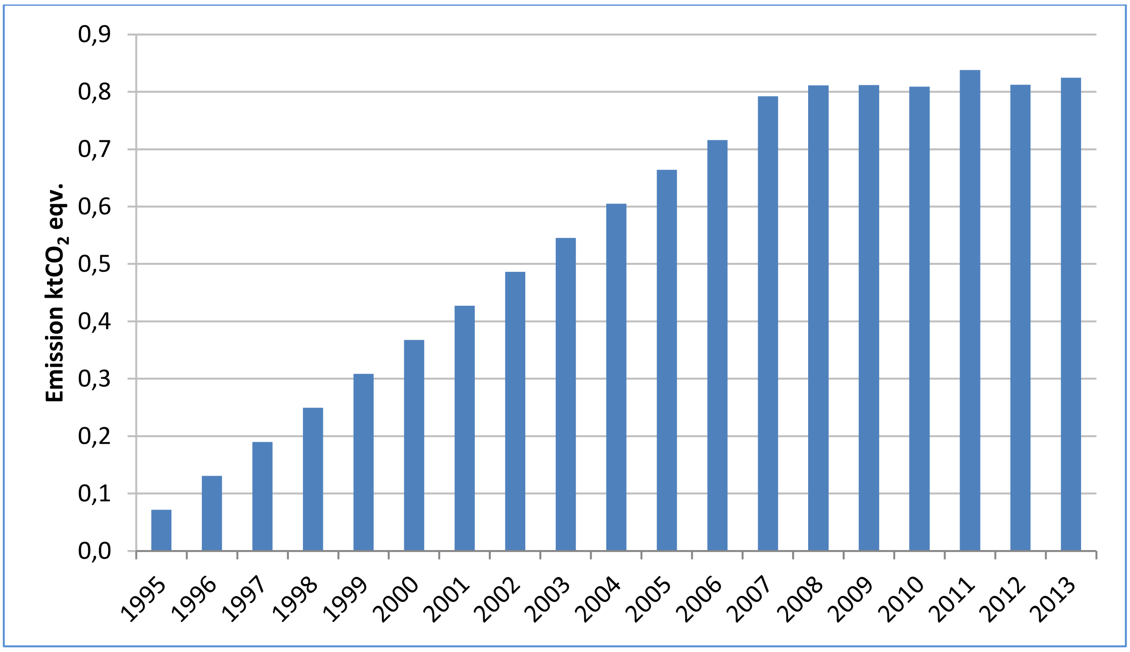


Figure 4-24. Fluorinated gas emissions from commercial refrigeration in accommodation and catering businesses for 1995-2013

The total emissions of fluorinated gases from commercial refrigeration are provided in Table 4-30.

Table 4-30. Total emissions of fluorinated gases from commercial refrigeration for 1995-2013

Year	Emissions from commercial refrigeration	Emissions from drink coolers, kt CO_2 eqv.	Emissions from commercial refrigeration in accommodation and	Total emissions from commercial

	(supermarkets, shops, skating rinks), kt CO_2 eqv.		catering businesses, kt CO_2 eqv.	refrigeration, kt CO_2 eqv.
1995	1.08	NO	0.07	1.15
1996	1.35	0.02	0.13	1.50
1997	1.68	0.05	0.19	1.92
1998	2.09	0.08	0.25	2.41
1999	2.60	0.16	0.31	3.06
2000	3.23	0.22	0.37	3.81
2001	4.02	0.28	0.43	4.73
2002	5.20	0.35	0.49	6.04
2003	7.12	0.41	0.55	8.08
2004	9.48	0.47	0.60	10.56
2005	12.28	0.54	0.66	13.48
2006	15.53	0.61	0.72	16.85
2007	19.11	0.70	0.79	20.61
2008	23.84	0.74	0.81	25.40
2009	29.67	0.80	0.81	31.28
2010	38.68	0.84	0.81	40.33
2011	42.97	0.85	0.84	44.66
2012	47.65	0.87	0.81	49.34
2013	52.93	0.91	0.82	54.67

Uncertainties and time-series consistency

Emission uncertainty was estimated using Approach 1 of the 2006 IPCC Guidelines (p. 3.27). Uncertainty estimates of activity data and emission factors are presented in Table 4-31.

Table 4-31. Uncertainty (UN) estimates of fluorinated gas emissions in the sub-category of commercial refrigeration equipment

Emission source	Input data UN, %	EF during operation UN, %	Input data UN, %	Recovery EF UN, %	Total emission UN, %
CRF 2.F.1.a Commercial refrigeration					45
Refrigeration in supermarkets and shops	30	15	30	15	47
Drink coolers	5	10	10	10	18
Refrigeration in accommodation and catering businesses	20	10	20	10	31

Domestic Refrigeration (CRF 2.F.1.b)

Emissions of fluorinates gas from the charging process of new equipment were estimated using following factors and assumptions:

Following the company data:

- the average charge of the equipment with refrigerant is 120 g;
- the emission factor during the initial charging of new equipment k – 0.5%.

Emissions of HFCs due to the charging process of new equipment were calculated using the following equation (2006 IPCC Guidelines, Volume 3, part 2 p. 7.50):

$$E_{charge,\,t} = M_t \times k$$

where:

$E_{charge,\,t}$ – emission during system manufacture/assembly in year t, t;

M_t – amount of HFC charged into new equipment in year t, t;

k – emission factor of assembly losses of the HFC charged into new equipment, %.

Estimates demonstrated in Figure 4-25.

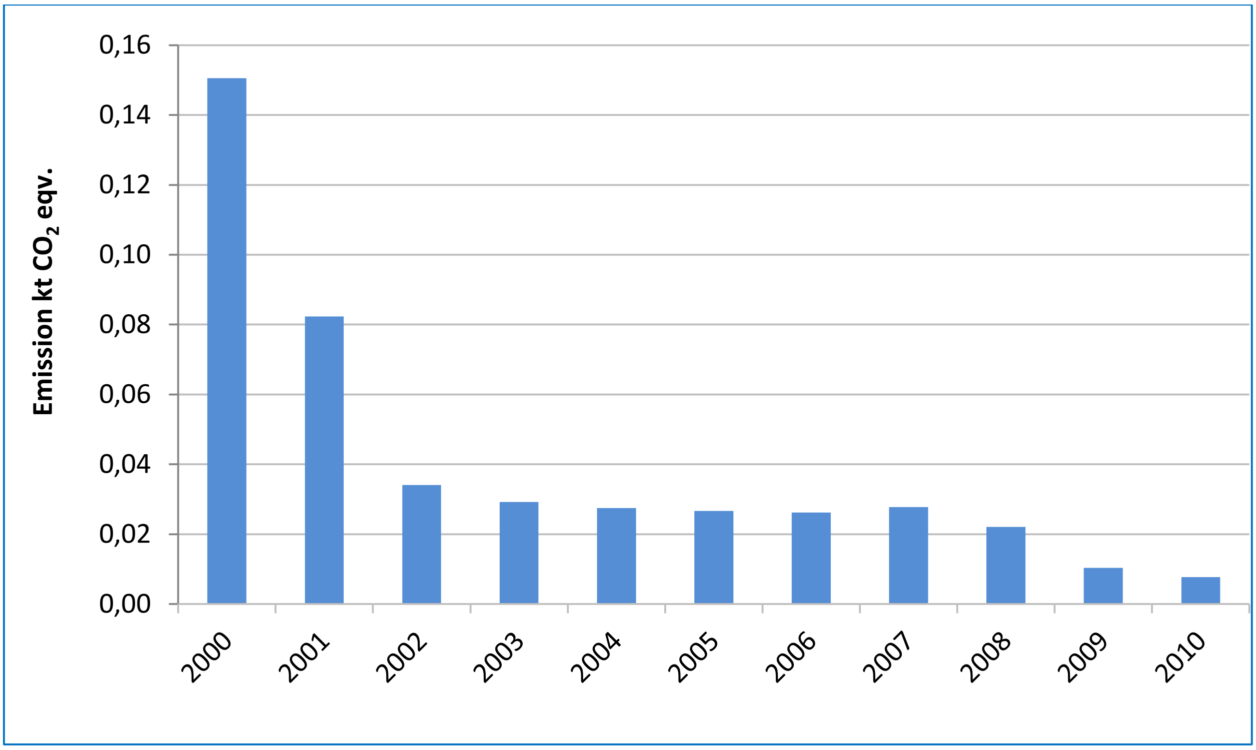


Figure 4-25.Fluorinated gas emissions during the initial charging of refrigerant into domestic refrigerators manufactured by company for 2000-2010

The largest amounts of fluorinated gases (0.15 kt CO_2 eqv.) were emitted in 2000 as a result of rather extensive use of the refrigerant R-134a for the initial charging of domestic refrigerators at the company (about 80% of the total amount used). The use of this refrigerant in the subsequent years gradually went down. The use of the refrigerant R-134a for the charging of new equipment was completely discontinued from 2011.

The following data from Statistics Lithuania was used for the estimation of emissions from the stock of HFCs in existing domestic refrigerators:

- the number of inhabitants in Lithuania;
- the average size of households in Lithuania;
- the percentage of households using domestic refrigerators.

Due to absence of sufficient data for estimating the amount of HFCs charged in domestic refrigerators and the percentage of domestic refrigerators containing HFCs, the following assumptions based on expert judgment were made:

- the average amount of refrigerant charged in a refrigerator is 120 g (data source: AB Snaigė);
- the average amount of refrigerant charged in a freezer is 150 g (according to the data of UAB EMP Recycling, the charge is 30% higher than in refrigerators);
- 13% of refrigerators (of the total number) used to be filled with HFC-134a until 1995. The same assumption is applied to freezers (based on laboratory analysis of gases collected from recycled domestic refrigerators, data source: UAB EMP Recycling);
- 5% of refrigerators (of the total number) used to be filled with HFC-125 until 1995. The same assumption is applied to freezers (based on laboratory analysis of gases collected from recycled domestic refrigerators, data source: UAB EMP Recycling);
- average annual refrigerant loss/leakage is 0.4% of the quantity in stock (emission factor during the operation of the equipment) (revised according to 2006 IPCC Guidelines, Volume 3, part 2, p. 7.52);
- 30% of refrigerators operating in 1995-2013 were filled with HFC-134a. The same assumption is applied to freezers;
- 7% of refrigerators operating in 1995-2013 were filled with HFC-125. The same assumption is applied to freezers.

Annual leakage from the stock in the domestic refrigerators was calculated using the following equation (2006 IPCC Guidelines, Volume 3, part 2, p. 7.50):

$$E_{lifetime,\, t} = B_t \times x$$

where:

$E_{lifetime,\, t}$ – amount of HFCs banked in existing systems in year t, t;

B_t – amount of HFCs banked in existing systems in year t, t;

x – emission factor of HFCs of each sub-application bank during operation, accounting for average annual leakage and average annual emission during servicing, %.

Emissions at system disposal were calculated from 2010 using the following factors and assumptions:

- the average lifetime of the refrigerator is 20 years (data source: UAB EMP Recycling);
- the average lifetime of the freezer is 15 years (data source: UAB EMP Recycling);
- the amount of recycled gases recovered from refrigerators in 2010 was 19% of all gases subject to disposal and in 2011-2013 – 47% of all disposable gases (based on the percentage of domestic refrigerators recycled in Lithuania) (data source: UAB EMP Recycling);
- the amount of recycled gases recovered from freezers in 2010 was 58% of all gases subject to disposal and in 2011-2013 – 53% of all disposable gases (based on the percentage of domestic freezers recycled in Lithuania) (data source: UAB EMP Recycling);
- the residual gas amount at system disposal (refrigerators) is 92% of the initial charge filled into the system during the production process;
- the remaining gas amount at system disposal (freezers) is 94% of the initial charge filled into the system during the production process.

Emissions at disposal of domestic refrigeration equipment were calculated using the following formula (2006 IPCC Guidelines, p. 7.51):

$$E_{end\text{-}of\text{-}life,\, t} = M_{t\text{-}d} \times p \times (1\text{-}\eta_{rec,d})$$

where:

$E_{end\text{-}of\text{-}life,\, t}$ – amount of HFCs emitted at system disposal in year t, t;

$M_{t\text{-}d}$ – amount of HFCs initially charged into new systems installed in year (t-d), t;

p – residual charge of HFCs in equipment being disposed of expressed in percentage of full charge, %;

$\eta_{rec,d}$ – recovery efficiency at disposal, which is the ratio of recovered HFCs referred to the HFCs contained in the system, %.

Total emissions:

$$E_{total,\, t} = E_{charge,\, t} + E_{lifetime,\, t} + E_{end\text{-}of\text{-}life,\, t}$$

Estimated total emissions of fluorinated gases from domestic refrigeration and freezers are provided in Table 4-32.

Table 4-32. Total fluorinated gas emissions from domestic refrigeration for 1995-2013

Year	**Emissions from manufacturing kt CO_2 eqv.**	**Emissions from operation (refrigerators) kt CO_2 eqv.**	**Emissions from disposal (refrigerators) kt CO_2 eqv.**	**Emissions from operation (freezers) kt CO_2 eqv.**	**Emissions from disposal (freezers) kt CO_2 eqv.**	**Total, kt CO_2 eqv.**
1995	NO	0.22	NO	0.02	NO	0.24
1996	NO	0.22	NO	0.02	NO	0.23
1997	NO	0.23	NO	0.02	NO	0.24
1998	NO	0.24	NO	0.03	NO	0.26
1999	NO	0.25	NO	0.04	NO	0.29
2000	0.15	0.26	NO	0.04	NO	0.46
2001	0.08	0.27	NO	0.05	NO	0.40
2002	0.03	0.28	NO	0.06	NO	0.37
2003	0.03	0.29	NO	0.07	NO	0.39
2004	0.03	0.30	NO	0.07	NO	0.41
2005	0.03	0.33	NO	0.08	NO	0.44
2006	0.03	0.32	NO	0.09	NO	0.44
2007	0.03	0.33	NO	0.09	NO	0.45
2008	0.02	0.32	NO	0.08	NO	0.42
2009	0.01	0.35	NO	0.09	NO	0.45
2010	0.01	0.37	2.10	0.10	0.06	2.64
2011	NO	0.38	1.38	0.10	0.07	1.93
2012	NO	0.39	1.38	0.10	0.07	1.94
2013	NO	0.40	1.38	0.10	0.07	1.94

Fluorinated gas emissions have increased since 2010 as a result of inclusion of emissions at the time of disposal of equipment in 2010 and since then.

Estimates of fluorinated gas emissions from domestic refrigerators in Lithuania for 1995-2013 are demonstrated in Figures 4-26 below.

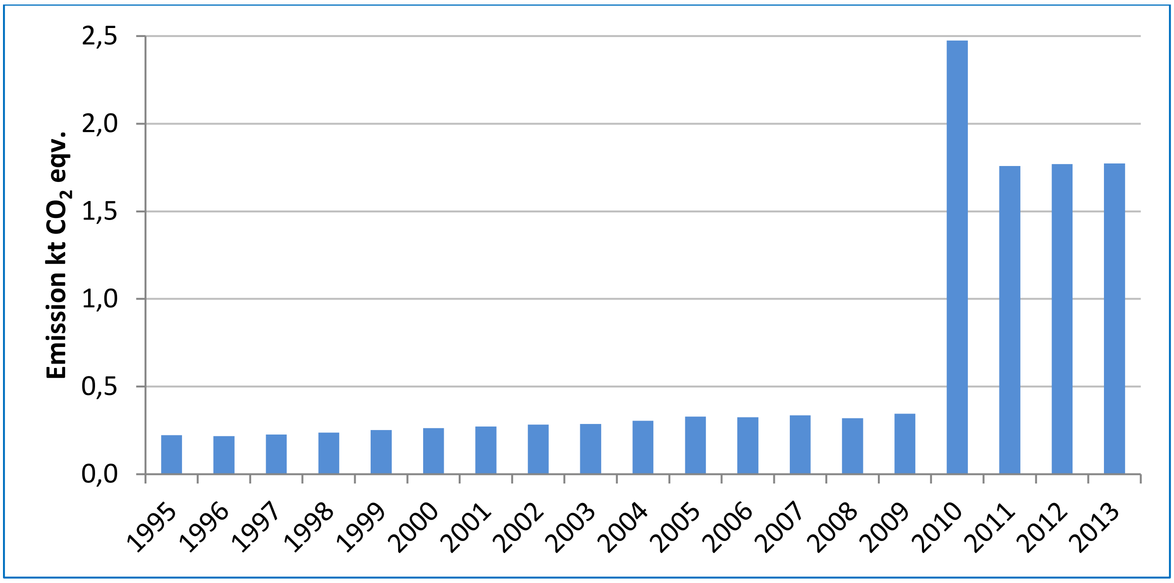


Figure 4-26. Fluorinated gas emissions from domestic refrigerators in Lithuania for 1995-2013

Estimates of fluorinated gas emissions from domestic freezers are demonstrate in Figure 4-27 below.

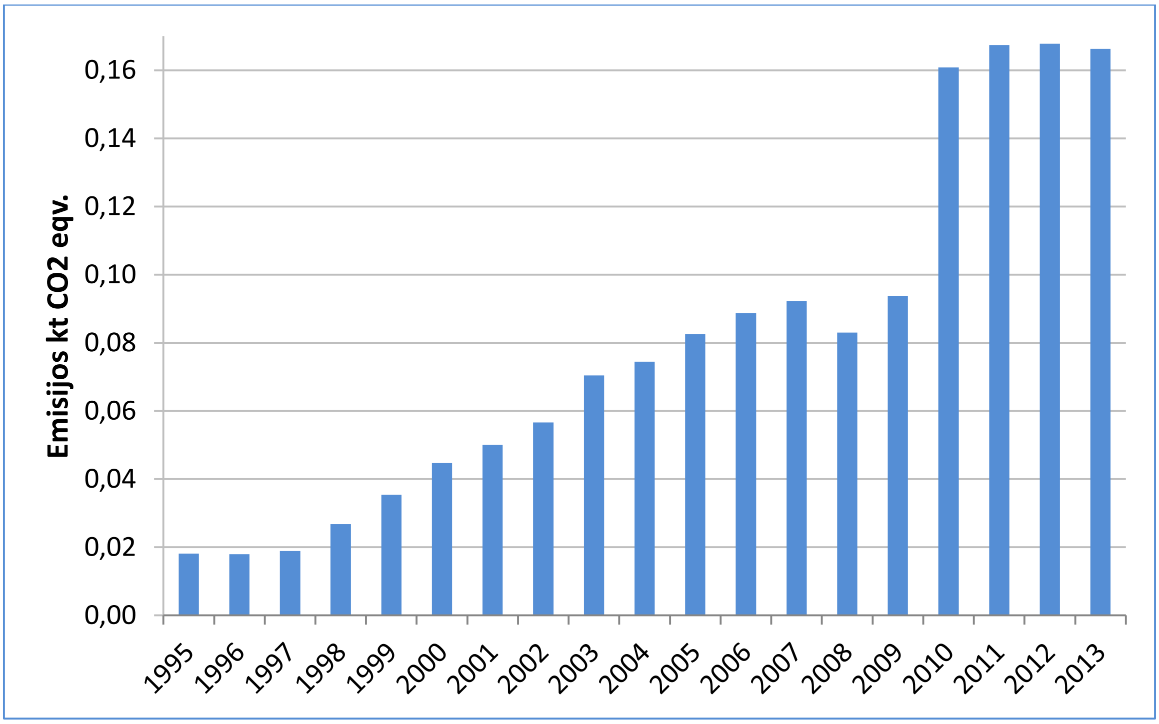


Figure 4-27. Fluorinated gas emissions from domestic freezers in Lithuania for 1995-2013

Uncertainties and time-series consistency

Emission uncertainty was estimated using Approach 1 of the 2006 IPCC Guidelines (p. 3.27). Uncertainty estimates of activity data and emission factors are presented in Table 4-33.

Table 4-33. Uncertainty (UN) estimates of fluorinated gases emissions in the sub-category of domestic refrigeration

Emission source	Input data UN, %	EF during operation UN, %	Input data UN, %	Recovery EF UN, %	Total emission UN, %
CRF 2.F.1.b Domestic refrigeration					28
Domestic refrigerators	10	20	10	20	31
Domestic freezers	10	20	10	20	31

Industrial Refrigeration (CRF 2.F.1.c)

The methodology for the revision of the calculation model used in the national report is described in the section Commercial Refrigeration. Emissions from industrial refrigeration in 2013 were calculated using EPA database (made up of companies reports) and revised assumption on the change in the amount of substances.

The following fluorinated gas uses in industrial refrigeration were assessed:

- meat processing;
- milk processing;
- fish processing;
- fruit and vegetable processing;
- beverage production;
- processing of berries and mushrooms;
- prefabricated food products;
- poultry processing;
- PET production;
- other industries.

Emissions from end-of-life industrial refrigeration equipment were estimated using equation (2006 IPCC Guidelines, Volume 3, part 2, p. 7.51):

$$E_{end\text{-}of\text{-}life,\ t} = M_{t-d}\ x\ \ p\ \ x\ \ (1-\eta_{rec,d})$$

where:

$E_{end\text{-}of\text{-}life,\ t}$ – amount of HFCs emitted at system disposal in year t, t;

M_{t-d} – amount of HFCs initially charged into new systems installed in year (t-d), t;

p – residual charge of HFCs in equipment being disposed of expressed in percentage of full charge, %;

$\eta_{rec,d}$ – recovery efficiency at disposal, which is the ratio of recovered HFCs referred to the HFCs contained in the system, %.

Recovery efficiency at disposal (z) value 90% is based on expert judgement. After consultations with several refrigeration and A/C equipment servicing companies it was concluded that as a common practice in Lithuania refrigerants from industrial refrigeration equipment are usually extracted before decommissioning and reused in other systems. 90% recovery efficiency at disposal value is also maximum value of the best estimates (expert judgement) range given in 2006 IPCC Guidelines Volume 3, part 2, Table 7.9, p. 7.52.

Estimations of fluorinated gas emissions from industrial refrigeration are demonstrated in Figure 4-28 below.

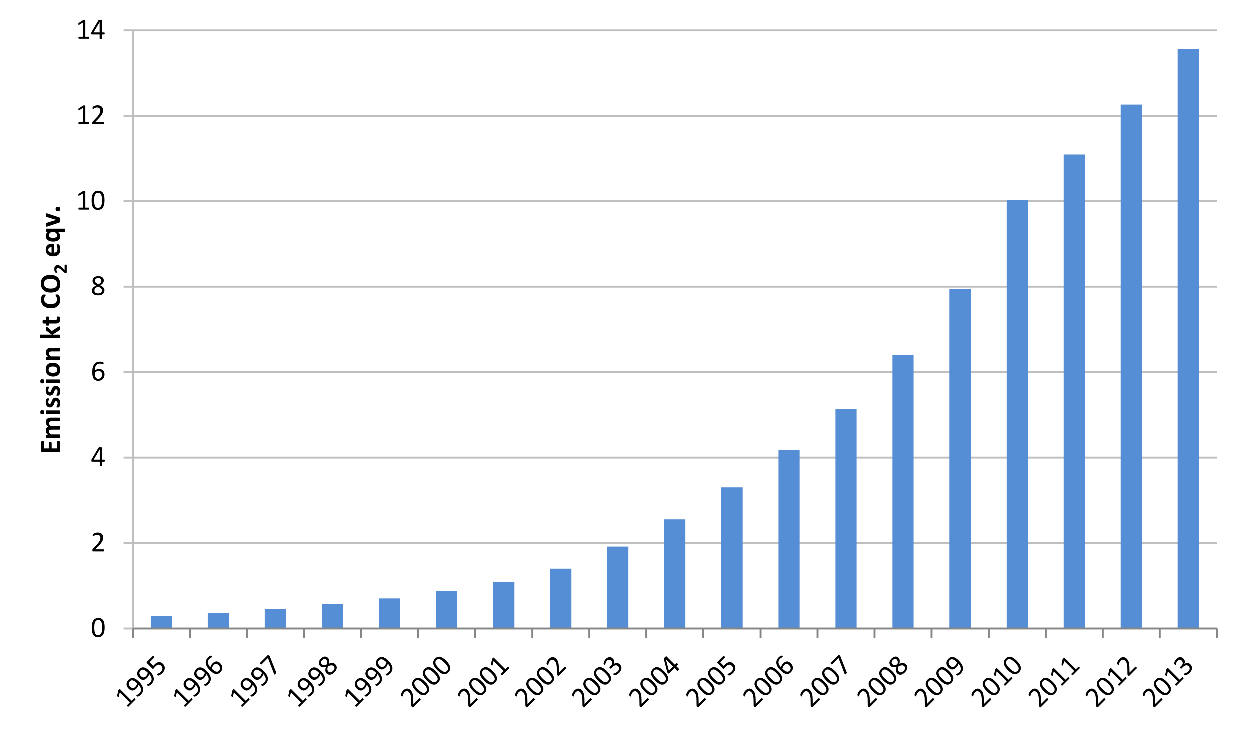


Figure 4-28. Fluorinated gas emissions from industrial refrigeration for 1995-2013, kt CO_2 eqv.

Uncertainties and time-series consistency

Emission uncertainty was estimated using Approach 1 of the 2006 IPCC Guidelines (p. 3.27). Uncertainty estimates of activity data and emission factors are presented in Table 4-34.

Table 4-34. Uncertainty (UN) estimates of fluorinated gas emissions in the sub-category of industrial refrigeration

Emission source	Input data UN, %	EF during operation UN, %	Input data UN, %	Recovery EF UN, %	Total emission UN, %
CRF 2.F.1.4c Industrial refrigeration	30	15	30	15	47

Transport Refrigeration (CRF 2.F.1.d)

Transport refrigeration category is divided to refrigerated road vehicles and refrigerated rail vehicles sub-categories.

Refrigerated road vehicles

Fluorinated gas emissions from refrigerated road vehicles equipment are assessed following the 2006 IPCC Guidelines. Assessments are based on the number of refrigerated vehicles registered on the territory of the Republic of Lithuania. The data on vehicles with refrigeration units registered in Lithuania in 1992-2013 by vehicle class and year of manufacture was obtained from the state enterprise Regitra.

The following classes of freight vehicles and semi-trailers were considered:

- refrigerated trucks;
- refrigerated vans;
- refrigerated semi-trailers.

The said refrigerated vehicles were manufactured in 1993-2013. In addition, Regitra provided the average lifetime of the vehicles by class.

Four companies servicing refrigerated vehicles were contacted in order to specify the refrigerants used, the average refrigerant charge in refrigerated vehicles, and factors of emission at the time of operation; however, a partial reply was received only from one company, private limited liability company UAB Sadomaksa. According to the data of the said company, the refrigerants used in refrigeration equipment are R-134a and R-404a:

- R-134a and R-404a are used in freight vehicles up to 3.5 t (trucks, vans, semi-trailers);
- mainly R-404a is used in freight vehicles above 3.5 t (trucks, vans, semi-trailers).

Following the German experience, it was assumed that if two refrigerants are used in one vehicle category, the use of each refrigerant is considered to be 50%.

There is no data available on the original factory charge, therefore the emission factor during the initial charging and the emissions were not assessed.

The assessment of emissions during the operation of the equipment was based on the following factors and assumptions:

1. the average amount of refrigerant charged in the equipment in the below listed vehicle classes is as follows (according to the data on freight vehicles by their weight provided by UAB Sadomaksa):
   - 2 kg in refrigerated trucks and refrigerated vans up to 3.5 t;
   - 7 kg in refrigerated trucks and refrigerated vans over 3.5 t;
   - 2 kg in refrigerated semi-trailers up to 3.5 t;
   - 7 kg in refrigerated semi-trailers over 3.5 t
2. the emission factor during the operation of the equipment is 30% (2006 IPCC Guidelines, p. 7.52);
3. there is no data available for the assessment of the emission factor during equipment servicing, therefore this factor was assumed to be included in the emission factor during operation.

Emissions during lifetime were calculated using the following equation (2006 IPCC Guidelines, p. 7.50):

$$E_{lifetime,\,t} = B_t \;x\; x$$

where:

B_t – amount of HFCs banked in existing systems in year t, t;

x – emission factor of HFCs for each sub-application bank during operation, %.

The assessment of emissions of fluorinated gases at system disposal was based on the following assumptions:

- the initial charge remaining is 50% (2006 IPCC Guidelines, p. 7.52);
- there is no data available on recycling processes of refrigerated vehicles, therefore recovery efficiency was not assessed.

Emissions at end-of-life were calculated using the following equation (2006 Guidelines, p. 7.51):

$$E_{end\text{-}of\text{-}life,\ t} = M_{t\text{-}d} \ x \ p \ x \ (1\text{-}\eta_{rec,\ d})$$

where:

$M_{t\text{-}d}$ – amount of HFCs initially charged into new systems installed in year (t-d), t;

p – residual charge of HFC in equipment being disposed of expressed in percentage of full charge, %;

$\eta_{rec,d}$ – recovery efficiency at disposal, which is the ratio of recovered HFCs referred to HFCs contained in the system, %.

HFC gases have been used in refrigerated vehicles since 1993, which is demonstrated by the German experience in the production of refrigerated vehicles. Most of refrigerated vehicles which are operated in Lithuania were manufactured in Western Europe (including Germany), therefore fluorinated gas emissions during equipment operation have also been assessed since 1993.

Estimations of fluorinated gas emissions from refrigerated road vehicles are demonstrated in Figure 4-29 below.

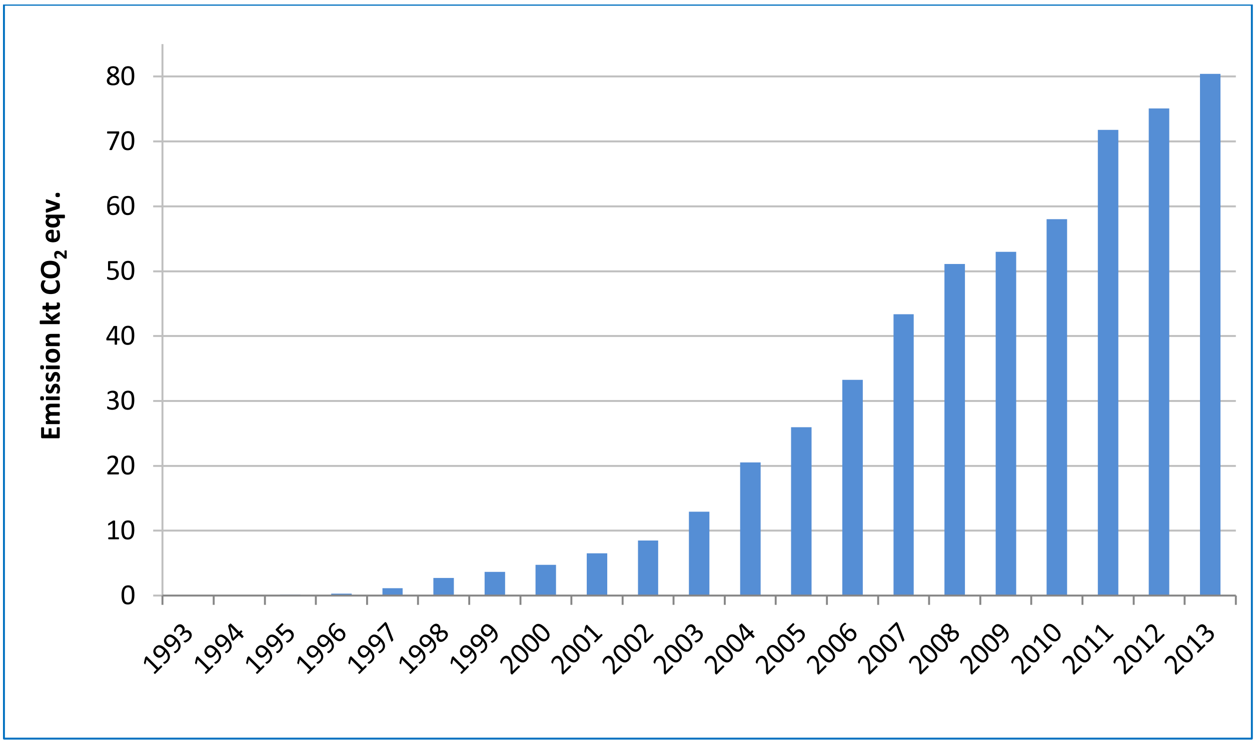


Figure 4-29. Fluorinated gas emissions from refrigerated road vehicles for 1993-2013

Train – freight wagons

The refrigerant R-134s has been used in refrigerated freight wagons since 2006. The number of freight wagons was continuously going down during the period 2006-2012. Radviliškis freight wagon depot of the joint-stock company AB Lietuvos geležinkeliai was contacted to obtain necessary data.

AB Lietuvos geležinkeliai provided the number of refrigerated freight wagons operated in 2006-2013 pointing out that every wagon has two refrigeration equipments. The refrigerant used in most wagons is R-134a. In addition, a small percentage of R-22 is also used, its use is assumed to be around 20%.

There is no data available on the original factory charge therefore the emission factor during the initial charging and the emissions were not assessed.

Freight wagons of Radviliškis freight wagon depot carry goods to Eastern countries riding in Lithuania only a short segment of the whole trip. Upon consultation of the head of the company, it was assumed that only 10% of fluorinated gas emissions during the operation of the refrigeration equipment shall attributed to Lithuania.

The assessment of the emissions during equipment operation was based on the following factors and assumptions:

1. Pursuant to the data of Radviliškis freight wagon depot of AB Lietuvos geležinkeliai:

- the average amount of refrigerant charged in the equipment is 5 kg;
- the emission factor during the operation of the equipment is 10%.

2. Other assumptions:

- 80% of all freight wagons are charged with the refrigerant R-134a for the period 2006-2011;
- there is no data available for the assessment of the emission factor during equipment servicing, therefore this factor was assumed to be included in the total emission factor.

Emissions during the lifetime were calculated using the following equation (2006 IPCC Guidelines, p. 7.50):

$$E_{lifetime,\,t} = B_t \;\; x\, x$$

where:

B_t – amount of HFCs banked in existing systems in year t, t;

x – emission factor of HFCs for each sub-application bank during operation, %.

Despite the fact, that the refrigeration equipment in freight wagons is fairly new – operated since 2006 and its lifetime is about 28 years and according to data provided by AB Lietuvos Geležinkeliai some wagons were modernized by removing refrigeration equipment during the period 2009-2012.

The assessment of emissions of fluorinated gases at system disposal was based on the following assumptions:

- the residual charge in the system being disposed is 50% (is calculated according to data provided by AB Lietuvos Geležinkeliai);

- recovery efficiency at disposal is 25% (is calculated according to data provided by AB Lietuvos Geležinkeliai);

Emissions at system disposal were calculated using the following equation (2006 Guidelines, Volume 3, part 2, p. 7.51):

$$E_{end\text{-}of\text{-}life,\,t} = M_{t\text{-}d} \times p \times (1-\eta_{rec,\,d})$$

where:

$M_{t\text{-}d}$ – amount of HFCs initially charged into new systems installed in year (t-d), t;

p – residual charge of HFC in equipment being disposed of expressed in percentage of full charge, %;

$\eta_{rec,\,d}$ – recovery efficiency at disposal, which is the ratio of recovered HFCs referred to HFCs contained in the system, %.

Estimates of fluorinated gas emissions from freight wagons are demonstrated in Figure 4-30 below.

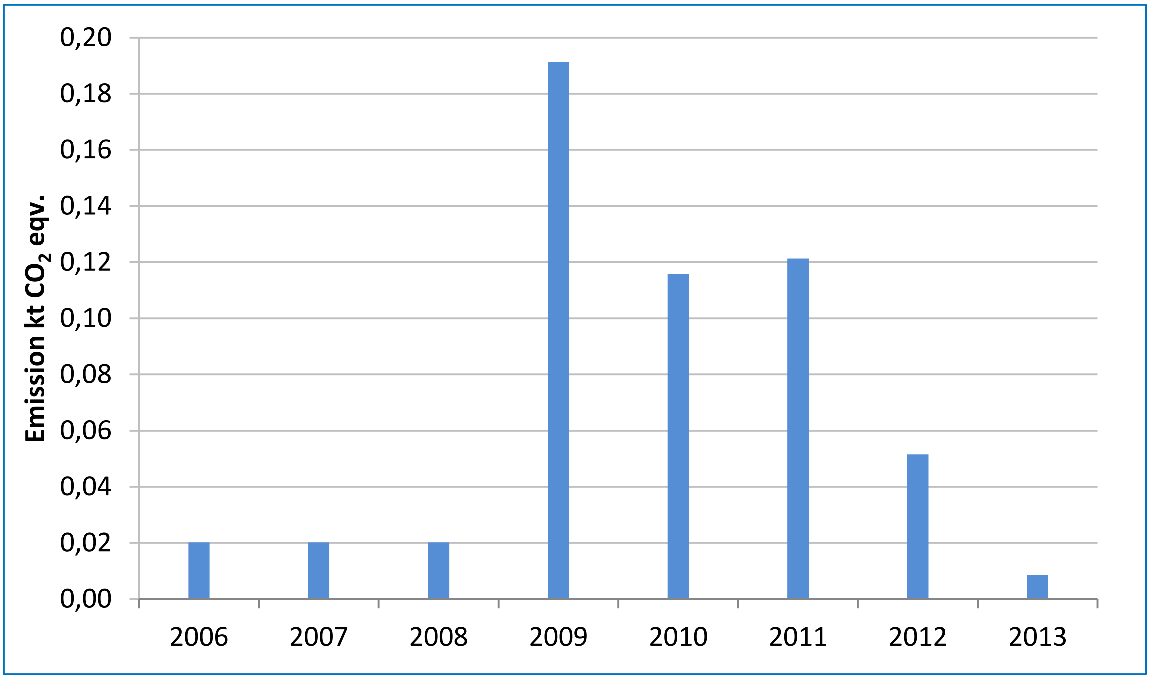


Figure 4-30. Fluorinated gas emissions from freight wagons for 2006-2013

As seen in Figure 4-27 emissions over the period of 2009-2012 were higher than in the period of 2006-2008 and 2013. The main reason of increased emissions is that there were estimated emissions of fluorinated gases at system disposal over the period of 2009-2012.

Total fluorinated gas emissions from transport refrigeration were calculated using the following formula:

$$E_{total,\,t} = E_{lifetime,\,t} + E_{end\text{-}of\text{-}life,\,t}$$

Estimates of the total fluorinated gas emissions from transport refrigeration are provided in Table 4-35.

Table 4-35. Total fluorinated gas emissions from transport refrigeration for 1993-2013

Year	Emissions from refrigerated road vehicles, kt CO_2 eqv.	Emissions from refrigerated rail vehicles, kt CO_2 eqv.	Total HFC emissions in sub-category, kt CO_2 eqv.
1993	0.01	NO	0.01
1994	0.04	NO	0.04
1995	0.14	NO	0.14
1996	0.29	NO	0.29
1997	1.15	NO	1.15
1998	2.73	NO	2.73
1999	3.66	NO	3.66
2000	4.75	NO	4.75
2001	6.50	NO	6.50
2002	8.49	NO	8.49
2003	12.95	NO	12.95
2004	20.53	NO	20.53
2005	25.95	NO	25.95
2006	33.28	0.02	33.30
2007	43.39	0.02	43.41
2008	51.09	0.02	51.11
2009	53.00	0.19	53.19
2010	58.01	0.12	58.13
2011	71.77	0.12	71.89
2012	75.11	0.05	75.16
2013	80.41	0.01	80.42

Shipping containers

A few companies were interviewed in order to identify Lithuanian companies which operate shipping containers. During the interview, private limited liability company UAB Klaipėdos šaldytuvų terminalas (Klaipėda Refrigerator Terminal) pointed out that most of their cold storage facilities are stationary, meanwhile joint stock company Klaipėdos smeltė does not have any refrigerated containers at all. Private limited liability company UAB Containerships has shipping containers which are shipped all over the world and serviced abroad as well.

Fluorinated gas emissions from shipping containers were not assessed for the following reasons:

- the number of shipping containers in Lithuania is not available and difficult to establish;
- most refrigerated containers ship cargo all over the world and practically do not call Lithuanian ports and are serviced in foreign countries.

Reefers

According to the data provided by the Lithuanian Maritime Safety Administration, seven reefers (six transport vessels and one fishing vessel) were registered at the Register of Seagoing Ships of the Republic of Lithuania as on 31 July 2012. Refrigeration equipment for the needs of the crew and passengers is installed on 36 cargo and fishing vessels. The average lifetime of marine vessels is 30-50 years.

The data of reefer vessels registered in Lithuania in 2000-2013 is provided by Statistics Lithuania is presented in Figure 4-31.

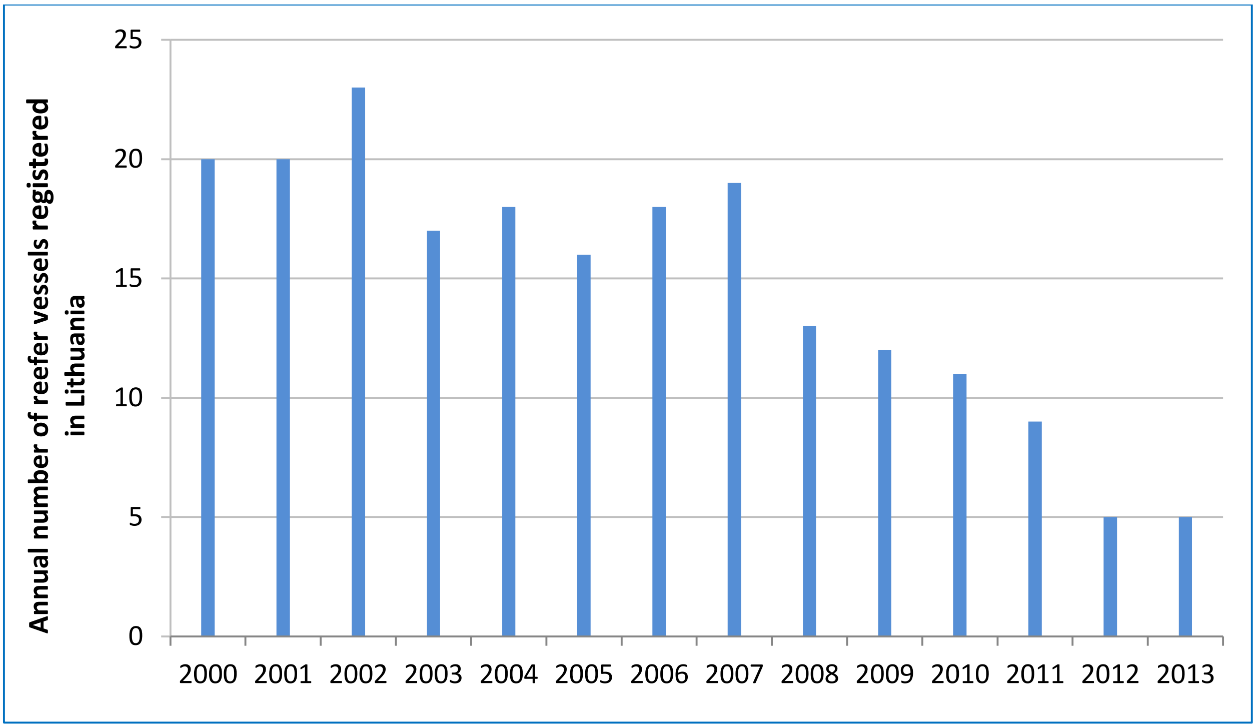


Figure 4-31. Reefer vessels registered in Lithuania in 2000-2013

Fluorinated gas emissions from reefer vessels were not assessed for the following reasons:

- according to specialists, the annual number of reefer vessels with the Lithuanian flag calling Klaipėda Seaport is very small;
- the part of the voyage spent by reefer vessels at the shores of the Republic of Lithuania is not known;
- there is no data available from companies servicing refrigeration equipment, therefore it is difficult to establish average refrigerant charges and the emission factor during the operation of the equipment;
- reefer vessels migrate/ship freight all over the world.

Uncertainties and time-series consistency

Emission uncertainty was estimated using Approach 1 of the 2006 IPCC Guidelines (p. 3.27). Uncertainty estimates of activity data and emission factors are presented in Table 4-36.

Table 4-36. Uncertainty (UN) estimates of fluorinated gas emissions in the sub-category of commercial refrigeration in 2013

Emission source	Input data UN, %	EF during operation UN, %	Input data UN, %	Recovery EF UN, %	Total emission UN, %
CRF 2.F.1.d Refrigeration in vehicles					31
Refrigerated road vehicles	10	20	10	20	31
Refrigerated rail vehicles	5	5	5	5	7

Mobile Air-Conditioning (CRF 2.F.1.e)

Road vehicles with air-conditioning

Fluorinated gas emissions from this equipment were estimated following the 2006 IPCC Guidelines and on the basis of the statistical data on vehicles registered in the Republic of Lithuania. The data on vehicles registered in 1991-2013 by vehicle category and year of manufacture was obtained from state enterprise Regitra:

- M1 – passenger cars;
- M2 – buses ≤ 5 t;
- M3 – buses > 5 t;
- N1 – freight vehicles up to 3.5 t;
- N2 – freight vehicles from 3.5 to 12 t;
- N3 – freight vehicles above 12 t.

The vehicles considered in this report were manufactured in 1993-2013. The company Regitra also provided the average lifetime by vehicle category. The percentage of vehicles equipped with air conditioning in the vehicle fleet of Lithuania by vehicle category and year of manufacture was estimated on the basis of vehicle suppliers (Table 4-37).

Table 4-37. Estimated percentage of vehicles equipped with air conditioning by year of manufacture and vehicle category

Year of manufacture	M1	M2	M3	N1	N2	N3
1990	20%	0%	0%	0%	0%	25%
1991	24%	0%	0%	0%	0%	28%
1992	28%	0%	0%	0%	0%	31%
1993	32%	0%	0%	0%	0%	34%
1994	36%	0%	0%	0%	0%	37%
1995	40%	0%	0%	0%	0%	40%
1996	44%	2%	2%	2%	2%	43%
1997	48%	4%	4%	4%	4%	46%
1998	52%	6%	6%	6%	6%	49%
1999	56%	8%	8%	8%	8%	52%
2000	60%	10%	10%	10%	10%	55%
2001	64%	18%	18%	18%	18%	63%
2002	68%	26%	26%	26%	26%	71%
2003	72%	34%	34%	34%	34%	79%
2004	76%	42%	42%	42%	42%	87%
2005	80%	50%	50%	50%	50%	95%
2006	84%	58%	58%	58%	58%	96%
2007	88%	66%	66%	66%	66%	97%
2008	92%	74%	74%	74%	74%	98%
2009	96%	82%	82%	82%	82%	99%
2010	100%	90%	90%	90%	90%	100%
2011	100%	94%	94%	94%	94%	100%
2012	100%	94%	94%	94%	94%	100%
2013	100%	94%	94%	94%	94%	100%

There is no data available on the original factory charge therefore the emission factor during the initial charging and the emissions were not estimated.

The assessment of the emissions during the operation of the equipment was based on the following factors and assumptions:

1. Data of a vehicle maintenance company UAB Sadomaksa:

- the average annual amount of refrigerant in the equipment:

M2 – buses ≤ 5 t – 8 kg;

M3 – buses > 5 t – 13 kg;

2. 2006 IPCC Guidelines (p. 7.52):

- the average annual amount of refrigerant in the equipment:

M1 – passenger car– 0.7 kg

N1 – freight vehicles up to 3.5 t – 0.7 kg;

N2 – freight vehicles from 3.5 to 12 t – 1.2 kg;

N3 – freight vehicles above 12 t – 1.2 kg;

- the emission factor during the operation of the equipment (for all vehicle categories) is 15%.

3. Other assumptions:

- there is no data available for the assessment of the emission factor during equipment maintenance, therefore this factor was assumed to be included in the emission factor during operation.

Emissions of HFCs during the lifetime of the equipment were calculated using the following equation (2006 IPCC Guidelines, Volume 3, part 2, p. 7.50, Tier 2a):

$$E_{lifetime,\,t} = B_t \; x \, x$$

where:

B_t – amount of HFCs banked in existing systems in year t, t;

x – emission factor of HFCs for each sub-application bank during operation, accounting for average annual leakage and average annual emission during servicing, %.

The assessment of emissions at system disposal was based on the following factors and assumptions:

1. Data of state enterprise Regitra:

- The lifetime of vehicles:

M1 – passenger car – 17 years;

M2 – buses ≤ 5 t – 16 years;

M3 – buses > 5 t – 21 years;

N1 – freight vehicles up to 3.5 t – 22 years;

N2 – freight vehicles from 3.5 to 12 t – 23 years;

N3 – freight vehicles above 12 t – 20 years.

2. Other assumptions:

- the residual gas amount in the system being disposed is 85%;
- there is no data available on recycling of vehicle air-conditioning systems, therefore the factor of recovery efficiency was not estimated.

Emissions at system end-of-life were calculated using the following equation (2006 IPCC Guidelines, Volume 3, part 2, p. 7.51):

$$E_{end\text{-}of\text{-}life,\ t} = M_{t\text{-}d} \times p$$

where:

M_{t-d} – amount of HFCs initially charged into new systems installed in year (t-d), t;

p – residual charge of HFCs in equipment being disposed of expressed in percentage of full charge, %.

There are calculated emissions from disposal passenger car (M1), buses ≤ 5 t (M2) and freight vehicles above 12 t – 1.2 kg (N3) with air-conditioning systems filled with HFC-134a in this report. Air conditioning systems of freight vehicles (N1, N2) are also filled with HFC-134a gases, but their lifetime is 22-23 years and emissions at system end-of-life were not calculated. Emissions of HFC-125 and HFC-143a at system disposal were not calculated as well, because the lifetime of the buses > 5 t (M3) with air-conditioning systems filled with R404a (blend of HFC-125 (44%), HFC-143a (52%) %) and HFC-134a (4%)) is 21 year.

It is likely that fluorinated gases contained in vehicle air-conditioning systems are not collected or recovered in Lithuania and are simply emitted into the atmosphere.

Estimations of fluorinated gas emissions from vehicles with air conditioning are demonstrated in Figure 4-32 below.

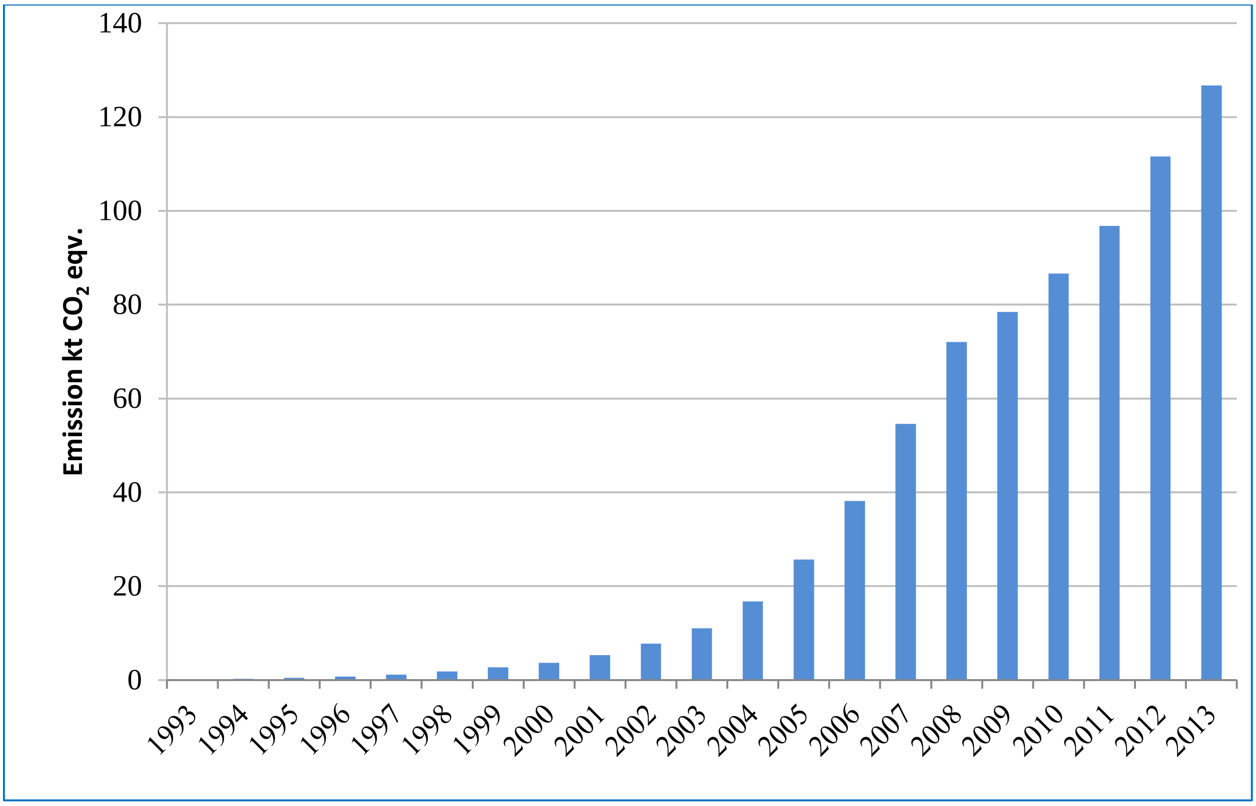


Figure 4-32. Fluorinated gas emissions from vehicles with air conditioning for 1993-2013

Trains – passenger carriages with air conditioning

There is no data available on the original factory charge, therefore the emission factor during the initial charging and the emissions were not assessed.

The assessment of the emissions during the operation of the equipment was based on the following factors and assumptions:

1. Data of the Passenger Transportation Directorate of the company AB Lietuvos geležinkeliai:

- the average annual amount of refrigerant in UKV-type air conditioner is 10 kg;
- the emission factor during the operation of the equipment is 2%.

2. Other assumptions:

- there is no data available for the assessment of the emission factor during equipment maintenance, therefore this factor was assumed to be included in the emission factor during operation.

Emissions of HFCs during the lifetime of the equipment were calculated using the following equation (2006 IPCC Guidelines, p. 7.50):

$$E_{lifetime,\ t} = B_t \ x\ x$$

where:

B_t – amount of HFCs banked in existing systems in year t, t;

x – emission factor of HFCs for each sub-application bank during operation, accounting for average annual leakage and average annual emission during servicing, %.

The air-conditioning equipment installed in passenger carriages which belongs to the company AB Lietuvos geležinkeliai is rather new – it has been used since 2006, its lifetime has not expired yet and so emissions at system disposal were not estimated.

Estimates of fluorinated gas emissions from passenger carriages are demonstrated in Figure 4-33 below.

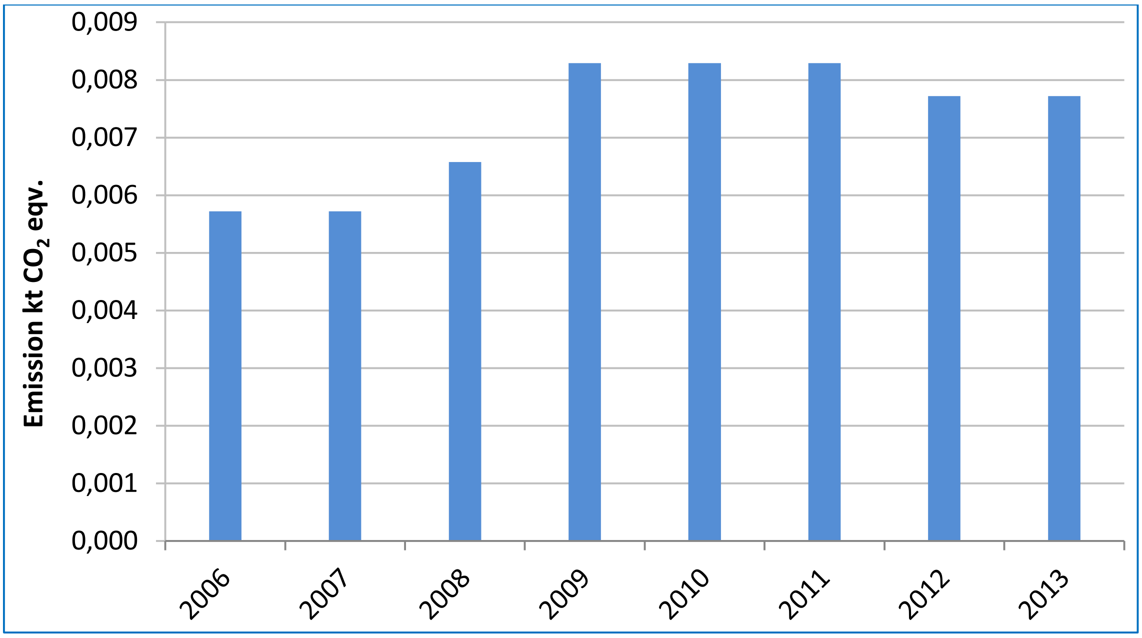


Figure 4-33. Fluorinated gas emissions from passenger carriages for 2006-2013

Total emissions:

$$E_{total,\,t} = E_{lifetime,\,t} + E_{end\text{-}of\text{-}life,\,t}$$

Estimates of fluorinated gas emissions from mobile air-conditioning systems are presented in Table 4-38.

Table 4-38. Total HFC emissions from mobile air conditioning for the period 1993-2013

Year	Emissions from vehicles with air conditioning, kt CO_2 eqv.	Emissions from rail vehicles with air conditioning, kt CO_2 eqv.	Total emissions, kt CO_2 eqv.
1993	0.10	NO	0.10
1994	0.25	NO	0.25
1995	0.47	NO	0.47
1996	0.71	NO	0.71
1997	1.12	NO	1.12
1998	1.84	NO	1.84
1999	2.70	NO	2.70
2000	0.00	NO	0.00
2001	5.28	NO	5.28
2002	7.78	NO	7.78
2003	11.01	NO	11.01
2004	16.78	NO	16.78
2005	25.65	NO	25.65

2006	38.17	0.006	38.18
2007	54.58	0.006	54.59
2008	72.05	0.007	72.06
2009	78.46	0.008	78.47
2010	86.64	0.008	86.65
2011	96.77	0.008	96.78
2012	111.61	0.008	111.62
2013	126.69	0.008	126.70

Uncertainties and time-series consistency

Emission uncertainty was estimated using Approach 1 of the 2006 IPCC Guidelines (p. 3.27).Uncertainty estimates of activity data and emission factors are presented in Table 4-39.

Table 4-39. Uncertainty (UN) estimates of fluorinated gas emissions in the sub-category of mobile air conditioning

Emission source	Input data UN, %	EF during operation UN, %	Input data UN, %	Recovery EF UN, %	Total emission UN, %
CRF 2.F.1.e Mobile air conditioning					31
Air-conditioning equipment in road vehicles	10	20	10	20	31
Air- conditioning equipment in rail vehicles	5	5	-	-	7

Stationary Air-Conditioning (CRF 2.F.1.f)

Air-conditioning and ventilation equipment

Taking into account the EPA database analysis results obtained during the 2012 study on the use of HFCs in Lithuania, emissions from stationary air-conditioning systems were estimated observing the following recommendations:

- the amounts of HFC-125, HFC-134a, HFC-143a, HFC-32 declared in the EPA database of 2013 are deemed to be annual recharge amounts in air-conditioning systems;
- the amount of gases contained in air-conditioning systems in 2013 = annual recharge *10 (assumption that the annual amount of gases in the systems is ten times larger than the amount of recharge);
- pursuant to the information that refrigerants have been used in stationary air-conditioning systems since 1995 (information provided in national reports of other countries), it was assumed that the initial amount of refrigerants in the systems was 1% as compared to the year 2012. The amounts of refrigerants for 1996-1999 were estimated by way of direct interpolation;
- the emission factor during the operation of the equipment is 10% (upper range limit of the factor given in the 2006 IPCC Guidelines).

Emissions of HFCs during the **lifetime of the equipment** were calculated using the following equation (2006 IPCC Guidelines, Volume 3, part 2, p. 7.50, Tier 2a):

$$E_{lifetime,\,t} = B_t \;x\; x$$

where:

B_t – amount of HFCs banked in the existing systems in year t, t;

x – emission factor of HFCs for each sub-application bank during operation, accounting for average annual leakage and average annual emission during servicing, %.

Emissions from the stationary A/C equipment initial charging and decommissioning were calculated taking into account the following assumptions:

- Based on study „Analysis of the use of fluorinated GHG in Lithuania in 1990-2011“ results, it was considered that the lifetime of the stationary A/C equipment is 15 years, which is in the range of lifetime values provided in 2006 IPCC Guidelines (10-20 years). Taking into account that HFCs have been used in stationary A/C equipment in Lithuania since 1995, end-of-life emissions were estimated for 2010-2013 years.
- Emissions during the initial charging of stationary A/C were estimated for all-time series, using emission factor 0.6%, which is based on 2012 study on F-gases experts recommendations (average range limit of the factor given in the 2006 IPCC Guidelines, Volume 3, part 2, Table 7.9, p. 7.52).
- initial charge remaining factor – 80% (2006 IPCC Guidelines, Volume 3, part 2, p. 7.52).
- Recovery efficiency at disposal – 80% is based on expert judgement. After consultations with several refrigeration and A/C equipment servicing companies it was concluded that as a common practice in Lithuania refrigerants from A/C equipment are usually extracted before decommissioning and reused in other systems.

Emissions from end-of-life stationary A/C equipment were estimated using equation (2006 Guidelines, Volume 3, part 2, p. 7.51):

$$E_{end\text{-}of\text{-}life,\, t} = M_{t-d} \ x \ p \ x \ (1-\eta_{rec,\, d})$$

where:

M_{t-d} – amount of HFCs initially charged into new systems installed in year (t-d), t;

p – residual charge of HFC in equipment being disposed of expressed in percentage of full charge, %;

$\eta_{rec,\ d}$ – recovery efficiency at disposal, which is the ratio of recovered HFCs referred to HFCs contained in the system, %.

Estimates of fluorinated gas emissions from stationary air-conditioning systems are demonstrated in Figure 4-34 below.

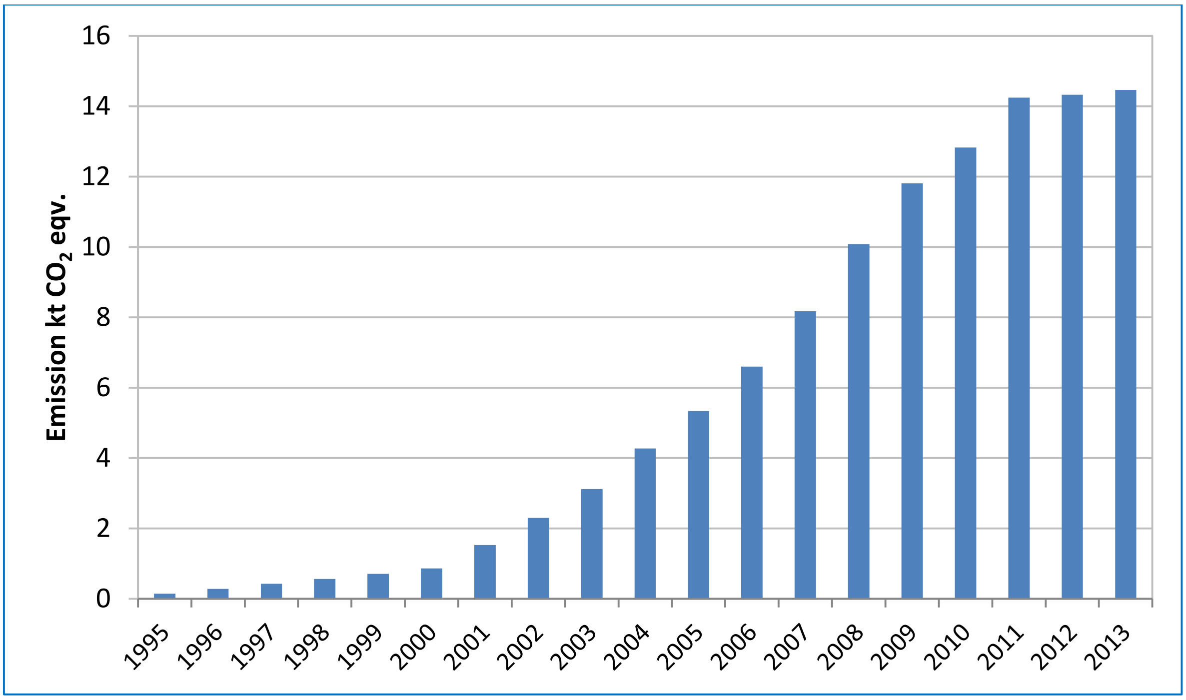


Figure 4-34. Fluorinated gas emissions from stationary air conditioning for 1995-2013

Heat pumps

Lithuanian Geothermal Association and companies which are engaged in installation and service heat pumps were contacted with a request to provide necessary data.

The Lithuanian Geothermal Association provided the following information:

- in Lithuania heat pumps have been installed since 2005, the largest number was installed in 2007 m., (about 700 units), approximately 400 units were installed in 2008;
- the average amount of refrigerant charged in the equipment is about 3 kg, though 6 kg is also possible;
- the main refrigerants are HFC-407C and HFC-410A;
- the lifetime of the equipment is around 15 years;
- there are no leakages of emission during the operation of the equipment.

Companies installing heat pumps consider information on the number of installed heat pumps as confidential information, therefore the only source of information is summary data provided by EurObserv'ER (http://www.eurobserv-er.org/default.asp) (2009-2013) and by Lithuanian Geothermal Association (2005-2008). Following the data provided by private liability companies and by the Lithuanian Geothermal Association, the following assumptions were formulated:

- the proportion of new geothermal/aerothermal pumps installed until 2010 was 75% : 25%, and from 2010 – 50% : 50% (aerothermal heating tends to occupy an increasing market share);
- the average amount of refrigerant charged in the equipment is 3 kg;
- R-407C accounts for about 80% and R-410A – for approximately 20% of the total amount of refrigerants in geothermal pumps, meanwhile 100% of aerothermal pumps are filled with R-410A;
- in Lithuania heat pumps have been installed since 2005, their lifetime is 15 years, therefore emissions at system disposal were not estimated.

The calculations of emissions during the charging and operation of the equipment were made using the factors in the lower range limit given in the 2006 IPCC Guidelines:

- the emission factor during the initial charging is 0.2%;
- the emission factor during the operation of the equipment is 1%.

Emissions of HFCs during the initial charging of new equipment were calculated using the following equation (2006 IPCC Guidelines, Volume 3, part 2, p. 7.50, Tier 2a):

$$E_{charge,\ t} = M_t \ x \ \ k$$

where:

$E_{Charge,\ t}$ – emissions during system manufacture/assembly in year t, t;

M_t – amount of HFCs charged into new equipment in year t, t;

k – emission factor of assembly losses of HFCs charged into new equipment, %.

Emissions during lifetime:

$$E_{lifetime,\ t} = B_t \ \ x \ x$$

where:

B_t – amount of HFCs banked in existing systems in year t, t;

x – emission factor of HFCs for each sub-application bank during operation, accounting for average annual leakage and average annual emission during servicing, %.

Total emissions:

$$E_{total,\ t} = E_{charge,\ t} \ x \ E_{lifetime,\ t}$$

Emissions in this sector were calculated for 2005-2013 on the basis of specific information on the beginning of the installation of these systems in Lithuania (2005). Estimates of fluorinated gas emissions from heat pumps are demonstrated in Figure 4-35 below.

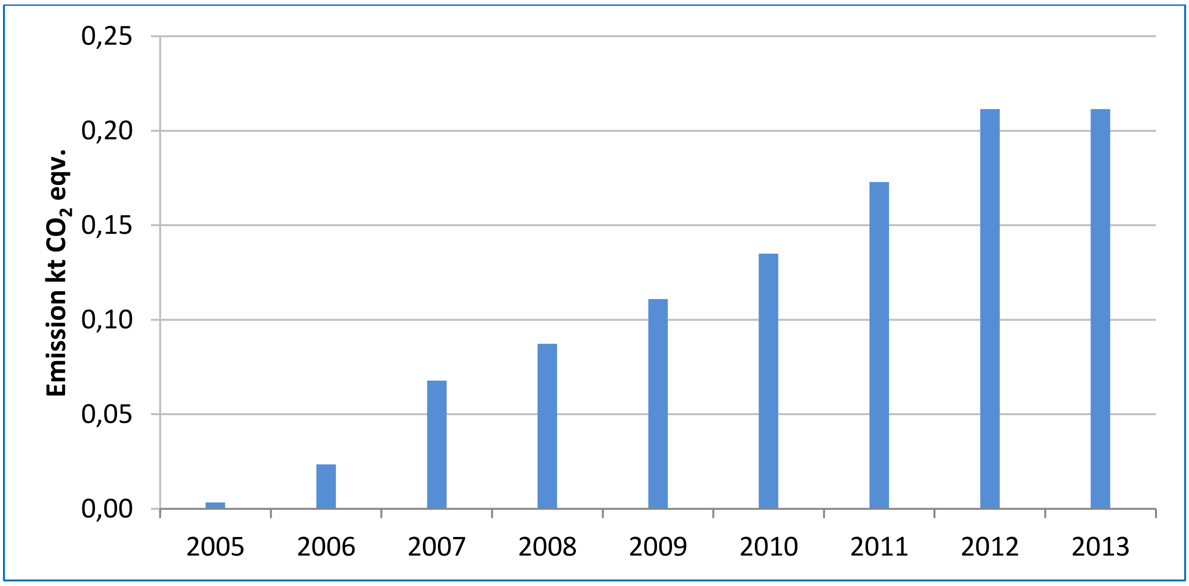


Figure 4-35. Fluorinated gas emissions from heat pumps for 2005-2013

Estimates of total fluorinated gas emissions from stationary air conditioning and heat pumps are provided in Table 4-40. There was increase in number of installed heat pumps according Study carried out by EurObser'ER in 2013, due to the reinstallation of the equipment. This is also supported by the growth in 2012.

Table 4-40. Total HFC emissions from stationary air conditioning and heat pumps for the period 1995-2013

Year	Emissions from stationary air conditioning, kt CO_2 eqv.	Emissions from heat pumps, kt CO_2 eqv.	Total HFC emissions, kt CO_2 eqv.
1995	0.15	NO	0.15
1996	0.29	NO	0.29
1997	0.43	NO	0.43
1998	0.57	NO	0.57
1999	0.71	NO	0.71
2000	0.87	NO	0.87
2001	1.53	NO	1.53
2002	2.31	NO	2.31
2003	3.12	NO	3.12
2004	4.28	NO	4.28
2005	5.34	0.00	5.34
2006	6.61	0.02	6.63
2007	8.18	0.07	8.25
2008	10.08	0.09	10.17
2009	11.81	0.11	11.92
2010	12.83	0.13	12.96
2011	14.25	0.17	14.42
2012	14.33	0.21	14.54
2013	14.46	0.21	14.67

Uncertainties and time-series consistency

Emission uncertainty was estimated using Approach 1 of the 2006 IPCC Guidelines (p. 3.27). Uncertainty estimates of activity data and emission factors are presented in Table 4-43.

Table 4-41. Uncertainty (UN) estimates of fluorinated gas emissions in the sub-category of stationary air conditioning

Emission source	Input data UN, %	EF during operation UN, %	Input data UN, %	Recovery EF UN, %	Total emission UN, %
CRF 2.F.1.f Stationary air conditioning					35
Air-conditioning and ventilation equipment	30	20	-	-	36
Heat pumps	20	20	-	-	28

4.7.1.3 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission. Following ERT recommendation category specific quality procedures are planned to be implemented in the next submission.

4.7.1.4 Category-specific planned improvements

The new EU Regulation No 517/2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006 came into force in May 2014. The ambitious new Regulation will reduce F-gas emissions by two-thirds of today's levels by 2030 and ban the use of F-gases in some new equipment where viable climate-friendly alternatives are readily available. The main novelty and driver for moving towards climate-friendly technologies is the introduction of a phase-down measure which from 2015 will limit the total amount of HFCs – the most significant group of F-gases – sold in the EU and reduce their quantities in steps to one-fifth of today's sales by 2030. This measure is accompanied by a number of new restrictions on the use and sale of F-gases in equipment. Taking into account this new important legislation, review of assumptions used to estimate F-gases emissions is planned for the next submission.

4.7.2 Foam Blowing Agents (CRF 2.F.2)

The 2012 study on the use of HFCs in Lithuania verified the information provided in the last year's National Report that HFCs are not used for foam manufacture in Lithuania. A number of producers of foams for construction or packaging are using BASF technology in which foams are blown by the steam. Lithuanian producer of domestic refrigerators AB Snaigė uses cyclopentane for production of insulation foams.

4.7.2.1 Category Description

Foam blowing agent category are divided into two sub-categories: closed cells (CRF 2.F.2a) and open cells (CRF 2.F.2.b).

Closed Cells (CRF 2.F.2.a)

In this sector HFCs are emitted only from the use of imported foam products containing fluorinated gases. Eleven biggest companies importing foam products were interviewed in 2013. Two companies using closed cell polyurethane (PU) foams (insulation spray) have confirmed the use of products containing F-gases and provided data on the total amount of material used and composition of the F-gases (HFC-365mfc, HFC-134a, HFC-245fa, HFC-227ea). According to the data provided by UAB Termomontažas, actual amounts of F-gases used for the foam blowing constitute 7.5% of the foam material by weight.

Open Cells (CRF 2.F.2.b)

The 2012 study on the use of HFCs in Lithuania verified that HFCs are not used for foam manufacture in Lithuania, so for the category "CRF 2.F.2.b Open Cells" notation key "NO" is used.

4.7.2.2 Methodological issues

Closed Cells (CRF 2.F.2.a)

The following assumptions and calculations were made on the basis of summary information provided by companies and in national reports and literature of other countries:

1. The amounts (import and export) used in Lithuania were estimated following the statistical data on PU foam import and export for 2004-2013 provided by Statistics Lithuania;

2. 50% of this amount accounts for systems with HFCs (data source: UAB Termosnaigė);

3. Blends used in systems with fluorinated gases:

- Variant I: 93% HFC-365mfc, 7% HFC-227ea;
- Variant II: 95% HFC-365mfc, 5% HFC-245fa;
- Variant III: 100% HFC-134a;

Frequency of the use of these blends: Variant I – 60%, Variant II – 20%, Variant III – 20% (based on the 2012 National Report of Lithuania, Estonia and Germany and other literature);

4. Estimations included the initial amount of HFCs for PU foam production in the system;

5. Following the 2006 IPCC Guidelines (p. 7.35):

- the first year loss emission factor is 10%;
- the annual loss emission factor is 4.5%;
- the lifetime of the system is 20 years, therefore emissions at system disposal were not estimated.

Emissions of HFCs from closed cell foam were calculated using the following equation (2006 IPCC Guidelines, Volume 3, part 2, p. 7.33, Tier 2a):

$$Emissions_t = M_t \times EF_{FYL} + Bank_t \times EF_{AL}$$

where:

M_t – total HFCs used in manufacturing new closed-cell foam in year t, t;

EF_{FYL} – first year loss emission factor, fraction;

$Bank_t$ – HFC charge blown into closed-cell foam manufacturing between year t and year t-n, t;

EF_{AL} – annual loss emission factor, fraction.

According to the information received from companies, HCF 141b was used until 2004 (which is verified by data from other countries and literary sources). When the use of this gas was prohibited, other blowing agents were started to be used (HFC-365mfc, HFC-227ea, HFC-245 fa, HFC-134a), therefore emissions in Lithuania were estimated for the period 2004-2013.

Estimations of fluorinated gas emissions from closed cell foam are demonstrated in Figure 4-36 below.

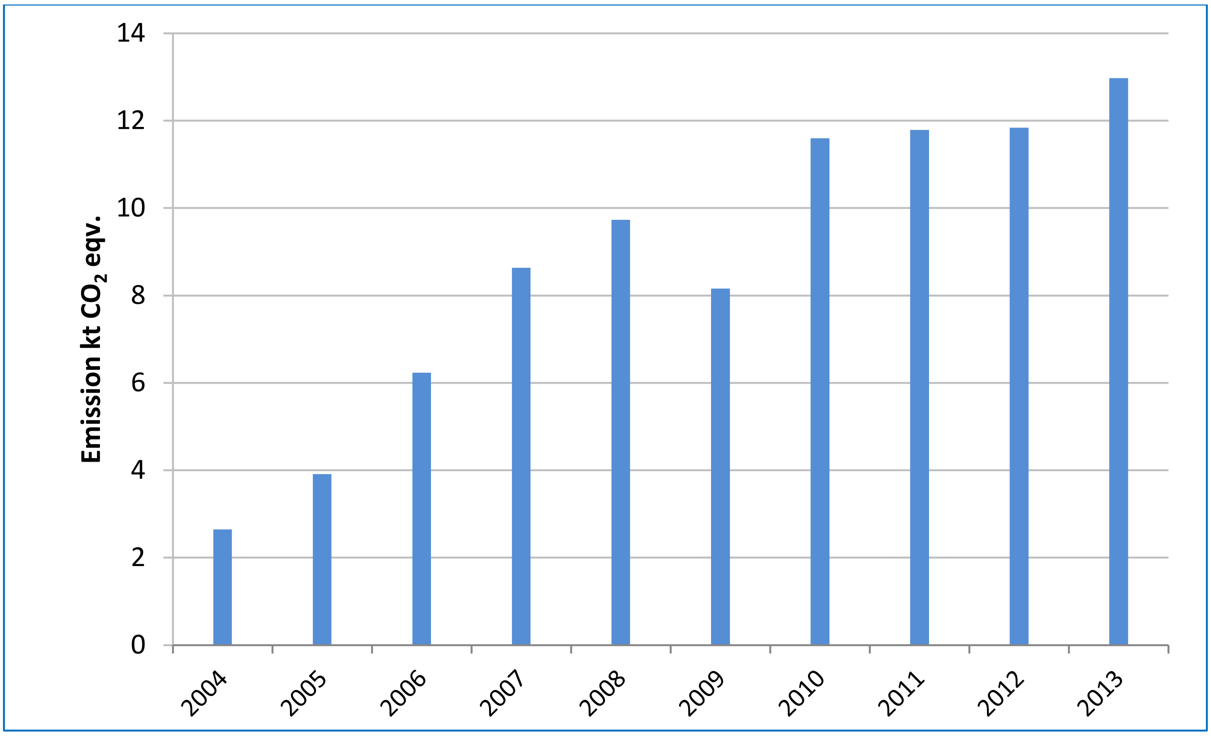


Figure 4-36. Emissions from closed cell foam for 2004-2013

Foam

Private limited liability company UAB Vita Baltic International, which has been operating in Lithuania since 1997 and which belongs (is part of) the VITA GROUP, one of the largest polyurethane producers in the world, informed that it has never used fluorinated gases in its production and has been using chlorides instead.

Estimates of fluorinated gas emissions from foam blowing are presented in Table 4-42.

Table 4-42. Total HFC emissions from foam blowing for the period 2004-2013

Year	Emissions from foam blowing, kt CO_2 eqv.
2004	2.65
2005	3.91
2006	6.23
2007	8.63
2008	9.73
2009	8.16
2010	11.60
2011	11.79
2012	11.84
2013	12.97

4.7.2.3 Uncertainties and time-series consistency

Emission uncertainty was estimated using Approach 1 of the 2006 IPCC Guidelines (p. 3.27). Uncertainty estimates of activity data and emission factors are presented in Table 4-43.

Table 4-43. Uncertainty (UN) estimates of fluorinated gas emissions in the sub-category of foam blowing

Emission source	Input data UN, %	EF during operation UN, %	Input data UN, %	Recovery EF UN, %	Total emission UN, %
CRF 2.F.2 Foam blowing	30	30	-	-	42

4.7.2.4 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

4.7.2.5 Category-specific planned improvements

No source-specific improvements have been planned.

4.7.3 Fire Protection (CRF 2.F.3)

4.7.3.1 Category Description

The following information on fluorinated gas use in fire protection systems was provided as a result of the Study 2012 and EPA database:

- the main source of fluorinated gases in fire extinguishers is automatic gas systems;
- the main gas is FM 200 (HFC-227ea), which has been used since 1996;
- small amounts of HFC-23 have also been used;
- the average amount of gas contained in one system totals 100 kg, however, the range is 50-500 kg (or even 1.000 kg), therefore it is not appropriate to estimate gas amounts on the basis of the number of installed systems;
- as from the year 2008, basically only FM 200 is use meanwhile FS49C2 (R866) is no longer in use;
- fluorinated gases are not used in new installed fire extinguishing systems;
- systems were triggered by fire or accidentally, when all gasses are emitted into the atmosphere, only once or twice a year, therefore the emission factor used for emission calculations was the one recommended in the 2006 IPCC Guidelines (1.5%);
- there are no recovery systems yet.

The Ministry of National Defence provided data on the amounts of HFC-236fa contained in fire protection systems installed in vehicles. So far these systems have not been triggered. Emissions were estimated using the emission factor recommended in the 2006 IPCC Guidelines (1.5%).

4.7.3.2 Methodological issues

Emissions were calculated using the methodology described below. The amounts of FS49C2 and emissions were estimated on the basis of the EPA data because no other data was available. The annual amounts for 2000-2013 were estimated on the basis of the following assumptions:

- the gas has been used since 2000;
- the amount of the gas in 2000 comprised 20% of the amount in 2011;
- the amount of the gas in 2012-2013 is estimated on the basis of the EPA data;
- the gas has not been used in systems since 2007;
- the emission factor is 1.5% (2006 IPCC Guidelines).

The annual amounts of HFC-227ea were estimated on the basis of:

- information provided by companies;
- assumption that installation of the systems depends on construction trends (data of Statistics Lithuania on the useful floor area of completed buildings for 2000-2010);
- the amount of the gas in 2011-2013 is estimated on the basis of the EPA data;
- the emissions factor is 1.5% (2006 IPCC Guidelines).

The lifetime of the equipment is 20 years (the lifetime of military equipment is longer, 25-30 years) therefore emissions at system disposal were not estimated.

Emissions of HFCs from fire protection systems were calculated using the following equation (2006 IPCC Guidelines, Volume 3, part 2, p. 7.61):

$$Emissions_t = Bank_t \ x \ EF$$

where:

$Bank_t$ – bank of agent in fire protection equipment in year t, t;

EF – fraction of agent in equipment emitted each year.

Estimates of fluorinated gas emissions from fire protection systems are demonstrated in Figure 4-37 below.

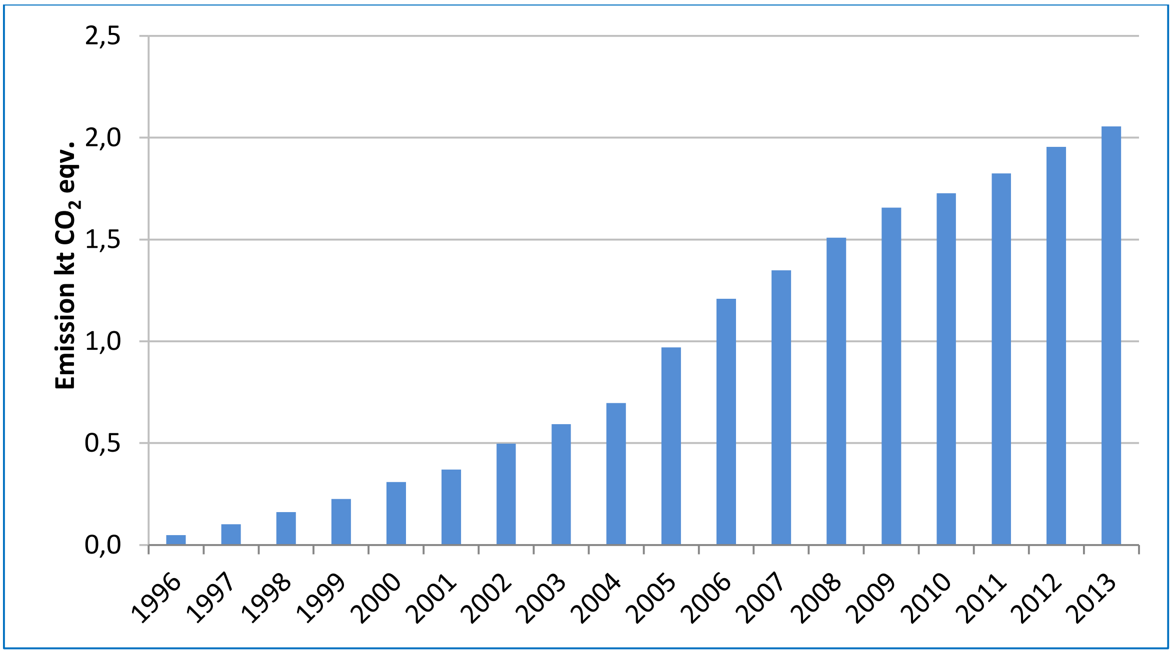


Figure 4-37. Fluorinated gas emissions from fire protection systems for 1996-2013

Emissions were estimated for the period 1996-2013 on the basis of information provided by companies on the beginning of the gas use.

Estimates of fluorinated gas emissions from fire protection systems are presented in Table 4-44.

Table 4-44. Total HFC emissions from fire protection systems for the period 1996-2013

Year	Emissions from fire protection systems, kt CO_2 eqv.
1996	0.05
1997	0.10

1998	0.16
1999	0.23
2000	0.31
2001	0.37
2002	0.50
2003	0.59
2004	0.70
2005	0.97
2006	1.21
2007	1.35
2008	1.51
2009	1.66
2010	1.73
2011	1.82
2012	1.96
2013	2.06

4.7.3.3 Uncertainties and time-series consistency

Emission uncertainty was estimated using Approach 1 of the 2006 IPCC Guidelines (p. 3.27). Uncertainty estimates of activity data and emission factors are presented in Table 4-45.

Table 4-45. Uncertainty (UN) estimates of fluorinated gas emissions in the sub-category of fire protection

Emission source	Input data UN, %	EF during operation UN, %	Total emission UN, %
CRF 2.F.3 Fire Protection	20	20	28

4.7.3.4 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

4.7.3.5 Category-specific planned improvements

No source-specific improvements have been planned.

4.7.4 Aerosols (CRF 2.F.4)

Based on the results of the study "Analysis of the use of fluorinated greenhouse gases in Lithuania in 1990-2011", there are no production of aerosols containing F-gases in Lithuania, all aerosols are imported and products containing F-gases have not been identified. Therefore, only emissions from metered dose inhalers are reported under this sector.

4.7.4.1 Category Description

Aerosols category are divided into two sub-categories metered dose inhalers (CRF 2.F.4.a) and other (CRF 2.F.4.b).

Metered Dose Inhalers (CRF 2.F.4.a)

Data on total annual sales of metered dose inhalers containing HFCs and a specific amount of HFC-134a initially charged in product was obtained from the State Medicines Control Agency under the Ministry of Health of the Republic of Lithuania.

The data was available for the period 2004-2013. Emissions for the period 1995-2003 were extrapolated, taking into account that metered dose inhalers containing F-gases started to be registered in Lithuania's Register of Medicinal Products from 1994 year and making an assumption that emissions in 1995 constituted 50% of emissions in 2004.

Other (CRF 2.F.4.b)

HFC emissions from other aerosols production is not occurring in Lithuania so for the category "CRF 2.F.4.b Other" notation key "NO" is used.

4.7.4.2 Methodological issues

Metered Dose Inhalers (CRF 2.F.4.a)

Emissions of HFCs from metered dose inhalers were calculated using the following equation (2006 IPCC Guidelines, Volume 3, part 2, p. 7.28):

$$E_t = S_t \times EF + S_{t-1} \times (1 - EF)$$

where:

S_t – quantity of HFCs contained in aerosol products sold in year t, t;

S_{t-1} – quantity of HFCs contained in aerosol products sold in year t-1, t;

EF – emission factor (fraction of chemical emitted during the first year).

Estimates of fluorinated gas emissions from metered dose inhalers are demonstrated in Figure 4-38 below.

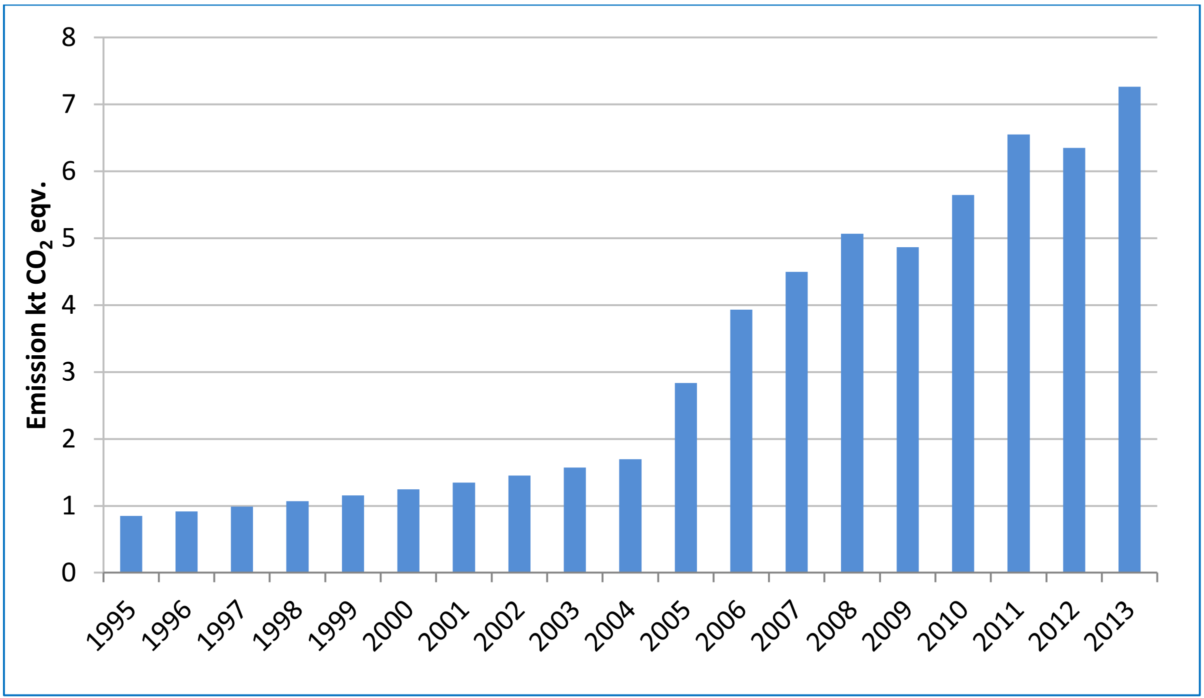


Figure 4-38. Fluorinated gas emissions from metered dose inhalers for 1995-2013

Estimates of HFC emissions from metered dose inhalers are presented in Table 4-46.

Table 4-46. Total HFC emissions from metered dose inhalers for the period 1995-2013

Year	Emissions from metered dose inhalers, kt CO_2 eqv.
1995	0.85
1996	0.92
1997	0.99
1998	1.07
1999	1.15
2000	1.25
2001	1.35
2002	1.45
2003	1.57
2004	1.70
2005	2.84
2006	3.93
2007	4.50
2008	5.06
2009	4.87
2010	5.65
2011	6.55
2012	6.35
2013	7.26

4.7.4.3 Uncertainties and time-series consistency

Emission uncertainty was estimated using Approach 1 of the 2006 IPCC Guidelines (p. 3.27). Uncertainty estimates of activity data and emission factors are presented in Table 4-52.

Table 4-47. Uncertainty (UN) estimates of fluorinated gas emissions in the sub-category of metered dose inhalers

Emission source	Input data UN, %	EF during operation UN, %	Total emission UN, %
CRF 2.F.4.a Metered dose inhalers	5	5	7

4.7.4.4 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

4.7.4.5 Category-specific planned improvements

No source-specific improvements have been planned.

4.7.5 Solvents (CRF 2.F.5)

The two studies of the use of fluorinated gases (2008 and 2012) have not identified any potential area for application for the solvents containing fluorinated gases. Taking into account the experience from other countries it is very unlikely that solvents containing fluorinated gases are used in significant quantities in Lithuania. Therefore notation keys „NA" (1990-1994) and „NO" (1995-2013) are used.

4.7.6 Other Applications (CRF 2.F.6)

HFC emissions from other applications are not occurring in Lithuania so for the category "CRF 2.F.6.a Emissive" and "CRF 2.F.6.b Contained" notation key "NO" is used.

4.8 Other product manufacture and use (CRF 2.G)

This section covers emissions of sulphur hexafluoride (SF_6) from electrical equipment and from other product use. SF_6 is used for electrical insulation and current interruption in equipment used in the transmission and distribution of electricity and in hospitals providing oncological treatment. In 2013 the SF_6 emissions were estimated at 0.397 kt CO_2 eqv.

4.8.1 Electrical Equipment (CRF 2.G.1)

4.8.1.1 Category Description

Sulphur hexafluoride (SF_6) is used for electrical insulation and current interruption in equipment used in the transmission and distribution of electricity. Most of the SF_6 used in electrical equipment is used in gas insulated switchgear and substations and in gas circuit breakers.

The Lithuanian energy management system was reorganized in 2011. The 2012 study on the use of HFCs in Lithuania identified all electrical equipment which was transferred from the balance of some companies to others, drawing up a single register. The data was provided by the following companies:

- AB Litgrid, operator of the electricity transmission system;
- AB Lesto, operator of the electricity distribution network;
- AB Lietuvos energija, operator of electrical equipment.

At present, high voltage equipment, which suffers operational losses and requires annual recharge is managed by the company AB Litgrid. Medium voltage equipment is leak proof and will be returned to the manufacturer after the expiry of its lifetime.

AB Litgrid provided exact data on annual operating losses meanwhile other companies pointed out that there have been no emissions from their equipment. Operating losses from electric equipment are relevant exclusively to high voltage grid. High voltage is operated by a single company AB Litgrid. SF_6 containing units used in medium voltage grid are hermetic. Leak proof is guaranteed and serviced by the producer. At the end of the service period the units will be returned to the producer. Up until now the companies operating medium voltage grid were not asked to provide any measurements or tests to proof emissions from sealed units.

All companies maintained that the lifetime of their equipment has not expired yet therefore there have been no emissions at system disposal (but even in such case the equipment would be forwarded to the manufacturer).

Private limited liability company UAB Orlen Lietuva and joint stock company AB Lifosa also declared the use of the SF_6 gas in their equipment:

- the SF_6 gas has been contained in high voltage power equipment of AB Lifosa since 2000, no operating losses have been registered so far;
- the SF_6 gas has been contained in many facilities operated by AB Orlen Lietuva for about 15 years, the equipment is hermetic, no maintenance has been required so far (in such case the equipment would be forwarded to the manufacturer).

4.8.1.2 Methodological issues

Following the 2006 IPCC Guidelines, emissions were estimated using Tier 3 method (on the basis of the data directly obtained from each company) for the period 1995-2013 (first operating losses were registered in 1995).

Estimates of SF_6 emissions in the sub-category of electrical equipment are demonstrated in Figure 4-39 below.

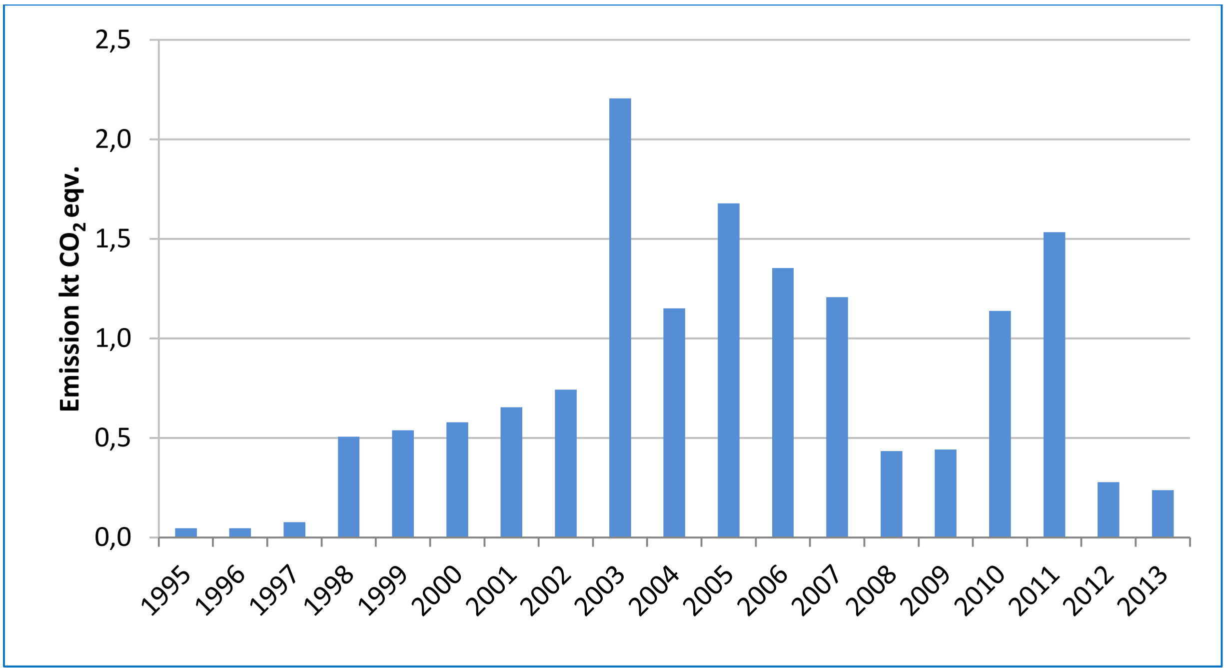


Figure 4-39. SF_6 emissions from electrical equipment for 1995-2013

AB Litgrid was asked to comment on the emission variations. It was explained that the emissions cover both allowable operating losses and leakages due to various technical faults and in due to system reorganization.

Estimates of fluorinated gas emissions from electrical equipment are presented in Table 4-55.

Table 4-48. Total SF_6 emissions from electrical equipment for the period 1995-2013

Year	Emissions from electrical equipment, kt CO_2 eqv.
1995	0.05
1996	0.05
1997	0.08
1998	0.51
1999	0.54
2000	0.58
2001	0.65
2002	0.74
2003	2.21
2004	1.15
2005	1.68
2006	1.35
2007	1.21

2008	0.43
2009	0.44
2010	1.14
2011	1.53
2012	0.28
2013	0.24

4.8.1.3 Uncertainties and time-series consistency

Emission uncertainty was estimated using Approach 1 of the 2006 IPCC Guidelines (p. 3.27). Uncertainty estimates of activity data and emission factors are presented in Table 4-49.

Table 4-49. Uncertainty (UN) estimates of SF_6 emissions in the sub-category of electrical equipment systems

Emission source	Input data UN, %	EF during operation UN, %	Total emission UN, %
CRF 2.G.1 Electrical equipment	5	5	7

4.8.1.4 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

4.8.1.5 Category-specific planned improvements

No source-specific improvements have been planned.

4.8.2 SF_6 and PCFs from other Product Use (CRF 2.G.2)

4.8.2.1 Category Description

The entities surveyed during the 2012 study on the use of HFCs in Lithuania also included:

- largest manufacturers of double-glazed windows;
- hospitals providing oncological treatment.

Manufacturers of sound-proof double-glazed windows confirmed that the SF_6 gas is not used in Lithuania. The gas used instead is inert argon (in rare cases – crypton).

The surveyed hospitals which apply radiation therapy for cancer treatment confirmed the use of accelerators containing the SF_6 gas:

- Kauno klinikos, Hospital of Lithuanian University of Health Sciences (5 units),
- Institute of Oncology Vilnius University (4 units),
- Šiauliai County Hospital (1 unit),
- Klaipėda University Hospital (1 unit).

SF_6 gas emissions were estimated based on the data provided directly by the hospitals for 1999-2011 (the first devices were put into operation in 1999).

Emissions increased in 2000, 2003, 2006, 2009, and 2011 due to the use of the equipment Mevatron MD2 in the hospital Kauno klinikos, when the total amount of the SF_6 gas was emitted during the replacement of the magnetron. According explanation received from the hospital Kauno klinikos, during the change of magnetron due the specifics of the operation all amount of SF_6 gas is emitted directly to atmosphere. There is no information on the specific years when the magnetron was replaced, however, it is known that it was replaced four times from the start of its operation, so it was assumed that the replacements took place at regular intervals. This equipment was dismantled in 2011.

Estimates of SF_6 emissions from accelerators (in radiation therapy facilities) are demonstrated in Figure 4-40 below.

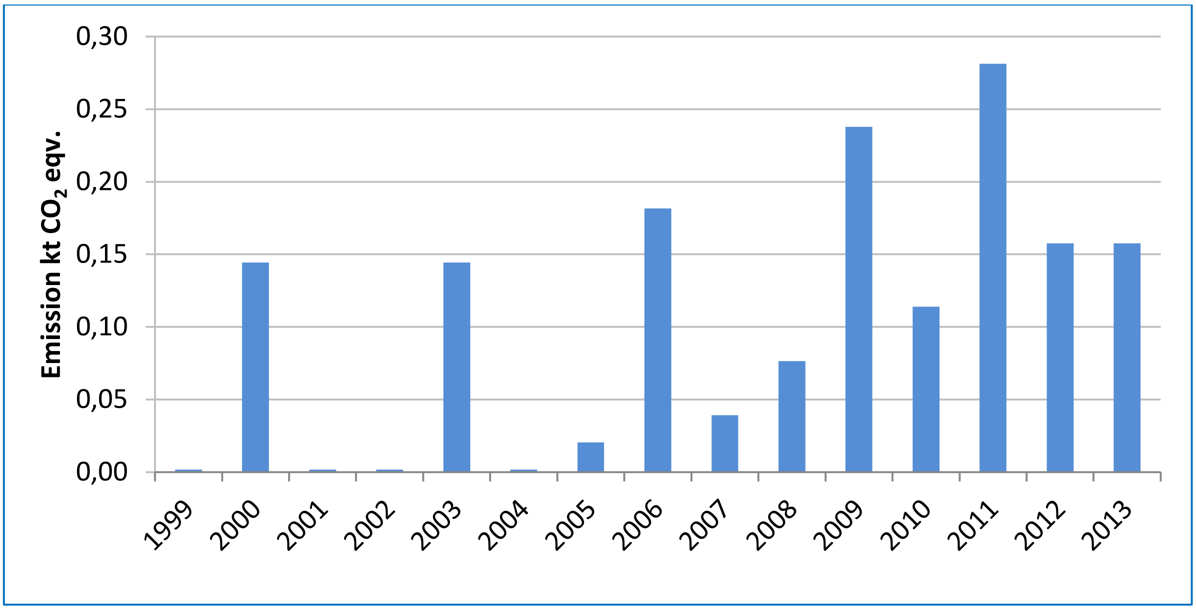


Figure 4-40. SF_6 emissions from accelerators (in radiation therapy facilities) for 1999-2013

Estimates of SF_6 emissions from accelerators (in radiation therapy facilities) are presented in Table 4-50.

Table 4-50. Total HFC emissions from fire from accelerators (in radiation therapy facilities) for the period 1999-2013

Year	Emissions from accelerators (in radiation therapy facilities), kt CO_2 eqv.
1999	0.002
2000	0.144
2001	0.002
2002	0.002
2003	0.144
2004	0.002
2005	0.020
2006	0.182
2007	0.039
2008	0.077
2009	0.238
2010	0.114
2011	0.281
2012	0.157
2013	0.157

4.8.2.2 Uncertainties and time-series consistency

Emission uncertainty was estimated using Approach 1 of the 2006 IPCC Guidelines (p. 3.27). Uncertainty estimates of activity data and emission factors are presented in Table 4-51.

Table 4-51. Uncertainty (UN) estimates of fluorinated gas emissions from accelerators (in radiation therapy facilities)

Emission source	Input data UN, %	EF during operation UN, %	Total emission UN, %
CRF 2.G.2 SF_6 and PCFs from other Product Use	5	5	7

4.8.2.3 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

4.8.2.4 Category-specific planned improvements

No source-specific improvements have been planned.

4.8.3 N_2O from Product Uses (CRF 2.G.3)

4.8.3.1 Category Description

This category includes emissions from the use of N_2O for anesthesia and N_2O emissions from aerosol cans.

The data from anesthesia on the N_2O sales was available since 2005. Activity data was provided by the State Medicines Control Agency. Emissions for 1990-2004 were extrapolated with the increasing trend accordingly.

Currently there is no possibility to collect data from N_2O emissions from aerosol cans in Lithuania. However, N_2O emissions from aerosol cans in Lithuania was estimated based on Belgium data (Belgium greenhouse inventory report, 2014).

4.8.3.2 Methodological issues

N_2O emissions from N_2O used in anesthesia were estimated taking into account amount of N_2O sold in Lithuania. Following the 2006 IPCC, it was assumed that 100 % of N_2O sold for anesthesia was emitted to the air, therefore activity data is equal to estimated emissions.

According to, Belgium inventory report the N_2O emissions from aerosol cans were newly estimated on the basis of the average European consumption (number of food aerosol can/inhab) obtained from DETIC (Belgian-Luxembourg Association of producers and distributors of soaps, cosmetics, detergents, cleaning products, hygiene and toiletries, glues, and related products) for the year 2012. Because of a lack of activity data before 2012, this average consumption is assumed to be constant over time. The activity data (number of aerosol cans) is then calculated for the complete time series on the basis of the number of inhabitant. The emission factor for N_2O is 7.6 g/can (as estimated in the Netherlands on the basis of data provided by one producer) and is assumed to be constant over time.

N_2O emissions from medical applications and from aerosol cans are shown in Table 4-52.

Table 4-52. Estimated N_2O emissions from medical applications and aerosol cans, kt/year

Year	N_2O emissions from anesthesia, kt CO_2eq.	N_2O emissions from aerosol cans, kt CO_2eq.
1990	93.35	2.70
1991	91.56	2.70
1992	89.77	2.70
1993	87.98	2.69
1994	86.20	2.67
1995	84.41	2.65
1996	82.62	2.63
1997	80.83	2.61
1998	79.04	2.59
1999	77.26	2.57
2000	75.47	2.55
2001	73.68	2.53
2002	71.89	2.51
2003	70.10	2.49
2004	68.32	2.47
2005	66.53	2.43
2006	37.68	2.39
2007	28.92	2.36
2008	4.17	2.33
2009	9.28	2.31
2010	3.24	2.26
2011	3.52	2.21
2012	2.50	2.18
2013	2.60	2.16

4.8.3.3 Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- Uncertainty of activity data is assumed to be 5%;
- Emission factor uncertainty is assumed to be 5%;
- Combined uncertainty is 7%.

4.8.3.4 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

4.8.3.5 Category-specific planned improvements

No source-specific improvements have been planned.

4.8.4 Other (CRF 2.G.4)

HFC emissions from other sources are not occurring in Lithuania so for the category "CRF 2.G.4 Other" notation key "NO" is used.

4.9 Other (CRF 2.H)

4.9.1 Pulp and paper industry (CRF 2.H.1)

4.9.1.1 Category Description

In Lithuanian inventory this category includes non-fuel emissions of NOx, NMVOC and SO_2 from paper and pulp production. Pulp was produced in 1990-1993 in a single paper mill. Data on the pulp production was provided by company. Variations of pulp production are shown in Figure 4-41. Pulp is not produced in Lithuania since 1993. From 1994 to 2012 paper and corrugated board used for manufacturing of sanitarian and domestic products are made in the process of recycling the secondary raw material – waste-paper. Paper is produced in two companies in Lithuania.

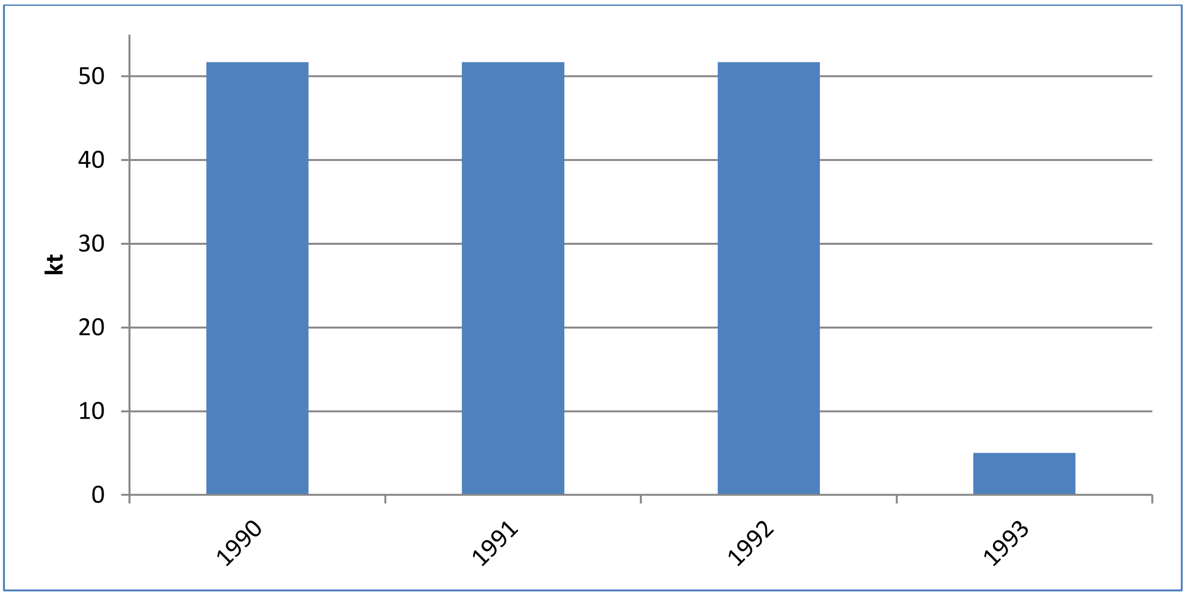


Figure 4-41. Pulp production

4.9.1.2 Methodological issues

Emissions of NO_x, NMVOC and SO_2 from pulp and paper manufacturing were calculated using EMEP/EEA emission inventory guidebook 2013. The company used acid sulphite pulping process for production of pulp. NO_x, NMVOC and SO_2 emissions were calculated from pulp production data using default emission factors shown in Table 4-53 (EMEP/EEA, 2H1. Pulp and paper industry, Table 3.3, p. 17).

Table 4-53. Emission factors for pulp production

Pollutant	EF, kg/tonne dried pulp
NO_x	2
NMVOC	0.2
SO_2	4

Estimated NMVOC emissions from pulp and paper production were converted to CO_2 using method provided in 2006 IPCC (Volume 1, Chapter 7, box 7.2, p. 7.6). Estimated NOx, NMVOC, CO_2 and SO_2 emissions from pulp production are shown in Table 4-54.

Table 4-54. Estimated emissions from pulp and paper production, kt/year

Year	NO_x	NMVOC	CO_2 eqv.	SO_2
1990	0.103	0.010	0.023	0.207
1991	0.103	0.010	0.023	0.207
1992	0.103	0.010	0.023	0.207
1993	0.010	0.001	0.002	0.020
1994-2013	NO	NO	NO	NO

4.9.1.3 Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- Uncertainty of activity data is assumed to be 10%;
- Emission factor uncertainty is assumed to be 5%;
- Combined uncertainty is 11.2%.

Historical data on production of pulp was obtained from production company and covers period 1990-1993. Production of pulp was stopped in 1993.

4.9.1.4 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

4.9.1.5 Category-specific planned improvements

No source-specific improvements have been planned.

4.9.2 Food and beverages industry (CRF 2.H.2)

4.9.2.1 Category Description

NMVOC emissions from food and drink production are calculated based on data provided by Statistics Lithuania[22]. Data is available for 2000-2013. Data on production of the following beverages was used for greenhouse gas emission inventory: spirits and liqueurs, grape wine, fruit and berry wine, sparkling grape wine and beer (Table 4-55).

Table 4-55. Total annual production of beverages, thousand decaliters in 2000-2013

Year	Spirits and liqueurs	Grape wine	Fruit and berry wine	Sparkling grape wine	Beer
2000	854	169	1.245	234	21.049
2001	899	127	889	302	21.935
2002	909	203	872	269	26.885
2003	932	140	890	215	26.417
2004	1.068	249	983	267	26.898
2005	1.230	463	1.055	322	28.946
2006	1.519	388	1.161	409	29.340
2007	1.853	342	1.374	544	28.564

[22] Database of Statistics Lithuania

2008	1.542	297	1.371	538	29.685
2009	1.038	246	1.233	294	27.623
2010	893	290	1.370	434	29.182
2011	932	175	1.421	437	30.511
2012	933	225	1.434	423	28.406
2013	1.095	133	1.776	441	28.863

Note: Spirits and liqueurs are expressed as 100% alcohol

Average for the period 2000-2013 was used to estimate production of beverages for the period 1990-1999.

Data for period 2000-2013 on production of the following products was used for greenhouse gas emission inventory: animal rendering, fish meal processing, bread, biscuits, sugar, margarine, animal feed, coffee roasting. Average for the period 2000-2013 was used to estimate food production for the period 1990-1999.

4.9.2.2 Methodological issues

Emissions of NMVOC from food and beverage industry were calculated using EMEP/EEA emission inventory guidebook 2013. NMVOC emissions were calculated using default emission factors (EMEP/EEA, 2.H.2 Food and beverage industry). Emission factors are provided in Table 4-56.

Table 4-56. Emission factors for beverages and food production

Product	**Category in Lithuanian Statistics**	**Emission factor (NMVOC)**
Beverages, kg/hl beverage		
Spirits (unspecified)	Spirits and liqueurs	15.0
Wine	Grape wine	0.08
	Fruit and berry wine	
	Sparkling grape wine	
Beer	Beer	0.035
Food production, kg/tonne product		
Meat, fish and poultry		0.3
Bread		4.5
Flour production		1
Sugar production		10
Margarine and solid cooking fats		10
Animal feed		1

Estimated NMVOC emissions from pulp and paper production were converted to CO_2 using method provided in 2006 IPCC (Volume 1, Chapter 7, box 7.2, p. 7.6). Estimated NMVOC and CO_2 emissions from food and drink production are shown in Table 4-57.

Table 4-57. Estimated emissions from food and drink production kt/year

Year	**NMVOC**	**CO_2 eqv.**
1990	4.4	9.8
1991	4.4	9.8
1992	4.4	9.8
1993	4.4	9.8

1994	4.4	9.8
1995	4.4	9.8
1996	4.4	9.8
1997	4.4	9.8
1998	4.4	9.8
1999	4.4	9.8
2000	3.9	8.6
2001	3.8	8.4
2002	4.2	9.2
2003	4.1	9.0
2004	4.4	9.8
2005	4.7	10.3
2006	4.8	10.7
2007	5.6	12.4
2008	4.5	9.8
2009	4.0	8.9
2010	3.9	8.6
2011	4.2	9.3
2012	4.3	9.4
2013	4.8	10.7

4.9.2.3 Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- Activity data was obtained from Statistics Lithuania publications. Uncertainty is assumed to be 5%;
- Emission factor uncertainty is assumed to be 5%;
- Combined uncertainty is 7.1%.

Data is consistent over the time-series. Data on total annual production of food and drink products were taken from Statistics Lithuania publications.

4.9.2.4 Category-specific QA/QC and verification

All quality procedures according to the Lithuanian QA/QC plan have been implemented during the work with this submission.

4.9.2.5 Category-specific planned improvements

No source-specific improvements have been planned.

5 AGRICULTURE (CRF 3)

5.1 Overview of the sector

Greenhouse gas (GHG) emissions from agriculture sector in Lithuania include: methane (CH_4) emissions from enteric fermentation of domestic livestock; CH_4 and nitrous oxide (N_2O) (direct and indirect) emissions from manure management; direct and indirect N_2O emissions from managed soils; carbon dioxide (CO_2) emissions from soil liming and application of urea. Direct N_2O emissions from agricultural soils include emissions that occur from application of synthetic nitrogen (N) containing fertilizers, application of organic fertilizers (manure, sewage sludge and compost), N deposited on pasture, range and paddock soils by grazing animals, nitrogen that is returned to soil with crop residues, including N-fixing crops and forages, N mineralized from loss in soil organic C, and cultivation of organic soils. Indirect N_2O emission sources include emissions from atmospheric deposition and from nitrogen leaching and run-off. Source of CO_2 emissions is liming of soils (lime and dolomite) and application of urea. Rice is not cultivated and savannahs do not exist in Lithuania, therefore reported as "NO" in CRF tables. Field burning of agricultural residues is prohibited by the legislation[23] and reported as "NO".

Key categories analysis was performed using *Approach 1* and *Approach 2*. The results of both analyses are presented in Table 5-1. Analysis showed that twelve relevant categories from agriculture sector were indicated as the key categories.

Table 5-1. Key category from Agriculture sector in 2013

IPCC Category	Greenhouse gas	Identification criteria
3.A.1 Enteric Fermentation - Cattle	CH_4	L1, L2, T1, T2
3.B.1.1 Manure Management - Cattle	CH_4	L1
3.B.1.3 Manure Management - Swine	CH_4	T1
3.B.1 Manure Management - Other	N_2O	T2
3.B.2 Manure Management - Cattle	N_2O	T2
3.B.2 Manure Management - Indirect N_2O Emissions	N_2O	L2, T2
3.D.1.1 Direct N_2O Emissions From Managed Soils - Inorganic N Fertilizers	N_2O	L1, L2,T2
3.D.1.2 Direct N_2O Emissions From Managed Soils - Organic N Fertilizers	N_2O	L1,T1, T2
3.D.1.3 Direct N_2O Emissions From Managed Soils - Urine and dung deposited by grazing animals	N_2O	L1, T1, T2
3.D.1.4 Direct N_2O Emissions From Managed Soils - Crop Residues	N_2O	L1, L2, T1, T2
3.D.1.6 Direct N_2O Emissions From Managed Soils - Cultivation of organic soils	N_2O	L1, L2, T1, T2
3.D.2.1 Indirect N_2O Emissions From Managed Soils - Atmospheric deposition	N_2O	L2
3.D.2.2 Indirect N_2O Emissions From Managed Soils - Nitrogen leaching and run-off	N_2O	L1, L2

[23] Order of the Minister of Environment No 269 Concerning the environmental protection requirements for burning dry grass, reeds, straw and garden waste, as amended. In force from 9th of September, 1999

Emissions were evaluated using methodology of 2006 IPCC Guidelines for National Greenhouse Gas Inventories (*IPCC 2006*).

In 2013 – 4429.44 kt CO_2 eqv. of GHG emissions originated from Agriculture sector. The major part of these emissions (54.5%) comprised from managed soils (Figure 5-1).

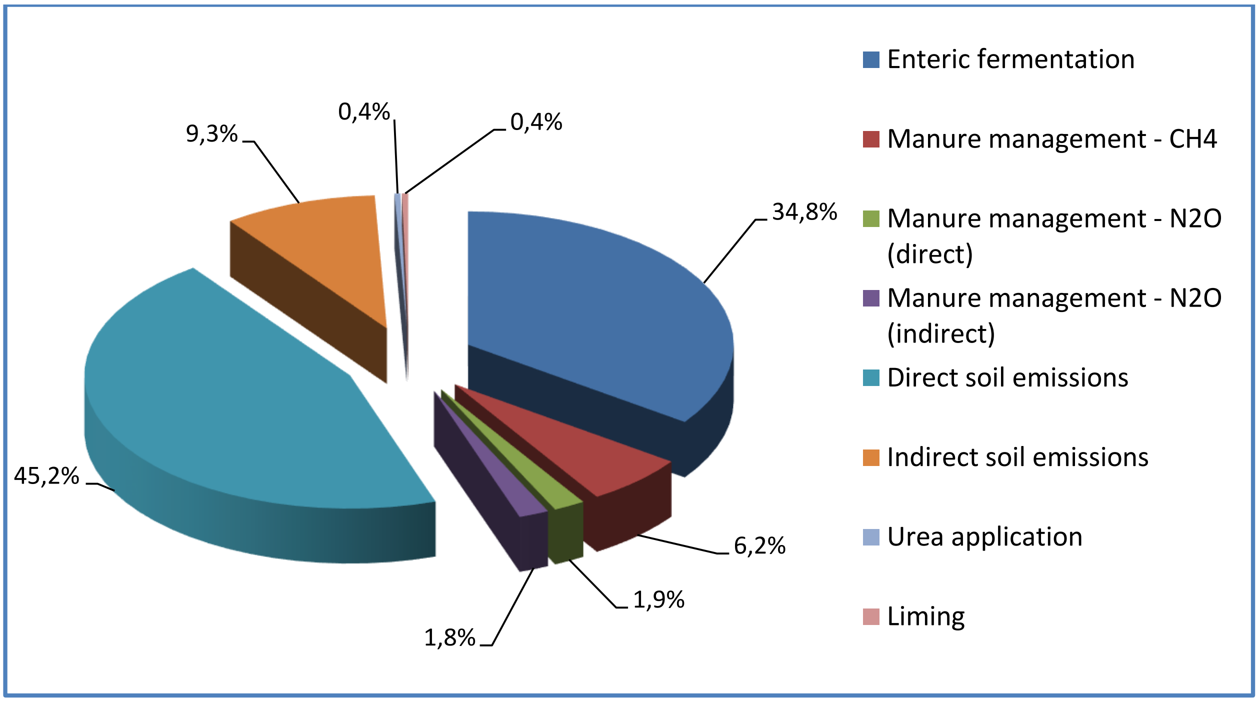


Figure 5-1. The share of emissions by categories from key sources within the sector in 2013, %

In 2013 N_2O emissions contributed 58% of the total GHG emission from Agriculture sector. The major part of CH_4 emissions from agriculture sector originates from digestive processes. Enteric fermentation constituted 85% of the total CH_4 emissions comprising from Agriculture sector. From 1990 to 2013 emissions from agriculture sector have decreased by 49% (Figure 5-2, Table 5-2). Figure below also presents CO_2 emissions from liming and urea application. These categories contributed 0.7% to the total emissions from Agriculture sector in 2013.

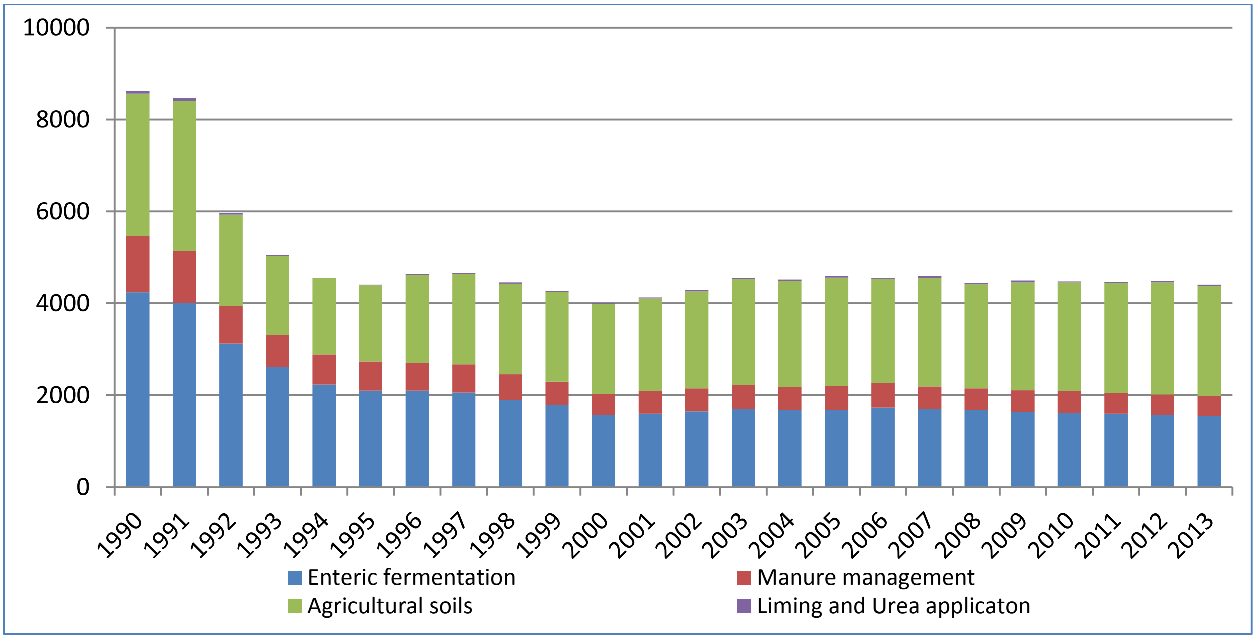


Figure 5-2. Emissions by category during the period 1990-2013, kt CO_2 eqv.

Emissions from Agriculture sector decreased substantially in the beginning of 90's. The agriculture sector contributed 24% of the national GDP in 1992 and employed 19% of the labor force. Lithuania's agriculture, efficient according to the past soviet standards, produced a huge surplus that could not be consumed domestically. Lithuania was producing crops, developing livestock farming and food processing industry. Crops accounted for 1/3 and livestock for 2/3 of the total value of agricultural output. Lithuanian agricultural production was high enough to allow the export of about 50% of the total output.

Significant reforms were introduced in the early 90s, particularly after the restoration of independence. The reform included the re-establishment of private ownership and management in the Agriculture sector. Legislation defined dismemberment of the collective farms, but they did not definitively ensure their replacement by at least equally productive private farms or corporations. Agricultural production decreased by more than 50% from 1989 to 1994. The farms were broken into small holdings, averaging 8.8 ha in size, often not large enough to be economically viable.

Table 5-2. GHG emissions from agriculture sector by sources during the period 1990-2013, kt CO_2 eqv.

Year	Enteric fermentation	Manure management			Agricultural soils		Liming	Urea application	Total
			Direct	Indirect	Direct	Indirect			
	CH_4	CH_4	N_2O	N_2O	N_2O	N_2O	CO_2	CO_2	CO_2 eqv
1990	4236.3	685.4	313.9	230.0	2485.6	614.9	20.6	35.7	**8622.28**
1991	4001.2	636.6	287.1	214.3	2616.0	652.2	20.6	41.7	**8469.72**
1992	3127.3	458.7	205.9	152.0	1650.5	337.2	20.6	14.8	**5966.90**
1993	2610.3	401.9	170.8	127.0	1464.0	262.6	2.7	7.2	**5046.60**
1994	2235.9	387.3	152.0	113.8	1413.4	243.7	2.6	7.2	**4556.04**
1995	2101.8	380.1	143.6	109.0	1419.7	239.1	4.0	6.7	**4404.02**
1996	2101.6	359.2	137.3	105.1	1616.5	299.5	13.4	13.3	**4645.90**
1997	2061.5	368.8	136.7	105.8	1655.6	307.5	13.1	13.7	**4662.75**
1998	1892.4	344.8	122.9	96.6	1665.1	303.6	13.8	14.0	**4453.27**
1999	1785.2	307.8	110.6	88.7	1652.8	298.6	9.4	15.8	**4268.83**
2000	1568.3	280.5	96.9	78.6	1663.3	294.7	7.6	16.5	**4006.46**
2001	1601.0	305.2	100.7	84.3	1710.6	303.8	5.6	17.2	**4128.41**
2002	1645.3	315.8	102.2	87.6	1787.9	324.4	9.0	19.4	**4291.67**
2003	1702.7	320.5	104.3	91.0	1946.8	358.7	8.2	19.5	**4551.76**
2004	1676.9	315.7	102.1	90.9	1947.0	357.9	7.9	19.7	**4517.30**
2005	1681.4	323.4	102.4	93.7	1986.5	367.2	6.9	31.4	**4592.19**
2006	1734.3	329.1	104.0	96.6	1899.9	355.3	7.3	18.9	**4544.83**
2007	1703.4	295.8	98.1	90.6	1984.1	381.5	6.7	31.4	**4590.88**
2008	1673.2	292.3	94.7	88.1	1898.9	364.9	10.7	19.3	**4441.36**
2009	1635.6	289.6	91.6	88.4	1956.5	389.4	6.9	36.2	**4493.23**
2010	1614.1	294.1	89.9	88.5	1969.4	396.2	6.3	15.7	**4473.41**
2011	1595.7	275.9	86.3	83.8	1993.9	403.8	8.7	14.2	**4461.87**
2012	1568.7	280.6	85.2	83.4	2023.0	414.7	10.9	15.7	**4482.30**
2013	1543.7	274.1	85.3	81.5	2001.2	413.3	16.7	15.7	**4430.59**

After 1990 agricultural companies and enterprises were prevailing types of farming in Lithuania. During the land reform implementation process, the number of agricultural companies and their produced agricultural production amount was constantly decreasing, but the most effective farms were formed during this period. On the contrary, during this period the number of livestock kept in private farms was increasing. In 1996-1997 dairy cattle productivity in private farms was about 3296-3301 kg per cow and reached 3444 kg in 1998, but in 1999 decreased to 3223 kg and was lower than in agricultural companies and enterprises (3266 kg). The purchase prices of milk decreased by 8% in 1999 comparing to 1998 and could have an impact on milk productivity indicators. Overall, during 1990-2012 dairy cattle productivity increased by 40% calculating whole milk or 42.1% calculating 4% fat corrected milk. Data on average milk yield per year per cow are presented in Table 5-3. Data obtained from Statistics Lithuania.

Table 5-3. Average milk yield, kg per cow

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Milk yield	3734	3481	3080	2910	2925	3010	3093	3205
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Milk yield	3384	3228	3673	3903	4003	4015	4176	4312
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Milk yield	4484	4708	4778	4811	4901	5026	5227	5315

5.2 Enteric fermentation (CRF 3.A)

5.2.1 Category description

CH_4 emission from enteric fermentation of domestic livestock includes emissions from cattle (dairy cattle and non-dairy cattle), sheep, goats, horses, swine, rabbits, nutria and fur-bearing animals (minks, foxes and polar foxes). Methods for treating poultry in this context are not yet developed. Population of poultry is presented in Table 5-4 as it is used for calculations in subsector Manure management. Activity data have been obtained from Statistics Lithuania[24]. The population of dairy cattle in 2013 has decreased by 62.5% comparing with 1990. In the same time non-dairy cattle population decreased by 73.1%, population of horses decreased by 72.2%, swine population – by 69%. The population of sheep increased by 76.3%, goats – by 65.4%. Generally decline of the livestock population was caused by the changes in economy due to collapse of the Soviet Union. However the population of sheep in the past few years increased due to promotion of farming in poorer lands.

Table 5-4. Data on livestock population, thous. heads

Year	Dairy cattle	Non-dairy cattle	Sheep	Goats	Horses	Swine	Rabbits	Nutria	Fur-bearing animals	Poultry
1990	842.0	1.479.5	56.5	5.2	79.9	2435.9	73.4	17.3	158.2	16815.0
1991	831.9	1.364.7	58.1	6.3	82.6	2179.8	73.7	17.1	155.9	16994.0
1992	737.8	963.2	51.7	8.8	79.7	1359.8	83.5	13.3	146.1	8258.9
1993	678.1	706.2	45.0	10.4	81.3	1196.1	92.8	10.3	99.5	8728.2
1994	614.9	537.5	40.0	12.4	78.2	1259.8	88.0	10.0	94.7	8848.8
1995	586.0	479.1	32.3	14.6	77.6	1270.0	84.2	8.9	90.0	8444.2
1996	589.9	464.2	28.2	16.9	81.4	1127.6	93.9	7.1	93.4	7775.4
1997	582.8	433.4	24.0	18.5	78.5	1200.1	119.3	4.8	90.5	7423.2
1998	537.7	390.0	15.8	23.7	74.3	1159.0	102.5	3.5	45.6	6749.3
1999	494.3	403.5	13.8	24.7	74.9	936.1	85.4	2.2	41.8	6372.6

[24] Statistics Lithuania. *Available from: http://www.stat.gov.lt/en/*

2000	438.4	309.9	11.5	23.0	68.4	867.6	82.3	2.2	44.8	5576.5
2001	441.8	310.0	12.3	23.7	64.5	1010.8	74.1	2.0	51.6	6576.1
2002	443.3	335.8	13.6	22.0	60.7	1061.0	74.6	1.6	60.5	6848.1
2003	448.1	364.0	16.9	27.2	63.6	1057.4	98.3	1.5	92.3	8066.7
2004	433.9	358.0	22.1	26.9	63.6	1073.3	96.6	1.4	131.5	8419.4
2005	416.5	383.8	29.2	22.0	62.6	1114.6	99.9	1.7	172.2	9397.1
2006	399.0	439.8	36.6	20.8	60.9	1127.1	103.5	2.9	172.7	9440.0
2007	404.5	383.4	43.3	19.7	55.9	923.2	102.1	1.7	161.0	9874.8
2008	394.7	376.2	47.5	16.6	54.4	897.1	103.5	1.3	175.2	9107.5
2009	374.6	384.7	52.5	14.7	49.0	928.2	107.5	1.3	120.1	9308.7
2010	359.8	388.2	58.5	16.0	44.7	929.4	103.5	1.4	175.7	9466.3
2011	349.5	402.8	60.4	15.0	36.4	790.3	98.1	0.3	193.1	8921.2
2012	331.0	398.1	82.8	13.6	29.5	807.5	99.5	0.6	305.1	9085.6
2013	315.7	397.8	99.6	13.8	22.2	754.6	102.7	0.6	341.6	9761.6

CH_4 emissions are primarily related to cattle, which, in 2013 contributed almost 96% of the total emission from enteric fermentation (Table 5-5). In 2013 dairy cattle produced 61.3% and non-dairy cattle – 34.7% of CH_4 emissions from enteric fermentation. The share of other livestock emissions to the total enteric fermentation emissions was small. Emission from swine comprised 1.3%, horses – 0.6%, sheep and goats – 2.0% of the total emission from enteric fermentation.

CH_4 emission from enteric fermentation comprised around 85% of the total CH_4 emission from livestock and 35% of the total emissions from agriculture sector. In 2013, comparing with 2012, CH_4 emission from enteric fermentation decreased by 1.6%. During the period 1990-2013 CH_4 emission from enteric fermentation decreased by 63.6% (Table 5-5).

Table 5-5. CH_4 emissions from enteric fermentation by livestock categories, kt

Year	**Cattle**		**Sheep**	**Goats**	**Horses**	**Swine**	**Rabbits, nutria and fur-bearing animals**
	Dairy	**Non-dairy**					
1990	85.43	79.30	0.66	0.03	1.44	2.53	0.07
1991	82.37	73.15	0.68	0.03	1.49	2.26	0.07
1992	69.90	51.63	0.61	0.04	1.43	1.41	0.07
1993	63.21	37.85	0.53	0.05	1.46	1.24	0.07
1994	57.31	28.81	0.47	0.06	1.41	1.30	0.06
1995	55.16	25.68	0.38	0.07	1.40	1.31	0.06
1996	56.06	24.88	0.33	0.08	1.47	1.17	0.07
1997	56.11	23.23	0.28	0.09	1.41	1.25	0.08
1998	52.75	20.06	0.19	0.12	1.34	1.18	0.07
1999	47.74	21.01	0.16	0.12	1.35	0.97	0.06
2000	44.34	15.96	0.14	0.12	1.23	0.89	0.05
2001	45.63	15.89	0.14	0.12	1.16	1.04	0.05
2002	46.06	17.25	0.16	0.11	1.09	1.09	0.05
2003	46.83	18.64	0.20	0.14	1.14	1.09	0.07
2004	46.15	18.22	0.26	0.13	1.14	1.10	0.07
2005	44.80	19.66	0.34	0.11	1.13	1.14	0.08
2006	43.65	22.88	0.43	0.10	1.10	1.13	0.08
2007	45.38	20.13	0.51	0.10	1.01	0.93	0.08
2008	44.56	19.75	0.56	0.08	0.98	0.92	0.08

2009	42.55	20.30	0.62	0.07	0.88	0.92	0.08
2010	41.24	20.72	0.69	0.08	0.80	0.95	0.08
2011	40.56	20.94	0.71	0.07	0.65	0.82	0.08
2012	39.33	20.93	0.97	0.07	0.53	0.83	0.09
2013	37.84	21.40	1.17	0.07	0.40	0.78	0.09

The overall reduction of CH_4 emission was caused by decrease in livestock population, having the greatest impact on emissions (excluding sheep, goats, rabbits and minks). Although the number of sheep, rabbits, minks, partially goats has increased, this augmentation did not have a substantial effect to the reduction in CH_4 emissions. In case of dairy cattle the decrease of population was partly counterbalanced by an increase in productivity of livestock resulting in higher emission per animal.

5.2.2 Methodological issues

5.2.2.1 Choice of methods

Cattle are the most important producer of CH_4 among all domestic animals due to their digestive system, relatively high weight and number comparing to other livestock population. Cattle are the key source due to the contribution to the total GHG emissions. Therefore *Tier 2* method was applied in order to estimate CH_4 emission factors (EF) from enteric fermentation of dairy and non-dairy cattle. *Tier 2* method was also used for CH_4 EF estimation from enteric fermentation of sheep and swine (Table 5-6). To estimate CH_4 EF from enteric fermentation of goats, horses, rabbits, nutria and fur-bearing animals (minks, foxes and polar foxes) the *Tier 1* method was used.

Table 5-6. Information on methods and EF used for estimation of emissions from enteric fermentation

Animal category	Sub-categories			Method applied	Emission factor
Dairy cattle				Tier 2	CS
Non-dairy cattle	Suckling cows			Tier 2	CS
	Less than 1 year old	Calves for slaughter		Tier 2	CS
		For breeding	Bulls	Tier 2	CS
			Heifers	Tier 2	CS
	From 1 to 2 years old	Bulls		Tier 2	CS
		Heifers	For slaughter	Tier 2	CS
			For breeding	Tier 2	CS
	2 years old and older	Bulls		Tier 2	CS
		Heifers	For slaughter	Tier 2	CS
			For breeding	Tier 2	CS
		Other cows		Tier 2	CS
Sheep	Mature Breeding ewes			Tier 2	CS
	Other Mature Sheep (>1 year)			Tier 2	CS
	Ewe over 1 years			Tier 2	CS
	Ewe lambs to 1years			Tier 2	CS
	Baa-lambs to 1 years			Tier 2	CS
Swine	Breeding sows			Tier 2	CS
	Replacement sows			Tier 2	CS
	Piglets < 2 months (< 20 kg)			Tier 2	CS
	Growing pigs (20-50 kg)			Tier 2	CS
	Growing pigs (50-80 kg)			Tier 2	CS
	Growing pigs (80-110 kg)			Tier 2	CS
	Pigs > 110 kg (8 months and >)			Tier 2	CS

	Gilts for breeding	Tier 2	CS
	Boars	Tier 2	CS
Goats		Tier 1	IPCC
Horse		Tier 1	IPCC
Rabbits		Tier 1	Russian emission factor
Nutria		Tier 1	Russian emission factor
Fur-bearing animals		Tier 1	Norwegian emission factor

5.2.2.2 Characterization of livestock population

CH_4 emission calculations are based on the annual livestock population data. Livestock population data were obtained from the database and publications of Statistics Lithuania (as of 1st of January)[25]. The data given in the database and publications of Statistics Lithuania is collected by applying continuous accountability for agriculture companies and applying sampling methods for farmers and households.

In Lithuanian inventory livestock category cattle (CRF 3.A) consists of dairy cattle and non-dairy cattle. Calculating CH_4 emissions dairy cattle are taken as a single category, not dividing in to subsequent categories (Table 5-4).

Non-dairy cattle category, according to database of Statistics Lithuania, consists of 11 subcategories (Tables 5-6, 5-7). For the period 1990-1996 not all information on relevant 11 sub-categories was available in the database of Statistics Lithuania. At that period non-dairy cattle category was divided in to the following sub-categories: bulls, dairy cattle, heifers from 1 to 2 years old, and heifers 2 years and older, therefore the data for this period was interpolated, based on the data of the subsequent years.

[25] Data on livestock population Statistics Lithuania reports as of 1st of January for the previous year, e.g. data reported 1st of January 2014 would represent data of 2013. *Note: this reporting format might, in some cases, be the cause of disparities between national and international databases.*

Table 5-7. The number of non-dairy cattle by sub-categories in Lithuania, thous. heads

Year	Cattle sub-categories										
	Suckling cows	Cattle less than 1 year old			Cattle from 1 to 2 years old			Cattle 2 years old and older			Other cows
		For slaughter	Bulls for breeding	Heifers for breeding	Bulls	Heifers for slaughter	Heifers for breeding	Bulls	Heifers for slaughter	Heifers for breeding	
1990	-	344.7	48.9	300.9	228.6	63.3	268.2	56.7	23.9	119.3	25.1
1991	-	318.0	45.1	277.5	210.9	58.4	247.4	52.3	22.0	110.0	23.1
1992	-	224.4	31.8	195.9	148.8	41.2	174.6	36.9	15.5	77.7	16.3
1993	-	164.5	23.3	143.6	109.1	30.2	128.0	27.1	11.4	56.9	12.0
1994	-	125.2	17.8	109.3	83.1	23.0	97.4	20.6	8.7	43.3	9.1
1995	-	111.6	15.8	97.4	74.0	20.5	86.8	18.4	7.7	38.6	8.1
1996	-	108.2	15.3	94.4	71.7	19.9	84.1	17.8	7.5	37.4	7.9
1997	-	101.0	14.3	88.1	67.0	18.5	78.6	16.6	7.0	34.9	7.3
1998	-	114.5	13.2	81.5	54.3	14.2	64.6	12.0	4.5	24.3	7.0
1999	-	113.4	16.0	80.7	60.9	21.6	61.9	12.9	5.7	24.7	5.7
2000	0.3	81.2	12.4	68.5	44.1	15.9	53.5	7.9	4.0	19.3	2.8
2001	0.8	81.3	10.6	72.1	42.5	12.0	55.3	9.0	2.8	20.1	3.4
2002	0.9	79.9	13.5	81.2	46.0	11.6	65.2	8.4	3.5	22.2	3.4
2003	1.7	83.7	14.7	90.5	45.0	13.0	73.6	9.1	4.4	24.8	3.5
2004	2.3	84.1	14.8	89.9	40.8	11.7	73.5	8.0	3.8	25.8	3.4
2005	4.5	90.6	17.0	93.0	45.4	15.2	76.0	8.9	4.0	26.7	2.5
2006	9.4	89.0	22.6	109.9	53.8	17.1	89.3	8.7	2.4	35.1	2.5
2007	8.1	71.5	19.7	94.3	49.2	10.4	87.4	7.4	1.9	31.4	2.2
2008	11.8	68.0	19.0	95.0	42.3	10.4	88.7	5.7	2.3	30.9	2.1
2009	13.6	64.9	19.8	98.1	44.2	8.4	94.8	5.7	2.4	31.0	2.0
2010	15.4	65.2	20.3	94.7	45.1	7.8	94.8	6.7	2.3	33.7	2.2
2011	16.3	61.4	22.7	116.6	40.6	6.6	96.9	6.4	2.5	30.8	2.0
2012	18.9	56.3	23.5	113.4	40.6	6.5	97.8	6.2	2.6	30.1	2.1
2013	27.1	55.2	23.1	108.2	42.4	6.2	95.0	6.6	2.2	29.7	2.1

The average weight of dairy cattle in 1990 was based on expert judgement. In 2013 the average weight of most common Lithuanian breeds – black-and-white and red dairy cattle, has been calculated on the basis of expert judgement. The average weight of other national dairy cattle breeds has been calculated using available references[26]. Data on the average weight of dairy cattle is presented in Table 5-8. The average weight of dairy cattle during the period 1991-2013 was interpolated.

Table 5-8. The average weight of dairy cattle during the period 1990-2013, kg

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Weight	575	576	577	578	579	580	580	581
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Weight	582	583	584	585	586	587	588	589
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Weight	590	590	591	592	593	594	595	596

Average weight of suckling cows has been calculated using available data on number of bred breeds of animals and their typical weight, indicated in the reference sources[27]. Weight and weight gain of non-dairy cattle in each sub-category were estimated based on data provided by the expert. Average weight of non-dairy cattle was calculated in accordance with the average weight of each non-dairy cattle sub-category proportionally to its population:

$$m_{average} = \frac{(\sum m_i \cdot population_i)}{population_{total}}$$

where:

$m_{average}$ – average weight of non-dairy cattle, kg;
m_i – average weight of each non-dairy cattle sub-category, kg;
$population_i$ – population of each non-dairy cattle sub-category, thous. heads;
$population_{total}$ – total population of non-dairy cattle sub-category, thous. heads.

Data on average weight of non-dairy cattle is presented in table below (Table 5-9).

Table 5-9. The average weight of non-dairy cattle during the period 1990-2013, kg

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Weight	326.2	326.2	326.2	326.3	326.3	326.3	326.3	326.4
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Weight	307.6	311.0	308.1	307.7	309.0	309.6	307.8	309.4
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Weight	315.3	319.7	320.8	323.1	327.9	318.3	322.6	330.5

Based on expert judgement the average weight gain was estimated for each non-dairy cattle subcategory which remains constant for the whole time period. Basing on this data average weight gain of non-dairy cattle was estimated:

$$w_{average} = \frac{(\sum w_i \cdot population_i)}{population_{total}}$$

where:

[26] Gyvulininkystės žinynas. Baisogala (en. Livestock manual. Institute of Animal Science of LVA), 2007, p. 38-45
[27] Gyvulininkystės žinynas. Baisogala (en. Livestock manual. Institute of Animal Science of LVA), 2007, p. 67-71
Jukna Č., Jukna V. Mėsinių galvijų auginimas (en. Beef cattle rearing), 2004, Kaunas

$w_{average}$ – average weight gain of non-dairy cattle, kg/day;
w_i – average weight gain of each non-dairy cattle sub-category, kg/day;
$population_i$ – population of each non-dairy cattle sub-category, thous. heads;
$population_{total}$ – total population of non-dairy cattle sub-category, thous. heads.

Calculated average weight gain of non-dairy cattle except mature cattle is presented in Table 5-10.

Table 5-10. The average weight gain of non-dairy cattle except mature cattle during the period 1990-2013, kg

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Weight gain	0.743	0.743	0.743	0.743	0.743	0.743	0.743	0.743
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Weight gain	0.751	0.754	0.748	0.748	0.742	0.737	0.737	0.740
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Weight gain	0.741	0.735	0.730	0.726	0.727	0.725	0.723	0.725

The total number of swine population and population by sub-categories were obtained from Statistics Lithuania. This data is presented in Table 5-4 (total population of swine) and in Table 5-11.

Table 5-11. The number of swine by sub-categories in Lithuania, thous. heads

Year	**Sows**		**Piglets till 2 months (20 kg)**	**Growing pigs**			**Pigs > 8 months**	**Boars**	**Gilts for breeding**
	Main*	**Replacement**		**20-50 kg**	**50-80 kg**	**80-110 kg**			
1990	125.4	47.9	450.2	587.1	586.6	391.0	186.8	8.1	52.8
1991	112.3	42.9	402.9	525.3	525.0	349.9	167.1	7.3	47.2
1992	70.0	26.7	251.3	327.7	327.5	218.2	104.3	4.5	29.5
1993	61.6	23.5	221.1	288.3	288.1	192.0	91.7	4.0	25.9
1994	64.9	24.8	232.9	303.6	303.4	202.2	96.6	4.2	27.3
1995	65.4	25.0	234.7	306.1	305.8	203.8	97.4	4.2	27.5
1996	58.1	22.2	208.4	271.8	271.6	181.0	86.5	3.8	24.4
1997	60.4	31.4	219.6	292.9	295.6	167.9	94.2	4.5	33.7
1998	51.8	24.4	231.1	272.5	281.4	183.6	85.1	4.0	25.2
1999	45.8	17.4	159.4	216.8	237.9	153.5	79.8	3.9	21.6
2000	43.6	16.5	160.4	210.8	208.3	133.1	72.2	3.1	17.4
2001	54.5	19.2	188.5	258.4	241.3	153.4	69.7	3.6	22.2
2002	54.6	20.9	196.1	255.7	255.5	170.3	81.3	3.5	23.0
2003	64.0	14.6	194.3	249.3	236.4	205.7	75.3	2.2	15.6
2004	65.5	14.5	199.0	263.0	232.1	208.8	72.7	2.0	15.7
2005	64.4	18.0	222.0	272.6	232.3	215.5	71.5	1.9	16.4
2006	66.6	15.3	249.8	260.7	252.3	198.1	66.6	2.0	15.6
2007	49.1	13.2	191.5	205.3	250.6	122.1	70.7	1.3	19.3
2008	52.4	12.8	162.9	238.9	210.2	146.7	59.1	1.2	12.9
2009	57.6	10.3	229.0	202.2	204.4	152.8	55.0	1.4	15.4
2010	56.9	10.9	171.9	247.7	211.5	158.3	56.5	1.4	14.3
2011	42.8	10.3	138.6	208.5	202.3	117.4	54.1	1.1	15.2
2012	42.3	9.4	140.4	220.7	219.0	113.9	49.0	0.9	11.8
2013	40.3	8.2	126.9	208.0	187.5	119.4	53.0	0.8	10.6

*Selected for second and subsequent farrowing

The average weight of swine was estimated based on the same methodology as for average weight of non-dairy cattle (Table 5-12).

Table 5-12. The average weight of swine during the period 1990-2013, kg

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Weight	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.5
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Weight	68.3	71.5	68.9	69.5	70.2	71.4	70.8	69.4
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Weight	67.8	67.7	68.8	67.0	68.9	68.1	66.7	68.0

The total number of sheep population for the period 1990-2013 is reported in Table 5-4. Since the number of sheep by sub-categories in 1990-2006 is not available, they are calculated according to the average data of herd structure in 2007-2013 (Table 5-13).

Table 5-13. The number of sheep by sub-categories in Lithuania during the period 1990-2013, thous. heads

Year	**Sheep sub-category**				
	Mature ewe	**Ewe over 1 years**	**Ewe lambs to 1 years**	**Baa-lambs to 1 years**	**Rams over 1 year**
1990	25.1	11.7	8.6	4.8	6.2
1991	25.8	12.1	8.8	5.0	6.4
1992	23.0	10.7	7.9	4.4	5.7
1993	20.0	9.3	6.8	3.9	5.0
1994	17.8	8.3	6.1	3.4	4.4
1995	14.4	6.7	4.9	2.8	3.6
1996	12.5	5.9	4.3	2.4	3.1
1997	10.7	5.0	3.6	2.1	2.6
1998	7.0	3.3	2.4	1.4	1.7
1999	6.1	2.9	2.1	1.2	1.5
2000	5.1	2.4	1.7	1.0	1.3
2001	5.5	2.6	1.9	1.1	1.4
2002	6.0	2.8	2.1	1.2	1.5
2003	7.5	3.5	2.6	1.4	1.9
2004	9.8	4.6	3.4	1.9	2.4
2005	13.0	6.1	4.4	2.5	3.2
2006	16.3	7.6	5.6	3.1	4.0
2007	19.2	9.0	6.6	3.7	4.8
2008	21.1	9.9	7.2	4.1	5.2
2009	23.3	10.9	8.0	4.5	5.8
2010	26.0	12.2	8.9	5.0	6.4
2011	26.9	12.5	9.2	5.2	6.6
2012	36.8	17.2	12.6	7.1	9.1
2013	44.3	20.7	15.1	8.5	11.0

5.2.2.3 Calculation of CH_4 emission factors for cattle, swine and sheep

CH_4 emissions from enteric fermentation were calculated using the following equation[28]:

[28] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, eq. 10.19, p. 10.28

$$CH_{4\,emissions} = \frac{EF_{(T)} \cdot N_{(T)}}{10^6}\ (kt\ CH_4\ yr^{-1})$$

where:
$EF_{(T)}$ – emission factor for each animal category, kg head^{-1} yr^{-1};
$N_{(T)}$ – the number of head of livestock species/category in the country;
T – species/category of livestock.

National emission factors for dairy and non-dairy cattle were calculated in accordance with *Tier 2* method using the following equation[29]:

$$EF = \frac{(GE \cdot (\frac{Y_m}{100}) \cdot 365)}{55.65}$$

where:
EF – emission factor, kg CH_4 head^{-1} yr^{-1};
*G*E – gross energy intake, MJ head^{-1} day^{-1};
Y_m – methane conversion factor, per cent of gross energy in feed converted to methane (for cattle were assumed to be 6.5%[30], for mature sheep and lambs to 1 year – 6.5 and 4.5%[31] respectively, for pigs – 0.6%). CH_4 conversion factor for calves up to ten[32], lambs up to five[33] and piglets up to five-seven[34] days was assumed to be zero as they are consuming only milk;
55.65 – energy content of methane, MJ/kg CH_4.

The main sources of activity data used in calculations of CH_4 EF for dairy cattle were: feeding situation, milk yield, fat content in milk. For estimation of EF for entire time period GE was calculated on the basis of amount of feed which consumed by cattle[35] and on the basis of feed accumulation standards[36]. Average milk yield per cow are presented in Table 5-14.

Table 5-14. Average milk yield and milk fat content during the period 1990-2013

Year	Milk yield (kg head^{-1} day^{-1})	Fat content (%)
1990	10.23	4.10
1991	9.54	4.10
1992	8.44	4.10
1993	7.97	4.10
1994	8.01	4.10
1995	8.25	4.10
1996	8.47	4.10
1997	8.78	4.10
1998	9.27	4.12
1999	8.84	4.13
2000	10.06	4.13
2001	10.69	4.08

[29] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, eq. 10.21, p.
[30] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Table 10.12, p. 10.30
[31] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Table 10.13, p. 10.31
[32] Gyvulininkystės žinynas. Baisogala (en. *Livestock manual*. *Institute of Animal Science of LVA*), 2007, p. 104
[33] Zapasnikienė, B. Mitybos normos avims ir ožkoms (en. *Nutrition rates for sheep and goats*). 2 lentelė, p. 11
[34] Gyvulininkystės žinynas. Baisogala (en. *Livestock manual*. *Institute of Animal Science of LVA*), 2007, p. 281
[35] Juška, R. *et al.* Studija „Lietuvos mėšlo tvarkymo sistemose susidarančių metano ir azoto suboksido kiekio tyrimai ir įvertinimas" (en. *Survey and evaluation of methane and nitrous oxide emission content in manure management systems of Lithuania. Study*), 2012
[36] Gyvulininkystės žinynas. Baisogala (en. *Livestock manual*. *Institute of Animal Science of LVA*), 2007, p. 616

2002	10.97	4.06
2003	11.00	4.11
2004	11.44	4.14
2005	11.81	4.11
2006	12.28	4.12
2007	12.90	4.16
2008	13.09	4.16
2009	13.18	4.17
2010	13.43	4.17
2011	13.77	4.17
2012	14.32	4.20
2013	14.56	4.21

To estimate the EF for dairy cattle and non-dairy cattle in the period 1990-2013 gross energy of feed was calculated using the following equation[37]:

$$GE = 0.0239 \cdot CP + 0.0398 \cdot C_{Fat} + 0.0201 \cdot C_{Fiber} + 0.0175 \cdot NFE$$

where:
GE – gross energy intake, MJ head^{-1} day^{-1};
CP – crude protein, g/kg in DM;
C_{Fat} – crude fat, g/kg in DM;
C_{Fibre} – crude fiber, g/kg in DM;
NFE – nitrogen-free extracts, g/kg in DM.

GE was estimated by multiplying GE per kg of every feed from amount of the necessary feed in dry matter, then summing and calculating the amount required per day:

$$GE = \frac{GE \cdot (F_{quantity} \cdot DM)}{365}$$

where:
GE – the amount of gross energy, MJ/kg feed;
$F_{quantity} \cdot$ DM – the amount of forage during the year, kg (expressed as dry matter).

The diet nutrition indicators for dairy cattle that were used to calculate gross energy are presented in Table 5-15.

Table 5-15. Average diet nutrition indicators for dairy cattle, kg/kg DM

Year	Crude protein	Crude fat	Crude fiber	Nitrogen-free extracts	Dry matter
1990	1.764	0.329	3.267	6.690	13.65
1991	1.695	0.318	3.210	6.547	13.33
1992	1.575	0.298	3.111	6.296	12.77
1993	1.532	0.291	3.075	6.207	12.57
1994	1.532	0.291	3.075	6.207	12.57
1995	1.557	0.296	3.097	6.260	12.69
1996	1.583	0.300	3.118	6.314	12.81
1997	1.618	0.305	3.146	6.386	12.97

[37] Kulpys H., Šeškevičienė J., Jeroch H. Žemės ūkio gyvulių ir paukščių mitybos fiziologinės reikmės (en. *Agriculture livestock and poultry nutrition physiological needs*). Kaunas, 2004, p. 30

1998	1.669	0.314	3.189	6.493	13.21
1999	1.626	0.307	3.154	6.404	13.01
2000	1.755	0.328	3.260	6.672	13.61
2001	1.815	0.337	3.310	6.797	13.89
2002	1.832	0.340	3.324	6.833	13.97
2003	1.850	0.343	3.338	6.869	14.05
2004	1.901	0.351	3.381	6.976	14.29
2005	1.935	0.357	3.409	7.048	14.45
2006	1.987	0.365	3.452	7.155	14.69
2007	2.055	0.378	3.488	7.365	14.95
2008	2.073	0.381	3.496	7.418	15.01
2009	2.090	0.384	3.505	7.470	15.07
2010	2.115	0.389	3.519	7.549	15.17
2011	2.150	0.396	3.537	7.654	15.30
2012	2.218	0.409	3.572	7.863	15.55
2013	2.244	0.414	3.586	7.942	15.64

Calculated average gross energy intake for dairy cattle is presented in Table 5-16.

Table 5-16. Average gross energy intake for dairy cattle, MJ/head/day

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Gross energy	238.0	232.3	222.2	218.6	218.6	220.8	222.9	225.8
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Gross energy	230.1	226.5	237.3	242.3	243.7	245.1	249.4	252.3
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Gross energy	256.6	263.2	264.8	266.4	268.9	272.1	278.7	281.1

The average daily feed intake for each subcategory of non-dairy cattle were calculated on the basis of amount of feed which are fed to cattle[38] and according to feed accumulation standards. These data is indicated in the national reference book of livestock production[39] according to national zootechnical activity data – weight and weight gain.

The diet nutrition indicators for non-dairy cattle used to calculate gross energy are given in Table 5-17.

Table 5-17. Average diet nutrition indicators for non-dairy cattle, kg/kg DM

Sub-category	**Crude protein**	**Crude fat**	**Crude fiber**	**Nitrogen free extracts**	**DM kg/day**
Suckling cows	1.473	0.319	3.472	5.928	12.44
Cattle to 1 year for slaughter	0.819	0.199	1.053	2.409	4.91
Bulls to 1 year for breed	0.748	0.197	0.129	2.788	5.59
Heifers to 1 year for breed	0.704	0.179	0.977	2.002	4.26
Bulls from 1 to 2 years	1.476	0.322	2.496	4.755	10.15

[38] Juška, R. *et al.* Studija „Lietuvos mėšlo tvarkymo sistemose susidarančių metano ir azoto suboksido kiekio tyrimai ir įvertinimas" (en. *Survey and evaluation of methane and nitrous oxide emission content in manure management systems of Lithuania. Study*), 2012

[39] Gyvulininkystės žinynas. Baisogala (en. *Livestock manual*. *Institute of Animal Science of LVA*), 2007, p. 616

Heifers from 1 to 2 years for slaughter	1.229	0.299	2.279	3.701	8.65
Heifers from 1 to 2 years for breed	1.020	0.237	2.272	3.302	7.66
Bulls at 2 years	1.238	0.238	2.333	5.217	9.64
Heifers at 2 years for slaughter	1.409	0.317	2.664	4.133	11.49
Heifers at 2 years for breed	1.430	0.295	2.224	4.602	9.43
Dairy cattle for slaughter	1.681	0.418	3.425	4.902	13.0

Average gross energy intake for non-dairy cattle subcategories are given in Table 5-18.

Table 5-18. Calculated average gross energy intake for non-dairy cattle subcategories, MJ/head/day

Cattle sub-categories		**Gross Energy**
Suckling cows		221.4
Cattle less than 1 year old	For slaughter	90.8
	Bulls for breeding	100.4
	Heifers for breeding	78.6
Cattle from 1 to 2 years old	Bulls	181.5
	Heifers for slaughter	151.8
	Heifers for breeding	137.3
Cattle 2 years old and older	Bulls	177.3
	Heifers for slaughter	171.2
	Heifers for breeding	171.2
Other cows		211.5

Pasture-cowshed time estimations are based on the data of the national zootechnical activity data[40][41]. Values of CH_4 EF estimated for enteric fermentation of dairy cattle using country specific data and *Tier 2* method are presented in Table 5-19.

Table 5-19. Calculated emission factors for dairy cattle, kg CH_4/head/year

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
EF	101.46	99.02	94.74	93.21	93.21	94.13	95.04	96.27
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
EF	98.10	96.57	101.15	103.29	103.90	104.51	106.35	107.57
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
EF	109.40	112.19	112.89	113.58	114.63	116.02	118.81	119.86

Calculated emission factors for dairy cattle vary across the time period due to the changes in milk yield and feed consumption. The linear correlation between EF and milk yield, which together with the energy of maintenance requirement, influences the GE intake are high (Figure 5-3).

[40] Gyvulininkystės žinynas (en. *Livestock manual*). Mokslas, Vilnius, 1976, p. 98-99

[41] Tarvydas V. *et al.* Šėrimo normos, pašarų struktūra ir sukaupimas galvijams (en. *Feeding rate, feed composition and accumulation for cattle*). Vilnius, 1995, p. 4

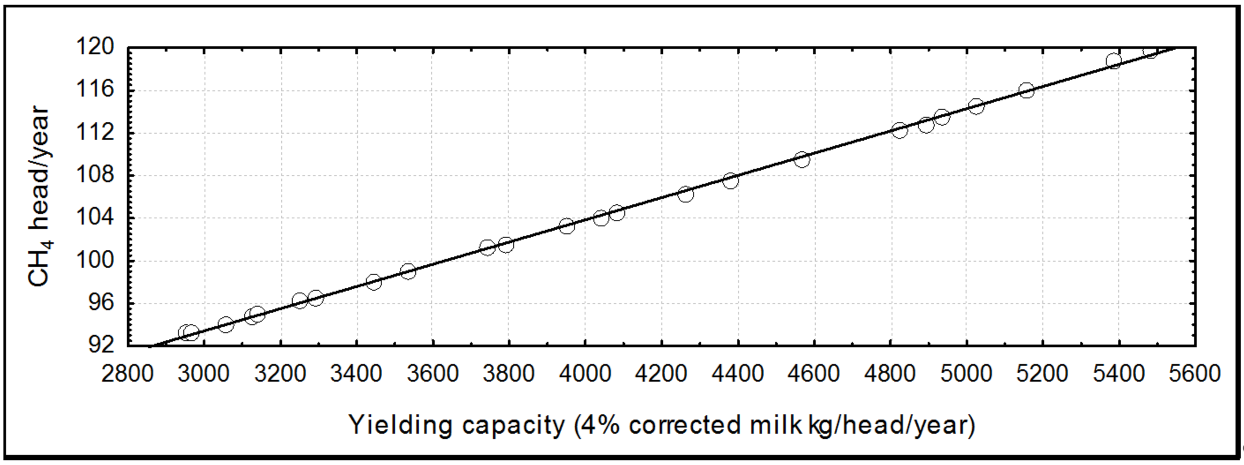


Figure 5-3. Correlation between yielding capacity (4% fat corrected milk, kg/head/year) and EF (CH_4/head/year) during the period 1990-2013

EF of CH_4 during the period 1990-1993 has decreased due to the reduced productivity of dairy cattle. During the period 1994-1998 EF has increased but in 1999 EF has decreased again as productivity of milk per head has decreased. EF for non-dairy sub-cattle categories are presented in Table 5-20.

Table 5-20. EF from enteric fermentation of non-dairy cattle sub-categories, kg CH_4/head/year

Cattle sub-categories		Emission factor
Suckling cows		94.39
Cattle less than 1 year old	For slaughter	37.65
	Bulls for breeding	41.63
	Heifers for breeding	32.59
Cattle from 1 to 2 years old	Bulls	77.38
	Heifers for slaughter	64.72
	Heifers for breeding	58.53
Cattle 2 years old and older	Bulls	75.57
	Heifers for slaughter	72.99
	Heifers for breeding	72.99
Other cows		90.17

Calculated emission factors for non-dairy cattle vary across the time period due to the distribution of animals in sub-categories (Table 5-21).

Table 5-21. Calculated emission factors for non-dairy cattle, kg CH_4/head/year

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
EF	53.60	53.60	53.60	53.60	53.60	53.60	53.60	53.60
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
EF	51.42	52.07	51.50	51.27	51.36	51.21	50.88	51.23
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
EF	52.02	52.51	52.49	52.77	53.37	51.97	52.55	53.78

While calculating emission factors for enteric fermentation of non-dairy cattle it was determined that weaning age of calves is up to ten days[42]. At this age they are nourished by milk only and CH_4 conversion factor was assumed to be zero.

[42] Gyvulininkystės žinynas. Baisogala (en. *Livestock manual. Institute of Animal Science of LVA*), 2007, p. 104

Determining CH_4 emission from swine, gross energy was also calculated on the basis of feed accumulation standards presented in the above mentioned national reference book for animal production.

Gross energy for swine was calculated using the same methodology as for cattle. Average diet nutrition indicators used to calculate gross energy for sub-categories of swine are presented in Table 5-22.

Table 5-22. Average diet nutrition indicators for swine used to calculate gross energy, kg/kg DM

Sub-category		**Crude protein**	**Crude fat**	**Crude fiber**	**Nitrogen-free extracts**	**DM kg/day**
Sows mated	Main	0.274	0.069	0.175	1.207	1.85
	Replacement	0.313	0.080	0.158	1.287	1.74
Sows nursing young	Main	0.919	0.342	0.330	2.944	5.02
	Replacement	1.056	0.397	0.384	3.431	5.83
Piglets to 28 days (<10 kg)		0.004	0.001	0.0005	0.001	0.02
Growing pigs		0.230	0.060	0.076	0.992	1.5
Boars	Mature	0.366	0.083	0.173	1.367	2.1
	Young for breed	0.385	0.093	0.543	1.359	2.13
Pigs for breed		0.320	0.080	0.144	1.215	1.83

Calculated average gross energy intakes and emission factors for relevant sub-category of swine are presented in Table 5-23.

Table 5-23. Calculated average gross energy intake and emission factors for swine sub-categories

Sub-category		**GE (MJ/head/day)**	**EF (kg CH_4/head/year)**
Sows mated	Main	33.27	1.31
	Replacement	36.35	1.43
Sows nursing young	Main	93.74	3.69
	Replacement	108.79	4.28
Boars	Mature	39.44	1.55
	Young for breed	39.96	1.57
Piglets (to 28 days)	Nursery (to 28 days)	0.32	0.01
Growing-finishing		26.81	1.06
Pigs for breed		34.99	1.38

Calculated average gross energy and emission factors for swine during the period 1990-2013 are presented in Table 5-24.

Table 5-24. Average gross energy intake and emission factors of swine

Year	**GE (MJ/head/day)**	**EF (kg CH_4/head year)**
1990	26.4	1.04
1991	26.4	1.04
1992	26.4	1.04
1993	26.3	1.04
1994	26.3	1.04
1995	26.3	1.04
1996	26.3	1.03
1997	26.5	1.04

1998	26.0	1.02
1999	26.4	1.04
2000	26.1	1.03
2001	26.2	1.03
2002	26.2	1.03
2003	26.2	1.03
2004	26.1	1.03
2005	25.9	1.02
2006	25.6	1.01
2007	25.7	1.01
2008	26.0	1.02
2009	25.2	0.99
2010	26.0	1.02
2011	26.3	1.03
2012	26.1	1.03
2013	26.2	1.03

Calculating emission factors used for calculation of CH_4 emission from enteric fermentation of swine it was determined that weaning age of piglets is up to five-seven days[43]. At this age they are nourished by milk only and CH_4 conversion factor was assumed to be zero. Calculated emission factors for swine vary across the time period due to distribution of animals in sub-categories.

The diet nutrition indicators for sheep are given in Table 5-25. Determining CH_4 emission from sheep, gross energy was calculated using the same methodology as for cattle. Calculated average gross energy intake and emission factors for sheep are presented in Tables 5-26.

Table 5-25. Average diet nutrition indicators for sheep used to calculate gross energy, kg/kg DM

Sub-category	**Crude protein**	**Crude fat**	**Crude fiber**	**Nitrogen-free extracts**	**DM kg/day**
Mature Breeding ewes	0.244	0.055	0.504	0.864	1.82
Ewe over 1 years	0.198	0.047	0.468	0.753	1.60
Ewe lambs to 1years	0.141	0.029	0.259	0.491	0.99
Baa-lambs to 1years	0.138	0.034	0.190	0.486	0.90
Rams	0.273	0.061	0.549	0.942	2.01

Table 5-26. Average gross energy intake and emission factors of sheep

Sub-category	**GE (MJ/head/day)**	**EF (kg CH_4/head/year)**
Mature ewes	33.27	14.19
Ewe over 1 years	29.18	12.44
Ewe lambs to 1years	18.23	5.31
Baa-lambs to 1years	16.78	4.06
Rams over 1 years	36.44	15.54

[43] Gyvulininkystės žinynas. Baisogala (en. *Livestock manual. Institute of Animal Science of LVA*), 2007, p. 281

Calculating emission factors of CH_4 from enteric fermentation of sheep it was determined that weaning age of lambs is up to five days[44]. At this age they are nourished by milk only and CH_4 conversion factor was assumed to be zero.

5.2.2.4 Calculation of CH_4 emission factors for other animals

Comparing with cattle contribution of other livestock to the whole CH_4 emission from enteric fermentation is very small, therefore CH_4 emission from enteric fermentation of goats and horses are estimated using *Tier 1* method. As no default IPCC or national emission factors for fur-bearing animals, rabbits and nutria are available, the Norwegian emission factor for fur-bearing animals and Russian emission factors for rabbits and nutria were used in calculations (Table 5-27).

Table 5-27. Default emission factors for other animal categories used for CH_4 calculations from enteric fermentation

Animal category	EF (kg CH_4/head/year)	Reference
Goats	5	*2006 IPCC*. Table 10.10, p. 10.28
Horses	18	*2006 IPCC*. Table 10.10, p. 10.28
Rabbits	0.59	Russian NIR 2014. Table 6.6, p. 199
Nutria	0.35	Russian NIR 2014. Table 6.6, p. 199
Fur-bearing animals (foxes, polar foxes, minks)	0.1	Norway NIR 2014. Table 6.7, p. 259

5.2.3 Uncertainties and time-series consistency

Uncertainties of CH_4 emissions from enteric fermentation are estimated based on the uncertainty of livestock population and emission factors uncertainty.

Activity data uncertainty

Activity data on livestock population for the whole time period was collected from Statistics Lithuania. Data provided by Statistics Lithuania is collected by applying continuous accountability for agriculture companies and applying sampling methods for farmers and households. The subject of research is about 10 thousand farms what constitutes about 4% of registered farms in the statistical database. The simple random stratified sampling has been chosen from the elements of population list for the research. If the livestock population is smaller than 1000 thousand heads, or if the population of cattle is smaller than 500 thousand heads, 5% accuracy requirements are applied according to the regulation of the European Community No 1165/2008 on the data accuracy requirements.

Complete data on swine and non-dairy cattle herd structure is available only since 1997-1998 from the statistical sources, therefore for the calculations of gross energy intake of swine and non-dairy cattle categories the constant values of 1997-1998 herd structure data were used in order to estimate and fill the gap of 1990-1996 period.

Overall uncertainty for activity data for enteric fermentation is assumed to be ±5%.

Emission factor uncertainty

[44] Zapasnikienė, B. Mitybos normos avims ir ožkoms (en. *Nutrition rates for sheep and goats*). 2 lentelė, p. 11

Emission factors which are not based on country-specific data may be highly uncertain. Emission factors estimated using simple *Tier 1* method may be uncertain to ±30-50%[45]. Emission factors estimated using the *Tier 2* method is likely to be in the order of ±20%[46].

Overall uncertainty

Combined uncertainty was calculated using *2006 IPCC* eq. 3.1[47]. This approach requires uncertainty values of the main activity data used and uncertainty of emission factor. Combined uncertainty was estimated to be ±20.6%.

5.2.4 Category-specific QA/QC and verification

Quality control procedures were conducted by performing checks in activity data for the whole time period, consistency check of data entered in CRF with calculation sheets, trends of emissions for each category, relevance of methodology applied.

5.2.5 Category-specific planned improvements

The collection of more accurate data on cattle weight gain and more accurate parameters for calculation of GE intake for sheep are planned for the next submission.

5.3 Manure management – CH_4 emissions (CRF 3.B.1)

5.3.1 Category description

CH_4 is produced from the decomposition of organic matter remaining in the manure under anaerobic decomposition. The amount of CH_4 produced from manure depends on: manure characteristics linked to animal type and diets, the amount of feed consumed the digestibility of the feed, the type of waste management system and the climate conditions during the storage.

Calculations of GHG emission from manure management were performed using the same livestock population data as described in section Enteric fermentation (see Chapter 5.2).The information on manure management systems were collected during the investigation[48].

Total CH_4 emissions from manure management of domestic livestock contributed 6.1% to the total agricultural emissions or 15.1% of the total CH_4 emissions in 2013. In 2013, comparing with 2012, CH_4 emissions from manure management decreased by 2.3%. In 2013 the highest CH_4 emission from manure management systems among different categories of domestic animals was determined in swine breeding category (Table 5-28). The use of anaerobic digester for biogas-treatment in 2004-2011 slightly reduced CH_4 emissions. However in 2011 a single operating biogas plant stopped working.

Table 5-28. CH_4 emission from manure management by animal category, kt

Year	Dairy cattle	Non-dairy cattle	Sheep	Goats	Horses	Swine	Poultry	Fur-bearing animals, rabbits and nutria
1990	5.12	5.08	0.026	0.001	0.12	14.20	2.73	0.125

[45] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, p. 10.28
[46] *2000 IPCC Agriculture, p. 4.28*
[47] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 3, eq. 3.1, p. 3.28
[48] Juška, R. *et al.* Studija „Lietuvos mėšlo tvarkymo sistemose susidarančių metano ir azoto suboksido kiekio tyrimai ir įvertinimas" (en. *Survey and evaluation of methane and nitrous oxide emission content in manure management systems of Lithuania. Study*), 2012

1991	5.00	4.77	0.027	0.001	0.13	12.76	2.66	0.124
1992	4.29	3.42	0.024	0.001	0.12	7.99	2.38	0.115
1993	3.93	2.55	0.021	0.001	0.13	7.05	2.31	0.082
1994	3.60	1.97	0.018	0.002	0.12	7.46	2.24	0.078
1995	3.51	1.79	0.015	0.002	0.12	7.54	2.15	0.074
1996	3.61	1.76	0.013	0.002	0.13	6.72	2.06	0.076
1997	3.65	1.67	0.011	0.002	0.12	7.24	1.98	0.074
1998	3.47	1.39	0.007	0.003	0.12	6.88	1.88	0.042
1999	3.18	1.50	0.006	0.003	0.12	5.67	1.80	0.037
2000	2.98	1.15	0.005	0.003	0.11	5.23	1.70	0.039
2001	3.10	1.17	0.006	0.003	0.10	6.14	1.65	0.042
2002	3.17	1.28	0.006	0.003	0.09	6.46	1.57	0.048
2003	3.25	1.41	0.008	0.004	0.10	6.45	1.53	0.072
2004	3.24	1.40	0.010	0.003	0.10	6.32	1.46	0.098
2005	3.18	1.57	0.013	0.003	0.10	6.55	1.40	0.126
2006	3.13	1.91	0.017	0.003	0.10	6.56	1.32	0.128
2007	3.29	1.69	0.020	0.003	0.09	5.38	1.25	0.119
2008	3.26	1.73	0.022	0.002	0.08	5.32	1.16	0.128
2009	3.14	1.81	0.024	0.002	0.08	5.35	1.08	0.091
2010	3.08	1.90	0.027	0.002	0.07	5.55	1.01	0.129
2011	3.06	1.94	0.028	0.002	0.06	4.90	0.92	0.139
2012	2.99	2.00	0.038	0.002	0.05	5.09	0.84	0.216
2013	2.91	2.19	0.046	0.002	0.03	4.78	0.76	0.241

Comparing to 1990 CH_4 emissions from manure management decreased by 60% in 2013 (Figure 5-4). In 2005-2013 CH_4 emission from manure management decreased by 15.2%.

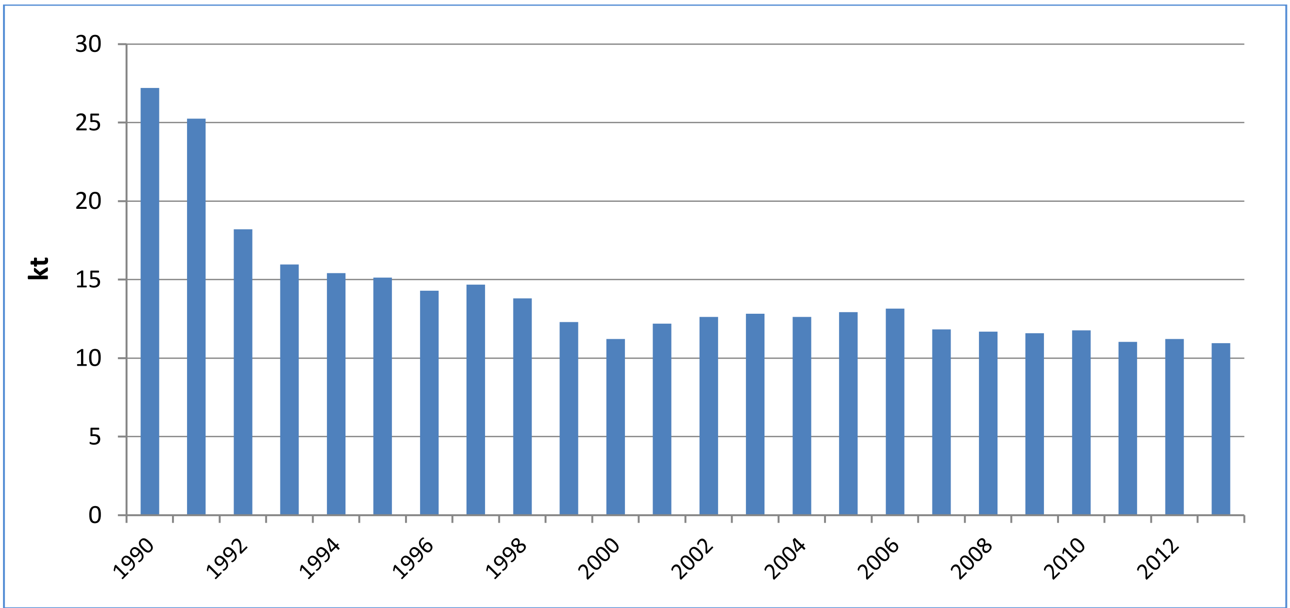


Figure 5-4. CH_4 emission from manure management during the period 1990-2013, kt

The overall reduction of CH_4 emissions from manure is caused by a decrease in total number of livestock population (excluding sheep, goats, rabbits and minks), but in the case of dairy and non-dairy cattle the attrition of animals is partly counterbalanced by increase in emissions per animal.

Emission increase was caused by increase of volatile solid excretion and related to gross energy intake.

5.3.2 Methodological issues

5.3.2.1 Choice of methods

CH_4 emissions from manure management systems of cattle, swine and sheep were calculated using *Tier 2* method. Emissions from cattle and swine sub-categories represent a significant share of emissions.

Tier 2 method for estimation of CH_4 emission from manure management systems requires detailed information on animal characteristics and the manner in which manure is treated. Emission from goats, horses, rabbits, nutrias, fur-bearing animals and poultry have a minor impact to the total CH_4 emission from manure management, therefore *Tier 1* method has been applied to estimate CH_4 emissions from these livestock categories. The summary of methods that were used for calculation of CH_4 emission from manure management is presented in Table 5-29.

Table 5-29. Methods and emission factors used to estimate CH_4 emission from manure management

Animal category	Method applied	Emission factor
Dairy cattle	Tier 2	CS
Non-dairy cattle	Tier 2	CS
Sheep	Tier 2	CS
Goats	Tier 1	IPCC 2006
Horses	Tier 1	IPCC 2006
Swine	Tier 2	CS
Poultry	Tier 1	IPCC 2006
Rabbits	Tier 1	IPCC 2006
Nutria	Tier 1	IPCC 2006
Minks	Tier 1	IPCC 2006
Foxes	Tier 1	IPCC 2006
Polar foxes	Tier 1	IPCC 2006

5.3.2.2 Characterization of manure management systems

Assumption on manure fraction that remains on pasture was based on dairy and non-dairy cattle grazing time period. Bulls, partly calves and cows for slaughter, normally are kept in stalls throughout the year. Calves, heifers for breeding and milk production and beef cattle are grazed in pastures for approximately 145 days per year, the same as dairy cattle[49][50].

In 2013 during the stable period 39% of cow manure was treated in the solid manure management systems and 21% in the liquid manure management systems. About 40% of cow manure was deposited on pastures.

Manure from other cattle categories distributed as follows: 40.5% in solid manure management systems, 20.9% in liquid manure management systems and 7.3% in deep bedding manure management systems. About 31.3% of manure was deposited on pastures.

[49] Gyvulininkystės žinynas (en. *Livestock manual*). Mokslas, Vilnius, 1976, p. 98-99

[50] Tarvydas V. et al. Šėrimo normos, pašarų struktūra ir sukaupimas galvijams (en. *Feeding rate, feed composition and accumulation for cattle*). Vilnius, 1995, p. 4

The most common manure management system for swine manure treatment is liquid manure management system, which accounts for 87% of the total manure management systems. Around 11% of manure is managed as solid manure including 2% manure managed as deep bedding.

When the number of small farms who used solid manure management systems relatively decreased, the number of animals kept in the bigger herds, where the liquid manure management systems are used, relatively increased. Therefore it is assumed that share of liquid manure management system increased in 2013, thus, based on this assumption, the data on manure management systems for cattle and swine categories have been extrapolated.

Since 1990 almost all fur-bearing animals, rabbits and nutrias breeders used solid manure management systems. Liquid manure management systems have been started to be used only during the past few years in four fur-bearing animals' farms.

Methane conversion factors (MCF) for cattle, swine, sheep and goats manure management systems were taken as default values from *IPCC 2006* (Table 5-30). For anaerobic digester *IPCC 2006* gives MCF value range from 0 to 100%. In calculation Lithuania uses 0% MCF value as the single company that was treating manure (during the period 2004-2011) in anaerobic digesters states that there is no leakage or release of CH_4 from the system and all CH_4 is combusted for energy production.

Table 5-30. MCF values for manure management systems[51] ,%

Manure management systems					
Pasture/Range/ Paddock	Solid storage	Liquid/Slurry		Anaerobic digester	Cattle and Swine deep bedding > 1 month
		With natural crust cover	Without natural crust cover		
1	2	10	17	0	17

Data on manure management systems used in calculations for dairy cattle, non-dairy cattle and swine are provided in Figures 5-5, 5-6 and 5-7 respectively.

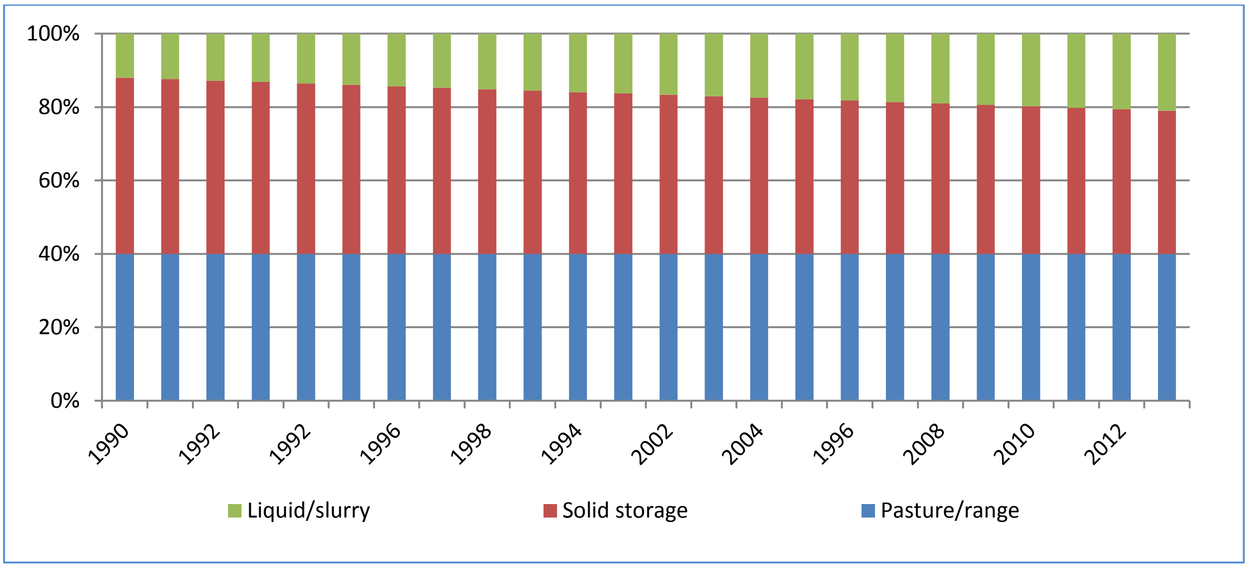


Figure 5-5. Data on manure management systems for dairy cattle, %

[51] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Table 10.17, p. 10.44-10.47

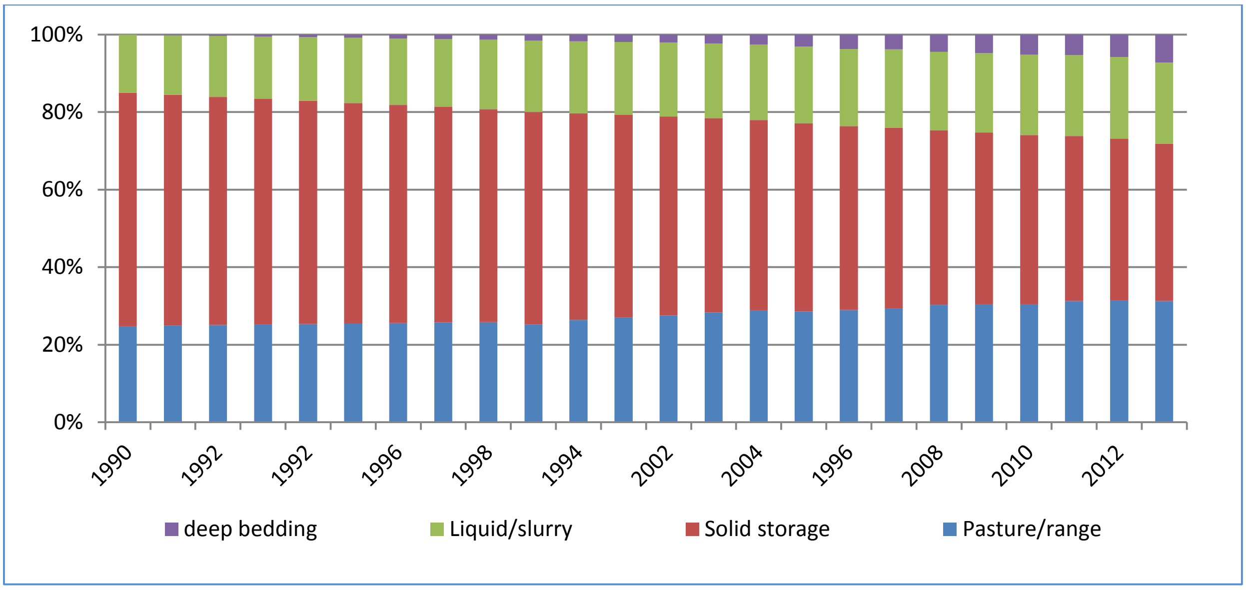


Figure 5-6. Data on manure management systems for non-dairy cattle, %

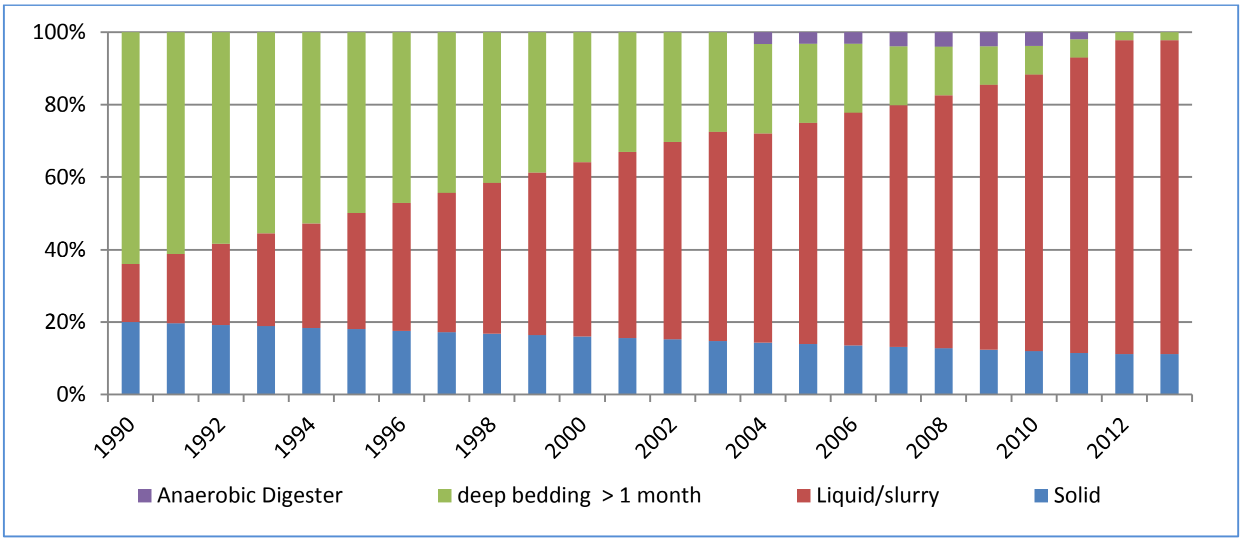


Figure 5-7. Data on manure management systems for swine, %

5.3.2.3 Calculation of CH_4 emissions

CH_4 emissions from manure management were calculated using the following equation[52]:

$$CH_{4\,manure} = \sum_{(T)} \frac{\left(EF_{(T)} \cdot N_{(T)}\right)}{10^6}$$

Where:

$CH_{4\,manure}$ – CH_4 emissions from manure management, for a defined population, kt CH_4 yr^{-1};
$EF_{(T)}$ – emission factor for the defined livestock population, kg CH_4 $head^{-1}$ yr^{-1};
$N_{(T)}$ – the number of head of livestock species/category T in the country;
T – species/category of livestock.

CH_4 emission factors for cattle, swine and sheep were determined using the fallowing equation[53]:

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[52] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Eq. 10.22, p. 10.37
[53] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Eq. 10.23, p. 10.41

$$EF_{(T)} = \left(VS_{(T)} \cdot 365\right) \cdot \left[B_{0(T)} \cdot 0.67kg/m^3 \cdot \sum_{S,k} \frac{MCF_{S,k}}{100} \cdot MCF_{(T,S,k)}\right]$$

where:
$EF_{(T)}$ – annual CH_4 emission factor for livestock category *T*, kg CH_4 animal^{-1} yr^{-1};
$VS_{(T)}$ – daily volatile solid excreted for livestock category *T*, kg dry matter animal^{-1} day^{-1};
365 – basis for calculating annual VS production, days yr^{-1};
$B_{0(T)}$ – maximum methane producing capacity for manure produced by livestock category *T*, m^3 CH_4 kg^{-1}of VS excreted;
0.67 – conversion factor of m^3 CH_4 to kg CH_4;
$MCF_{(S, k)}$ – methane conversion factors for each manure management system *S* by climate region *k*, %;
$MS_{(T, S, k)}$ – fraction of livestock category *T's* manure handled using manure management system *S* in climate region *k*.

The VS excretion rate, calculated for dairy and non-dairy cattle, sheep and swine were estimated from feed intake levels[54]:

$$VS = \left[GE \cdot \left(1 - \frac{DE\%}{100}\right) + (UE \cdot GE)\right] \cdot \left[\left(\frac{1 - ASH}{18.45}\right)\right]$$

where:
VS – volatile solid excretion per day on a dry-organic matter basis, kg VS day^{-1};
GE – gross energy intake, MJ day^{-1};
DE% – digestibility of the feed in percent;
(UE • GE) – urinary energy expressed as fraction of GE;
ASH – the ash content of manure calculated as a fraction of the dry matter feed intake;
18.45 – conversion factor for dietary GE per kg of dry matter, MJ kg^{-1}.

Gross energy consumption values for dairy cattle, non-dairy cattle, swine and sheep were calculated using same methodology as described in Chapter 5.2. Volatile solid excretion rate for cattle was calculated using digestible energy of the feed (65% for cattle, 75% for swine and 60% for sheep), ash content of manure (8% for cattle, 2% for swine and 8% for sheep)[55].

Calculated daily VS excretions for dairy cows, other cattle, swine and sheep are shown in Table 5-31.

Table 5-31. Daily VS excretions for dairy, non-dairy cattle, swine and sheep, kg-dm/day

Year	**Cattle**		**Swine**	**Sheep**
	Dairy	**Non-dairy**		
1990	4.63	2.47	0.38	0.62
1991	4.52	2.47	0.38	0.62
1992	4.32	2.47	0.38	0.62
1993	4.25	2.47	0.38	0.62
1994	4.25	2.47	0.38	0.62
1995	4.29	2.47	0.38	0.62
1996	4.34	2.47	0.38	0.62
1997	4.39	2.47	0.38	0.62

[54] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Eq. 10.24, p. 10.42
[55] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Table 10A-9, p. 10.82; p. 10.42

1998	4.47	2.37	0.37	0.62
1999	4.41	2.40	0.38	0.62
2000	4.61	2.37	0.37	0.62
2001	4.71	2.36	0.38	0.62
2002	4.74	2.37	0.38	0.62
2003	4.77	2.36	0.38	0.62
2004	4.85	2.34	0.37	0.62
2005	4.91	2.36	0.37	0.62
2006	4.99	2.40	0.37	0.62
2007	5.12	2.42	0.37	0.62
2008	5.15	2.42	0.37	0.62
2009	5.18	2.43	0.36	0.62
2010	5.23	2.46	0.37	0.62
2011	5.29	2.39	0.38	0.62
2012	5.42	2.42	0.37	0.62
2013	5.47	2.47	0.38	0.62

Calculated VS value for sheep shown in Table 5-33 is higher than the default values presented in *IPCC 2006*.

CH_4 producing capacities B_0 (0.18 m^3 CH_4/kg VS for non-dairy cattle, 0.45 m^3 CH_4/kg VS for swine, 0.19 m^3 CH_4/kg VS for sheep) also were taken from *IPCC 2006*[56]. Country-specific value of CH_4 producing capacities B_0 = 0.21 CH_4/kg for dairy cattle were used[57].

The emission factor for dairy cattle has increased as a result of the increasing milk yield and the changes in housing types of animals when solid manure management was replaced by slurry-based system (Table 5-32). Methane conversion factor for slurry manure is higher than solid manure MCF.

Table 5-32. Calculated EF for dairy cattle, kg CH_4/head/year

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
EF	6.08	6.01	5.82	5.79	5.86	5.99	6.12	6.27
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
EF	6.46	6.43	6.81	7.03	7.14	7.26	7.47	7.63
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
EF	7.84	8.12	8.26	8.39	8.55	8.74	9.04	9.21

Tables 5-33 and 5-34 present EF for non-dairy cattle and swine. Calculated EF for sheep during the time period 1990-2013 was constant – 0.46 (kg CH_4/head/year) due to proportional distribution of animals in sub-categories.

[56] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Tables 10A-5, 10A-7, 10A-9.P, p. 10.78-10.82
[57] Matulaitis, R. *The effectiveness of implements on mitigation of greenhouse gas emission and pollution reduction from manure*. Summary of Doctoral Dissertation. Kaunas, 2014

Table 5-33.Calculated EF used for calculation of CH_4 emission from manure management of non-dairy cattle sub-categories during the period 1990-2013, kg CH_4/head/year

Year	Cattle sub-categories										
	Suckling cows	Cattle less than 1 year old			Cattle from 1 to 2 years old			Cattle 2 years old and older			Other cows
		For slaughter	Bulls for breeding	Heifers for breeding	Bulls	Heifers for slaughter	Heifers for breeding	Bulls	Heifers for slaughter	Heifers for breeding	
1990	-	2.39	3.09	1.72	5.59	4.00	3.01	5.46	4.51	3.75	6.51
1991	-	2.44	3.15	1.75	5.69	4.08	3.06	5.55	4.58	3.82	6.61
1992	-	2.49	3.20	1.78	5.78	4.16	3.11	5.65	4.65	3.89	6.71
1993	-	2.53	3.25	1.81	5.88	4.24	3.16	5.74	4.72	3.97	6.81
1994	-	2.58	3.30	1.84	5.97	4.32	3.21	5.83	4.79	4.04	6.90
1995	-	2.63	3.35	1.86	6.06	4.39	3.26	5.92	4.86	4.11	7.00
1996	-	2.68	3.40	1.89	6.16	4.47	3.31	6.02	4.93	4.18	7.10
1997	-	2.72	3.45	1.92	6.25	4.55	3.36	6.11	5.00	4.25	7.20
1998	-	2.77	3.50	1.95	6.35	4.63	3.41	6.20	5.07	4.32	7.30
1999	-	2.82	3.56	1.98	6.44	4.71	3.46	6.29	5.14	4.39	7.40
2000	23.44	2.86	3.61	2.01	6.53	4.79	3.51	6.39	5.21	4.47	7.50
2001	23.44	2.91	3.66	2.04	6.63	4.86	3.56	6.48	5.27	4.54	7.60
2002	23.44	2.96	3.71	2.06	6.72	4.94	3.61	6.57	5.34	4.61	7.70
2003	23.44	3.00	3.76	2.09	6.82	5.02	3.66	6.66	5.41	4.68	7.80
2004	23.44	3.05	3.81	2.12	6.91	5.10	3.71	6.76	5.48	4.75	7.90
2005	23.44	3.10	3.86	2.15	7.00	5.18	3.76	6.85	5.55	4.82	8.00
2006	23.44	3.14	3.91	2.18	7.10	5.26	3.81	6.94	5.62	4.89	8.10
2007	23.44	3.19	3.97	2.21	7.19	5.33	3.85	7.03	5.69	4.97	8.20
2008	23.44	3.24	4.02	2.24	7.29	5.41	3.90	7.13	5.76	5.04	8.30
2009	23.44	3.28	4.07	2.26	7.38	5.49	3.95	7.22	5.83	5.11	8.40
2010	23.44	3.33	4.12	2.29	7.47	5.57	4.00	7.31	5.90	5.18	8.50
2011	23.44	3.38	4.17	2.32	7.57	5.65	4.05	7.40	5.97	5.25	8.60
2012	23.44	3.43	4.22	2.35	7.66	5.73	4.10	7.50	6.04	5.32	8.70
2013	23.44	3.47	4.27	2.38	7.76	5.80	4.15	7.59	6.11	5.39	8.80

Table 5-34. Calculated EF used for calculation of CH_4 emission from manure management of swine category during the period 1990-2013,kg CH_4/head/year

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
EF	5.83	5.85	5.87	5.90	5.92	5.94	5.96	6.04
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
EF	5.94	6.05	6.03	6.07	6.09	6.10	5.89	5.88
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
EF	5.82	5.82	5.92	5.76	5.97	6.20	6.31	6.34

EF for non-dairy cattle and swine have increased as a result of increasing number of housing variety for livestock when solid manure management systems are being replaced by slurry manure management systems.

For calculating CH_4 emissions from horses, goats, poultry, rabbits, nutria and fur-bearing animals default *IPCC 2006* EF were used (Table 5-35).

Table 5-35. EF used for calculation of CH_4 emission from manure management, kg CH_4/head/year[58][59]

Animal category	Emission Factor
Goats	0.13
Horses	1.56
Layers (dry)	0.03
Layers (wet)	1.2
Broilers	0.02
Turkeys	0.09
Ducks	0.02
Geese	0.078
Other poultry	0.078
Rabbits	0.08
Nutria	0.68
Fur-bearing animals	0.68

5.3.3 Uncertainties and time-series consistency

CH_4 emission from manure management was calculated based on activity data and emission factors. Overall uncertainties result from uncertainty of livestock population (Chapter 5.2.3), uncertainty of emission factors and uncertainty values of other relevant parameters. However, the data on excretion and distribution of manure among the management systems are less reliable.

Activity data uncertainty

As elaborated in Chapter 5.2.3 uncertainty value for livestock population is ±5%. The uncertainty of the manure management system usage data can be ±10% or less[60]. Uncertainties in estimates of methane producing capacity (B_0) for cattle and swine are ±15%[61]. In study on evaluation of country specific B_0 in Lithuania uncertainty of B_0 for dairy cattle for solid manure was estimated

[58] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Table 10.15, p. 10.40
[59] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Table 10.16, p. 10.41
[60] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, p. 10.48
[61] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Table 10A-4, p. 10.77

±19%, for liquid manure – ±30%[62]. Basing on expert judgement it was estimated that uncertainty value of B_0 is ±18%.

Emission factor uncertainty

2006 IPCC indicates that for the *Tier 1* method there is a larger uncertainty range for the default factors. For *Tier 1* method uncertainty for CH_4 EF is estimated to be ±30%. Improvements achieved by *Tier 2* methodologies are estimated to reduce uncertainty ranges in emission factors to ±20%.

Overall uncertainty

Combined uncertainty was calculated using *2006 IPCC* eq. 3.1[63]. This approach requires uncertainty values of the main activity data used and uncertainty of emission factor. Combined uncertainty was estimated to be ±27.4%.

5.3.4 Category-specific QA/QC and verification

Same general QC procedures as applied for category Enteric fermentation were applied for category Manure management – check of activity data for the whole time period, consistency check of data entered in CRF with calculation sheets, trends of emissions for each category, relevance of methodology applied, etc.

5.3.5 Category-specific planned improvements

Lithuania will continue improving collection of activity data on manure management systems usage.

5.4 Manure management – N_2O emissions (CRF 3.B.2)

5.4.1 Direct N_2O emission

5.4.1.1 Category description

During manure storage and handling manure emits nitrous oxide (N_2O) through nitrification or denitrification. The amount of emitted N_2O depends on: nitrogen and carbon content in manure, type of manure storage system, duration of time manure is stored, climatic condition during the storage. N_2O is the most potent agricultural GHG with warming potential 298 times greater than that of CO_2.

The emission of N_2O is calculated based on the amount of nitrogen excretion per animal and manure management system. Emission estimates from manure deposited during grazing period are calculated and described in the section "Urine and dung deposited by grazing animals" (Chapter 5.6.1.2).

Direct N_2O emissions from manure management constituted 85.3 kt CO_2 eqv. or 1% of the total Agriculture sector emissions in 2013. In 2013 comparing with 1990 direct N_2O emissions from manure management decreased by 72.8% (Figure 5-8). From 2005 to 2013 direct N_2O emissions decreased 18.3%. Calculated N_2O emissions from different manure management systems are presented in Table 5-36.

[62] Matulaitis, R. *The effectiveness of implements on mitigation of greenhouse gas emission and pollution reduction from manure*. Summary of Doctoral Dissertation. Kaunas, 2014

[63] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 3, eq. 3.1, p. 3.28

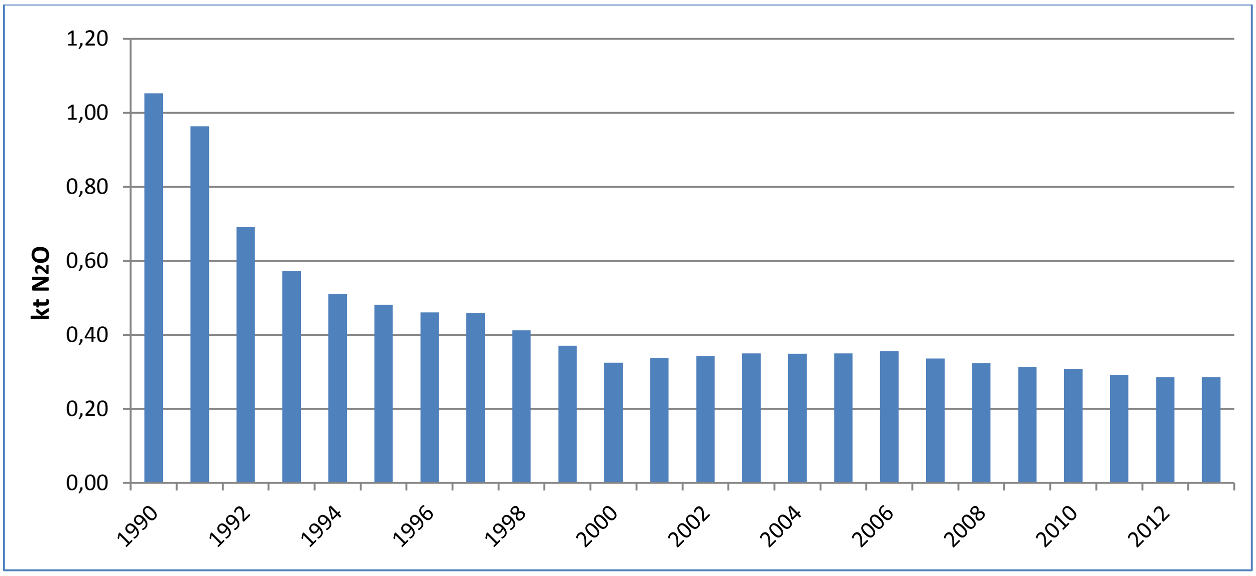

Figure 5-8. Direct N_2O emission from manure management during the period 1990-2013, kt

Table 5-36. Calculated N_2O emissions for different manure management systems, kt

Year	Manure management system		
	Liquid system	Solid storage and dry lot	Other systems
1990	0.14	0.61	0.30
1991	0.13	0.57	0.26
1992	0.10	0.43	0.16
1993	0.09	0.35	0.13
1994	0.08	0.30	0.13
1995	0.07	0.28	0.13
1996	0.08	0.28	0.11
1997	0.08	0.27	0.11
1998	0.07	0.25	0.10
1999	0.07	0.23	0.08
2000	0.06	0.20	0.06
2001	0.07	0.20	0.07
2002	0.07	0.21	0.07
2003	0.07	0.21	0.06
2004	0.07	0.21	0.06
2005	0.07	0.21	0.06
2006	0.08	0.22	0.06
2007	0.08	0.21	0.04
2008	0.08	0.20	0.04
2009	0.08	0.19	0.04
2010	0.08	0.19	0.03
2011	0.08	0.18	0.03
2012	0.08	0.18	0.02
2013	0.08	0.18	0.03

5.4.1.2 Methodological issues

To estimate N_2O emissions from manure management of cattle and sheep *Tier 2* method was used. For calculation of N_2O emission from other livestock categories (swine, goats, horses, poultry, rabbits, nutria and fur-bearing animals) *Tier 1* method was used.

Activity data

The data on population of livestock were obtained from the database of Statistics Lithuania (1990-2013). More detailed information on livestock population and distribution of livestock sub-categories is provided in Chapter 5.2.1.

Fractions of the total annual excretion of livestock managed in specific manure management systems are presented in Figure 5-5, Figure 5-6, Figure 5-7 in section above as well as in Table 5-37 and Figure 5-9.

Table 5-37. Percentage of manure production per animal waste management systems, %

Year	Solid storage and dry lot	Liquid system	Pasture, range and paddock	Other systems
Sheep				
1990-2013	54.8	-	45.2	-
Goats				
1990-2013	54.8	-	45.2	-
Horses				
1990-2013	8	-	92	-
Rabbits				
1990-2013	100	-	-	-
Fur-bearing animals				
1990-2006	100	-	-	-
2007	92.7	7.3	-	-
2008	85.3	14.7	-	-
2009-2013	78	22	-	-
Nutria				
1990-2013	100	-	-	-

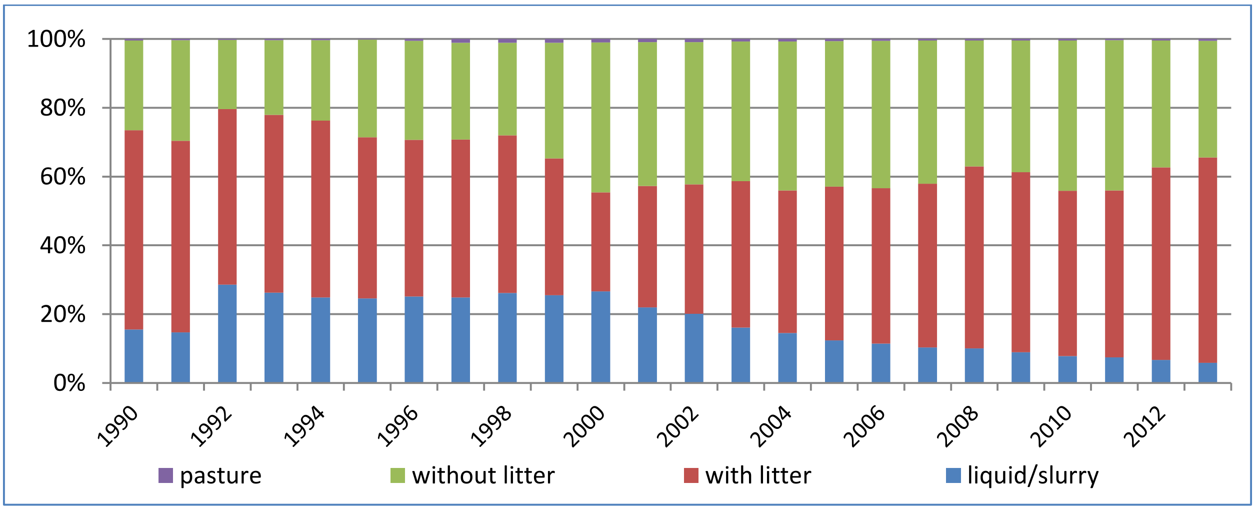

Figure 5-9. Poultry manure production per animal waste management systems, %

Calculation of N_2O emissions

N_2O emissions from manure management are calculated by multiplying the total amount of N excretion (from all animal categories) in each type of manure management system by an emission factor for that type of manure management system. Emissions are then summed over all manure management system[64]:

$$N_2O_{D(mm)} = \left[\sum_S \left[\sum_T \left(N_T \cdot Nex_{(T)} \cdot M_{(T,S)}\right)\right] \cdot EF_{3(S)}\right] \cdot \frac{44}{28}$$

where:
$N_2O_{D(mm)}$ – direct N_2O emissions from manure management, kg N_2O yr^{-1};
$N_{(T)}$ – number of head of livestock species/category *T* in the country;
$Nex_{(T)}$ – annual average N excretion per head of species/category *T* in the country, kg N $animal^{-1}$ yr^{-1};
$MS_{(T,S)}$ – fraction of total annual nitrogen excretion for each livestock species/category *T* that is managed in manure management system *S* in the country, dimensionless;
$EF_{3(S)}$ – emission factor for direct N_2O emissions from manure management system *S* in the country, kg N_2O-N/kg N in manure management system *S*;
S – manure management system;
T – species/category of livestock;
44/28 – conversion of $(N_2O\text{-}N)_{(mm)}$ emissions to $N_2O_{(mm)}$ emissions.

The annual amount of N excreted for dairy and non-dairy cattle as well as sheep categories were calculated using the following equation:

$$N_{excretion} = N_{intake} - N_{retention}$$

where:
Nex – annual N excretion rates, kg N $animal^{-1}$ yr^{-1};
N_{intake} – the annual N intake per head of animal, kg N $animal^{-1}$ yr^{-1};
$N_{retention}$ – fraction of annual N intake that is retained by animal, kg N $animal^{-1}$ yr^{-1}.

Annual nitrogen intake for cattle, sheep and swine categories was calculated according to equation:

$$N_{intake} = \frac{CP}{6.25} \cdot 365$$

where:
N_{intake} – the annual N intake per head of animal, kg N $animal^{-1}$ yr^{-1};
CP – amount of crude protein in diet of animal, kg/day $animal^{-1}$ day^{-1};
6.25 – conversion from kg of dietary protein to kg of dietary N, kg feed protein $(kg\ N)^{-1}$.

The nitrogen retained in dairy and non-dairy cattle was estimated using the following equation[65]:

$$N_{retention_{(T)}} = \left[\frac{Milk \cdot \left(\frac{MilkPR\%}{100}\right)}{6.38}\right] + \left[\frac{WG \cdot \left[268 - \left(\frac{7.03 \cdot NE_g}{WG}\right)\right]}{\frac{1000}{6.25}}\right]$$

where:
$N_{retention(T)}$ – daily N retained per animal of category *T*, kg N $animal^{-1}$ day^{-1};
Milk – milk production, kg $animal^{-1}$ day^{-1};

[64] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, eq. 10.25, p. 10.54
[65] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, eq. 10.33, p. 10.60

MilkPR% – percent of protein in milk, calculated as [1.9 + 0.4 * %Fat], where %Fat is an input, assumed to be 4%;
6.38 – conversion from milk protein to milk N, kg protein (kg N)$^{-1}$;
WG – weight gain, input for each livestock category, kg day^{-1};
268 and 7.03 – constants;
NE_g – net energy for growth, calculated in livestock characterisation, based on current weight, mature weight, rate of weight gain, and *IPCC* constants, MJ day^{-1};
6.25 – conversion from kg dietary protein to kg dietary N, kg Protein (kg N)$^{-1}$.

Nitrogen retention values for sheep were accepted as default values for the fraction of N intake that retained by the animal per year (0.10) multiplying by N intake per animal per year[66].

Net energy for growth (NE_g) for non-dairy cattle was calculated according equation[67]:

$$NE_g = 22.2 \cdot \left(\frac{BW}{C \cdot MW}\right)^{0.75} \cdot WG^{1.097}$$

where:
NE_g – net energy needed for growth, MJ day^{-1};
BW – the average live body weight of the animals in the population, kg;
C – a coefficient with a value of 0.8 for females, 1.0 for castrates and 1.2 for bulls;
MW – the mature live body weight of an adult female in moderate body condition, kg;
WG – the average daily weight gain of the animals in the population, kg day^{-1}.

The annual amount of N excreted for swine, horses, goats and poultry were calculated using equation[68]:

$$Nex_{(T)} = N_{rate(T)} \cdot \frac{TAM}{1000} \cdot 365$$

where:
$Nex_{(T)}$ – annual N excretion for livestock category *T*, kg N animal^{-1} yr^{-1};
$N_{rate(T)}$ – default N excretion rate[69], kg N (1000 kg animal mass)$^{-1}$ day^{-1};
$TAM_{(T)}$ – typical animal mass for livestock category *T*, kg animal^{-1}.

The expert data for goats mass used in derivation of N excretion are 33.8 kg. Other country specific mass data used in calculations of nitrogen excretion are provided in Tables 5-38 and 5-39. The default mass data for breeding and market swine were taken from *2006 IPCC*[70].

Table 5-38. Horses mass value used for calculation of N excretion, kg

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Weight	520	514	508	503	497	491	485	479
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Weight	473	468	462	456	450	444	438	433
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Weight	427	421	415	409	403	398	392	386

66 *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, Table 10.20, p. 10.60
67 *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, eq. 10.6, p. 10.17
68 *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, eq. 10.30, p. 10.57
69 *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, Table 10.19, p. 10.59
70 *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, Table 10A-7, 10A-8, p. 10.80-10.81

Table 5-39. Poultry mass value used for calculation of N excretion, kg

Layer hens	Broilers	Turkeys	Ducks	Geese	Other poultry
1.56	0.89	7.76	1.58	6.0	1.36

The annual amount of N excretion per animal for dairy, non-dairy cattle and sheep were calculated based on the total annual N intake and total annual N retention of the animal. Annual N intake per animal for cattle, sheep and swine were calculated in accordance with the tables[71] of forage sustenance and ration. Calculated annual N excretion per animal per year is presented in Tables 5-40 and 5-41.

Table 5-40. Calculated N excretion factors for cattle, horses and swine used in the estimates of N_2O emissions, kg N/head/yr

Year	Livestock category			
	Cattle		Horses	Swine
	Dairy	Non-dairy		
1990	82.3	41.1	56.9	12.0
1991	79.7	41.1	56.3	12.0
1992	74.9	41.1	55.7	12.0
1993	73.3	41.1	55.0	12.0
1994	73.2	41.1	54.4	12.0
1995	74.3	41.1	53.8	12.0
1996	75.3	41.1	53.1	12.0
1997	76.7	41.1	52.5	12.2
1998	78.7	38.2	51.8	11.9
1999	77.0	38.9	51.2	12.0
2000	82.0	38.2	50.6	11.9
2001	84.4	38.0	49.9	12.0
2002	84.9	38.1	49.3	12.0
2003	85.7	38.0	48.6	11.9
2004	87.7	37.6	48.0	11.9
2005	89.1	37.9	47.4	11.9
2006	91.1	38.7	46.7	11.8
2007	93.7	39.3	46.1	11.9
2008	94.3	39.4	45.5	11.8
2009	95.1	39.7	44.8	11.9
2010	96.1	40.4	44.2	11.8
2011	97.4	38.8	43.5	11.8
2012	100.2	39.4	42.9	11.6
2013	101.2	40.7	42.3	11.6

Table 5-41. Calculated N excretion factors for sheep, goats and poultry (excluding geese and other poultry) used in the estimates of N_2O emissions during the period 1990-2013, kg N/head/yr

Sheep	Goats	Poultry			
		Layer hens	Broilers	Turkeys	Ducks
10.50	15.81	0.47	0.36	2.09	0.48

[71] Gyvulininkystės žinynas. Baisogala (en. *Livestock manual. Institute of Animal Science of LVA*), 2007, p. 584-601

The default Nitrogen excretion data for geese and other poultry as well as nutria, rabbits and fur-bearing animals were taken from *Revised 1996 IPCC*[72] and *2006 IPCC*[73] (Table 5-42).

Table 5-42. Default N excretion values for livestock categories, kg N/head/yr

Animal category	Nitrogen excretion
Rabbits	8.10
Minks, nutria	4.59
Foxes, polar foxes	12.09
Geese and other poultry	0.6

5.4.1.3 Uncertainties and time-series consistency

N_2O emission from manure management was calculated based on activity data and emission factors. Overall uncertainties result from uncertainty of livestock population (Chapter 5.2.3), uncertainty of emission factors and uncertainty values of other relevant parameters.

Activity data uncertainty

As elaborated in Chapter 5.2.3 uncertainty value for livestock population is ±5%. The uncertainty of the manure management system usage data can be ±10% or less (Chapter 5.3.3). The uncertainty ranges for the default N excretion rate calculating N excretion for goats, swine, horses, rabbits, nutria and fur-bearing animals as well as poultry (excluding sub-categories geese and other poultry) is ±50%. N excretion rate for cattle and sheep were estimated using *Tier 2* method and based on expert judgement it was assumed that uncertainty is ±20%. Overall uncertainty for direct N_2O emissions from MMS activity data was estimated to be ±55%.

Emission factor uncertainty

The uncertainty of EF for estimation of N_2O emissions in accordance with the data of *IPCC 2006* are in the range of -50 – +100% taking average value of ±75%.

Overall uncertainty

Combined uncertainty was calculated using *2006 IPCC* eq. 3.1[74]. This approach requires uncertainty values of the main activity data used and uncertainty of emission factor. Combined uncertainty was estimated to be ±93%.

5.4.1.4 Category specific QA/QC and verification

General QC procedures applied for this category – check of activity data for the whole time period, consistency check of data entered in CRF with calculation sheets, trends of emissions for each category, relevance of methodology applied, etc.

5.4.1.5 Category-specific planned improvements

Lithuania will continue improving collection of activity data on manure management system usage.

[72] *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*: Workbook. Vol. 1. Table 4-6, p. 4.10
[73] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, Table 10.19, p. 10.59
[74] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 3, eq. 3.1, p. 3.28

5.4.2 Indirect N_2O emission (CRF 3.B.2)

5.4.2.1 Category description

Indirect emissions result from volatile nitrogen losses that occur primarily in the forms of ammonia (NH_3) and nitrogen oxides (NO_x). Nitrogen losses begin at the point of excretion in housings and other animal production areas[75].

Average N losses from manure management systems due to volatilization and leaching were 17.4 kt in 2013. In 2013, comparing with 1990, average N losses from manure management decreased by 64.6%. Average N losses from manure management decreased by 13% during the period 2005-2013 (Figure 5-10).

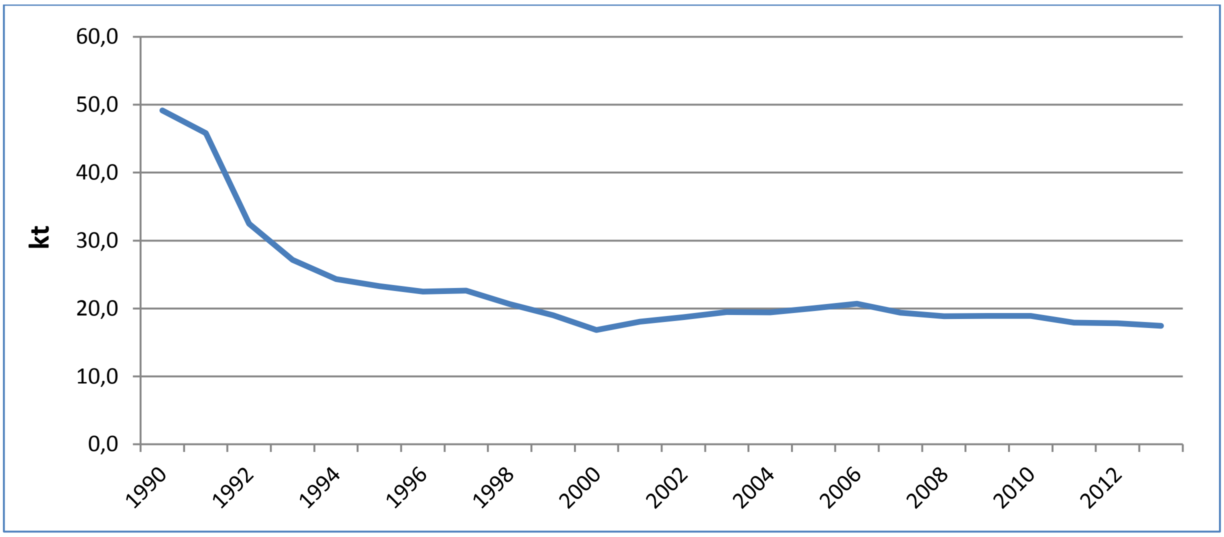

Figure 5-10.N losses due to volatilization of NH_3 and NO_x and leaching during the period 1990-2013, kt

N losses due to volatilization in forms of NH_3 and NO_x and due to leaching from different manure management systems are presented in Table 5-43.

Table 5-43. Calculated N losses due to volatilization and leaching from different manure management systems, kt

Year	N losses due to volatilization			N losses due to leaching
	AWMS			
	Liquid system	Solid storage	Other systems	Solid storage
1990	9.60	29.37	9.97	0.34
1991	9.51	27.09	9.00	0.33
1992	7.42	20.00	4.91	0.28
1993	6.59	16.05	4.38	0.24
1994	6.31	13.49	4.43	0.22
1995	6.40	12.51	4.27	0.20
1996	6.44	12.22	3.71	0.20
1997	6.88	11.91	3.73	0.19
1998	6.65	10.62	3.29	0.18
1999	6.19	9.95	2.75	0.17
2000	5.80	8.51	2.42	0.15

[75] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, p. 10.52

2001	6.55	8.68	2.74	0.16
2002	7.04	8.89	2.73	0.16
2003	7.38	9.13	2.85	0.18
2004	7.44	8.91	2.83	0.19
2005	7.86	8.97	2.94	0.19
2006	8.29	9.27	2.89	0.20
2007	7.71	8.78	2.63	0.20
2008	7.73	8.45	2.42	0.20
2009	7.97	8.26	2.41	0.20
2010	8.09	8.17	2.40	0.21
2011	7.82	7.79	2.16	0.21
2012	8.06	7.65	2.05	0.25
2013	7.78	7.47	2.11	0.27

Indirect N_2O emissions from manure management due to volatilization and leaching were 81.5 kt CO_2 eqv. or 4.1% of the total agriculture emissions in 2013. In 2013 comparing with 1990 indirect N_2O emissions from manure management due to volatilization decreased by 64.6%. From 2005 to 2013 indirect N_2O emissions from manure management decreased by 13.0% (Figure 5-11).

Calculated indirect N_2O emissions due to volatilization of N from different manure management systems are presented in Table 5-44.

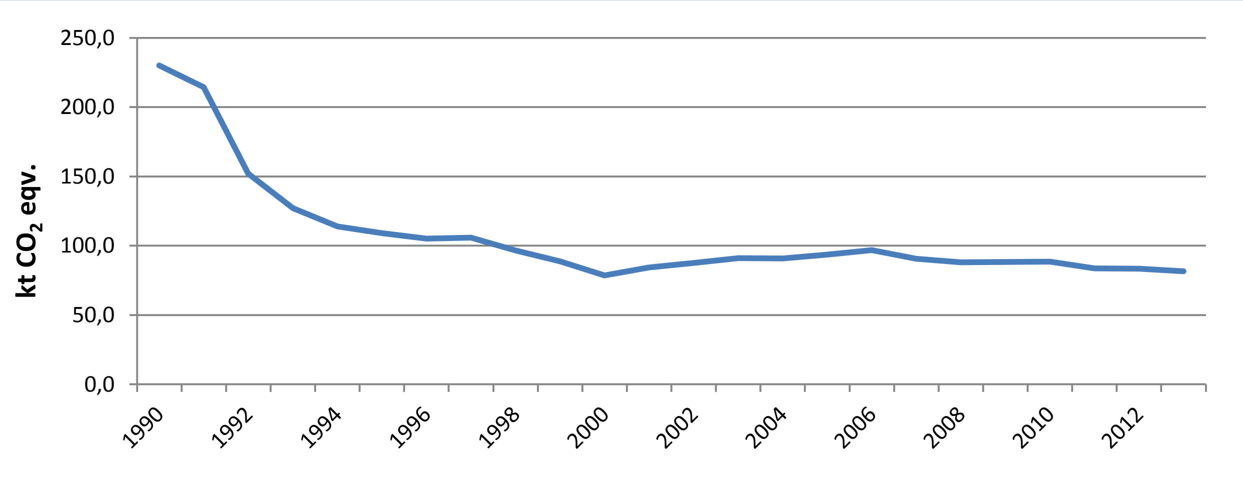

Figure 5-11. Indirect N_2O emissions from manure management due to volatilization and leaching during the period 1990-2013, kt CO_2 eqv.

Indirect N_2O emissions due to volatilization of N from different manure management are presented in table 5-46.

Table 5-44. Calculated indirect N_2O emissions from different manure management systems, kt

Year	**AWMS**		
	Liquid system	**Solid storage**	**Other systems**
1990	0.1508	0.4615	0.1566
1991	0.1494	0.4257	0.1414
1992	0.1166	0.3143	0.0771
1993	0.1035	0.2523	0.0689
1994	0.0991	0.2119	0.0696

1995	0.1006	0.1966	0.0671
1996	0.1012	0.1921	0.0582
1997	0.1080	0.1872	0.0586
1998	0.1046	0.1669	0.0517
1999	0.0973	0.1564	0.0432
2000	0.0912	0.1338	0.0380
2001	0.1029	0.1364	0.0430
2002	0.1106	0.1396	0.0429
2003	0.1160	0.1435	0.0449
2004	0.1169	0.1400	0.0445
2005	0.1236	0.1410	0.0462
2006	0.1303	0.1457	0.0454
2007	0.1211	0.1379	0.0414
2008	0.1215	0.1328	0.0380
2009	0.1252	0.1298	0.0379
2010	0.1272	0.1284	0.0378
2011	0.1228	0.1224	0.0339
2012	0.1267	0.1202	0.0322
2013	0.1222	0.1174	0.0332

5.4.2.2 Methodological issues

To estimate indirect N_2O emissions from manure management the *Tier 1* method was used.

N losses due to volatilization in forms of NH_3 and NO_x from manure management systems was calculated multiplying the amount of nitrogen excreted from all livestock categories and managed in each manure management system by a fraction of volatilized nitrogen[76].

$$N_{volatalization-MMs} = \sum_S \left[\sum_T \left[\left(N_{(T)} \cdot Nex_{(T)} \cdot MS_{(T,S)} \right) \cdot \left(\frac{Frac_{GasMS}}{100} \right)_{(T,S)} \right] \right]$$

where:

$N_{volatilization-MMS}$ – amount of manure nitrogen that is lost due to volatilization of NH_3 and NO_x, kg N yr^{-1};

$N_{(T)}$ – number of head of livestock species/category *T* in the country;

$Nex_{(T)}$ – annual average N excretion per head of species/category *T* in the country, kg N $animal^{-1}$ yr^{-1};

$MS_{(T,S)}$ – fraction of total annual nitrogen excretion for each livestock species/category *T* that is managed in manure management system *S* in the country, dimensionless;

$Frac_{GasMS}$ – percent of managed manure nitrogen for livestock category *T* that volatilizes as NH_3 and NO_x in the manure management system *S*, % (Table 5-45).

Table 5-45. Default values for nitrogen loss due to volatilization of NH3 and NOx from manure management, %

Animal type	Manure management system	$Frac_{GasMS}$
Dairy cattle	Liquid	40
	Solid	30
Non-dairy cattle	Liquid	40
	Solid	45

[76] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, eq. 10.26, p. 10.54

	Deep bedding	30
Swine	Liquid	48
	Solid	45
	Deep bedding	40
Poultry (layer hens-wet)	Liquid	40
	Without litter	55
	With litter	40
Horses, sheep, goats, rabbits, nutria, fur-bearing	Solid	12

The *Tier 1* method was applied for calculations indirect N_2O emissions due to volatilization of Nin forms of NH_3 and NO_x from manure management[77].

$$N_2O_{G(mm)} = (N_{volatalization-MMS} \cdot EF_4) \cdot \frac{44}{28}$$

where:
$N_2O_{G(mm)}$ – indirect N_2O emissions due to volatilization of N from Manure Management in the country, kg N_2O yr^{-1};
EF_4 – emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces, kg N_2O-N (kg NH_3-N + NO_x-N volatilized)$^{-1}$; default value is 0.01 kg N_2O-N[78] (kg NH_3-N + NO_x-N volatilized)$^{-1}$.

Nitrogen that leaches into soil and/or run-off during solid storage of manure at outdoor areas or in feedlots can be estimated using the following formula[79]:

$$N_{leaching-MMS} = \sum_S \left[\sum_T \left[\left(N_{(T)} \cdot Nex_{(T)} \cdot MS_{(T,S)}\right) \cdot \left(\frac{Frac_{leachMS}}{100}\right)\right]\right]$$

where:
$N_{leaching\text{-}MMS}$ – amount of manure nitrogen that leached from manure management systems, kg N yr^{-1};
$N_{(T)}$ – number of head of livestock species/category *T* in the country;
$N_{ex(T)}$ – annual average N excretion per head of species/category *T* in the country, kg N $animal^{-1}$ yr^{-1};
$MS_{(T,S)}$ – fraction of total annual nitrogen excretion for each livestock species/category *T* that is managed in manure management system *S* in the country, dimensionless;
$Frac_{leachMS}$ – percent of managed manure nitrogen losses for livestock category *T* due to runoff and leaching[80] during solid storage of manure.

The indirect N_2O emissions from leaching and runoff of nitrogen from manure management systems are estimated using the following equation[81]:

$$N_2O_{L(mm)} = \left(N_{leaching-MMS} \cdot EF_5\right) \cdot \frac{44}{28}$$

where:

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[77] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, eq. 10.27, p. 10.56
[78] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 11, Table 11.3, p. 11.24
[79] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, eq. 10.28, p. 10.56
[80] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 11, Table 11.3, p. 11.24
[81] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, eq. 10.29, p. 10.57

$N_2O_{L(mm)}$ – indirect N_2O emissions due to leaching and runoff from manure management in the country, kg N_2O yr^{-1};
EF_5 – emission factor for N_2O emissions from nitrogen leaching and runoff, kg N_2O-N/kg N leached and runoff (default value 0.0075 kg N_2O-N[82] (kg N leaching/runoff)$^{-1}$.

5.4.2.3 Uncertainties and time-series consistency

Indirect N_2O emission from manure management was calculated based on activity data and emission factors. Overall uncertainties result from uncertainty of livestock population (Chapter 5.2.3), uncertainty of emission factors and uncertainty values of other relevant parameters.

Activity data uncertainty

As elaborated in Chapter 5.2.3 uncertainty value for livestock population is ±5%. The uncertainty of the manure management system usage data can be ±10% or less (Chapter 5.3.3). The uncertainty ranges for the default N excretion rate calculating N excretion for goats, swine, horses, rabbits, nutria and fur-bearing animals as well as poultry (excluding sub-categories geese and other poultry) is ±50%. N excretion rate for cattle and sheep were estimated using *Tier 2* method and based on expert judgement it was assumed that uncertainty is ±20%. Overall uncertainty for direct N_2O emissions from MMS activity data was estimated to be ±55%.

Emission factor uncertainty

The uncertainty of EF_4 and EF_5 for estimation of indirect N_2O emissions from volatilization and leaching in accordance with the range given in *IPCC 2006* was estimated to be ±240% and ±163% respectively.

Overall uncertainty

Combined uncertainty was calculated using *2006 IPCC* eq. 3.1[83]. This approach requires uncertainty values of the main activity data used and uncertainty of emission factor. Combined uncertainty was estimated to be ±246% for N_2O emissions from volatilization and ±172% for N_2O emissions from leaching and run off.

5.4.2.4 Category-specific QA/QC and verification

General QC procedures applied for this category – check of activity data for the whole time period, consistency check of data entered in CRF with calculation sheets, trends of emissions for each category, relevance of methodology applied, etc.

5.4.2.5 Category-specific planned improvements

Collection of more accurate data on manure utilization and usage in biogas plants in Lithuania is planned. Additional data should enable better and more reliable judgments on N_2O emissions from manure management.

5.5 Rice cultivation (CRF 3.C)

Rice is not cultivated in Lithuania therefore reported as NO.

5.6 Agricultural soils (CRF 3.D)

Agricultural soils include direct and indirect nitrous oxide (N_2O) emissions (Table 5-2). Managed soils represent a large source of N_2O emissions. N_2O emission from managed soils contributed

[82] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 11, Table 11.3, p. 11.24
[83] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 3, eq. 3.1, p. 3.28

54.5% of the total GHG emission from agriculture sector and 77.6% from the total N_2O emissions in Lithuania. N_2O emissions from agricultural soils were also identified as a key category (see Table 5-1).

5.6.1 Direct N_2O emissions from managed soils

5.6.1.1 Category description

This source category includes direct N_2O emissions from agricultural soils. Assessing direct N_2O emissions from agricultural soils, anthropogenic nitrogen inputs were considered from: application of synthetic fertilizers and animal manure, cultivation of N-fixing crops, incorporation of crop residues into soils, soil nitrogen mineralization due to cultivation of organic soils and application of sewage sludge and compost to agricultural land as soil amendment. A major direct source of N_2O is the use of synthetic fertilizer (Figure 5-13). Similarly the use of animal manure as fertilizer leads to substantial emissions of N_2O from agricultural soils. The trend of N_2O emissions from direct N_2O emissions from managed soils are presented in table below (Figure 5-12).

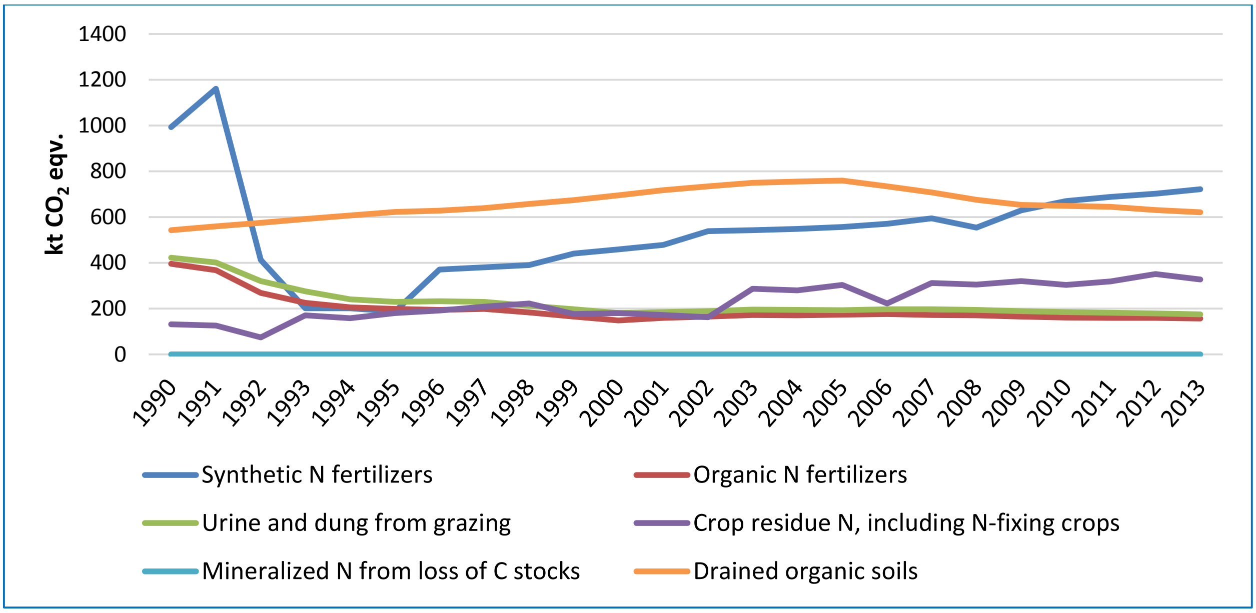

Figure 5-12. N_2O emissions from sub-categories of agricultural soils during the period 1990-2013, kt CO_2 eqv.

Comparing with 1990 N_2O emissions have decreased by 22.3% in 2013 mainly due to reduction in consumption of synthetic N fertilizers. Also there was a decrease in consumption of organic N fertilizers and urine and dung deposited on soil from grazing animals. This reduction is closely related to decrease in livestock population. The figure below shows the share of each sub-category of direct N_2O emissions from managed soils in 2013.

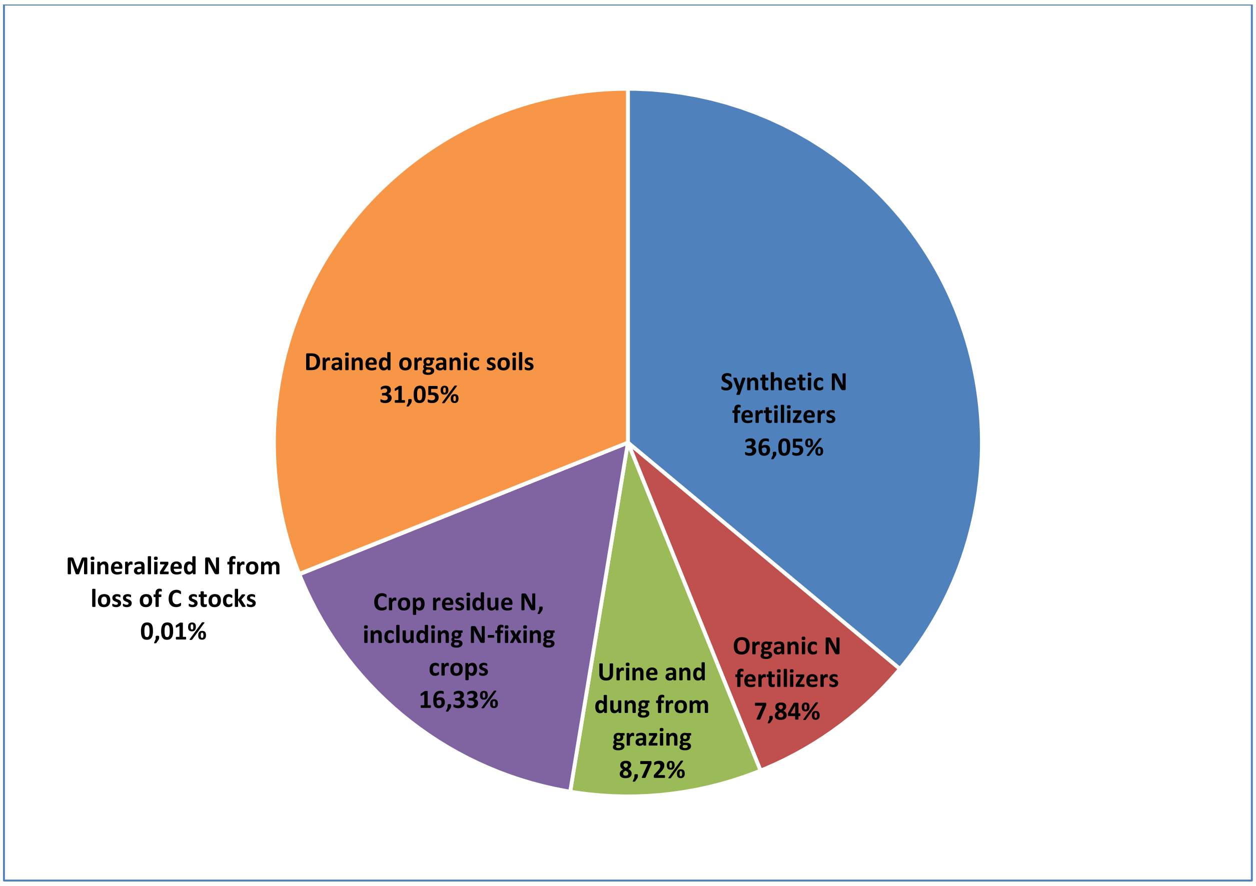

Figure 5-13. The share of N_2O emissions from direct N_2O emissions from managed soils by sub-category in 2013, %

The major part of emissions originates from consumption of synthetic N fertilizers and from drained/managed organic soils. 16.33% of emissions composed from crop residues.

5.6.1.2 Methodological issues

Direct N_2O emissions from managed soils were estimated using *IPCC 2006* guidelines Tier 1 method. The following equation was used to estimate direct N_2O emissions from managed soils[84]:

$$N_2O_{Direct} - N = N_2O - N_{N\ inputs} + N_2O - N_{OS} + N_2O - N_{PRP}$$

Where:

$$N_2O - N_{N\ inputs} = [(F_{SN} + F_{ON} + F_{CR} + F_{SOM}) \cdot EF_1]$$

$$N_2O - N_{OS} = [(F_{OS,CG,Temp} \cdot EF_{2CG,Temp}) + (F_{OS,CG,Trop} \cdot EF_{2CG,Trop}) + (F_{OS,F,Temp,NR} \cdot EF_{2F,Temp,NR}) + (F_{OS,F,Temp,NP} \cdot EF_{2F,Temp,NP}) + (F_{OS,F,Trop} \cdot EF_{2F,Trop})$$

$$N_2O - N_{PRP} = [(F_{PRP,CPP} \cdot EF_{PRP,CPP}) + (F_{PRP,SO} \cdot EF_{PRP,SO})]$$

where:

$N_2O_{Direct-N}$ – annual direct N_2O–N emissions produced from managed soils, kg N_2O–N yr^{-1};

N_2O–$N_{N\ inputs}$ – annual direct N_2O–N emissions from N inputs to managed soils, kg N_2O–N yr^{-1};

[84] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, eq. 11.1, p. 11.7

$N_2O–N_{OS}$ – annual direct $N_2O–N$ emissions from managed organic soils, kg $N_2O–N$ yr^{-1};
$N_2O–N_{PRP}$ – annual direct $N_2O–N$ emissions from urine and dung inputs to grazed soils, kg $N_2O–N$ yr^{-1};
F_{SN} – annual amount of synthetic fertilizer N applied to soils, kg N yr^{-1};
F_{ON} – annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N yr^{-1};
F_{CR} – annual amount of N in crop residues (above-ground and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils, kg N yr^{-1};
F_{SOM} – annual amount of N in mineral soils that is mineralized, in association with loss of soil C from soil organic matter as a result of changes to land use or management, kg N yr^{-1};
F_{OS} – annual area of managed/drained organic soils, ha (subscripts CG, F, Temp, Trop, NR and NP refer to Cropland and Grassland, Forest Land, Temperate, Tropical, Nutrient Rich, and Nutrient Poor, respectively);
F_{PRP} – annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr^{-1} (the subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and Other animals, respectively);
EF_1 – emission factor for N_2O emissions from N inputs, kg $N_2O–N$ (kg N input)$^{-1}$;
EF_{1FR} – emission factor for N_2O emissions from N inputs to flooded rice, kg $N_2O–N$ (kg N input)$^{-1}$;
EF_2 – emission factor for N_2O emissions from drained/managed organic soils, kg $N_2O–N$ ha^{-1} yr^{-1} (the subscripts CG, F, Temp, Trop, NR and NP refer to cropland and grassland, forest land, temperate, tropical, nutrient rich, and nutrient poor, respectively);
EF_{3PRP} – emission factor for N_2O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals, kg $N_2O–N$ (kg N input)$^{-1}$ (the subscripts CPP and SO refer to cattle, poultry and pigs, and sheep and other animals, respectively).

Conversion of N_2O-N emissions to N_2O emissions for reporting purposes is performed by using the following equation:

$$N_2O = N_2O - N \cdot 44/28$$

Emission factors (EF) used in calculations are taken from *IPCC 2006* and presented in Table below.

Table 5-46. Emission factors used in calculations of direct N_2O emissions from managed soils[85]

Emission Factor	**Default value**
EF_1 for N addition from mineral and synthetic fertilizers, crop residues and N mineralized from mineral soils as a result of soil carbon loss (kg N_2O-N (kg N)$^{-1}$)	0.01
$EF_{2\ CG,\ Temp}$ for temperate organic crop and grassland soils (kg $N_2O–N$ ha^{-1})	8.0
$EF_{2F,\ Temp,\ Org,\ R}$ for temperate and boreal organic nutrient rich forest soils (kg $N_2O–N$ ha^{-1})	0.6
$EF_{2F,\ Temp,\ Org,\ P}$ for temperate and boreal organic nutrient poor forest soils (kg $N_2O–N$ ha^{-1})	0.1
$EF_{3PRP,\ CPP}$ for cattle (dairy, non-dairy and buffalo), poultry and pigs (kg $N_2O–N$ (kg N)$^{-1}$)	0.02
$EF_{3PRP,\ SO}$ for sheep and 'other animals' (kg $N_2O–N$ (kg N)$^{-1}$)	0.01

[85] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, Table 11.1, p. 11.11

Applied synthetic fertilizers (F_{SN})

The main data required to estimate amount of nitrogen that is being deposited on soil is consumption of nitrogen containing synthetic fertilizers. There is no national data available for consumption of nitrogen fertilizers in Lithuania (except for the period 1990-1994). In order to fulfil the gap Lithuania was using several different data sources (including Eurostat data and data of JSC Agrochema), but eventually data was recalculated using a single data source – International Fertilizer Industry Association (IFA)[86]. IFA statistics provides data for the whole time period and this assures consistency in time series. Figure 5-14 provides trend of N fertilizers consumption in Lithuania.

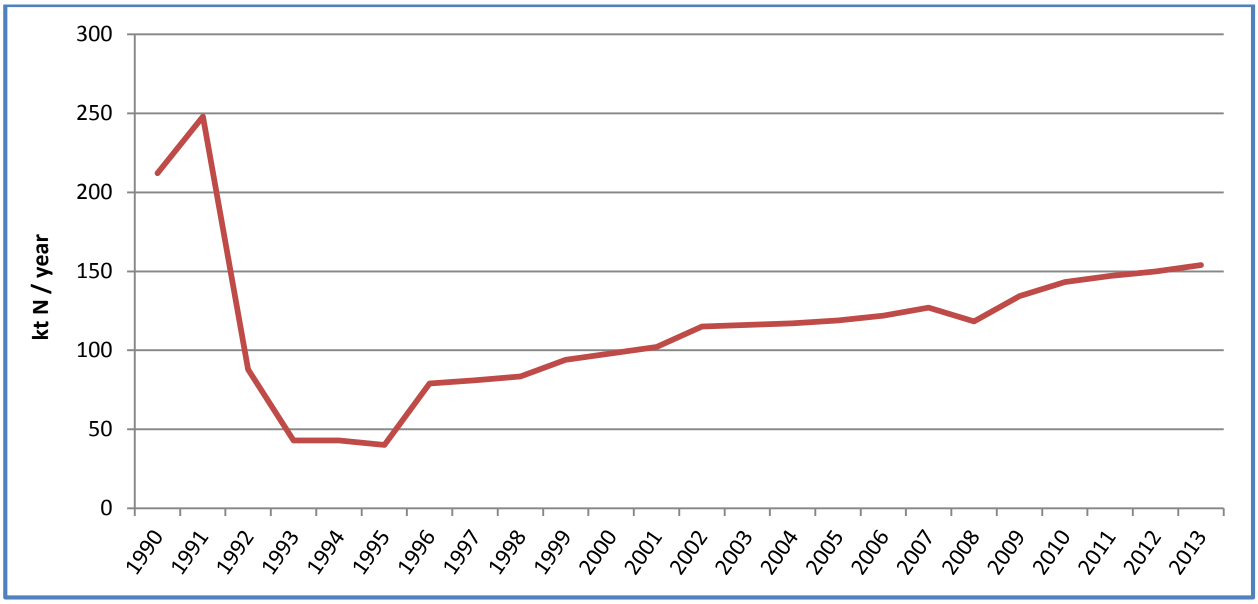

Figure 5-14. Total synthetic N fertilizers consumption in Lithuania during the period 1990-2013, kt N/year

After the restoration of Lithuanian independence consumption of fertilizers drastically declined up to 40 kt per year in 1995. During the following years consumption rose as the economy was progressing together with the growth of agriculture, demand of crops and vegetables. The consumption dropped somewhat in 2008 due to economic crisis.

To calculate N_2O emissions from consumption of synthetic fertilizers default emission factor Table 5-46) was used. To convert N_2O-N emissions to N_2O emissions value was multiplied by 44/28.

Applied organic N fertilizers (F_{ON})

Amount of organic N inputs to soil in Lithuania refers to applied animal manure (other than by grazing animals), sewage sludge that is used as soil amendment and compost application as soil fertilizer. Overall organic N input to soil is calculated using *Tier 1* method[87]:

$$F_{ON} = F_{AM} + F_{SEW} + F_{COMP}$$

where:
F_{ON} – total annual amount of organic N fertiliser applied to soils other than by grazing animals, kg N yr^{-1};

[86] Available from: *http://ifadata.fertilizer.org/ucSearch.aspx*
[87] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, eq. 11.3, p. 11.12

F_{AM} – annual amount of animal manure N applied to soils, kg N yr^{-1};
F_{SEW} – annual amount of total sewage N that is applied to soils, kg N yr^{-1};
F_{COMP} – annual amount of total compost N applied to soils, kg N yr^{-1}.

Animal manure applied to soils (F_{AM})

The main data that is used for calculation of animal manure nitrogen is described in category Manure management. This data includes population of livestock (Statistics Lithuania), fraction of total annual nitrogen excretion for each livestock category that is managed in different manure management systems[88], annual average N excretion per animal category, etc.

Animal manure in Lithuania is applied to soil as organic fertilizers. N inputs to soil were estimated using the following equation:

$$F_{AM} = N_{MMS\_Avb} \cdot [1 - (Frac_{FEED} + Frac_{FUEL} + Frac_{CNST})]$$

$$N_{MMS_{Avb}} = \sum_{S}\left\{\sum_{(T)}\left[\left[\left(N_{(T)} \cdot Nex_{(T)} \cdot MS_{(T,S)}\right) \cdot \left(1 - \frac{Frac_{LossMS}}{100}\right)\right] + \left[N_{(T)} \cdot MS_{(T,S)} \cdot N_{beddingMS}\right]\right]\right\}$$

where:
N_{MMS_Avb} – amount of managed manure nitrogen available for application to managed soils or for feed, fuel, or construction purposes, kg N yr^{-1};
$N_{(T)}$ – number of head of livestock species/category *T* in the country;
$Nex_{(T)}$ – annual average N excretion per animal of species/category *T* in the country, kg N $animal^{-1}$ yr^{-1};
$MS_{(T,S)}$ – fraction of total annual nitrogen excretion for each livestock species/category *T* that is managed in manure management system *S* in the country, dimensionless;
$Frac_{LossMS}$ – amount of managed manure nitrogen for livestock category *T* that is lost in the manure management system *S*, %;
$N_{beddingMS}$ – amount of nitrogen from bedding (to be applied for solid storage and deep bedding MMS if known organic bedding usage), kg N $animal^{-1}$ yr^{-1};
S – manure management system;
T – species/category of livestock.

As there is no data available on the fraction of manure that is being used as feed, fuel or material for construction therefore $F_{AM} = N_{MMS\_Avb}$.

Activity data used in calculations is presented in previous chapters: livestock populations (see Table 5-4), N excretion values were calculated in sub-category Manure management – N_2O (see Chapter 5.4.1.2), fraction of annual nitrogen excreted for each livestock category from each MMS type was indicated is sub-category Manure management and is presented in Chapter 5.3.2.2. Amount of managed manure nitrogen for each livestock category that is lost in the MMS

[88] Juška, R., *et al Survey and evaluation of methane and nitrous oxide emission content in manure management systems of Lithuania*. Study (*Lietuvos mėšlo tvarkymo sistemose susidarančių metano ir azoto suboksido kiekio tyrimai ir įvertinimas*. Studija). Lietuvos sveikatos mokslų universitetas, Gyvulininkystės institutas. Baisogala, 2012

($Frac_{LossMS}$)[89] was taken from *IPCC 2006* as well as data on amount of nitrogen from bedding material[90].

Sewage sludge applied to soils (F_{SEW})

Sewage sludge from wastewater treatment plants is used as soil amendment in Lithuania. According to the national database of waste – sewage sludge with recovery code R10 is being treated as useful amendment for agricultural soil[91]. Sewage sludge corresponding to this code is municipal sewage sludge which is used for land treatment seeking to benefit the agricultural soils.

Data on the quantities of R10 sewage sludge for the periods 1991-1999 and 2004-2012 was obtained from Lithuanian Environmental Protection Agency (EPA) which collects information and manages waste database. The data on quantities of sewage sludge (R10) for the years 1990, 2000-2003 are not reliable. It is not clear how much sewage sludge has been used on agricultural soils during these years. As a result, it was decided to use interpolation in order to fulfil the gap of data for the period 2000-2003. It was assumed that annual amount of sewage sludge in 1990 is similar to that of 1991 based on this assumption the same amount of sewage sludge was used both in 1990 and 1991.

To calculate the nitrogen input from application of sewage sludge the data of nitrogen concentration (%) was used. This data was obtained from EPA. Availability of data covered the period 2004-2009. Data on N concentration in sewage sludge for the period 1990-2003 was not available as at that time such data was not collected in Lithuania. Information on N concentration in sewage sludge for the years 2010-2013 was not available at the time of inventory preparation. To fill the gaps of missing information on N concentration in sewage sludge for the period 1990-2003 and 2010-2013 the arithmetic average value of the years 2004-2009 was used (3.75%).

The following equation was used for calculation of nitrogen input from sewage sludge application to agricultural soils:

$$F_{SEW} = S_{SLUDGE} \cdot \frac{S_N}{100}$$

where:
F_{SEW} – annual amount of total sewage N that is applied to soils, kg N yr^{-1};
S_{SLUDGE} – annual amount of sewage sludge applied to agricultural soils, kg d.m. yr^{-1};
S_N – nitrogen content in dry matter, %.

Compost applied to soils (F_{COMP})

Using the financial resources of 2004-2006 EU ISPA/Cohesion funds Lithuania started improving municipal solid waste management system. The main task was to build 11 modern regional landfills and to close all the old landfills and dumps. This project also included construction of green waste composting sites (GWCS). The period 2004-2006 financed construction of 13 GWCS in different regional landfills. Second part of the project was implemented using finances from 2007-2013 EU Structural funds continuing projects started during 2004-2006. The period 2007-

89 *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Table 10.23, p. 10.67
90 *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, p. 10.66
91 Lietuvos Respublikos Aplinkos ministro 2011 m. gegužės 3 d. įsakymas Nr. D1-368 „Dėl Lietuvos Respublikos aplinkos ministro 1999 m. liepos 14 d. įsakymo Nr. 217 „Dėl atliekų tvarkymo taisyklių patvirtinimo“ pakeitimo ir aplinkos ministro 2002 m. gruodžio 31 d. įsakymo Nr. 698 „Dėl alyvų atliekų tvarkymo taisyklių patvirtinimo“ ir jį keitusių įsakymų pripažinimo netekusiais galios / Žin., 2011, Nr. 57-2721; 2011, Nr. 150-7100; 2012, Nr. 16-697

2013 financed construction of 39 GWCS in different regional landfills. Most of these GWCS have started accepting green waste in 2011 and producing compost in 2013. Few of the 11 regional waste management centres (RWMC) provided data on quantities of compost that was sold as organic fertilizers. As required these RWMC also provided data on dry matter content and compost composition that includes amount of N (kg/kg). Average DM content in compost was 56.4% and average content of N in DM – 0.0075 kg/kg.

To calculate amount of N that was deposited on soil using compost as organic fertilizer the following equation was used:

$$F_{COMP} = (S_{COMP} \cdot \frac{DM}{100}) \cdot C_N$$

where:
F_{COMP} – annual amount of total compost N that is applied to soils, kg N yr^{-1};
S_{COMP} – annual amount of compost applied to soils, kg yr^{-1};
DM – dry matter content in compost, %;
C_N – nitrogen content in compost, kg/kg.

Unfortunately until the GWCS were started operating no data on compost use in Lithuania was available therefore reported as NO. No data on amount of compost used in private farms is available.

Urine and dung from grazing animals (F_{PRP})

Annual amount of N deposited on pasture, range and paddock soils by grazing animals (F_{PRP}) was estimated using parameters estimated in category Manure management. The main data used was: number of livestock by category, fraction of total annual N excretion of each livestock category that was deposited on pasture, range and paddock soils, and annual average N excretion per head of livestock category. To estimate N deposited on pasture, range and paddock soils the following equation was used:

$$F_{PRP} = \sum_T \left[\left(N_{(T)} \cdot Nex_{(T)} \right) \cdot MS_{(T,PRP)} \right]$$

where:
F_{PRP} – annual amount of urine and dung N deposited on pasture, range, paddock and by grazing animals, kg N yr^{-1};
$N_{(T)}$ – number of head of livestock species/category *T* in the country;
$Nex_{(T)}$ – annual average N excretion per head of species/category *T* in the country, kg N $animal^{-1}$ yr^{-1};
$MS_{(T,PRP)}$ – fraction of total annual N excretion for each livestock species/category *T* that is deposited on pasture, range and paddock.

Crop residue N returned to soils (F_{CR})

In order to calculate the amount of nitrogen that is returned to soil by crop residues, including N-fixing crops and forage country specific, international and default data was used.

The common practice in Lithuania is to process the straw after harvesting cereals. If the straw is left on the field it has to be chopped and evenly spread on the field, if the straw is removed from the field after harvesting for the further use it is being removed as the whole (no chopping applied). The most common practice of straw use is for bedding. It is estimated that around 40%

to 50% of straw harvested annually is used for livestock bedding in solid storage and deep bedding manure management systems[92]. In recent years it is also a case when straw is being removed for the usage as biomass in renewable energy. However there is no data available how much harvested straw could be removed for energy purposes therefore it is assumed that amount of straw (around 65%) that is not used for bedding is left on the field as crop residue.

According to the common practice in Lithuania the stubble are usually left on the field in order to increase soil fertility and reduce growth of tares. The stubble left on the field after harvest is from 5 to 30 cm depending on the crop type and agricultural machinery used. It is a good practice to plough up the field after harvesting. Together with stubble plant roots are also left on the field. In some cases reviewing scientific research stubble was identified as part of the plant that includes both roots and steam (5-30 cm).

In order to estimate amount of N (F_{CR}) returned to soil with crop residues it was assumed that crop consists of grain (product), straw and stubble (stubble includes steam and roots). As mentioned above it was assumed that around 65% of straw is left on the field as crop residues and the rest of the straw is removed from the field as bedding material. In order to quantify the amount of straw and stubble left on the field data on harvesting index (HI)[93] and product and straw ratio was used.

$$HI = \frac{P_F}{B_F}$$

where:
HI – harvesting index, the ratio between product and total crop biomass;
P_F – amount of crop harvested, t;
B_F – total plant biomass, t.

Using statistical data on crop harvested (thous. tones) and HI of each crop type total crop biomass produced was identified. This data let to identify the amount of straw and amount of stubble left on the field as crop residues. For each crop type country specific dry matter values for straw[94] and stubble[95] were applied. Other important data used was N content in different type of crop straw and stubble[96].

Using all available country specific data and other scientific data sources annual amount of N from different crop categories (kg/ha) was estimated. Table below shows amount of N returned to soil with straw and stubble (including roots) residues in 2013. Values vary within the time period as calculations strongly depend on amount of crops harvested and area of harvest.

Table 5-47. N returned to soil with crop residues of the main crops in 2013, N kg/ha yr^{-1}

Crop type	**Straw**	**Stubble**
Winter wheat	12.13	5.60
Spring wheat	9.86	4.56
Triticale	8.82	1.91
Rye	5.32	3.53

[92] Augalinės kilmės atliekų panaudojimo tręšimui, jų normų nustatymo, kitų augalinių trąšų žemės ūkyje naudojimo būdų tyrimai, analizė ir įvertinimas. Ataskaita (en. *Analysis and assessment of crop residues application as soil fertilizers, identification of their norms, and usage of other plant waste as fertilizers in agriculture. Report*), 2011, p. 3
[93] Slapauskas *et al.* Augalu produktyvumas (en. *Productivity of plants*), 2008. 1.3 lentele, p. 18
[94] Gyvulininkystės žinynas. Baisogala (en. Livestock manual. Institute of Animal Science of LVA), 2007
[95] Prof. L. Špokas. Mano ūkis 2009/4 "Sėkmingai javapjūtei pamatai klojami iš anksto"
[96] Doc. Dr. V. Liako tyrimai; Gyvulininkystės žinynas. Baisogala (en. Livestock manual. Institute of Animal Science of LVA), 2007

Barley	10.55	2.62
Oats	9.48	3.20
Grain maize	46.59	6.99
Winter rape	13.34	6.23
Spring rape	10.72	6.18

To estimate annual amount of nitrogen returned to soil with crop residues amount of nitrogen from each crop type residues (kg/ha) was multiplied by total area of each crop type.

Similar methodology was applied estimating N retuned to soil with residues of beet and root vegetables. It was assumed that all top mass was left as residues (i.e. leaves). Country specific data on production and residues ratio[97] was used to estimate the amount of residues left on the field as well as CS data on N amount in the residues[98] (Table 5-48).

Table 5-48. N returned to soil with residues of the main beet and root vegetables in 2013, N kg/ha yr^{-1}

Vegetable type	**Product: Residue ratio**	**N in residues (g/kg)**
Potatoes	0.2	48.0
Sugar beet	0.7	23.312
Fodder beet	0.4	26.192

To estimate N returned to soil from N-fixing crops and forage/ pasture renewal was estimated using the following equation[99]:

$$F_{CR} = \sum_{T} \{Crop_{(T)} \cdot Frac_{Renew(T)} \cdot [(Area_{(T)} - Area\ burnt_{(T)} C_f) \cdot R_{AG(T)} \cdot N_{AG(T)} \cdot (1 - Frac_{Remoce(T)}) + Area_{(T)} \cdot R_{BG(T)} \cdot N_{BG(T)}]\}$$

where:

F_{CR} – annual amount of N in crop residues (above and below ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually, kg N yr^{-1};
$Crop_{(T)}$ – harvested annual dry matter yield for crop *T*, kg d.m. ha^{-1};
$Area_{(T)}$ – total annual area harvested of crop *T*, ha yr^{-1};
Area burnt $_{(T)}$ – annual area of crop *T* burnt, ha yr^{-1};
C_f – combustion factor (dimensionless);
$Frac_{Renew\ (T)}$ – fraction of total area under crop *T* that is renewed annually;
$R_{AG(T)}$ – ratio of above-ground residues dry matter ($AG_{DM(T)}$) to harvested yield for crop *T* ($Crop_{(T)}$), kg d.m. (kg d.m.)$^{-1}$;
$N_{AG(T)}$ – N content of above-ground residues for crop *T*, kg N (kg d.m.)$^{-1}$;
$Frac_{Remove(T)}$ – fraction of above-ground residues of crop *T* removed annually for purposes such as feed, bedding and construction, kg N (kg crop-N)$^{-1}$;
$R_{BG(T)}$ – ratio of below-ground residues to harvested yield for crop *T*, kg d.m. (kg d.m.)$^{-1}$;
$N_{BG(T)}$ – N content of below-ground residues for crop *T*, kg N (kg d.m.)$^{-1}$;
T – crop or forage type.

Amount of crop by type harvested and area harvested was obtained from Statistics Lithuania. There is no field burning of agricultural residues in Lithuania (Chapter 5.8) therefore assumed to

[97] Komposto, naudojamo žemės ūkyje, kokybės reikalavimų analizė ir įvertinimas. Ataskaita, 2011. 3 lentele, p. 12 (en. *Quality analysis and assessment of comport used in agriculture*. Report, 2011, Table 3, p. 12)
[98] *ibid*
[99] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, eq. 11.6, p. 11.14

be zero. Fraction of crop by type that is renewed is assumed to be 1. Ratio of above-ground residues, ratio of below-ground residues, N content of above-ground residues and N content of below-ground residues were taken as default values for each crop type from *IPCC 2006*[100]. Fraction that is being removed for bedding, feed or construction was assumed to be zero as there is no information available.

Mineralized N resulting from loss of soil organic C stocks in mineral soils (F_{SOM})

The amount of N mineralized from loss in soil organic C in mineral soils through land use change or management practices was estimated using the following equation[101]:

$$F_{SOM} = \sum_{LU} \left[\left(\Delta C_{Mineral,\ LU} \cdot \frac{1}{R} \right) \cdot 1000 \right]$$

where:
F_{SOM} – the net annual amount of N mineralized in mineral soils as a result of loss of soil carbon through change in land use or management, kg N;
$\Delta C_{Mineral,\ LU}$ – average annual loss of soil carbon for each land-use type (LU), tones C;
R – C:N ratio of the soil organic matter;
LU – land-use and/or management system type.

Average annual loss of soil carbon due to land use change or management systems was obtained from LULUCF sector. The C:N ratio values were taken from *IPCC 2006*. Default value of 10 for management systems and 15 for land use change[102].

Area of drained/managed organic soils (F_{OS})

To estimate N_2O emissions from drained/managed organic soils the data on organic soils area of Cropland, Grassland and Forest land were taken from LULUCF sector. Organic forest soils area is further divided in to nutrient rich and nutrient poor soils. This area is than multiplied by emission factors for each land use category: Cropland and Grassland – $EF_{2\ CG,Temp,Org}$ (8 kg N_2O-N/ha); Forest land – $EF_{2F,Temp,Org,R}$ (0.6 kg N_2O-N/ha for nutrient rich soils) and $EF_{2F,Temp,Org,P}$ (0.1 kg N_2O-N/ha for nutrient rich soils). Emission factors were obtained from *IPCC 2006* choosing EF for temperate climate (Table 5-46).

5.6.1.3 Uncertainty and time-series consistency

Activity data uncertainty

It is very difficult to estimate the actual uncertainty of activity data used to estimate direct N_2O emissions from managed soils. Most of uncertainty values were estimated basing on expert assumptions. Activity data uncertainty values are provided in the table below for each sub-category of direct N_2O emissions from managed soils.

Table 5-49. Uncertainty values for each direct N_2O emissions from managed soils sub-category

Activity data	**Uncertainty value**
Consumption of Synthetic N fertilizers	±15%
Manure N applied to soils	±20%
Sewage sludge N applied to soils	±30%
Compost N applied to soils	±15%

[100] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, Table 11.2, p. 11.17
[101] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, eq. 11.8, p. 11.16
[102] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, p. 11.16

N deposited on pasture, range and paddock by grazing animals	±20%
N returned to soil by crop residues, including N-fixing crops and forage/pasture renewal,	±30%
Mineralization associated with loss of soil organic matter	±10%
Drained/managed organic soils	±10%

Emission factor uncertainty

For the *Tier 1* method there is a larger uncertainty range for the default factors. For *Tier 1* method uncertainty of N_2O EF were estimated basing on EF uncertainty range: EF_1 – ±135%; $EF_{2\ CG,\ Temp}$ – ±137.5%; $EF_{2F,\ Temp,\ Org,\ R}$ – ±66.7%; $EF_{2F,\ Temp,\ Org,\ P}$ – ±140%; $EF_{3PRP,\ CPP}$ – ±132.5%; $EF_{3PRP,\ SO}$ – ±135%.

5.6.1.4 Category-specific QA/QC and verification

General quality control procedures where applied estimating direct N_2O emissions from managed soils: analysis of activity data trends, consistency check of calculated emissions and imported data to CRF reporter, consistency check of activity data sources, completeness check and etc.

5.6.1.5 Category-specific planned improvements

Lithuania is planning to collect more accurate data (updated data) on consumption of compost applied to agricultural land, more accurate data on sewage sludge applied as soil amendment (updated data) in 2013 and content of N in sewage sludge. It is also planned to improve calculations of N_2O from crop residues including N-fixing crops employing more country specific data.

5.6.2 Indirect N_2O emissions from managed soils

5.6.2.1 Category description

In order to estimate indirect N_2O emissions from managed soils the following sources where included: application of synthetic N fertilizers, organic N fertilizers, urine and dung N deposited on pasture, range and paddock by grazing animals, N in crop residues, including N-fixing crops and forage/pasture renewal returned to soils, and N mineralization associated with loss of soil organic matter resulting from change of land use or management on mineral soils. N_2O emissions occurs from the volatilization of N as NH_3 and oxides of N (NOx), and the deposition of these gases and their products NH_4^+ and NO_3^- onto soils and the surface of lakes and other waters, and leaching and runoff from land of N from different N input sources mentioned above.

5.6.2.2 Methodological issues

Both volatilization and leaching and run-off N_2O emissions were estimated using *Tier 1* method. Default emission factors and fraction values from *IPCC 2006* were used (Table 5-50).

Table 5-50. Default EF and fraction values used to estimate indirect N_2O emissions from managed soils

Parameter	Value
EF_4 (N volatilization and re-deposition), kg N_2O–N (kg NH_3–N + NOx–N volatilized)$^{-1}$	0.010
EF_5 (leaching / runoff), kg N_2O–N (kg N leaching / runoff)$^{-1}$	0.0075

$Frac_{GASF}$ (Volatilization from synthetic fertilizer], (kg NH_3–N + NOx–N) (kg N applied)$^{-1}$	0.10
$Frac_{GASM}$ (Volatilization from all organic N fertilizers applied , and dung and urine deposited by grazing animals), (kg NH_3–N + NOx–N) (kg N applied or deposited)$^{-1}$	0.20
$Frac_{LEACH-(H)}$ (N losses by leaching/runoff for regions where Σ(rain in rainy season) - Σ(PE in same period) > soil water holding capacity, OR where irrigation (except drip irrigation) is employed), kg N (kg N additions or deposition by grazing animals)$^{-1}$	0.30

Atmospheric deposition of N volatilized from managed soils

N_2O emissions from atmospheric deposition of N volatilized from managed soil were estimated using the following equation[103]:

$$N_2O_{(ATD)} - N = \left[(F_{SN} \cdot Frac_{GASF}) + \left((F_{ON} + F_{PRP}) \cdot Frac_{GASM}\right)\right] \cdot EF_4$$

where:
$N_2O_{(ATD)}$–N – annual amount of N_2O–N produced from atmospheric deposition of N volatilized from managed soils, kg N_2O–N yr^{-1};
F_{SN} – annual amount of synthetic fertilizer N applied to soils, kg N yr^{-1};
$Frac_{GASF}$ – fraction of synthetic fertilizer N that volatilizes as NH_3 and NOx, kg N volatilized (kg of N applied)$^{-1}$ (Table 5-50);
F_{ON} – annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N yr^{-1};
F_{PRP} – annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr^{-1};
$Frac_{GASM}$ – fraction of applied organic N fertilizer materials (F_{ON}) and of urine and dung N deposited by grazing animals (F_{PRP}) that volatilizes as NH_3 and NOx, kg N volatilized (kg of N applied or deposited)$^{-1}$ (Table 5-50);
EF_4 – emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, (kg N–N_2O (kg NH_3–N + NOx–N volatilized)$^{-1}$) (Table 5-50).

N leaching and run-off from managed soils

N_2O emissions from N leaching and run-off from managed soil were estimated using the following equation[104]:

$$N_2O_{(L)} - N = (F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}) \cdot Frac_{LEAC-(H)} \cdot EF_5$$

where:
$N_2O_{(L)}$–N – annual amount of N_2O–N produced from leaching and runoff of N additions to managed soils in regions where leaching/runoff occurs, kg N_2O–N yr^{-1};
F_{SN} – annual amount of synthetic fertilizer N applied to soils, kg N yr^{-1};
F_{ON} – annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N yr^{-1};

[103] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, eq. 11.9, p. 11.21
[104] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, eq. 11.10, p. 11.21

F_{PRP} – annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr^{-1};
F_{CR} – amount of N in crop residues, including N-fixing crops, and from forage/pasture renewal, returned to soils annually in regions where leaching/runoff occurs, kg N yr^{-1};
F_{SOM} – annual amount of N mineralized in mineral soils associated with loss of soil C from soil organic matter as a result of changes to land use or management in regions where leaching/runoff occurs, kg N yr^{-1};
$Frac_{LEACH-(H)}$ – fraction of all N added to/mineralized in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff, kg N (kg of N addition)$^{-1}$ (Table 5-50);
EF_5 – emission factor for N_2O emissions from N leaching and runoff, kg N–N_2O (kg N leached and runoff)$^{-1}$ (Table 5-50).

5.6.2.3 Uncertainty and time-series consistency

Activity data uncertainty

Same data as used in category direct N_2O emissions are applied in category indirect N_2O emissions from managed soils. Uncertainty for activity data of category Atmospheric deposition – ±20%; Nitrogen Leaching and Run-off – ±20%.

Emission factor uncertainty

For the *Tier 1* method there is a larger uncertainty range for the default factors. For *Tier 1* method uncertainty values of indirect N_2O EF were estimated basing on EF uncertainty range: EF_4 – ±240%; EF_5 – ±163.3%.

5.6.2.4 Category-specific QA/QC and verification

General quality control procedures where applied estimating indirect N_2O emissions from managed soils: analysis of activity data trends, consistency check of calculated emissions and imported data to CRF reporter, consistency check of activity data sources, completeness check and etc.

5.6.2.5 Category-specific planned improvements

Improvements planned in category direct N_2O emissions from managed soils will be applied to category indirect N_2O emissions.

5.7 Prescribed burning of savannas (CRF 3.E)

Savannas do not exist in Lithuania therefore emission from prescribed burning of savannas is reported as "NO".

5.8 Field burning of agricultural residues (CRF 3.F)

Field burning of agricultural residues is prohibited by the legislation (Order of the Minister of Environment No 269 concerning the environmental protection requirements for burning of dry grass, reeds, straw and garden waste as amended, In force from September 9, 1999)[105], therefore emission from field burning of agricultural residues is reported as "NO".

[105] LR aplinkos ministro 1999 m. rugsėjo 1 d. įsakymas Nr. 269 „Dėl Aplinkos apsaugos reikalavimų deginant sausą žolę, nendres, šiaudus bei laukininkystės ir daržininkystės atliekas patvirtinimo" / Valstybės Žinios, 1999, Nr. 75-2284,aktuali akto redakcija, galiojanti nuo 2010 07 04

5.9 CO_2 emissions from liming (CRF 3.G)

5.9.1 Category description

Starting with 30s in Lithuania, like in most of the Europe, intensive analysis on liming standards and soils had started. Technique on liming dust spreading in Lithuania was established in 70s based on scientific research and systematic analysis of soil liming. Following this in 80s every year around 200 thousand ha of acid soils were limed. However in the first years of independence (early 90s) liming was almost suspended due to lack of energetic resources. Later liming was restricted due to lack of financial resources. In mid 90s only 1/10 of acid soils were limed[106].

There are a lot of studies and scientific research conducted analyzing efficiency of different liming products, impact on soil pH, fertility and other parameters. Unfortunately there are no official data sources that collect data on limestone or dolomite consumption in Lithuania. For this reason data was collected from the major companies that sell liming products. These products include special fertilizers for soil liming, by-products of production or waste products that are generated during production process. Major providers of liming products are companies that operate quarries and extracts constructions material (crashed stones, granite, limestone etc.). Other providers of liming products are sugar producers. During production of sugar the lime mud is generated as a waste product which is later on used as a liming product for acid soils.

The data provided by the companies varied in time period as it depends on the year when companies began to produce products for soil liming. The actual data for soil liming products used is available for the period 1993-2013 (data provided by the companies). However the period 1990-1992 is not fulfilled with data that's why assumptions were made basing on the literature and expert judgement.

As mentioned above after the independence liming drastically reduced due to lack of financial and technical resources. Before the 90s liming had exceeded 200 thous. ha per year and was aiming to reach 270 – 300 thous. ha per year. The standard rate was also growing and reached 4,5 t/ha (straight $CaCO_3$) during 70s and early 80s[107]. The extant of area limed in early 90s was estimated to be around 10,4 thous. ha. Basing on this information and standard rate of 4,5 t/ha estimates for the period 1990-1992 were calculated in order to fulfil the data gap.

The figure below shows trend of CO_2 emissions from liming of agricultural soils. As emissions depend on the quantity of liming products consumed it has a direct link to the assumption of data availability. Data provided by the company varies through the time period and is strongly related to the economic factors e.g. economic crisis, demand of construction material, production of sugar etc.

[106] Ežerinskas, V. Kalkinės medžiagos ir kalkinimas (en. *Liming products and liming*). Lietuvos žemdirbystės institutas, 1999. ISBN 9986-527-60-0

[107] Knašys, V. Dirvožemių kalkinimas (en. *Soil liming*). Mokslas, 1985

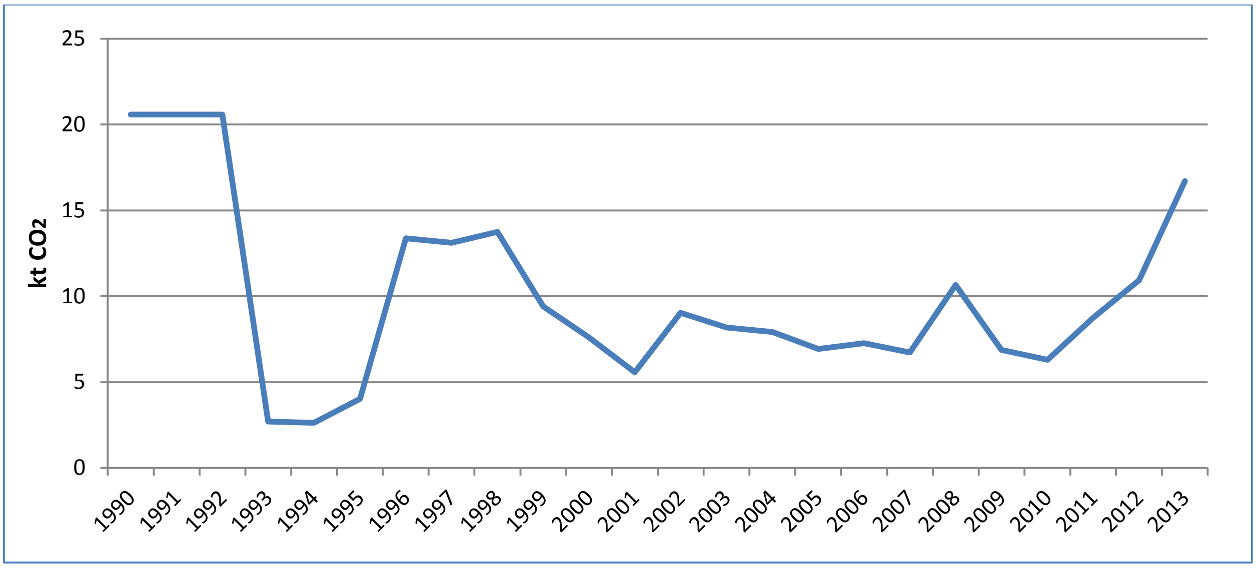

Figure 5-15. CO_2 emissions from application of liming products in agricultural lands

5.9.2 Methodological issues

Estimating CO_2 emission from agricultural soils liming it was very important to know the actual percentage of $CaCO_3$ + $MgCO_3$ in product used for liming. Other important parameter is the dry matter of product as some products (e.g. lime mud) contains high percentage of humidity.

Depending on data availability and analysis done companies provided data on main parameters which were used in calculations. The following equation was used to estimate the annual amount of calcic limestone ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$):

$$M_{Limestone\ or\ dolomite} = M_{Product} \cdot \frac{C}{100} \cdot \frac{DM}{100}$$

where:

$M_{Limestone\ or\ dolomite}$ – amount of calcic limestone ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$), tonnes d.m. yr^{-1};

$M_{Product}$ – amount of product used for soil liming, tonnes yr^{-1};

C – amount of $CaCO_3$ + $MgCO_3$ in the product, %;

DM – dry matter of product used for soil liming, %.

The main parameters of liming products that were used for soil liming are provided in Table 5-51.

Table 5-51. Parameters used for estimation of CO_2 emissions from liming

Parameter	Dolomite	Cement dust	Limestone	Crushed limestone	Lime mud
	%				
$CaCO_3$ + $MgCO_3$	86,9 - 98,4	76,2 - 82,4	95 - 97	90*	77,5* - 83,9
Average	**92,6**	**79,3**	**96**	**90**	**80,7**
Dry matter	78,2 – 98,6	98,5 – 99	98,5*	90*	40 – 67
Average	**88,4**	**98,7**	**98,5**	**90**	**53,5**

* Theoretical recommended value[108]

[108] Ežerinskas, V. Kalkinės medžiagos ir kalkinimas (en. *Liming products and liming*). Lietuvos žemdirbystės institutas, 1999. ISBN 9986-527-60-0

CO_2 emissions from additions of limestone or dolomite to agriculture soils are calculated using equation[109]:

$$CO_2 - C\ Emissions = (M_{Limestone} \cdot EF_{Limestone}) + (M_{Dolomite} \cdot EF_{Dolomite})$$

To convert CO_2-C emissions to CO_2 emissions the amount was multiplied by 44/12.

5.9.3 Uncertainty and time-series consistency

Activity data uncertainty

The main activity data used for calculations was lime and dolomite consumption for agricultural land liming. All data was collected from the main distributors of liming products with data indicated dry matter content and $CaCO_3$ + $MgCO_3$ content in the product based on laboratorial measurements. Knowing that not necessary all amount of sold liming products were used at the year they were sold and also knowing that there could be some other products in the market assumption was made that uncertainty of activity data is ±10%.

Emission factor uncertainty

Uncertainty of EF is ±50% as given in *IPCC 2006*[110].

Overall uncertainty

Combined uncertainty was calculated using *2006 IPCC* eq. 3.1[111]. This approach requires uncertainty values of the main activity data used and uncertainty of emission factor. Combined uncertainty for CO_2 emissions from liming was estimated to be ±51%.

5.9.4 Category-specific QA/QC and verification

General quality control procedures where applied estimating CO_2 emissions from liming of soils: analysis of activity data trends, consistency check of calculated emissions and imported data to CRF reporter, consistency check of activity data sources, completeness check and etc.

5.9.5 Category-specific planned improvements

No specific improvements are currently planned.

5.10 CO_2 emissions from urea application (CRF 3.H)

5.10.1 Category description

Emissions from urea application in agricultural soils constituted 15.72 kt /CO_2. It is around 0.4% from the total emissions originating from agriculture sector.

5.10.2 Methodological issues

As there is now national data source for consumption of synthetic N fertilizers is available the data was obtained from database of IFA. This database gives consumption of synthetic N fertilizers for the whole time period (1990-2012) and consumption of synthetic N fertilizers by type since 2008 including data on consumption of urea. Data on consumption of urea during the

[109] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, eq. 11.12 p. 11.27
[110] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, p. 11.27
[111] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 3, eq. 3.1, p. 3.28

period 2005-2007 was taken from the study on fertilizers[112]. The gap of data for the period 1990-2004 was filled by taking average percentage of urea in total amount of synthetic N fertilizers. This percentage on average was 10.7%.

CO_2 emissions from urea fertilization were estimated using the following equation[113]:

$$CO_2 - C\ Emission = M \cdot EF$$

where:
CO_2–C Emission – annual C emissions from urea application, tonnes C yr^{-1};
M – annual amount of urea fertilization, tonnes urea yr^{-1};
EF – emission factor, tonnes of C (tonnes of urea)$^{-1}$.

Emission factor of 0.20 for urea was applied[114]. Estimated CO_2–C emissions multiplied by 44/12 to convert CO_2–C emissions into CO_2.

5.10.3 Uncertainty and time-series consistency

Activity data uncertainty

Main activity data is consumption of urea fertilizer. As most of the data was obtained based on assumptions the uncertainty value for activity data was assumed to be around ±30%.

Emission factor uncertainty

Uncertainty of EF is ±50% as given in *IPCC 2006*[115].

Overall uncertainty

Combined uncertainty was calculated using *2006 IPCC* eq. 3.1[116]. This approach requires uncertainty values of the main activity data used and uncertainty of emission factor. Combined uncertainty for CO_2 emissions from urea application was estimated to be ±58.3%.

5.10.4 Category-specific QA/QC and verification

General quality control procedures where applied estimating CO_2 emissions from urea application to soils: analysis of activity data trends, consistency check of calculated emissions and imported data to CRF reporter, consistency check of activity data sources, completeness check and etc.

5.10.5 Category-specific planned improvements

No specific improvements are currently planned.

[112] Taikomojo mokslinio tyrimo „Lietuvos ūkyje naudojamų trąšų analizė ir pasiūlymai dėl nacionalinio reglamentavimo pakeitimų, atsižvelgiant į agrochemijos, saugumo ir sveikatos reikalavimus" ataskaita (en. *Analysis on fertilizers used in Lithuanian and recommendations in pursuance of changes in national legislation, taking in to account agrochemical, safety and health requirements*). Lietuvos agrarinių ir miškų mokslo centro agrocheminių tyrimų laboratorija, Kaunas, 2010
[113] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, eq. 11.13 p. 11.32
[114] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, p. 11.32
[115] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, p. 11.32
[116] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 3, eq. 3.1, p. 3.28

6 LAND USE, LAND-USE CHANGE AND FORESTRY (CRF 4)

6.1 Overview of LULUCF

Land Use, Land Use Change and Forestry (LULUCF) sector in Lithuania is of most importance as it has been constantly acting as a sink during two periods of time: 1990-1995 and 1998-2013 (Figure 6-1). Only in 1996-1997 LULUCF sector was emitting more greenhouse gases than absorbing. Severe storms followed by beetles invasions and other calamities had a huge impact on CO_2 emissions, especially from forest land. However, LULUCF sector over the last few years in average has removed 10 million tonnes of CO_2. The sink in the last few years was nearly 50% of the total national emissions, if including LULUCF.

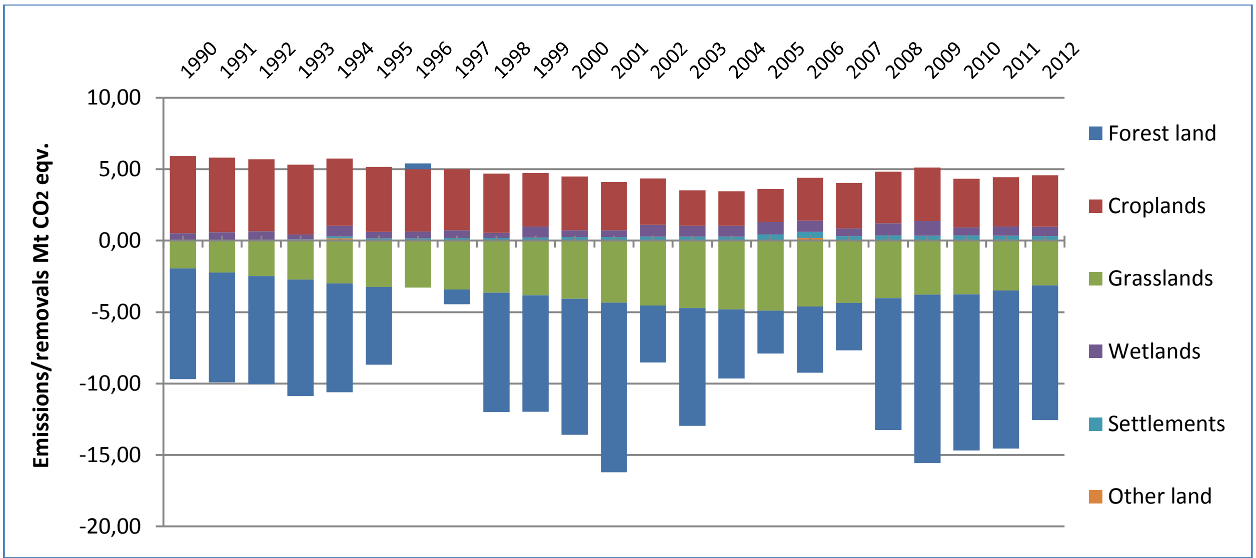

Figure 6-1. Net CO_2 eqv. emissions and removals from LULUCF sector during the period 1990-2013 by land use category.

The positive values shows emissions and negative – removals

Lithuania has improved and made its reporting system of greenhouse gases from LULUCF sector more transparent, consistent over time, complete and comparable since 2011 when practically new accounting and reporting system has been built up and today has a clear subordination among data providers and executors. There are several organizations and data providers responsible for provision of the official data related to LULUCF reporting in Lithuania. These organizations and data providers are presented below:

- **National Land Service** (*NLS*) under the Ministry of Agriculture[117] provides data on Lithuanian Land Fund – all private, state owned and belonging to municipalities land on Lithuanian territory. Data is distributed between relevant reporting land use categories.
- **Lithuanian State Forest Cadastre** (*LSFC*) managed by **State Forest Service** (*SFS*) provides up to date information associated with registered areas of forest land and detail information about all forest holdings regardless their ownership[118].
- **National Forest Inventory** (*NFI*)[119] executed by SFS provides objective and known accuracy data associated with forest land, forest land use and forest resources (growing stock volume,

[117] Available from: *http://www.nzt.lt/go.php/lit/English*
[118] Available from: *http://www.amvmt.lt*
[119] Available from: *http://www.amvmt.lt*

annual increment, felling, dead wood and etc.). Information for this dataset is collected by using unique sampling technique already since 1998. Data presented by NFI is used for monitoring and reporting of land use and land use changes under the Convention requirements as a continuation of the implemented Studies that were conducted in order to gather missing historical information (see Chapter 6.1.1. for description).

Official statistics on relevant land use categories and their changes in Lithuania are provided by:

- **Statistics Lithuania** publishes all statistical information in their annual publications "Statistical Yearbook of Lithuania" and provides numerical statistical databases on their website[120].
- Statistical data about Lithuanian forests and forestry related issues are published in annual reports "Forest assessment", annual publications – "Lithuanian Statistical Yearbook of Forestry", periodical publications of NFI and National forest resources assessment (*FRA*) reports[121].
- **National Land Service** (*NLS*) publishes annual statistical information on all land use categories in Lithuania in publication "Land Fund of the Republic of Lithuania"[122].

To ensure transparency, consistency, comparability, completeness and accuracy of the greenhouse gas accounting and reporting from LULUCF sector, several legal acts were adopted or amended in order to establish background connections between different institutions, providing data for greenhouse gas accounting:

- **Resolution on forest land conversion to other land and compensation for converted forest land** / Government resolution – regulates human induced conversion of forest land to other land and compensation for the lost forest land.
- **Regulation on National forest inventory by sampling method** / Amendment of the Order of the Minister of Environment – launches country wise sample based monitoring of all land use and land use changes.
- **Harmonised principles for data collection and reporting on LULUCF** / *Order of the Minister of Environment* – sets the main principles for data collection and reporting on LULUCF.
- **Rules for afforestation of non-forest land** / *Amendment of the Minister of Environment and Minister of Agriculture* – determines human induced afforestation/reforestation registration routines.
- **Inventory and registration of natural afforestation of non-forest land** / *Order of the Minister of Environment and Minister of Agriculture* – determines natural afforestation/reforestation inventory and assessment routines.
- **Regulation on State Forest Cadastre** / *Amendment of the Government resolution* – sets State Forest Cadastre as the main data provider for KP LULUCF.
- **Harmonized methodology for GHG emissions and removals accounting under LULUCF** / *Order of the Minister of Environment and Minister of Agriculture* – sets the main requirements for data collection and accounting of greenhouse gases emissions and removals under LULUCF.

[120] Available from: *http://www.stat.gov.lt/en/*
[121] Available from: *http://www.fao.org/forestry/fra/en/*
[122] Available from: *www.zis.lt/download.php/fileid/77*

These acts are constantly amended or substituted following the new requirements adopted by United Nations Framework Convention on Climate Change (UNFCCC) or EU legislation or introducing new improved methodologies for estimation of greenhouse gases emissions and removals from LULUCF sector.

Following the requirements of 2006 IPCC Guidelines for National Greenhouse Gas Inventories (*IPCC 2006*) provision of official statistics since 2012 has been improved substantially, and associated land-use area changes were assessed, constantly monitored and revised, using unique net of permanent sample plots of NFI:

1) For the period 1990-2011 results are presented using data of the studies conducted;
2) Since 2012 all data concerning land use, land use changes is based on direct annual field measurements executed by NFI.

Data sources that have been used until 2012 for determination of the total land area and for monitoring its changes were not harmonised between themselves and data presented was not always precise or did not fulfil the requirements of the UNFCCC. Most of the results were fragmented and did not fully covered the required period starting with the base year 1990. Due to different inventory methodologies and definitions of land use categories for each inventory, the presented results not only did not comply but in some cases even contradicted each other. Furthermore, land use definitions used by official statistics, on which basis land area was estimated, did not comply with the previously used *IPCC 2003* nor with current *IPCC 2006* guidelines (Table 6-5). For instance, meadows and natural pastures were assigned to croplands in national definition, though it comes under grassland category under IPCC definition. Therefore, implementing UNFCCC and its Kyoto Protocol requirements in order to comprehensively identify and quantify areas specific to LULUCF activities annually in the period of 1990-2011, two studies were launched. The study "*Forest land changes in Lithuania 1990-2011*" (*Study-1*) was addressed to recover land use changes specifically to forests and study "*Changes of areas of Croplands, Grasslands, Wetlands, Settlements and Other lands in Lithuania during 1990-2011*" (*Study-2*) – was addressed to track changes of croplands, grasslands, wetlands, settlements and other lands. Thus, by implementing these studies Lithuania became able to identify land use areas and to monitor their changes for the whole time series starting with 1990. The main differences of these two studies comparing with the previous practice was recalculation of all area changes (and construction of yearly land transition matrix) using single data collection instrument – uniform network of *NFI* (launched in 1998) permanent sample plots and secondly – building all the computations and assumptions based on the data, directly collected from the individual plots. Therefore, one of the fundamental outcomes of these two studies was creation of a single and comprehensive database of land use areas in Lithuania (Figure 6-2).

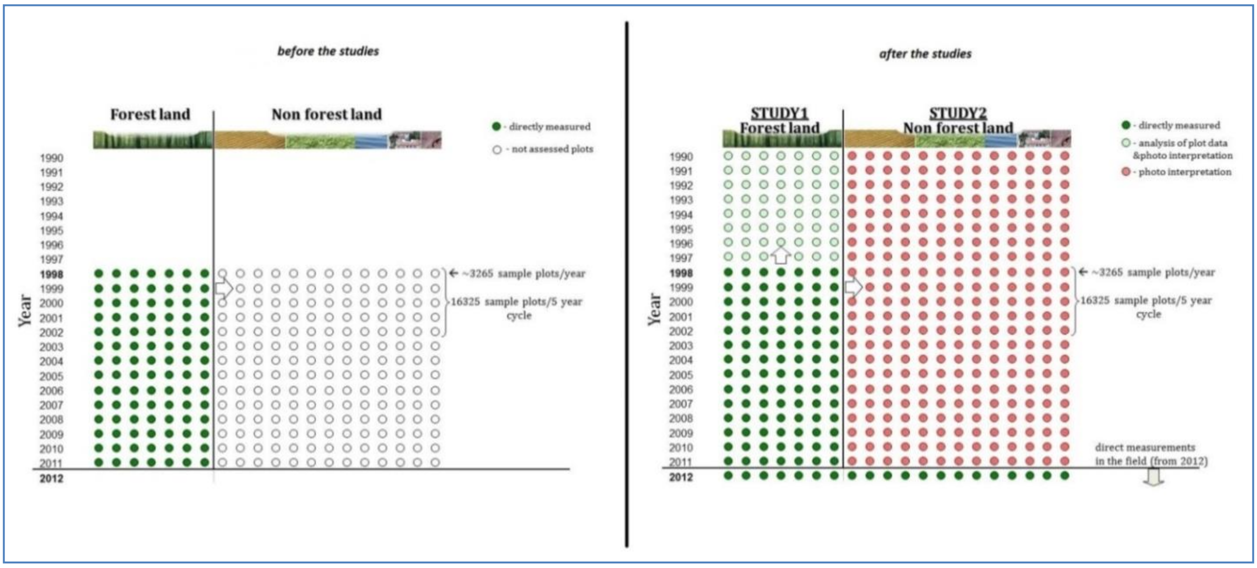

Figure 6-2. Data owned for the assessment of land-use changes before the studies (*NFI* data since 1998) and assessment of the land-use changes on *NFI* sample plots grid after implementation of the studies for the period 1990-2011.

Filled dots represent data that was owned before/after the studines

Furthermore, with the help of GIS techniques, analysing historical datasets of *LSFC*, aerial photography archives, provided by *SLF* and other available material, wall-to-wall areas of afforestation, reforestation and deforestation activities were mapped, identified and classified during the conduction of *Study-1*.

According to *NLS* data total land area of Lithuania is 6530 thous. ha, forest land occupy 32.6%, croplands – 45.7%, grasslands – 7.3%, wetlands – 5.8%, settlements and other land covers 4.8% and 3.8% respectively, for the date 01.01.2014. According to *NFI* data, total land area is 6530 thous. ha. Forest land occupy 33.5%, croplands – 32.6%, grasslands – 23.1%, wetlands – 5.2%, settlements – 5.3% and other land – 0.2% of the total land area in Lithuania (Figure 6-3).

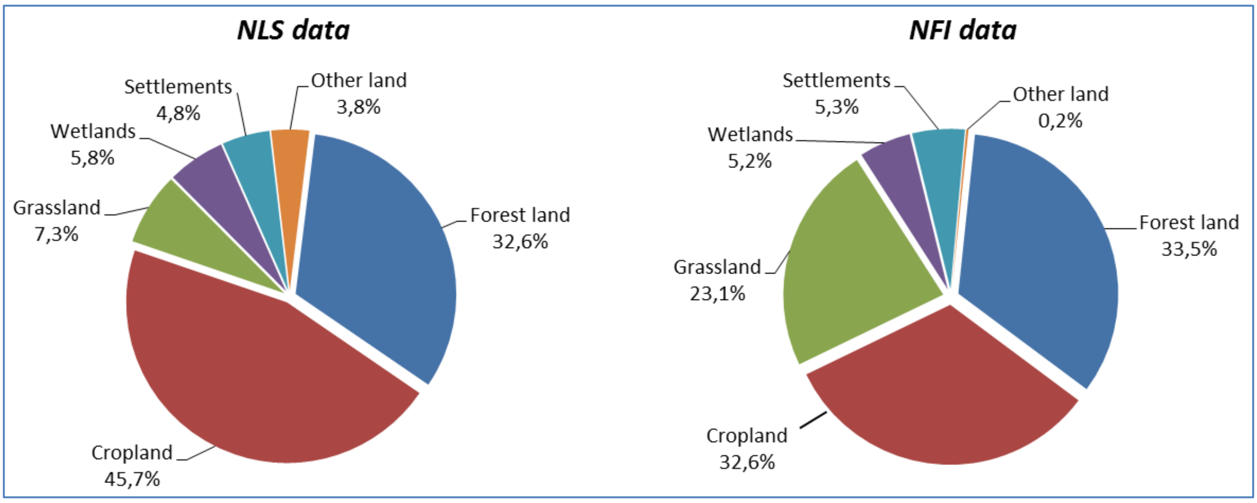

Figure 6-3. Comparison of land-use categories presented by *NLS* and latest *NFI* data. 01.01.2014

Differences between *NLS* and *NFI* data are caused by different definitions of land use categories. *NLS* uses National definitions while *NFI* data on land uses is based on those required by UNFCCC and described in IPCC. For the greenhouse gas reporting *NFI* data on total land area has been distributed among relevant land use categories.

Several emission sources in the LULUCF sector are identified as key categories. They are listed in Table 6-2 (Level and Trend assessment).

Table 6-1. Key category from LULUCF in 2013

IPCC Category	***Greenhouse gas***	***Identification criteria***
4.A Forest land-4(II) organic soils	CO_2	L1,L2,T1,T2
4.A.1 Forest land remaining forest land - carbon stock change in biomass	CO_2	L1,L2,T1,T2
4.A.1 Forest land remaining forest land - net carbon stock change in dead wood	CO_2	T1,T2
4.A.2 Land converted to forest land - carbon stock change in biomass	CO_2	L1,L2,T1,T2
4.A.2 Land converted to forest land - net carbon stock change in litter	CO_2	L1,L2,T1,T2
4.B.1 Cropland remaining cropland - net carbon stock change in mineral soils	CO_2	T1,T2
4.B.1 Cropland remaining cropland - net carbon stock change in organic soils	CO_2	L1,L2, T2
4.B.2 Land converted to cropland - net carbon stock change in mineral soils	CO_2	L1, L2,T2
4.B.2 Land converted to cropland- carbon stock change in biomass	CO_2	L1,L2,T1,T2
4.C.2 Land converted to grassland - net carbon stock change in mineral soils	CO_2	L1,L2,T1,T2
4.D.1 Wetlands remaining wetlands -net carbon stock change in organic soils	CO_2	L1, L2,T1,T2
4.E.2 Land converted to settlements	CO_2	L1,L2,T1,T2
4.G Harvested wood products	CO_2	L1,L2,T1,T2

6.1.1 Study "*Forest land changes in Lithuania during 1990-2011*" (*Study-1*)

The *Study-1* was carried by the team of experts of Aleksandras Stulginskis University (former Lithuanian University of Agriculture) together with *NFI* experts and Lithuanian Association of Impartial Timber Scalers. The *Study-1* was completed in the middle of April of 2012 and explicit study results were presented in the final report[123].

The *Study-1* was split into two parts and was aimed: (a) to identify annual forest land areas and their changes which occurred in Lithuania during the period of 1990-2011, following the *IPCC 2003* (which is now in line with *IPCC 2006*) and the requirements of UNFCCC on the unique permanent sample plots grid of *NFI*, and (b) to achieve the annual wall-to-wall mapping of afforested, reforested and deforested land areas following requirements of the UNFCCC and its Kyoto Protocol (Figure 6-7).

Forest land areas and their changes that were identified (annually in 1990-2011):

- forest land remaining forest land areas (*FF*);
- forest management areas (*FM*);
- forest land areas converted to forest land less than 20 years ago (*LF*);
- human induced afforested/reforested areas – where forest was growing before the afforestation for at least 50 years (*A1*), and where forest was growing before the reforestation for at least 50 years (*R1*) but ceased to be forest on 31 December 1989 and then converted (afforested/reforested) to forest;
- naturally afforested/reforested areas, where forest was growing before the afforestation for at least 50 years (*A2*), and where forest was growing before the reforestation for at

[123] Darbo *„Miško žemės plotų kaitos Lietuvoje 1990-2011 m. įvertinimas"* ataskaita [en. Study *„Estimation of forest land changes in Lithuania during 1990-2011"*, report] / Lietuvos nepriklausomų medienos matuotojų asociacija, Akademija, Kauno r., 2012. 100 p.

least 50 years (*R2*), but ceased to be forest on 31st December 1989 and then converted (afforested/reforested) to forest;

– deforested areas (*D*).

To have a clear view on the forest land situation 50 years ago, GIS database was developed to store boundaries of forest land in around 1950's. Orthophotos based on the aerial photographs mainly from 1946-1949 were used as the basic source material. Orthophotos were scanned, geo-referenced and the borders of forest land were manually digitized. The scale of orthophotos was 1:10°000, simultaneously; the developed database was meeting the requirements of mapping at a scale 1:10°000. In that sense, this data base is fully compatible with the geographic database of forest compartments kept at *SFC* and integrally with existing databases fits for the analysis of forest land area changes. Some gaps with missing orthophotos (mainly for country borderland and city areas) were filled using other map material, compatible in terms of scale, development date and content. Most of such maps were Soviet time topographic maps, but there were also German, Polish, US military maps used for some areas. The developed database was crosschecked for any topological errors, like overlapping of polygons, gaps, etc. In addition to forest land, the database includes polygons identified as wooded areas on peat lands, city forests and parks, etc.

Further, annual identification of forest land covers and forest land-uses was carried out on 16325 systematically distributed *NFI* sample plots, focusing on the period of 1990-2011 and using the definitions of valid versions of Lithuanian Forest Law and *IPCC 2003* (which is in line with *IPCC 2006*). All available auxiliary data sets (such as *SFC* data, maps from previous stand-wise forest inventories, topographic maps, orthophotos, satellite images, etc.) with the information gathered during direct field visits were used to facilitate the identification of land cover and land-use categories in a long-term. Data captured in National Forest Inventory databases 1998-2011 were used as well. Stand and tree age, origin of stands, registered in permanent sample plots description cards, combining with cartographical data were the main sources for identification of afforested/reforested stands, especially those possibly appearing in the period of 1990-1998, before the original beginning of *NFI*. All sample plots were manually inspected and the solutions taken were based on the decisions of highly skilled engineers with the forest inventory practice.

To achieve the annual wall-to-wall mapping of forest land areas and to detect changes several types of source material were used: *SFC*, National Paying Agency's (*NPA*) information on afforested agricultural, non-agricultural and abandoned land, Lithuanian forest resource database at a scale of 1:50°000, all available country orthophotos that were developed during the analysed period, satellite maps from CORINE, USGS[124], other projects done by the contractors. The main data source used was the geographic data from the *SFC*. These data sets include borders of all forest compartments in the country (around 1.3 mill polygons) and are associated with the data describing stand characteristics in the compartment. Age of all stands was updated to fit defined datum-line – the year 2011. Then, the year of forest stand becoming forest, according to definition used in Forest Law was estimated, subtracting the age of stand from 2011 (and adding 10 years for naturally regenerated forests). After, the origin of each compartment identifying whether the forest appeared on forest or other (i.e. non-forest) land was checked, two basic and one additional criteria were used: forest was assumed to be grown on non-forest land if it was attributed in a special attribute field as grown on non-forest land. However, such identification was completely dependent on the content and quality of the previous stand-wise forest inventories and there were numerous forest compartments, actually

[124] Available from: *http://earthexplorer.usgs.gov/*

grown on non-forest land, omitted. Therefore, special spatial overlay and selection techniques were developed and applied to identify forests, that are currently available but were missing 50 years ago (according to developed database referring to 1950's). In case of failure ancillary solution how to identify afforestation/reforestation was determined. It was intended to use stand attribute from stand register and posit that forest compartment was first time inventoried during the last stand-wise forest inventory. However, such approach faced some limitations while reflecting established forests, as the *SFC* data was based on the information originating from stand-wise forest inventory. Stand-wise forest inventories in Lithuania are carried on a 10-years cycle basis, thus, there were some regions with quite outdated information on the compartments and missing stands boundaries, established already after the stand-wise inventory. Several solutions were used to fill such gaps of information. Firstly, information from the recent stand-wise forest inventories was acquired from forest inventory contractors, which had not been officially delivered to the *SFS*. Next, all non-forest compartments stored in the *SFC* database were checked for the records on potentially established forests there. Simultaneously, State forest enterprises were asked to confirm the facts of recently established forests. And, finally, data from *NPA* was acquired to represent the borders of afforested areas that were applied for EU subsidies. Special geo-processing technique was developed to eliminate overlapping in space and time of afforested/reforested areas, resulted by repeated identification of considered areas in independent input data sets.

The decision, whether the forest stand detected growing on non-forest land was either afforested or reforested, was taken based on simple spatial queries – verifying presence or absence of the forest land at the certain area in 1950's.

Several techniques were used to detect deforested areas during the last two decades. First of all, deforestation accounted in the *SFC* was taken into account. Recent non-forest land areas, identified as forest stand during the previous forest inventories were also candidates to be assigned to the deforestation category. Next, there were some records in the *SFC* attributed to officially registered deforestation category. And, finally, deforestation was manually mapped using available GIS, orthophotos and satellite images data. It was assumed, that the GIS database of Lithuanian forest resources at a scale of 1:50°000 developed in 1998-1999 represents the year 1990 as it was based on SPOT satellite images from around 1990-1992 and stand-wise forest inventory maps compiled before 1991. The accuracy of forest cover identification in that database was confirmed by the *NFI* to be around 95%. Thus, the differences between the forest covers in the GIS database of Lithuanian forest resources at a scale of 1:50°000 and *SFC* were reasoned by the imperfections of the first data set or the deforestation. All such areas were visually checked and all deforestations were identified using orthophotos available for Lithuania (referring to 4 dates in the period from 1990).

GIS database was developed to store forest land-use polygons, distributed by feature classes, representing forest land remaining forest land (*F1*), forest land remaining forest land, but where forest appeared less than 20 years ago (*F2*), human induced afforestation (*A1*), natural afforestation (*A2*), human induced reforestation (*R1*), natural reforestation (*R2*) and deforestation (*D*). Such feature classes were created to represent each year in the period of 1990-2011.

The *Study-1* (with *Study-2*) report contains an annual forest land-use change table (matrix, Table 6-2) for the period 1990-2011 which fits the requirements of *IPCC 2003* (and also is in line with *IPCC 2006*). The *Study-1* also resulted in enhancement of forest inventory, introducing mandatory registration of all forest compartments fitting the afforestation/reforestation requirements of

IPCC 2003, and the development of GIS based forest cadastre information system following the principles of continuous forest management.

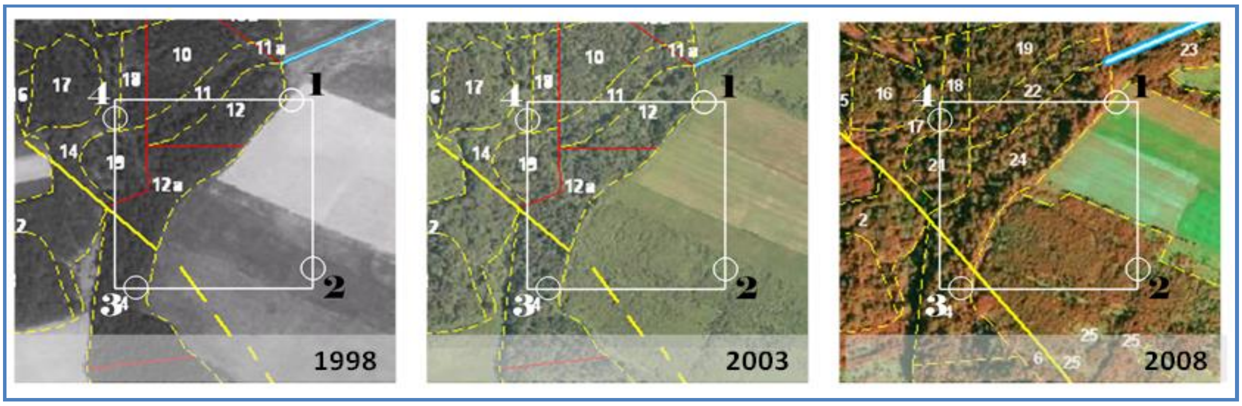

Figure 6-4. Land use changes according to *NFI* data

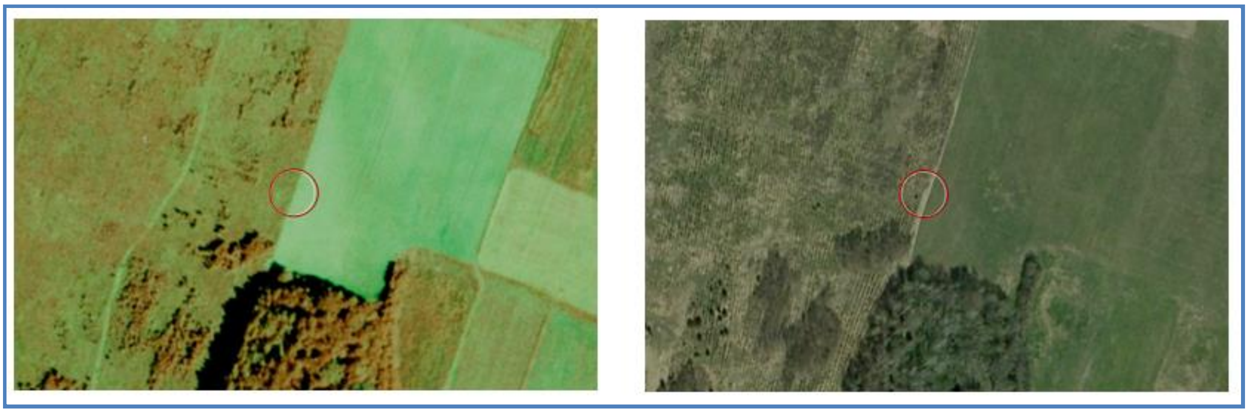

Figure 6-5. Grassland converted to Forest Land

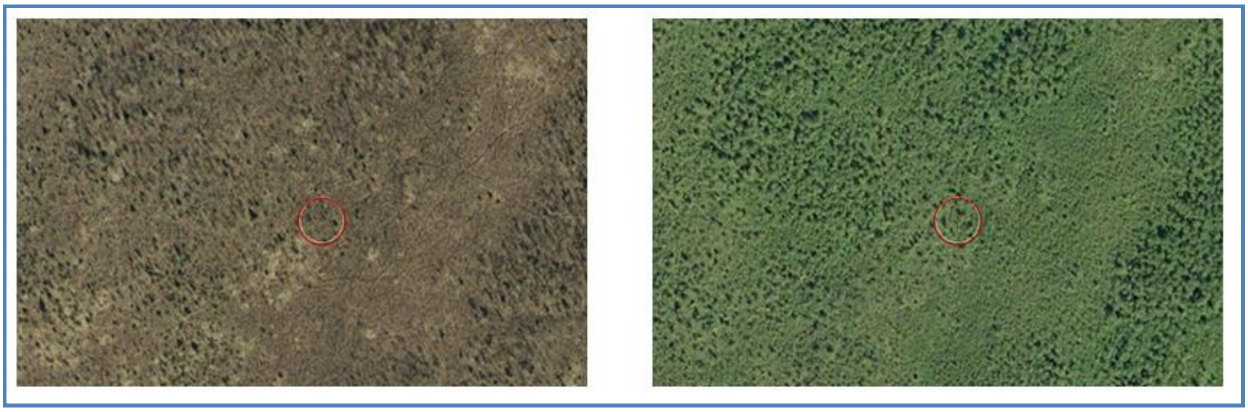

Figure 6-6. Wetland converted to Forest Land

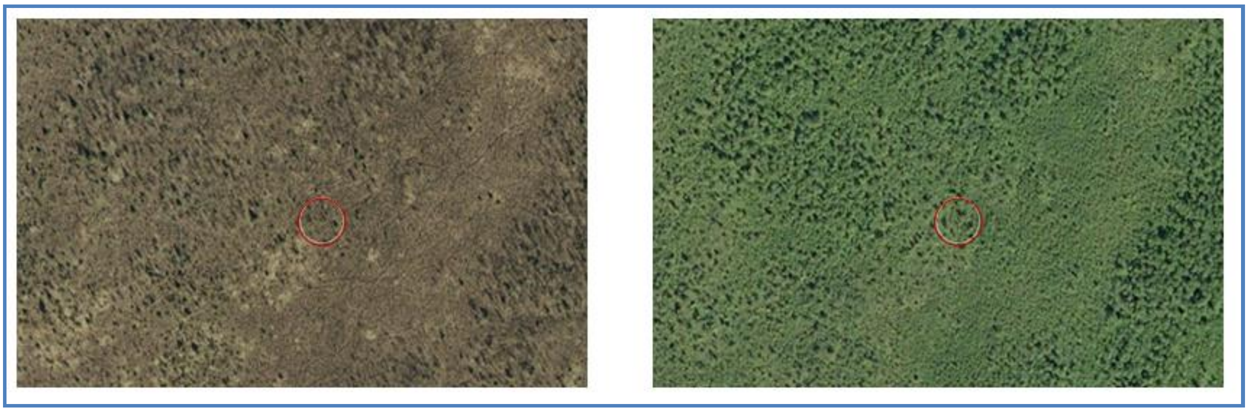

Figure 6-7. Wetland converted to Forest Land

6.1.2 Study "*Changes of areas of Croplands, Grasslands, Wetlands, Settlements and Other lands in Lithuania during 1990-2011*" (*Study-2*)

The *Study-2* was executed by the specialists of *SLF*. The study was completed in the end of April 2012. It was aimed to identify annual Croplands, Grasslands, Wetlands, Settlements and Other land areas and the changes which occurred in Lithuania during the period of 1990-2011, following the requirements of *IPCC 2003* (which are in line with *IPCC 2006*).

Annual identification of different land categories was carried on 16325 systematically distributed sample plots available from Lithuanian *NFI* focusing on the period of 1990-2011. Land use changes were identified analysing all available historical data on land uses in statistical and graphical form as well as assessing historical data collection methods. The following actions were executed:

- analysis of data sources and land use data collection;
- identification of land areas on sample plots;
- compilation of sample plots databases;
- analyses of Croplands, Grasslands, Wetlands, Settlements and Other lands statistical data;
- justification of research methodology and harmonization of applied methods.

The main data sources that were used: land areas analogical inventory plans of 1990; 1995-1998, 2005-2006, 2009-2010 digital orthophotos maps S 1:10°000 (*ORT10LT*), Lithuanian Land Fund statistical data, declaration database of land areas and croplands.

Land areas and their changes were assessed based on NFI sample plots grid and statistical data provided by Land Fund together with digital orthophotos maps, satellite images and declarations database of land areas and croplands. In depth analysis was executed on approximately 11 thous. systematically distributed permanent sample plots falling on non-forest land.

In the course of analysis (with *Study-1*) land-use change matrix (annual change of areas of Croplands, Grasslands, Wetlands, Settlements and Other lands) in Lithuania during 1990-2011 was prepared (Table 6-2). Proposals on land use definitions harmonization used in 1990-2011 and the development of the harmonized methodology for the data evaluation and estimation of removals and emissions for LULUCF sector according to the UNFCCC requirements was elaborated.

Identification of land use categories using different available historical data is presented in Figure 6-8. The same tract of sample plots is depicted in every photo but in different time periods and was assessed by *SLF* experts.

Data sources	NFI permanent plots			
	1	2	3	4
	Land use categories			
Land use plan, 1990	S	CL	GL	CL
Orthophoto map, 1995	S	CL	GL	CL
Orthophoto map, 2005	S	CL	GL	GL
Orthophoto map, 2009	S	CL	CL	GL
Land declaration database, 2010	S	CL	CL	GL

Figure 6-8. Identification of land use changes according to *NFI* permanent sample plots and cartographical data

a – land use plan, 1990; b, c and d – orthophoto maps 1995, 2005, 2009;
e – map according to land declaration database, 2010

The study resulted in the following outputs (on annual bases for the period of 1990-2011):

– area calculations made and land use change matrix prepared (with *Study-1*);
– annual change of Croplands, Grasslands, Wetlands, Settlements and Other lands areas identified;
– report, showing considered land unit changes prepared;
– proposals on land use definitions harmonization and development of the harmonized methodology for the data evaluation and estimation of removals and emissions for LULUCF sector according to the UNFCCC requirements elaborated[125].

As the result of *Study-1* and *Study-2* which are based on point sampling method (*NFI* permanent sample plots net) land transition matrix was compiled for each year for the period of 1990-2011. Since 2012 land use transition matrix is continuously updated using *NFI* data (Table 6-2; Annex VI).

Table 6-2. Yearly land transition matrix for 2013, ha (01.01.2013 - 01.01.2014)

Land category	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	**Final**	**Net change**
Forest land	2184788	799	3595	0	0	0	2189182	**4394**
Cropland	0	2073352	57915	0	0	0	2131267	**17574**
Grassland	0	39142	1467043	399	399	0	1506985	**-25562**
Wetlands	0	0	399	341897	0	0	342297	**0**
Settlements	0	399	3595	0	342297	0	346291	**3595**
Other land	0	0	0	0	0	13979	13979	**0**
Initial	**2184788**	**2113693**	**1532547**	**342297**	**342696**	**13979**	**6530000**	**0**

The summary of methods used for estimation of carbon stock change and GHG emissions/removals reported under the LULUCF sector is presented in Table 6-3.

Table 6-3. Reported emissions/removals and calculation methods for LULUCF sector categories

CRF category	**Stock change reported**	**Emission / removal reported**	**Methods used**
4.A Forest Land	carbon/CO_2	CO_2; N_2O; CH_4	T1; T2
4.B Cropland	carbon/CO_2	CO_2; N_2O; CH_4	T1
4.C Grassland	carbon/CO_2	CO_2; N_2O; CH_4	T1
4.D Wetland	carbon/CO_2	CO_2	T1
4.E Settlement	carbon/CO_2	CO_2	T1
4.F Other Land	carbon/CO_2	CO_2	T1
4.G Harvested Wood Products	carbon/CO_2	CO_2	T1

Reconciliation of the executed studies

Necessity of the studies conducted. Both studies were launched in order to recover land use data since 1990, required by UNFCCC (*Study-2*), and to meet the requirements for the land identification under the Articles 3.3 and 3.4 of the Kyoto Protocol (*Study-1*). This was done considering available data since 1998, based on Lithuanian National Forest Inventory, which has been started at that time, and missing data for the period of 1990-1997 as it is required by UNFCCC and Kyoto Protocol for GHG reporting.

[125] Harmonized methodology for data collection and estimations of emissions and removals of greenhouse gases from LULUCF has been approved by the order of the Ministers of Environment and Agriculture, Nr. D1-819/3D-790 on 2012.10.09.

Initially annual land use and land-use changes identification, which was done on sample plots basis, is a single study divided into two parts seeking to speed up and increase the quality of plots assignment to different land use categories. Connecting element for both studies was uniform *NFI* sample plots grid covering all Lithuanian territory. *NFI* sample plots network was used as a basis for data collection on land use and land-use changes.

Solutions taken. The analysis of *NFI* sample plots could be divided into three steps that were taken by qualified experts. First of all, recorded data on sample plots of *NFI* 1998 has been considered, such as stand characteristics (age, retrieved from tree borings etc.), site description, records on previous land use before the establishment of sample plot etc. Secondly, analysis of all available orthophoto maps and data from *SFC* for the unknown period (1990-1997) has been carried out. This was done trying to trace the exact moment in time when minimal characteristics of forest, as it is required by Law on Forests, were reached. Lastly, analysis of archive land planning maps and *SFI* material was implemented with the aim to identify and to synchronize land use categories with the recorded sample plot data. This analysis of plots, identified on Forest land (~6000) was carried out by SFS together with Aleksandras Stulginskis University and all other plots (~10000) – by Lithuanian Land Fund. After the completion of assignment of all plots available on Lithuanian territory (16325) to different land use categories (FL, CL, GL, WL, SL, OL) by years (1990, 1991, … 2011), final decisions and required calculations were done by *SFS*. Any overlaps were eliminated allowing only one answer (assignment to any land use category) for each plot for each year during the data processing.

The visual comparability of both studies is represented in Figure 6-9.

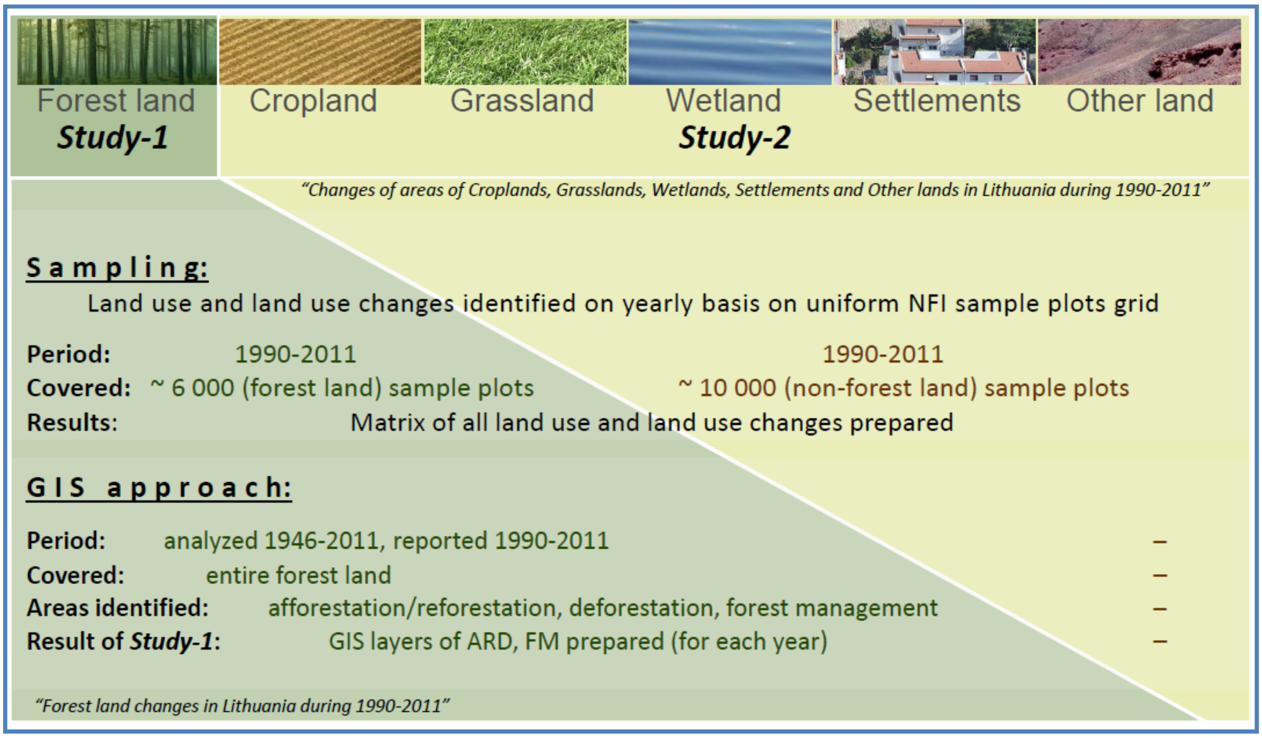

Figure 6-9. Studies on land use changes in 1990-2011

The way forward. Accomplished studies presented required data for the time period of 1990-2011 according to UNFCCC and its Kyoto Protocol requirements. It also encouraged adopting relevant legislation (legal acts were adopted in 2011-2012, see Chapter 6.1), setting the rules, and also obliging, forest owners and managers to register newly afforested, reforested and deforested areas to *SFC*, which is serving as the main data provider for ARD areas identification reported under the Kyoto Protocol from 2012.

6.1.3 National definitions of all categories used in the inventory

Even though requirements for greenhouse gas inventories methodology has changed, obliging parties to use *IPCC 2006* instead of previously used *IPCC 2003* Guidance, but this had no impact on the definitions of land use categories that Lithuania has been constantly using since the beginning of the inventory nor to the area estimations. The land areas used in this inventory are consistent with those defined in *IPCC 2006* as they are consistent with *IPCC 2003*. However, some of the national definitions of land-use areas are broader than those required by Good Practice Guidance so they were merged to fit *IPCC 2006* (Table 6-5).

Forest land is defined according to the Law on Forests of the Republic of Lithuania[126]. Forest – is a land area not less than 0.1 hectare in size covered with trees, the height of which in a natural site in the mature age is not less than 5 meters, other forest plants as well as thinned or vegetation-lost forest due to the acts of nature or human activities (cutting areas, burnt areas, clearings). Tree lines up to 10 meters of width in fields, at roadsides, water bodies, in living areas and cemeteries or planted at the railways protection zones as well as single trees and bushes, parks planted and grown by man in urban and rural areas are not defined as forests. The procedures for care, protection and use of these plantings shall be established by the Ministry of Environment. Forest stands with stocking level (approximately equivalent to crown cover) less than 30% are not acceptable for high productivity forestry. This threshold is used when including land areas into afforested land areas (Table 6-4).

Table 6-4. Selected parameters defining forest in Lithuania for reporting under LULUCF

Parameter	Value
Minimum land area	0.1 ha
Minimum crown cover	30%
Minimum height at mature age	5 m

Cropland. The area of cropland comprises of the area under arable crops as well as orchards and berry plantations. According to national definitions - arable land is continuously managed or temporary unmanaged land, used and suitable to use for cultivation of agricultural crops, also fallows, inspects, plastic cover greenhouses, strawberry and raspberry plantations, areas for production of flowers and decorative plants. Arable land set aside to rest for one or several years (<5 years) before being cultivated again as part of an annual crop-pasture rotation is still included under cropland. Orchards and berry plantations are areas planted with fruit trees and fruit bushes (apple-trees, pear-trees, plum-trees, cherry-trees, currants, gooseberry, quince and others). Under this category only those orchards and berry plantations are included that are planted on other than household purpose land and mainly used for commercial purposes. Orchards and berry plantations planted in small size household areas and only used for householders' meanings are included under Settlements category. All croplands are managed land.

Grassland. Grassland includes meadows and natural pastures planted with perennial grasses or naturally developed, on a regular basis used for moving and grazing. Grasslands cultivated for less than 5 years, in order to increase ground vegetation, still remain grasslands. All grasslands are managed land.

[126] Available from: *http://www3.lrs.lt/pls/inter3/dokpaieska.showdoc_l?p_id=437404&p_query=&p_tr2=2*

Wetlands. Wetlands include peat extraction areas and peat lands which do not fulfil the definition of other categories. Water bodies and swamps (bogs) are also included under this category. Peat extraction areas are considered as managed land.

Settlements. All urban territories, power lines, traffic lines and roads are included under this category as well as orchards and berry plantations planted in small size household areas and only used for householders' meanings. Only the areas of settlements remaining settlements and lands converted to settlements are reported. Settlements are managed land.

Other land. All other land which is not assigned to any other category such as quarries, sand - dunes and rocky areas is defined as Other land. Only area of other land is reported.

Table 6-5. National definitions for land use categories and relevant land use category defined in IPCC 2006

National definitions for land use categories and subcategories										
Agricultural land							Other land			
Arable land	Orchards and berry	Meadows and natural pastures	Forest land	Roads	Settlements	Water bodies	Swamps (bogs)	Trees and bushes plantations in urban areas	Disturbed land	Unmanaged land
Relevant category in *IPCC 2006*										
Cropland		Grassland	Forest land	Settlements		Wetlands		Settlements	Other land	

Information on extension of unmanaged forest and grassland

According to the Annex of draft decision -/CMP.1 (Land use, Land-use Change and Forestry) contained in document FCCC/CP/2001/13/Add.1 definitions of forest management and grazing land management are the following:

– **Forest management** is a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner.
– **Grazing land management** is a system of practices on land used for livestock production aimed at manipulating the amount and type of vegetation and livestock produced.

In accordance with these definitions, all forest lands in Lithuania are managed, but there are managed and unmanaged grasslands.

6.1.4 Land use changes

Forest coverage in Lithuania remains continuously increasing during the last decades (Figure 6-11). Natural and human induced afforestation increased forest land area by 127.8 thous. ha since 1990 (Table 6-7). If would compare todays` situation with 1946, forest area increased more than one third and in some counties forest expansion has almost doubled.

Declared croplands area in Lithuania was decreasing since 1990 to 2005. This is closely related to Lithuanian history. Significant reforms were introduced in the early 90's, particularly after the restoration of independence with the purpose of re-establishment of private ownership and management in the agriculture sector. The legislations were adopted for dismemberment of the collective farms, but they did not ensure their replacement by at least equally productive private farms or corporations. Agricultural production decreased by more than 50% from 1989 to 1994. The farms were broken into small holdings, averaging 8.8 ha in size, often not large enough to be economically viable. Area of grasslands prevailed.

Croplands and Grasslands area has changed dramatically in Lithuania since 2005. This is the result of introduced Single Area Payment Scheme (*SAPS*) since 2004. *SAPS* is a form of support whereby direct payment is made for agricultural land irrespective to the type of production carried out on the land, and this might be one of the reasons of decrease in grasslands area. Furthermore, in 2004 when Lithuania became the member of EU, communities Structural Funds became available. In order to use funding from EU Structural Funds efficiently, the Single Programming Document (*SPD*) of Lithuania for 2004–2006 was prepared. The strategy provided in the *SPD* was divided into priorities and implemented on the basis of one or several measures. Support for Rural and Fisheries development was provided under the measures of the 4th *SPD* priority. The main objective of the Rural and Fisheries Development priority is to develop an advanced agriculture, forestry, and fishery sector on the basis of natural resources and the traditions of inhabitants and by investing in alternative activities, traditional farming, and economic diversification. This support is a non-repayable grant of between 45% and 100% of eligible expenses. In 2004–2006, 191 million EUR was allocated to implement the measures of the Rural and Fisheries Development priority. According to the support contracts signed, the largest amount of funding (95 million EUR) was allocated to beneficiaries who submitted applications for the measure named "Investments into Agricultural Holdings". These measures resulted in agricultural land management, hence increase in croplands area and decrease in grasslands that were ploughed for agricultural purposes.

Table 6-6. National land use data for 1990-2013, thous. ha[127]

Years	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	Total
1990	2061.4	2426.0	1307.7	159.6	324.3	47.5	6530.0
1991	2068.6	2386.5	1350.0	154.4	325.5	41.5	6530.0
1992	2074.6	2346.6	1392.0	152.9	327.1	33.6	6530.0
1993	2079.7	2311.0	1431.5	151.3	324.7	27.2	6530.0
1994	2082.5	2269.5	1473.0	151.2	329.1	21.2	6530.0
1995	2084.9	2233.1	1513.4	151.2	328.7	15.2	6530.0
1996	2090.1	2215.9	1510.2	149.3	327.5	15.2	6530.0
1997	2093.7	2183.6	1555.7	149.3	329.1	15.2	6530.0
1998	2097.3	2134.5	1600.4	148.8	330.3	15.2	6530.0
1999	2100.1	2088.5	1643.2	148.0	331.5	15.2	6530.0
2000	2105.7	2029.0	1697.1	145.3	334.3	14.8	6530.0
2001	2108.9	1967.5	1755.8	144.8	335.1	14.4	6530.0
2002	2113.3	1918.8	1799.3	145.7	335.9	13.6	6530.0
2003	2118.9	1876.8	1836.5	144.8	335.9	13.6	6530.0
2004	2126.9	1854.9	1828.3	144.4	336.3	13.2	6530.0
2005	2134.9	1835.3	1862.4	143.7	337.9	12.4	6530.0
2006	2142.1	1893.2	1796.2	142.0	339.9	13.2	6530.0
2007	2150.4	1952.7	1729.5	140.4	340.7	12.8	6530.0
2008	2157.2	2026.6	1647.2	140.4	341.5	13.6	6530.0

[127] Data for 1990 -2011: Forest Land – *Study-1*; Cropland, Grassland, Wetland, Settlement, Other Land – *Study-2*. Data for 2012 and subsequent years – *NFI*

Years	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	Total
2009	2160.0	2080.5	1580.2	141.2	341.9	13.6	6530.0
2010	2166.4	2084.9	1579.7	140.0	341.9	13.6	6530.0
2011	2173.2	2090.5	1567.7	139.6	341.9	13.6	6530.0
2012	2184.8	2113.7	1532.5	138.8	342.7	14.0	6530.0
2013	2189.2	2132.1	1506.9	138.8	346.3	14.0	6530.0

Table 6-7. Land use changes between 1990 and 2013

Land use	1990	2013	LUC
	thous. ha		
Forest Land (FL)	2061.4	2189.2	127.8
Cropland (CL)	2426.0	2132.1	-293.9
Grassland (GL)	1307.7	1506.9	199.2
Wetland (WL)	159.6	138.8	-20.8
Settlements (SL)	324.3	346.3	22.0
Other Land (OL)	47.5	14.0	-33.5

6.1.5 GHG sinks and releases

Annual CO_2 emissions and removals for the period 1990-2013 are provided in Table 6-8 (evaluated net CO_2 emissions and removals from LULUCF sector). LULUCF sector in Lithuania has continuously been CO_2 sink with the only emissions of 2557.85 kt CO_2 in 1996 and 898.93 kt CO_2 in 1997. Removals were ranging from -2908.11 kt CO_2 to -12133.2 kt CO_2 during the accounting period. In average -6462.0 kt CO_2 are removed every year. Removal of CO_2 mainly corresponds to forest land with the smaller share from grasslands.

Table 6-8. Evaluated total emissions and removals from LULUCF sector, kt CO_2 eqv.

Year	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	Total
1990	-7755.34	5392.00	-1939.73	523.29	NO,NE	NO,NE	-3875.44
1991	-7694.24	5202.87	-2219.53	556.24	42.39	NO,NE	-4026.85
1992	-7554.81	5041.24	-2480.88	583.97	71.24	11.48	-4071.83
1993	-8148.53	4876.05	-2725.21	340.67	77.95	19.43	-5218.88
1994	-7615.95	4707.48	-2985.82	737.09	143.00	162.12	-4457.47
1995	-5442.73	4534.30	-3228.51	446.54	152.35	25.67	-2908.11
1996	394.42	4374.11	-3282.11	463.67	143.55	23.91	2557.85
1997	-1021.16	4281.58	-3419.72	539.81	156.79	23.91	898.93
1998	-8344.19	4147.20	-3650.89	348.64	168.66	29.63	-7286.45
1999	-8150.15	3730.77	-3825.24	782.67	184.21	27.87	-7175.16
2000	-9507.51	3763.63	-4074.25	466.31	230.23	27.87	-9134.57
2001	-11870.06	3372.48	-4338.28	472.73	229.42	33.63	-12133.22
2002	-3977.95	3241.37	-4539.71	844.94	237.38	33.62	-4292.43
2003	-8244.18	2503.88	-4723.13	752.15	241.37	39.42	-9705.81
2004	-4831.81	2424.93	-4807.57	759.21	245.37	35.46	-6868.99
2005	-3002.41	2306.31	-4886.99	880.00	401.29	35.46	-5153.35
2006	-4623.68	3003.89	-4612.03	780.26	426.15	181.66	-5794.65
2007	-3321.49	3176.77	-4350.30	519.31	293.70	41.21	-4813.54
2008	-9236.34	3592.82	-4010.15	859.45	311.00	52.77	-9377.38

2009	-11774.97	3722.10	-3783.21	1033.13	326.51	23.91	-10995.31
2010	-10929.43	3413.96	-3752.36	548.72	321.23	58.52	-11211.46
2011	-11072.62	3456.72	-3482.12	639.65	291.97	58.52	-11154.30
2012	-9447.85	3606.12	-3115.63	641.96	277.38	56.29	-8914.70
2013	-11179.96	3817.97	-2899.49	876.66	317.79	48.33	-9973.94

6.2 Forest Land (CRF 4.A)

Neither definition of forest land nor reporting of GHG has changed since the 1st Commitment Period in forest land category and is as following: land area not less than 0.1 hectare in size covered with trees, the height of which in a natural site in the mature age is not less than 5 meters, other forest plants as well as thinned or vegetation – lost forest due to the acts of nature or human activities (cutting areas, burnt areas, clearings). Tree lines up to 10 meters of width in fields, at roadsides, water bodies, in living areas and cemeteries or planted at the railways protection zones as well as single trees and bushes, parks planted and grown by man in urban and rural areas are not defined as forests. All forest land is considered as managed.

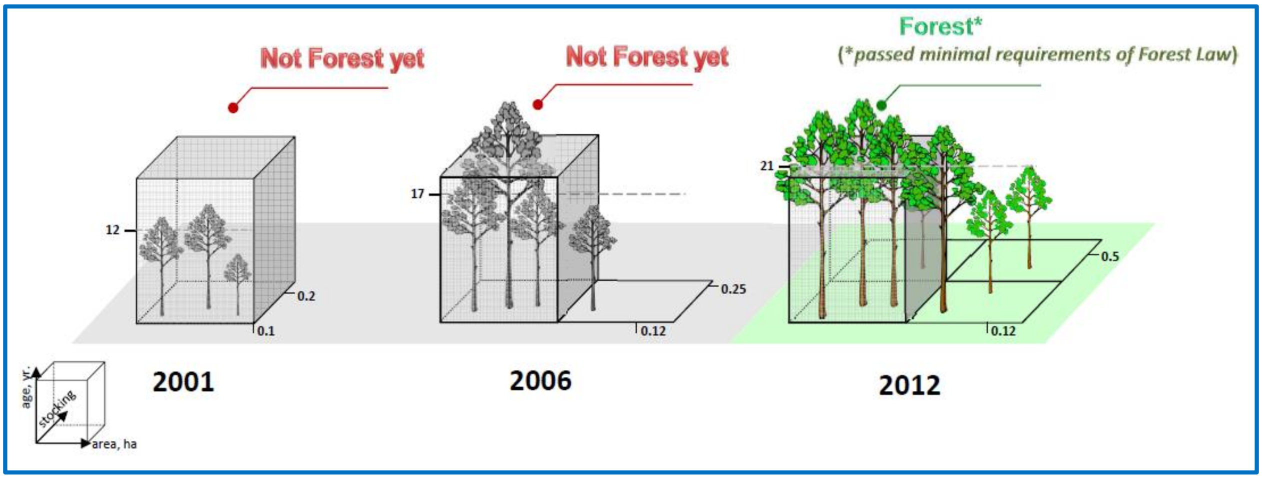

Figure 6-10. Definition of forest applied in Lithuania. Group of trees becomes forest only when reaching certain parameters

6.2.1 Source category description

Forest land area

Forest coverage in Lithuania was expanding continuously since 1948 (Figure 6-11). However data on forest coverage in Lithuania during inter-war period is very limited and the exact data is still unknown.

Expert judgement made by the authors of "*The Chronicle of Lithuanian Forests. XX Century*"[128] allowed presuming forest coverage to be around 21% in 1938, even though some authors argue that only small part of heavily afforested areas of Vilnius region (south-eastern part of Lithuania) were included into this number at that time, and around 150 thous. ha could be unaccounted.

The lowest forest coverage has been accounted during the World War II and through occupation period, because no forest preservation policy existed at that time.

During the period when Lithuania was part of Soviet Union, forest accounting was rather thorough – unfortunately only in State owned forests. Forests belonging to "kolkhozes"

[128] Lietuvos Respublikos Aplinkos Ministerija, Miškų departamentas. Lietuvos miškų metraštis. XX amžius. Vilnius, 2003

(collective farms) and being less than 10 ha were disregarded as well as those belonging to small farms and being less than 1 ha.

After restoration of independence in 1991, there were no legal obstacles for implementation of forest accounting. However, the land reform had also started at that time, so the *SFI* has been suspended or even discontinued as less important. In 1996, when the new cycle of *SFI* has been started numerous naturally afforested areas were found that were missing in the previous inventories or in State land accounting related documents.

Although forests cover a large part of Lithuanian territory and constitute to 2189.2 thous. ha which is more than 33% of the country. It is estimated and forecasted that Lithuanian forest area should account for at least 35% considering the needs of the nature frame and landscape. Despite that forest land area has increased significantly and many new forests have been planted on private and State land the need for further enlargement of forest land still remains. According to the NLS under Ministry of Agriculture[129] there are more than 168 thous. ha of land that is not used for agriculture or is unsuitable for that. 72% of such land belongs to the State and is aimed to be afforested increasing forest coverage by about 3%. A similar target is also set in the Master Plan[130] for the territory of the Republic of Lithuania. However, this process is slowed down by incomplete land reform, problems related to the transfer of free land from the state land fund to managers of state-owned forests for afforestation, as well as legal restrictions linked with afforestation of land that has relatively high productivity. Therefore it is reasonable to increase forest coverage by harmonizing the scope with other land use needs.

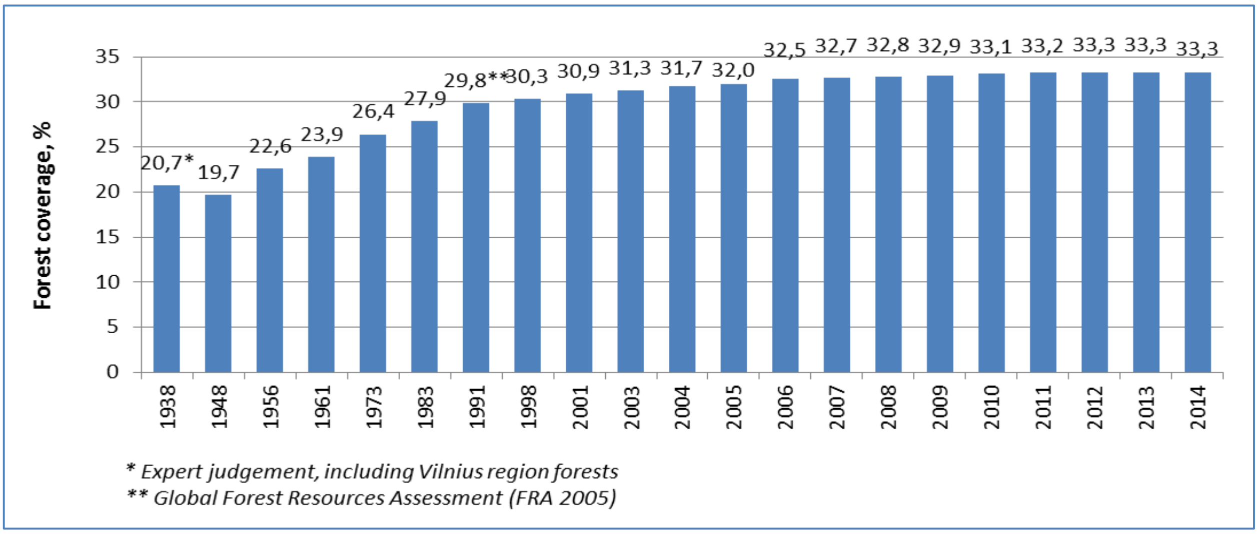

Figure 6-11. Forest coverage 1988-2014.01.01

According to Lithuanian Statistical Yearbook of Forestry by 1st of January 2014, total forest land area in 2013 was 2176.6 thous. ha, covering 33.3% of the country's territory. Since 2003 average forest area per capita increased from 0.59 ha to 0.74 ha. Around half of all forest land in Lithuania is of State importance – 1081.0 thous. ha. In 2013 around 803 thous. ha of forests were registered as private at the State enterprise Centre of Registers. After intersection of layers of all forests and private holdings the estimated area of private forests was slightly readjusted to 858 thous. ha. Since the 1st of January 2003, the forest land area has increased by 131.7 thous. ha corresponding to more than 2% of the total forest cover. During the same period, forest stands expanded by 105 thous. ha to 2056 thous. ha. Average annual increase in forest area is about 5

[129] Available from: *http://www.nzt.lt/go.php/eng/News/3390/35/486*
[130] Available from: *http://www3.lrs.lt/pls/inter2/dokpaieska.showdoc_l?p_id=284951*

thous. ha. Following prior official data of Forest Assessment[131] annual increase was more than 10 thous. ha. Huge difference in forest coverage is explained by insufficient data previously used by Forest Assessment. As of 1st of January 2014 Forest Assessment that is based on data of *SFC* shows nearly the same forest coverage as the *NFI*, which is based on permanent sample plots data (Figure 6-12).

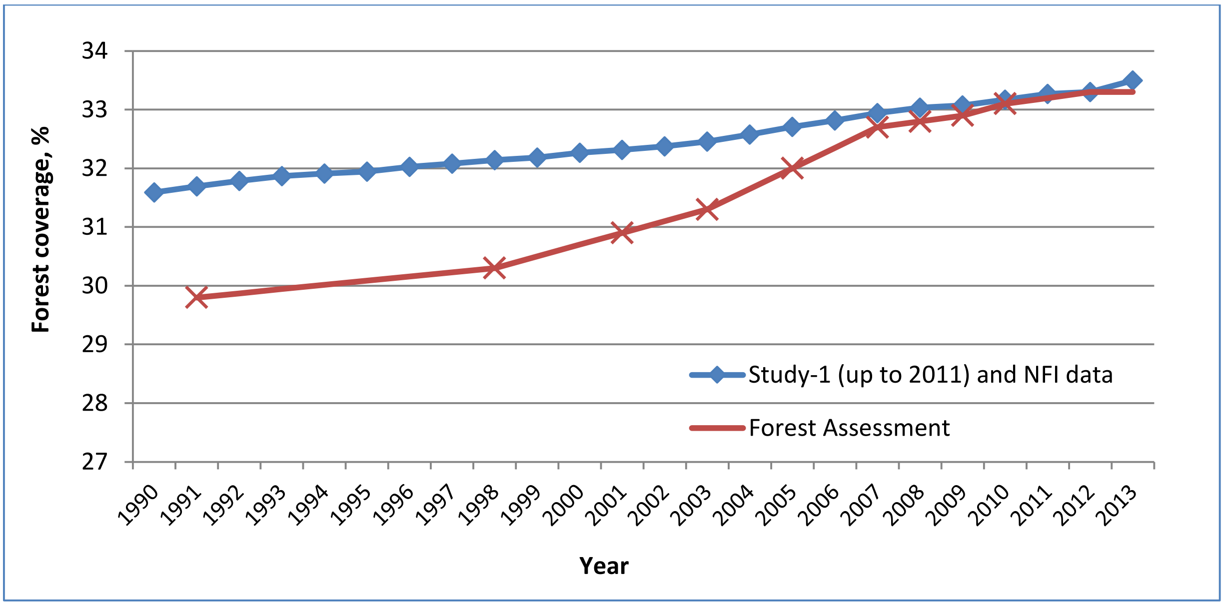

Figure 6-12. Changes in forest coverage in Lithuania 1990-2013, 2014.01.01

All Lithuanian forests are distributed into four functional groups. In the beginning of 2014, distribution of forests by functional groups was as follows: group I (strict nature reserves) – 26.3 thous. ha (1.2%); group II (ecosystems protection and recreational forests) – 266.5 thous. ha (12.2%); group III (protective forests) – 331.3 thous. ha (15.2%); and group IV (exploitable forests) – 1552.6, thous. ha (71.3%) (Figure 6-13).

[131] Kuliešis, A., Vižlenskas, D., Butkus, A. et al. 2010. *Forest Assessment*. State Forest Service

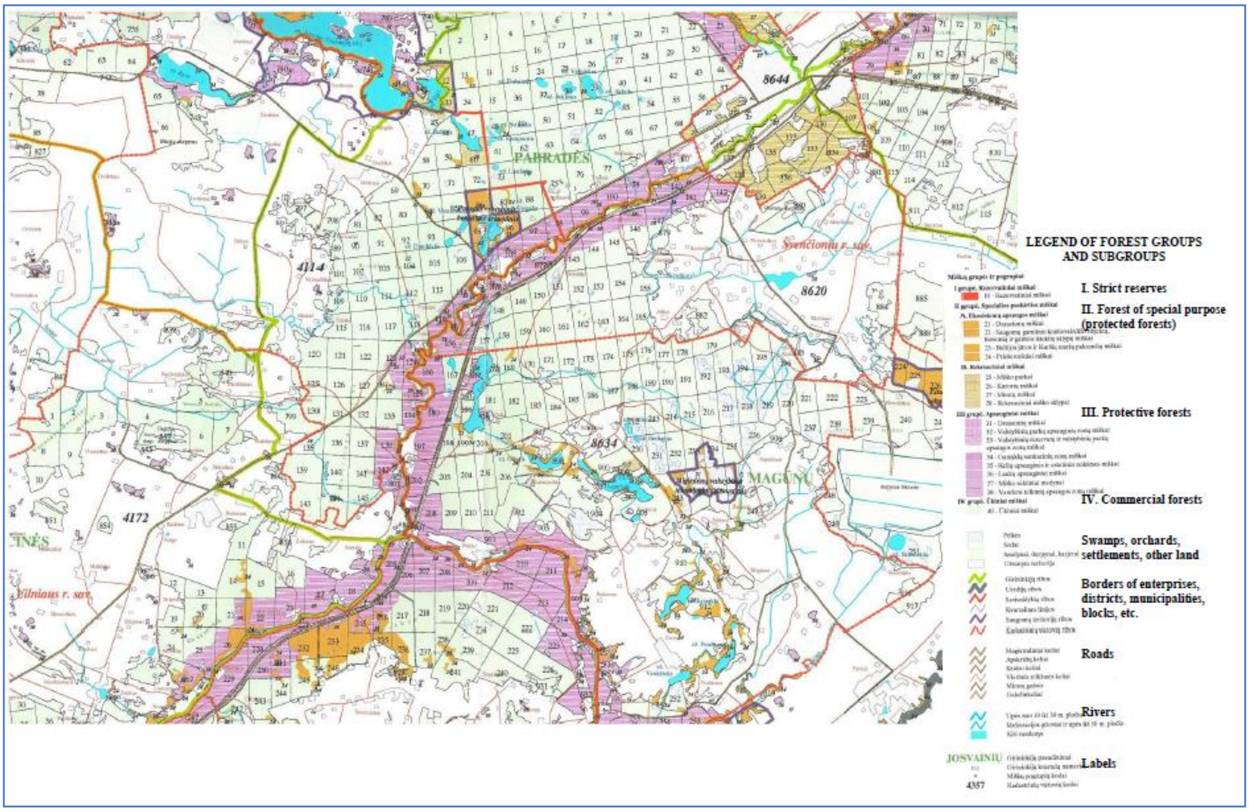

Figure 6-13. Scheme of forest distinguished by functional groups

Occupying 1152.5 thous. ha, coniferous stands prevail in Lithuania, covering 56.1% of the forest area (Figure 6-14). They are followed by softwood deciduous forests (934.3 thous. ha, 40.6%). Hardwood deciduous forests occupy 69 thous. ha (3.4%). Over the last 11 years total area of softwood deciduous forests increased by 130.4 thous. ha. The area of hardwood deciduous has decreased by 18.1 thous. ha and coniferous forest by 7.5 thous. ha. Scots pine (*Pinus sylvestris*) occupies the biggest share in Lithuanian forests – 720.3 thous. ha. Compared to 2003, the area of pine expanded by 8.8 thous. ha. Norway spruce (*Picea abies*) covers 429.6 thous. ha, with a reduction of 15.7 thous. ha. Birch (*Betula pendula*) covers the largest area among deciduous trees. Since 2003, it has increased by 67.5 thous. ha and reached 459.7 thous. ha by 2013. Area of Black alder (*Alnus glutinosa*) increased by 27.2 thous. ha to the total of 146.7 thous. ha. The area of grey alder (*Alnus incana*) expanded by 4.7 thous. ha i.e. less than the black alder, reaching 126.7 thous. ha. The area of aspen (*Populus tremula*) stands expanded by 25.2 thous. ha to 82.5 thous. ha. Oak (*Quercus robur*) forests increased from 35.7 thous. ha to 42.5 thous. ha. The area of ash (*Fraxinus excelsior*) stands diminished by 51.6% to 26.5 thous. ha.

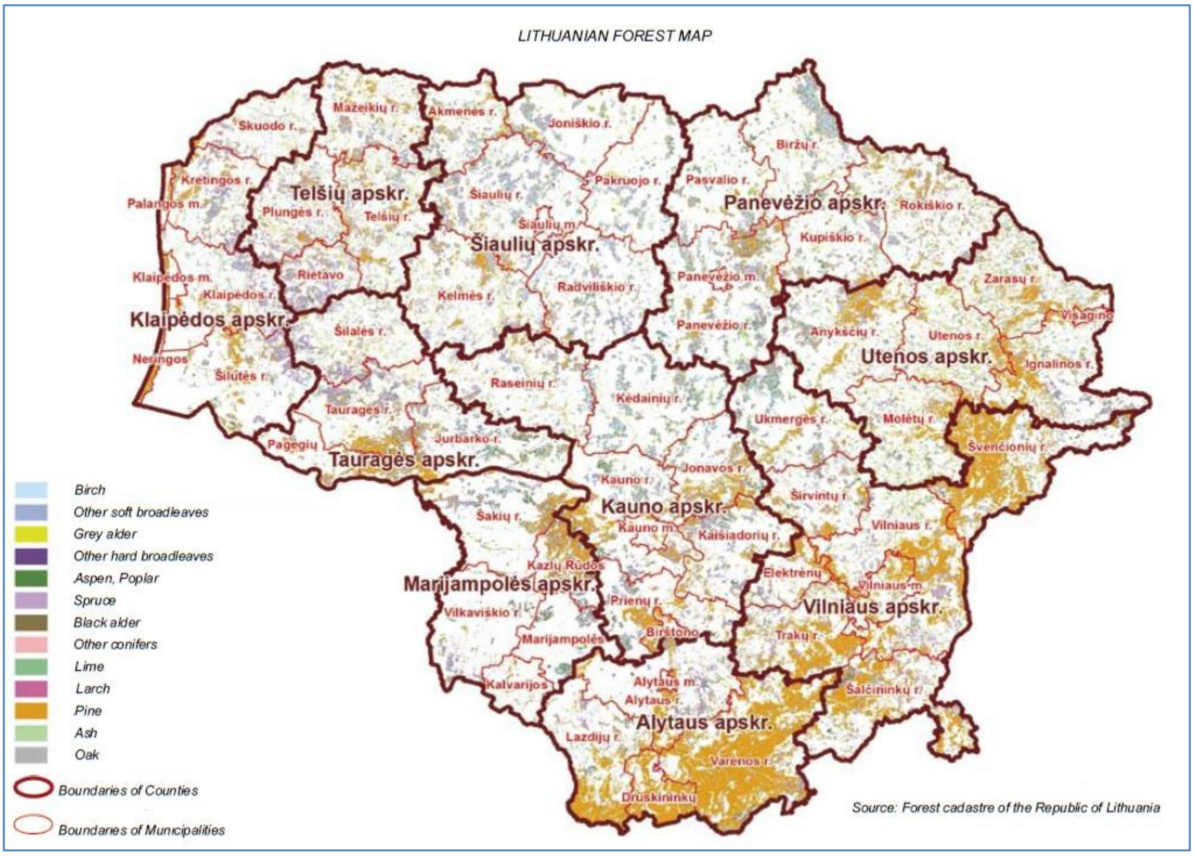

Figure 6-14. Lithuanian forest map by prevailing tree species

Forest Inventories

The traces of forest inventory in Lithuania date back to the middle of the 16th century, when Grigoryi Volovich wrote a report on ,,*The inspection of woods and game crossing tracks...*" in which he described the state of forest tracts of those times. In 19th century forest inventory on the territory of Lithuania was carried out by Russian, Polish and German specialists. Forest inventory and management planning came into existence in 1922 under the Department of Forestry at the Ministry of Agriculture. It employed 25-30 specialists. Primary inventory of state forests was completed by the year 1937. After World War II forest inventory renewed its functioning at the end of 1944. In 1955-1957 for the first time were inventoried all the forests of collective-farms and other stock – holders. Thus, in the second half of the 20th century all the forests of the Republic were inventoried. Repeated forest inventories took place in: 1958-1963, 1966-1977, 1978-1987, and 1988-2001. The methods of Lithuanian forest inventory and management planning until 1966 were based on Russian forest inventory instructions adapted to Lithuanian conditions. As a result of scientific research, experiments and soil investigations conducted in 1959-1966, forest management started to be planned on soil - typological basis. Owing to the joint efforts of forestry leaders of the Republic, researchers (*J. Kenstavičius and M. Vaičys*) and forest management planning specialists, "Rules of forest management planning on soil - typological basis" were worked out. The main principles of these regulations, being gradually improved, remained till the end of the 20th century. Aero photos were introduced into forest management planning practice in 1950, simplified soil studies and mensuration based and sampling methods and angle count plots started since 1966. In 1969-1971 methodical principles were elaborated, programs were worked out and electronic calculating machines started to be used. In the last decade of the 20th century personal computers and geo-informational systems were introduced, mapping became fully automatized. Forest management planning had special sub-units: supervision of elaborated plans, hunting management, management planning of protected areas and recreational forests, technological planning of final felling's, application of remote sensing methods and geo-information system, state assessment of forests resources. The most significant for the strategic planning of forestry and the development of forest management was started in 1998 with national inventory of Lithuanian forests by sampling method. The data obtained allowed to increase the accuracy and reliability of information on forest resources of the country by ownership categories, to define them with a required accuracy, to broaden essentially the scope of information.

After Lithuania regained its independence, the Ministry of Forestry made a decision obliging forest management planning specialists to carry out land reform and restore ownership rights on former private forests. This work comprised the greatest part (40%) of forest management planning activities at the end of the 20th century and the beginning of the 21st century.

Standwise Forest Inventory

Standwise forest inventory by complete survey of forest lands (*SFI*) region by region covers whole country in 10 years. It is executed already 90 years. *SFI* is obligatory to all ownership forms. During the inventory forest stands are singled out, their quantitative and qualitative characteristics are provided, forest health is assessed and silvicultural measures foreseen. Each year *SFI* inventoried area is nearly 200-250 thous. ha what is 10% of the total forest land area (Figure 6-15).

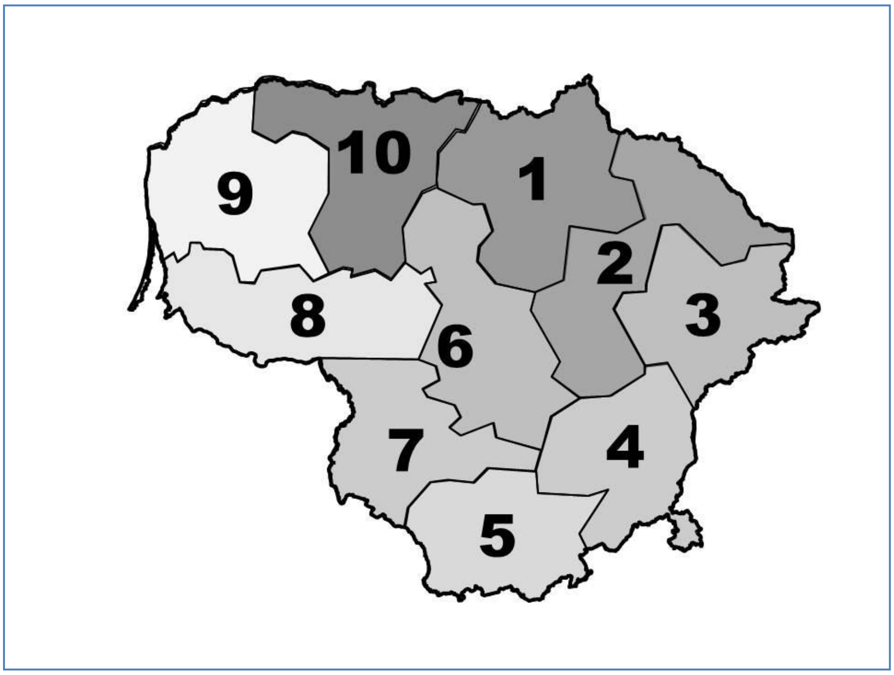

Figure 6-15. Execution of *SFI* over ten year period through the whole territory of Lithuania

Based on the inventory results forest management plans (Figure 6-16) are prepared for forest enterprises, state parks, recreational and protected areas. Some of the archived cartographical material owned by *SFI* is presented in figures below.

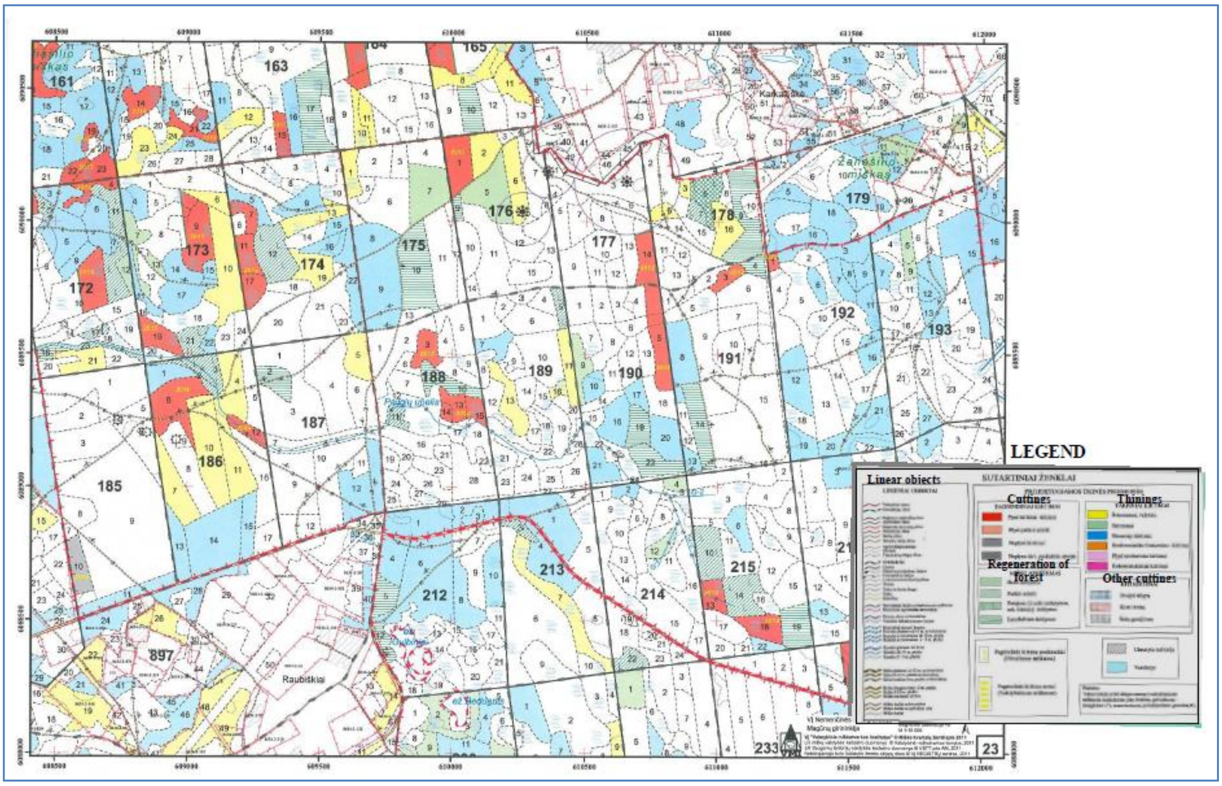

Figure 6-16. Forest management plan (planned forestry activities presented on scheme of forest blocks and compartments; S1:10°000)

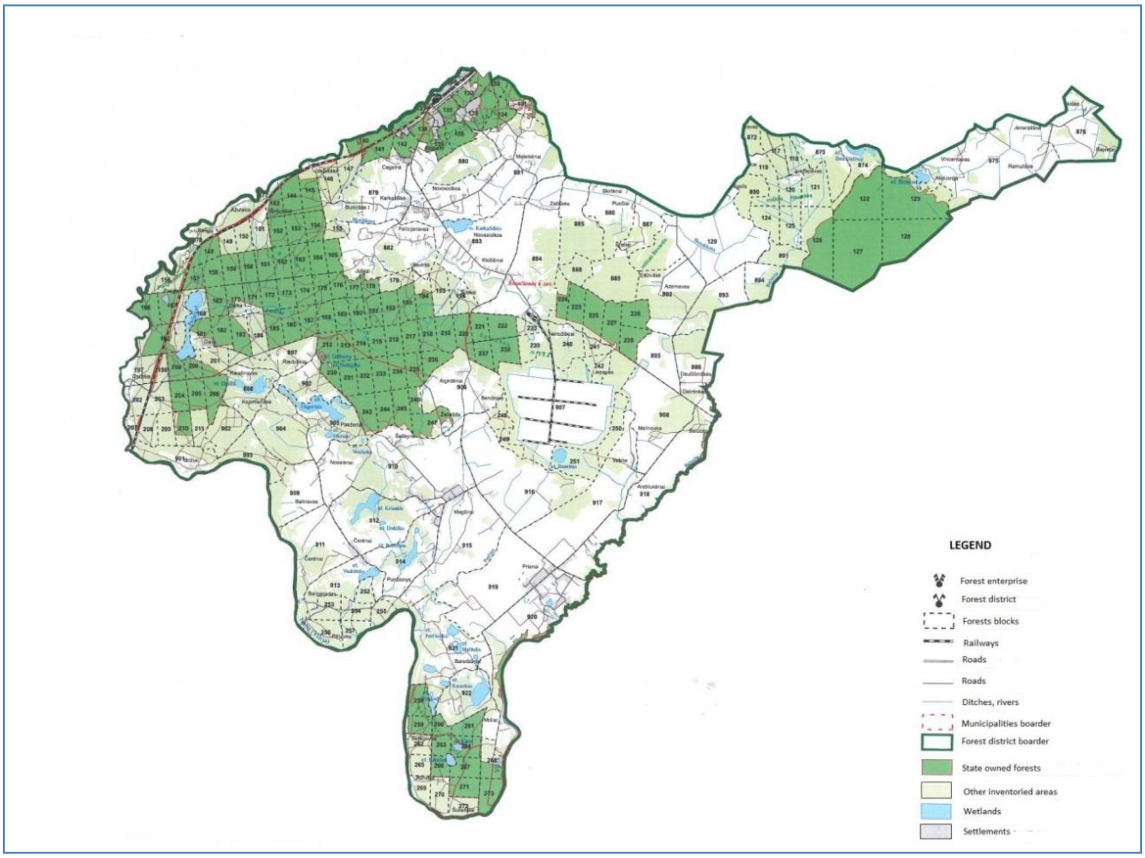

Figure 6-17. Scheme of the Forest District (S 1:10°000)

National Forest Inventory

NFI is using sampling method as a comprehensive and continuous monitoring of all Lithuanian forests. It was established in 1998. It was launched by the State Forest Management and Inventory Institute under the Ministry of Agriculture and Forestry. Its activity is consolidated by Forest Law of the Republic of Lithuania (2001, 2011, 2012 ed. .) and it is conducted by the *SFS* following the Regulations of National Forest Inventory, approved in 2004 and revised in 2012. Data presented by *NFI* is used while making forest policy decisions (forestry related laws, forestry programmes etc.), planning forestry activities (large scale forest management planning, country forestry planning etc.), planning forest industry investments and modelling forestry related scenarios (forest resources development etc.).

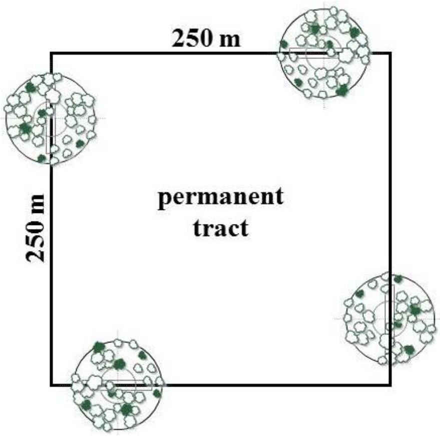

Figure 6-18. Tract of permanent sample plots

NFI is based on continuous, multistage sampling and GIS integrated technology and is organized in the same manner for all forests of Lithuania. The systematic grid (16325 permanent sample plots) of the *NFI* of Lithuania covers all land categories (Figure 6-18) including inland waters.

Sampling is conducted using a 4×4 km systematic grid with a random starting point. The systematic grid assures a uniform distribution of plots over the entire country and regular monitoring of conversion amongst land use categories. The sample units are arranged to square shape clusters and include four permanent, regularly measured plots (Figure 6-19).

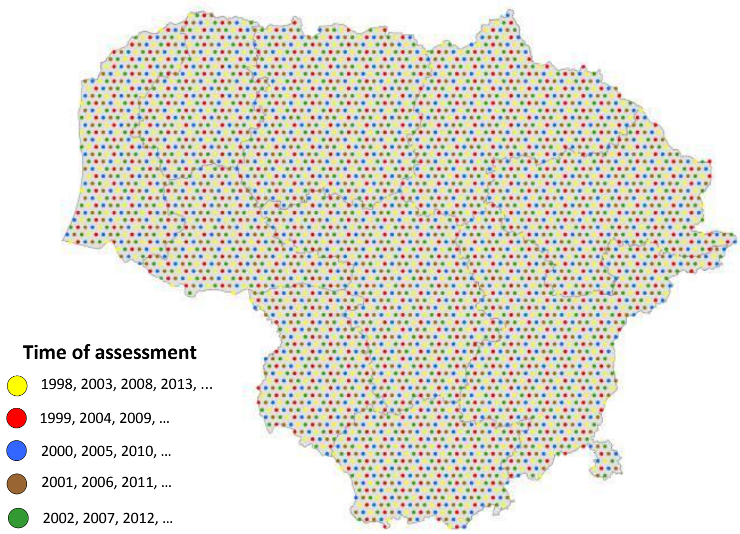

Figure 6-19. Distribution of NFI clusters of plots on Lithuanian territory

Taking into account the number of homogeneous stands (strata), minimal growing stock volume and increment estimation accuracy, 5600 permanent sample plots were established on forest land over a 5-year period. Approximately 1120 permanent sample plots are re-measured each year. The *NFI* plots annually cover the entire country each year with the total number of plots measured over the 5-year inventory cycle reaching a sampling intensity of one sample plot per 400 ha.

The aim of establishment of permanent sample plots is to reliably estimate (by direct measurements) growing stock volume, gross increment, mortality and fellings, to control the dynamics of forest areas in the country.

Following the order of the Minister of Environment[132] and renewed Regulations of *NFI*[133] field measurements in all land use categories of Lithuania were started in 2012 in more than 16 thous. permanent sample plots. The main aim of non-forest land measurements is to (a) monitor land use changes, required by UNFCCC, and (b) to measure living trees outside the forest land.

Lithuanian State Forest Cadastre

The purpose of *LSFC* is to collect, compile, process, systematize, store, use, update and provide data on Lithuanian forests. *LSFC* is a component of state registers' system. The structure of *LSFC* is based on natural-geographical principle. A forest tract is considered to be the unit of *LSFC* registration. Thus, *LSFC* is a database of forest tracts. It has been created employing the information of forest land compartments data base, originated from the *SFI* data.

Primary functions of *LSFC*:

1) Drawing up a technical draft of *LSFC*, including:

– regulations on separation of registration units and on attribution of code numbers to forest tracts;
– regulations on attaching and updating attributes of forest tracts;
– formulation of technical requirements for software;
– regulations on data provision to stake-holders and other cadastres.

2) Systematizing geographical data of forest tracts for entire country.

To work out the hierarchical system of forest tracts, the territory of Lithuania was subdivided into 6 regions, separated by the beds of the biggest rivers. Each region was divided into districts dominated by a forest tract larger than 10000 ha. Each forest tract smaller than 10000 ha is subordinated to the district of dominating tract and acquires a part of its code number. Such code number of a small forest tract identifies both its geographical location and hierarchical position. Records of an identified forest tract are combined with the database of forest land compartments. Each forest land compartment receives a forest tract code number besides its own number. Information on compartments serves as a basis for forest tract information summary.

An interior numbering of blocks occur in each forest tract separately. Such approach will gradually result in a stable system of block numbers, irrespective to forest`s administrative division or its ownership category. *LSFC* database is being updated on a regular basis following the outcome of every next standwise inventory, the information on carried out silvicultural measures, on ownership, administrative boundaries and other changes, on newly planted or naturally regenerated forests provided by forest enterprises and other institutions.

LSFC data are integrated with the data of other cadastres and registers such as those of real estate, protected areas, territorial administrative units, cultural values; as well as with other layers, namely the code of forest seed breeding Ingredients, training and experimental forests etc.

[132] Order of the Minister of Environment No D1/27 12th January 2012 on Approval of Harmonised Principles for data collection and reporting on LULUCF

[133] Order of the Minister of Environment No D1-570 8th November 2004 on regulation of national forest inventory by sampling method

Organic and mineral soils

NFI provides data on forest land distribution by forest soils (Table 6-9). According to NFI[134] data, area of mineral soils amounts to 84.3% and area of organic soils – 15.7% of the total forest area. Drained organic forest soils constitute to 7.9% of the total forest land. This area consists of 2.6% infertile and 5.3% of fertile drained organic forest soils.

Table 6-9. Forest land area by mineral and organic soils 1990-2013, thous. ha

Year	Mineral soils	Organic soils			Total forest land
		Not drained	Drained	Total	
1990	1737.7	160.8	162.8	323.6	2061.4
1991	1743.8	161.3	163.4	324.8	2068.6
1992	1748.8	161.8	163.9	325.7	2074.6
1993	1753.2	162.2	164.3	326.5	2079.7
1994	1755.6	162.4	164.5	327.0	2082.5
1995	1757.6	162.6	164.7	327.3	2084.9
1996	1762.0	163.0	165.1	328.1	2090.1
1997	1765.0	163.3	165.4	328.7	2093.7
1998	1768.0	163.6	165.7	329.3	2097.3
1999	1770.4	163.8	165.9	329.7	2100.1
2000	1775.1	164.2	166.4	330.6	2105.7
2001	1777.8	164.5	166.6	331.1	2108.9
2002	1781.5	164.8	167.0	331.8	2113.3
2003	1786.2	165.3	167.4	332.7	2118.9
2004	1793.0	165.9	168.0	333.9	2126.9
2005	1799.7	166.5	168.7	335.2	2134.9
2006	1805.7	167.1	169.2	336.3	2142.1
2007	1812.8	167.7	169.9	337.6	2150.4
2008	1818.5	168.3	170.4	338.7	2157.2
2009	1820.9	168.5	170.6	339.1	2160.0
2010	1826.3	169.0	171.1	340.1	2166.4
2011	1832.0	169.5	171.7	341.2	2173.2
2012	1841.8	170.4	172.6	343.0	2184.8
2013	1845.5	170.8	172.9	343.7	2189.2

Soils are classified by using Forest soils classification prepared by M. Vaičys[135]. Prof. M. Vaičys studied forest soil genesis and collected abundant data on soil properties. New soil-forming processes in Lithuanian forest soils, such as lessivation and browning, were also ascertained. Later on, original methods of large-scale forest soil mapping were prepared. In the 1960–1970s, under the guidance of Prof. M. Vaičys all forest soils in Lithuania were mapped and the national genetic classification of forest soils was prepared. An original classification of the humidity and trophicity of forest sites based on soil-typological groups was offered by Prof. M. Vaičys as well. While becoming a member of European Union necessity of preparation of new Lithuanian Soils Classification, which would be harmonized with World Soil Map legend, has emerged (S 1:5000000, FAO – UNESCO, 1990). First version of such classification was presented in 1997 by M. Vaičys et al. Later it was developed, adjusted and finally approved in 1999. The new Lithuanian

[134] Lithuanian National Forest Inventory 2003-2007, "*Forest resources and their dynamics*"

[135] M.Vaičys *et al.,* 2006. *Miško augaviečių tipai* (en. Forest soil types)

Soils Classification (LTDK-99) was quite recital, and was difficult to use for forest inventories which are based on forest soil types, therefore it was harmonized with forest soil types used in forest inventory, forestry, forest related science etc. The final harmonized forest soil type classification is presented in Figure 6-20.

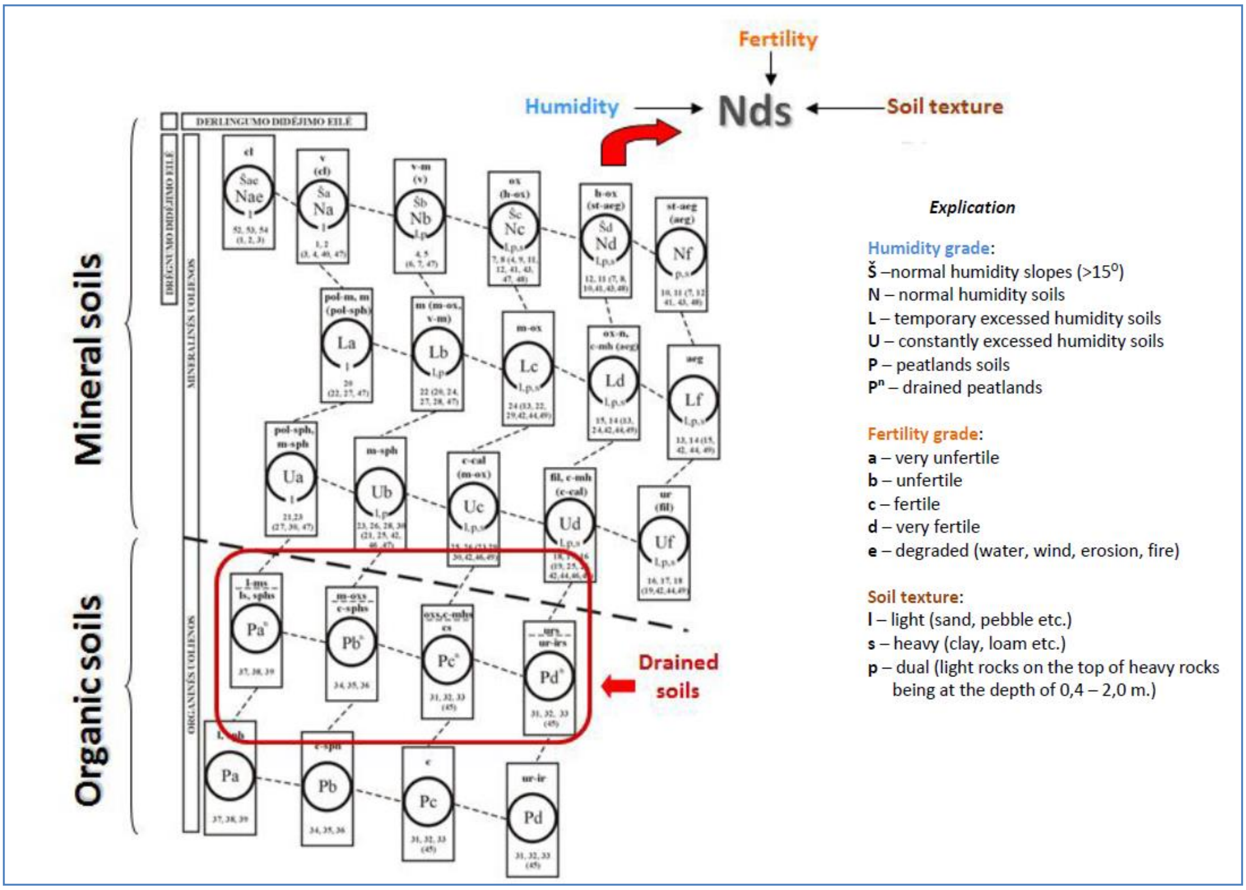

Figure 6-20. Classification of forest soil types

In this GHG inventory Lithuania defines organic soils and drained organic soils on forest land category as they are classified in the above mentioned soil classification system. Definition of organic soils in LTDK-99 is in line with the definition and requirements of *IPCC 2006*, hence organic soils are identified with peat and peaty soil layer equal to or being more than 30 cm of the total thickness. Drained organic soils are defined as organic soils identified with peat and peaty soil layer equal to or being more than 20 cm of the total thickness.

Living and dead trees volume in Forest land

Living trees volume (growing stock volume) was estimated in forest stand areas corresponding to *Study-1* "Forest Land changes in Lithuania during 1990-2011" up to 2012 and latest *NFI* data. For estimation of changes in growing stock volume period of inventory years were divided in two time series: 1990-2001 and 2002-2013.

Total growing stock volume in the period of 1990-2001 was estimated using the following data sources: forest land area determined during the *Study-1*, percentage of forests stands area from total forest land area and mean growing stock volume of stands (Table 6-10). Forest stands area from total forest land area varied from 96.5% to 97% depending on the assessment year. This percentage is presenting forest land area without dead stands, clear-cut areas, forest blanks, forest roads, forest block lines, technological and fire-break belts and other small areas related to forest facilities.

Using available data six time points were selected to identify mean growing stock volume in stands: 1988, 1992, 1995, 1997, 1999 and 2000. However, only since 2002 known accuracy growing stock volumes, based on *NFI* permanent sample plots information are available, therefore volumes for the unknown years from the period of 1988-2001 were modelled using available data in the mentioned time points.

Mean growing stock volume per hectare in stands for 1988 and 1999 was used from the research[136]. Forest stand yield was estimated based on *SFI* data and data on fellings during the period 1922-1999. To demonstrate reliability of *SFI* data during 1958-1999, forest stand yield balance model and data from *SFI* by sampling method in 1969 was applied. Based on earlier mentioned methods mean growing stock volume in 1988 resulted to be 194 m^3/ha, in 1999 - 214 m^3/ha.

Data on mean growing stock volume per hectare for 1992 and 1995 was used from Lithuanian forest resources assessment[137]. Mean growing stock volume for 1997 was taken from Lithuanian forest statistics[138]. Data for the year 2000 was obtained from Lithuanian Statistical Yearbook of Forestry[139]. Note that, taking into account underestimation of mean growing stock volume for 1992, 1995, 1997 and 2000, making the harmonization of this data with the data of the research[140] for 1988 and 1999 together with *NFI* data for 2002, it was adjusted by 13%.

Total growing stock volume for the period of 2002-2013 was estimated based on permanent NFI sample plots data. In 2002 Lithuanian *NFI* has finished establishment of permanent sample plots and started providing objective annual data on wood resources in Lithuanian forests (Chapter 6.2.1).

Increase in mean annual volume in 2000-2002 has been caused by accumulation of volume in stands due to restricted main use fellings after the spruce dieback in 1999[141].

Table 6-10. Growing stock volume identified according to Study-1, Forest assessment data and results of other researches

Year	Mean volume identified, m^3/ha	Mean annual volume change, m^3/ha	Forest land area, thous. ha.	Percentage of forest stands area, %	Total growing stock volume, thous. m^3
1988	194.0	-	-	-	-
1989	196.4	2.3	-	-	-
1990	198.7	2.3	2061.4	97.0	397614.2
1991	201.1	2.3	2068.6	97.0	403640.9
1992	203.4	2.3	2074.6	97.0	409540.9
1993	205.7	2.3	2079.7	97.0	415127.3

136 Kuliešis, A. 2000. *Lietuvos miškų našumo apskaita, reguliavimas ir naudojimas*. *Mokslas ir miškininkystė XXI amžiaus išvakarėse*, p 127-133 [en. *Stand yield inventory, regulation and using in Lithuanian forests*. *Science and forestry on the eve of XXI century*]

137 Valstybinis miškotvarkos institutas. 1993 (1996) *Lietuvos miško ištekliai*. 1993 (1996). [en. Forest Inventory and Management Institute. *Lithuanian Forest resources*]

138 Valstybinis miškotvarkos institutas. 1998. *Lietuvos miškų statistika*. [en. Forest Inventory and Management Institute. *Lithuanian Forest statistics*]

139 Valstybinė miškų tarnyba. *Lietuvos miškų ūkio statistika*. 2009. [en. State Forest Service. *Lithuanian Statistical Yearbook of Forestry*]

140 Kuliešis, A. 2000. *Lietuvos miškų našumo apskaita, reguliavimas ir naudojimas*. *Mokslas ir miškininkystė XXI amžiaus išvakarėse*, p 127-133 [en. *Stand yield inventory, regulation and using in Lithuanian forests*. *Science and forestry on the eve of XXI century*]

141 Kuliešis, A., Kulbokas, G. 2008. *Dubravos miško medynų pokyčiai nepalankių gamtinių veiksnių poveikio laikotarpiu*. Miškininkystė, Nr. 2(65), p 55-67 [en. *Changes in Dubrava forest stands during the impact of adverse natural factors*]

Year	Mean volume identified, m^3/ha	Mean annual volume change, m^3/ha	Forest land area, thous. ha.	Percentage of forest stands area, %	Total growing stock volume, thous. m^3
1994	207.9	2.3	2082.5	97.0	420253.1
1995	210.2	2.3	2084.9	96.5	423117.2
1996	209.1	-1.1	2090.1	96.5	421889.8
1997	207.9	-1.1	2093.7	97.0	422508.5
1998	211.0	3.0	2097.3	97.0	429503.3
1999	214.0	3.0	2100.1	97.0	436273.0
2000	218.1	4.1	2105.7	96.5	443412.2
2001	222.4	4.3	2108.9	96.5	452850.6
2002	226.7	4.3	-	-	-

Based on data presented above, total growing stock volume for the period of 1990-20113 was estimated (Table 6-11).

Table 6-11. Total growing stock volume estimated on growing stock volume analysis during 1988-2001 and NFI permanent sample plots data during 2002-2013

Year	Growing stock volume, thous. m^3
1990	397306.4
1991	403407.3
1992	409304.6
1993	414888.1
1994	420011.3
1995	422874.2
1996	421648.1
1997	422266.9
1998	429176.5
1999	435941.5
2000	443159.8
2001	452593.5
2002	454588.4
2003	461979.4
2004	465794.6
2005	467095.0
2006	469471.5
2007	470875.7
2008	476053.5
2009	484616.3
2010	494285.3
2011	503565.7
2012	511532.6
2013	521272.4

Main differences in growing stock volume appear to be in the period of 1990-2000, especially in 1996-1999. On the earlier submission total growing stock volume estimations were based mainly on expert assumptions and the rough linear trend. As the one of result of the executed *Study-1*, data on total forest area was presented, which has made an impact on total growing stock volume data as well. Decrease in annual volume change in 1996-1997 (-1226 and 619 thous. m^3) is the result of spruce dieback, caused by bark beetle *Ips Typographus* what resulted in a huge damages for spruce stands[142]. Even though mean annual volume change for 1997 is negative (-1.1 m^3/ha) but the total annual volume change is positive due conversion of non-forest land to Forest land (0.8 thous. ha) and accumulated volume from this land use category (42 thous. m^3).

Table 6-12 presents annual growing stock volume and growing stock volume changes by tree species. The partition of total growing stock volume was made using *NFI* permanent sample plots data of tree species composition. For the period of 2002-2013 annual *NFI* data was used, and for the period 1990-2001 – due to the lack of statistical data, data was modelled using *NFI* data for 2002.

Table 6-12. Annual change of growing stock volume, thous. m^3

Year	Growing stock volume			Annual change of growing stock volume		
	Coniferous	Deciduous	Total	Coniferous	Deciduous	Total
1990	224296.6	173009.8	397306.4	3444.2	2656.7	6100.9
1991	227740.9	175666.4	403407.3	3444.2	2656.7	6100.9
1992	231070.1	178234.4	409304.6	3329.3	2568.0	5897.3
1993	234222.3	180665.8	414888.1	3152.2	2431.4	5583.6
1994	237114.5	182896.7	420011.3	2892.2	2230.9	5123.1
1995	238730.8	184143.4	422874.2	1616.3	1246.7	2863.0
1996	238038.6	183609.5	421648.1	-692.2	-533.9	-1226.1
1997	238387.9	183879.0	422266.9	349.3	269.4	618.8
1998	242288.7	186887.8	429176.5	3900.8	3008.8	6909.6
1999	246107.8	189833.7	435941.5	3819.1	2945.8	6765.0
2000	250182.9	192976.9	443159.8	4075.1	3143.3	7218.4
2001	255508.6	197084.9	452593.5	5325.7	4108.0	9433.7
2002	256634.8	197953.6	454588.4	1126.2	868.7	1994.9
2003	261513.4	200465.9	461979.4	4878.6	2512.4	7391.0
2004	263853.6	201941.0	465794.6	2340.1	1475.1	3815.2
2005	264417.7	202677.3	467095.0	564.1	736.3	1300.4
2006	266726.6	202744.9	469471.5	2308.9	67.5	2376.5
2007	269802.6	201073.1	470875.7	3076.0	-1671.8	1404.2
2008	273555.6	202497.9	476053.5	3753.0	1424.9	5177.8
2009	278365.9	206250.4	484616.3	4810.3	3752.5	8562.7
2010	285687.8	208597.5	494285.3	7321.9	2347.1	9669.0
2011	290992.9	212572.8	503565.7	5305.1	3975.2	9280.4
2012	295457.0	216075.6	511532.6	4464.1	3502.8	7966.9
2013	302116.8	219155.7	521272.4	6681.3	2747.6	9428.9

Note: Negative annual growing stock volume change shows decrease between two periods.

Volume of dead tree stems was assessed for two periods as well as growing stock volume. The total dead tree stems volume for the period of 1990-2001 was estimated using forest land area determined during the *Study-1*, percentage of forests stands area from the total forest land area

[142] Kuliešis, A., Kulbokas, G. 2008. *Dubravos miško medynų pokyčiai nepalankių gamtinių veiksnių poveikio laikotarpiu*. Miškininkystė, Nr. 2(65), p 55-67 [en. *Changes in Dubrava forest stands during the impact of adverse natural factors*]

and mean volume of dead tree stems in stands. Mean volume of dead tree stems was estimated taking into account data of spruce dieback in 1993-1996[143].

For the period 2002-2013 total standing and lying volume of dead tree stems was estimated using accurate data of *NFI* permanent sample plots. Deciduous and coniferous were separated using *NFI* data of dead tree stems species composition.

The foliage and needles biomass for separate tree species was estimated as a percentage from the total stem volume, using models designed by V. Usolcev. Models were adapted to Lithuanian stands taking into account forest area by dominant tree species (Lithuanian Statistical Yearbook of Forestry, 2011). Computations resulted that needles take 7% from the total stem volume and foliage share is 3% from the total stem volume. Estimated volumes of needles and foliage biomass were not included into total dead tree stems biomass (Table 6-13).

Table 6-13. Total and mean dead tree stems volume changes during 1990-2013

Year	Total volume of dead tree stems, thous. m^3	Total volume of coniferous dead tree stems, thous. m^3	Total volume of deciduous dead tree stems, thous. m^3	Mean dead tree stems volume, m^3/ha
1990	10740.1	5139.9	5600.1	5.2
1991	10978.2	5358.5	5619.7	5.3
1992	11311.8	5675.9	5635.9	5.5
1993	11743.6	6093.5	5650.1	5.6
1994	12466.4	6808.8	5657.6	6.0
1995	13221.2	7586.2	5635.0	6.3
1996	13254.1	7605.1	5649.0	6.3
1997	12939.5	7251.5	5688.0	6.2
1998	12554.9	6857.1	5697.8	6.0
1999	12266.1	6560.7	5705.4	5.8
2000	12032.1	6341.0	5691.1	5.7
2001	12050.4	6350.6	5699.7	5.7
2002	12513.4	6594.7	5918.8	5.9
2003	12803.4	6566.9	6244.7	6.0
2004	13823.6	7070.4	6783.2	6.5
2005	15155.2	7374.2	7812.1	7.1
2006	16825.3	7770.3	9086.6	7.9
2007	18367.3	8423.6	9975.3	8.5
2008	20175.7	9124.2	11074.9	9.4
2009	21121.2	9408.8	11714.1	9.8
2010	21462.2	9622.3	11843.4	9.9
2011	22369.8	10002.0	12370.8	10.3
2012	22803.0	10093.6	12709.3	10.4
2013	22954.7	10122.2	12832.5	10.5

Volumes of standing and lying dead tree stems in forests were increasing since 1990. The peak was recorded in the period of 1994-1997 (Table 6-14). That is explained by spruce dieback, caused by the bark beetle *Ips Typographus*, when more than 13000 thous. m^3 of dead tree stems

[143] Kuliešis, A., Kulbokas, G. 2008. *Dubravos miško medynų pokyčiai nepalankių gamtinių veiksnių poveikio laikotarpiu*. Miškininkystė, Nr. 2(65), p 55-67 [en. *Changes in Dubrava forest stands during the impact of adverse natural factors*]

were accumulated in forests (Figure 6-22). Volume of dead tree stems was stabilized only after 1998.

Another steady increase of dead tree stems has started since 2001. Reasons for that are the following: storm damages in 2000-2005[144], low number of commercial thinning, endorsed international environmental agreements committing to leave more deadwood in stands to maintain biodiversity (Natura 2000[145], etc.). In 2013 10.5 m^3/ha of merchantable dead tree stems were accumulated in stands to decay, what is almost twice more if comparing with 1990.

Table 6-14. Total dead tree stems volume and their changes during 1990-2013, thous. m^3

Year	Dead tree stems volume			Annual change of dead tree stems volume		
	Coniferous	Deciduous	Total	Coniferous	Deciduous	Total
1990	5139.9	5600.1	10740.1	218.6	19.5	238.1
1991	5358.5	5619.7	10978.2	218.6	19.5	238.1
1992	5675.9	5635.9	11311.8	317.4	16.3	333.6
1993	6093.5	5650.1	11743.6	417.7	14.1	431.8
1994	6808.8	5657.6	12466.4	715.2	7.6	722.8
1995	7586.2	5635.0	13221.2	777.5	-22.7	754.8
1996	7605.1	5649.0	13254.1	18.9	14.0	32.9
1997	7251.5	5688.0	12939.5	-353.6	39.0	-314.6
1998	6857.1	5697.8	12554.9	-394.4	9.8	-384.7
1999	6560.7	5705.4	12266.1	-296.4	7.6	-288.8
2000	6341.0	5691.1	12032.1	-219.6	-14.3	-233.9
2001	6350.6	5699.7	12050.4	9.6	8.6	18.3
2002	6594.7	5918.8	12513.4	244.0	219.0	463.1
2003	6563.9	6239.5	12803.4	-30.8	320.8	290.0
2004	7067.4	6756.2	13823.6	503.5	516.7	1020.2
2005	7371.2	7784.0	15155.2	303.9	1027.8	1331.6
2006	7767.3	9058.0	16825.3	396.1	1274.0	1670.1
2007	8420.6	9946.7	18367.3	653.3	888.7	1542.0
2008	9124.2	11051.5	20175.7	703.6	1104.8	1808.4
2009	9408.8	11712.4	21121.2	284.6	661.0	945.6
2010	9622.3	11839.9	21462.2	213.5	127.4	341.0
2011	10002.0	12367.8	22369.8	379.7	527.9	907.6
2012	10093.6	12706.3	22803.0	91.6	341.6	433.2
2013	10122.2	12832.5	22954.7	28.6	126.2	154.8

Fellings

Over 1990-1995 felling rates in all Lithuanian forests (irrespective of their ownership) were unstable, but still slightly increasing and reached the peak in 1995 with the total of 9.43 mill. m^3 of living trees felled. After 1995 fellings were decreasing to 7.71 mill. m^3 of living trees felled in 1997 and then started to increase. The highest point over the whole accounting period was reached in 2003 (10.34 mill. m^3 of living trees felled) and then started slightly to decrease until 2012 (8.05 mill. m^3 of living trees felled). In the past year, marginal increase in forest fellings is

[144] Available from: *http://www.msat.lt/lt/miskai/misku-bukle/vejo-pazeidimai-istorija-ir-prognoze/*
[145] Available from: *http://www.natura.org/sites.html*

observed (8.13 mill. m^3). Changes in total forest fellings (living trees) for the period of 1990-2013 are presented in the Figure 6-21.

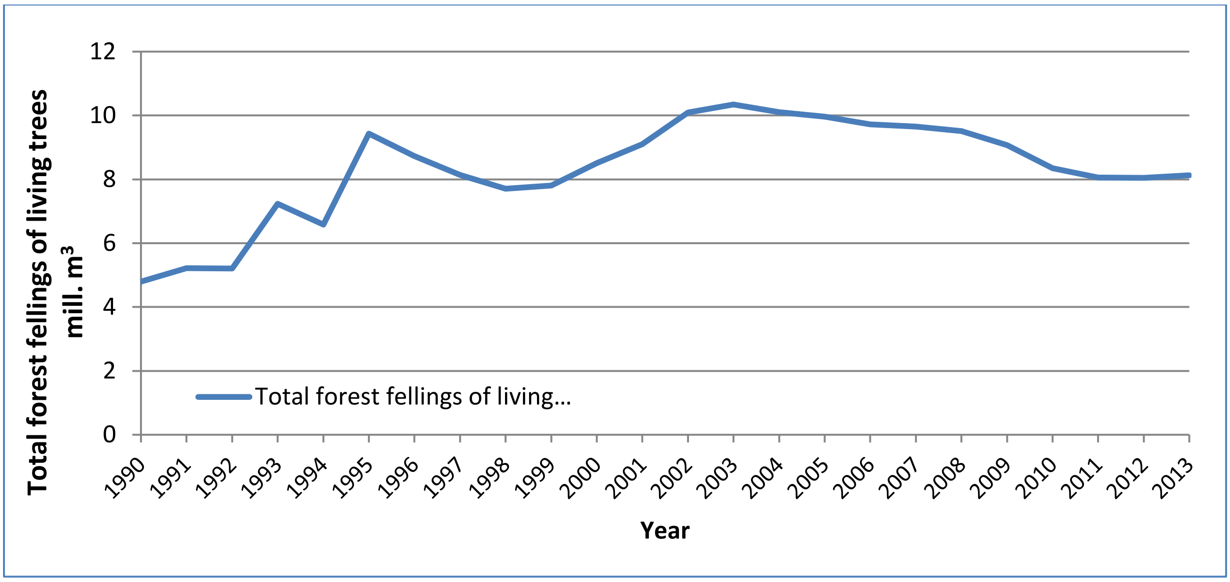

Figure 6-21. Total forest fellings (living trees) in all forests respectful of their ownership, 1990-2013

Biomass burning

Data on areas affected by forest fires is provided by the Directorate General of State Forests (*DGSF*). *DGSF* under the Ministry of Environment performs the functions of founder of the State forest enterprises and coordinator of their activities as well as legislator of mandatory norms for them regarding reforestation, forest protection and management.

Lithuania is one of the few countries in Europe that has uniform system of state fire prevention measures, comprising monitoring, preventive and fire control measures that are established and maintained in forests irrespective of the forest ownership type. Every forest enterprise presents data on forest fires to the *DGSF* every year.

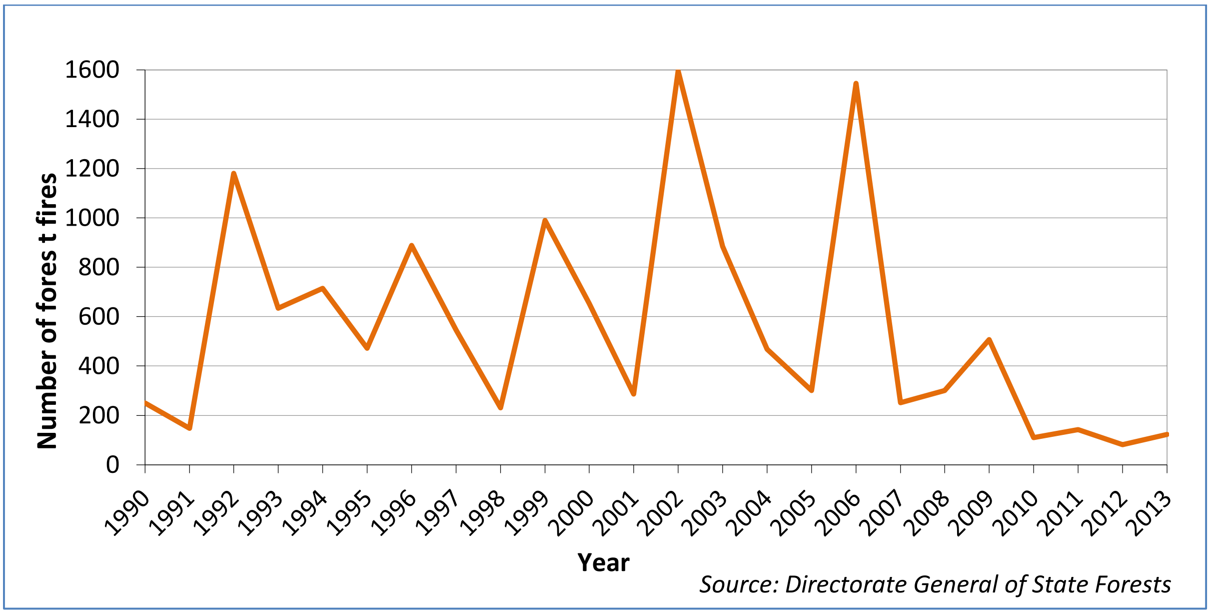

Figure 6-22. Number of forest fires in Lithuania during the period 1990-2013

Forests in Lithuania refer to a high natural fire potentiality, however the modern fire monitoring system prevents large scale forest fires and burned areas mostly are miserable. They are distributed into three fire potentiality classes: I – high potentiality (38% of the total forest area), II – medium potentiality (22% of the total forest area) and III – low potentiality (40% of the total forest area). The distribution of forests according to natural fire potentiality classes is presented in Figure 6-23.

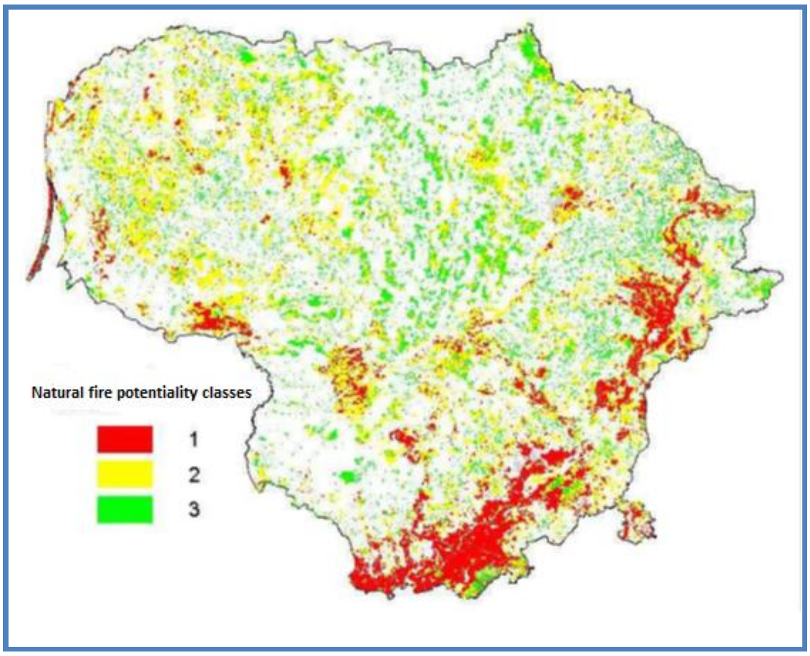

Figure 6-23. Lithuanian forests according to natural fire potentiality classes

Prescribed burning of forest biomass is not used in Lithuania.

A unique fire assessment system has been established in Lithuania since 2013. State Forest Service together with General Directorate of State Forests has worked out a methodology to assess forest fire after-effects in terms of greenhouse gas accounting directly in situ.

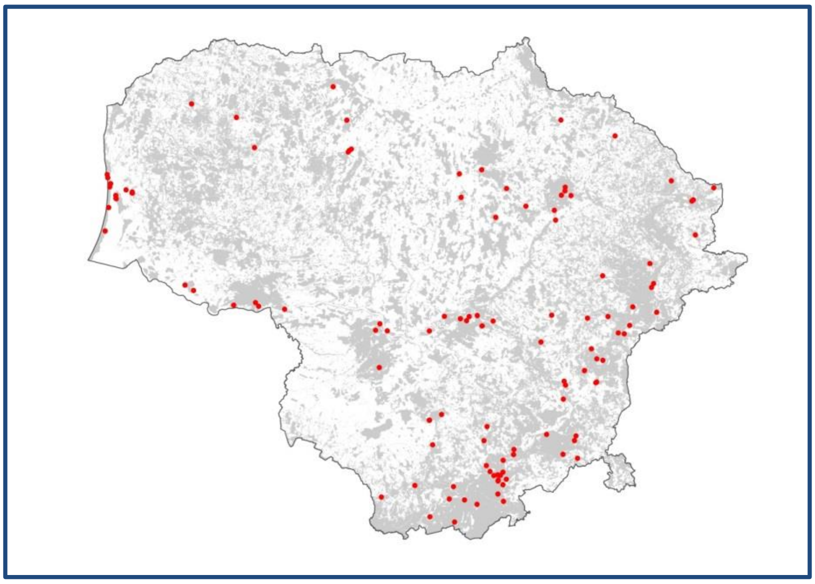

Figure 6-24. Locations of forest fires in 2013

Special assessment table (Table 6-15) has been established with detail information on fire. The table contains information which allows locating forest fire, to estimate area that was burnt and to assess damage that has been done in terms of greenhouse gas accounting. In the table below only partial information that should be filled in the forest fire assessment table is presented. The first part of this table contains information on owner of forest (State forest enterprise), unique forest fire number, date, forest district, block number, site number and coordinates.

Table 6-15. Example of fire assessment table

Area of forest fire	Type of fire	Burnt biomass (*enter code only*)*					Burnt peat (depth of burnt peat, cm)
		Merchantable wood	Dead-wood	Needles, leaves, shoots	Bark of living trees	Forest litter	

Table 6-16 listed below is presenting percentage of burnt biomass expressed by codes that are used by fire damages assessing experts from State forest enterprises or local forest districts.

Table 6-16. Codes table

Degree of burnt biomass	Intensity	Code
No burnt biomass	0%	0
Low	1-25%	1
Moderate	26-60%	2
Strong	61-99%	3
Completely burnt biomass	100%	4

Volume of burnt biomass of the area affected by forest fire is estimated by overlapping GIS layers of the center coordinate of fire location and data of the total growing stock volume by *SFI*. Burnt peat depth is expressed in centimeters of average burnt peat layer over the fire site and is estimated by assessing persons.

Figure 6-25. Forest stand before fire and after

Windbreaks and windfalls

Statistical Yearbook of Forestry provides data on windbreaks and windfalls. However, according to the data collection principles used by *NFI*, volumes of windbreaks and windfalls are included in volumes of dead trees, or removals by sanitary or other fellings. Therefore, to avoid double counting, windbreaks and windfalls were not included in calculations for carbon losses.

Forest fertilization

Fertilization of forest land is not applicable in Lithuania. There is no available data to confirm any fertilization of forest land occurring since 1990.

Fertilization and liming of forest land is possible using biofuel ashes, but there are only several studies presented in Lithuania, evaluating impact of ashes application on forest land, however clear evidences of such application efficiency are still unknown[146].

Fertilization of forest land with other mineral fertilizers is still not economically efficient due to high prices of fertilizers and unclear benefit on forest growth in our climatic conditions.

6.2.2 Methodological Issues

6.2.2.1 Forest land remaining Forest land

The GHG inventory for Forest land remaining Forest land involves estimations of changes in carbon stock in five carbon pools (above-ground biomass, below-ground biomass, dead wood and litter, and soil organic matter) as well as estimations of non-CO_2 gases from those pools. The algorithm for assessment of carbon stock changes in carbon pools is given below:

$$\Delta C_{LU_i} = \Delta C_{AB} + \Delta C_{BB} + \Delta C_{DW} + \Delta C_{LI} + \Delta C_{SO} + \Delta C_{HWP}$$

ΔC_{LUi} – carbon stock changes for a stratum of a land-use category;
ΔC_{AB} – annual change in carbon stock in above-ground biomass, t C yr^{-1};
ΔC_{BB} – annual change in carbon stock in below-ground biomass, t C yr^{-1};
ΔC_{DW} – annual change in carbon stock in deadwood, t C yr^{-1};
ΔC_{LI} – annual change in carbon stock in litter, t C yr^{-1};
ΔC_{SO} – annual change in carbon stock in soil, t C yr^{-1};
ΔC_{HWP} – annual change in carbon stock in harvested wood products, t C yr^{-1}.

Carbon stock changes in living biomass

Living biomass pool in this greenhouse gas inventory refers to above-ground biomass and below-ground biomass. The estimation of carbon stock changes in living biomass is consistent with the *Method 2* further described in the *IPCC 200*6, which is also called as the stock change method. Estimations of carbon stock changes by using this method requires biomass carbon stock inventories for a given forest area in two points in time. Biomass change is the difference between the biomass at $time_2$ and $time_1$, divided by the number of years between the inventories[147]:

$$\Delta C_{LB} = \frac{(C_{t_2} - C_{t_1})}{(t_2 - t_1)} \quad \text{and} \quad C = (\Delta AGB + \Delta BGB) \cdot CF \quad (\textit{modified eq. 2.8})$$

where:
ΔC_{LB} – annual change in carbon stock in living biomass (includes above- and belowground biomass) in total forest land, t C yr^{-1};
C_{t2} – total carbon in biomass calculated at time t_2, t C;

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[146] Ozolinčius R., Armolaitis K., Mikšys V., Varnagirytė-Kabašinskienė I. 2010. *Recommendations for compensating wood ash fertilization* (2[nd] revised edition)
[147] *2006 IPCC Guidelines for National Greenhouse Gas Inventories. Vol. 4, Ch. 2, eq. 2.8, p. 2.12*

C_{t1} – total carbon in biomass calculated at time t_1, t C;
ΔAGB – above-ground biomass change, t d. m.;
ΔBGB – below-ground biomass change, t d. m.;
CF – carbon fraction of dry matter (broadleaves – 0.48; coniferous – 0.51), t C (tonne d. m.)$^{-1}$.[148]

Annual growing stock volume (GSV) changes starting with 2003 for category Forest land remaining forest land was estimated based on *NFI* data using the following steps:

1. Annual GSV changes in all forest areas (total forest management and afforested/reforested area) are estimated using sampling method. This estimation is based on the change in GSV on the same area (re-measured permanent sample plots data $V_{rem_{t2}} - V_{rem_{t1}}$) and adding GSV increment (ΔV_{new}) of the first measurement of permanent sample plots i.e. new afforested areas or other plots which have no re-measurement data;
2. Annual GSV changes of afforested/reforested areas are estimated combining wall-to-wall and sampling methods. Estimation is based on area assessment by wall-to-wall method and mean GSV assessment by sampling method which is derived using relationship between mean GSV and age of forest in permanent plots of afforested/reforested areas (Figure 11-14);
3. Estimation of annual GSV change in Forest Management area is based on the difference between all forests annual GSV changes (*step 1*) and annual GSV change of afforested/reforested areas (*step 2*).

The equations presenting calculations on growing stock volume change in Forest land remaining Forest land are shown below:

$$\Delta FF_t = \left(\left(V_{rem_{t2}} - V_{rem_{t1}}\right) + \Delta V_{new}\right) - \Delta F_2$$

where:
ΔFF_t – growing stock volume change for Forest land remaining Forest land for the defined year, m^3;
V_{remt1} – growing stock volume calculated at time t_1, m^3;
V_{remt2} – growing stock volume calculated at time t_2, m^3;
ΔV_{new} – growing stock volume change of the new measured sample plots, m^3;
ΔF_2 – growing stock volume change of new forest areas, m^3.

Above-ground biomass

Above ground biomass refers to all living biomass above the soil including stem, stump, bark, branches, seeds and foliage. Calculation of above-ground biomass is based on volume of living trees stems with bark, basic wood density and biomass expansion factor. However, *IPCC 2006* requires to use biomass conversion and expansion factor (BCEF), which is based on country specific data, but while Lithuania has no country specific values we are using previous methodology to estimate above and below ground biomass. Above-ground biomass is calculated by employing slightly modified eq. 2.8, (p. 2.12) of *IPCC 2006*:

$$\Delta AGB = (\Delta GS) \cdot WD \cdot BEF$$

where:
ΔAGB – above-ground biomass change, t d. m.;
ΔGS – change of tree stems volume with bark, m^3;

[148] *2006 IPCC Guidelines for National Greenhouse Gas Inventories. Vol. 4, Ch. 4, Table 4.3, p. 4.48*

WD – basic wood density, t d. m. m^{-3};
BEF – biomass expansion factor.

Basic wood density (WD) was estimated on the basis of data provided in Table 4.14 of the *IPCC 2006* (p. 4.71). Density values for coniferous and deciduous were calculated as weighted average values related to GSV (Table 6-17).

Above ground biomass was calculated for broadleaves and coniferous separately. For the period of 2002-2013 data of *NFI* was used, and for the period of 1990-2001 mean value for the known time period was used.

Table 6-17. Total growing stock volume (NFI, 2013) and average basic wood density values

Species	Total growing stock volume (mill m^3).	Basic wood density, tonnes d. m. m^{-3}	
		By species	Weighted average
Pine	216.0	0.42	
Spruce	85.9	0.40	
Total coniferous	**301.9**		**0.41**
Birch	88.5	0.51	
Aspen	36.5	0.35	
Black alder	48.9	0.45	
Grey alder	21.7	0.45	
Oak	11.6	0.58	
Ash	4.0	0.57	
Total deciduous	**211.2**		**0.47**
Overall total	**513.1**		**0.44**

Default values of biomass expansion factor (BEF) for conversion of tree stems volume with bark to above-ground tree biomass were estimated using national tables of merchantable wood volume (for branches) and leaves-needles biomass data by Usolcev (Усольцев, В. А. 2001; 2002; 2003[149]). Rate of BEF for coniferous was estimated to be 1.221 and 1.178 for deciduous. The rates of BEF estimated for Lithuania are very close to the rates presented in *IPCC 2006* in Table 4.5 (p. 4.50), what shows the consistency between the chosen methods.

Below-ground biomass

Below-ground biomass refers to all living biomass of live roots. Below-ground biomass is calculated by using modified eq. 2.8 (p. 2.12) of the *IPCC 2006* which requires data for above-ground biomass and root-to-shoot ratio. Default values of root-to-shoot ratios R were estimated using data of Usolcev and Table 4.4 (*IPCC 2006*, p. 4.49): for coniferous – 0.26; for deciduous – 0.19:

$$\Delta BGB = \Delta AGB \cdot R$$

where:
ΔBGB – below-ground biomass change, t d. m.;
ΔAGB – above-ground biomass change, t d. m.;
R – root-to-shoot ratio, dimensionless.

[149] Усольцев В.А. 2001. *Фитомасса лесов Северной Евразии. База данных и география*. 707с., Якатеринбург. Усольцев В.А. 2002. *Фитомасса лесов Северной Евразии. Нормативы и элементы географии*. 762с. Якатеринбург. Усольцев В.А. 2003. *Фитомасса лесов Северной Евразии. Предельная продуктивность и география*. 405 с., Якатеринбург.

Carbon fraction of dry matter

Carbon fraction (CF) value of above ground forest biomass for broadleaves forest equal to 0.48 tonne C (tonne d. m.)$^{-1}$ and 0.51 tonne C (tonne d. m.)$^{-1}$ for coniferous provided in the *IPCC 2006* (Table 4.3, p. 4.48) was used for estimation of CF in dry biomass matter.

Carbon stock change in dead organic matter

For the greenhouse gas inventory Lithuania defines dead organic matter (DOM) as it is described in *IPCC 2006* (Ch. 4.2.2), which provides two types of dead organic matter pools: dead wood and litter.

Lithuania assumes that there are no changes in carbon stocks in litter in forest land remaining forest land therefore uses default value of 24 tonnes per hectare. Notation key „NO" is used in the CRF.

Annual change in carbon stocks in dead organic matter in Forest Land remaining Forest Land is calculated following the summarizing equation for calculation of changes in dead organic matter carbon pools which is equal to the sum of carbons stock in dead wood (measured available dead wood) and carbon stock in dead wood that is left on site after fellings (BGB). Dead wood that is left on site after fellings is assumed to be below-ground biomass which is roots. It is assumed that BGB decays in equal parts in 5 years. Modified eq. 2.17 (p. 2.21) of *IPCC 2006* has been used to calculate carbon stock change in dead organic matter:

$$\Delta C_{DOM} = \Delta C_{DW} + \Delta C_{DWH}$$

where:
ΔC_{DOM} – annual change in carbon stocks in dead organic matter, t C yr^{-1};
ΔC_{DW} – change in carbon stocks in dead wood (measured dead stems), t C yr^{-1};
ΔC_{DWH} – change in carbon stocks in dead wood (BGB left on site after fellings), t C yr^{-1}.

Annual change of biomass of dead trees stems is calculated by using stock change method and employing equation 2.19 (p. 2.23) of *IPCC 2006*:

$$\Delta C_{FF_{DW}} = \left[\frac{A \cdot \left(B_{t_2} - B_{t_1}\right)}{T}\right] \cdot CF$$

where:
ΔC_{FFDW} – annual change in carbon stocks in dead wood in forest land remaining forest land, t C yr^{-1};
A – area of managed forest land remaining forest land, ha;
B_{t1} – dead wood stock at time t_1 for managed forest land remaining forest land, t d. m. ha^{-1};
B_{t2} – dead wood stock at time t_2 (the second time) for managed forest land remaining forest land, t d. m. ha^{-1};
T (= t_2 - t_1) – time period between time of the second stock estimate and the first stock estimate, yr.;
CF – carbon fraction in dry biomass matter (broadleaves – 0.48; coniferous – 0.51), tonnes C (tonne d. m.)$^{-1}$ (*IPCC 2006*, Table 4.3, p. 4.48).

$$\Delta C_{FF_{DW}} = \frac{\Delta B}{T} \cdot CF$$

where:
ΔC_{FFDW} – annual change in carbon stocks in dead wood in forest land remaining forest land, t C yr^{-1};
ΔB – dead wood stock change for managed forest land remaining forest land, t d. m. ha^{-1};
T (= $t_2 - t_1$) – time period between time of the second stock estimate and the first stock estimate, yr.;
CF – carbon fraction in dry biomass matter (broadleaves – 0.48; coniferous – 0.51), tonnes C (tonne d. m.)-1 (*IPCC 2006*, Table 4.3, p. 4.48).

$$\Delta B = B_{t_2} - B_{t_1}$$

where:
ΔB – dead wood stock change for managed forest land remaining forest land, t d. m. ha^{-1};
B_{t1} – dead wood stock at time t_1 for managed forest land remaining forest land, t d. m. ha^{-1};
B_{t2} – dead wood stock at time t_2 (the second time) for managed forest land remaining forest land, t d. m. ha^{-1}.

$$B_t = AGB + BGB$$

where:
AGB – above-ground biomass, t d. m.;
BGB – below-ground biomass, t d. m.

$$AGB = V_{dw} \cdot WD \cdot BEF$$

where:
V_{dw} – available dead wood volume, m^3;
WD – basic wood density, t d. m. m^{-3};
BEF – biomass expansion factor.

$$BGB = AGB \cdot R$$

where:
AGB – above-ground biomass, t d. m.;
R – root-to-shoot ratio, dimensionless.

Carbon stock change in soil organic matter

Carbon stock change in drained organic forest soils was calculated using equation 2.26 (p. 2.35 of *IPCC 2006*):

$$\Delta C_{FOS} = A_{Drainage} \cdot EF_{Drainage}$$

where:
ΔC_{FOS} – CO_2 emissions from drained organic forest soils, t C yr^{-1};
$A_{Drainage}$ – area of drained organic forest soils, ha;
$EF_{Drainage}$ – emission factor for CO_2 from drained organic forest soils, t C ha^{-1} yr^{-1}.

Default value of emission factor for drained organic soils in managed forests provided in Table 4.6 (p. 4.53 of *IPCC 2006*) was used in calculations. Default $EF_{Drainage}$ for temperate forests is 0.68 tonnes C ha^{-1} yr^{-1}.

Non-CO_2 emissions from drainage of forest soils

For estimation of non-CO_2 emissions from drained forest soils Lithuania uses default *Tier 1* method. *Tier 1* eq. 11.1 (p. 11.7 of *IPCC 2006*) is applied with a simple disaggregation of drained forest soils into *nutrient rich* and *nutrient poor* areas and default emission factors are used.

$$N_2O_{emissions_{FF}} = \sum \left(A_{FF_{organic\,IJK}} \cdot EF_{FF_{drainage,\ organic\,IJK}}\right) + A_{FF_{mineral}} \cdot EF_{FF_{drainage,\ mineral}} \cdot \frac{44}{28} \cdot 10^{-6}$$

where:
N_2O emissions $_{FF}$ – emission of N_2O in units of nitrogen, kg N;
$A_{FF_{organic}}$ – area of drained forest organic soils, ha;
$A_{FF_{mineral}}$ – area of drained forest mineral soils, ha;
$EF_{FF_{drainage,\ organic}}$ – emission factor for drained forest organic soils, kg N_2O-N ha^{-1} yr^{-1};
$EF_{FF\ drainage,\ mineral}$ – emission factor for drained forest mineral soils, kg N_2O-N ha^{-1} yr^{-1};
IJK – soil type, climate zone, intensity of drainage, etc. (depends on the level of disaggregation).

NFI provides data on forest land distribution by forest soils (Table 6-9). According to *NFI*[150] data, area of mineral soils amounts to 84.3% and area of organic soils – 15.7% of the total forest area. Drained organic forest soils constitute to 7.9% of the total forest land. This area consists of 2.6% infertile and 5.3% of fertile drained organic forest soils. Area of lands converted to Forest land was also included into estimations.

Lithuania has no data on drained mineral forest soils, therefore emissions or removals from drained mineral forest soils are not estimated. Emissions and removals estimations of drained organic forest soils include areas of land converted to Forest land.

CH_4 emissions are estimated using a simple emission factor approach further described in eq. 2.6 (Ch. 2.2.2.1, p. 2.18 of *Wetlands Supplement*). CH_4 emissions are estimated for drained organic soils where there are ditches or drainage canals.

$$CH_{4\_organic} = \sum_{c,n,p} = A_{c,n,p} \cdot ((1 - Frac_{ditch}) \cdot EF_{CH4_{land\ c,n}} + Frac_{ditch} \cdot EF_{CH4_{ditch\ c,p}}))$$

where:
$CH_{4\_organic}$ – annual CH_4 loss from drained organic soils, kg CH_4 yr^{-1};
$A_{c,n,p}$ – land area of drained organic soils in a land-use category in climate zone c, nutrient status n and soil type p, ha;
$EFCH_{4\_land\ c,n}$ – emission factors for direct CH_4 emissions from drained organic soils, by climate zone c and nutrient status n, kg CH_4 ha^{-1} yr^{-1};
$EFCH_{4\_ditch\ c,p}$ – emission factors for CH_4 emissions from drainage ditches, by climate zone c and soil type p, kg CH_4 ha^{-1} yr^{-1};
$Frac_{ditch}$ – fraction of the total area of drained organic soil which is occupied by ditches (where 'ditches' are considered to be any area of man-made channel cut into the peatland).

Biomass Burning

Data on areas affected by forest fires on areas under the category Forest land remaining Forest land is provided by the *DGSF*. However, data on wildfires on lands converted to Forest land is not so accurate, therefore Lithuania, following recommendations made by ERT 2012, subdivides the

[150] Lithuanian National Forest Inventory 2003 – 2007. Forest resources and their dynamics

forest area burned on the basis of the proportional contribution of each category to the total forest land area.

Carbon release from burnt biomass was calculated using eq. 2.27 (p. 2.42 of *IPCC 2006*):

$$L_{fire} = A \cdot M_B \cdot C_f \cdot G_{ef} \cdot 10^{-3}$$

where:
L_{fire} – quantity of GHG released due to fire, t of GHG;
A – area burnt, ha;
M_B – mass of 'available' fuel, tonnes ha^{-1};
C_f – combustion factor (or fraction of biomass combusted), dimensionless;
G_{ef} – emission factor, g (kg d. m.)$^{-1}$.

M_B value of 71 t/ha for 1990-2012 has been used and 88.2 t/ha for 2013 considering results presented by the national forest fire assessment project. C_f equals to 0.64 for 1990-2012 period, and 0.2 for 2013.

Average values of emission factor G_{ef} for CO_2, N_2O and CH_4 gases were calculated based on the values presented in the Table 2.5 (p. 2.47 of the *IPCC 2006*) and are equal to:

CO_2 – 1569 g (kg d. m.)$^{-1}$;
CH_4 – 4.7 g (kg d. m.)$^{-1}$;
N_2O – 0.26 (kg d. m.)$^{-1}$.

6.2.2.2 Land converted to Forest land

Land use area calculations of Land converted to Forest land are further described in chapter 6.2.1. The total area of land converted to Forest land between 1990 and 2013 were computed by using sample plots data of *NFI*.

The land-use categories from which areas have been converted to Forest land are the following: Croplands, Grasslands, Wetlands, Settlements and Other land.

Yearly land transition matrixes of conversions from one land use category to Forest land were created based on year of the conversion and the category converted. Annual land transition matrix for conversion of Croplands to Forest land is presented in the table below.

Table 6-18. Yearly land transition matrix for Croplands converted to Forest Land

Years after conversion	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	NO	NO	399.4	798.8	798.8	2795.9	1597.7	NO	399.4	1997.1	1997.1	**798.8**
2	NO	NO	399.4	399.4	798.8	798.8	2795.9	1597.7	NO	399.4	1997.1	**1997.1**
3	NO	**1198.2**	NO	798.8	399.4	798.8	798.8	2795.9	1597.7	NO	399.4	**1997.1**
4	**399.4**	399.4	798.8	NO	798.8	399.4	798.8	798.8	2795.9	1597.7	NO	**399.4**
5	NO	399.4	399.4	798.8	NO	798.8	399.4	798.8	798.8	2795.9	1597.7	**NO**
6	NO	NO	NO	399.4	798.8	NO	798.8	399.4	798.8	798.8	2795.9	**1597.7**
7	NO	NO	NO	399.4	399.4	798.8	NO	798.8	399.4	798.8	798.8	**2795.9**
8	NO	NO	**1198.2**	NO	399.4	399.4	798.8	NO	798.8	399.4	798.8	**798.8**
9	NO	**399.4**	399.4	798.8	NO	399.4	399.4	798.8	NO	798.8	399.4	**798.8**
10	NO	NO	399.4	399.4	798.8	NO	399.4	399.4	798.8	NO	798.8	**399.4**
11	NO	NO	NO	NO	399.4	798.8	NO	399.4	399.4	798.8	NO	**798.8**
12	NO	NO	NO	NO	NO	399.4	798.8	NO	399.4	399.4	798.8	**NO**
13	NO	NO	NO	**1198.2**	NO	NO	399.4	798.8	NO	399.4	399.4	**798.8**
14	NO	NO	**399.4**	399.4	**1198.2**	NO	NO	399.4	798.8	NO	399.4	**399.4**
15	NO	NO	NO	399.4	399.4	**1198.2**	NO	NO	399.4	798.8	NO	**399.4**
16	NO	NO	NO	NO	399.4	399.4	**1198.2**	NO	NO	399.4	798.8	**NO**
17	NO	NO	NO	NO	NO	399.4	399.4	**1198.2**	NO	NO	399.4	**798.8**
18	NO	NO	NO	NO	NO	NO	399.4	399.4	**1198.2**	NO	NO	**399.4**
19	NO	NO	NO	**399.4**	NO	NO	NO	399.4	399.4	**1198.2**	NO	**NO**
20	NO	NO	NO	NO	**399.4**	NO	NO	NO	399.4	399.4	**1198.2**	**NO**
	399.4	2396.5	4393.5	7189.4	7988.3	10384.7	11982.4	11982.4	12381.8	13979.4	15577.1	**15177.7**

Carbon stock changes in living biomass

For the estimation of carbon stock changes in living biomass, growing stock volume of Lands converted to Forest land was estimated using data of *NFI* permanent sample plots on mean growing stock volume of non-forest Lands converted to Forest land according to the year of conversion (Figure 6-26). 2nd order polynomial trend was used to come up with mean growing stock volume and mean growing stock volume increment of lands converted to Forest land. It should be noted, that according to definition of forest in Lithuania, stands are becoming forest when reaching certain requirements for forest (e.g. age), therefore mean growing stock volume for lands converted to forest at year 1 are not equal to zero, because it is more likely that these stands will contain growing stock volume accumulated in stands for 10 or more years (presumed time-frame for reaching certain requirements for forest) (Table 6-19).

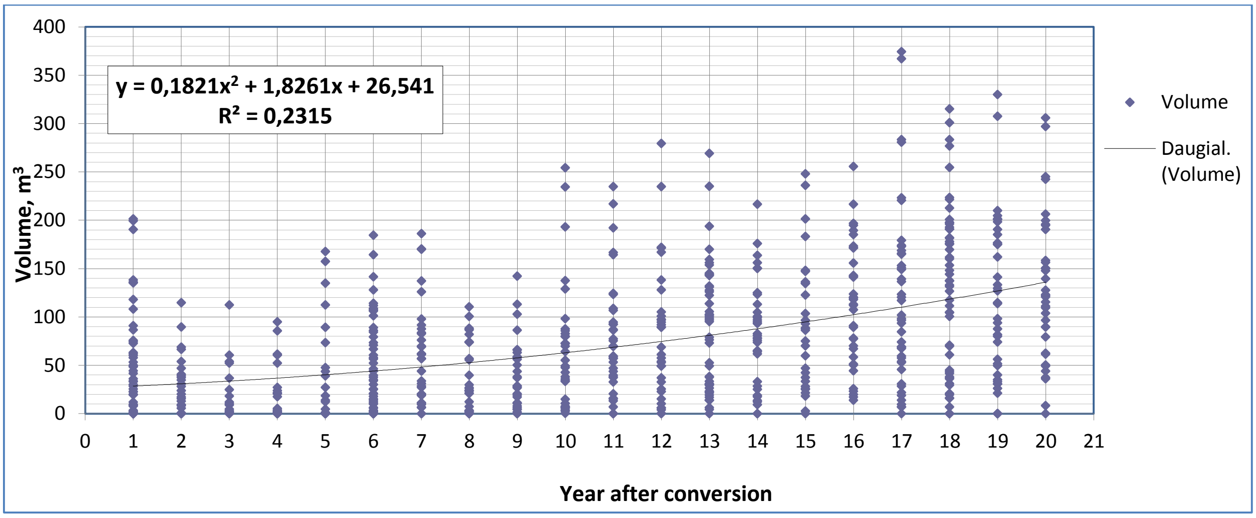


Figure 6-26. *NFI* data on growing stock volume of non-forest lands converted to forest land at the year of conversion to Forest land

Table 6-19. Mean GSV and GSV increment based on NFI data on lands converted to Forest land at the year of conversion

Year after conversion	Mean growing stock volume, m^3/ha	Growing stock volume change, m^3/ha
1	28.5	2.0
2	30.9	2.4
3	33.7	2.7
4	36.8	3.1
5	40.2	3.5
6	44.1	3.8
7	48.2	4.2
8	52.8	4.6
9	57.7	4.9
10	63.0	5.3
11	68.7	5.7
12	74.7	6.0
13	81.1	6.4
14	87.8	6.7
15	94.9	7.1
16	102.4	7.5

17	110.2	7.8
18	118.4	8.2
19	127.0	8.6
20	135.9	8.9

GSV change for land converted to Forest land was estimated by using equation presented below:

$$\Delta V = \sum \left(A_i \cdot \left(V_{t_2} - V_{t_1} \right) \right)$$

where:
ΔV – GSV change on land converted to Forest land, m^3;
A_i – area according to land use category, ha;
V_{t1} – GSV at time t_1, m^3;
V_{t2} – GSV at time t_2, m^3.

Annual change in carbon stocks in living biomass in land converted to Forest land was calculated by using eq. 2.15 (p. 2.20 of *IPCC 2006*):

$$\Delta C_B = \Delta C_G + \Delta C_{Conversion} - \Delta C_L$$

where:
ΔC_B – annual change in carbon stocks in living biomass in land converted to forest land, tonnes C yr^{-1};
ΔC_G – annual increase in carbon stocks in living biomass due to growth in land converted to forest land, tonnes C yr^{-1};
$\Delta C_{Conversion}$ – annual change in carbon stocks in living biomass due to actual conversion to forest land, tonnes C yr^{-1};
ΔC_L – annual decrease in carbon stocks in living biomass due to losses from harvesting, fuel wood gathering and disturbances in land converted to forest land, tonnes C yr^{-1}.

Annual change in carbon stocks in living biomass due to actual conversion to forest land was calculated employing equation 2.16 (p. 2.20 of *IPCC 2006*):

$$\Delta C_{Conversion} = \sum_i \left\{ \left[B_{After_i} - B_{Before_i} \right] \cdot \Delta A_{To\ forest_i} \right\} \cdot CF$$

where:
$\Delta C_{Conversion}$ – change in carbon stocks in living biomass in land annually converted to forest land, tonnes C yr^{-1};
$B_{Before\,i}$ – biomass stocks on land type *i* immediately before conversion, tonnes d. m. ha^{-1};
$B_{After\,i}$ – biomass stocks that are on land immediately after conversion of land type *i*, tonnes d. m. ha^{-1} (in other words, the initial biomass stock after artificial or natural regeneration);
$\Delta A_{To\ forest\,i}$ – area of land-use i annually converted to forest land, ha yr^{-1};
CF – carbon fraction of dry matter (broadleaves – 0.48; coniferous – 0.51), tonnes C (tonne d. m.)$^{-1}$ (Table 4.3, p. 4.48 of *IPCC 2006*);
i – represent different types of land converted to forest.

B_{After} value was modelled by using Figure 6-25.

Above-ground biomass

Above ground biomass refers to all living biomass above the soil including stem, stump, bark, branches, seeds and foliage. Calculation of above-ground biomass is based on volume of living trees stems with bark, basic wood density and biomass expansion factor. However, *IPCC 2006* requires to use biomass conversion and expansion factor (BCEF), which is based on country specific data, but while Lithuania has no country specific values we are using previous methodology to estimate above and below ground biomass. Above-ground biomass is calculated by employing slightly modified eqv. 2.8, (p. 2.12 of *IPCC 2006*):

$$\Delta AGB = (\Delta GS) \cdot WD \cdot BEF$$

where:
ΔAGB – above-ground biomass change, t d. m.;
ΔGS – change of tree stems volume with bark, m^3;
WD – basic wood density, t d. m. m^{-3};
BEF – biomass expansion factor.

Basic wood density (WD) was estimated on the basis of data provided in Table 4.14 (p. 4.71 of *IPCC 2006*). Density values for coniferous and deciduous were calculated as weighted average values related to growing stock volume (Table 6-20).

Above ground biomass was calculated for broadleaves and coniferous separately. For the period of 2002-2013 data of *NFI* was used, and for the period of 1990-2001 mean value for the known time period was used.

Table 6-20. Total growing stock volume and average basic wood density values

Species	**Total growing stock volume (mill m^3). Average 2002-2009**	**Basic wood density, tonnes d. m. m^{-3}**	
		By species	**Weighted average**
Pine	190.6	0.42	
Spruce	762.4	0.40	
Total coniferous	**267.0**		**0.41**
Birch	83.2	0.51	
Aspen	34.0	0.35	
Black alder	41.2	0.45	
Grey alder	21.6	0.45	
Oak	11.2	0.58	
Ash	9.0	0.57	
Total deciduous	**200.1**		**0.47**
Overall total	**467.1**		**0.44**

Default values of biomass expansion factor (BEF) for conversion of tree stems volume with bark to above-ground tree biomass were estimated using national tables of merchantable wood volume (for branches) and leaves-needles biomass data by Usolcev (Усольцев, В. А. 2001; 2002; 2003[151]). Rate of BEF for coniferous was estimated to be 1.221 and 1.178 for deciduous. The rates of BEF estimated for Lithuania are very close to the rates presented in Table 34.5 (p. 4.50 of *IPCC 2006*), what is showing the consistency between the chosen methods.

[151] Усольцев В.А. 2001. *Фитомасса лесов Северной Евразии.База данных и география*. 707с., Якатеринбург. Усольцев В.А. 2002. *Фитомасса лесов Северной Евразии. Нормативы и элементы географии*. 762с. Якатеринбург.

Below-ground biomass

Below ground biomass refers to all living biomass of live roots. Below-ground biomass is calculated by using modified eq. 2.8 (p. 2.12 of *IPCC 2006*) which requires data for above-ground biomass and root-to-shoot ratio. Default values of root-to-shoot ratios R were estimated using data of Usolcev and Table 4.4 (p. 4.49 of *IPCC 2006*): for coniferous – 0.26, for deciduous – 0.19.

$$\Delta BGB = \Delta AGB \cdot R$$

where:
ΔBGB – below-ground biomass change, t d. m.;
ΔAGB – above-ground biomass change, t d. m.;
R – root-to-shoot ratio, dimensionless.

Carbon fraction of dry matter

Default value of 0.5 tonne C (tonne d. m.)$^{-1}$ provided in *IPCC 2006* (Table 4.3, p. 4.48) was used for estimation of carbon fraction (CF) in dry biomass matter.

Change in carbon stock in dead organic matter

It was assumed that carbon stock in litter in land converted to Forest land accumulates in 20 years period and then it remains stable. The average value of carbon stock in litter is 24 t per ha per 20 years. This value was accepted for Forest land, using values for cold temperate dry and moist region from Table 2.2 (p. 2.27 of *IPCC 2006*). Average value accumulated in litter in land converted to Forest land is equal to 1.2 t/ha (24 t/ha/20 years). Change in carbon stock in litter in land converted to Forest land was calculated using area from annual land use conversion to forest land matrix.

For Land converted to Forest Land it was assumed that there is no dead organic matter at the moment of conversion. After conversion, dead organic matter starts to accumulate and reaches steady state after 20 years, at the end of conversion period.

Change in carbon stock in soil organic matter

NFI provides data on forest land distribution by forest soils (Table 6-9). According to *NFI*[152] data, area of mineral soils amounts to 84.3% and area of organic soils – 15.7% of the total forest area. Drained organic forest soils constitute to 7.9% of the total forest land. Due to the lack of accurate data on drained organic soils in land converted to Forest land, it was assumed that the same proportion of drained organic soils as it is accepted for Forest land remaining Forest land category refers also to lands converted to Forest land.

Carbon stock change in drained organic forest soils was calculated using eq. 2.26 (p. 2.35 of *IPCC 2006*):

$$\Delta C_{FOS} = A_{Drainage} \cdot EF_{Drainage}$$

where:
ΔC_{FOS} – CO_2 emissions from drained organic forest soils, t C yr^{-1};
$A_{Drainage}$ – area of drained organic forest soils, ha;
$EF_{Drainage}$ – emission factor for CO_2 from drained organic forest soils, t C ha^{-1} yr^{-1}.

[152] Lithuanian National Forest Inventory 2003 – 2007. Forest resources and their dynamics

Default value of emission factor for drained organic soils in managed forests provided in Table 4.6 (p. 4.53 of *IPCC 2006*) was used in calculations. Default $EF_{Drainage}$ for temperate forests is 0.68 tonnes C ha^{-1} yr^{-1}.

Data on areas affected by forest fires on areas under the category Forest land remaining Forest land is provided by the *DGSF*. However, data on wildfires on lands converted to Forest land is not so accurate, therefore Lithuania, following recommendations made by ERT 2012, subdivides the forest area burned on the basis of the proportional contribution of each category to the total forest land area.

Carbon release from burnt biomass on lands converted to Forest land was calculated using the same methodology as it was used for Forest land remaining Forest land and employing equation 2.27 (p. 2.42 of *IPCC 2006*):

$$L_{fire} = A \cdot M_B \cdot C_f \cdot G_{ef} \cdot 10^{-3}$$

where:
L_{fire} – quantity of GHG released due to fire, t of GHG;
A – area burnt, ha;
M_B – mass of 'available' fuel, tonnes. ha^{-1};
C_f – combustion factor (or fraction of biomass combusted), dimensionless;
G_{ef} – emission factor, g (kg d. m.)$^{-1}$.

MB value of 71 t/ha for 1990-2012 has been used and 88.2 t/ha for 2013 considering results presented from the national forest fire assessment Project.

C_f equals to 0.64 for 1990-2012 period, and 0.2 for 2013.

Average values of emission factor G_{ef} for CO_2, N_2O and CH_4 gases were calculated based on the values presented in the Table 2.5 (p. 2.47 of *IPCC 2006*) and are equal to:

CO_2 – 1569 g (kg d. m.)$^{-1}$;
CH_4 – 4.7 g (kg d. m.)$^{-1}$;
N_2O – 0.26 g (kg d. m.)$^{-1}$.

Non-CO_2 emissions from drainage of forest soils

Non-CO_2 emissions from drainage of lands converted to forest land were included into calculations of non-CO_2 emissions of Forest land remaining Forest land.

6.2.3 Quantitative overview of carbon emissions/removals from the sector

The total area of forest land, Forest Land remaining Forest Land, and area of Land converted to Forest Land are provided in the Table 6-21 below.

Table 6-21. Forest land area changes during the period 1990-2013, thous. ha

Year	**Forest land**	**Forest land remaining Forest land**	**Land converted to Forest land**					
			Cropland	*Grassland*	*Wetlands*	*Settlements*	*Other land*	**Total land converted to Forest land**
1990	2061.4	1959.5	0.4	66.3	34.0	NO	1.2	101.9
1991	2068.6	1961.9	0.8	68.7	35.5	0.4	1.2	106.6
1992	2074.6	1964.3	1.2	71.1	35.9	0.4	1.6	110.2

1993	2079.7	1969.1	2.4	71.5	34.7	0.4	1.6	110.6
1994	2082.5	1972.7	2.4	70.7	34.4	0.8	1.6	109.8
1995	2084.9	1975.9	2.4	69.9	34.4	0.8	1.6	109.0
1996	2090.1	1980.3	2.8	69.5	35.1	0.8	1.6	109.8
1997	2093.7	1983.9	3.6	69.1	34.7	0.8	1.6	109.8
1998	2097.3	1989.1	3.6	69.5	32.4	0.8	2.0	108.2
1999	2100.1	1993.1	4.0	68.7	31.6	0.8	2.0	107.0
2000	2105.7	2002.3	4.4	64.7	31.2	0.8	2.4	103.4
2001	2108.9	2006.7	5.2	64.7	29.2	0.8	2.4	102.2
2002	2113.3	2012.2	5.2	65.5	27.2	0.8	2.4	101.1
2003	2118.9	2018.2	6.0	65.1	26.4	1.2	2.0	100.7
2004	2126.9	2021.4	6.4	68.7	27.2	1.2	2.0	105.4
2005	2134.9	2025.4	7.2	71.9	26.8	1.2	2.4	109.4
2006	2142.1	2030.6	8.0	73.5	26.4	1.2	2.4	111.4
2007	2150.4	2036.2	10.4	72.3	27.6	1.2	2.8	114.2
2008	2157.2	2041.0	12.0	73.9	26.4	1.2	2.8	116.2
2009	2160.0	2047.8	12.0	72.7	23.6	1.2	2.8	112.2
2010	2166.4	2058.2	12.4	72.3	20.4	1.2	2.0	108.2
2011	2173.2	2065.4	14.0	73.1	18.0	0.8	2.0	107.8
2012	2184.8	2071.4	15.6	78.7	16.8	0.8	1.6	113.5
2013	2189.2	2076.5	15.2	78.3	16.8	0.8	1.6	112.6

Carbon stock change in living biomass

Area and growing stock volume in Forest Land remaining Forest Land was increasing annually since 1990 to 2013 except 1996 when total growing stock volume resulted in losses comparing to previous years due to spruce dieback (Table 6-22). Annual change in area converted to Forest land was ranging from 0 ha change between the period 1996-1997 to the highest decrease of 4.0 thous. ha between the periods 2008-2009 and 2009-2010 (Table 6-21). The changes of growing stock volume are also related to area changes in Land converted to Forest Land.

Table 6-22. Annual change in growing stock volume in Forest Land remaining Forest Land and Land converted to Forest Land categories

Year	Forest land remaining forest land			Land converted to forest land (≤ 20 years stands)			Total, thous. m^3
	Coniferous thous. m^3	Deciduous, thous. m^3	Total, thous. m^3	Coniferous thous. m^3	Deciduous, thous. m^3	Total, thous. m^3	
1990	223337.4	167462.0	390799.5	959.2	5547.7	6506.9	397306.4
1991	226722.9	169779.0	396501.9	1017.9	5887.4	6905.4	403407.3
1992	229993.9	172010.0	402004.0	1076.2	6224.4	7300.6	409304.6
1993	233138.1	174395.1	407533.2	1084.2	6270.8	7355.0	414888.1
1994	236012.7	176524.1	412536.7	1101.8	6372.7	7474.5	420011.3
1995	237596.2	177581.5	415177.7	1134.6	6562.0	7696.6	422874.2
1996	236883.0	176925.9	413808.8	1155.6	6683.6	7839.3	421648.1
1997	237199.5	177005.5	414204.9	1188.4	6873.5	8061.9	422266.9
1998	241099.6	180010.4	421110.0	1189.1	6877.4	8066.5	429176.5
1999	244902.8	182864.6	427767.5	1205.0	6969.0	8174.0	435941.5
2000	249053.9	186447.3	435501.3	1129.0	6529.6	7658.6	443159.8
2001	254368.5	190490.8	444859.3	1140.1	6594.1	7734.2	452593.5

Year	Forest land remaining forest land			Land converted to forest land (≤ 20 years stands)			Total, thous. m³
	Coniferous thous. m³	Deciduous, thous. m³	Total, thous. m³	Coniferous thous. m³	Deciduous, thous. m³	Total, thous. m³	
2002	255503.7	191411.8	446915.5	1131.1	6541.8	7672.9	454588.4
2003	260282.4	194162.2	454444.5	1231.1	6303.8	7534.9	461979.4
2004	262755.9	195178.2	457934.1	1097.7	6762.8	7860.5	465794.6
2005	263191.3	195811.7	459003.0	1226.4	6865.6	8092.0	467095.0
2006	265424.3	195951.1	461375.4	1302.3	6793.7	8096.0	469471.5
2007	268526.9	194178.4	462705.3	1275.8	6894.6	8170.4	470875.7
2008	272096.0	195636.0	467731.9	1459.7	6862.0	8321.6	476053.5
2009	277059.6	199519.3	476578.9	1306.3	6731.1	8037.4	484616.3
2010	284695.7	202232.2	486927.9	992.1	6365.3	7357.4	494285.3
2011	290293.9	206163.3	496457.2	699.0	6409.5	7108.5	503565.7
2012	294736.9	209639.2	504376.1	720.1	6436.4	7156.5	511532.6
2013	302116.8	219155.7	521272.4	733.8	6390.3	7124.1	528396.5

The total living biomass was fluctuating in Forest land remaining Forest Land from -881.8 thous. t d. m. up to 6016.3 thous. t d. m. during the period of 1990-2013. Living biomass losses of 881.4 thous. t d. m. were inventoried in 1996. The mean value of annual carbon stock change is about 1603.8 kt. The largest living biomass decrease for Land converted to Forest land was observed in 1999-2003 and 2008-2009. This is related to decrease in area of Lands converted to Forest Land category. The carbon stock change values are varying between 159.8 and 197.4 kt per year (Table 6-23).

Table 6-23. Annual carbon stock change due to living biomass change in Forest Land (emissions – negative sign, removals – positive sign)

Year	Forest land remaining forest land				Land converted to forest land (≤ 20 years stands)				Total Carbon stock change, kt
	Above-ground biomass stock change, t d. m.	Below-ground biomass stock change, t d. m.	Total living biomass stock change, t d. m.	Carbon stock change, kt	Above-ground biomass stock change, t d. m.	Below-ground biomass stock change, t d. m.	Total living biomass stock change, t d. m.	Carbon stock change, kt	
1990	2977614.0	684382.9	3661996.9	1821.82	275130.8	54878.7	330009.4	159.81	1981.63
1991	2977614.0	684382.9	3661996.9	1821.82	291103.8	58064.7	349168.5	169.09	1990.91
1992	2872739.2	660445.6	3533184.8	1757.83	306716.1	61178.8	367894.9	178.16	1935.98
1993	2894495.5	660133.8	3554629.3	1765.72	310012.4	61836.3	371848.6	180.07	1945.79
1994	2617779.3	598111.7	3215891.0	1598.02	315250.6	62881.1	378131.7	183.11	1781.14
1995	1378175.7	317344.9	1695520.5	843.82	323506.1	64527.8	388033.9	187.91	1031.72
1996	-720025.8	-161798.5	-881824.3	-436.77	328590.0	65541.8	394131.9	190.86	-245.91
1997	202504.4	49566.6	252071.0	126.98	336133.1	67046.4	403179.6	195.24	322.23
1998	3616168.4	823742.3	4439910.7	2204.96	335572.9	66934.7	402507.6	194.92	2399.88
1999	3484203.6	795275.4	4279479.0	2126.12	338308.9	67480.4	405789.3	196.51	2322.63
2000	4061675.3	917182.8	4978858.0	2468.40	319123.5	63653.6	382777.1	185.36	2653.77
2001	4899240.7	1117092.6	6016333.3	2988.41	320906.7	64009.3	384916.0	186.40	3174.81
2002	1078213.1	244642.4	1322855.4	656.45	317687.6	63367.2	381054.8	184.53	840.98
2003	3001796.6	732817.6	3734614.2	1880.35	311445.7	62446.6	373892.3	181.24	2061.59
2004	1194533.6	302434.8	1496968.4	759.30	323144.5	64292.3	387436.7	187.53	946.83
2005	299881.8	72772.3	372654.1	187.40	330639.2	66039.8	396679.1	192.14	379.55
2006	856052.3	240145.3	1096197.5	568.02	330464.7	66205.5	396670.2	192.25	760.27
2007	248961.6	149967.7	398929.3	246.93	333599.1	66730.8	400329.9	193.97	440.89
2008	2875922.5	677706.3	3553628.8	1776.63	338799.8	68197.6	406997.3	197.42	1974.06

Year	Forest land remaining forest land				Land converted to forest land (≤ 20 years stands)				Total Carbon stock change, kt
	Above-ground biomass stock change, t d. m.	Below-ground biomass stock change, t d. m.	Total living biomass stock change, t d. m.	Carbon stock change, kt	Above-ground biomass stock change, t d. m.	Below-ground biomass stock change, t d. m.	Total living biomass stock change, t d. m.	Carbon stock change, kt	
2009	4565867.0	1034717.9	5600584.9	2778.57	301820.1	60499.6	362319.8	175.62	2954.19
2010	4385346.8	1087249.9	5472596.7	2764.02	306965.9	60977.7	367943.6	178.05	2942.07
2011	4286352.8	998432.7	5284785.5	2636.07	300513.7	58985.7	359499.4	173.58	2809.65
2012	3763200.4	870697.7	4633898.0	2308.34	304211.4	59756.5	363967.9	175.76	2484.10
2013	4560802.7	1098674.9	5659477.6	2841.90	305176.0	59992.8	365168.8	176.37	3018.26

Carbon stock change in dead organic matter

Dead wood is inventoried for Forest Land remaining Forest Land. Dead wood pool also includes below-ground biomass which has left on site during the forest fellings. Above-ground biomass of dead wood which is available during forest fellings is assumed to be removed.

Table 6-24 provides values of stock change in biomass and carbon stock change in dead wood. The data represents tendency of annual accumulation of dead wood in forest land since 1990 to 2013.

Table 6-24. Annual carbon stock change in Forest Land remaining Forest Land due to change in dead organic matter

Year	Dead wood				Dead wood from forest fellings		Total carbon stock change in dead organic matter, kt
	Above-ground biomass stock change, t d. m.	Below-ground biomass stock change, t d. m.	Total biomass stock change, t d. m.	Carbon stock change, kt	Below-ground biomass stock change, t d. m	Carbon stock change, kt	
1990	113525.0	28777.6	142302.6	72.20	114516.7	57.08	129.28
1991	113525.0	28777.6	142302.6	72.20	50101.0	24.97	97.17
1992	158305.2	40543.6	198848.8	101.10	38888.0	19.38	120.48
1993	204386.4	52606.8	256993.1	130.79	270068.5	134.62	265.42
1994	341035.7	88381.9	429417.5	218.86	134557.1	67.07	285.93
1995	354004.1	92899.4	446903.5	228.36	432061.9	215.37	443.73
1996	16484.2	3755.0	20239.2	10.05	238099.3	118.69	128.74
1997	-145492.0	-39304.8	-184796.8	-95.00	83978.9	41.86	-53.14
1998	-180532.4	-47308.0	-227840.4	-116.39	-37217.9	-18.55	-134.94
1999	-135537.3	-35527.1	-171064.4	-87.39	-36740.8	-18.31	-105.70
2000	-111199.6	-28370.9	-139570.5	-70.91	17416.1	8.68	-62.22
2001	9202.7	2065.9	11268.5	5.58	109745.1	54.71	60.29
2002	233351.6	52384.4	285736.1	141.50	219013.1	109.17	250.67
2003	158856.5	29166.7	188023.2	89.70	202707.3	101.10	190.80
2004	516464.4	114731.5	631195.8	311.94	111342.2	55.56	367.50
2005	698652.3	142763.9	841416.2	409.29	39812.7	19.87	429.17
2006	875186.9	179347.8	1054534.7	513.23	-22998.2	-11.38	501.85
2007	788122.3	171287.4	959409.7	472.15	-45155.5	-22.29	449.86
2008	928580.1	199631.3	1128211.4	554.07	-51402.5	-25.41	528.66
2009	491324.7	102736.1	594060.8	290.22	-84649.8	-42.06	248.16
2010	169483.7	39244.0	208727.7	103.99	-145745.6	-72.48	31.51
2011	464179.8	100715.2	564895.0	277.91	-142532.4	-70.96	206.95
2012	226116.6	46981.7	272098.3	132.24	-104541.3	-52.08	80.15
2013	81709.7	16468.2	98177.9	47.63	-56515.2	-28.10	19.53

Carbon stock change in soil

Carbon stock in dead organic matter has been increasing due to expansion of mineral soils in Forest Land remaining Forest Land and Land converted to Forest Land categories. Data on organic soils is presented by *NFI*, which is assessing soil type during inventory process by using Forest soils classification methodology prepared by prof. M. Vaičys. For more detailed information see chapter 6.2.1.

Table 6-25. Annual carbon loss in Forest land remaining Forest land and land converted to Forest land from drained organic soils

Year	Forest land remaining Forest land		Land converted to Forest land												Total area of drained organic soils, thous. ha	Total emissions, kt C
			Area of drained organic soils , thous. ha						Emissions, kt C							
	Area of drained organic soils, thous. ha	Emissions, kt C	Cropland	Grassland	Wetlands	Settlements	Other land	Total	Cropland	Grassland	Wetlands	Settlements	Other land	Total		
1990	154.8	-105.3	0.03	5.2	2.7	NO	0.09	8.05	0.0	-3.6	-1.8	0.00	-0.1	-5.5	162.8	-110.8
1991	155.0	-105.4	0.06	5.4	2.8	0.03	0.09	8.39	0.0	-3.7	-1.9	-0.02	-0.1	-5.7	163.4	-111.1
1992	155.2	-105.5	0.09	5.6	2.8	0.03	0.13	8.68	-0.1	-3.8	-1.9	-0.02	-0.1	-5.9	163.9	-111.4
1993	155.6	-105.8	0.19	5.6	2.7	0.03	0.13	8.71	-0.1	-3.8	-1.9	-0.02	-0.1	-5.9	164.3	-111.7
1994	155.8	-106.0	0.19	5.6	2.7	0.06	0.13	8.61	-0.1	-3.8	-1.8	-0.04	-0.1	-5.9	164.5	-111.9
1995	156.1	-106.1	0.19	5.5	2.7	0.06	0.13	8.55	-0.1	-3.8	-1.8	-0.04	-0.1	-5.9	164.7	-112.0
1996	156.4	-106.4	0.22	5.5	2.8	0.06	0.13	8.61	-0.2	-3.7	-1.9	-0.04	-0.1	-5.9	165.1	-112.3
1997	156.7	-106.6	0.28	5.5	2.7	0.06	0.13	8.61	-0.2	-3.7	-1.9	-0.04	-0.1	-5.9	165.4	-112.5
1998	157.1	-106.9	0.28	5.5	2.6	0.06	0.16	8.49	-0.2	-3.7	-1.7	-0.04	-0.1	-5.8	165.7	-112.7
1999	157.5	-107.1	0.32	5.4	2.5	0.06	0.16	8.39	-0.2	-3.7	-1.7	-0.04	-0.1	-5.7	165.9	-112.8
2000	158.2	-107.6	0.35	5.1	2.5	0.06	0.19	8.11	-0.2	-3.5	-1.7	-0.04	-0.1	-5.6	166.4	-113.1
2001	158.5	-107.8	0.41	5.1	2.3	0.06	0.19	8.01	-0.3	-3.5	-1.6	-0.04	-0.1	-5.5	166.6	-113.3
2002	159.0	-108.1	0.41	5.2	2.1	0.06	0.19	7.92	-0.3	-3.5	-1.5	-0.04	-0.1	-5.4	167.0	-113.5
2003	159.4	-108.4	0.47	5.1	2.1	0.09	0.16	7.86	-0.3	-3.5	-1.4	-0.06	-0.1	-5.4	167.4	-113.8
2004	159.7	-108.6	0.50	5.4	2.1	0.09	0.16	8.24	-0.3	-3.7	-1.5	-0.06	-0.1	-5.7	168.0	-114.3
2005	160.0	-108.8	0.57	5.7	2.1	0.09	0.19	8.55	-0.4	-3.9	-1.4	-0.06	-0.1	-5.9	168.7	-114.7
2006	160.4	-109.1	0.63	5.8	2.1	0.09	0.19	8.71	-0.4	-3.9	-1.4	-0.06	-0.1	-6.0	169.2	-115.1
2007	160.9	-109.4	0.82	5.7	2.2	0.09	0.22	8.93	-0.6	-3.9	-1.5	-0.06	-0.2	-6.1	169.9	-115.5
2008	161.2	-109.6	0.95	5.8	2.1	0.09	0.22	9.09	-0.6	-4.0	-1.4	-0.06	-0.2	-6.2	170.4	-115.9
2009	161.8	-110.0	0.95	5.7	1.9	0.09	0.22	8.77	-0.6	-3.9	-1.3	-0.06	-0.2	-6.0	170.6	-116.0
2010	162.6	-110.6	0.98	5.7	1.6	0.09	0.16	8.46	-0.7	-3.9	-1.1	-0.06	-0.1	-5.8	171.1	-116.4
2011	163.2	-111.0	1.10	5.8	1.4	0.06	0.16	8.46	-0.8	-3.9	-1.0	-0.04	-0.1	-5.8	171.7	-116.7
2012	163.6	-111.3	1.23	6.2	1.3	0.06	0.13	8.92	-0.8	-4.2	-0.9	-0.04	-0.1	-6.1	172.6	-117.4
2013	164.0	-111.6	1.20	6.2	1.3	0.06	0.13	8.90	-0.8	-4.2	-0.9	-0.04	-0.1	-6.1	172.9	-117.7

Biomass burning

The default mean burned biomass values per hectare were used. Carbon emissions are related with burned area (Table 6-26). The largest carbon emissions were observed in 1992 (29.9 kt CO_2) and in 2006 (36.9 kt CO_2). This is the result of repetitive draughts (1992, 1994, 2002, 2006)[153] and irresponsible human behaviour with fire in over-dried forests. Forest fires resulted in nearly 1 million EUR losses for State forests in 2002 – 2006. 97% of all forest fires in Lithuania are caused by direct human activities (transportation, littering etc.) and only 1% is caused by natural circumstances e.g. thunder.

Table 6-26. Annual carbon stock change due to biomass burning

Year	Area burned, ha	Emissions, kt CO_2
1990	134.0	4.44
1991	64.0	2.12
1992	971.0	32.19
1993	355.0	11.77
1994	355.0	11.77
1995	355.0	11.77
1996	355.0	11.77
1997	355.0	11.77
1998	54.0	1.79
1999	342.9	11.37
2000	327.1	10.84
2001	111.1	3.68
2002	746.4	24.75
2003	436.2	14.46
2004	253.2	8.39
2005	50.8	1.69
2006	1199.3	39.76
2007	38.0	1.26
2008	112.4	3.73
2009	315.3	10.45
2010	21.5	0.71
2011	292.8	9.71
2012	20.29	0.67
2013	24.70	0.56

6.2.4 Uncertainty assessment

Lithuanian reporting system is mostly based on sampling method therefore national methodology was employed while estimating overall uncertainty.

Information obtained during *NFI* is based on the data of especially small size. The total number of allocated permanent plots in Lithuanian forests during the *NFI* of 1998-2007 comprised only slightly more than 264 ha. Information derived from this part of forests and trees is generalized to represent more than 2.1 mill. ha of Lithuanian forests. One sample tree (in permanent plots) represents 8000 trees. Several indices are important characterizing statistical information, namely, data accuracy and validity. Data accuracy depends on the variation of parameters of the measured object, sampling volume and measurement accuracy. Measurement accuracy may be increased by applying advanced measuring devices, more precise (often even more time saving)

[153] Lithuanian Hydrometeorological Service. Available from: *www.meteo.lt*

instrumental measurement methods and decreasing the influence of subjective "human" factor. Data validity is determined by the stability of the chosen sampling design (main parameters of which are: size of sample plots, clustering, location etc.) to assess the analyzed object, as well as by methods and standards applied to estimate (measure) different parameters, elimination of any possible parameter estimation biases in the inventory system, etc. However, the obtained accurate data not necessarily guarantee the validity of the information on the analyzed object. In other words, the use of highly precise up-to-date devices may not ensure sufficient data validity if they are collected, for instance, in subjectively selected sampling areas.

Lithuanian *NFI* system is developed so that the desired accuracy of results is in line with the maximum validity of information. Initial desired accuracy of *NFI* results is determined already in the first stage of *NFI* planning – prior to inventory, when the necessary sampling intensity is defined, measurement methods and tools are selected.

A two-stage sampling was tested for *NFI* sample plots, while estimating area distribution. In the first stage sample plots were allocated and assessed in the map of a satellite image. In the second stage the plots were allocated and assessed on the ground. According to a large extent first-stage sampling, forest land area may be assessed very accurately, i.e. with 0.15% precision. It would correspond to 3000 ha forest area error in the whole country. However, forest land identified in a satellite image map failed to comply with the reality. According to ground *NFI* estimation even in 9.8% of cases, i.e. so many times forest land was not detected in nature. And on the contrary, by ground method additionally 6.6% of plots on forest land were identified, which were not recognized in the satellite image. Thus, the assessment of forest land according to satellite images is of a comparatively low accuracy and in this phase it was eliminated.

Total forest land area according to yearly measurements of plots or according to the data of plots measured over a certain number of years is estimated by using the following equations:

$$Q_m = Q \cdot p_m \quad \text{or} \quad Q_m = K_m \cdot q_R; \quad Q_m = \frac{p_m \cdot q_R}{500}$$

where:
Q – total area of Lithuanian territory (6 530 000 ha);
Q_m – forest land area, ha;
p_m – part of forest land area.

Part of forest land area is calculated using the following equation:

$$p_m = \frac{K_m}{K}$$

where:
K_m – sum of plots or their parts on forest land, ascertained during inventory;
K – total number of plots in Lithuania.

Number of sample plots is estimated:

$$K = \frac{Q}{q_R}$$

where:
Q – total area of Lithuanian territory;
q_R – area, represented by one sample plot (399.41 ha).

The error of forest land assessment is estimated:

$$P_{Q_m} = \sqrt{\frac{1 - p_m}{(K - 1)p_m}} \cdot 100$$

where:
p_m – part of forest land area;.
K – total number of plots in Lithuania.

Estimation accuracy of different stand parameters depends on the variation of estimated parameter (expressed by variation coefficient $V_{\%}$) in the analyzed set. The most actual is growing stock volume variation in sample plots of stand communities covering a large diversity of natural conditions. This parameter in Lithuania has not been studied yet. The first reliable data on growing stock volume variation in sample plots of entire stand communities were obtained after the first five – year period of *NFI* in 1998-2002. Having re-measured permanent sample plots in 2003-2007, these data sets were supplemented with the new information both on the growing stock volume and on the variation of gross volume increment, volume change, the volume of felled and dead trees. Variation of growing stock volume in sample plots, depending on site conditions and stand parameters, were analyzed in 500 m^2 size permanent and temporary sample plots allocated in stands. The dependence of growing stock volume variation coefficient on dominant tree species, stand age, stocking level, site humidity and fertility and on site index, expressed by tree height at maturity, has been determined.

Overall uncertainties were estimated by using *Tier 1* method further described in *IPCC 2006*, which is also known as simple error propagation method.

To estimate uncertainty of a product of several quantities eq. 3.1 (p. 3.28 of *IPCC 2006*) was used:

$$U_{Total} = \sqrt{U_1^2 + U_2^2 + \cdots U_n^2}$$

where:
U_{Total} – percentage uncertainty in the product of the quantities (half the 95% confidence interval divided by the total and expressed as a percentage);
U_i – percentage uncertainties associated with each of the quantities, i=1,...n.

For estimation of overall uncertainty, the following equation of IPCC 2006 was used (eq. 3.2, p. 3.28):

$$U_E = \frac{\sqrt{(U_E \cdot E_1)^2 + (U_2 \cdot E_2)^2 + \cdots (U_n \cdot E_n)^2}}{|E_1 + E_2 + \cdots E_n|}$$

where:
U_E – percentage uncertainty of the sum;
U_i – percentage uncertainty associated with source/sink I;
E_i – emission/removal estimate for source/sink i.

The growing stock volume per 1 ha of all Lithuanian forests, based on permanent and temporary sample plots, was estimated with 0.9% accuracy. The lowest standard error (1.3%) was estimated for pine stands (dominant tree species in Lithuania) and the highest (5.1%) for ash and oak stands (lowest prevalence). To be consistent with *IPCC 2003* uncertainties should be reported as a confidence interval giving the range within which the underlying value of an uncertain quantity is through to lie for a specific probability. 95% confidence interval is used by Lithuania in uncertainty estimations.

For Forest Land remaining Forest Land it was assumed that uncertainty of area is 2.3%. Uncertainties of emission factor were estimated using *Tier 1* error propagation method described in eq. 3.2 (*IPCC 2006*). For Forest Land remaining Forest land uncertainty of emission factor was assumed to be about 31.1%.

For Land converted to Forest Land it was assumed that uncertainty of area is 12.2%. Uncertainty of emission factor was assumed to be about 38.4%.

Table 6-27. Uncertainty values

Indicator	Land Use Category	Unit	Uncertainty, %
Growing stock volume	Forest Land remaining Forest land	m^3	2.6
	Land converted to Forest Land	m^3	12.8
Area	Forest Land remaining Forest land	ha	2.3
	Land converted to Forest Land	ha	11.8
Emission factor	Forest Land remaining Forest land	kt CO_2	35.5
	Land converted to Forest Land	kt CO_2	35.2

6.2.5 Source-specific QA/QC and verification

National Forest Inventory Department of the Lithuanian State Forest Service is responsible for reporting of greenhouse gas emissions and removals from LULUCF sector. The main duties of *NFI* department regarding greenhouse gas accounting are:

- Collection of activity data and emission factors used to calculate emissions and removals;
- Selection of methods for calculation of emissions and removals;
- Emission and removals estimates;
- Uncertainty assessment;
- Checking and archiving of input data, prepared estimates and used materials;
- Preparation of Common Reporting Format (CRF) tables and NIR parts for LULUCF and KP LULUCF;
- Implementation of QA/QC plan and specific QA/QC procedures;
- Providing the final estimates (CRF tables and relevant parts of NIR) for the EPA;
- Evaluating requirements for new data, based on internal and external reviews.

NFI department is managed by 16 well educated, experienced employees who are periodically trained and examined, participate in international workshops, seminars etc. 6 persons are responsible for collection of data on forest land and 4 persons on non-forest land, 2 employees are responsible for LULUCF and KP LULUCF data analysis, provision of methodological guidance and preparation of GHG reports.

QA/QC for data collection, data processing issues, preparation of reporting tables achieved by State Forest Service, elaborated control routines of executed LULUCF activities are ensured with the help of procedures established by Environmental Protection Agency. Every GHG emissions and removals submission is presented to scientific-advisory board, where chosen methods, activity data, emission factors and other parameters are discussed and approved.

The following procedures were carried out to ensure QC/QA procedures described in *IPCC 2006* (Ch. 4.4.3, p. 4.44):

- periodical trainings of field crews and individual training of new staff;
- data consistency and completeness control – carried out during measurements by field crews while entering data, and during processing of data after field works;
- independent internal check assessments – carried out on 5% of measured sample plots by *NFI* Control team;
- independent external check assessments and judgments of data processing procedures and algorithms used in the course of *NFI*, elaborated models, uncertainties etc. – carried out by third parties;
- cross checking of statistics gathered from permanent and temporary sample plots, comparison of *NFI* and *SFI* results;
- domestic and external expert analysis and reviews;
- data archiving (maintenance and storage) in several forms and copies in order to recover lost or corrupted data etc.

Applied QA/QC system ensures accuracy of reported information and it is in agreement with the QA/QC system requirements described in *IPCC 2006*.

6.2.6 Category-specific planned improvements

In 2015 Lithuania is expecting to launch several studies for development of national values for carbon stocks in soil and forest litter in forest land and non-forest land and to estimate carbon stocks in dead-wood.

6.3 Cropland (CRF 4.B)

The area of cropland comprises of the area under arable crops as well as orchards and berry plantations. According to the national definition – arable land is continuously managed or temporary unmanaged land, used and suitable to use for cultivation of agricultural crops, also fallows, cold frames and, plastic cover greenhouses, strawberry and raspberry plantations, areas for production of flowers and decorative plants. Arable land set aside for one or several years (<5 years) before being cultivated again as part of an annual crop-pasture rotation is still included under cropland. Orchards and berry plantations are areas planted with fruit trees and fruit bushes (apple-trees, pear-trees, plum-trees, cherry-trees, currants, gooseberry, quince and others). Under this category only those orchards and berry plantations are included that are planted on other than household purpose land and mainly used for commercial purposes. Orchards and berry plantations planted in small size household areas and only used for householders' needs are included under Settlements category. All croplands are managed lands.

6.3.1 Source category description

Two source categories are accounted under this category: emissions from Cropland remaining Cropland and emissions from Land converted to Cropland. Estimated carbon stocks are presented in the table below.

Table 6-28. Estimated carbon stocks under Cropland land use category

Land Use Category			Changes in soil C stocks

	Carbon stock change in biomass	Carbon stock change in dead organic matter	Mineral soils	Organic soils
Cropland remaining Cropland (CC)	√	NO	√	√
Land converted to Cropland (LC)	√	NO	√	√

Information on data sources used for calculations are presented in Table 6-29.

Table 6-29. Information on data sources used for estimation of cropland land area

Sources used	Source data used
Soviet kolkhozzes' land use plans	1990
Orthophoto maps	NLF: 1995-1998; 2005, 2009, 2010
Land areas and croplands declarations database	2010-2011

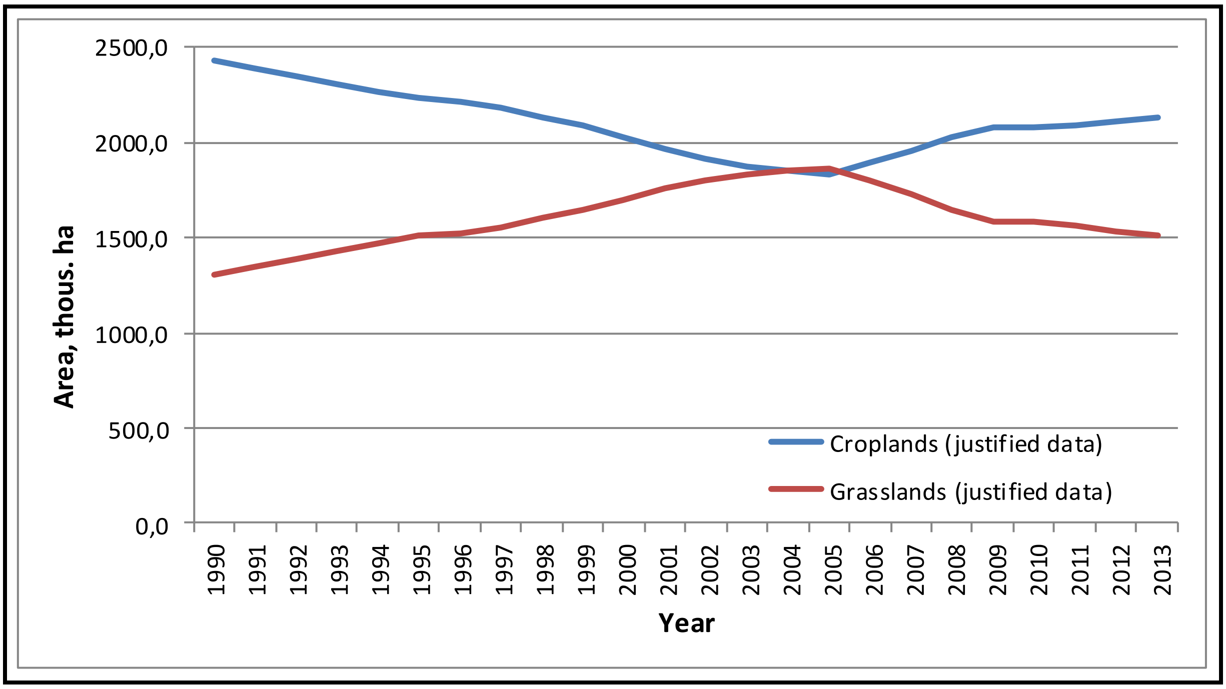


Figure 6-27. Comparison between estimated cropland and grassland area based on study and evened (data analysis techniques applied) data

By seeking methodological correctitude and trying to avoid high range data jumps (reduce the inter-annual variations), data adjustment has been made based on the reference points (1990, 1995, 2005, 2009) which had topographical data (Figure 6-27).

6.3.2 Methodological issues

6.3.2.1 Cropland remaining Cropland

Areas continuously managed as Croplands and areas converted to Croplands after 20 consecutive years followed conversion reported in the category Cropland remaining Cropland (CC). The annual greenhouse gas emissions and removals from this category include:

- Estimates of annual change in C stocks from all C pools and sources;
- Estimates of annual emission of non-CO_2 GHG from all pools and sources.

Carbon stock changes in living biomass

The change in biomass is only estimated for perennial woody crops. Statistics Lithuania reports total area of orchards and berry plantations in Lithuania being ~45 thous. ha in 1990 to ~30 thous. ha in recent years. Lithuania reports only perennial woody biomass accumulated in commercial orchards (apple, pears, plums and cherries) and Salix plantations (because significantly expanded since 2012-2013). Since 1999 reliable statistical data on areas of commercial orchards in Lithuania obtained from annual statistical reports of the State enterprise Agricultural Information and Rural Business Centre (AIRBC)[154]. Area of commercial orchards in 1990 obtained from scientific publication of Venskutonis[155]. Data on area of commercial orchards during the period 1990-1998 was obtained using data interpolation. In recent years area of fruit-trees commercial orchards stabilized at about 3.3 thous. ha, with over 90% of apple plantations.

Above-ground woody biomass

Default *Tier 1* method was used to estimate carbon stock changes in woody biomass. The area of perennial woody cropland was multiplied by a net estimate of biomass accumulation from growth and losses associated with harvest or gathering (eq. 2.7, Ch. 2 of *IPCC 2006*). Losses have been estimated by multiplying a carbon stock value by the area of cropland on which perennial woody crops are being harvested.

Default coefficients for above-ground woody biomass growth rate were used (Table 5.1, Ch. 5 of *IPCC 2006*):

- Above-ground biomass carbon stock at harvest – 63 tonnes C ha^{-1};
- Harvest/maturity cycle – 30 yr;
- Biomass accumulation rate (G) – 2.1 tonnes C ha^{-1} yr^{-1};
- Biomass carbon loss (L) – 63 tonnes C ha^{-1} yr^{-1}.

Below-ground biomass

The default assumption for *Tier 1* is that there is no change in below-ground biomass of perennial trees in agricultural systems. Default values for below-ground biomass for agricultural systems are not available.

Carbon stock change in dead organic matter

The default *Tier 1* method was used (*IPCC 2006*), it assumes that the dead wood and litter stocks are not present in Cropland or are at equilibrium in agroforestry systems and orchards. Thus, there is no need to estimate the carbon stock changes for these pools.

Carbon stock change in soil organic matter

Soil C inventory include estimates of soil organic C stock changes for mineral soils and CO_2 emissions from organic soils due to enhanced microbial decomposition caused by drainage and associated management activity.

Using *Approach 1* data (*IPCC 2006*), Lithuania do not track individual land transitions, therefore soil organic carbon stock (SOC) changes are computed for inventory time periods (i.e. 1990-2002 and 2003-2013). SOC have been estimated for 1990, 2003 and 2013 inventory years using JRC estimated carbon stocks (SOC_{ref}) of agricultural soils[156] and default stock change factors (Land

[154] Available from: *http://www.vic.lt/*
[155] Venskutonis, V. *Sodininkystė*. Vilnius 1999 [en. *Horticulture*]
[156] Available from: *http://eusoils.jrc.ec.europa.eu/library/Themes/SOC/CAPRESE/*

use F_{LU}, management F_{MG}, input F_I). Annual rates of carbon stock change are estimated as the difference in stocks at two points in time divided by the time dependence of the stock change factors.

The Climatic Zone layer is defined based on the classification of *IPCC 2006*. Lithuania is in a single – cool temperate moist climate zone.

Country has limited and/or defragmented specific data on Cropland management systems. For instance national statistics provide annual bare-fallowing areas, but it is not known if it's frequent. According to overviews the area under reduced tillage has been increased in the period 1999-2004[157], but reliable statistics for such land accounting is not available and therefore not included into calculations.

Stratification of management systems have been made based on national statistics for woody crops and available in *Faostat* statistics[158] on Arable land area certified organic.

Mineral soils

Relevant stock change factors for F_{LU}, F_I and F_{MG} for different management activities on Cropland were taken from Table 5.5 (p. 5.17 of *IPCC 2006*). The default 20 year time period was used for calculations of stock changes.

Croplands in Lithuania represent area that has been continuously managed over 20 years, predominantly it is annual crops. Main tillage practice is full tillage, described as substantial soil disturbance with full inversion and frequent tillage operations and small part of the surface covered by residues at planting time. Land mainly has medium residue return when all crop residues are returned to the field. Removals of residues are usual compensated by organic matter supplements from green manure or other type of manure.

Perennial and Organic management systems specified for Croplands and the relevant factors were used in calculations. For perennial croplands: F_{LU} – 1, F_{MG} – 1.15 and F_I – 1.0; for organically managed croplands: F_{LU} – 0.69, F_{MG} – 1.0 and F_I – 1.02.

Organic soils

Data presented by *NFI* permanent sample plots measured in 2012 was used. Organic soils constitute 0.7% from the total croplands area, it was assumed that this value is applicable to both categories – Croplands remaining Croplands and to Lands converted to Croplands.

Tier 1 method was used in order to calculate carbon stock change in organic soils (eq. 2.26 of *IPCC 2006*).

Default emission factors from Table 5.6 (p. 5.19 of *IPCC 2006*) were used along with area estimates for drained organic soils in cold temperate climate region. 5 tonne C ha^{-1} yr^{-1} emission factor was used.

Non-CO_2 greenhouse gas emissions from biomass burning

[157] Šiuliauskas A., Liakas V. *Beplūgė žemdirbystė Lietuvos ūkiuose* (en. *Ploughless agriculture in Lithuanian farms*). Žemės ūkis. 2005. Nr. 2, p. 4-5

[158] Available from: *http://faostat.fao.org/site/377/default.aspx*

There is no controlled burning of Cropland in Lithuania, emissions of non-CO_2 only results from wildfires. Cropland wildfires are infrequent and burnt area normally are small (0.2-0.3 thous. ha), but peak values can exceed 1 thous. ha (in 2005).

Emissions from Cropland category were estimated employing the eq. 2.27 (Ch. 2, p. 2.42 of *IPCC 2006*).

National estimates of M_b (mass of fuel available for combustion (tonnes ha^{-1})) for agricultural residues (post-harvest field burning) are in a range of 1.92-2.27 t ha^{-1} dry matter for main grown cereal crops. Mean value of 2.08 (t ha^{-1}) was used for calculations along with default emission factors (Table 2.5, p.2.47 of *IPCC 2006*).

Activity data on Cropland area burnt was obtained from statistics of Fire and rescue department[159].

6.3.2.2 Land converted to Cropland

Estimation of annual greenhouse gas emissions and removals from Land Converted to Cropland includes the following:

- Estimates of annual change in C stocks from all C pools and sources: biomass (above-ground and below-ground biomass); dead organic matter (dead wood and litter) and soils (soil organic matter);
- Estimates of non-CO_2 gases (CH_4, CO, N_2O, NO_x) from burning of above-ground biomass and DOM.

The cumulative areas over a 20-year transition period reported in the figure below (Figure 6-28).

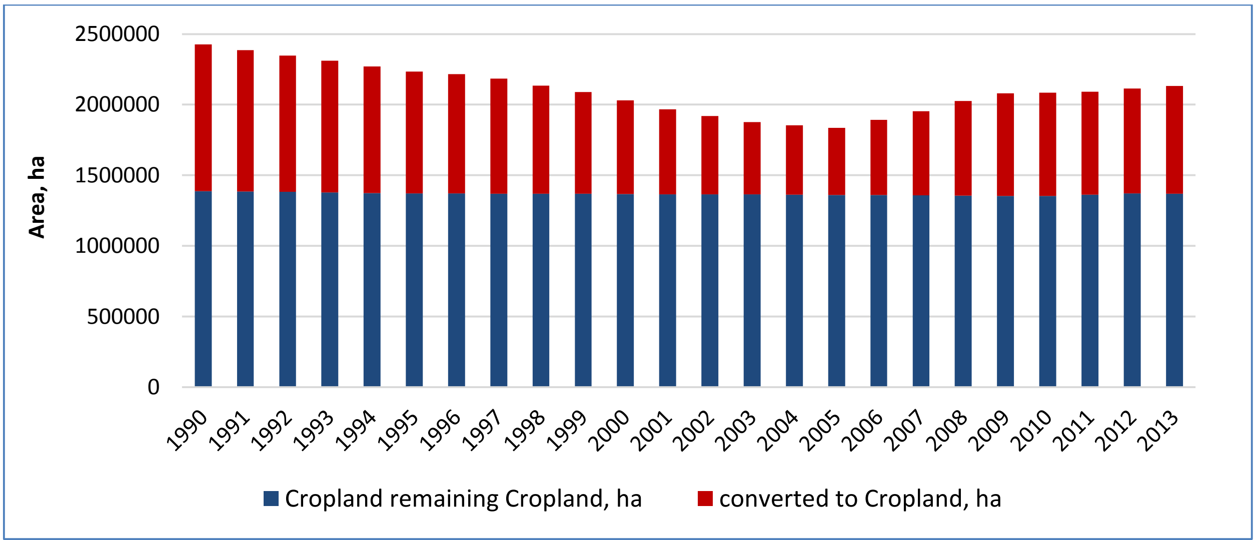


Figure 6-28. Cropland area changes during the period 1990-2013, ha

For each year, the cumulative total area reported under the category Land converted to Cropland category is accounted as equal to the cumulative area that has been converted to that land use over the last 20 years, areas of second land-use change during the 20-year conversion period subtracted by the cumulative total.

[159] Fire and Rescue Department under the Ministry of the Interior of the Republic of Lithuania. Available from: *http://www.vpgt.lt/*

According to information obtained from *NFI*, during the last decades there have been no conversions of Forest land to Cropland.

Carbon stock changes in living biomass

Tier 2 was used to estimate annual change in carbon stocks in living biomass on Land converted to Cropland employing the eq. 2.15 and 2.16 (Ch. 2, p. 2.20 of *IPCC 2006*). Area estimates for Land Converted to Cropland were disaggregated according to prevailing vegetation. Average carbon stock change per hectare has been estimated for each type of conversion.

It is assumed that the prevailing vegetation is removed entirely which leads to emissions, resulting almost zero amount of carbon remaining in biomass. Carbon stocks in biomass are assumed to be zero immediately after conversion (B_{AFTER}), in subsequent years, change in biomass of annual crops is also considered to be zero because carbon gains in biomass from annual growth are offset by losses from harvesting.

Biomass carbon stock in initial land-use categories (B_{BEFORE}) are assumed to be 2.4 t ha^{-1} d. m. in Grasslands, Wetlands and Settlements, 0.0 t ha^{-1} d. m. in Other Land.

Carbon stock change in dead organic matter

Lithuania has no estimates of the dead wood and litter in the initial land-use systems (except FL) prior to conversion. Therefore it is assumed that dead wood and litter stocks are not present or are at equilibrium.

Carbon stock change in soil organic matter

Estimations of change in C stocks in mineral soils in Lands converted to Cropland were based on same methodological approaches as for Cropland remaining Cropland and guidance for estimating changes in soil C stocks provided in Section 2.3.3 of Chapter 2 (*IPCC 2006*).

Mineral soils

Calculation of carbon stocks in mineral soils on Lands converted to Cropland were based on equation 2.25 (p. 2.30, Ch. 2 of IPCC 2006). Country-specific reference C stocks, default stock change factors (Table 5.5, p. 5.17, of *IPCC 2006*) and default 20 year time period for stock changes were used for calculations.

Organic soils

Area of organic soils was assumed to be 0.7% of all conversions to Croplands. Calculation of carbon stocks in organic soils on Lands converted to Cropland were based on same methodological approaches as for Cropland remaining Cropland described in chapter 6.3.2.1.

Non-CO_2 greenhouse gas emissions from biomass burning

The approach used to estimate non-CO_2 emissions from biomass burning in Land Converted to Cropland is essentially the same as for Cropland Remaining Cropland.

Statistics of Fire and rescue department on Cropland area burnt do not provide details to separate Cropland remaining Cropland and Land converted to Cropland, therefore all non-CO_2 greenhouse gas emissions accounted in Cropland remaining Cropland.

6.3.3 Uncertainty assessment

The activity data were obtained from The National Land Service (NLS) and State enterprise Agricultural Information and Rural Business Centre (AIRBC).

The emission factors were employed from *IPCC 2006*.

The uncertainty rates for activity data and emission factors used in the estimates are reported in Table below (Table 6-30).

Table 6-30. Values of uncertainties for Cropland

Input	**Uncertainties, %**	**References**
Activity data		
Cropland area	±2.2	*Study 2*
Emission factors		
G (biomass accumulation)	±75	*IPCC 2006*, p. 5.9
L (biomass loss)	±75	*IPCC 2006*, p. 5.9
F_{LU} F_{MG} F_I	NA	
EF (organic soils)	±90	*IPCC 2006*, p. 5.19

Uncertainties for non-CO_2 gases are likely to be at least 20%.

6.3.4 Category-specific QA/QC and verification

The QC/QA includes quality control activities described in *IPCC 2006*. Activity data and emissions/removals are compared with estimates of other countries. If errors were found they were corrected. Moreover, country-specific data was incorporated in to inventory.

6.3.5 Category-specific planned improvements

Lithuania plans to continue to employ more country-specific values/factors and implement more detailed stratification of management systems.

6.4 Grassland (CRF 4.C)

According to national definition – grassland includes meadows and natural pastures planted with perennial grasses or naturally developed, on a regular basis used for moving and grazing. Grasslands cultivated for less than 5 years, in order to increase soil vegetation, still remain grasslands. Grassland category contains both managed and unmanaged grasslands.

6.4.1 Source category description

Two source categories are accounted under this category: emissions from Grassland remaining Grassland and emissions from Land converted to Grassland. Estimated carbon stocks are presented in the table below.

Table 6-31. Estimated carbon stocks under Grassland category

Land Use Category			**CS change in soils**

	CS change in biomass	CS change in dead organic matter	Mineral soils	Organic soils
Grassland remaining Grassland	NO	NO	NO*	√
Land converted to Grassland	√	NO	√	√

**Assumed to be close to zero, therefore reported as NO*

6.4.2 Methodological issues

6.4.2.1 Grassland remaining Grassland

Areas continuously managed as Grassland and areas converted to Grassland after 20 consecutive years followed conversion reported in the category Grassland remaining Grassland (GG).

The annual greenhouse gas emissions and removals from Grassland Remaining Grassland include:

- Estimates of annual change in C stocks from all C pools and sources;
- Estimates of annual emission of non-CO_2 gases from all pools and sources.

Carbon stock changes in living biomass

Grassland management practices in Lithuania mainly are static; therefore biomass is in an approximate steady-state. Default *Tier 1* method (p. 6.6 of *IPCC 2006*) was used assuming no change in biomass in Grassland Remaining Grassland.

Carbon stock change in dead organic matter

Default *Tier 1* method was used assuming that the dead wood and litter stocks are at equilibrium, so there is no need to estimate the carbon stock changes for this pool.

Carbon stock change in soil organic matter

Area of organic and mineral soils was determined by using data of *NFI* permanent sample plots measured in 2012, according to which area of organic soils constitute to 10.5% and area of mineral soils 89.5%.

Grassland management data are limited in Lithuania, country expert's report[160] that due to domestic political-economic circumstances, about 50% of grasslands are abandoned and have been turning into natural habitats/climatic ecosystems during last two decades. Therefore using *Tier 1/2* methods organic C stocks changes in mineral soil over a 1990-2013 period estimated to be 0.

Mineral Soils

Grasslands in Lithuania mainly represents non-degraded and sustainably managed grasslands, but without significant management improvements during the last decades.

Soil organic C stocks has been estimated for the inventory period of 1990-2013 using JRC estimated carbon stocks (SOC_{ref}) for agricultural soils[161] and the relevant stock change factors. Factors for F_{LU}, F_I and F_{MG} for different management activities on Grassland were taken from

[160] Balezentiene, L., Bleizgys, R. 2011. *Short-term inventory of GHG fluxes in semi-natural and anthropogenized grassland*. Polish Journal of Environmental Studies. 20:255-262

[161] Available from: *http://eusoils.jrc.ec.europa.eu/library/Themes/SOC/CAPRESE/*

Table 6.2 (p. 6.16 of *IPCC 2006*). For all grasslands (excluding those on organic soils) F_{LU} factor of 1 (error NA) was used.

As grassland management activities in Lithuania are not changing, it was assumed that annual carbon stock changes in mineral soils for Grassland remaining Grassland are close to zero.

Organic soils

Using data presented by National Forest Inventory permanent sample plots measured in 2012, organic soils constitute 10.5% from the total Grasslands area, it was assumed that this value is equally correct to Grasslands remaining Grasslands and to Lands converted to Grasslands.

Tier 1 method was used in order to calculate carbon stock change in grassland organic soils (eq. 2.26, p. 2.35 of *IPCC 2006*).

Emission factor of 0.25 tonnes C ha^{-1} yr^{-1} for a cold temperate climate has been used for calculations (Table 6.3, p. 6.17 of *IPCC 2006*).

Inorganic C

No method is provided for estimation of the change in soil inorganic C stocks due to limited scientific data for derivation of stock change factors; thus the net flux for inorganic C stocks is assumed to be zero (p.2.29 of *IPCC 2006*).

Non-CO_2 greenhouse gas emissions from biomass burning

In Lithuania there is no controlled burning of Grassland and emissions of non-CO_2 only results from wildfires. Grassland wildfires are infrequent and burnt area normally averaged at ≤5 thous. ha, but peak value can exceed 32.6 thous. ha (in 2006).

Emissions from Grassland category were estimated employing the eq. 2.27 (Ch. 2, p. 2.42 of *IPCC 2006*).

National estimates of Mass of Fuel Available for Combustion (M_b) are not available; therefore default data provided in Table 2.4 (Ch. 2, p. 2.45 of *IPCC, 2006*) for the mass of fuel consumed were used.

Activity data on Grassland area burnt was obtained from statistics of Fire and rescue department[162].

6.4.2.2 Land converted to Grassland

The cumulative areas of grassland over a 20-year transition period reported in Figure 6-29. For each year, the cumulative total area reported under Land converted to Grassland (LG) category accounted as equal to the cumulative area that has been converted to that land use over the last 20 years, areas of second land-use change during the 20-year conversion period subtracted by the cumulative total.

[162] Fire and Rescue Department under the Ministry of the Interior of the Republic of Lithuania. Available from: *http://www.vpgt.lt/*

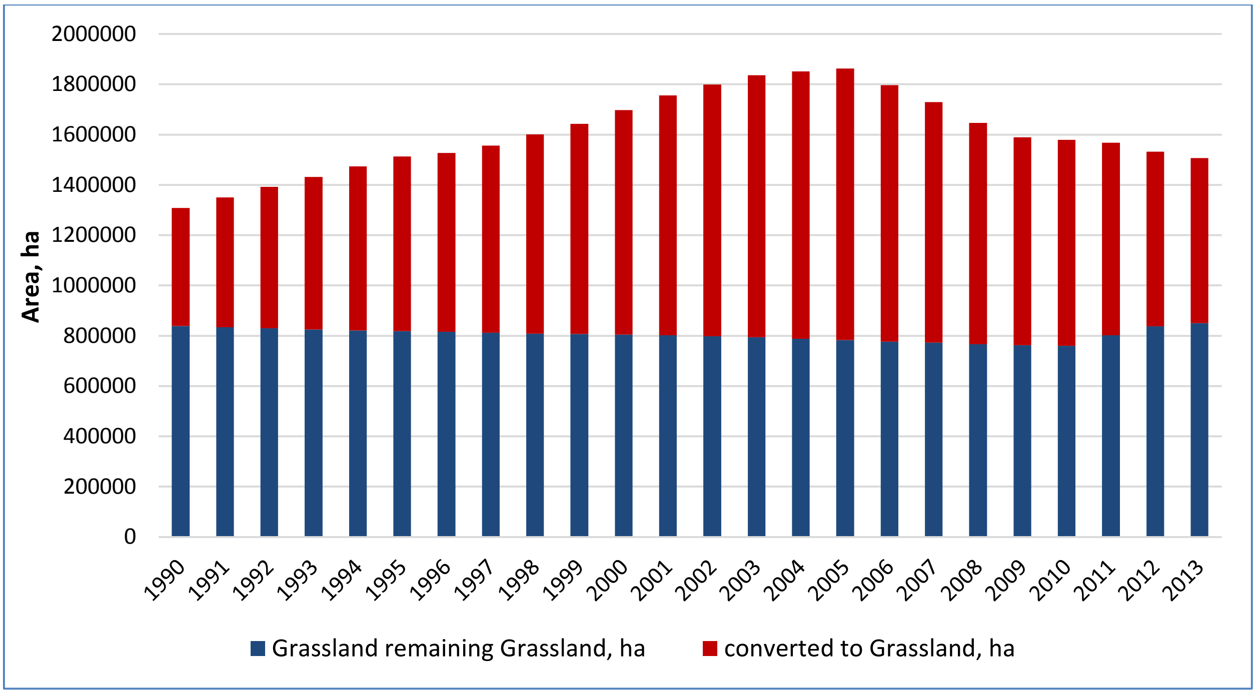


Figure 6-29. Grassland area changes during the period 1990-2013, ha

Based on information obtained from *Study-1* and *Study-2* during the last decades there have been no conversions of Forest land to Grasslands.

Estimation of annual greenhouse gas emissions and removals from Land Converted to Grassland involves estimation of changes in carbon stock from five carbon pools: above-ground biomass, belowground biomass, dead wood, litter, and soil organic matter.

All emissions of non-CO_2 GHG reported in Grasslands remaining Grasslands category.

Carbon stock changes in living biomass

For lands converted to Grassland, carbon emissions and removals are based on estimating the effects of replacement of one vegetation type by grassland vegetation (p. 6.5 of *IPCC 2006*).

Tier 2 was used to estimate annual change in carbon stocks in living biomass on Land converted to Grassland employing eq. 2.15 and 2.16 (Ch. 2, p. 2.20 of *IPCC 2006*). Area estimates for Land Converted to Grassland were disaggregated according to original vegetation and average carbon stock change per hectare is estimated for each type of conversion.

It is assumed that all biomass is lost immediately from the previous ecosystem after conversion and residual biomass (B_{AFTER}) is thus assumed to be zero.

Biomass carbon stock in initial land-use categories (B_{BEFORE}) are assumed to be 2.4 t ha^{-1} d. m. in Croplands, Wetlands and Settlements, 0.0 t ha^{-1} d. m. in Other Land.

Default value of 2.4 t ha^{-1} d. m. carbon stock in biomass after conversion for cold temperate wet climate zone has been used (Table 6.4, p. 6.27 of *IPCC 2006*).

Carbon stock changes in dead organic matter

Lithuania has no estimates of the dead wood and litter in the initial land-use systems (except FL) prior to conversion. Therefore it is assumed that dead wood and litter stocks are not present or are at equilibrium.

Carbon stock changes in soil organic matter

Estimations of change in C stocks in mineral soils on Lands converted to Grassland were based on same methodological approaches as for Grassland remaining Grassland and guidance for estimating changes in soil C stocks are provided in Section 2.3.3 (Ch. 2 of *IPCC 2006*).

Mineral soils

Calculation of carbon stocks in mineral soils on Lands converted to Grassland were based on eq. 2.25 (Ch. 2, p. 2.30 of *IPCC 2006*). Country-specific reference C stocks, default stock change factors (Table 5.5, p. 5.17 of IPCC 2006) and default 20 year time period for stock changes were used for calculations.

Organic soils

It was assumed Croplands converted to Grasslands has 0.7% share of organic soils, Settlements, Other Land converted to Grasslands are only mineral soils, and finally Wetlands converted to Grasslands are exceptionally organic soils.

Tier 1 method was used in order to calculate carbon stock change in organic soils (eq. 2.26, p. 2.35 of *IPCC 2006*).

Emission factor of 0.25 tonnes C ha^{-1} yr^{-1} for a cold temperate climate has been used for calculations (Table 6.3, p. 6.17 of *IPCC 2006*).

Non-CO_2 greenhouse gas emissions from biomass burning

Same approach used to estimate non-CO_2 emissions from biomass burning in Land Converted to Grassland as for Grassland Remaining Grassland.

Statistics of Fire and rescue department on Grassland area burnt do not provide details to separate Grassland remaining Grassland and Land converted to Grassland, therefore all non-CO_2 greenhouse gas emissions accounted in Grassland remaining Grassland.

6.4.3 Uncertainty assessment

Activity data was obtained from *NLS* and *NFI Study-2*. The emission factors were employed from *IPCC 2006*. The uncertainty rates for activity data and emission factors are reported in Table 6-32.

Table 6-32. Values of uncertainties for Grassland

Input	Uncertainties, %	References
Activity data		
Grassland area	±1.2	*Study 2*
Emission factors		
F_{LU} F_{MG} F_I	NA	*IPCC 2006*, p. 6.16
EF (organic soils)	±90	*IPCC 2006*, p. 6.17

Uncertainties for non-CO_2 gases are likely to be at least 50%.

6.4.4 Category-specific QA/QC and verification

The QC/QA includes the quality control activities described in *IPCC 2006*. Activity data and emission values are compared with emission values of other countries. If errors were found they were corrected. Moreover, country-specific data incorporated in inventory.

6.4.5 Category-specific planned improvements

Lithuania plans to continue to employ more country-specific values/factors.

6.5 Wetland (CRF 4.D)

Wetlands include peat extraction areas and peatlands which do not fulfil the definition of other categories. Water bodies and swamps (bogs) are also included under this category. Peat extraction areas are considered as managed land. Differences in perception of wetland definition leads to various estimations of Lithuanian wetlands area, it varies from 243.3 to 609.7 thous. ha[163].

6.5.1 Source category description

Two source categories are accounted under this category: emissions from Wetlands remaining Wetlands and emissions from Land converted to Wetlands.

Data on wetland area were taken from the *Study-2* and *NFI*. Wetlands remaining Wetlands area distributed into separate groups of unmanaged, peat extraction areas (monitored by Lithuanian Geological Service), managed flooded and other managed (degraded drained bogs). Estimated emissions summarized in Table 6-33, emissions from unmanaged Wetlands are not estimated.

Table 6-33. Estimated GHG emissions from managed Wetlands

Land Use Category	CO_2	CH_4	N_2O
Peatlands Remaining Peatlands	√	NO	√
Land Being Converted for Peat Extraction	NO	NO	NO
Flooded Land Remaining Flooded Land	NO	NO	NO
Land Converted to Flooded Land	√	NO	NO

6.5.2 Methodological issues

6.5.2.1 Peatlands remaining Peatlands

CO_2 emissions

Default *Tier 1* method was used to estimate emissions from peatlands with undergoing active peat extraction (eq. 7.3, p. 7.8 of *IPCC 2006*). On-site emissions estimated using eq. 7.4 (p. 7.11 of *IPCC 2006*). Default emission factors from Table 7.4 (p. 7.13 of *IPCC 2006*) have been used:

- 0.2 t C ha^{-1} yr^{-1} for nutrient poor peatlands,
- 1.1 t C ha^{-1} yr^{-1} for nutrient rich peatlands.

Off-site emissions estimated using eq. 7.5 (p. 7.11 of *IPCC 2006*), along with expert judgement made on weight conversion factor 0.43 tonnes C. Area of managed peatlands is continuously decreasing since 1990, therefore changes in C stocks in living biomass on managed peat lands are assumed to be zero.

Non-CO_2 emissions

[163] Taminskas, J., Pileckas, M., Šimanauskienė, R., Linkevičienė, R., 2011. *Lithuanian wetlands: classification and distribution*. Baltica, Vol. 24, Special Issue // Geosciences in Lithuania: challenges and perspectives, 151–162. Vilnius

Default *Tier 1* method was applied to estimate non-CO_2 emissions from Peatlands remaining Peatlands. CH_4 emissions are assumed to be insignificant in these drained peatlands.

N_2O emissions from drained wetlands estimated using eq. 7.7 (p. 7.15 of *IPCC 2006*). Default emission factor from Table 7.6 (p. 7-16 of *IPCC 2006*) has been used – 1.8 kg N_2O-N ha^{-1} yr^{-1} for nutrient rich peatlands.

Tier 1 method only considers nutrient-rich peatlands.

6.5.2.2 Land Being Converted for Peat Extraction

The area of managed peatlands is continuously decreasing since 1990, therefore no Land that was converted for peat extraction have been reported.

6.5.2.3 Flooded Land Remaining Flooded Land

The area of flooded lands covers more than 90 000 ha in Lithuania. No default *IPCC 2006* methodologies are provided for Flooded Land remaining Flooded Land emissions estimation, any preliminary estimates of CH_4 emissions from this source have been developed in Lithuania.

6.5.2.4 Land Converted to Flooded Land

CO_2 **emissions**

Carbon stock change due to land conversion to permanently flooded land was estimated employing eq. 7.10 (p. 7.20 of *IPCC 2006*). Area estimates for Land Converted to Flooded Land were disaggregated according to prevailing vegetation and average carbon stock change per hectare is estimated for each type of conversion. It was assumed that carbon stock after conversion is zero.

No *IPCC 2006* methodology is provided on estimations of carbon stock changes from soils due to land conversion to Flooded Land.

Non-CO_2 **emissions**

No preliminary estimates of CH_4 emissions from this source have yet been developed in Lithuania.

6.5.3 Uncertainty assessment

CO_2 emissions from Wetlands were evaluated as a result of forest land conversion to Wetlands. Converted areas are relatively small and based on expert judgment it was assumed that uncertainty of activity data is about 80%. Emission factor uncertainty was assumed to be about 20%.

For other conversions uncertainty of activity data assumed to be 50% (p. 7.17 of *IPCC 2006*), emission factor uncertainty assumed to be about 100% (p. 7.16 of *IPCC 2006*).

6.5.4 Category-specific QA/QC and verification

Quality assurance and control procedures described in *IPCC 2006* were conducted.

6.5.5 Category-specific planned improvements

No further improvements are planned within the following years.

6.6 Settlement (CRF 4.E)

NLS indicates two subcategories under settlements category – built-up area and roads. All urban territories, power lines, traffic lines and roads as well as orchards and berry plantations planted in small size household areas and only used for householders' needs are included under this category.

According to national definition – urban territories are squares, playgrounds, stadiums, airports, yards, grave lands and buildings. Roads are land areas with engineering structure for transportation and traffic. In rural regions, areas with no special road cover used for mechanical and non-mechanical transport traffic and bridleways for animals were also included.

6.6.1 Source category description

The carbon pools estimated for Settlements are above-ground and below-ground biomass, DOM, and soils. Two source categories are accounted under this category: emissions from Settlements remaining Settlements and emissions from Land converted to Settlements, following methodology of *IPCC 2006* (sections 8.2 and 8.3).

6.6.2 Methodological issues

6.6.2.1 Settlements remaining Settlements

Areas continuously managed as a Settlements and areas converted to Settlements after 20 consecutive years followed conversion reported in the category Settlements remaining Settlements (SS).

Carbon stock changes in living biomass

Lithuania has no appropriate activity data and/or developed emission factors. Therefore *Tier 1* approach was used, it assumes no change in carbon stocks in living biomass in Settlements Remaining Settlements; in other words, the growth and loss terms balance. This method assumes, that changes in biomass carbon stocks due to growth in biomass are fully offset by decreases in carbon stocks due to removals (i.e., by harvest, pruning, clipping) from both living and from dead biomass (e.g. fuelwood, broken branches, etc.). Therefore, according to *Tier 1* method $\Delta C_G = \Delta C_L$ for all plant components, and $\Delta C_B = 0$ (eq. 2.7, p. 2.12 of *IPCC 2006*).

Carbon stock changes in dead organic matter

Tier 1 method assumes that dead wood and litter stocks are at equilibrium, and so there is no need to estimate carbon stock changes for these pools. For *Tier 1* emission factors and activity data are not needed no need to estimate uncertainty.

Carbon stock changes in soil organic matter

Mineral soils

According to *Tier 1* method inputs are equal to outputs and it means that soil C stocks do not change in Settlements Remaining Settlements.

Organic soils

No organic soils accounted in category, organic soils are accounted in Forest Land, Croplands, Grassland and Wetlands categories.

6.6.2.2 Land converted to Settlement

The cumulative areas over the 20 year transition period are reported in Figure 6-30. For each year, the cumulative total area reported under Land converted to Settlements category accounted as equal to cumulative area that has been converted to that land use over the last 20 years, areas of second land-use change during the 20 year conversion period subtracted by the cumulative total.

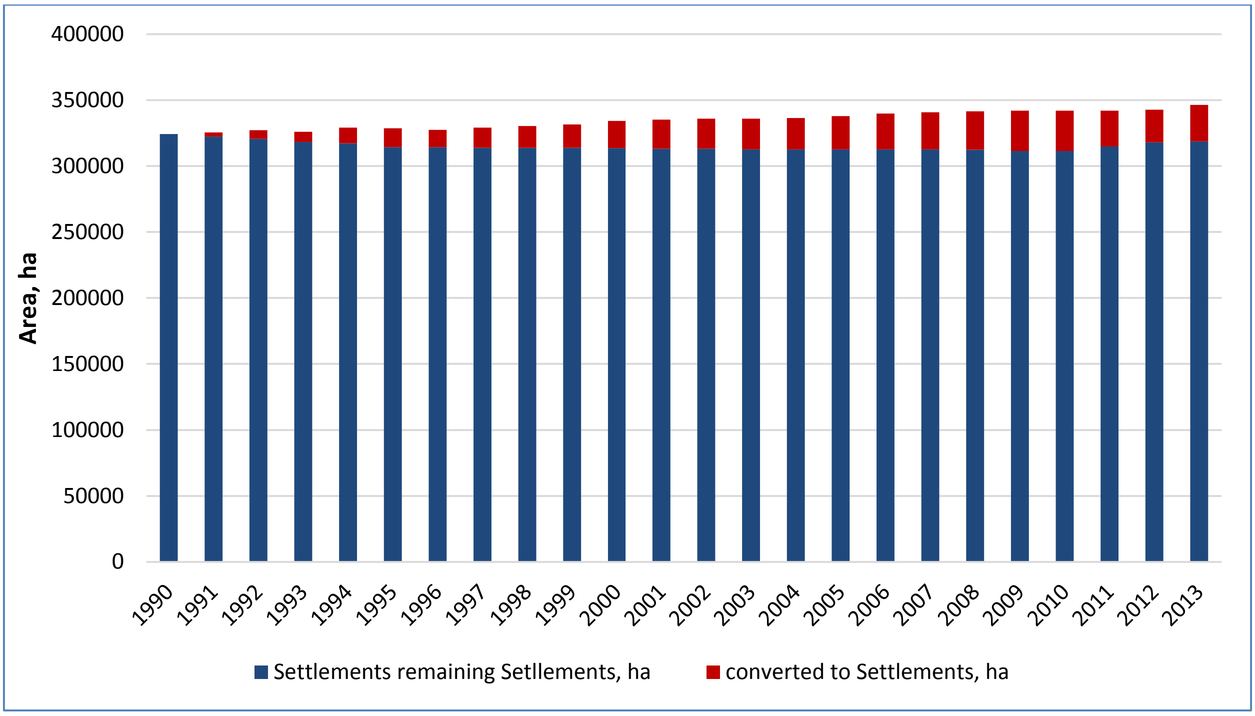


Figure 6-30. Settlements area changes during the period 1990-2013, ha

All land conversions to Settlements (LS) except conversion of Forest land accounted as Settlements remaining Settlements.

Carbon stock changes in living biomass

Tier 2 was used to estimate annual change in carbon stocks in living biomass on Land converted to Settlements employing the eq. 2.15 and 2.16 (Ch. 2, p. 2.20 of *IPCC 2006*). Area estimates for Land Converted to Settlements were disaggregated according to prevailing vegetation and average carbon stock change on a per hectare basis is estimated for each type of conversion.

For calculation of carbon stock changes caused by conversion of Forest land, Croplands and Grasslands to Settlements, it was assumed that all above ground forest biomass as well as dead wood and surface soil (litter) organic matter was removed entirely as a result of conversion.

Biomass carbon stock in initial land-use categories (BBEFORE) are assumed to be 2.4 t ha^{-1} d. m. in Croplands, Grasslands and Wetlands, 0.0 t ha^{-1} d. m. in Other Land.

Carbon stock changes in dead organic matter

Lithuania has no estimates of the dead wood and litter in the initial land-use systems (except FL) prior to conversion. Therefore it assumes that dead wood and litter stocks are not present.

Carbon stock changes in soil organic matter

Estimations of change in C stocks in mineral soils on Lands converted to Settlements were based on guidance for estimating changes in soil C stocks, provided in Section 2.3.3 (Ch. 2 of *IPCC 2006*).

Mineral soils

Calculation of carbon stocks in mineral soils on Lands converted to Settlements were based on eq. 2.25 (Ch. 2, p.2.30 of *IPCC 2006*). Country-specific reference C stocks, default stock change factors (Table 5.5, p. 5.17, of *IPCC 2006*) and default 20 year time period for stock changes were used for calculations.

Organic soils

No organic soils have been accounted in category Land converted to Settlements.

6.6.3 Uncertainty assessment

CO_2 emissions from Settlements were evaluated as a result of Land conversions to Settlements. Converted areas are relatively small and based on expert judgment it was assumed that uncertainty of activity data is about 80%. Emission factor uncertainty was assumed to be about 20%.

6.6.4 Category-specific QA/QC and verification

Quality control procedures described in *IPCC 2006* were established when calculating emissions from Settlements category.

6.6.5 Category-specific planned improvements

No further improvements are planned within the following years.

6.7 Other Land (CRF 4.F)

6.7.1 Source category description

This category is included for overall land area consistency checking. All land not classified as Forest land, Croplands, Grasslands, Wetlands and Settlements were defined as Other land and reported together as a separate category in the CRF Reporter. Disturbed land and unmanaged land accounted under Other land category.

6.7.2 Methodological issues

6.7.2.1 Other Land Remaining Other Land

Changes in carbon stocks and non-CO_2 emissions and removals are not estimated according to *IPCC 2006* guidelines.

6.7.2.2 Land converted to Other Land

Carbon stock changes in living biomass

Tier 2 method was used to estimate annual change in carbon stocks in living biomass on Land converted to Other land employing the eq. 2.15 and 2.16 (Ch. 2, p. 2.20 of *IPCC 2006*). Area estimates for Land Converted to Other land were disaggregated according to prevailing vegetation and average carbon stock change on a per hectare basis is estimated for each type of conversion.

For calculation of carbon stock changes caused by conversion to Other land, it was assumed that all above ground forest biomass as well as dead wood and surface soil (litter) organic matter was removed entirely as a result of conversion.

Biomass carbon stock in initial land-use categories (BBEFORE) are assumed to be 2.4 t ha^{-1} d. m. in Croplands, Grasslands and Wetlands, 0.0 t ha^{-1} d. m. in Other Land.

Carbon stock changes in dead organic matter

Lithuania has no estimates of dead wood and litter in the initial land-use systems (except FL) prior to conversion. Therefore no emissions or removals by sinks related to DOM have been estimated for Land conversions to Other Land.

Carbon stock changes in soil organic matter

Estimations of change in C stocks in mineral soils in Land converted to Other land were based on method for estimating changes in soil C stocks, provided in Section 2.3.3 (Ch. 2 of *IPCC 2006*).

Mineral soils

Calculation of carbon stocks in mineral soils on Lands converted to Other land were based on eq. 2.25 (Ch. 2, p. 2.30 of *IPCC 2006*). Country-specific reference C stocks and default stock change factors (Table 5.5, p. 5.17 of *IPCC 2006*) has been used. Soil carbon stocks after conversion assumed to be zero for Land converted to Other Land.

Organic soils

No organic soils accounted in category Land converted to Other land.

6.7.3 Uncertainty assessment

CO_2 emissions from Other land were evaluated as a result of conversions to Other land. Default uncertainty value of 75% for estimated CO_2 emissions/removals has been used based on expert judgment.

6.7.4 Category-specific QA/QC and verification

Quality control procedures described in *IPCC 2006* were established when calculating emissions from Other Land category.

6.7.5 Category-specific planned improvements

No further improvements are planned within the following years.

6.8 Harvested Wood Products (CRF 4.G)

6.8.1 Source category description

Harvested Wood Products (HWP) accounting has been identified as mandatory for the second commitment period according to Decision 2/CMP.7 and Decision 2/CMP.8. Annual changes in carbon stocks and associated CO_2 emissions and removals from the HWP has to be accounted using *IPCC 2006* and 2013 KP-Supplement's methodology (*IPCC 2013 Revised*).

Lithuania defines semi-finished commodities relevant for the application of the guidance on estimating the HWP emissions and removals in line with the Decision 2/CMP.7.

Sawnwood (Decision 2/CMP.7 refers to this as "sawn wood"): Wood that has been produced from both domestic and imported round wood, either by sawing lengthways or by a profile-chipping process and that exceeds 6 mm in thickness. It includes planks, beams, joists, boards, rafters, scantlings, laths, boxboards and "lumber", etc., in the following forms: unplaned, planed, end-jointed, etc. It excludes sleepers, wooden flooring, mouldings (sawnwood continuously shaped along any of its edges or faces, like tongued, grooved, rebated, Vjointed, beaded, moulded, rounded or the like) and sawnwood produced by resawing previously sawn pieces. It is reported in cubic metres solid volume.

Wood-based panels (Decision 2/CMP.7 refers to this as "wood panels"): This product category is an aggregate comprising veneer sheets, plywood, particle board, and fibreboard. It is reported in cubic metres solid volume.

Paper and paperboards (Decision 2/CMP.7 refers to this as "paper"): Paper and paperboard category is an aggregate category. In the production and trade statistics, it represents the sum of graphic papers; sanitary and household papers; packaging materials and other paper and paperboard. It excludes manufactured paper products such as boxes, cartons, books and magazines, etc. It is reported in metric tonnes.

HWP are divided into two groups: *solid wood products* (sawnwood, wood based panels and round wood) and *paper products* (paper and paperboards).

Non-CO_2 greenhouse gases from HWP pool are reported under energy sector.

The HWP model presented in *IPCC 2006* requires activity data since 1961, which includes: production data, imports, exports of HWP. Several sources of information were used to obtain required activity data for estimation of greenhouse gas emissions and removals from HWP pool. The general activity data on defined HWP categories (round wood, sawnwood, wood-based panels, paper and paper board) was obtained from FAOSTAT databases. However, FAOSTAT databases contain information only since 1992 up to date; therefore additional national data for historic production capacities as well as exports and imports was included. Production capacities from 1960 until 1990 (1992) were obtained from „The Chronicle of Lithuanian Forests. XX Century“[164]. Some data presented in „The Chronicle of Lithuanian Forests. XX Century“ refers to five year time period, starting from 1955, therefore annual data was modelled. Production capacities for 1990 – 1992 were obtained from Statistics Lithuania[165].

Noteworthy, that information provided by Statistics Lithuania almost equals data provided by FAOSTAT for the presented years, therefore doubts for data validity presented by Statistics Lithuania for 1990-1992 were rejected. Apparently differences in HWP production, imports and exports until 1992 are related with Lithuania's status of that period. Being the part of Soviet Union meant producing goods according to the plan, not to the real market demand, therefore production, import and export capacities were tremendous comparing to these days. However "The Chronicle of Lithuanian Forests. XX Century" testifies that there was no import of round wood in Lithuania until 1992.

[164] Lietuvos Respublikos Aplinkos Ministerija, Miškų departamentas. *Lietuvos miškų metraštis*. XX amžius. Vilnius, 2003
[165] Available from: *http://www.stat.gov.lt/en/*

Additionally, IPCC model requires estimating annual rate of increase for industrial round wood production as an input parameter for historic period 1900-1961. Being no activity data available for this time span, default value for Europe, 0.0151 (Table 12.3 of IPCC 2006) has been chosen.

Table 6-34. Activity data used for estimations

Sawn-wood			Wood-based panels			Paper and Paperboard			Round wood			
Year	**Production, m^3**	**Export, m^3**	**Year**	**Production, m^3**	**Export, m^3**	**Year**	**Production, tonnes**	**Export, tonnes**	**Year**	**Production, m^3**	**Import, m^3**	**Export, m^3**
1960	885000.0	0.00	**1960**	39800.0	14726.0	**1960**	83000.0	51457.0	**1960**	1740000.0	968000.0	29637.3
1965	1044000.0	0.00	**1965**	58400.0	21608.0	**1965**	114000.0	70675.9	**1965**	2420000.0	1080000.0	41219.8
1970	1313000.0	0.00	**1970**	91300.0	33781.0	**1970**	159000.0	98574.3	**1970**	2814000.0	1066000.0	47930.7
1975	1098000.0	0.00	**1975**	133900.0	49543.0	**1975**	240000.0	148791.4	**1975**	2587000.0	1161000.0	44064.3
1980	855000.0	0.00	**1980**	165500.0	61235.0	**1980**	235000.0	145691.6	**1980**	2472000.0	699000.0	45000.0
1985	934000.0	0.00	**1985**	168100.0	62197.0	**1985**	265000.0	164290.5	**1985**	2648000.0	693000.0	44000.0
1990	775800.0	0.00	**1990**	197900.0	73223.0	**1990**	217600.0	134904.2	**1990**	2667000.0	456000.0	74000.0
1991	664000.0	0.00	**1991**	185500.0	68635.0	**1991**	214500.0	132982.3	**1991**	2908000.0	228475.5	179739.0
1992	105000.0	27402.0	**1992**	233000.0	40934.0	**1992**	50000.0	623.0	**1992**	3160000.0	951.0	285478.0
1993	699000.0	99447.0	**1993**	158600.0	43684.0	**1993**	30500.0	4200.0	**1993**	4508000.0	1275.5	285447.0
1994	760000.0	289000.0	**1994**	154800.0	86600.0	**1994**	22900.0	16300.0	**1994**	3992000.0	1600.0	889500.0
1995	940000.0	767200.0	**1995**	156400.0	104600.0	**1995**	28900.0	19400.0	**1995**	5960000.0	16200.0	1769900.0
1996	1450000.0	1098000.0	**1996**	197300.0	151900.0	**1996**	31000.0	21000.0	**1996**	5540000.0	19100.0	956600.0
1997	1250000.0	986400.0	**1997**	273300.0	210400.0	**1997**	25000.0	33000.0	**1997**	5149000.0	101900.0	767200.0
1998	1150000.0	670300.0	**1998**	270400.0	175200.0	**1998**	37300.0	25600.0	**1998**	4879000.0	90100.0	793200.0
1999	1150000.0	719003.0	**1999**	184000.0	140107.0	**1999**	37000.0	24578.0	**1999**	4924000.0	77861.0	939748.0
2000	1300000.0	823040.0	**2000**	270290.0	211060.0	**2000**	52630.0	37100.0	**2000**	5500000.0	60570.0	1202850.0
2001	1200000.0	750370.0	**2001**	304800.0	234140.0	**2001**	68170.0	43440.0	**2001**	5700000.0	96300.0	1324700.0
2002	1300000.0	918400.0	**2002**	312400.0	192000.0	**2002**	78000.0	29990.0	**2002**	6115000.0	103700.0	1436500.0
2003	1400000.0	1015000.0	**2003**	371000.0	219000.0	**2003**	92000.0	63000.0	**2003**	6275000.0	78000.0	1453000.0
2004	1450000.0	922682.0	**2004**	393000.0	187837.0	**2004**	99000.0	71850.0	**2004**	6120000.0	223559.0	1219622.0
2005	1445000.0	912547.0	**2005**	398000.0	170966.0	**2005**	113000.0	87140.0	**2005**	6045000.0	287906.0	1173919.0
2006	1466000.0	803358.0	**2006**	378000.0	132415.0	**2006**	11900.0	94136.0	**2006**	5870000.0	210097.0	1143515.0
2007	1380000.0	666565.0	**2007**	547000.0	182145.0	**2007**	124200.0	112764.0	**2007**	6195000.0	394599.0	1718247.0
2008	1109200.0	429300.0	**2008**	617400.0	207641.0	**2008**	122700.0	94576.0	**2008**	5594381.0	235616.0	1234112.0
2009	1011000.0	432654.0	**2009**	610900.0	216902.0	**2009**	85800.0	75587.0	**2009**	5459531.0	208547.0	776253.0
2010	1272000.0	555388.0	**2010**	716000.0	311223.0	**2010**	129229.0	123233.0	**2010**	7096860.0	332142.0	1441955.0
2011	1260000.0	583623.0	**2011**	823600.0	276974.0	**2011**	156518.0	132661.0	**2011**	7004000.0	272055.0	1989937.0
2012	1150000.0	620459.0	**2012**	825000.0	306152.0	**2012**	118000.0	125774.0	**2012**	6921000.0	310654.0	1593343.0
2013	1120000.0	634247.0	**2013**	855900.0	363405.0	**2013**	136700.0	111704.0	**2013**	7053000.0	383973.0	2044876.0

The Chronicle of Lithuanian Forests. XX Century — Statistics Lithuania — FAO

Estimated changes in carbon stocks in harvested wood products are presented in Table 6-35. According to the estimates, harvested wood products pool has been acting as a CO_2 sink in 1990 and during the period 2000-2013. Note that annual carbon balance of HWP's varies substantially. The major reason for pool being a source in the 1991-2000 could be economic recession after regained Independence and diminished consumption of both solid wood products as well as paper products.

Table 6-35. Carbon stock changes in HWP

	Solid wood products, kt CO_2	**Paper products, kt** CO_2	**Total, kt** CO_2
1990	-119.84	24.19	-147.05
1991	65.12	20.30	36.20
1992	89.50	166.43	218.52
1993	214.37	126.38	312.84
1994	324.04	70.58	370.51
1995	559.11	45.16	567.49
1996	390.94	49.37	416.20
1997	335.46	2.28	313.55
1998	38.54	-24.05	5.76
1999	83.11	-8.40	67.76
2000	-20.20	-20.65	-47.48
2001	-2.40	-30.74	-34.06
2002	-73.53	-58.55	-128.94
2003	-236.37	-38.96	-263.58
2004	-620.96	-73.62	-693.38
2005	-814.63	-72.38	-897.74
2006	-875.00	-75.92	-948.72
2007	-1120.76	-51.98	-1172.28
2008	-885.68	-61.24	-960.42
2009	-574.16	31.38	-545.13
2010	-834.16	-37.95	-870.43
2011	-972.20	-74.22	-1035.90
2012	-884.53	-48.44	-906.43
2013	-844.80	-110.44	-908.54

6.8.2 Methodological issues

Emissions and removals from harvested wood products are estimated using stock change method, and only HWP in use are considered. Emissions and removals from HWP at solid waste disposal sites are excluded from the reporting.

The worksheet provided in *IPCC 2006* is a tool for estimating annual carbon balance under any of the proposed HWP approaches. The model consists of two elements: solid wood products and paper products. Both variables have different half-life values. Greenhouse gas accounting for HWP pool in the worksheet is based on first order decay function with default half-life values (eq. 2.8.5, p. 2.120 of *IPCC 2013 Revised*).

$$C \cdot (i+1) = e^{-k} \cdot C_{(i)} + \left[\frac{(1-e^{-k})}{k}\right] \cdot inflow(i)$$

$$\Delta C(i) = C(i+1) - C(i)$$

where:
i – year;
C(*i*) – the carbon stock in the particular HWP category at the beginning of year *i*, kt C;
k – decay constant of FOD for each HWP category (HWP_j) given in units yr^{-1} (*k* = ln(2)/HL, where HL is half-life of the HWP pool in years);
Inflow(*i*) – the inflow to the particular HWP category (HWP) during year *i*, kt C yr^{-1};
ΔC(*i*) – carbon stock change of the HWP category during year *i*, kt C yr^{-1}.

Lithuania uses default half-life values for „products in use" carbon pools and associated fraction retained each year listed in the Table 7-36 (Table 12.2, p. 12.17 of *IPCC 2006*).

Table 6-36. Default half-life values for „products in use" carbon pools and associated fraction retained each year

	Solid wood products	Paper products
Half-life (years)	30	2
Decay rate *k* (*k*=ln(2)/half-life)	0.023	0.347

6.8.3 Uncertainty assessment

Overall activity data for HWP production, imports and exports was used from FAO databases, therefore uncertainty for such data was applied as it is suggested by *IPCC 2006* (Table 12.6, p. 12.22) and is equal to ±15%. EF was calculated using *IPCC 2006* (Table 12.6, p. 12.22) and is equal to ±59%.

6.8.4 Category-specific QA/QC and verification

Quality control and quality assurance objectives and procedures for Lithuanian GHG inventory at the national level are presented in Chapter 1.6. The activity data presented for greenhouse gas emission/removal assessment for HWP are judged to be the most reliable as there was no additional data sources founded.

6.8.5 Category-specific planned improvement

Lithuania is participating in the Norway grants project together with Norwegian Government and is expecting to launch study for development of the national HWP accounting system in upcoming years.

7 WASTE (CRF 5)

7.1 Overview of Waste Sector

In Lithuania greenhouse gases (GHG) emissions from Waste Sector originate from the following sources:

- Solid Waste Disposal (including sewage sludge) (CRF 5.A);
- Biological Treatment of Solid Waste (CRF 5.B);
- Incineration and Open Burning of Waste (CRF 5.C);
- Wastewater Treatment and Discharge (CRF 5.D).

Few emission sources from Waste Sector were identified as key source category, by level and trend, without LULUCF.

Table 7-1. Key category from Waste in 2013

IPCC Category	*Greenhouse gas*	*Identification criteria*
5.A Solid Waste Disposal	CH4	L1,L2,T1,T2
5.D Wastewater Treatment and Discharge	CH4	L1,L2,T1,T2

GHG emissions from Waste Sector are summarized in Table 7-2.

Table 7-2. Summary of GHG emissions from Waste Sector, kt CO_2 eqv.

Year	Solid waste disposal	Sewage sludge	Biological treatment	Wastewater treatment	Waste incineration	Total
1990	984	44.7	7.6	609.1	2.7	1,648
1991	1,008	45.6	7.6	610.0	2.7	1,674
1992	1,030	46.3	2.8	563.1	0.8	1,643
1993	1,046	49.6	2.6	564.0	2.2	1,664
1994	1,053	47.6	7.1	511.3	0.7	1,620
1995	1,054	48.6	10.2	533.3	2.6	1,649
1996	1,057	53.6	8.8	526.5	0.9	1,647
1997	1,061	57.7	7.6	521.3	0.9	1,649
1998	1,061	62.1	6.7	503.3	1.0	1,634
1999	1,059	66.8	12.1	469.1	0.4	1,607
2000	1,067	69.4	3.8	463.6	1.2	1,605
2001	1,102	71.1	9.0	462.1	1.6	1,646
2002	1,115	69.1	10.7	437.0	1.4	1,633
2003	1,128	67.2	9.5	408.3	3.8	1,617
2004	1,112	61.9	8.1	401.9	2.0	1,586
2005	1,093	59.0	13.0	378.5	3.7	1,547
2006	1,080	54.9	10.6	357.3	3.4	1,506
2007	1,066	50.6	13.0	349.6	0.7	1,480
2008	1,050	46.2	14.5	358.1	0.7	1,470
2009	1,038	46.5	14.4	320.7	0.7	1,420
2010	1,019	45.3	12.5	298.7	1.5	1,377
2011	933	42.8	16.0	289.8	4.6	1,286
2012	913	42.3	18.2	286.7	1.1	1,261
2013	860	40.3	23.1	265.8	0.8	1,190

Solid waste disposal on land including disposal of sewage sludge is the largest GHG emission source from Waste Sector. It contributed around 75.7% of the total GHG emission from Waste Sector in 2013 (72.3% excluding disposal of sewage sludge). GHG emissions occurring due to solid waste and sewage sludge disposal on land were increasing slightly from 1990 to 2001 and then started to decrease due to reduction of disposed waste, extraction of landfill gas, anaerobic digestion of sewage sludge.

Certain increase of emissions was observed from 2001 to 2004 and was caused mainly by disposal of large amounts of organic sugar production waste. In later years the producers managed to hand this waste over to farmers for use in agriculture and GHG emissions declined.

Variations of GHG emissions from solid waste disposal on land during the period 1990 to 2013 are shown in Figure 7-1.

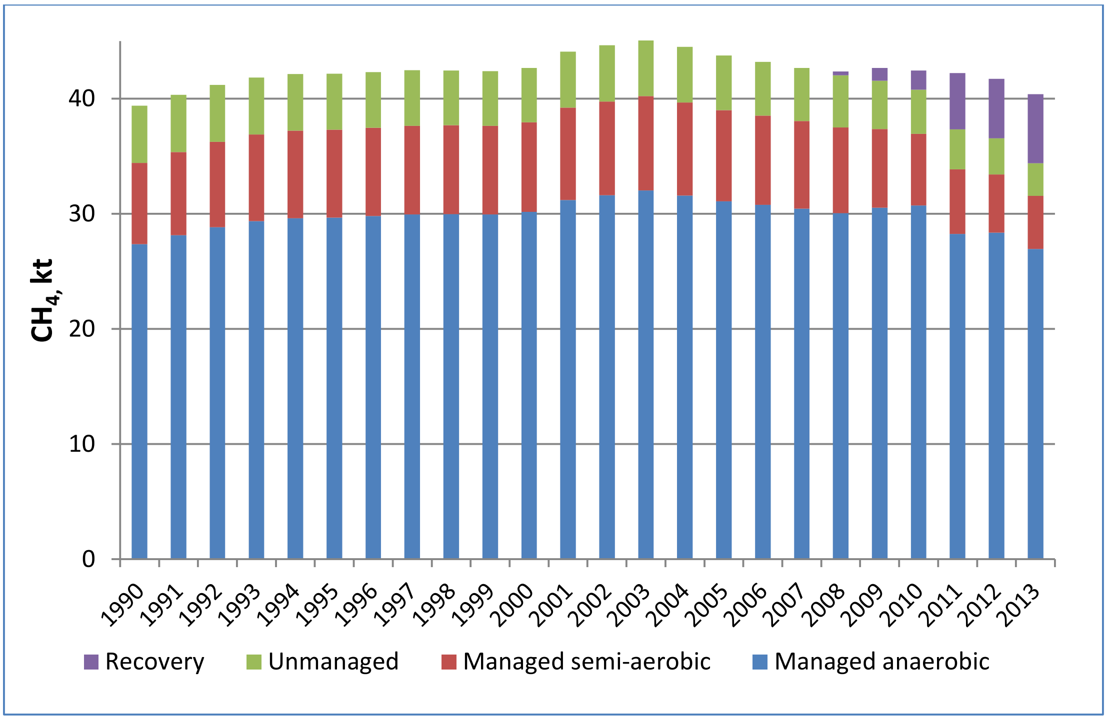


Figure 7-1.Variations of GHG emissions in Waste Sector (1990-2013)

Wastewater treatment and discharge contributed around 25.7 % of GHG emissions from Waste Sector in 2013 including 2.1% contribution of sewage sludge management. Wastewater in Lithuania is treated in aerobic treatment systems with minimum CH_4 generation. However, significant part of population still does not have connection to public sewerage systems and emissions from sewage collected from septic tanks are significant.

Waste incineration is used in Lithuania on a very small scale contributing during the period 1990-2013 on average less than 0.1 % of the total waste GHG emission.

7.2 Solid waste disposal on land (CRF 5.A)

7.2.1 Overview of waste management in Lithuania

Waste generation and disposal

The total amount of waste generated annually in Lithuania is about 5 million tonnes (Table 7-3). Major part of waste is generated in industrial sector of which about 100 kt - hazardous waste. Annual municipal waste generation is a bit more than 1 million tonnes.

Table 7-3. Waste collection and treatment in 2013, kt

		D1,D5	D2, D4, D6	R1	D10	R2-R9	R10, R11	D8, D9, D14, R12,S5
01	Chemical compound wastes	0.01	-	-	0.13	5.31	-	2.25
02	Chemical preparation wastes	0.04	-	-	0.18	0.04	-	0.55
03	Other chemical wastes	0.35	22.29	0.02	0.20	37.67	-	11.80
05	Health care and biological wastes	0.23			0.01	0.28	-	0.08
06	Metallic wastes	0.41	-	-	-	18.88	-	130.91
07	Non-metallic wastes	12.56		47.87	0.23	290.25	0.00	12.23
08	Discarded equipment	0.00	0.02		0.02	11.51	0.14	14.74
09	Animal and vegetal wastes	7.26	-	2.26	-	99.05	0.08	42.61
10	Mixed ordinary wastes	2900.30	6.23	150.77	0.00	21.19	-	137.43
11	Common sludge	5.30	3.42			22.43	7.05	5.32
12	Mineral wastes	228.18			0.01	462.72	71.07	46.67
	Total	**3.154.66**	**31.97**	**200.93**	**0.77**	**969.33**	**78.34**	**404.58**

*List of treatment operations is provided in Table 7-4. below.
Source: Lithuanian EPA

In early 1990s there were about 1000 landfills and dumps in Lithuania. In late 1990s waste management strategies were developed foreseeing development of waste management infrastructure including construction of new regional landfills complying with EU requirements closure of existing landfills and dumps and provision of necessary equipment required for safe and efficient operation of waste management facilities.

During the reorganization of waste management infrastructure, all landfills and dumps not in line with the environmental protection and public health safety requirements were closed. The disposal of waste in the old landfills was stopped in July of 2009 and since then all waste is disposed of in 11 regional non-hazardous waste landfills.

Table 7-4. List of waste treatment operations

Waste disposal operations	
D 1	Deposit into or on to land (e.g. landfill, etc.)
D 2	Land treatment (e.g. biodegradation of liquid or sludgy discards in soils, etc.)
D 3	Deep injection (e.g. injection of pumpable discards into wells, salt domes or naturally occurring repositories, etc.)
D 4	Surface impoundment (e.g. placement of liquid or sludgy discards into pits, ponds or lagoons, etc.)

D 5	Specially engineered landfill (e.g. placement into lined discrete cells which are capped and isolated from one another and the environment, etc.)
D 6	Release into a water body except seas/oceans
D 7	Release to seas/oceans including sea-bed insertion
D 8	Biological treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are discarded by means of any of the operations numbered D 1 to D 12
D 9	Physico-chemical treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are discarded by means of any of the operations numbered D 1 to D 12 (e.g. evaporation, drying, calcination, etc.)
D 10	Incineration on land
D 11	Incineration at sea
D 12	Permanent storage (e.g. emplacement of containers in a mine, etc.)
D 13	Blending or mixing prior to submission to any of the operations numbered D 1 to D 12
D 14	Repackaging prior to submission to any of the operations numbered D 1 to D 13
D 15	Storage pending any of the operations numbered D1 to D 14 (excluding temporary storage, pending collection, on the site where the waste is produced)
Waste recovery operations	
R 1	Use principally as a fuel or other means to generate energy
R 2	Solvent reclamation/regeneration
R 3	Recycling/reclamation of organic substances which are not used as solvents (including composting and other biological transformation processes)
R 4	Recycling/reclamation of metals and metal compounds
R 5	Recycling/reclamation of other inorganic materials
R 6	Regeneration of acids or bases
R 7	Recovery of components used for pollution abatement
R 8	Recovery of components from catalysts
R 9	Oil re-refining or other reuses of oil
R 10	Land treatment resulting in benefit to agriculture or ecological improvement
R 11	Use of waste obtained from any of the operations numbered R 1 to R 10
R 12	Exchange of waste for submission to any of the operations numbered R 1 to R 11
R 13	Storage of waste pending any of the operations numbered R 1 to R 12 (excluding temporary storage, pending collection, on the site where the waste is produced)

Source: Lithuanian EPA

Recovery of landfill gas started at 2 landfills in 2008. Currently landfill gas is recovered in 3 operating and 6 closed landfills[166].

In order to encourage waste recovery and recycling and to minimize disposal in the landfills, regional waste management systems were equipped with appropriate waste management facilities including bulky waste collection sites, green waste composting sites etc.

According to data provided by municipalities[167], waste collection services were provided to 94.8% of population. Differences between provision of services in cities, towns and rural areas are decreasing. In 2012-2013, waste collection services were provided to 97% of population in towns and cities with population exceeding 1000 inhabitants and to 94% of population in small towns and villages with population less than 500 inhabitants.

[166] National Waste Management Plan
[167] Data collected by Environmental Protection Agency

Waste reporting

There was no recording or reporting of waste generation or disposal in Lithuania during the Soviet Rule.

After declaration of independence in 1990 Environmental Protection Department was established which initialized collection of statistical data on waste generation and management. Installations generating or handling waste were obliged to record waste generation, recovery and disposal activities from 1991. The first reports covering waste management activities in 1991 were submitted to the Environmental Protection Department in 1992.

Waste generation, treatment and disposal were recorded and reported according to the waste classification categories shown in Table 7-9 and waste disposal and recovery operations listed in Table 7-10.

Table 7-9. Waste classification 1990

A. Non-hazardous waste	
A.01	Manure and animal faeces
A.02	animal-tissue waste
A.03	Green waste
A.04	Forest waste
A.05	wastes from mineral excavation
A.06	Gravel, stones
A.07	Food waste
A.08	Textile waste
A.09	Natural fibre waste
A.10	Synthetic fibre waste
A.11	Wood waste
A.12	Paper and cardboard waste
A.13	Plastic and polymer waste
A.14	Rubber waste
A.15	Glass waste
A.16	Ferrous metal waste
A.17	Non-ferrous metal waste
A.18	end-of-life vehicles, household appliances
A.19	Construction material waste
A.20	Natural leather waste
A.21	Natural fur waste
A.22	Mixed municipal waste
A.23	Other waste
B. Hazardous waste	
B.01	Sanitary wastes of medicine services
B.02	Pharmaceutical wastes (unfit medicine, narcotics, veterinary remedies)
B.03	Wood preservatives wastes (wood antiseptics with heavy metals)
B.04	Biocides and phytopharmaceutical wastes (unfit pesticides, insecticides and etc.
B.05	Organic solvent wastes
B.06	Halogenated organic substances, excluding solvents
B.07	Wastes contaminated with cyanides
B.08	Oil products wastes without water
B.09	Oil/water, hydrocarbon/water (mixtures and emulsions)

B.10	Wastes containing or contaminated with polychlorinated diphenyls, triphenyls or polybrominated diphenyls
B.11	Tarry materials arising from refining, distillation and any pyrolytic treatment
B.12	Wastes of paints, dyes, pigments
B.13	Waste of resins, latex, plasticizers, glues/adhesives
B.14	Waste of chemicals, which are not identified or are new and whose effects on man and/or environment are not known
B.15	Pyrotechnics and explosive materials waste
B.16	Photographic processing materials waste (developers, fixing agents, photo-materials)
B.17	Wastes contaminated with polychlorinated dibenzofuran
B.18	Wastes contaminated with polychlorinated dibenzo dioxin
B.19	Animal soaps, fats, waxes
B.20	Non-halogenated organic substances excluding solvents (residuals of antifreeze, solvents containing formaldehydes, residuals of organic synthesis)
B.21	Inorganic waste without heavy metals
B.22	Cinders, ashes (boilers cinders, chimney ashes)
B.23	Contaminated soil (specify contaminant)
B.24	Hardening salts without cyanides
B.25	Metallic dust (specify metals)
B.26	Catalysts waste
B.27	Solutions and sludge containing heavy metals
B.28	Spent filter materials (contaminated with chemicals)
B.29	Scrubber sludges
B.30	Sewage sludges
B.31	Decarbonisation residuals
B.32	Ion-exchange column residual
B.33	Residual from cleaning and washing of equipment
B.34	Wastes of lamps and batteries
B.35	Vegetable oil waste
B.36	Radioactive residual (waste containing radionuclides or contaminated with them)
B.37	Any other hazardous waste not mentioned above in this list

Table 7-10. Waste disposal and recovery operations 1990

Waste disposal operations	
D1	Deposit onto land (in dumps)
D2	Land treatment (e.g. biodegradation of liquid or sludgy discards in soils, etc. In this case soil is only medium of wastes neutralisation. If waste is used as fertiliser, its code is R10. Biological treatment of polluted soil belongs to group D8.
D3	Deep injection (e.g. injection of pumpable discards into wells, salt domes or naturally occurring repositories, etc.)
D4	Surface impoundment (e.g. placement of liquid or sludge discards into pits, ponds or lagoons, etc.)
D5	Specially engineered landfill (e.g. placement into lined discrete cells which are capped and isolated from one another and the environment, etc.
D6	Release into a water body except seas
D7	Release into seas
D8	Biological treatment not specified elsewhere in this table

D9	Physical chemical treatment not specified in this table. The materials which are formed during this treatment must be disposed of according table 5a
D10	Incineration without energy or incineration using additional fuel when quantity of incoming energy is not higher than additional energy
	Waste recovery operations
R1	Use as a fuel or other means to generate energy
R2	Solvent regeneration
R3	Recycling of organic substances which are not used as solvents
R4	Recycling and utilisation of metals and metal compounds
R4.1	Utilisation of metals in ceramics
R4.2	Other methods of regeneration and utilisation
R5	Regeneration of other inorganic materials (except metals and metal compounds)
R6	Regeneration of acids or bases
R7	Recovery of components used for pollution abatement
R8	Recovery of components from catalysts
R9	Used oil re-refining or other reuses of previously used oil (except using for fuel) If waste from oil products are used for fuel or energy, it belongs to group R.1.
R9.1	Regeneration of waste from oil products
R9.2	Recovery of spent oil products in ceramic production
R9.3	Other methods of recovery and recycling of spent oil products
R10	Land treatment resulting in benefit to agriculture
R12	Buying and selling of wastes for recycling or recovery
R14	Wastes usage as secondary raw materials
R15	Wastes composting
R16	Waste recovery using other methods

The Environmental Protection Department was reorganized to the Ministry of Environmental Protection in 1994 which became the Ministry of Environment in 1998. The Minster of Environment approved new version of the Waste management regulation in 1999 (Order of the Minister of Environment No. 217 from July 14, 1999) including modifications of recording and reporting procedures.

Waste management regulation 1999 transposed basic requirements of the EU Waste framework directive (75/442/EEC) including list of waste and list of hazardous waste but established national version of waste disposal and recovery operations (Table 7-11).

Table 7-11. Waste disposal and recovery operations 1999

1	Waste disposal
1.1	Disposal of non-hazardous waste into or onto land
1.2	Storage of non-hazardous waste more than a year
1.3	Incineration of non-hazardous waste without energy recovery
1.4	Disposal of non-hazardous waste by other methods
1.5	Disposal of hazardous waste into or onto land
1.6	Storage of hazardous waste more than three months
1.7	Incineration of hazardous waste without energy recovery
1.8	Disposal of hazardous waste by other methods
1.9	Export of wastes for disposal

2	Use of waste for energy recovery
2.1	Use of non-hazardous waste for energy recovery
2.2	Use of hazardous waste for energy recovery
2.3	Export of wastes for energy recovery
3	Waste recycling
3.1	Physical-chemical treatment of non-hazardous waste
3.2	Biological treatment of non-hazardous waste
3.3	Treatment of hazardous waste
3.4	Treatment of bulky waste
3.5	Waste export for recycling
4	Waste collection and transport
4.1	Collection of wastes from population and organizations which are not obliged to record wastes
4.2	Collection and transport of industrial waste
4.3	Loading, repacking and sorting of non-hazardous waste to be transported
4.4	Collection and transport of hazardous waste
4.5	Loading, repacking and sorting of hazardous waste to be transported
5	Brokerage in waste management sector

New version of the Waste Management Regulation was approved by the Minister of Environment in December 2003 (Order of the Minister of Environment No. 722 from December 30, 2003). The new Regulation contained several changes in reporting requirements including classification of waste treatment, recovery and disposal operations provided in Annex II to the directive 75/442/EEC. Waste generation and management reports in accordance with the new requirements were provided by both waste generating and waste managing undertakings in the beginning of 2005 covering year 2004.

According to the Waste Management Regulation, waste management undertakings including waste importing companies as well as waste generating industries which are obliged to have Integrated pollution prevention and control (IPPC) permits must keep records of waste generation and treatment. Waste recoding is also mandatory for enterprises involved in technical maintenance of vehicles and generating hazardous waste.

Waste recording log must be kept in the location of waste generation and must be submitted to the authorized officials of the Ministry of Environment, counties or municipalities upon their request.

Waste generation and treatment should be recorded at least once per week. If waste is generated or treated not continuously, each separate generated or treated quantity must be recorded.

Recording should include:

- geographic origin of waste,
- industrial origin of waste,
- source name,
- waste code in Waste List,
- statistical classification code,
- waste name,
- amount of generated, received, treated or dispatched waste,
- treatment method,
- receiving facility (if waste was dispatched).

Waste recovery and disposal undertakings are obliged to provide annual reports on waste management to the regional environmental protection departments (REPD) of the Ministry of Environment. Waste generating industries obliged to have IPPC permits must provide annual recording reports. Both types of reports are very similar and have only minor differences and must include summarized waste recording data.

The reports are collected by the regional environmental protection departments and transferred to the Environmental Protection Agency which is responsible for data processing and keeping waste database.

In May 2011 the Minister of Environment approved new Rules on Recoding and Reporting of Waste Generation and Management which came into force in 2012. The additional requirements were included in the new Rules: the submission of reports on recording and reporting of waste generation and management to the REPD for undertakings which collect or transport hazardous waste or act as dealers and brokers of hazardous waste. Reporting according to the new Rules started in 2013 covering waste generation and management in 2012.

7.2.2 Category description

Municipal waste generation and disposal

In the initial stages of data collection waste was not weighed and amount of waste disposed of in landfills and dumps was evaluated on volume basis. In early 1990s municipal waste was collected and transported to landfills by municipal waste collection companies and their income (as well as salaries of truck drivers) depended on the amount of waste delivered to landfills. Therefore very often they were going to landfills with half-empty collection trucks but recording full loads.

It is generally agreed that the amount of generated and disposed waste in early 90s was overestimated. In the report on the status of environment in Lithuania in 2001 published by the Lithuanian Ministry of Environment[168] it was assumed that generation of municipal waste should be about 750 kt annually.

Starting from 1999 amount of waste disposed of in landfills has stabilized at approximately 1 million tonnes. It was agreed in the discussion at the Ministry of Environment[169] that this value should be the most realistic evaluation of municipal waste disposal for the period 1990-1998.

Reliability of waste disposal data was further discussed with the leading Lithuanian experts in waste management statistics[170]at the Ministry of Environment on 27th of October 2010. During the meeting was agreed that even the information from waste generation and disposal are collected from 1991, but during the period 1991-1998 recorded data are clearly not reliable and overestimated. At this period there were no weighing of waste at the disposal sites and the amounts of disposed waste were estimated visually causing substantial errors. Waste handlers were

[168] State of the Environment 2001, p. 85th Ministry of Environment of the Republic of Lithuania, Vilnius, 2002

[169] Meeting at the Ministry of Environment with the Head of Waste Division Ingrida Kavaliauskienė and senior specialist Ingrida Rimaitytė, September 25, 2009

[170] Meeting at the Ministry of Environment with participation of Ingrida Kavaliaiuskienė, Head of the Waste Management Strategy Division of the Ministry of Environment, Audrius Naktinis, Chief Specialist of the Waste Management Division of the Ministry of Environment and Sandra Netikšaitė, Chief Specialist of the Pollution and Waste Management Accounting Division, Lithuanian Environmental Protection Agency

interested in showing higher amounts of collected waste and used to apply higher factors for volume-to-weight conversion.

Reliability of waste disposal data has increased with improved control and monitoring of reporting system, recording process and accumulated experience, it should be considered that waste disposal data collected from 1999 are reliable and could be used for evaluating CH_4 generation in landfills.

The experts also concluded that there is no reason to believe that municipal waste generation and disposal during 1991-1998 were substantially different from generation and disposal during 1999-2008, i.e. the total annual amount of municipal waste disposed of in Lithuania should have been about 1 million tonnes or about 300 kg per person per year.

Based on comparison of variation of data on gross domestic product (GDP) and waste disposal per capita (Figure 7-2) it is reasonable to assume that changes of waste generation and disposal per capita are correlated with the changes of GDP but annual changes of waste generation are approximately 10 times lower than changes of GDP.

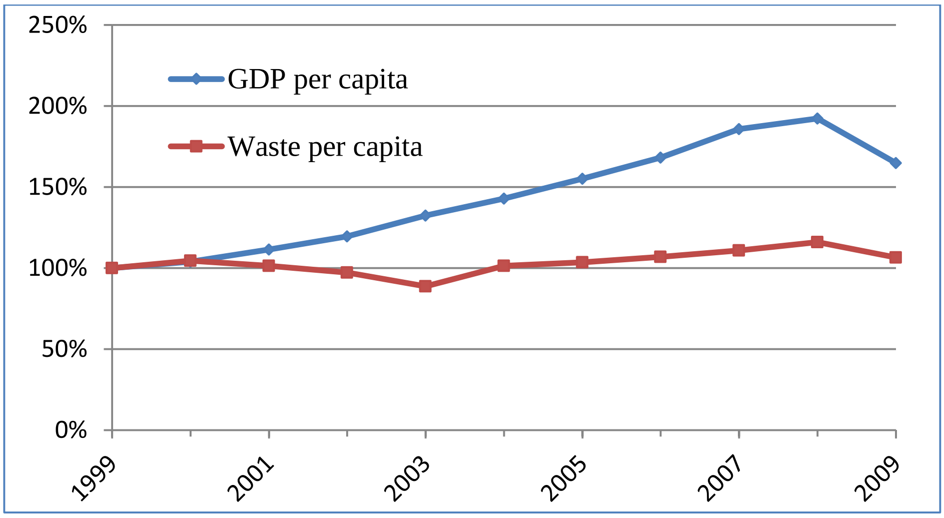


Figure 7-2. Variations of GDP and waste disposal per capita during 1999-2009

Evaluated changes of waste generation and disposal per capita during 1991-1998 based on assumption that annual change of waste generation and disposal comprises one tenth of annual variation of GDP per capita are shown in Table 7-12.

Table 7-12. Variation of GDP per capita and evaluated changes of municipal waste generation and disposal per capita

Year	Per capita	
	GDP	Waste generation and disposal
1991	-5.8%	-0.58%
1992	-21.2%	-2.12%
1993	-15.8%	-1.58%
1994	-9.1%	-0.91%
1995	5.4%	0.54%
1996	6.0%	0.60%
1997	8.3%	0.83%
1998	8.4%	0.84%

The meeting of experts at the Ministry of Environment agreed that calculated waste disposal data for 1991-1998 based on assumption that annual change of per capita amount of waste disposed to landfills makes 10% of per capita GDP change provide much more realistic information than the data collected by statistics.

Actual statistical data on municipal waste disposal to landfills were used for calculation of CH_4 emissions from landfills during 1999-2013. For the period 1990-1998 waste disposal was evaluated using estimated annual changes shown in Table 7-12 and population number provided by the Statistics Lithuania.

The first regional landfill complying with the requirements of the EU landfill directive 1999/31/EC was put into operation in 2007. Construction of regional landfills were completed in 2009 and starting from 2010 municipal wastes disposed of in only in newly constructed landfills.

Biodegradable waste of industrial and commercial origin

Together with mixed municipal waste, biodegradable waste is disposed to the landfills by industries and commercial organisations.

From 1991 when collection of data of waste handling and treatment was started, waste classification and definitions of various waste disposal and treatment operations have been changed several times. Currently waste statistical data collected by the Lithuanian Environmental Protection Agency are ordered according to two classification systems: European waste list adopted by the European Commission[171] and mainly substance oriented waste statistical nomenclature developed by the EUROSTAT and provided in the EU waste statistics regulation (EC) No 2150/2002 as amended[172]. However, data collected prior to adoption of EU waste classification, especially during 1991-1999, cause certain difficulties in interpretation and identification of specific waste categories and disposal methods.

The following categories of industrial and commercial waste were selected from the EUROSTAT statistical nomenclature for including in calculation of CH_4 emissions from landfills:

- Paper and cardboard waste
- Wood waste
- Textile waste
- Waste of food preparation and products
- Green waste
- Sewage sludge

Data reported on disposal of biodegradable waste of industrial and commercial origin in landfills are provided in Table 7-13.

Table 7-13. Reported data on disposal of biodegradable waste of industrial and commercial origin in landfills in 1991-2013, kt

[171] Commission Decision of 3 May 2000 replacing Decision 94/3/EC establishing a list of wastes pursuant to Article 1(a) of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishing a list of hazardous waste pursuant to Article 1(4) of Council Directive 91/689/EEC on hazardous waste (2000/532/EC)
[172] *Official Journal L 332 , 09/12/2002 P. 0001 - 0036,*
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:332:0001:0036:EN:PDF

Year	Paper and cardboard wastes	Wood wastes	Textile wastes	Food waste	Green wastes	Sewage sludge	Total
1990	12.93	33.02	12.37	45.32	30.38	197.1	331.1
1991	12.93	33.02	12.37	45.32	30.38	197.1	331.1
1992	4.92	30.00	4.15	56.61	26.43	258.4	380.5
1993	7.77	19.23	6.75	31.60	29.65	149.6	244.6
1994	5.84	20.19	1.86	14.79	22.00	209.9	274.6
1995	4.68	42.83	1.04	15.98	26.24	308.9	399.6
1996	5.49	25.30	1.39	33.11	14.87	306.9	387.1
1997	5.10	27.31	1.25	13.65	9.68	328.0	385.0
1998	4.33	6.28	2.31	12.55	7.87	355.2	388.5
1999	5.34	4.80	2.23	68.10	7.33	322.1	409.9
2000	1.26	3.64	6.06	215.88	3.51	312.7	543.0
2001	0.82	2.00	3.14	151.09	4.27	233.8	395.1
2002	0.73	3.01	3.82	185.52	4.60	227.0	424.7
2003	1.44	2.94	1.70	88.50	3.84	142.1	240.5
2004	0.40	4.61	2.86	2.27	5.06	176.9	192.1
2005	0.53	24.05	2.50	1.91	22.18	135.0	186.2
2006	0.19	4.88	1.83	1.91	13.78	116.0	138.6
2007	0.67	0.81	1.96	3.21	9.32	96.9	112.9
2008	0.13	4.61	1.34	3.18	6.54	68.3	84.1
2009	0.05	5.12	2.02	2.57	8.02	43.4	61.2
2010	0.04	0.98	3.18	2.39	5.64	36.78	49.0
2011	0.00	0.94	3.77	0.00	10.96	36.02	51.7
2012	0.09	0.45	4.66	0.00	4.08	48.98	58.3
2013	0.00	0.63	3.42	0.00	11.00	38.76	53.8

The amounts of industrial waste disposed of in landfills in 1990 were assumed to be the same as in 1991.

In early 1990s, the revenues for MSW collection companies depended on the amount of waste delivered to landfills, but the loads were not weighed and an overestimation of the weight of the loads is therefore suspected. On the other hand, industrial and commercial waste was transported by the companies generating the waste and was subject to a fee per truckload of waste deposited, not per the weight of each truckload of waste. Therefore the industries were interested to send trucks to landfills as full as possible. Substantially smaller variations of disposed industrial wastes in early nineties also confirm that reported amounts of industrial waste were more realistic.

Higher amounts of disposed industrial waste in early 90s were caused by inadequate control and inspection during the first years of independence. Later control of waste disposal was improved and industries were forced to find other ways of waste management.

High amount of food waste in 2000-2002 were disposed in municipal landfills by sugar production plants which at that time were bought by Danish companies and increased production very significantly. Later food waste generated in sugar production plants was used as fodder for animals, mainly swine, and its disposal stopped.

Waste Composition

Average composition of municipal solid waste was evaluated in a number of cases in 1996-2003 by experimental measurements carried out during the feasibility studies of development of regional waste management system and construction of new landfills in various regions of Lithuania (Table 7-14). The data shows no significant changes of waste composition in time or by different regions. Based on this, it was assumed that waste composition was comparatively stable during investigated period.

The data were summarized by the Ministry of Environment and published in the report "Status of the Environment 2004[173] (Table 7-15).

The report provides summary of data obtained by various analytical tests. Bearing in mind that waste analyses were performed by various companies using different methodologies, and distinguishing different waste components, it is impossible to tell what specific waste was included in the category 'other waste'.

The lowest fraction of biodegradable waste was found in waste collected from rural areas in Panevėžys region. It is understandable that biodegradable waste fraction in waste collected from rural areas is substantially lower than in urban areas. Fluctuations of average waste composition including waste of both rural and urban origin are less significant. The available data doesn't show any specific trends, therefore a single set of values was selected for calculations.

The measurements were performed in the framework of feasibility studies for establishment of the regional waste management systems. Samples for analysis were collected from municipal waste, industrial waste was not sampled. Analyses were performed by companies performing feasibility studies. Analytical procedures were not described in the studies. Separate companies used different methodologies, even the components of waste composition were different. Therefore it is difficult to compare and summarize the results.

[173] Ibid.

Table 7-14. Measured waste composition of various regions of Lithuania

Waste composition	**Kaunas**				**Kaunas region 2003**			**Klaipėda**	**Vilnius**			**Utena**	**Panevėžys, 2004**			
	1996	**1997**	**1998**	**1999**	**City**	**Towns**	**Rural**	**2000**	**1999**	**2001**	**County average**	**2003**	**City**	**Towns**	**Rural**	**Overall**
Biowaste	39%	46%	35%	41%	41%	53%	34%	56%	47%	52%	42%	43%	43%	39%	28%	38%
Paper	10%	7%	12%	12%	8%	10%	10%	19%	13%	9%	13%	15%	6%	9%	1%	5%
Cardboard	6%	7%	9%	1%	8%											
Plastic	7%	10%	11%	10%	7%	5%	5%	8%	7%	13%	9%	8%	6%	8%	5%	6%
Glass	9%	6%	8%	8%	9%	7%	12%	9%	10%	6%	9%	6%	9%	5%	11%	9%
Metal	3%	3%	3%	4%	3%	3%	3%	2%	4%	4%	3%	3%	2%	2%	4%	3%
Wood	-	-	-	-	-	-	-	-	-	-	-	1%	-	-	-	-
Other burnable	14%	14%	16%	11%	14%	9%	9%	-	-	-	-	6%	-	-	-	-
Other non-burnable	12%	7%	6%	13%	5%	8%	18%	-	-	-	-	10%	-	-	-	-
Hazardous	-	-	-	-	1%	1%	1%	1%	-	-	-	0%	-	-	-	-
Other	-	-	-	-	4%	4%	8%	5%	19%	16%	24%	8%	34%	38%	52%	40%

Table 7-15. Average composition of MSW in Lithuania as reported in 'Status of the Environment 2004

Ingredient	**Amount**
Paper and cardboard	14%
Wood	2%
Textile	4%
Food (kitchen) waste	42%
Green waste	0%
Total biodegradable	**62%**
Plastic	9%
Metal	3%
Composite packaging	2%
Glass	9%
Leather and rubber	1%
Construction and demolition waste	4%
Sand, sweepings	4%
Hazardous waste	2%
Other	4%

Source: *"Status of the Environment 2004" published by the Lithuanian Ministry of Environment*

In 2011 the Minister of Environment obliged regional waste management centres responsible for landfill operation in Lithuania to carry out analysis of composition of municipal waste in all landfills.

Waste composition should be evaluated in 2012, 2013, 2016, 2018 and 2020 four times per year: in winter, spring, summer and autumn.

For sample collection, a waste collection truck from each municipality delivering waste to landfill has to be selected by landfill operator. Waste sample for analysis is collected from five spots of unloaded waste heap ("envelope" method). At least 0.5 tonne sample is to be collected from municipalities with population more than 100 thou. and 0.3 tonne from municipalities with population less than 100 thou.

Waste fractions to be identified during analysis are listed in Table 7-16.

Table 7-16. Waste fractions to be identified during municipal waste analysis

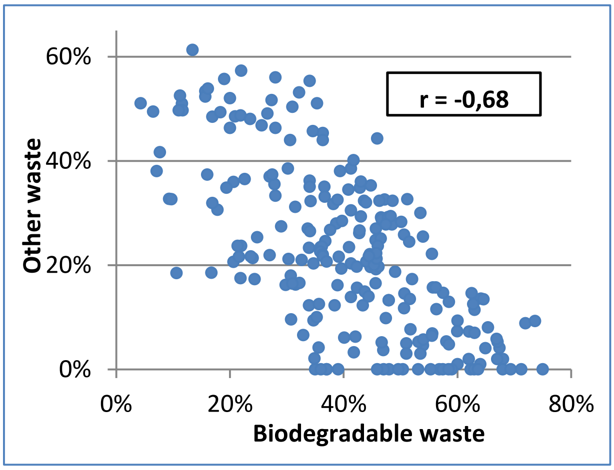
1	Paper and cardboard including packaging
2	Green waste
3	Wood waste including packaging
4	Biodegradable food production waste
5	Natural fibre waste
6	Other municipal biodegradable waste
7	Total municipal biodegradable waste
8	Plastic waste including packaging
9	Composite packaging waste
10	Metal waste including packaging
11	Glass waste including packaging
12	Inert waste (ceramics, concrete, stones, etc.)
13	Other non-hazardous waste
14	Waste electric and electronic equipment

15	Waste batteries and accumulators
16	Other hazardous waste
17	Other municipal waste

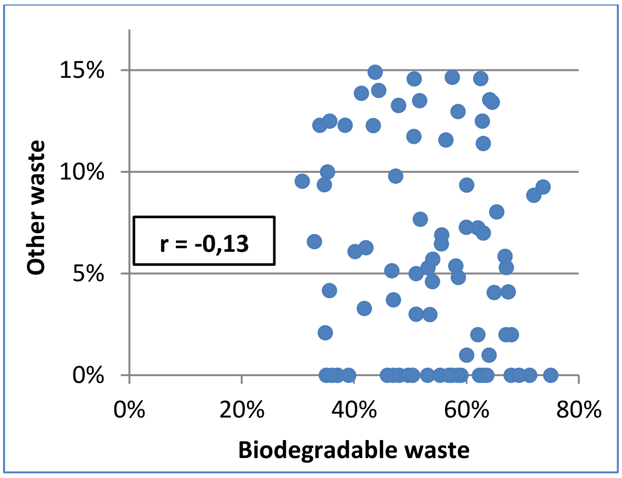
Comparison of available data obtained in 2013 and 2014 showed that significant correlation is observed between the total amount of biodegradable waste and ”other municipal waste” (fraction 17) (r = -0.68) which means that biodegradable waste was not fully segregated and certain fraction of biodegradable waste was accounted as other waste (Figure 7-3, a).

2012

a

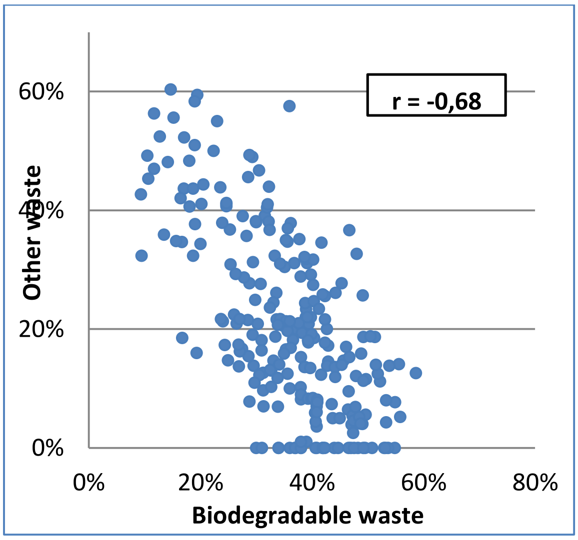


b



2013

a



b

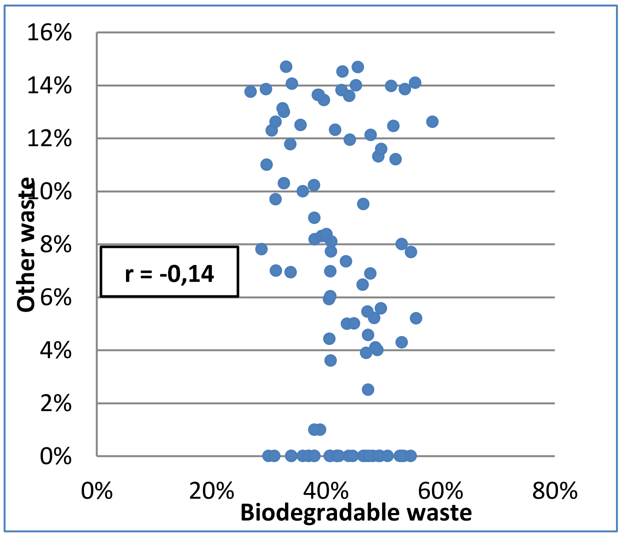


Figure 7-3. Correlation between the total fraction of biodegradable waste and unidentified fraction of “other waste” in reported data on waste composition;

a - all available data,
b - data from regions in which “other waste” is less than 15%

It is obvious that data showing large amount of "other municipal waste" are not reliable. Therefore data with "other municipal waste" exceeding 15% were discarded. Remaining data seemed to be more reliable showing no correlation between the amount of biodegradable waste and other waste (r = -0.13, Figure 7-3, b). These data were used for further analysis and evaluation of average waste composition.

Summary of data on the total amount of biodegradable waste (fraction 7) reported by Marijampolė, Šiauliai, Panevėžys and Vilnius regional waste management centres is provided in Table 7-17.

Table 7-17. Summary of data on the total amount of biodegradable waste (fraction 7) reported by Marijampolė, Šiauliai, Panevėžys and Vilnius regional waste management centres

Parameter	Total	Cities	Towns	Spring	Summer	Autumn	Winter
Number of analyses	82	15	67	25	20	19	18
Minimum	30.8%	34.8%	30.8%	33.9%	41.3%	30.8%	32.9%
Maximum	75.0%	72.0%	75.0%	75.0%	73.6%	68.0%	71.2%
Average	53.2%	56.1%	52.6%	53.2%	56.0%	55.5%	47.9%
Standard deviation	11.3%	11.1%	11.3%	11.5%	10.0%	9.5%	12.4%

The result of data analysis (Table 7-17) showed no significant difference between data on biodegradable waste established in cities and towns or in various seasons and it was decided to use average values for calculations (Table 7-18).

Table 7-18. Summary data on municipal waste composition

No	Ingredient	Minimum	Maximum	Average	Standard deviation
2012					
1	Paper and cardboard including packaging	2.0%	25.6%	9.2%	4.7%
2	Green waste	0.0%	49.4%	13.3%	12.5%
3	Wood waste including packaging	0.0%	20.3%	3.1%	3.8%
4	Biodegradable food production waste	0.0%	53.7%	15.7%	11.9%
5	Natural fibre waste	0.0%	14.6%	5.6%	3.3%
6	Other municipal biodegradable waste	0.0%	38.7%	6.3%	9.5%
7	**Total municipal biodegradable waste**	**30.8%**	**75.0%**	**53.2%**	**11.3%**
8	Plastic waste including packaging	4.3%	38.8%	15.0%	6.5%
9	Composite packaging waste	0.0%	11.1%	2.2%	2.5%
10	Metal waste including packaging	0.0%	10.9%	2.8%	2.3%
11	Glass waste including packaging	1.0%	33.0%	6.8%	4.6%
12	Inert waste (ceramics, concrete, stones, etc.)	0.0%	31.3%	10.2%	8.2%
13	Other non-hazardous waste	0.0%	26.1%	3.3%	5.6%
14	Waste electric and electronic equipment	0.0%	5.2%	0.4%	0.9%
15	Waste batteries and accumulators	0.0%	2.1%	0.1%	0.3%
16	Other hazardous waste	0.0%	3.0%	0.1%	0.5%
17	Other municipal waste	0.0%	14.9%	5.9%	5.1%
2013					

1	Paper and cardboard including packaging	1.0%	25.3%	8.9%	4.2%
2	Green waste	0.0%	24.8%	6.8%	5.7%
3	Wood waste including packaging	0.0%	7.9%	2.2%	2.2%
4	Biodegradable food production waste	2.4%	44.2%	13.9%	10.6%
5	Natural fibre waste	0.0%	20.5%	5.0%	4.5%
6	Other municipal biodegradable waste	0.0%	25.6%	5.4%	6.1%
7	**Total municipal biodegradable waste**	**24.9%**	**58.6%**	**42.3%**	**7.6%**
8	Plastic waste including packaging	6.0%	36.0%	18.1%	5.3%
9	Composite packaging waste	0.0%	14.0%	4.5%	3.6%
10	Metal waste including packaging	0.0%	27.7%	4.4%	4.3%
11	Glass waste including packaging	0.3%	24.0%	9.6%	5.0%
12	Inert waste (ceramics, concrete, stones, etc.)	0.0%	38.0%	8.8%	6.7%
13	Other non-hazardous waste	0.0%	36.3%	4.5%	6.6%
14	Waste electric and electronic equipment	0.0%	6.3%	0.9%	1.3%
15	Waste batteries and accumulators	0.0%	2.8%	0.1%	0.3%
16	Other hazardous waste	0.0%	4.6%	0.1%	0.6%
17	Other municipal waste	0.0%	14.8%	6.7%	5.3%

Composition of biodegradable waste in municipal waste stream was determined in the following way (Table 7-19):

- in 1990-2003: assumed corresponding to composition reported by the Ministry of Environment in *"Status of the Environment 2004"*
- in 2004-2011: established by linear interpolation of 2003 and 2012 data.
- in 2012 and 2013: assumed corresponding to average composition determined in 2012 and 2013 (see Table 7-18)

Table 7-19. Assumed composition of municipal biodegradable waste

Year	Paper and cardboard waste	Wood waste	Textile waste	Food waste	Green waste
1990	14.0%	2.0%	4.0%	42.0%	0.0%
1991	14.0%	2.0%	4.0%	42.0%	0.0%
1992	14.0%	2.0%	4.0%	42.0%	0.0%
1993	14.0%	2.0%	4.0%	42.0%	0.0%
1994	14.0%	2.0%	4.0%	42.0%	0.0%
1995	14.0%	2.0%	4.0%	42.0%	0.0%
1996	14.0%	2.0%	4.0%	42.0%	0.0%
1997	14.0%	2.0%	4.0%	42.0%	0.0%
1998	14.0%	2.0%	4.0%	42.0%	0.0%
1999	14.0%	2.0%	4.0%	42.0%	0.0%
2000	14.0%	2.0%	4.0%	42.0%	0.0%
2001	14.0%	2.0%	4.0%	42.0%	0.0%
2002	14.0%	2.0%	4.0%	42.0%	0.0%
2003	14.0%	2.0%	4.0%	42.0%	0.0%
2004	13.5%	2.1%	4.2%	39.8%	1.5%
2005	12.9%	2.2%	4.4%	37.6%	3.0%

2006	12.4%	2.4%	4.5%	35.4%	4.4%
2007	11.9%	2.5%	4.7%	33.1%	5.9%
2008	11.3%	2.6%	4.9%	30.9%	7.4%
2009	10.8%	2.7%	5.1%	28.7%	8.9%
2010	10.2%	2.8%	5.2%	26.5%	10.4%
2011	9.7%	3.0%	5.4%	24.3%	11.9%
2012	9.2%	3.1%	5.6%	22.1%	13.3%
2013	8.9%	2.2%	5.0%	19.3%	6.8%

Table 7-20 provides data on the total amount of biodegradable waste disposed of in landfills obtained by adding biodegradable waste of industrial and commercial origin (Table 7-13) to municipal biodegradable waste estimated using percentages provided in Table 7-19.

It was assumed that amount and composition of waste of industrial and commercial origin in 1990 was the same as in 1991.

Table 7-20. Biodegradable components in landfilled waste evaluated for calculation of CH_4 generation (kt)

Year	Paper and cardboard	Wood wastes	Textile wastes	Food waste	Green wastes	Total
1990	13.5%	4.4%	4.6%	41.1%	2.4%	66.1%
1991	13.5%	4.4%	4.6%	41.1%	2.4%	66.1%
1992	13.0%	4.3%	3.9%	42.4%	2.2%	65.8%
1993	13.5%	3.5%	4.3%	41.3%	2.5%	65.1%
1994	13.7%	3.7%	3.9%	40.9%	2.0%	64.2%
1995	13.3%	5.6%	3.8%	40.1%	2.3%	65.0%
1996	13.5%	4.1%	3.8%	42.0%	1.3%	64.7%
1997	13.7%	4.4%	3.9%	41.1%	0.9%	63.9%
1998	14.0%	2.5%	4.1%	41.9%	0.7%	63.2%
1999	13.4%	2.3%	3.9%	44.7%	0.6%	64.9%
2000	11.6%	1.9%	3.8%	51.1%	0.3%	68.7%
2001	12.2%	1.9%	3.7%	48.9%	0.4%	67.1%
2002	11.8%	1.9%	3.7%	50.6%	0.4%	68.3%
2003	12.8%	2.1%	3.8%	46.7%	0.4%	65.7%
2004	13.3%	2.5%	4.4%	39.4%	1.9%	61.6%
2005	12.4%	4.3%	4.4%	36.0%	4.8%	61.9%
2006	12.2%	2.8%	4.6%	34.8%	5.6%	59.9%
2007	11.7%	2.5%	4.8%	33.0%	6.7%	58.7%
2008	11.2%	3.0%	4.9%	30.8%	7.9%	57.7%
2009	10.6%	3.2%	5.2%	28.5%	9.5%	56.9%
2010	10.1%	2.9%	5.5%	26.4%	10.8%	55.7%
2011	9.6%	3.0%	5.7%	23.9%	12.8%	54.9%
2012	9.1%	3.1%	6.1%	21.8%	13.7%	53.8%
2013	8.7%	2.3%	5.4%	18.9%	8.3%	43.5%

There are no data and even no speculations on waste composition during the historic period 1950-1989. Assumption that waste composition in years 1950-1990 was the same as in later period has some, though not very firm, background, while we have no background at all for assuming that composition was different with higher or lower fraction of biodegradables. Therefore, the final composition of biodegradable waste determined for 1990 was used also for calculation of methane emissions in historic years 1950-1989.

Historic waste disposal

Using the first order decay method for calculation of CH_4 emissions from landfilled biodegradable waste requires historical data of waste disposal as the model takes into consideration long-term digestion process. Therefore information of historic waste disposal is necessary.

The amount of waste disposed to landfills during 1950-1989 was evaluated on the basis of the following considerations.

During the period of 1950–1990 Lithuanian population grew approximately 1% per year, but started to decline after the restoration of independence (Figure 7-4).

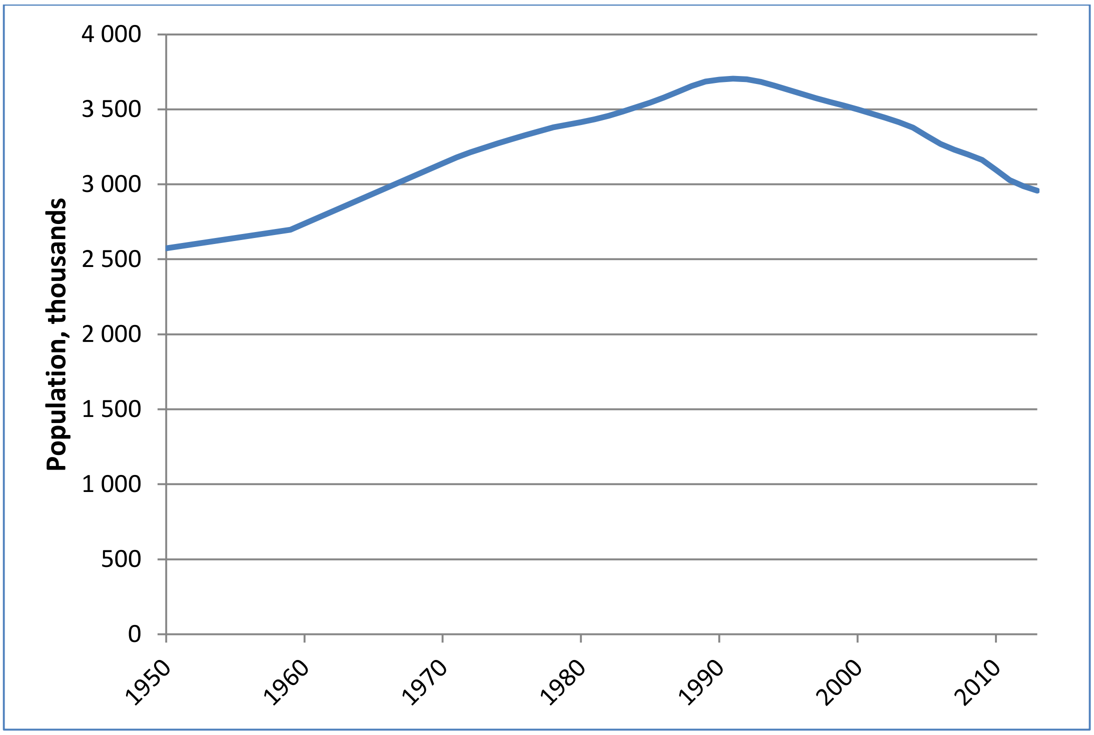


Figure 7-4. Variation of population in Lithuania in 1950-2013[174]

Economic indicators characterizing standards of welfare in Soviet command economy during 1950-1990 and economic indicators of free market economy since restoration of independence in 1990 are completely different and their direct comparison is not possible.

Economic development during the Soviet period was characterized by the "total public product". Changes of the total public product[175] evaluated by the Statistics Lithuania are shown in Figure 7-5. It should be noted, however, that it was measured in current prices and did not reflect correctly the change in living standard.

[174] Statistics Lithuania

[175] GDP: Conversion from material product balances to the system of national accounts in 1980-1990 at current prices. Lithuanian Department of Statistics, Vilnius, 1994

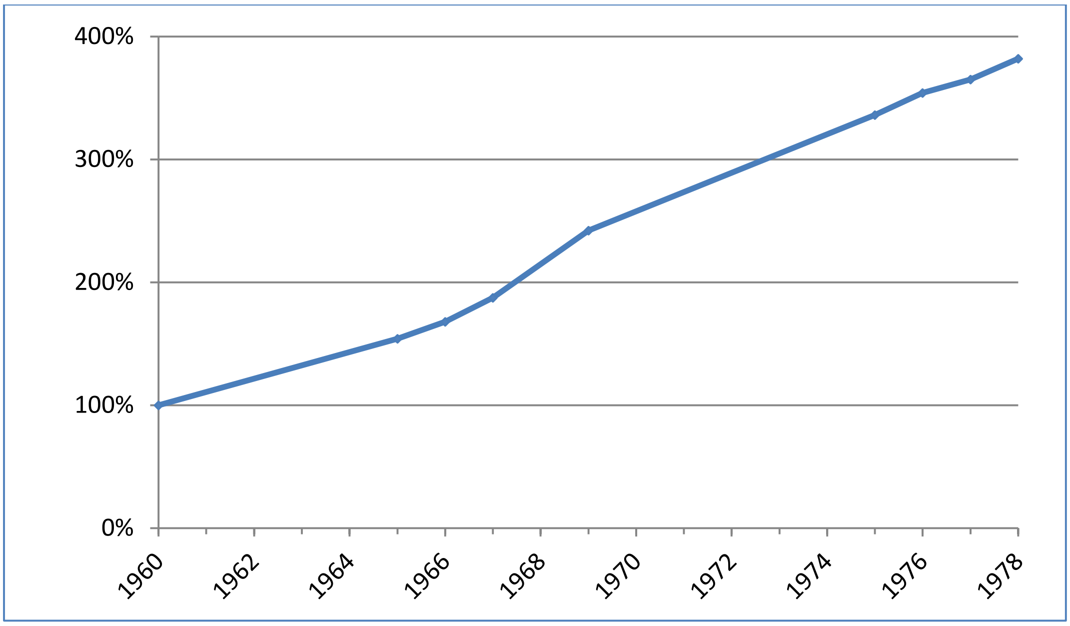


Figure 7-5. Variation of the total public product from 1960 to 1978

The Statistics Lithuania have recalculated economic indicators of the last decade of the Soviet power in Lithuania and obtained GDP values which are comparable to GDP after transition to free market economy[176]. Relative variations of population and GDP per capita from 1980 (1990 = 100%) are shown in Figure 7-6.

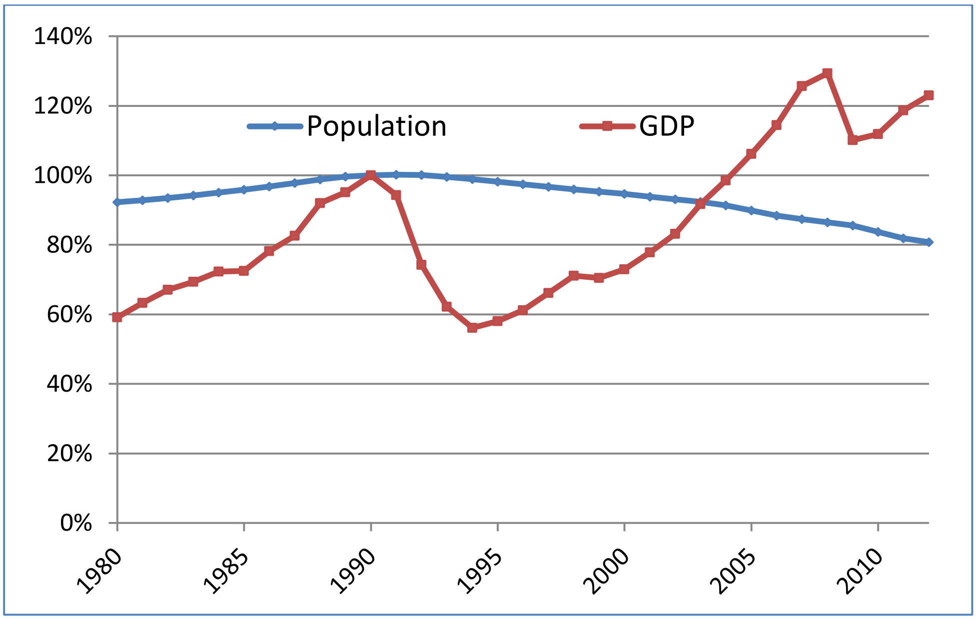


Figure 7-6. Relative variation of population and GDP per capita from 1980 (1990 = 100%)

It was assumed that the amount of waste per capita disposed of in landfills depends on consumption (standard of living) and availability of waste disposal facilities.

For evaluation of waste generation it was assumed that waste generation during the period 1950-1990 was increasing continuously and the growth rate was depending on two factors: number of

[176] Ibid.

population and consumption. As it was quoted above, population growth during this period was close to 1% determining at least 1% growth in the total waste generation.

The period of 1950-1989 starts just 5 years after the World War II when the most of Lithuania was still in ruins, facilities and infrastructure for waste collection were actually non-existent. Therefore application of the same parameters for evaluation of waste disposed of in landfills in post-war period and 1990s when waste collection and disposal facilities and infrastructure were already in place, though inadequately managed, was considered not correct.

In 1950s waste collection services were provided only to small fraction of population in major cities and growth of the amount of waste disposed of in landfills was instigated not so much by increasing consumption but rather by expansion of waste collection areas and infrastructure. Therefore it was assumed that disposal of waste during this period was increasing substantially faster than in 90s.

It was assumed that expansion of provided waste management services and improvement of living standards caused increase of waste generation per capita by about 1% annually.

When extrapolating waste disposal, it was assumed that composition of degradable waste (in per cent), including both municipal and industrial waste, was the same as in 1990.

The estimated total amounts of waste were then in a next step divided over 3 types of disposal sites based on the relation between the types of disposal sites and the population in major cities, smaller towns and rural areas. From 2007 out-phasing of the old landfill sites and putting in operation of new landfills was taken into consideration.

Variation of municipal waste disposal (not including separately disposed biodegradable waste of industrial and commercial origin) from 1950 to 1990 is based on these assumptions and is shown in Figure 7-7.

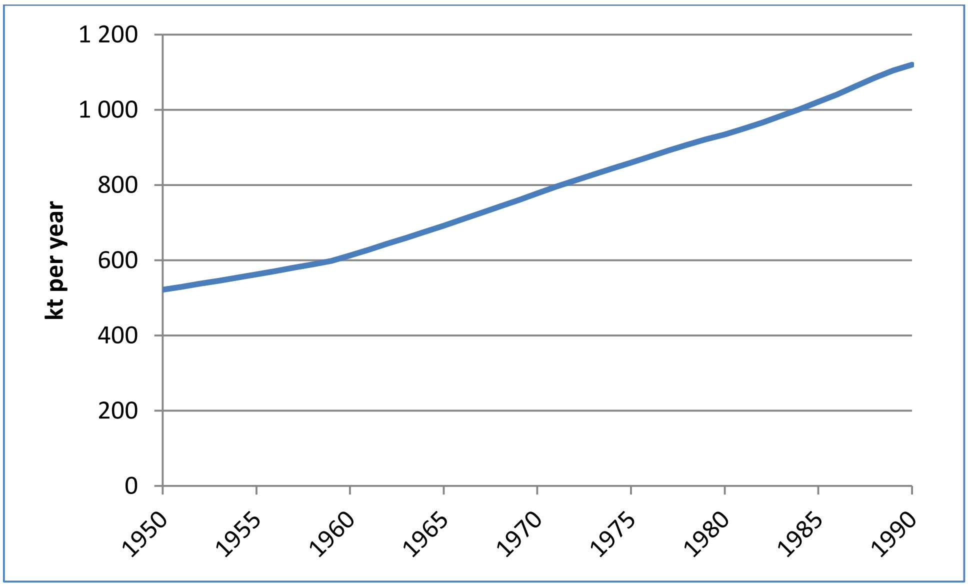


Figure 7-7. Assumed variation of municipal waste disposal from 1950 to 1990

There are no data on either municipal or industrial/commercial waste disposal during the period 1950-1990 and it was not possible to make any distinction between variation of disposed municipal and industrial/commercial wastes. Evaluation of waste disposal for the period 1950-

1989 was performed applying the same methodology as for the total amount of wastes including both municipal and industrial/commercial waste.

Amount of industrial and commercial waste disposed of in 1990 was assumed to be the same as in 1991. Data on disposal of industrial and commercial waste from 1991 to 1998 were taken from the database of the Environmental Protection Agency.

The final composition of biodegradable waste (including both municipal and industrial/commercial waste) determined for 1990 was used also for calculation of methane emissions in historic years 1950-1989.

Sensitivity analysis

Assumption that the amount of waste disposed of per capita in landfills in 1950-1989 was increasing on average by 1% should be considered as very rough, most probably containing significant error, and it is very important to evaluate whether erroneous assumption could have a significant impact on the final results of methane emission.

Growth of the amount of disposed per capita waste in 1950-1989 by 1% was taken as base scenario and for comparison, methane emissions were calculated using alternative assumptions that disposed per capita waste amount in 1950-1989 was increasing by 0.5% and 2%.

It is obvious that in case of faster growth, in order to reach the same level in 1990, the initial waste amount disposed of in 1959 should be lower, and vice versa, in case of slower growth the initial amount should be higher. Evaluated initial amounts of waste that should have been disposed in 1950 in case of 0.5%, 1% and 2% average growth of disposed per capita waste are shown in Table 7-21.

Table 7-21. Evaluated initial amounts of waste that should have been disposed in 1950 in case of 0.5%, 1% and 2% average growth of disposed per capita waste

Parameter	Growth 0.5%	Growth 1%	Growth 2%
Disposal kg/person/year	277	226	151
Total disposal, kt per year	712	582	388

In case of waste growth rate reduced by halve compared to base scenario, initial waste amount increases only by 22.3%, while twice higher growth rate requires decline of initial waste amount by 33.4%.

Impact of different growth rates waste disposal in 1959-1989 on methane emissions in 1990-2013 is shown in Table 7-22.

Table 7-22. Impact of assumed different growth rates of waste disposal in 1959-1989 on methane emissions in 1990-2013 compared to base scenario (1% growth)

Year	Growth 0.5%	Growth 2%
1990	4.3%	-7.8%
1991	3.9%	-6.9%
1992	3.5%	-6.2%
1993	3.1%	-5.6%
1994	2.8%	-5.1%
1995	2.6%	-4.7%
1996	2.4%	-4.3%
1997	2.2%	-4.0%
1998	2.1%	-3.7%

1999	1.9%	-3.4%
2000	1.8%	-3.2%
2001	1.6%	-2.9%
2002	1.5%	-2.7%
2003	1.4%	-2.5%
2004	1.3%	-2.3%
2005	1.3%	-2.2%
2006	1.2%	-2.1%
2007	1.2%	-2.0%
2008	1.1%	-1.9%
2009	1.0%	-1.8%
2010	1.0%	-1.7%
2011	0.9%	-1.6%
2012	0.9%	-1.6%
2013	0.9%	-1.5%

As could be seen from the Table 7-22, in case of growth rate reduced by halve, i.e. larger amount of initial and, consequently, the total amount of disposed waste, maximum increase of methane emissions is 4.3%, average increase during the period 1990-2013 only 2%.

Assumption that waste disposal growth rate in 1950-1989 was twice higher than in the base scenario results in reduction of methane emissions by maximum 7.8%, on average 3.5%.

It is obvious that variations of obtained results using three various scenarios are quite small, significantly lower than uncertainty of evaluation of methane emissions, and possible error in estimating waste disposal in 1950-1989 could have only minor impact on final results.

Waste disposal practices

Historically Lithuanian landfills can be divided into three categories:

- landfills of major cities (county centres),
- landfills of smaller towns, and
- small landfills and dumps in rural areas.

Waste management in landfills of major cities include controlled placement of waste, periodic covering and mechanical compacting. These landfills correspond to the definition of anaerobic managed waste disposal sites.

Landfills of smaller towns are comparatively deep (>5 m of waste) but their management especially in the past was poor. These landfills correspond to the definition of managed semi-aerobic waste disposal sites.

Small landfills and dumps in rural areas were assigned to unmanaged waste disposal sites.

The amounts of waste disposed to the landfills of each type were evaluated in the following way.

Variations of urban and rural population in Lithuania during 2001-2011 are shown in Table 7-23. Separately data of populations in major cities and towns are not available from 1950. However, as seen from this table, the share of major cities in the total urban population is fairly constant and makes approximately 70%. It was assumed that this ratio continued for the whole discussed period starting from 1950. Estimated variations of population in major cities, towns and rural areas from 1950 are provided in Figure 7-8.

Table 7-23. Variations of urban and rural population (k) in Lithuania during 2001-2011

Year	Major cities	Towns	Total urban	Rural	Total
2001	1629	694	2323	1148	3471
2002	1622	681	2303	1140	3443
2003	1616	664	2280	1135	3415
2004	1604	645	2249	1128	3377
2005	1593	619	2212	1110	3323
2006	1585	594	2179	1091	3270
2007	1580	576	2156	1075	3231
2008	1556	579	2135	1063	3198
2009	1551	561	2112	1051	3163
2010	1531	537	2068	1029	3097
2011	1499	523	2021	1007	3028

Source: Statistics Lithuania

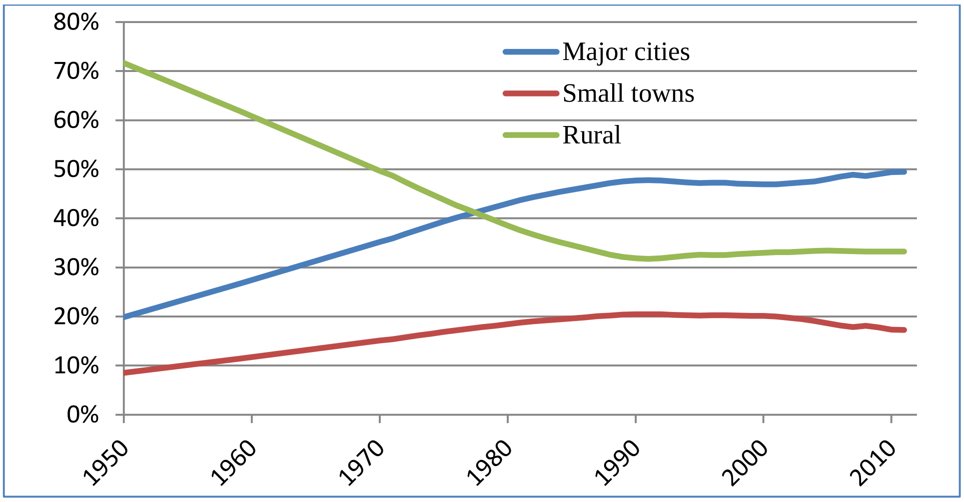


Figure 7-8. Estimated variations of population in major cities, towns and rural areas from 1950[177]

Conditions described above were applicable until 2007. From 2007 disposal practices started to change. Implementation of the Landfill directive 1999/31/EC requires construction of new solid waste landfills corresponding to the requirements set in the directive and closure of all existing landfills not complying with the requirements.

As a result, 10 municipal waste management regions were established in Lithuania and new landfills complying with the requirements of the Landfill directive were constructed. Old landfills and dumps were closed and all waste including waste from small towns and rural areas are currently disposed in a new managed landfills. The start of waste disposal in new managed regional landfills complying with the requirements of Landfill directive is shown in Table 7-24.

Table 7-24. The beginning of waste disposal in new managed regional landfills

Region	Start of the disposal
Alytus	January 2008
Marijampolė	April 2009
Tauragė	April 2009
Šiauliai	July 2007
Vilnius	January 2008
Telšiai	January 2008

[177] Statistics Lithuania

Klaipėda	July 2008
Kaunas	July 2009
Utena	April 2008
Panevėžys	October 2009

For the transition period 2007-2009, the regional waste management companies provided data (percentage) of wastes disposed in old and new landfills. Waste disposed in old landfills was divided into 3 categories depending on population distribution in cities, towns and rural areas, waste disposed of in new landfills was assigned to deep managed category.

Evaluated disposal of municipal waste in new regional landfills are shown in Table 7-25.

Table 7-25. Disposal of municipal waste in new regional landfills during 2007-2009

Region	**2007**			**2008**			**2009**		
	Popu-lation, %	**Disposal**		**Popu-lation, %**	**Disposal**		**Popu-lation, %**	**Disposal**	
		%	**kt**		**%**	**kt**		**%**	**kt**
Alytus	5.2	NO	NO	5.2	100	62	5.2	100	56
Kaunas	20.0	NO	NO	20.0	86	202	20.0	92	197
Klaipėda	11.3	NO	NO	11.3	76	100	11.3	79	96
Marijampolė	5.4	NO	NO	5.4	NO	NO	5.4	59	34
Panevėžys	8.4	NO	NO	8.4	NO	NO	8.4	57	51
Šiauliai	10.3	50	58	10.4	80	97	10.3	61	67
Tauragė	3.8	NO	NO	3.8	NO	NO	3.8	79	32
Telšiai	5.1	NO	NO	5.2	100	60	5.1	100	55
Utena	5.1	NO	NO	5.1	100	60	5.1	100	55
Vilnius	25.4	NO	NO	25.2	90	266	25.4	95	258
Total			58			846			902
Fraction of the total municipal waste			5.2%			72.2%			84.1%

The amount of waste disposed of in regional landfills (58 kt in 2007, 846 kt in 2008 and 902 kt in 2009) were added to the amount disposed in new managed landfills, the remaining amount was divided among the three types of landfills depending on the number of population in major cities, towns and rural areas and evaluated generation of municipal waste per capita.

During the meeting at the Ministry of Environment[178] it was agreed that the ratio of waste generation in major cities, towns and rural areas is approximately 2:1.5:1, Based on this assumption, waste disposal per capita in major cities, towns and rural areas (excluding waste disposed of in new landfills) were calculated as:

$$G_R = \frac{WT}{2 \times P_C + 1.5 \times P_T + P_R},$$

$$G_C = 2 \times G_R,$$

$$G_T = 1.5 \times G_R$$

where:

[178] Meeting at the Ministry of Environment with the Head of Waste Division Ingrida Kavaliauskienė and senior specialist Ingrida Rimaitytė, September 25, 2009

G_C, G_T and G_R are annual amount of waste disposed in cities, towns and rural areas (kg per capita per year),

WT is the total amount of disposed waste (tonne) minus waste disposed on the new regional landfills,

P_C, P_T and P_R are the number of population in cities, towns and rural areas (thousands).

The amounts of waste disposed off in anaerobic, semi-aerobic and unmanaged landfills (corresponding to waste delivered for disposal from major cities, towns and rural areas) were calculated by multiplying corresponding population number with the waste generation per capita of the corresponding category, namely for managed waste disposal sites: $2.G_R.Pc$; for unmanaged deep: $1.5 . G_R.Pt$; for unmanaged shallow: $1. G_R.P_R$.

Data on disposal of solid municipal waste in landfills of each category are provided in Table 7-26.

Table 7-26. Disposal of solid municipal waste landfills of different categories (kt)

Year	Old landfills			New regional landfills	TOTAL
	Managed anaerobic	Managed semi-aerobic	Unmanaged		
1990	676.6	217.5	225.8	-	1.119.9
1991	678.5	218.1	225.2	-	1.121.8
1992	662.8	213.1	221.5	-	1.097.4
1993	647.7	208.2	219.3	-	1.075.2
1994	635.9	204.4	217.7	-	1.058.1
1995	633.2	203.5	218.9	-	1.055.7
1996	632.8	203.4	217.7	-	1.054.0
1997	633.5	203.6	217.8	-	1.055.0
1998	632.9	203.4	219.9	-	1.056.2
1999	627.5	201.7	219.1	-	1.048.4
2000	648.1	208.3	227.7	-	1.084.2
2001	625.4	199.9	220.5	-	1.045.7
2002	600.4	188.9	210.9	-	1.000.1
2003	547.7	168.8	192.4	-	908.8
2004	624.1	188.1	219.4	-	1.031.6
2005	638.9	186.0	222.6	-	1.047.6
2006	662.7	186.2	228.0	-	1.076.9
2007	669.5	183.0	227.8	58.9	1.139.2
2008	200.8	56.0	68.6	847.0	1.172.5
2009	104.3	28.3	35.3	886.7	1.054.7
2010	-	-	-	1.050.3	1.050.3
2011	-	-	-	988.6	988.6
2012	-	-	-	782.6	782.6
2013	-	-	-	656.2	656.2

Sewage sludge disposal

Sewage sludge is disposed separately from solid waste on sites comparable to landfills. Statistical information on sewage sludge disposal are collected and stored in the same data base together with data on waste generation and management. Data on sewage sludge disposal were provided by the Lithuanian EPA responsible for collection and management of statistical information on waste management.

Up to 2005 wet sewage sludge generation and management data are reported and stored in the EPA database. From 2006 some companies started reporting amount of sludge expressed in dry matter. All data were carefully checked and converted to wet sludge using dry matter/wet sludge conversion factor 0.2[179]

Sewage sludge disposal conditions, same as solid waste, depend on the size of disposal site - in large cities large amounts of sludge are disposed, while in small towns disposal sites are smaller and thinner. A study on sewage sludge management[180] performed in 2012 concluded that about 73% of sewage sludge are disposed on shallow (depth <5 m) unmanaged sites for which use of MCF value 0.4 is recommended. Remaining 27% are disposed on deeper (depth >5 m) semi-aerobic sites for which MCF value 0.8 was recommended.

Amounts of sewage sludge (kt) disposed in landfills of different categories are provided in Table 7-27.

Table 7-27. Amount of sewage sludge (kt) disposed in landfills of different categories

Year	Semi-aerobic (MCF = 0.8)	Unmanaged (MCF = 0.4)	Total
1990	53.2	143.9	197.1
1991	53.2	143.9	197.1
1992	69.8	188.6	258.4
1993	40.4	109.2	149.6
1994	56.7	153.2	209.9
1995	83.4	225.5	308.9
1996	82.9	224.1	306.9
1997	88.6	239.4	328.0
1998	95.9	259.3	355.2
1999	87.0	235.1	322.1
2000	84.4	228.3	312.7
2001	63.1	170.7	233.8
2002	61.3	165.7	227.0
2003	38.4	103.7	142.1
2004	47.8	129.2	177.0
2005	36.5	98.6	135.1
2006	31.3	84.7	116.0
2007	26.2	70.8	97.0
2008	50.9	137.7	188.6
2009	41.9	113.2	155.1
2010	32.7	88.4	121.1
2011	41.9	113.3	155.2
2012	32.6	88.1	120.7
2013	24.8	67.0	91.8

Methane recovery

Landfill gas collection started in 2008 in closed Kaunas and Utena landfills. Initially, discrete data on methane recovery from landfills were not reported by the Statistics Lithuania, and information on methane recovery was collected by sending questionnaires to the Regional Waste

[179] Wet - dry conversion of sludges. ARGUS for Eurostat - Environment Statistics. Meeting of the Working Group "Statistics of the Environment", Sub-Group "Waste". Eurostat, 2008.

[180] Evaluation of methane generation from wastewater and sludge at wastewater treatment plants in Lithuania (Lietuvos nuotekų valymo įrenginių nuotekose ir dumble susidarančio metano kiekio tyrimai ir įvertinimas) Ekotermija, 2012

Management Centres. Later, when the number of landfill gas recovery sites and the volume of recovered gas increased, the Statistics Lithuania started recording the amount of recovered landfill gas separately.

Recovered methane is used for energy purposes and emissions from landfill gas combustion are included in the energy sector report. In order to be consistent, it was decided to use the same data for evaluating GHG emissions in both energy and waste disposal sectors.

The data on landfill gas recovery are reported by the Statistics Lithuania in million m^3 and in TJ. Both sets of data are collected from the Regional Waste Management Centres and are country specific. As these data are used for establishing GHG emissions in energy sector, it was decided to be consistent and use the same data for establishing methane recovery.

Amount of recovered methane in kt was calculated assuming that methane lower heating value is 50 TJ/kt[181]. Lower heating value of methane is its specific property and is reported in scientific reference manuals. Heating value of landfill gas in TJ depends on landfill gas composition and is equal to the amount of methane in landfill gas multiplied by its lower heating value.

Recovered methane both in landfills and in wastewater treatment plants, is used for energy purposes and emissions from these electricity- and heat-producing activities are included under the energy sector and reported in the 1A sector as biogas which includes biogas generated from landfills, sewage sludge and manure.

Data of CH_4 recovery from landfills are provided in Table 7-28.

Table 7-28. Methane recovery from landfills, kt

Year	Recovery
2008	0.34
2009	1.12
2010	1.66
2011	4.90
2012	5.14
2013	5.98

Source: Statistics Lithuania

At the municipal wastewater treatment plants methane is recovered in anaerobic digestion installations from sludge generated during wastewater treatment. Sludge for anaerobic digestion is collected separately and not accounted together with disposed sludge. Therefore methane recovery in anaerobic digestion plants is discussed in wastewater handling section.

Automatic anaerobic digestion facilities are operated under pressure lower than atmospheric and exclude any leakages of CH_4.

Anaerobic digestion facilities for sewage sludge are operated by corresponding wastewater treatment plants. As sludge is recycled within a plant, operators are not obliged to report its generation and consumption to the EPA, and data on sewage sludge used for biogas production in anaerobic digestion facilities are not available.

[181] http://www.engineeringtoolbox.com/gross-net-heating-values-d_420.html

7.2.3 Methodological issues

First Order Decay Model

CH_4 generation was evaluated using FOD model according to an IPCC Tier 2 approach (IPCC 2006). The model calculations were performed using national statistics of landfill site characteristics and amounts of waste fractions deposited each year.

The basic equation for the first order decay model is made available in the Excel file containing first order decay model provided by the European Commission[182]:

$$DDOC_m = DDOC_m(0) \cdot e^{-kt}$$

where:

$DDOC_m$ is the mass of decomposable degradable organic carbon (DOC) at any time,

$DDOC_m(0)$ is the mass of DOC at the start of the reaction, when t=0 and e^{-kt}=1,

t is time in years, and

k is the reaction constant.

The default assumption is that CH_4 generation from all the waste deposited each year begins on the 1st of January in the year after deposition. This is the same as an average six month delay until substantial CH_4 generation begins (the time it takes for anaerobic conditions to become well established).

The amount of degradable organic carbon disposed during a year decreases exponentially over time according to the first order decay equation resulting in corresponding exponential reduction of CH_4 generation. The total CH_4 generation at a given time *t* is a sum contributions from degradation of organic carbon disposed during the years from 1 to t.

Annual CH_4 emissions were calculated using formula (2006 IPCC, Volume 5, p. 3.8):

$$CH_4Emissions = \left[\sum_x CH_4generated_{x,T} - R_T\right] \times (1 - OX_T)$$

Where:

T - inventory year,

x – waste category or type/material

R_T -recovered CH_4 in year T (kt),

OX_T - oxidation factor (assumed OX_T = 0).

FOD model provided by the European Commission already contains all default parameters used in calculations.

The methodology was used for the whole waste including both municipal and industrial waste.

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[182] 2006 IPCC vol 5

Separate values of parameters, when available, were applied for different waste components (food waste, paper, wood, textiles, green waste and sewage sludge) and different types of landfills (deep managed, deep unmanaged, shallow unmanaged).

Methane correction factor

Waste management in landfills of major cities include controlled placement of waste, periodic covering and mechanical compacting. These landfills correspond to the definition of managed landfills with CH_4 correction factor = 1 (2006 IPCC, Volume 5, p. 3.14).

Landfills of smaller towns are comparatively deep (>5 m of waste) but their management, especially in the past, was poor. These landfills correspond to the definition of deep unmanaged landfills with CH_4 correction factor = 0.8 (2006 IPCC, Volume 5, p. 3.14).

Small landfills and dumps in rural areas were assigned to unmanaged shallow landfills (<5 m waste) with CH_4 correction factor = 0.4 (2006 IPCC, Volume 5, p. 3.14).

Other parameters

Other parameters:

DOC (weight fraction, wet basis) (2006 IPCC, Volume 5, p. 2.14):

Food waste	0.15
Paper	0.4
Wood	0.43
Textiles	0.24
Green waste	0.20

Country specific DOC value was used in calculations of methane emissions from sewage sludge. Average DOC value reported in the study[183] performed in 2012 was evaluated at 30% of sludge dry matter based on experimental analyses performed in various wastewater treatment facilities in Lithuania. Assuming that dry matter content in sewage sludge is about 20%, DOC value 0.06 was used for calculation of methane emissions from wet sludge.

CH_4 generation rate constant was chosen for the wet climate condition under the boreal and temperate climate zone provided in the 2006 IPCC Guidelines (Volume 5, p. 3.17). The reason for the selection of this value is that Lithuania is situated in the temperate climate zone, i.e. north of subtropics and south of subarctic area, and its climate is characterized as wet, i.e. precipitation exceeds evaporation.

CH_4 generation rate constant (years^{-1})(2006 IPCC, Volume 5, p. 3.17)

Food waste	0.185
Paper	0.06
Wood	0.03

[183] Evaluation of methane generation from wastewater and sludge at wastewater treatment plants in Lithuania (Lietuvos nuotekų valymo įrenginių nuotekose ir dumble susidarančio metano kiekio tyrimai ir įvertinimas) Ekotermija, 2012

Textile	0.06
Green waste	0.1
Sewage sludge	0.185
DOC_f (fraction of DOC dissimilated)	0.5 (2006 IPCC, Volume 5, p. 3.13)
Delay time (months)	6 (2006 IPCC, Volume 5, p. 3.19)
Fraction of CH_4 in developed gas	0.5 (2006 IPCC, Volume 5, p. 3.26)
Conversion factor C to CH_4	16/12 = 1.33 (2006 IPCC, Volume 5, p. 3.37)
Oxidation factor	0 (2006 IPCC, Volume 5, p. 3.15)

7.2.4 Uncertainties and time-series consistency

Uncertainties

Uncertainty of activity data was assumed to be 30% (2006 IPCC, Volume 1, Chapter 3, Table 3.5).

Uncertainties of separate input parameters for Tier 1 uncertainty analysis were taken as average values of uncertainties provided in 2006 IPCC, Volume 5, Chapter 3, Table 3.5 (Table 7-29).

Table 7-29. Uncertainties of separate input parameters

Parameter	IPCC 2006, v. 3, Table 3.5	Assumed average uncertainty
Degradable organic carbon	±20%	20%
Fraction of degradable organic carbon dissimilated	±20%	20%
Methane correction factor:		
MCF = 1	-10%, +0%	5%
MCF = 0.4	±30%	30%
MCF = 0.8	±20%	20%
Methane fraction in landfill gas	±5%	5%
Methane generation rate constant*	-40%, +300%	170%

* IPCC 2006, v. 3, Table 3.5 does not provide uncertainties for methane generation rate constant, therefore data from GPG 2000, p. 5.12, Table 5.2 were used in calculations)

Uncertainty of implied emission factor for three separate MCF values was established using 2006 IPCC,Volume. 1, Chapter 3, equation 3.1 (p. 3.28):

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \ldots + U_n^2},$$

Where:

U_{total} is the percentage uncertainty in the product of the quantities (half the 95% confidence interval divided by the total and expressed as a percentage);

U_i are the percentage uncertainties associated with each of the quantities.

Uncertainties of implied emission factors calculated using values from the third column of Table 7-29 are provided in Table 7-30.

Table 7-30. Overall uncertainties of implied emission factors

Methane correction factor	Uncertainties of implied emission factor
MCF = 1	172%
MCF = 0.4	175%
MCF = 0.8	174%

The overall uncertainty of emission factor for the total CH_4 emission comprising all three types of landfills was calculated using 2006 IPCC, Volume 1, Chapter 3, equation 3.2 (p. 3.28):

$$U_{total} = \frac{\sqrt{(U_1 \cdot x_1)^2 + (U_2 \cdot x_2)^2 + \ldots + (U_n \cdot x_n)^2}}{x_1 + x_2 + \ldots x_n}$$

where:

U_{total} is the percentage uncertainty in the sum of the quantities,

x_i and U_i are the uncertain quantities and the percentage uncertainties associated with them, respectively.

Calculated overall uncertainty of implied emission factor using average CH_4 emission values of disposed solid waste and sewage sludge over the period 1990-2012 is 122.7%.

Time-series consistency

Emissions from waste disposal on land were calculated for the whole time series using the same method and data sets.

Statistical data on waste disposal are available from 1991. It was assumed after consultations with the specialists of the Ministry of Environment that data on municipal waste disposal in 1991-1997 were overestimated, hence the data were corrected based on correlation with GDP. Historic data on waste disposal starting from 1950 were evaluated taking into account available data on variations of population, economic development and considering expansion of waste management infrastructure.

7.2.5 Completeness

Inventory of emissions from solid waste disposal on land covers methane emissions occurring in the whole territory of Lithuania during the period 1990 to 2013. The inventory takes account of all existing landfills and dumps divided in three categories (deep managed, deep unmanaged and shallow unmanaged) and includes emissions from various types of biodegradable materials (food waste, paper, wood, textile, green waste , sewage sludge) disposed of with municipal, industrial and commercial waste.

7.2.6 Category-specific QA/QC and verification

Data collection and calculations were performed in accordance with the requirements outlined in Section 6 of the Quality Assurance (QA) and Quality Control (QC) Plan[184].

Tier 1 General Inventory Level QC was performed based on recommendations provided in IPCC 2006 vol. 1 Chapter 6 and outlined in the QA/QC plan.

[184] National Greenhouse Gas Emission Inventory of the Republic of Lithuania. Quality Assurance and Quality control Plan 2011-2012. Vilnius, 2011.

Consistency of data between NIR and CRF has been checked.

Documentation on activity data and emission factors was crosschecked with the corresponding data in calculation model.

In case of large fluctuations in data, other experts or data providers were consulted to either provide the explanation or to identify a possible inconsistency or an error.

Explanations for recalculations were checked to ensure that they are clearly documented.

After the calculation is finished, EPA waste experts not directly involved in the emissions calculation of that year have reviewed the final report and CRF data checking the applied parameters, calculation methodology, as well as trend description in the NIR.

In addition, verification of methane emissions from solid waste disposal on land was performed by comparing per capita emission data with neighboring countries: Latvia, Estonia, Poland, and Denmark. The results are shown in Table 7-31.

Table 7-31. Comparison of GHG emissions from solid waste disposal on land (kg per capita)

Year	Lithuania 2013	Denmark 2012	Latvia 2012	Estonia 2012	Poland 2012
1990	10.6	12.7	5.9	5.5	11.5
1991	10.9	12.7	6.1	5.8	11.5
1992	11.1	12.5	6.4	6.3	11.5
1993	11.4	12.4	6.7	7.0	11.4
1994	11.5	11.7	6.9	7.5	11.3
1995	11.6	11.0	7.1	6.6	11.2
1996	11.7	10.6	7.2	7.2	11.3
1997	11.9	10.0	7.4	9.3	11.3
1998	12.0	9.4	7.6	10.9	11.5
1999	12.0	9.5	7.8	11.2	11.6
2000	12.2	9.3	8.1	12.5	11.6
2001	12.7	9.3	8.3	12.9	11.7
2002	13.0	8.7	8.4	12.4	11.6
2003	13.2	8.8	7.8	12.1	11.3
2004	13.2	7.9	7.5	12.4	11.2
2005	13.2	7.6	7.8	11.4	11.3
2006	13.2	7.9	8.3	11.3	11.3
2007	13.2	7.5	8.8	10.9	11.3
2008	13.1	7.2	9.2	10.9	11.2
2009	13.1	6.9	9.4	9.7	11.2
2010	13.1	6.2	9.8	9.7	11.1
2011	12.5	6.3	10.0	9.1	10.7
2012	12.4	6.0	10.4	8.6	10.6

Established methane emissions per capita from solid waste disposal on land in 1990 in Lithuania are 19% lower than in Denmark, but in 2010 substantially higher apparently because of significantly increased methane recovery in Denmark. Lithuania's emissions per capita in the beginning of the period (1990-1993) were lower than in Poland but later exceeded Polish values apparently due to reduction of population in Lithuania while Polish population number was increasing.

7.2.7 Category-specific planned improvements

No improvements are planned in this sector.

7.3 Biological treatment of waste (CRF 5.B)

7.3.1 Category description

Biological treatment of waste includes composting and anaerobic digestion. Anaerobic digestion in Lithuania is used for sewage sludge treatment in anaerobic digestion plants with methane (CH_4) recovery and combustion for energy, and thus the greenhouse gas emissions from the process are reported in the Energy Sector.

Evaluated CH_4 and N_2O emissions from waste composting are provided in Table 7-32.

Table 7-32. Evaluated CH_4 and N_2O emissions from waste composting

Year	Composted waste, kt	CH_4 emissions, kt	N_2O emissions, kt
1990	40.4	0.16	0.012
1991	40.4	0.16	0.012
1992	14.7	0.06	0.004
1993	13.7	0.05	0.004
1994	37.5	0.15	0.011
1995	53.6	0.21	0.016
1996	46.2	0.18	0.014
1997	40.4	0.16	0.012
1998	35.3	0.14	0.011
1999	64.1	0.26	0.019
2000	20.0	0.08	0.006
2001	47.6	0.19	0.014
2002	56.7	0.23	0.017
2003	50.0	0.20	0.015
2004	42.8	0.17	0.013
2005	68.7	0.27	0.021
2006	56.0	0.22	0.017
2007	68.7	0.27	0.021
2008	76.4	0.31	0.023
2009	75.9	0.30	0.023
2010	65.9	0.26	0.020
2011	84.7	0.34	0.025
2012	95.8	0.38	0.029
2013	121.8	0.49	0.037

As noted in the description of the Lithuanian waste reporting procedures, three classification systems were used for waste reporting since 1991.

The list of waste disposal and recovery operations during the reporting period 1991 to 1999 contained a recovery operation *R15 – composting* which was used to establish the amount of composted waste during this period.

New list of disposal and recovery operations was adopted from the year 2000 which contained entry *3.2 – biological treatment of non-hazardous waste*. It was assumed that all waste reported under this category was composted.

From 2004, waste reporting regulations changed again and list of waste disposal and recovery operations provided in the EU waste framework directive 75/442/EEC[185] was adopted. Biological treatment of waste was included in the operation *R3 - Recycling/reclamation of organic substances which are not used as solvents (including composting and other biological transformation processes)* but this category included also various other recycling operations.

In order to separate waste composting from other recycling/reclamation operations, a list of potentially compostable waste was compiled based on the European Waste Catalogue[186]:

Wastes from waste water treatment plants not otherwise specified
- 19 08 12 sludges from biological treatment of industrial waste water
- 19 08 14 sludges from other treatment of industrial waste water

Sludges and liquid wastes from waste treatment
- 19 06 03 liquor from anaerobic treatment of municipal waste
- 19 06 04 digestate from anaerobic treatment of municipal waste
- 19 06 05 liquor from anaerobic treatment of animal and vegetable waste
- 19 06 06 digestate from anaerobic treatment of animal and vegetable waste

Paper and cardboard wastes
- 15 01 01 paper and cardboard packaging
- 19 12 01 paper and cardboard from the mechanical treatment of waste
- 20 01 01 separately collected paper and cardboard

Wood wastes

Wastes from wood processing and the production of panels and furniture
- 03 01 01 waste bark and cork
- 03 01 05 sawdust, shavings, cuttings, wood, particle board and veneer

Wastes from pulp, paper and cardboard production and processing
- 03 03 01 waste bark and wood

Packaging (including separately collected municipal packaging waste)
- 15 01 03 wooden packaging

Construction and demolition wastes
- 17 02 01 wood

Wastes from the mechanical treatment of waste
- 19 12 07 wood other than that mentioned in 19 12 06

Separately collected fractions
- 20 01 38 wood

Textile wastes
- 20 01 10 Worn clothes
- 04 02 21 wastes from unprocessed textile fibres
- 04 02 22 wastes from processed textile fibres
- 15 01 09 textile packaging
- 19 12 08 wastes from the mechanical treatment of waste textiles
- 20 01 11 separately collected textile wastes

Animal waste of food preparation and products
- 02 01 02 animal-tissue waste
- 02 02 01 sludges from washing and cleaning

[185] Directive 75/442/EEC later was repealed and substituted by the directives 2006/12/EC and 2008/98/EC but the list of disposal and recovery operations remained unchanged.

[186] The European Waste Catalogue was established by the EU Commission Decision 2008/98/EC as amended and is adopted for use in all EU member states.

02 02 02	animal-tissue waste
02 02 03	materials unsuitable for consumption or processing
02 05 01	materials unsuitable for consumption or processing
Mixed waste of food preparation and products	
02 03 02	wastes from preserving agents
02 06 02	wastes from preserving agents
19 08 09	grease and oil mixture from oil/water separation containing only edible oil and fats
20 01 08	biodegradable kitchen and canteen waste
20 01 25	edible oil and fat
Green wastes	
02 01 07	wastes from forestry
20 02 01	biodegradable waste
Vegetal waste of food preparation and products	
02 01 01	sludges from washing and cleaning
02 01 03	plant-tissue waste
02 03 01	sludges from washing, cleaning, peeling, centrifuging and separation
02 03 04	materials unsuitable for consumption or processing
02 06 01	materials unsuitable for consumption or processing
02 07 01	wastes from washing, cleaning and mechanical reduction of raw materials
02 07 02	wastes from spirits distillation
02 07 04	materials unsuitable for consumption or processing
Slurry and manure	
02 01 06	animal faeces, urine and manure (including spoiled straw), effluent, collected separately and treated off-site
Household wastes	
20 03 01	mixed municipal waste
20 03 02	waste from markets
20 03 99	municipal wastes not otherwise specified
Wastes from aerobic treatment of solid wastes	
19 05 01	non-composted fraction of municipal and similar wastes
19 05 02	non-composted fraction of animal and vegetable waste
19 05 03	off-specification compost
Sludges from treatment of public sewerage water	
19 08 05	sludges from treatment of urban waste water
Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing	
02 02 04	sludges from on-site effluent treatment
02 03 05	sludges from on-site effluent treatment
02 04 03	sludges from on-site effluent treatment
02 05 02	sludges from on-site effluent treatment
02 06 03	sludges from on-site effluent treatment
02 07 05	sludges from on-site effluent treatment
03 03 11	sludges from on-site effluent treatment other than those mentioned in 03 03 10

It was assumed that all wastes included in the list were composted except paper and cardboard wastes, wood wastes, and textile wastes which, though containing degradable matter and could be composted, frequently are recycled by other methods.

Detailed data on waste treatment companies were available for 2006 to 2013. Based on this information data on composting was separated from other recycling activities and used for evaluation of GHG emissions.

Only aggregated data on recycling were available for 2000-2005. In order to evaluate composted fractions in the total amount of recycled waste, it was assumed that composted fractions of paper and cardboard, wood and textile wastes in 2000-2005 were the same as in 2006 to 2013.

Evaluated average composted fractions in the total amount of corresponding recycled wastes in 2006-2013:

- paper and cardboard waste 2.1%
- wood waste 29.6%
- textile waste 13.1%

Reported amount of composted municipal waste is very small, less than 0.4% of the total, and is reported only a few (six) years. Therefore municipal waste was not separated from the whole waste stream and methane emissions evaluated only from all composted wastes including municipal.

Currently only sewage sludge from municipal wastewater treatment plants is used in anaerobic digestion plants for biogas production. As biogas is produced by the wastewater treatment facilities and sludge used for anaerobic digestion is processed inside the facilities, it is not reported to the EPA and corresponding data are not available. Only sludge discharged from the anaerobic digestion facilities is included in the statistical reports. The data on produced biogas are reported to the national statistics and are available from the database of the Statistics Lithuania.

According to the representatives of companies operating anaerobic digestion plants, biogas production facilities are not leaking[187]. All produced biogas is used for energy production.

7.3.2 Methodological issues

The CH_4 and N_2O emissions of biological treatment can be estimated using the default method given in Equations 4.1 and 4.2 provided in 2006 IPCC, Volume 5, Chapter 4:

$$CH_4 Emissions = \sum (M \bullet EF_{CH4}) \bullet 10^{-3}$$

$$N_2O Emissions = \sum (M \bullet EF_{N2O}) \bullet 10^{-3}$$

Where:

CH_4 *Emissions* = total CH_4 emissions in inventory year, kt CH_4

N_2O *Emissions* = total N_2O emissions in inventory year, kt N_2O

M = mass of organic waste treated by biological treatment, kt

EFCH_4 = emission factor, g CH_4/kg waste treated

EFN_2O = emission factor, g N_2O/kg waste treated

Both equations were used for calculation of emissions from waste composting. The amount of sewage sludge used in anaerobic digestion process is not reported as, according to the Lithuanian legislation, reporting of waste recycled inside the plants in which it is generated is not obligatory.

[187] Mr. V. Puodžiūnas noted that leaking biogas would cause immediate explosion of a facility.

Data on biogas generation in anaerobic digestion processes were taken from the Statistics Lithuania which collects corresponding information.

7.3.3 Uncertainties and time-series consistency

Uncertainty

It was assumed that uncertainty of activity data is 40%.

Uncertainties in the default emission factors were estimated using the ranges given in 2006 IPCC Volume 5, Chapter 4, Table 4.1. For both CH_4 and N_2O the lower limit is close to zero and the upper limit is twice higher as average, i.e. uncertainty is 100%.

Overall uncertainties in both CH_4 and N_2O emission data are 108%.

Time-series consistency

Emissions from waste disposal on land were calculated for the whole time series using the same method and data sets. As collection of data on waste management started only in 1991, it was assumed that the amounts of generated and treated waste in 1990 were the same as in 1991.

7.4 Waste incineration (CRF 5.C)

Emissions from waste incineration without energy recovery are reported in the Waste Sector, while emissions from incineration with energy recovery are reported in the Energy Sector.

Incineration of waste is a source of greenhouse gas emissions, including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Normally, emissions of CO_2 from waste incineration are more significant than CH_4 and N_2O emissions.

Evaluated non-biogenic CO_2 emissions from waste incineration are provided in Table 7-33.

Table 7-33. Non-biogenic CO_2 emissions from waste incineration, (kt)

Year	Hazardous	Clinical Health care	Sewage sludge	Municipal	Total
1990	2.65	0.01	0.00	0.00	2.66
1991	2.65	0.01	0.00	0.00	2.66
1992	0.74	0.00	0.00	0.00	0.74
1993	2.14	0.00	0.00	0.00	2.14
1994	0.65	0.01	0.00	0.00	0.66
1995	2.50	0.01	0.00	0.00	2.51
1996	0.84	0.02	0.00	0.00	0.85
1997	0.82	0.04	0.00	0.00	0.85
1998	0.78	0.16	0.00	0.00	0.94
1999	0.34	0.07	0.00	0.00	0.41
2000	1.13	0.00	0.00	0.00	1.13
2001	1.44	0.10	0.00	0.00	1.54
2002	1.36	0.02	0.00	0.00	1.38
2003	3.69	0.00	0.00	0.00	3.70
2004	1.87	0.04	0.00	0.00	1.91
2005	3.36	0.24	0.00	0.00	3.60
2006	3.11	0.18	0.00	0.00	3.29
2007	0.19	0.47	0.00	0.00	0.66
2008	0.02	0.64	0.00	0.00	0.66
2009	0.01	0.68	0.00	0.00	0.70

2010	0.83	0.63	0.00	0.00	1.46
2011	4.09	0.36	0.00	0.00	4.45
2012	0.99	0.04	0.00	0.00	1.02
2013	0.76	0.00	0.00	0.00	0.77

Evaluated N_2O and CH_4 emissions from waste incineration are provided in Table 7-34.

Table 7-34. N_2O and CH_4 emissions from waste incineration, kt

Year	N_2O	CH_4
1990	0.0002	0.00016
1991	0.0002	0.00016
1992	0.0001	0.00006
1993	0.0002	0.00016
1994	0.0000	0.00005
1995	0.0001	0.00015
1996	0.0001	0.00005
1997	0.0001	0.00005
1998	0.0001	0.00006
1999	0.0000	0.00003
2000	0.0001	0.00007
2001	0.0001	0.00009
2002	0.0001	0.00008
2003	0.0002	0.00022
2004	0.0001	0.00011
2005	0.0002	0.00022
2006	0.0002	0.00020
2007	0.0000	0.00004
2008	0.0000	0.00004
2009	0.0000	0.00005
2010	0.0001	0.00009
2011	0.0003	0.00027
2012	0.0001	0.00006
2013	0.0000	0.00005

7.4.1 Category description

Incineration of hazardous waste, clinical waste, sewage sludge and municipal waste is recorded in the database of the Lithuanian EPA, however, the amount of incinerated waste is very small. GHG emissions from waste incineration on average comprise merely 0.11% of the total emissions in the waste sector and only in 2011 during testing of hazardous waste incinerator they reached 0.35%.

Emissions from waste incineration fluctuate quite strongly. In 1990-2005 small amounts of waste were incinerated in various combustion installations not meant specifically for waste incineration. There were no dedicated waste incineration facilities 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. Incinerated waste included calorific waste such as spent oils used, for example, for heating garages, etc.

Hospital waste incineration facility with nominal capacity 200 kg per hour was put in operation in 2006 in Vilnius. The facility includes rotary kiln, secondary combustion chamber and flue gas treatment unit. Temperature in the secondary combustion chamber can be raised up to 1100 ^oC. Flue gas is treated by injecting soda ash and activated carbon into the gas stream and then separating them in bag filter. Hospital waste incineration plant was closed in 2011 and is not operating since. There was no energy recovery in hospital waste incineration plant.

Construction of the hazardous waste incineration facility with nominal capacity 1000 kg per hour was completed in 2010 and test burning of hazardous waste started in November. Only about 820 tonnes of waste were incinerated in 2010 and about 4 kt in 2011. Because of contractual disputes plant operations in 2012 and 2013 were significantly reduced to approximately 1 and 0.75 kt.

The hazardous waste incineration facility comprises waste feeding unit, rotary kiln, secondary combustion chamber and flue gas treatment installation. Hazardous waste is incinerated at the minimum temperature 850^oC with at least 2 seconds residence time. If halogenated compounds are present, temperature is raised to 1100^oC. Flue gas treatment unit includes semi dry scrubber with activated carbon injection, bag filter and wet scrubber for finishing.

Energy (both heat and electricity) recovery is foreseen in hazardous waste incineration plant but only small amount of hazardous waste was incinerated in 2010-2013 during limited test runs supervised by equipment supplier and energy production was not recorded.

The data on waste incineration are reported in the framework of overall waste reporting obligations in accordance with the national waste classification in 1991-1999 and EU Waste List from 2000. As data on waste management were not collected in 1990, it was assumed that the amount of waste incinerated in 1990 was the same as incinerated in 1991.

Waste incineration facilities are obliged to report data split into categories of the EU Waste List. Reported data include waste received, waste treated, waste handed over to other treatment facilities, and waste stored by the end of the year.

Activity data of incinerated amounts of waste were obtained from Environment Protection Agency (EPA) waste database (Table 7-35). Data collection and validation procedures are described in chapter 7.1.

Types and amounts of incinerated wastes are provided in Table 7-35.

Table 7-35. Amounts of incinerated waste 1990-2013, (kt)

Year	Hazardous	Clinical Health care	Sewage sludge	Municipal	Total
1990	2.63	0.01	0.01	0.00	2.65
1991	2.63	0.01	0.01	0.00	2.65
1992	0.73	0.01	0.32	0.00	1.06
1993	2.12	0.00	0.30	0.18	2.61
1994	0.64	0.01	0.05	0.09	0.79
1995	2.48	0.01	0.00	0.01	2.50
1996	0.83	0.02	0.00	0.00	0.85
1997	0.81	0.04	0.00	0.00	0.85
1998	0.78	0.17	0.00	0.03	0.98

1999	0.34	0.07	0.00	0.01	0.42
2000	1.12	0.00	0.00	0.00	1.12
2001	1.43	0.11	0.00	0.00	1.54
2002	1.35	0.02	0.00	0.00	1.37
2003	3.66	0.00	0.00	0.00	3.67
2004	1.86	0.04	0.00	0.00	1.90
2005	3.33	0.26	0.00	0.00	3.59
2006	3.09	0.19	0.00	0.00	3.28
2007	0.18	0.52	0.00	0.00	0.70
2008	0.02	0.69	0.00	0.00	0.71
2009	0.01	0.74	0.00	0.00	0.76
2010	0.82	0.69	0.00	0.00	1.51
2011	4.06	0.39	0.00	0.00	4.45
2012	0.98	0.04	0.00	0.00	1.02
2013	0.75	0.00	0.00	0.00	0.77

7.4.2 Methodological issues

Carbon dioxide emissions

Carbon dioxide emissions from waste incineration were calculated using equation 5.1 provided in 2006 IPCC, Volume 5, p. 5.7):

$$CO_{emissions} = \sum_j (\mathrm{WF_j} \bullet \mathrm{dm_j} \bullet \mathrm{CF_i} \bullet \mathrm{FCF_j} \bullet \mathrm{OF_j}) \bullet 44/12$$

where:

CO_2 *Emissions* = CO_2 emissions in inventory year, kt/yr

WF_j = amount of incinerated waste type *j* (as wet weight)

dm_j = dry matter content in the waste type *j* (fraction)

CF_j = fraction of carbon in the dry matter (i.e., carbon content) of the waste type *j*

FCF_j = fraction of fossil carbon in the total carbon of the waste type *j*

OF_j = oxidation factor (fraction)

44/12 = conversion factor from C to CO_2

j = waste type: hazardous waste, clinical waste, sewage sludge or municipal waste

CO_2 emissions from hazardous waste and clinical waste incineration were calculated using fossil carbon content in wet waste provided in 2006 IPCC, Volume 2, Table 2.6, 25% for clinical waste and 27.5% (mean value of provided range) for hazardous waste.

The following set of parameters was used for calculation of CO_2 emissions from incineration of sewage sludge:

- Dry matter content 20%[188]
- Fraction of carbon in the dry matter 45% (2006 IPCC, Volume 5, Table 5.2)

[188] Wet - dry conversion of sludges. ARGUS for Eurostat - Environment Statistics. Meeting of the Working Group "Statistics of the Environment", Sub-Group "Waste". Eurostat, 2008.

- Fraction of fossil carbon in the total carbon 0% (2006 IPCC, Volume 5, Table 5.2)

Required parameters for calculation of CO_2 emissions from incineration of municipal waste were calculated using evaluated data on composition of MSW (see Table 7-19) and default values of dry matter content, total carbon content and fossil carbon fraction in separate waste components provided in 2006 IPCC, Volume 2, Table 2.4. Evaluated parameters are provided in Table 7-36.

Table 7-36. Evaluated dry matter content, total carbon content and fossil carbon fraction in MSW

Year	Dry matter content, %	total carbon content, % of dry weight	Fossil carbon fraction, % of total carbon
1990	34.3%	25.4%	0.94%
1991	34.3%	25.4%	0.94%
1992	34.3%	25.4%	0.94%
1993	34.3%	25.4%	0.94%
1994	34.3%	25.4%	0.94%
1995	34.3%	25.4%	0.94%
1996	34.3%	25.4%	0.94%
1997	34.3%	25.4%	0.94%
1998	34.3%	25.4%	0.94%
1999	34.3%	25.4%	0.94%
2000	34.3%	25.4%	0.94%
2001	34 3%	25.4%	0.94%
2002	34.3%	25.4%	0.94%
2003	34.3%	25.4%	0.94%
2004	33.8%	25.2%	0.97%
2005	33.2%	25.0%	1.00%
2006	32.7%	24.8%	1.03%
2007	32.2%	24.5%	1.06%
2008	31.6%	24.3%	1.09%
2009	31.1%	24.1%	1.12%
2010	30.6%	23.9%	1.15%
2011	30.0%	23.7%	1.18%
2012	29.5%	23.5%	1.21%
2013	24.4%	18.4%	1.09%

Combustion efficiency for all types of wastes is assumed to be 100% (2006 IPCC, Volume 5, Sec. 5.4.1.3).

Methane and nitrous oxide emissions

As quantities of incinerated waste are very low, it was decided to calculate methane and nitrous oxide emissions from the total amount of incinerated waste not dividing them into separate streams.

Methane and nitrous oxide emissions from waste incineration were calculate using equations provided in 2006 IPCC, VOLUME 5, Sec. 5.2.2 and 5.2.3:

$$CH_4 \; emission = (IW \cdot EFCH_4) \cdot 10^{-6}$$

$$CH_4 \; emission = (IW \cdot EFCH_4) \cdot 10^{-6}$$

Where:

CH_4 *emissions* = CH_4 emissions in inventory year, kt/yr

N_2O *emissions* = N_2O emissions in inventory year, kt/yr

IW = amount of incinerated waste, kt/yr

$EFCH_4$ = CH_4 emission factor (kg CH_4/kt of waste)

EFN_2O = N_2O emission factor (kg N_2O/kt of waste)

10^{-6} = conversion from kilogram to kilo tonnes

Bearing in mind irregular waste incineration activities and small quantities of incinerated waste CH_4 emission factor for stoker batch type incinerators provided in 2006 IPCC, Volume 5, Table 5.3 (60 kg/kt waste incinerated on a wet weight basis) was selected for emission calculations.

The main part of incinerated waste is comprised of hazardous industrial waste, therefore it was decided that default N_2O emission factor for all types of incinerated industrial wastes (100 g N_2O/t waste incinerated on a wet weight basis) should be applied.

7.4.3 Uncertainties and time-series consistency

Uncertainties

Activity data uncertainty for waste incineration was supposed to be higher than for solid waste disposal on land, and assumed to be 40%.

Assumed uncertainties for separate input parameters used for evaluation of CO_2 emissions and calculated overall uncertainties for separate waste streams are provided in table 7-37.

Table 7-37. Assumed uncertainties for separate input parameters used for evaluation of CO_2 emissions and calculated overall uncertainties for separate waste streams

	Hazardous waste	**Clinical waste**	**Sewaage sludge**	**MSW**
Dry matter content	NA	NA	30%	30%
fraction of carbon	NA	NA	40%	30%
Fraction of fossil carbon in the total carbon	40%	40%	30%	30%
Oxidation factor	2%	2%	2%	2%
Overall uncertainties	**56.6%**	**56.6%**	**70.7%**	**65.6%**

Evaluated uncertainty of the total CO_2 emission from waste incineration is 143%.

Uncertainty of emission factors for calculation of CH_4 and N_2O emissions was assumed to be 60%.

Combined uncertainties for CH_4 and N_2O emissions from waste incineration are 72%.

Time-series consistency

Emissions from waste incineration were calculated for the whole time series using the same method and data sets. As collection of data on waste management started only in 1991, it was assumed that the amounts of generated and treated waste in 1990 were the same as in 1991.

7.4.4 Category-specific QA/QC and verification

Data collection and calculations were performed in accordance with the requirements outlined in Section 6 of the Quality Assurance and Quality Control Plan[189].

Tier 1 General Inventory Level QC was performed based on recommendations provided in IPCC 2006 vol. 1 Chapter 6 and outlined in the QA/QC plan:

Consistency of data between NIR and CRF has been checked.

Documentation on activity data and emission factors was crosschecked with the corresponding data in calculation model.

In case of large fluctuations in data, other experts or data providers were consulted to either provide the explanation or to identify a possible inconsistency or an error.

Explanations for recalculations were checked to ensure that they are clearly documented.

After the calculation is finished, EPA waste experts not directly involved in the emissions calculation of that year have reviewed the final report and CRF data checking the applied parameters, calculation methodology, as well as trend description in the NIR.

7.4.5 Category-specific planned improvements

No improvements are planned for the next submission.

7.5 Wastewater Handling (CRF 5.D)

Wastewater is a source of methane (CH_4) when treated or disposed anaerobically. It is also a source of nitrous oxide (N_2O) emissions. Carbon dioxide (CO_2) emissions from wastewater are not considered because these are of biogenic origin.

Evaluated CH_4 and N_2O emissions from wastewater are shown in Tables 7-38 and 7-39.

Table 7-38. Evaluated CH_4 emissions from wastewater (kt)

Year	Total	Aerobic well managed	Aerobic not well managed	Anaerobic shallow lagoon	Untreated	Septic tanks	Latrine
1990	21.67	0.00	2.69	1.60	1.19	9.11	7.09
1991	21.70	0.00	2.69	1.60	1.19	9.13	7.10
1992	19.82	0.00	2.60	0.17	0.84	9.12	7.09
1993	19.86	0.00	2.37	0.28	1.09	9.07	7.06
1994	17.77	0.00	0.85	0.15	0.75	9.01	7.01
1995	18.66	0.00	2.07	0.12	0.58	8.94	6.95
1996	18.40	0.00	2.15	0.13	0.36	8.87	6.90
1997	18.21	0.00	1.32	0.53	0.69	8.81	6.85
1998	17.50	0.00	1.48	0.14	0.34	8.74	6.80
1999	16.15	0.00	0.44	0.17	0.25	8.60	6.69
2000	15.94	0.00	1.01	0.11	0.08	8.29	6.45
2001	15.90	0.00	1.49	0.07	0.12	8.00	6.22
2002	14.90	0.00	0.96	0.09	0.02	7.78	6.05
2003	13.75	0.00	0.72	0.08	0.02	7.27	5.66

[189] National Greenhouse Gas Emission Inventory of the Republic of Lithuania. Quality Assurance and Quality control Plan 2011-2012. Vilnius, 2011.

2004	13.50	0.00	0.94	0.26	0.01	6.92	5.38
2005	12.58	0.00	0.87	0.03	0.03	6.56	5.10
2006	11.75	0.00	0.94	0.29	0.01	5.91	4.59
2007	11.45	0.00	1.09	0.04	0.05	5.78	4.50
2008	11.91	0.00	0.77	0.03	0.04	6.23	4.84
2009	10.52	0.00	0.08	0.01	0.04	5.85	4.55
2010	9.78	0.00	0.06	0.14	0.03	5.37	4.18
2011	9.55	0.00	0.07	0.01	0.03	5.31	4.13
2012	9.54	0.00	0.05	0.01	0.02	5.32	4.14
2013	8.81	0.00	0.05	0.01	0.02	4.91	3.82

Table 7-39. Evaluated N_2O emissions from wastewater

Year	Protein consumption/ kg/person/year	N_2O emissions, kt
1990	27.7	0.226
1991	27.8	0.226
1992	27.9	0.227
1993	27.9	0.226
1994	28.0	0.225
1995	28.1	0.224
1996	28.1	0.223
1997	28.2	0.222
1998	28.3	0.221
1999	28.3	0.220
2000	28.4	0.219
2001	28.4	0.217
2002	28.5	0.216
2003	28.8	0.216
2004	29.1	0.216
2005	29.3	0.214
2006	29.6	0.213
2007	29.9	0.213
2008	28.8	0.203
2009	27.8	0.193
2010	26.7	0.182
2011	25.7	0.171
2012	24.6	0.162
2013	23.5	0.153

7.5.1 Category description

Methane is generated from wastewater in anaerobic conditions while nitrous oxide can be produced as nitrification and denitrification product in both aerobic and anaerobic conditions. This section covers CH_4 emissions from wastewater transportation and treatment as well as from septic tanks used by population not connected to centralised sewerage networks. CH_4 emissions from sewage sludge formed during wastewater treatment are covered by solid waste disposal on land section.

In most cases in Lithuania industrial wastewater is discharged to centralised municipal sewage collection networks and treated together with the domestic wastewater in centralised municipal treatment plants.

According to the information provided by the Lithuanian Water Suppliers Association[190] fraction of industrial wastewater exceeds 50% in six of 38 agglomerations with population equivalent more than 10 thousand. In one of them (Pasvalys) fraction of industrial wastewater comprises 87.5% of the total wastewater discharge. On average, industrial wastewater comprises about 20% of the total load of municipal wastewater treatment systems in Lithuania.

In addition, separate evaluation of CH_4 emissions from domestic and industrial wastewater is problematic because organic load in both domestic and industrial wastewater is measured predominantly as BOD.

There are close to 1800 wastewater discharge points in Lithuania registered by the Lithuanian EPA. Among them, some discharges from industries are also registered but representing only minor fraction of industrial discharges mainly from industries located in remote areas not covered by municipal sewerage collection systems. The major part of industrial wastewater is discharged into municipal sewerage networks and cannot be separated from municipal wastewater.

It is possible to identify 3 or 4 major industrial sectors with the largest potential for CH_4 emissions but COD data cannot be collected as industrial wastewater is discharged mainly together with municipal wastewater and, in addition, in most cases only BOD data are available. Default values or expert judgement for estimating COD values can be applied for these major industries but calculation of emissions based on these values will cause double counting as discharges of these industries have already been accounted for in emissions from municipal wastewater.

Expert judgements as well as default values are associated with substantial errors and uncertainties. We have country specific instrumental measurements of wastewater discharges and organic matter (BOD) content, and we are convinced that country specific instrumental measurements provide much more reliable and precise results than default data based on conditions in other, most frequently remote countries, or expert judgements.

Information of wastewater treatment and discharge in Lithuania is collected by the Lithuanian Environmental Protection Agency (EPA). Data collection is regulated by Order No. 408 of the Minister of Environment of the Republic of Lithuania of calculation of pollutant emissions to environment of 20th December 1999 as amended on 20th September 2001 and 3 January 2013. Pursuant to this legal act water users and/or wastewater dischargers must submit annual reports to institutions subordinated to Ministry of Environment - Regional Environmental Protection Departments (REPDs). REPDS perform primary data check of regional level and checked data are forwarded to the EPA. The EPA performs the final validation, processing and aggregation at national level.

Collected data include both BOD and COD, however, as seen from Table 7-40 both parameters are provided for the same samples without specification of municipal or industrial wastewater sources. Therefore, there is no possibility to separate industrial and municipal wastewater streams.

Table 7-40. Number of discharge points for which data on BOD and COD are provided in the statistics

Year	Number of discharge points included in the statistics		
	BOD	COD	Both BOD and COD
1991	657	46	45

[190] Lithuanian Water Suppliers Association. Certificate on municipal wastewater treatment plant capacity assessment, 2011.03.04.

1992	674	42	40
1993	612	37	34
1994	614	29	28
1995	641	35	33
1996	694	39	36
1997	697	42	41
1998	721	53	51
1999	745	52	50
2000	766	62	60
2001	724	59	56
2002	766	95	83
2003	781	162	158
2004	781	325	323
2005	808	452	447
2006	769	436	436

Statistics on treatment and discharge of organic pollutants collected by the EPA are available from 1991. It was assumed that wastewater generation, treatment and discharge in 1990 was the same as in 1991.

Reported BOD load to the Raseiniai mechanical treatment plant in 1992 was 27205 tonnes BOD. Bearing in mind that the plant provides service for approximately 12 thousands population, this amount corresponds to BOD generation of 2267 kg per capita per year, which is roughly 100 times higher than expected.

Raseiniai district is a rural municipality with almost two thirds of population residing in rural areas (61.9% in 1994 and 63.3% in 1995)[191]. Output of Raseiniai district industries in 1993 reached merely to 0.64% of the total Lithuanian output[192] while the number of population amounted to 1.3%. The single industrial facility generating substantial water pollution in Raseiniai is fish processing company UAB Norvelita but it was established only in 1995[193] and could not cause so significant BOD discharge in 1992.

Bearing that in mind, it was concluded that so large BOD discharge is an obvious outlier and corresponding figure was divided by 100.

Discharged wastewater is treated in various types of treatment plants all of which are basically aerobic though development of anaerobic conditions enabling methane formation is possible. All wastewater treatment facilities depending on potential for development of anaerobic conditions were divided in 4 categories (including wastewater discharge without treatment:

Aerobic treatment, well managed:

313 Biological treatment with N and P removal
311 Pneumatic aeration tanks
300 Biological treatment
304 Pneumatic aeration channels
305 Mechanical aeration channels
312 Mechanical aeration tanks
302 Biofilters
307 Other biological treatment facilities

[191] http://osp.stat.gov.lt/services-portlet/pub-edition-file?id=1883
[192] http://osp.stat.gov.lt/services-portlet/pub-edition-file?id=1869
[193] http://www.norvelita.lt/en/About_us

Aerobic treatment, not well managed:

100 Mechanical treatment
200 Physical-chemical treatment
201 Primary physico-chemical treatment
303 Natural treatment methods
900 Other facilities

Anaerobic shallow lagoon:

306 Biological ponds
400 Infiltration fields
500 Infiltration fields without discharge
600 Agricultural irrigation fields

Untreated wastewater:

0 Discharge without treatment

Estimated discharge of wastewater to the treatment facilities of various types is provided in Table 7-41.

Table 7-41. Estimated discharge of wastewater to the treatment facilities of various types

Year	Aerobic well managed		Aerobic not well managed		Anaerobic shallow lagoon		Untreated	
	BOD, kt	% of total	BOD, kt	% of total	BOD, kt	% of total	BOD, kt	% of total
1990	41.33	43.1	21.34	22.3	13.36	14.0	19.76	20.6
1991	41.33	43.1	21.34	22.3	13.36	14.0	19.76	20.6
1992	80.89	69.1	20.65	17.7	1.41	1.2	14.05	12.0
1993	31.02	44.2	18.78	26.7	2.33	3.3	18.09	25.8
1994	40.55	66.4	6.76	11.1	1.21	2.0	12.54	20.5
1995	31.48	53.8	16.47	28.1	0.99	1.7	9.59	16.4
1996	40.05	62.5	17.03	26.6	1.04	1.6	5.96	9.3
1997	46.79	63.8	10.48	14.3	4.45	6.1	11.58	15.8
1998	60.20	76.5	11.75	14.9	1.14	1.4	5.63	7.2
1999	63.46	87.4	3.46	4.8	1.45	2.0	4.24	5.8
2000	50.56	83.1	8.01	13.2	0.93	1.5	1.33	2.2
2001	56.21	79.5	11.80	16.7	0.58	0.8	2.08	2.9
2002	48.33	84.8	7.58	13.3	0.73	1.3	0.36	0.6
2003	62.18	90.2	5.71	8.3	0.70	1.0	0.38	0.5
2004	60.70	86.2	7.43	10.5	2.15	3.0	0.18	0.3
2005	58.16	88.5	6.91	10.5	0.21	0.3	0.45	0.7
2006	64.05	86.3	7.49	10.1	2.43	3.3	0.25	0.3
2007	66.73	87.3	8.65	11.3	0.30	0.4	0.79	1.0
2008	68.21	90.7	6.10	8.1	0.24	0.3	0.65	0.9
2009	69.21	98.1	0.65	0.9	0.10	0.1	0.59	0.8
2010	68.87	97.0	0.47	0.7	1.15	1.6	0.53	0.8
2011	71.96	98.4	0.54	0.7	0.12	0.2	0.53	0.7
2012	75.01	99.0	0.44	0.6	0.05	0.1	0.31	0.4
2013	75.01	99.0	0.44	0.6	0.05	0.1	0.31	0.4

Substantial part of Lithuanian population is still not connected to centralised sewer networks as shown in Table 7-42.

Table 7-42. Fraction of population having no connection to sewerage networks

Year	Fraction, %
1999	49.5
2000	48.1

2001	46.8
2002	45.9
2003	43.2
2004	41.6
2005	40.1
2006	36.7
2007	36.3
2008	39.5
2009	37.5
2010	35.2
2011	35.6
2012	36.1
2013	33.7

Source: Lithuanian Water Suppliers Association

Data on population connected to the sewerage network were provided by the Lithuanian Water Suppliers Association. The number of population connected to the sewerage network depends on variation of population residing in the area covered by wastewater collection services (Figure 7-9). Hence, fluctuation of percentage of population not connected to sewerage network is caused by migration of population to and from the area covered by wastewater collection services.

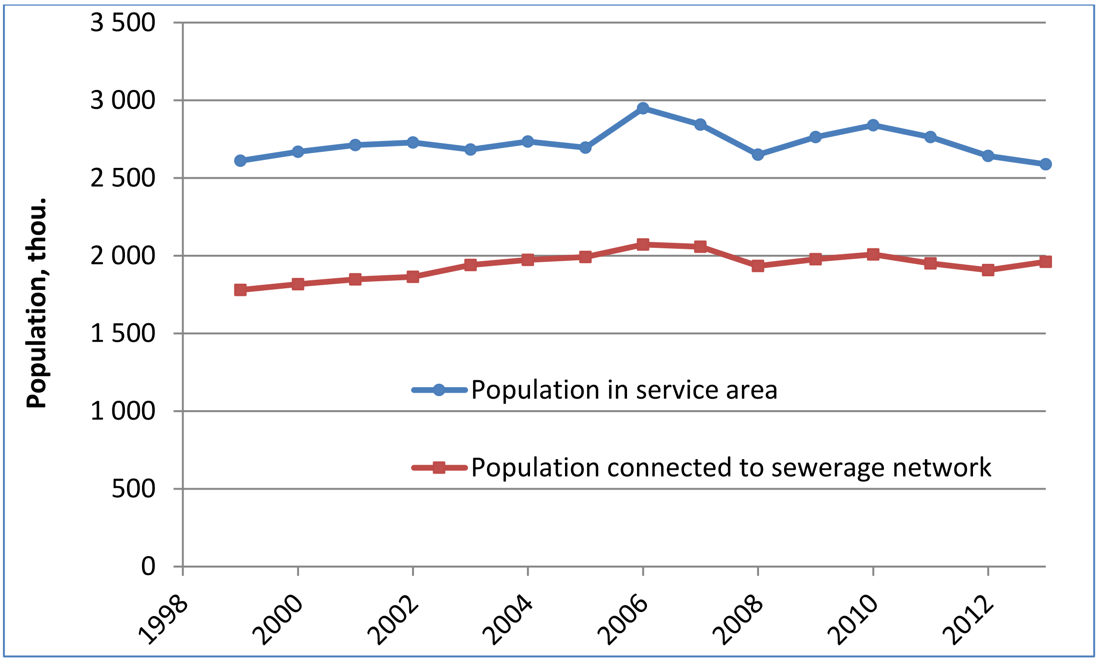

Figure 7-9. Variations of population residing in area covered by wastewater collection services and connected to sewerage network

7.5.2 Methodological issues

Methane emissions

The total amount of organically degradable material in the wastewater (TOW) is available from the EPA database.

Generation of organically degradable material by the population having no connection to sewerage networks was calculated using equation 6.3 provided in 2006 IPCC (Volume 5, section 6.2.2.3):

$$TOW = P \times k \times BOD \times 0.001 \times I \times 365$$

Where:

TOW = total organics in wastewater in inventory year, kg BOD/yr,

P = country population in inventory year, (person),

k = fraction of population having no connection to sewerage networks,

BOD = per capita BOD in inventory year (60 g/person/day, 2006 IPCC, Volume. 5, Table 6.4),

0.001 = conversion from grams BOD to kg BOD,

I = correction factor for additional industrial BOD discharged into sewers (assumed =1).

Degree of utilisation of treatment or discharge pathway among the Lithuanian population having no connection to sewers is similar to Russian rural population as provided in Table 6.5 of the 2006 IPCC (Volume 5, section 6.2.2.3) (60% connected to sewers, 30% using septic tanks, and 10% using latrines). Based on these data, recalculated for population having no connection to sewerage networks, it was assumed that septic tanks are used by 75% of population not connected to sewers and about 25% use latrines.

Methane emissions were evaluated using modified 2006 IPCC equation 6.1 (Volume 5, section 6.2.2.1):

$$CH_4 Emissions = \sum_i (EF_i \times (1-k) \times TOW_i),$$

Where:

TOW_i = total organics in specific wastewater stream *i* (aerobic well managed, aerobic not well managed, anaerobic shallow lagoon, untreated, septic tanks, and latrines) in inventory year, kg BOD/yr,

k = fraction of organic component removed as sludge in inventory year, kg BOD/yr, assumed = 0.3[194]

EF_i = emission factor, kg CH_4 / kg BOD.

The emission factor for each wastewater treatment and discharge pathway was calculated using equation 6.2 (2006 IPCC, Volume 5, section 6.2.2.1):

$$EF_i = B_o \times MCF_i$$

Where:

B_o = maximum CH_4 producing capacity, kg CH_4/kg BOD,

MCF_i = methane correction factor (fraction), 2006 IPCC, Volume 5, Table 6.3.

Default value of B_o, 0.6 kg CH_4/kg BOD was used (2006 IPCC, Volume 5, Table 6.2).

[194] Expert judgment by the Chief Manager of the Vilnius Wastewater Treatment Plant Mr. V. Puodžiūnas.

Default MCF values provided in 2006 IPCC, Volume 5, Table 6.3 was used (Table 7-43).

Table 7-43. MCF values used for calculation of methane emissions

Untreated wastewater discharged to rivers and lakes	0.1
Aerobic treatment, well managed	0.0
Aerobic treatment, not well managed	0.3
Anaerobic shallow lagoons	0.2
Septic systems	0.5
Latrine, wet climate	0.7

Methane recovery from sewage sludge

Anaerobic digestion installations with CH_4 recovery are operated by several water supply companies. Statistical data on biogas recovery from sewage sludge are reported by the Statistics Lithuania in TJ. The data were converted to kt using methane Lower Heating Value (LHV) = 50 TJ/kt.

Data on recovered biogas volume provided by the Statistics Lithuania correspond well with the data provided by water supply companies starting from 2004, showing relation between mass and volume 0.4 kt per million m^3. Data on methane recovery are provided in Table 7-44.

Table 7-44. CH_4 recovery, kt

Year	kt
1999	0.22
2000	0.84
2001	0.85
2002	1.24
2003	1.38
2004	0.86
2005	1.14
2006	1.24
2007	1.38
2008	1.40
2009	1.78
2010	2.50
2011	2.58
2012	2.60
2013	3.00

Recovered biogas is used for energy production and is reported in the 1A sector as biogas including biogas generated from landfills, sewage sludge and manure.

Nitrous oxide emissions

The activity data that are needed for estimating N_2O emissions are nitrogen content in the wastewater effluent, country population and average annual per capita protein generation (kg/person/yr). The total nitrogen in the effluent is estimated as follows (20065 IPCC, Volume 5, section 6.3.1.3, Equation 6.8):

$$N_{EFFLUENT} = P \times Protein \times F_{NPR} \times F_{NON-CON} \times F_{IND-COM} - N_{SLUDGE}$$

Where:

$N_{EFFLUENT}$ = total annual amount of nitrogen in the wastewater effluent, kg N/yr

P = human population

Protein = annual per capita protein consumption, kg/person/yr

F_{NPR} = fraction of nitrogen in protein, default = 0.16, kg N/kg protein

$F_{NON\text{-}CON}$ = factor for non-consumed protein added to the wastewater

$F_{IND\text{-}COM}$ = factor for industrial and commercial co-discharged protein into the sewer system

N_{SLUDGE} = nitrogen removed with sludge (default = zero), kg N/yr

Protein consumption per capita was evaluated by the Health education and disease prevention Centre[195] (77.4 g/capita/day in 1998, 78.1 g/capita/day in 2002, and 81.9 g/capita/day in 2007, 64.5 g/capita/day in 2013). Approximation of these data by least square method was used for evaluation of consumption during 1990 to 2013:

$$Protein, g/capital/day = 0.5116 \times year - 945.3$$

Default value 1.4 for non-consumed protein was used as defined 2006 IPCC, Volume 5, section 6.3.1.3 for developed countries using garbage disposals.

Default $F_{IND\text{-}COM}$ value 1.25 was used (2006 IPCC, Volume 5, section 6.3.1.3).

N_2O emissions from wastewater effluent were calculated using equation 6.7 provided in 2006 IPCC, Volume 5, Section 6.3.1.1:

$$N_2O\ emissions = N_{EFFLUENT} \times EF_{EFFLUENT} \times 44/28$$

Where:

N_2O *emissions* = N_2O emissions in inventory year, kg N_2O/yr

$N_{EFFLUENT}$ = nitrogen in the effluent discharged to aquatic environments, kg N/yr

$EF_{EFFLUENT}$ = emission factor for N_2O emissions from discharged to wastewater, kg N_2O-N/kg N

The factor 44/28 is the conversion of kg N_2O-N into kg N_2O.

The default 2006 IPCC emission factor for N_2O emissions from domestic wastewater nitrogen effluent is 0.005 g N_2O-N/kg N (2006 IPCC, Volume 5, section 6.3.1.2).

7.5.3 Uncertainties and time-series consistency

Uncertainty

Methane emissions

The following uncertainties were assumed for activity data:

- Total organics in wastewater (TOW) 30%

[195] A. Barzda. Study and evaluation of actual nutrition and nutrition habits of Lithuanian adult population. Doctoral dissertation (Suaugusių Lietuvos gyventojų faktiškos mitybos ir mitybos įpročių tyrimas ir vertinimas. Daktaro disertacijos santrauka.) Vilnius, 2011.

- population having no connection to sewerage networks 5%
- fraction of organic component removed as sludge 40%
- per capita BOD 30%

Default uncertainty ranges provided in 2006 IPCC, Volume 5, p. 6.17, Table 6.7 were used for parameters determining emission factors:

- maximum CH_4 producing capacity (B_o) 30%
- MCF
  - Aerobic treatment, well managed 10%
  - Aerobic treatment, not well managed 30%
  - Aerobic treatment, shallow lagoon 50%
  - Untreated 30%

Evaluated uncertainties of GHG emissions in separate wastewater streams are the following:

- Aerobic treatment, well managed 66.3%
- Aerobic treatment, not well managed 72.1%
- Aerobic treatment, shallow lagoon 82.5%
- Untreated 72.1%
- Septic tanks and latrines 52.2

Evaluated overall uncertainty is 46.5%.

Nitrous oxide emissions

It was assumed that uncertainty of activity data is 30% and uncertainty of emission factors is 50%. Combined uncertainty for N_2O emissions from human sewage calculated using equation 3.1 from 2006 IPCC, Volume. 1, Chapter 3) is 58%.

Time-series consistency

Emissions from wastewater handling were calculated for the whole time series using the same method and data sets.

7.5.4 Category-specific QA/QC and verification

Data collection and calculations were performed in accordance with the requirements outlined in Section 6 of the Quality Assurance and Quality Control Plan[196].

Tier 1 General Inventory Level QC was performed based on recommendations provided in IPCC 2006 vol. 1 Chapter 6 and outlined in the QA/QC plan:

Consistency of data between NIR and CRF has been checked.

Documentation on activity data and emission factors was crosschecked with the corresponding data in calculation model.

In case of large fluctuations in data, other experts or data providers were consulted to either provide the explanation or to identify a possible inconsistency or an error.

[196] National Greenhouse Gas Emission Inventory of the Republic of Lithuania. Quality Assurance and Quality control Plan 2011-2012. Vilnius, 2011.

Explanations for recalculations were checked to ensure that they are clearly documented.

After the calculation is finished, EPA waste experts not directly involved in the emissions calculation of that year have reviewed the final report and CRF data checking the applied parameters, calculation methodology, as well as trend description in the NIR.

7.5.5 Category-specific planned Improvements

No improvements are planned in this section.

8 OTHER (CRF 6)

Not applicable.

9 INDIRECT CO_2 AND NITROUS OXIDE EMISSIONS

9.1 Description of sources of indirect emissions in GHG inventory

Nitrogen oxides (NO_x = NO + NO_2), non-methane volatile organic compounds (NMVOC) and carbon monoxide (CO) are not greenhouse gases, but they have an indirect effect on the climate through the formation of ozone and their effects on the lifetime of the methane emission in the atmosphere. CO via its effects on hydroxyl radical (•OH), can help to promote abundance of methane in the atmosphere as well as increase ozone formation. NOx influence climate by their impact on other greenhouse gases. NMVOCs have some short lived direct radiative forcing properties, primarily influence climate via promotion of ozone formation and production of organic aerosols. Sulphur dioxide (SO_2) also has an indirect impact on climate, as it increases the level of aerosols with a subsequent cooling effect. Therefore, emissions of these gases are to some extent included in the inventory.

Lithuania joined the UNECE 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.

The Informative Inventory Report (IIR) covering the inventory of air pollutant emissions from Lithuania are the source of data in this report (Figure 2-12). The report contains information on Lithuanian's inventories for 1990-2013 years. Air emission inventory is based mainly on statistics published by Statistics Lithuania (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.

A large decrease in all indirect GHG emissions was caused by the structural changes in the economy after 1990 when political independence of Lithuania was restored (Figure 9-1). This led to lower emissions in energy and industrial production and to an overall decrease in the emissions from industrial processes between 1990 and 1995. In 1996 the economy began to recover and production increased. In 1994, the GDP dropped to 54% of the 1989 level but later started to increase again.

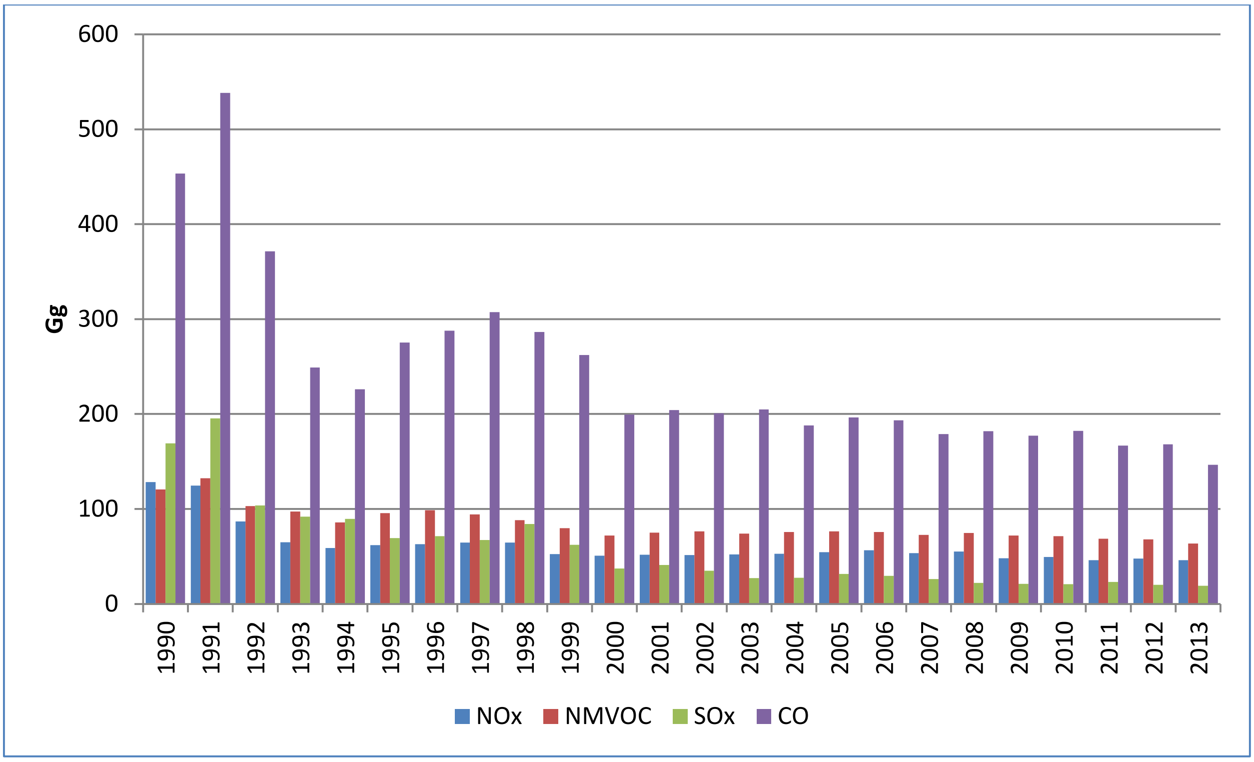

Figure 9-1. Development of non GHG gas and SO_2 emissions, 1990-2013 (source: LRTAP submission 2015[197])

A rapid decrease of indirect emissions followed the decline of the country economy in the 1990s. Since 2000, the GDP has been growing continuously. Tables 9-1 and 9-2 present results from the Level Assessment of the key source for 2005 and 2013. The sources that add up to at least 80% of the national total in 2013 are defined as being a key source for each pollutant.

[197] Emissions can be recalculated before 15 February 2015 regarding final LRTAP submission

Table 9-1. Key source analysis for the main pollutants in 2005

Component	**Key categories (Sorted from high to low and from left to right)**								**Total (%)**
SO_x	1 A 1 a Public electricity and heat production	1 A 1 b Refining / storage	1 B 2a iv Fugitive emissions oil: Refining / storage	1 A 4a i Commercial/institutional: Stationary					**80.6**
	31.8%	25.8%	14.4%	8.6%					
NO_x	1 A3b iii Road transport: Heavy duty vehicles	1 A 3 b i Road transport: Passenger cars	1 A 1 a Public electricity and heat production	1 A 3 c Railways	1 A 1 b Refining / storage	1 A 4 b i Residential: Stationary plants	1 A 2 f Stationary combustion in manufacturing industries and construction: Non-metallic minerals		**82.4**
	29.8%	21.8%	10.1%	7.6%	5.6%	3.8%	3.7%		
NMVOC	2 D 3d Coating applications	1 A 4 b i Residential: Stationary plants	1 B 2a iv Fugitive emissions oil: Refining / storage	2 D 3a Domestic solvent use including fungicides	1 A 3 b i Road transport: Passenger cars	2 H 2 Food and beverages industry	1 A 3b v Road transport: Gasoline evaporation	2 D 3e Degreasing	**82.2**
	19.6%	15.9%	12.8%	11.4%	10.1 %	6.1 %	3.2%	3.0%	
CO	1 A 4 b i Residential: Stationary plants	1 A 3 b i Road transport: Passenger cars							**85.1**
	50.6%	34.5%							

Table 9-2. Key source analysis for the main pollutants in 2013

Component	Key categories (Sorted from high to low and from left to right)							Total (%)
SO_x	1 B 2a iv Fugitive emissions oil: Refining / storage	1 A 4 b i Residential: Stationary plants	1 A 1 a Public electricity and heat production	1 A 4a i Commercial/institutional: Stationary	2 B10 a Chemical industry: Other			**86.1**
	31.3%	16.8%	16.5%	11.7%	9.7%			
NO_x	1 A3b iii Road transport: Heavy duty vehicles	1 A 3 b i Road transport: Passenger cars	1 A 1 a Public electricity and heat production	1 A 3 c Railways	1 A 4 b i Residential: Stationary plants	1 A 2 f Stationary combustion in manufacturing industries and construction: Non-metallic minerals	1 A 3a ii Domestic aviation	**82.8**
	46.0%	10.3%	7.7%	6.5%	4.5%	4.5%	3.3%	
NMVOC	2 D 3d Coating applications	1 A 4 b i Residential: Stationary plants	1 B 2a iv Fugitive emissions oil: Refining / storage	2 D 3a Domestic solvent use including fungicides	2 H 2 Food and beverages industry	1 A 1 a Public electricity and heat production	2 D 3e Degreasing	**81.7**
	21.0%	19.7%	12.5%	12.3%	7.6 %	5.3 %	3.3%	
CO	1 A 4 b i Residential: Stationary plants	1 A 3 b i Road transport: Passenger cars	1 A 1 a Public electricity and heat production (4.8%)					**84.4**
	69.7%	9.9%						

During the period 2005-2013, the emissions of sulphur dioxide has decreased by about 40%, from 31.39 kt in 2005 to 18.93 kt in 2013, conditioned by decline in energy production mainly due to substantial reduction of liquid fuel consumption. Oil products are very important fuels in Lithuania. However, their share in the primary energy balance has decreased steadily — from 42.4% in 1994 to 30.5% in 2001. This is related mostly to a reduction in the consumption of heavy fuel oil for producing electricity and district heat. The share of natural gas, the most attractive fuel over the long term, has increased. The role of coal has decreased throughout the period — from 3.7% in 1990 to 0.9% in 2001. In 2013, the most significant sectoral source of SO_x emissions was Fugitive emissions oil: Refining/storage (1.B.2a iv) (31.3 %), followed by emissions occurring from Residential: Stationary plants (1.A.4.b i) (16.8 %) sector (Table 9-1) and Electricity and heat production (1.A.1.a) (16.5 %). A combination of measures has led to the reductions in SO_x emissions in 1990-2013 almost in all sectors (Figure 2-13.). This includes fuel-switching from high-sulphur solid (e.g. coal) and liquid (e.g. heavy fuel oil) fuels to low sulphur fuels (such as natural gas) for power and heat production purposes within the energy, industry and domestic sectors, improvements in energy efficiency, and the installation of flue gas desulphurisation equipment in new and existing industrial facilities. The implementation of several directives within the EU limiting the sulphur content of fuel quality has also contributed to the decrease (UNECE, 2011).

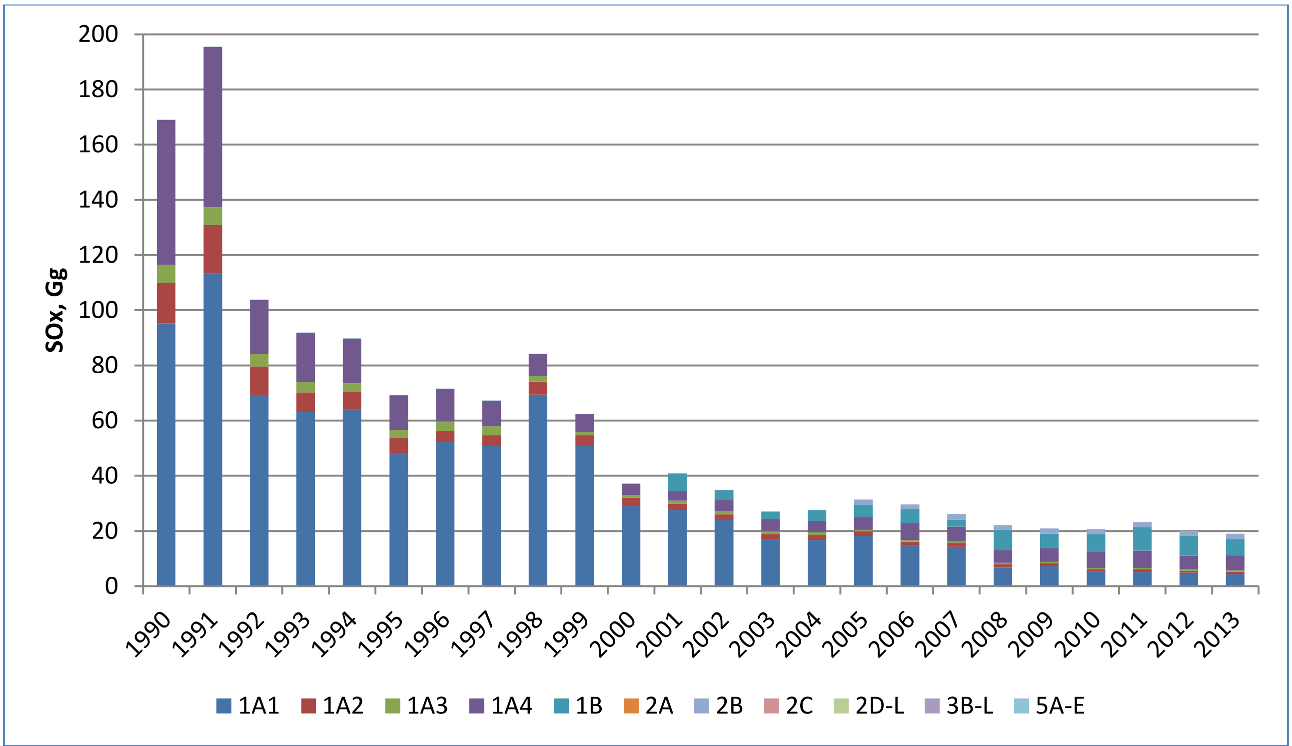

Figure 9-2. Emission trend for SO_x by sectors, 1990-2013

Total nitrogen oxides emissions have decreased by 64%, from 128.4 kt in 1990 to 46.2 kt in 2013 (Figure 2-14). The Road transport (1A3bi-iii) and Energy industry (1A1) sectors are main sources of nitrogen oxides emissions ~61.7% in 2005 and ~64% in 2013. The largest reduction of emissions in absolute terms since 1990 has occurred in the Electricity and heat production and Road transport sectors (Figure 2-14). The reduction was observed mainly due to decrease of energy production and fuel consumption in transport sector during the period of 1990-1994 (the consumption of gasoline by road transport reduced by 56% and diesel by 57%). Due to less effective implementation of the Euro Standarts Lithuania report an increase in NO_x emissions till 2008 (Figure 9-3).

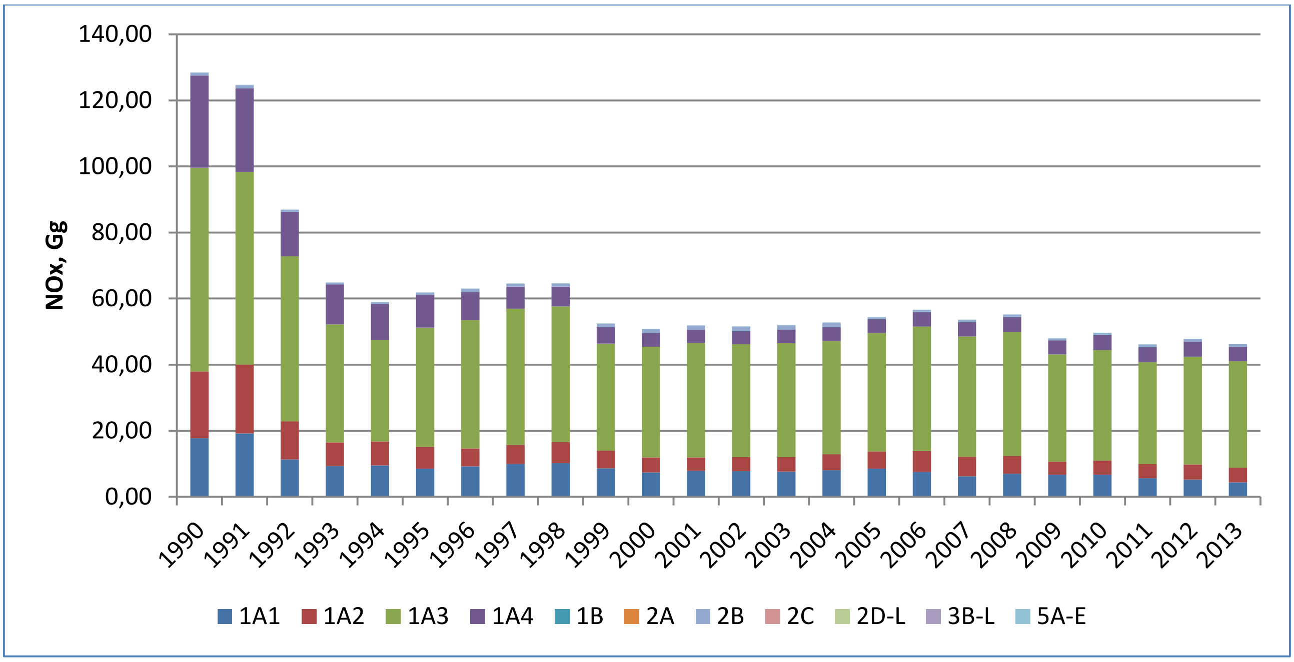

Figure 9-3. Emission trend for NOx by sectors, 1990-2013

The reductions from 2008 have been achieved despite the general increase in activity within this sector and have primarily been achieved as a result of fitting three-way catalysts to petrol fueled vehicles (the effect of catalytic degradation in newer cars was taken into account). In the electricity/energy production sector reductions have also occurred, in these instances as a result of measures such as the introduction of combustion modification technologies.

The NMVOC emissions are determined mainly by Solvent and Other Product Use (2.D-H), Road Transport (1.A.3.b) and Residential (1.A.4) sectors. The coating application (2.D.3.d) produced 19.6% and 21% of the 2005 and 2013 total of NMVOC emissions in Lithuania decreased from 33.9 in 2005 to 30.8 kt in 2013. NMVOC emissions have decreased by 17% between 2005 (76.3 kt) and 2013 (63.4 kt) (Figure 9-4).

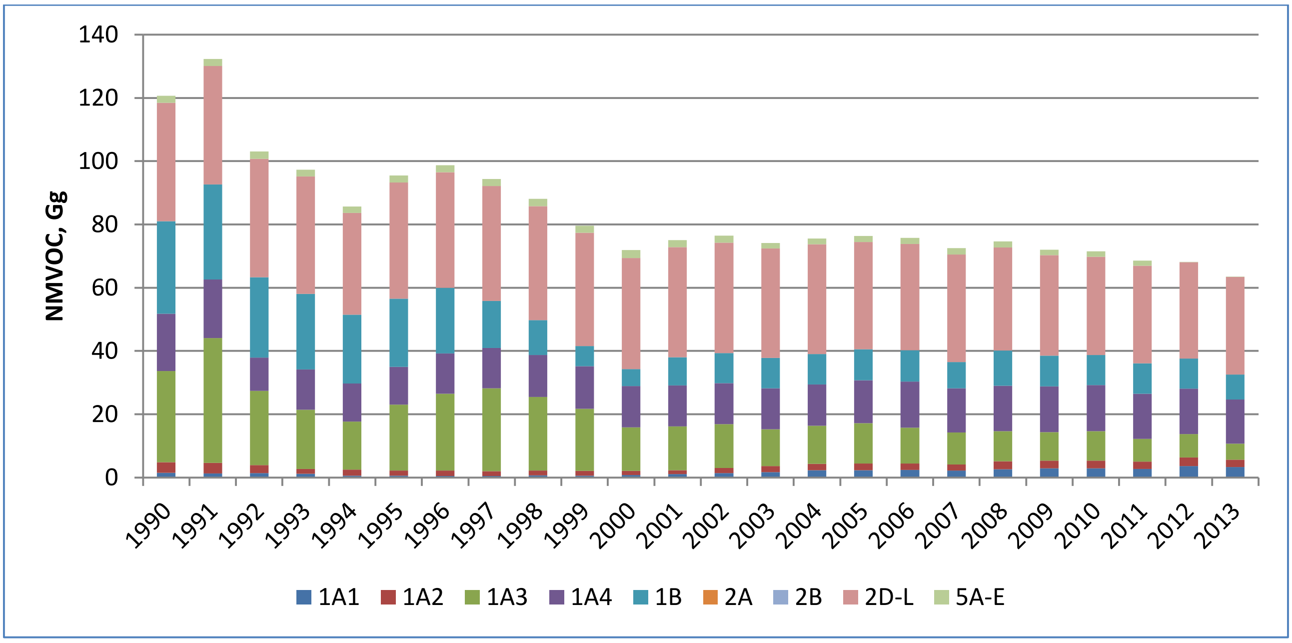

Figure 9-4. Emission trend for NMVOC by sectors, 1990-2013

Technological controls for volatile organic compounds (NMVOCs) in motor vehicles have been more successful than in the case of NO_x, and have contributed to a significant reduction in emissions from Road Transport (1.A.3.b), with the total transport sector's contribution having decreased by 61% between 2005 (12.8 kt) and 2013 (5.0 kt). Combustion sources in the Residential (1.A.4.b) and Fugitive emissions oil: Refining / storage (1.B.2.a iv) combined sectors are another important source, accounting for 32.2% of national total NMVOC emissions in 2013. The decline in emissions since 1990 has primarily been due to reductions achieved in the road transport sector due to the introduction of vehicle three-way catalytic converters (oxidation-reduction) and carbon canisters on petrol cars, for evaporative emission control driven by tighter vehicle emission standards, combined with limits on the maximum volatility of petrol that can be sold in EU Member States, as specified in fuel quality directives. The second reason of this change was decrease in use of motor fuel in transport sector and increase in a share of used diesel fuel compared to gasoline.

The CO emission trend shows decrease of emissions for period 2005-2013. The total CO emission decreased from 196.5 kt in 2005 to 146.4 kt in 2013 (Figure 2-16).

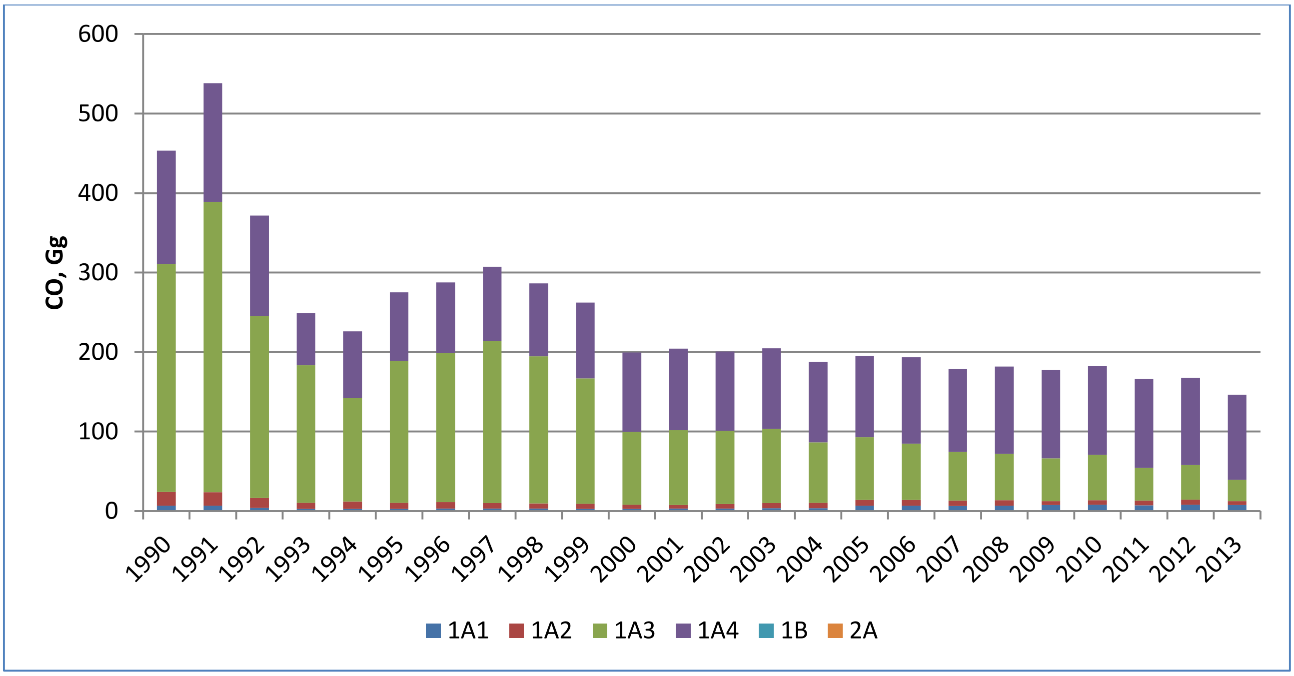

Figure 9-5. Emission trend for CO by sectors, 1990-2013

Carbon monoxide emissions, total 146.4 kt (2013), originates generally from the 1.A.4.b i Residential: Stationary plants sector. This sector generated the biggest part of the total CO emissions – 69.7% (2013). Road transport: Passenger cars (1.A.3.b i) sector contributing by only 9.9% of national total CO emissions in 2013. Carbon monoxide emissions continue to decline, driven by major reductions due to catalysts in gasoline vehicles in Road Transport (1.A.3.b), which is the principal source of CO (Figure 2-16).

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9.1.1 Methodological issues

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 point sources information system contains data that is reported by the facilities that have a pollution permit. Each facility submits data on the emissions of polluting substances together with data regarding fuel burnt, used solvents, liquid fuel distribution, etc. Data and process SNAP code are presented on each source of pollution and on the facility. The owners of point sources directly fill their calculated or measured annual emissions into the report. With regard to the calculation of emissions from road transport, the COPERT IV v.11 model methodology and emission factors were used (Tier 3). Emission factors for livestock and poultry manure management were taken from EMEP/EEA air pollutant emission inventory guidebook 2013. Number of livestock and poultry was taken from Department of Statistics and State enterprise Agricultural Information and Rural Business Centre. Waste sector activity was taken from EPA. Emission factors for waste sector were taken from EMEP/EEA air pollutant emission inventory guidebook 2013.

The main source of data for all energy industries in the Lithuania for the period 1990-2013 is Statistics Lithuania. Tier 1 methods was used in 1A1a, 1A1b, 1A1c, 1A2f, 1A4a, 1A4b, 1A4c, 1B2a for all compounds and Tier 2 in 1A1b for main pollutants (SO_x, NO_x, NMVOC, CO). The Tier 2 approach was applied with the activity data and the country-specific emission factors according to a country's fuel usage and installed combustion technologies in some energy sectors. In other sectors EMEP/EEA Emission guidebook 2013 EF for SO_x, NO_x, CO, NMVOC was used. Emissions were estimated by multiplying heat value of combusted fuel by corresponding emission factor.

International aviation and International navigation sectors are not included in national totals of SO_x, NO_x, NMVOC, CO presented in CRF inventory.

9.1.2 Uncertainties and time-series consistency

The uncertainty assessment has not yet been evaluated in Lithuania. Sources not estimated (NE) have not been estimated due to lack of emission factors in methodology or activity data.

9.1.3 Category-specific QA/QC and verification, if applicable

A quality management system has been developed to support the inventory of air pollutant emissions. The Lithuanian Quality Control (QC) system is designed to provide routine and consistent checks to ensure data correctness and completeness; identify and address errors and omissions and to 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. Before submitting data to CEIP/EEA NFR formats were checked with RepDab. Quality Assurance (QA) activities include a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process. 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 carried out. Before submitting IIR to CEIP/EEA, data were approved by The Environmental Protection Agency (EPA).

9.1.4 Category-specific recalculations, if applicable, including changes made in response to the review process and impact on emission trend

Based on in-depth review of emission inventories submitted under the UNECE LRTAP Convention and EU National Emissions Ceilings Directive major renewals in calculations were applied in 2015. Correction of activity data and sulphur/lead content in fuels was done 1990-2013. Emission factors were reviewed and corrected. Majority of activity data within all sectors were adjusted according NATIONAL GREENHOUSE GAS EMISSION INVENTORY REPORTS – CRF. The differences between CRF and LRTAP emission reports in 2013 are lower than 2.5%.

9.1.5 Category-specific planned improvements, if applicable (e.g. methodologies, activity data, emission factors, etc.), including tracking of those identified in the review process

Indirect N_2O emissions from deposition of nitrogen containing compounds emitted in the IPPU sector will be calculated in the next submission.

10 RECALCULATIONS AND IMPROVEMENTS

10.1 Recalculations

UNFCCC Parties agreed to apply 2006 IPCC Guidelines for National GHG Inventories as of GHG emission inventory submission due in 2015 (Decision 15/CP.17, adopted by the Conference of the Parties to the UNFCCC in Durban in 2011). The major recalculations were made implementing new methodology and changes in GWP values.

Energy sector

Emissions recalculated using updated EF values from 2006 IPCC Guidelines. Energy industries emissions recalculated using updated EF for residual fuel oil (petroleum refining) and not liquefied petroleum gas (CHP) based on EU ETS data.

Fuel consumption in 1.A.3.b Road Transportation sector dissagregated by vehichle type.

Fugitive emissions from natural gas recalculated using updated EFs from 2006 IPCC Guidelines.

Industrial Processes and Product Use

Emissions from 2.A.2 Lime production were recalculated using 2006 IPCC Guidelines (LKD introduced in calculations).

Emissions from 2.B.1. Ammonia production were recalculated using 2006 IPCC Guidelines (CO_2 recovered for urea production were subtracted).

Recalculation of CO_2 emissions from 2.C.1 Cast iron production based on 2006 IPCC Guidelines, NIR p. 230-231.

New categories 2.D.1 Lubricant use (NIR p. 232-233) and 2.D.2 Paraffin wax use (NIR p. 234-235) reported for the first time. Emissions from 2.D.3 Urea-based catalyst were reported for the first time (The methodology is described in chapter 3.4.3 in NIR, p.172). Emissions from 2.D.3 Solvent use, Asphalt roofing and Road paving with asphalt were recalculated due to change of EFs (EMEP/CORINAIR).

New category 2.F.3 Photovoltaics reported for the first time, NIR p. 243-244.

The use of HFC-152 in 2.F.1.b Domestic refrigeration were revised and considering the information gathered from EPA's F-gases database, the HFC-152 has been replaced by HFC-125.

Emissions from 2.G.3.b Propellant for pressure and aerosol products (NIR, p. 288-289) reported for the first time.

Emissions from 2.H.3 Consumption of carbonates in flue gas desulphurisation reported for the first time, NIR, p. 98-99.

Agriculture sector

Enteric fermentation

CH_4 conversion rates (Ym) has been changed. In 2014 submission CH_4 conversion rate for cattle was 6.0%, for mature sheep – 7.0%, for lambs – 6.0% and in 2015 submission CH_4 conversion rates has been changed to 6.5%, 6.5% and 4.5% respectively.

Manure management

Methane conversion factors (MCFs) for manure management systems were changed in line with 2006 IPCC Guidelines. There were changes also in estimation of N_2O emissions from Manure management for swine and poultry in 2015 submission: N_2O emission from swine was recalculated using 2006 IPCC methodology revising nitrogen excretion values; poultry were divided by species and emissions were recalculated according to 2006 IPCC methodology requirements.

Agricultural soils

Methodological changes were made to estimate emissions from Crop residues using more CS data in order to evaluate emissions more accurately, (NIR p. 340-343); AD changes to estimate emissions from Synthetic fertilizers use; in line with IPCC 2006 Guidelines emissions from new sources such as Other organic fertilizers applied to soils (NIR p. 339-340) and Mineralization/immobilization associated with loss/gain of soil organic matter were estimated for the first time (NIR p. 343).

New category 3.G Liming (NIR p. 347-349) was reported for the first time.

New category 3.H Urea application (NIR p. 349-350) was reported for the first time.

Land use, land use change and forestry sector

Forest land

Recalculation of CO_2 emissions/removals due to carbon stock changes in living biomass and dead wood using updated CF for broad-leaves (0,48) and coniferous (0,51) stands from 2006 IPCC Guidelines. Recalculation of CH_4 and N_2O emissions from forest wildfires because of national mass of fuel available for combustion used (NIR 391-393 p.)

Emissions from Harvested wood products category reported for the first time (NIR p. 425-429).

Waste sector

Emission from solid waste disposal were recalculated due to activity data update made by Lithuanian EPA. Recalculation of emissions from 5.C.1 Waste incineration based on 2006 IPCC Guidelines, NIR p. 468-474.

Recalculation of emissions from 5.D.1 based on 2006 IPCC Guidelines and due to AD changes: BOD generation was calculated dividing discharge after treatment by average treatment efficiency and AD update made by data provider the Nutrition Centre under the Ministry of Health, NIR, p. 474-484.

10.2 Planned improvements

Energy sector

Further investigate of the possibility using data provided in the EU ETS, reported by the operators for the energy sector emission estimates is planned.

Fuel consumption factors for road transport vehicles will be updated by the time when new data becomes available from COPERT model updates. Implementation of COPERT 4 11.0 version with a new subsector for very small (<0.8 l) gasoline and (<1.4 l) diesel passenger cars of Euro 4-6 technologies.

It is also planned to update recommended EF in energy sector conducting a study through Norway Grants partnership project.

It is planned to investigate the possibility to apply Tier 2 for estimation fugitive emissions from natural gas systems by developing country specific emission factor values.

Industrial Processes and Product Use

In order to increase the accuracy of the estimates and improve the time-series consistency, possibility to collect data on soda ash use by end use following ERT encouragement will be explored.

The new EU Regulation No 517/2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006 came into force in May 2014. The ambitious new Regulation will reduce F-gas emissions by two-thirds of today's levels by 2030 and ban the use of F-gases in some new equipment where viable climate-friendly alternatives are readily available. The main novelty and driver for moving towards climate-friendly technologies is the introduction of a phase-down measure which from 2015 will limit the total amount of HFCs – the most significant group of F-gases – sold in the EU and reduce their quantities in steps to one-fifth of today's sales by 2030. This measure is accompanied by a number of new restrictions on the use and sale of F-gases in equipment. Taking into account this new important legislation, review of assumptions used to estimate F-gases emissions and country specific quality procedures will be implemented during the work with next submission.

Agriculture sector

Enteric Fermentation

The collection of more accurate data on cattle weight gain and more accurate parameters for calculation of GE intake for sheep are planned for the next submission.

Manure Management

Lithuania will continue improving collection of activity data on manure management systems usage.

Agricultural soils

Lithuania is planning to updated data on consumption of compost applied to agricultural land, data on sewage sludge applied as soil amendment and content of N in sewage sludge. It is also planned to improve calculations of N_2O from crop residues including N-fixing crops employing more country specific data.

Land use, land use change and forestry sector

Forest Land

In 2015 Lithuania is expecting to launch several studies for development of national values for carbon stocks in soil and forest litter in forest land and non-forest land and to estimate carbon stocks in dead-wood (these studies will be conducted during Norway Grants partnership project).

Cropland

Lithuania plans to continue to employ more country-specific values/factors and implement more detailed stratification of management systems.

Grassland

Lithuania plans to continue to employ more country-specific values/factors.

Harvested Wood Products

Lithuania is participating in the Norway Grants partnership project and is expecting to launch study for development of the national HWP accounting system in upcoming years.

11 KP-LULUCF (CRF 7)

Not relevant for this submission.

12 INFORMATION ON ACCOUNTING KYOTO UNITS

12.1 Background information

The standard electronic format (SEF) report for 2014 is included in the submission (see "PREG1_LT_2014.xls" attached to the submission). The SEF tables include information on the AAU, ERU, CER, t-CER, l-CER and RMU in the Lithuania's registry as well as information on transfers of the units in 2014 to and from other Parties of the Kyoto Protocol.

12.2 Summary of information reported in the SEF tables

At the beginning of 2014, there were 147 145 268 AAUs in Lithuania's national holding accounts, 4 930 174 ERUs and 237 289 CERs were held in Entity holding accounts; meanwhile in other cancellation accounts there were 11 559 AAUs. In the retirement account there were 22 783 253 AAUs, 3 477 985 ERUs and 3 348 131 CERs.

However no units were surrendered by Lithuania's operators and retired to Lithuania's national retirement account.

At the end of 2014, 147 146 991 AAUs were left in National holding accounts; 3 998 002 ERUs and 207 646 CERs were held in Entity holding accounts; meanwhile in other cancellation accounts the remaining number of AAUs was 11 559. Certain number of units was left in the Retirement account: 22 783 253 AAUs, 3 477 985 ERUs and 3 348 131 CERs.

227 306 177 AAUs were issued on the basis of the assigned amount pursuant to Article 3, paragraphs 7 and 8.

During the reported year the registry did not contain any RMUs, t-CERs or l-CERs. Any units were held neither in the Article 3.3/3.4 net source cancellation accounts nor in the t-CER and l-CER replacement accounts. Full details on the accounting of Kyoto units are available in the SEF tables.

12.3 Discrepancies and notification

No discrepancies and notifications occurred in 2014.

12.4 Publicly accessible information

All non-confidential information required to be publicly accessible according to decision 13/CMP/1 is available in the public website of the EUTL:

http://ec.europa.eu/environment/ets/account.do?languageCode=en&account.registryCodes=LT&identifierInReg=&accountHolder=&search=Search&searchType=account&currentSortSettings=.

Some of the publicly available information is also accessible via Registry management office web page on www.laaif.lt.

12.5 Calculation of the commitment period reserve (CPR)

Not relevant for this submission.

12.6 KP-LULUCF accounting

Not relevant for this submission.

13 INFORMATION ON CHANGES IN NATIONAL SYSTEM

No changes in national system had occurred during preparation of NIR for the period 1990-2013.

14 INFORMATION ON CHANGES IN NATIONAL REGISTRY

The following changes to the national registry of Lithuania have occurred in 2014.

Reporting Item	Description
15/CMP.1 Annex II.E, paragraph 32.(a) Change of name or contact	Changes of the Registry administrators occurred in 2014: Registry administrator Monika Ozarinskienė (contact information: m.ozarinskiene@laaif.lt, 0037052169799) was replaced by Registry administrator Toma Juraitė (contact information: t.juraite@laaif.lt, 0037052169799).
15/CMP.1 annex II.E, paragraph 32.(b) Change regarding cooperation arrangement	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E, paragraph 32.(c) Change to database structure or the capacity of national registry	Versions of the CSEUR released after 6.1.7.1 (the production version at the time of the last Chapter 14 submission) introduced changes in the structure of the database. These changes were limited and only affected EU ETS functionality, No change was required to the database and application backup plan or to the disaster recovery plan. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E, paragraph 32.(d) Change regarding conformance to technical standards	Changes introduced since version 6.1.7.1 of the national registry were limited and only affected EU ETS functionality. However, each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production. No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E, paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E, paragraph 32.(f) Change regarding security	No change to security measures occurred during the reporting period.

Reporting Item	Description
15/CMP.1 annex II.E, paragraph 32.(g) Change to list of publicly available information	No change to the list of publicly available information occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change of the registry internet address occurred during the reporting period.
15/CMP.1 annex II.E, paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reporting period.
15/CMP.1 annex II.E, paragraph 32.(j) Change regarding test results	Changes introduced since version 6.1.7.1 of the national registry were limited and only affected EU ETS functionality. Both regression testing and tests on the new functionality were successfully carried out prior to release of the version to Production. The site acceptance test was carried out by quality assurance consultants on behalf of and assisted by the European Commission.

15 INFORMATION ON MINIMIZATION OF ADVERSE IMPACTS IN ACCORDANCE WITH ARTICLE 3, PARAGRAPH 14

Lithuania continues to finance various projects which minimize the adverse social, environmental and economic impacts of the developing countries.

In 2013 Lithuania has pledged to contribute to the Eastern European Energy Efficiency and Environment Fund, which is administered by European Bank for Reconstruction and Development (EBRD). The Contribution Agreement with EBRD was signed on 26th of September, 2014. According to this Agreement funds (105 000 EUR) equally shall be disbursed to different climate change mitigation and adaptation projects in Armenia, Georgia and Moldova.

In 2014, the Government of the Republic of Lithuania approved new procedures for the implementation of bilateral development cooperation projects. As Climate change is one of the priority areas in the Lithuania's Development cooperation and democracy promotion policy, at the end of 2014 the Ministry of Environment has launched a call for public and private entities to submit applications for installation and promotion of renewable energy technologies and Lithuania's experience in developing countries to help to reach climate change mitigation goals. After the evaluation process, in the first half of 2015 one project was selected for funding by the Development cooperation projects' selection Commission. It is planned that approximately 145 000 EUR will be granted to the project applicants by Minister of Environment in June, 2015. More detailed information of the project and its implementation will be outlined in the next year's report.

In 2014 Lithuania has contributed 50 000 EUR to the EIB's Eastern Partnership TA Trust Fund, which directs a large part of its funds towards the Climate Action (e.g. in 2013, 73% of the fund were directed for climate-related purposes).

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