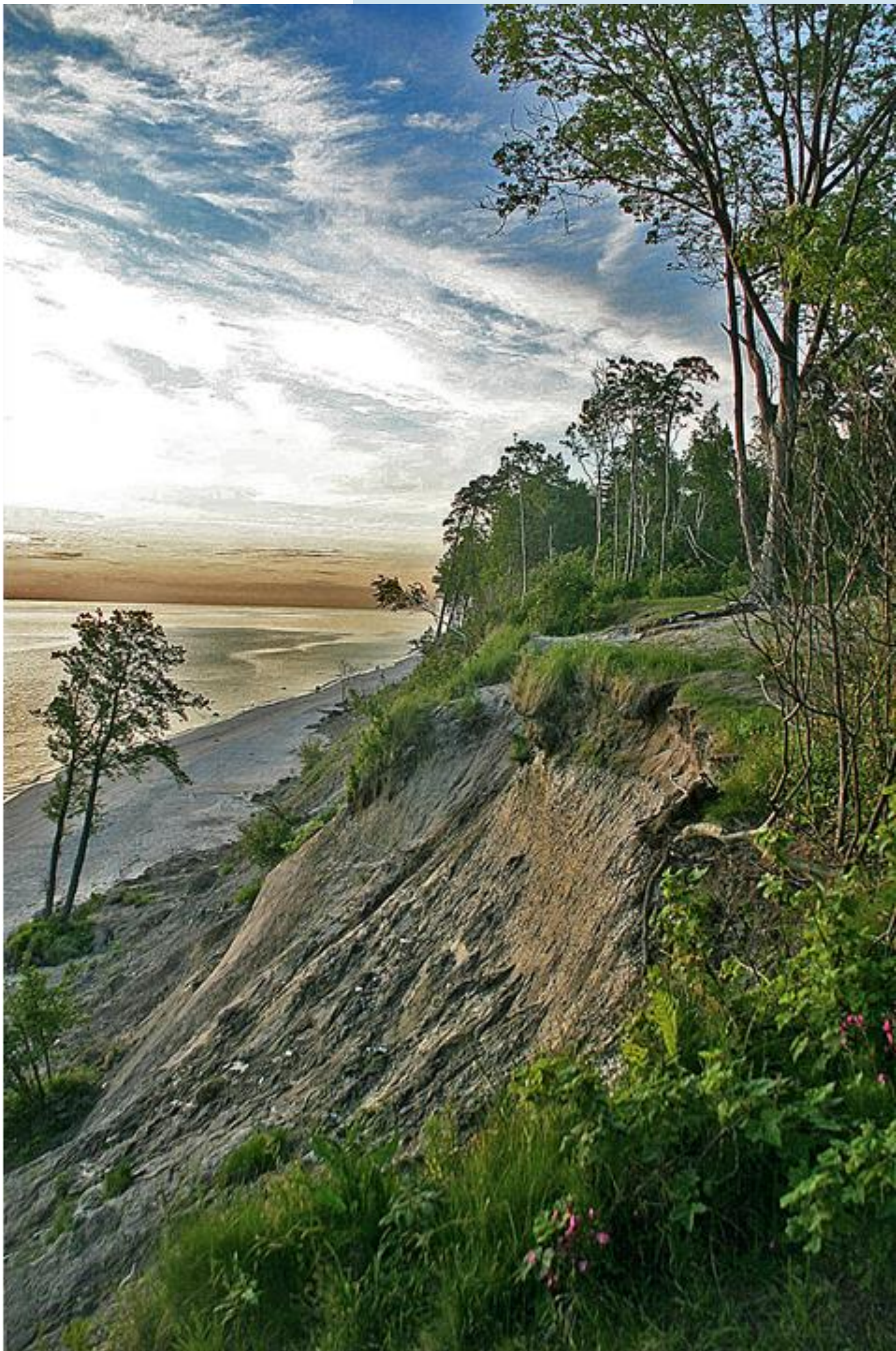
LITHUANIA'S NATIONAL INVENTORY REPORT 2014

GREENHOUSE GAS EMISSIONS 1990-2012



VILNIUS, 2014

PREFACE

Lithuania's GHG inventory submission under the United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol 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 1990-2012 including KP-LULUCF data tables for years 2008-2012
- SEF (Standard Electronic Format) tables for reporting of Kyoto units (AAUs, ERUs, CERs, tCERs, lCERs, RMUs) in the National registry during the year 2013.

Authors:

Dr. Inga Konstantinavičiūtė (Lithuanian Energy Institute), Dr. Steigvilė Byčenkienė (Institute of Physics of the Center for Physical Sciences and Technology)	*Energy sector*
Eglė Kairienė, Tomas Smilgius, Lina Vilniškė (Environmental Protection Agency)	*Industrial processes, Solvent and other product use sectors*
Dr. Remigijus Juška (Institute of Animal Science), Giedrė Raginytė (Environmental Protection Agency)	*Agriculture sector*
Dr. Romas Lenkaitis (Centre for Environmental Policy)	*Waste sector*
Dr. Ričardas Beniušis, Saulius Jezukevičius, Karolis Mickevičius (State Forest Service), Dr. Saulius Marcinkonis (University of Applied Sciences)	*LULUCF, KP-LULUCF sectors*
Monika Ozarinskienė (Lithuanian Environmental Investment Fund)	*GHG Registry*
Julija Kuklytė (Ministry of Environment)	*Information on minimization of adverse impacts (Art.3, para. 14)*
Jolanta Merkelienė (Ministry of Environment)	*Review and approval*
Rita Tijūnaitė, Eglė Kairienė, Giedrė Raginytė, Tomas Aukštinaitis (Environmental Protection Agency)	*Cross-cutting issues, QA/QC, NIR compilation*

Abbreviations

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
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
D	Deforested areas
DOC	Degradable Organic Carbon
EF	Emission Factor
EPA	Lithuanian Environmental Protection Agency
ERT	Expert Review Team
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
HFC	Hydrofluorocarbon
HSPP	Hydro Storage Power Plant
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 Cadastre
LULUCF	Land Use, Land-Use Change and Forestry
MCF	Methane correction factor
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
NFI	National Forest Inventory
NGO	Non-governmental organization
NHF	Nature Heritage Fund
NIR	National Inventory Report
NLS	National Land Service
NMVOC	Nonmethane volatile organic compounds
NO	Not occuring
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
SEF	Standard electronic format
SF_6	Sulphur hexafluoride
SFS	State Forest Service
SWDS	Solid Waste Disposal Sites
T	Trend
TOE	Tonne of Oil Equivalent
TPP	Thermal Power Plant
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 it`s greenhouse gas (GHG) emissions by 8% below 1990 level during the first commitment period 2008-2012.

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 Revised 1996 Guidelines for National Greenhouse gas Inventories (IPCC, 1997), Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000) and Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC, 2003), the Annotated outline of the National Inventory Report including elements under the Kyoto protocol (UNFCCC secretariat, 2009) and taking into account remarks by the UNFCCC expert review teams, provided in the Reports of the individual review of the annual submission of Lithuania.

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 Minister of Environment of 22nd of December, 2010, the 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. 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 ninth 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.

In addition, the inventory includes estimates of emissions of the precursors: nitrogen oxides (NO_x), 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 from 1990 to 2012.

For the preparation of the inventory CRF Reporter v.3.7.3 software has been used. The NIR includes trends of GHG emissions, description of each emission category relevant to CRF, key sources, uncertainty estimates, explanations on recalculations, planned improvements and procedure 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

A summary of Lithuania's GHG emissions and removals for 1990-2012 is presented in Table 1.

Table 1. Trends of greenhouse gas emissions by sectors during the period 1990-2012, CO_2 eqv., Gg

GHG source and sink categories	Energy	Industrial Processes	Solvent and Other Product Use	Agriculture	LULUCUF	Waste	Total (including LULUCF)	Total (excluding LULUCF)
1990	32653,20	4457,71	197,52	10289,83	-4293,55	1122,51	**44427,22**	**48720,77**
1991	34800,77	4500,75	195,83	9463,73	-4238,78	1143,96	**45866,26**	**50105,04**
1992	19602,36	2599,67	193,87	6652,20	-4244,53	1158,36	**25961,92**	**30206,45**
1993	15755,57	1646,11	191,53	5532,18	-5628,99	1175,92	**18672,32**	**24301,31**
1994	14779,51	1848,90	188,98	4868,15	-4502,74	1176,21	**18359,01**	**22861,75**
1995	13886,01	2137,61	186,36	4683,41	-3512,45	1178,88	**18559,82**	**22072,26**
1996	14405,65	2538,01	183,75	5049,79	1686,34	1181,41	**25044,95**	**23358,61**
1997	13961,23	2500,09	181,17	5225,86	64,69	1186,69	**23119,73**	**23055,05**
1998	14674,39	2917,57	178,61	4853,71	-7795,40	1188,91	**16017,79**	**23813,20**
1999	12326,59	2856,10	176,07	4710,42	-7839,08	1186,56	**13416,65**	**21255,73**
2000	10781,69	3024,37	173,54	4462,20	-9387,18	1190,58	**10245,21**	**19632,39**
2001	11436,61	3287,37	170,90	4604,92	-12831,81	1216,36	**7884,34**	**20716,15**
2002	11507,63	3464,99	168,67	4869,53	-5463,72	1221,04	**15768,14**	**21231,87**
2003	11505,58	3556,24	165,67	4995,01	-9870,59	1225,21	**11577,12**	**21447,71**
2004	12115,99	3752,64	162,77	5001,93	-6702,37	1197,80	**15528,77**	**22231,13**
2005	12798,40	4115,18	159,43	5070,74	-4834,12	1174,74	**18484,37**	**23318,49**
2006	12965,89	4372,93	127,99	5095,30	-4858,80	1145,64	**18848,95**	**23707,75**
2007	13200,38	6227,81	117,84	5449,27	-3606,11	1123,77	**22512,97**	**26119,08**
2008	13069,43	5562,26	91,19	5093,73	-8538,78	1115,65	**16393,48**	**24932,26**
2009	11833,19	2367,83	95,55	5042,59	-10668,85	1092,47	**9762,78**	**20431,63**
2010	12722,32	2230,32	87,48	5014,25	-10481,18	1064,22	**10637,40**	**21118,58**
2011	11877,96	3738,36	85,89	4986,85	-10574,63	990,91	**11105,35**	**21679,98**
2012	11885,26	3626,93	83,74	5059,98	-8076,62	966,38	**13545,66**	**21622,29**
2012/1990, %	**-63,60**	**-18,64**	**-57,61**	**-50,83**	**88,11**	**-13,91**	**-69,51**	**-55,62**

The most significant source of GHG emissions in Lithuania is energy sector with 55,0% share of the total emissions in 2012. Agriculture is the second most significant source and accounted for 23,4% of the total emissions. Emissions from industrial processes contributed 16,8% of the total GHG emissions, waste sector – 4,5%.

Main contributors in energy sector are Energy industries and Transport sectors. In 2012 these sectors composed 37,1% and 38,2% of the total GHG emisions from Energy sector respectively.

The composition of greenhouse gas emissions by sectors in 2012 is presented in Figure 1.

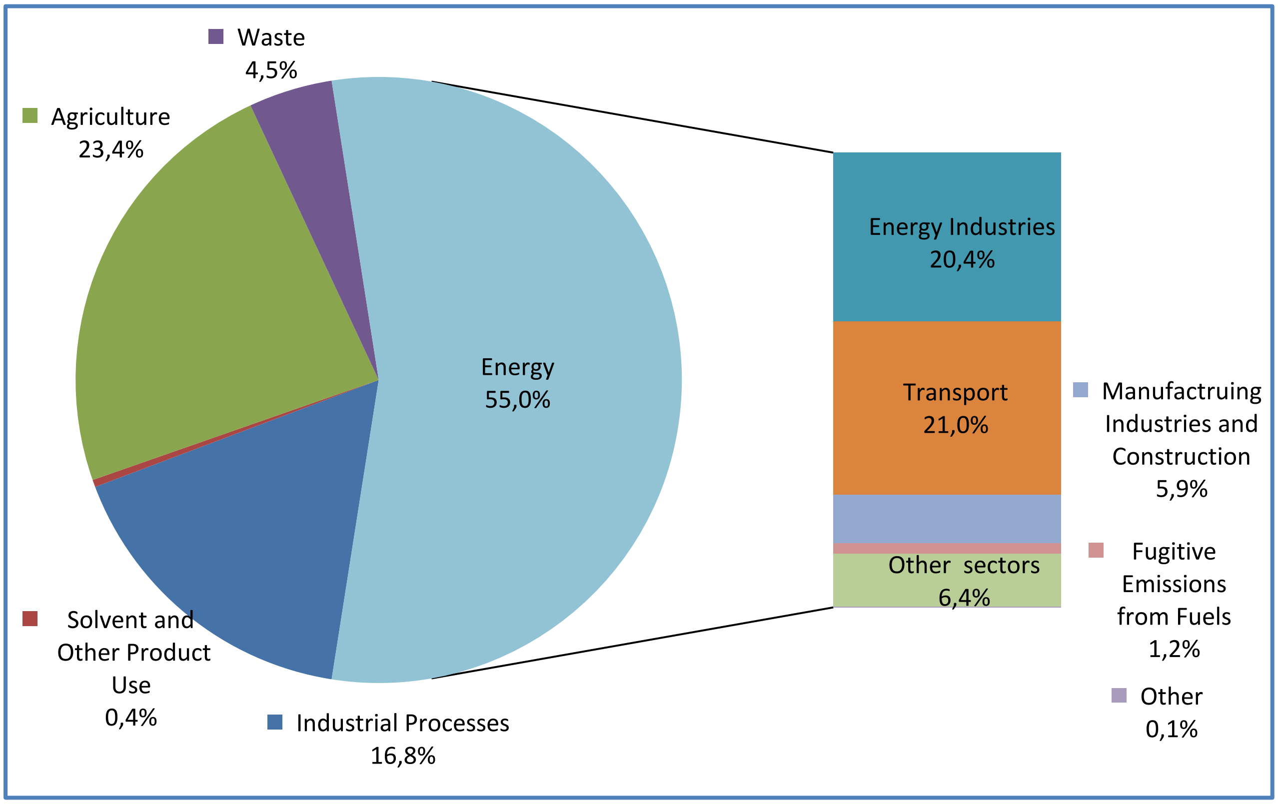

Figure 1. The composition of Lithuanian GHG emissions (CO_2 eqv.) by sectors (excl. LULUCF) in 2012

The total GHG emission (excl. LULUCF) amounted to 21622,29 Gg CO_2 eqv. in 2012. The emission have decreased by 55,6% 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 and SF_6.

The largest source of CO_2 emission is the energy sector that accounted 79,7% of the total national CO_2 emission (excl. LULUCF) in 2012. The energy industries contribute 38,6% and the transport sector accounts for 39,7% of the CO_2 emission in energy section.

Comparing with 2011 CO_2 emission from energy sector in 2012 have changed very slightly with a minor decrease of 0,01% wherein CO_2 emission from the energy industries decreased by 1,09% and emissions from transport increased by 0,56%.

The most important GHG in 2012 is CO_2, it contributed 65,6% of the total national GHG emissions expressed in CO_2 eqv., followed by N_2O (19,2%) and CH_4 (14,1%). HFCs and SF_6 together amounted 1,1% 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.

Total GHG emissions in 2012 comparing with 2011 decreased by 0,3% (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 1990-2012.

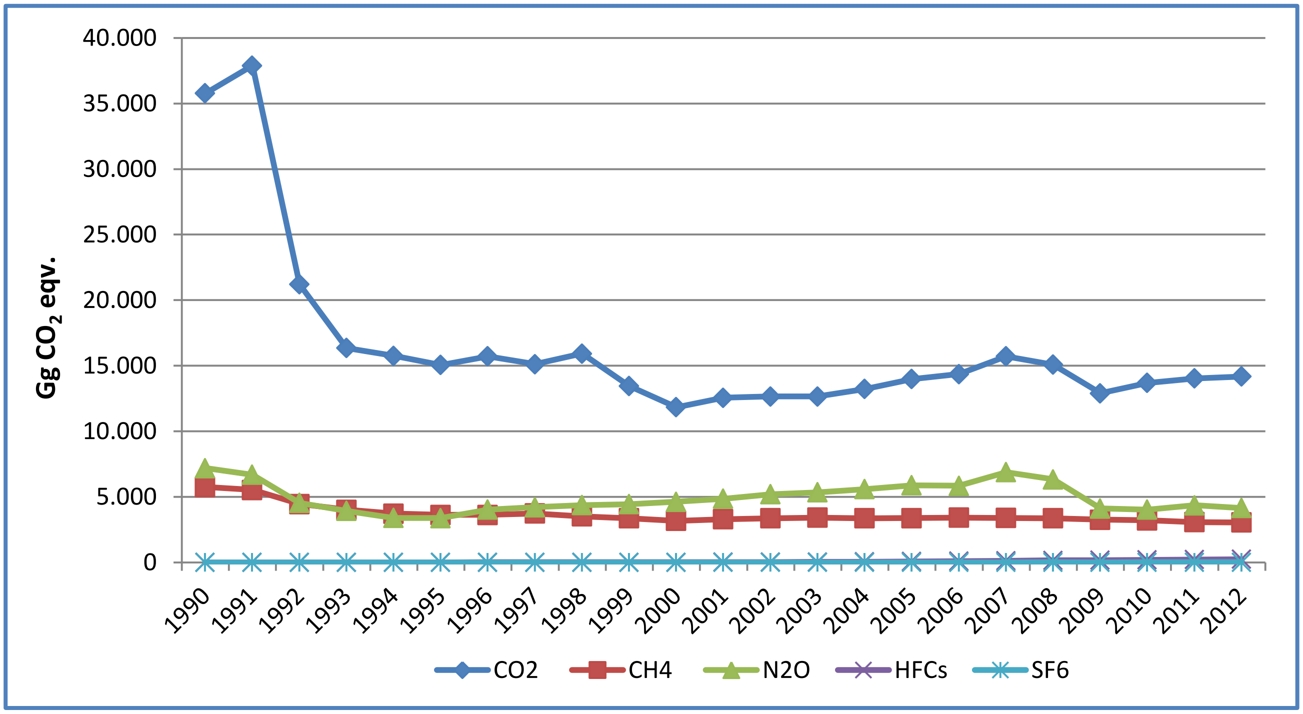

Figure 2. Trends of GHG emissions by gas in Gg CO_2 eqv. (excl. LULUCF)

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 55,0% share of the total emissions (excl. LULUCF) in 2012. Emissions from energy include CO_2, CH_4, N_2O gases.

CO_2 emission from energy sector contained 79,8% of the total national CO_2 emissions (excl. LULUCF) in 2012. The main categories are energy industries and transport which contribute 30,8% and 31,6% to the total national CO_2 emission (excl. LULUCF), respectively. Comparing with 2011 CO_2 emissions from energy sector decreased slightly by 0,01% wherein CO_2 emissions from energy industries decreased by 1,09% and emissions from transport sector increased by 0,56%. The emissions of CH_4 have increased by 0,7% and N_2O emissions increased by 5,0%.

The second important source of GHG emissions is agriculture sector accounting for 23,4% of the total GHG emissions (excl. LULUCF). This sector is the most significant source of CH_4 and N_2O emissions accounting for 55,4% and 80,4% of the total CH_4 and N_2O emissions, respectively. The main source of CH_4 emissions is enteric fermentation contributing 70% to the total agricultural CH_4 emissions. Agricultural soils are the most significant source of N_2O emissions accounting for 92,2% of the total agricultural N_2O emissions. Comparing with 2011 GHG emissions in agriculture sector in 2012 increased by 1,8%.

Emissions from industrial processes amount to 16,8% of the total GHG emissions (excl. LULUCF) in 2012. 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 sector contributing 16,4% to the total national CO_2 emissions (excl. LULUCF) in 2012. Nitric acid production is the single source of N_2O emissions in industrial processes sector and accounts for

14,4% in the total national N_2O emissions (excl. LULUCF) in 2012. The GHG emissions in 2012 from industrial processes has decreased by 3,0% comparing with 2011.

The use of solvents in industries and households contribute only 0,4% of the total GHG emissions (excl. LULUCF). The GHG emissions from this sector decreased by 2,6% in 2012 comparing with the previous year. This reduction was caused by population decrease.

Waste sector accounted for 4,5% of the total GHG emissions in 2012 (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 2,0% decline in CH_4 emission from waste sector in 2012.

PART 1:
ANNUAL INVENTORY SUBMISSION

1 INTRODUCTION

1.1 Background information regarding greenhouse gas inventories and climate change

1.1.1 Background information about climate change

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 anticyclonic 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 anticyclonic 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).

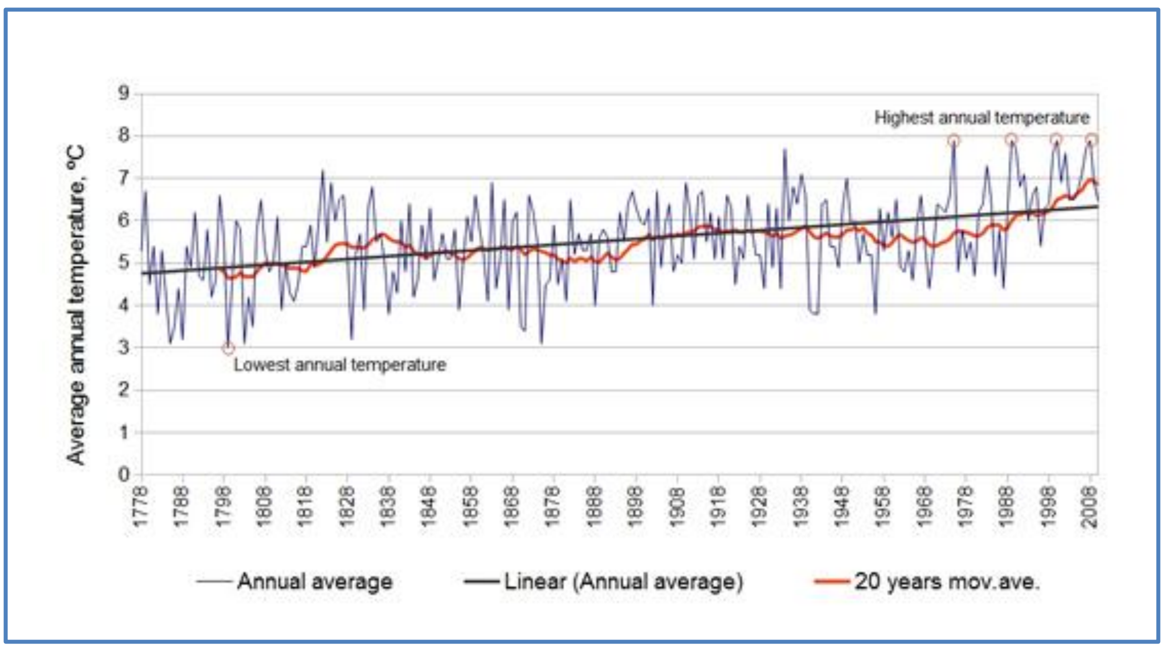

Figure 1-1. Average annual temperature in Vilnius, 1778-2010[1]

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

Average annual temperature, compared with the beginning of 20^{th} 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 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 21^{st} 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 21^{st} 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 21^{st} century cold spells (days when minimal temperature ≤ -15 °C) will occur only during January-February.

In 21^{st} 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 assumes 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 20^{th} 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 21^{st} 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 of Lithuania is being submitted to the secretariat of the UNFCCC, in compliance with the decisions of the Conference of the Parties 3/CP.5 and 11/CP.4. It also was 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.

Since 2004, inventory is prepared using common reporting format (CRF). From 2006 inventory is 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 and SF_6) and indirect (CO, NOx, SO_2, NMVOCs,) greenhouse gases. This report contains detailed information about Lithuania's GHG inventory for the period 1990-2012. The NIR includes description of the methodologies and data sources used for emissions estimation by sources and removals by sinks, and discussion of their trends. The purpose of report is to ensure the transparency, consistency, comparability, completeness and accuracy of GHG inventory. For the preparation of inventory CRF Reporter v.3.7.3 software 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 the methodology recommended by the Intergovernmental Panel on Climate Change (IPCC) in its Revised 1996 Guidelines for National Greenhouse gas Inventories (IPCC, 1997), Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000), Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC, 2003) and Annotated outline of the National Inventory Report including elements under the Kyoto Protocol (UNFCCC secretariat, 2009), Guidelines for National Greenhouse Gas Inventories (IPCC, 2006).

1.2 Institutional Arrangement and Process for Inventory Preparation

1.2.1 Overview of institutional, legal and procedural arrangements for inventory preparation

National system for Lithuanian GHG inventory preparation have 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.

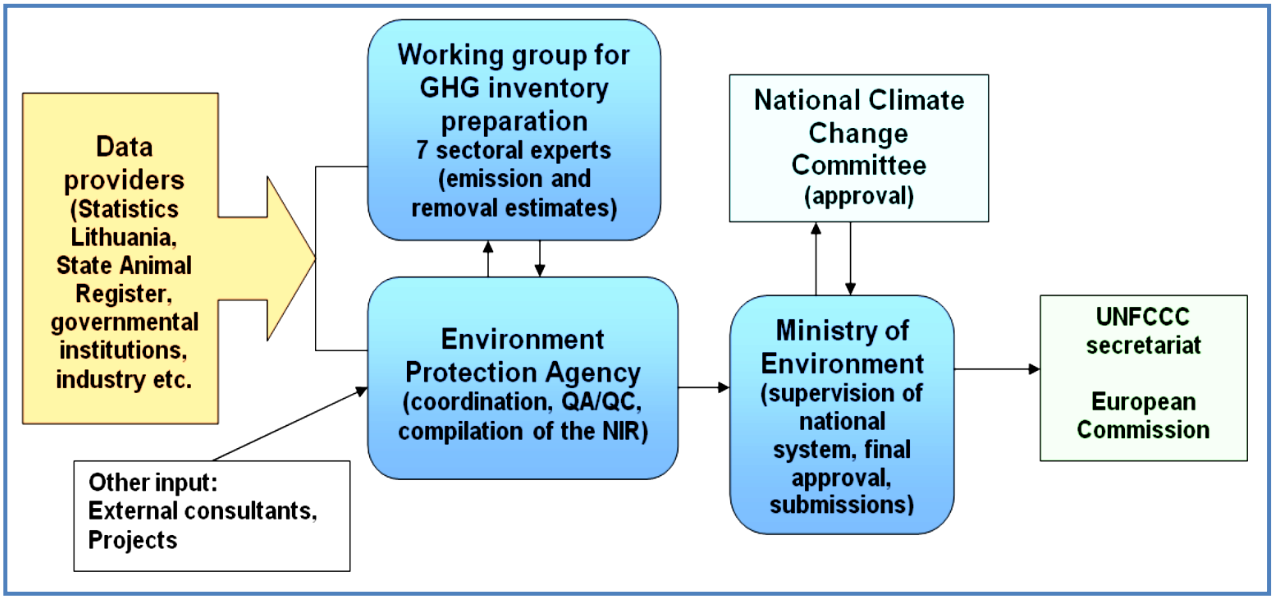

Figure 1-2. Institutional set-up for GHG inventory

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 draft inventory reports. Among its responsibilities are the following:

- Overall coordination of GHG inventory process;
- Preparation of legal basis necessary for national system functioning;
- An 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 suppliers for GHG inventory's Waste sector and data on F-gases.

At present the 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, consisting of 5 officials.

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;
- Cooperate with sectoral experts on the selection of methods complying with IPCC Good Practice Guidance for calculation of emissions giving the priority to key categories and categories with high uncertainty;
- Checking and archiving of supplied input data, prepared inventory and used materials;
- Key categories analysis;
- Overall uncertainty assessment;
- Preparation of CRF tables and compilation of NIR;
- Maintaining the GHG inventory database;
- Providing the final inventory (CRF tables and NIR) for Ministry of Environment;
- Evaluating requirements for new data, based on internal and external reviews;
- Other activities.

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.

The EPA establishes and operates GHG inventory database and archive, where archives of 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 (26th June 2012). The main QA/QC procedures under responsabilities 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 (23th 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 State Forest Service 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 State Forest Service 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;
- Uncertainty assessment for LULUCF and KP-LULUCF sector;
- Checking and archiving of input data, prepared estimates and used materials;
- Preparation of CRF tables and NIR parts for LULUCF and KP-LULUCF;
- Implementation of QA/QC plan and specific QA/QC procedures related to LULUCF and KP-LULUCF;
- Providing the final estimates (CRF tables and NIR part) for the Environmental Protection Agency;
- Evaluating requirements for new data, based on internal and external reviews.

In 2012 permanent staff of State Forest Service was complemented by 6 officials: 2 specialists were employed to work on data collection and GHG emissions and removals estimation from LULUCF and KP-LULUCF sectors and 4 specialists employed to conduct sampling of non-forest land of Lithuania's territory (necessary data collection for LULUCF and KP-LULUCF reporting).

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 DI-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 DI-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 good practice guidelines, of methodologies for calculation of GHG emissions setting priority to key categories and categories with high uncertainty level;
- Determination of activity data and appropriate emission factors;
- Calculation of emissions;
- Data quality control;
- Filling CRF tables for corresponding sectors, drafting relevant NIR sectoral chapters;
- Preparation of comments and answers to the questions and comments received during the EC and UNFCCC reviews;
- Other activities.

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 7 July 2009.

Data providers

Data providers are responsible for:

- collection of activity data,
- applying QC procedures (documentation in checklists 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 (2001-2012)*; *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“ (CO_2 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 (NO_x, 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 better data collection for the preparation of NIR, the amendment No 1540 of the Government Resolution No 388 of 7 April 2004 was adopted on 3 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 authorised institution - Environmental Protection Agency. The state science research institutes are authorised 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	All the available information required for GHG inventory's Energy

it's subordinates	sector's estimates preparation
Statistics Lithuania	All the available information required for GHG inventory preparation, including energy and fuel balance, economical 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.

In 2013 Lithuania was selected as one of the ten countries to participate in EU support project "Assistance to MS with KP reporting". This project was a valuable help to MS enabling to improve their reporting of GHG inventory. Lithuania had identified general issues that required improvments:

- Industrial processes – improvement in collection of activity data for F-gases;
- Agriculture sector – improvement in emission estimation form agricultural soils;
- LULUCF/KP-LULUCF – improvements in estimation of carbon stocks;
- Cross-cutting issues – improvement in estimation of uncertainties and key categories.

The support was provided by experience exchange between Lithuanian sectorial and project experts. The main form of support was wiki forum which was a convenient form of communication for all MS participating in this project. This forum was also helpful as more detailed issues could be discussed, not only those listed above. The support via wiki forum was being held during February-April 2013. The other form of support that was provided in April-June was workshops (one day visits to MS). One workshop was held in Lithuania in order to improve estimation on emissions from Agriculture soils subsector. Some of the issue were identified that could be further improved e.g. leakage and run-off subsector could be improved in the future submissions by analysing data that is being submitted under Helcom convention.

Other outcomes of the support project are:

- Improvements in calculation of key categories using a higher approach (Tier 2);
- Improvements in uncertainty evaluation using combined uncertainty analysis.

Norway Grants partnership project "Cooperation on GHG inventory" between Lithuania and Norway under the programme No 25 „Capacity-building and institutional cooperation between beneficiary state and Norwegian public institutions, local and regional authorities" is delayed and planned to be started in 2014. The partner of this programme will be Norwegian Climate and Pollution Agency (Klif), 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. Expected outcomes of the project are:

- A training programme for Lithuanian inventory experts to raise the technical competence of experts involved 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.
- 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 will be implemented during the years 2014-2016 and the budget allocated for this project amounts to 772 500 Eur.

A number of studies aiming to improve GHG inventory estimates were initiated and implemented in 2012:

National emission factors for energy sector development study. For calculation of emissions from the fuel combustion, some emission factors based on study conducted in 1997 are used, some EF were developed in 2010 based on research data from the Lithuanian oil refinery and the rest are default IPCC emission factors. Given that emissions from combustion of fuels are among the most important key categories, a study to develop country specific EFs was complited which accurately reflect the carbon content and other physical properties of fossil fuel consumed in country. The study was completed in 2012. The results of the study are applied for GHG calculations in this submission.

Study to determine the quantity of fluorinated gases (HFCs, PFCs and SF_6) use in Lithuania, development of the methods for emissions calculations and recommendations to improve F-gases data collection system. Lithuania's emission inventory for consumption of F-gases is based on a survey which was conducted in 2008. The scope of the survey was insufficient as only commercial and industrial refrigeration and air conditioning were covered, therefore further analysis was needed in order to complement GHG inventory and collect more detailed information on F-gases use in Lithuania during 1990-2010. This study was completed and implemented in 2012. The results of the study were applied for GHG calculations in this submission.

Study on research and evaluation of methane producing capacity and nitrous oxide in Lithuanian manure management systems. The study was developed and results are presented in this submission.

Study on research and analyses of methane emissions from waste-water and sludge. The study was required as data is not sufficient for the proper calculation of GHG emissions from waste sector. The study was completed in 2012 and results are applied in this submission.

1.3 Overview of the inventory preparation process

Lithuania prepares National Inventory Report 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 organisation 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 2014 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 2014

Activity	Responsible institutions	Deadlines
Updated QA/QC plan 2012-2013	EPA, MoE	August 2012
Data collection - sending of official letters to data providers; Methods development; QC procedures, data archiving	EPA, WG sectoral experts	September-October 2013
Meetings of all involved institutions for defining specific areas for improvements and recalculations	MoE, EPA, SFS, WG sectoral experts	September 2013
Sectoral experts input results to EPA	WG sectoral experts	October-November 2013
Filling CRF Reporter database, QC procedures, data archiving	EPA	November 2013
Prepare CRF tables and NIR part on LULUCF and KP-LULUCF and sending to EPA, data archiving	SFS	November 2013
Prepare draft NIR and send to MoE and other institutions for comments	EPA	By December 2013
Comments from MoE and others to EPA	MoE	By 15 December 2013
Submission of CRF tables, xml file and draft NIR to European Commission	MoE	By 15 January 2014
Possible CRF and NIR updates and final approval by MoE	EPA, WG sectoral experts, MoE	By March 2014
Sending NIR to NCCC for comments and final approval, QA procedures	MoE	By 15 March 2014
Submission of updated CRF tables, xml file and NIR to European Commission	MoE	By 15 March 2014
Submission of CRF tables, xml file and NIR to UNFCCC secretariat	MoE	By 15 April 2014

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.

1.4 Brief general description of methodologies and data sources used

1.4.1 Main Principles for GHG inventory

The main principles which Lithuania's GHG inventory should follow are set up in Updated UNFCCC reporting guidelines on annual inventories following incorporation of the provisions of decision 14/CP.11 (FCCC/SBSTA/2006/9). GHG inventory should be transparent, consistent, comparable, complete and accurate. Inventory should be prepared using comparable methodologies agreed upon by the Conference of the Parties (COP).

Transparency means that the assumptions and methodologies used for an inventory should be clearly explained to facilitate replication and assessment of the inventory by users of the reported information. The transparency of inventories is fundamental to the success of the process for the communication and consideration of information;

Consistency means that an inventory should be internally consistent in all its elements with inventories of other years. An inventory is consistent if the same methodologies are used for the base and all subsequent years and if consistent data sets are used to estimate emissions or removals from sources or sinks. An inventory using different methodologies for different years can be considered to be consistent if it has been recalculated in a transparent manner, in accordance with the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories and Good Practice Guidance for Land Use, Land-Use Change and Forestry;

Comparability means that estimates of emissions and removals reported in inventory should be comparable among Annex I Parties. For this purpose, the methodologies and formats agreed by the COP for estimating and reporting inventories Annex I Parties should be used. The allocation of different source/sink categories should follow the split of the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, and the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry, at the level of its summary and sectoral tables;

Completeness means that an inventory covers all sources and sinks, as well as all gases, included in the IPCC Guidelines as well as other existing relevant source/sink categories which are specific and, therefore, may not be included in the IPCC Guidelines. Completeness also means full geographic coverage of sources and sinks;

Accuracy is a relative measure of the exactness of an emission or removal estimate. Estimates should be accurate in the sense that they are systematically neither over nor under true emissions or removals, as far as can be judged, and that uncertainties are reduced as far as practicable. Appropriate methodologies should be used, in accordance with the IPCC good practice guidance, to promote accuracy in inventories.

1.4.2 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) and sulphur hexafluoride (SF_6). 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 (SO_x).

The GHG inventory is prepared in accordance with the methodology recommended by the IPPC in its publications:

- Revised 1996 Guidelines for National Greenhouse Gas Inventories, IPPC, 1997;
- Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, IPPC, 2000;

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

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 summarises 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	Individual production plants EU ETS emission data Industrial statistics database (Statistics Lithuania) F-gases database (EPA)
3. Solvents and Other Product Use	Statistics Lithuania database Published literature
4. Agriculture	The Register of Agricultural Information and Rural Business Centre of Ministry of Agriculture Agricultural Statistics database (Statistics Lithuania) Published literature
5. LULUCF	NFI (National Forest Inventory) State Forest inventory Lithuanian Statistical Yearbook of Forestry Published literature
6. 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 analysis, including for KP-LULUCF

1.5.1 GHG inventory (including and excluding LULUCF)

Key source categories analyses for the GHG inventory were performed according to the *IPCC 2000 Good Practice Guidance* and *IPCC GPG LULUCF 2003*. Tier 1 and Tier 2 level and trend assessment of the key source categories including and excluding LULUCF were conducted for all years for which inventory estimates are available. Level assessement with uncertainty (LU_{xt}) and trend assessment with uncertainty (TU_{xt}) were calculated using Tier 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 and SF_6. The categories identified by Tier 2 that are different from categories identified by Tier 1 were treated as key source 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.

Energy Sector is the main source of the GHG emissions accounting for 67% in 1990 and 55% in 2012 of the total emissions (excl. LULUCF). The second important sector is Agriculture Sector accounting for 21,1% in the base year and 23,4% in 2012 of the total GHG emissions (excl. LULUCF).

Tier 1 key category with a highest contribution to national total emission in 2012 is 1.AA.3.B Road transportation - diesel fuel (CO_2) accounting for 13,6% of the total emission (excl. LULUCF) whereas the key category with the highest contribution in the base year was 1.AA.1A Public electricity and heat production – liquid fuels (CO_2) accounting for 12,4% of the total emission (excl. LULUCF). The second most important source of greenhouse gas emissions in 2012 and 1990 is 1.AA.1.A Public electricity and heat production - gaseous fuel (CO_2). Its contribution to national total is 11,1% in 2012 and 11,9% in the base year.

Tier 2 key category with a highest contribution to national total emission in 2012 is 6.A. Solid Waste Disposal on Land (CH_4) and 4.D.3. Indirect Soil Emissions (N_2O) in 1990 excluding LULUCF.

Including LULUCF Tier 1 for both 2012 and 1990 5.A.1. Forest Land remaining Forest Land (CO_2) had the highest contribution to national total emission, while in Tier 2 highest contribution had 5.B Cropland (CO_2).

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

- 1. 1.AA.4 Other sectors, N_2O
- 2. 5.F Other land CO_2
- 3. 6.B. Waste-water Handling, CH_4
- 4. 6.B. Waste-water Handling, N_2O

Results of the Tier 1 and Tier 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 sources categories analysis by Level and by Trend (years 1990, 2012, 1990-2012)

KEY category	GHG	Level without LULUCF 1990	Level with LULUCF 1990	Level without LULUCF 2012	Level with LULUCF 2012	Trend (1990-2012) without LULUCF	Trend (1990-2012) with LULUCF	Approach used
1.AA.1.A Public electricity and heat production, gaseous fuel	CO_2	X	X	X	X	X	X	Tier 1 Tier 2
1.AA.1.A Public electricity and heat production, liquid fuel	CO_2	X	X	X	X	X	X	Tier 1 Tier 2
1.AA.1.B Petroleum refining, liquid fuel	CO_2	X	X	X	X	X	X	Tier 1 Tier 2
1.AA.2 Manufacturing industries and construction, gaseous fuels	CO_2	X	X	X	X	X	X	Tier 1 Tier 2
1.AA.2 Manufacturing industries and construction, liquid fuels	CO_2	X	X			X	X	Tier 1 Tier 2
1.AA.2 Manufacturing industries and construction, solid fuels	CO_2			X	X	X	X	Tier 1 Tier 2
1.AA.3.B Road transportation, diesel	CO_2	X	X	X	X	X	X	Tier 1 Tier 2
1.AA.3.B Road transportation, gasoline	CO_2	X	X	X	X	X	X	Tier 1
1.AA.3.B Road transportation, LPG	CO_2			X	X	X	X	Tier 1
1.AA.3.C Railways	CO_2	X		X				Tier 1
1.AA.3.E Off-road vehicles and machinery	CO_2	X	X	X		X	X	Tier 1 Tier 2
1.AA.4 Other sectors, biomass	CH_4			X	X	X	X	Tier 1 Tier 2
1.AA.4 Other sectors	N_2O					X		Tier 2
1.AA.4.A Commercial/Institutional	CO_2	X	X	X	X	X	X	Tier 1 Tier 2
1.AA.4.B Residential	CO_2	X	X	X	X	X	X	Tier 1 Tier 2
1.AA.4.C Agriculture /Forestry/Fisheries	CO_2	X					X	Tier 1
1.B Fugitive Emissions from Fuels	CH_4			X	X	X	X	Tier 1
2.A.1 Cement Production	CO_2	X	X	X	X	X	X	Tier 1
2.A.7 Bricks and tiles	CO_2					X		Tier 1
2.B.1 Ammonia Production	CO_2	X	X	X	X	X	X	Tier 1 Tier 2

2.B.2 Nitric Acid Production	N_2O	X	X	X	X	X		Tier 1 Tier 2
2.F.1 Refrigeration and Air Conditioning Equipment	HFC			X	X	X	X	Tier 1 Tier 2
4.A Enteric Fermentation, cattle	CH_4	X	X	X	X	X	X	Tier 1 Tier 2
4.B Manure Management	N_2O	X	X	X	X	X	X	Tier 1 Tier 2
4.B Manure Management, cattle	CH_4	X	X	X	X			Tier 1 Tier 2
4.B Manure Management, swine	CH_4	X	X	X	X		X	Tier 1 Tier 2
4.D.1.1 Direct Soil Emissions, Synthetic N fertilizers	N_2O	X	X	X	X	X		Tier 1 Tier 2
4.D.1.2 Direct Soil Emissions, manure fertilizers	N_2O	X	X	X	X	X	X	Tier 1 Tier 2
4.D.1.4 Direct Soil Emissions, Crop residues	N_2O	X		X	X	X	X	Tier 1 Tier 2
4.D.1.5 Direct soil Emissions Cultivation of histosols	N_2O	X	X	X	X	X	X	Tier 1 Tier 2
4.D.2 Pasture Range and Paddock Manure	N_2O	X	X	X	X	X	X	Tier 1 Tier 2
4.D.3 Indirect Emissions	N_2O	X	X	X	X	X	X	Tier 1 Tier 2
5.A.1 Forest Land remaining Forest Land	CO_2		X		X		X	Tier 1 Tier 2
5.A.2 Land converted to Forest Land	CO_2		X		X		X	Tier 1 Tier 2
5.B Cropland	CO_2		X		X		X	Tier 1 Tier 2
5.C Grassland	CO_2		X		X		X	Tier 1 Tier 2
5.E Settlements	CO_2				X		X	Tier 1 Tier 2
5.F Other land	CO_2						X	Tier 2
6.A Solid Waste Disposal on Land	CH_4	X	X	X	X	X	X	Tier 1 Tier 2
6.B Wastewater handling	CH_4	X		X				Tier 2
6.B Wastewater handling	N_2O					X		Tier 2

1.5.2 KP-LULUCF

Key category analysis for KP-LULUCF was developed according to the section 5.4 of the *IPCC 2003 GPG* for LULUCF. Categories under Articles 3.3 and 3.4 were considered as key if their contribution was greater than the smallest category considered key in the UNFCCC inventory (including LULUCF). The results are presented in Table 1-5.

Table 1-5. Key categories for KP Article 3.3 and 3.4. activities

Key categories of emissions and removals	Gas	Criteria used for key category identification	
		Associated category in UNFCCC inventory is key	Category contribution is greater than the smallest category considered key in the UNFCCC inventory (including LULUCF)
Forest Management	CO_2	Forest land remaining forest land	Yes

1.6 Information on the QA/QC plan including verification and treatment of confidentiality issues where relevant

1.6.1 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 19/CMP.1. 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 2012. The Ministry of Environment and the Environment Protection Agency was responsible for the development of the updated QA/QC Plan. The 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 of planned improvements.

As defined in *IPCC GPG 2000*, quality control (QC) is a system of routine technical activities, to measure and control the quality of the inventory as it is being developed. A basic quality control system should provide routine checks to ensure data integrity, correctness, and completeness and identify errors or omissions. In addition, procedures for documentation and archiving of inventory material and recording of all quality control activity data should be developed.

Quality assurance (QA) activities include planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process to verify that data quality objectives were met, ensure that the inventory represents the best possible estimate of emissions and sinks given the current state of scientific knowledge and data available, and support the effectiveness of the quality control program.

1.6.2 Quality control

EPA, as the coordinator of the GHG inventory and QA/QC Manager, has the following functions and responsibilities:

- Checking and archiving supplied input data;
- Checking assumptions and data selection criteria;
- Checking data inputs and references;
- Checking data processing procedures and emission calculations;
- Checking units, conversion and adjustment factors, etc.;
- Ensuring adequate documentation;
- Checking consistency of data between source categories;
- Checking data aggregation and transcription;
- Coordinating QA/QC activities, preparing QC and QA procedures;
- Providing the final inventory (CRF tables and NIR) for the MoE.

Quality control involves the following:
Evaluation of the data collection procedure, to establish whether:

- the necessary methods, activity data and emission factors (i.e. those in conformity with the IPCC Good Practice Guidance) have been used;
- the calculations have been made correctly;
- all time series data has been provided and calculated;
- the data and results for the current year have been compared with the data and results of the previous years;
- the notes and comments contain all necessary information on the data sources, calculation methods, etc.

Evaluation of the emission calculation, to establish:

- consistency of the emission factors used;
- correctness of the emission parameters, units, conversion factors used;
- correctness of the data transferred from spreadsheets to CRF tables;
- correctness of repeat calculations.

Evaluation of the preparation of respective chapters of the NIR, to establish:

- integrity of the structures of the inventory data;
- completeness of the inventory;
- consistency of time series;
- whether the emission estimates have been compared with previous estimates;
- whether the data tables of the National Inventory Report correspond to the text;
- whether all necessary information on the data sources, assumptions and calculation methodology have been provided.

Results of the checks are recorded in a quality control protocols. After a check, the protocol is 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 report (NIR) accordingly.

In addition to routine quality checks (Tier 1), source specific quality control procedures were applied, focusing on key categories and on categories with higher uncertainty. Source-specific QA/QC details are discussed in the relevant sections (Energy, Industrial processes, Agriculture and Waste) of the NIR.

The main QA/QC procedures under responsabilities 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 (23th July 2012).

Archiving

The proper archiving and reporting of the documentation related to inventory compilation process is also part of the QA/QC activities. Inventory documentation must be sufficiently comprehensive, clear and sufficient for all present and future experts to be able to obtain and review the references used and reproduce the inventory calculations.

The main archives of the GHG inventory are placed within the Environmental Protection Agency. In 2011 GHG inventory archive was transmitted to EPA from the Ministry of Environment 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 a 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 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. National GHG inventory archive is located in the EPA server and contains 5 main folders:

- General information (related legislation, IPCC methodologies, QA/QC plans and checklists forms, information sources or links and other useful information for report preparation);
- GHG data (subfolders grouped by years and by sectors – calculation sheets, emission factors, activity data, references, draft NIR, communication with sectoral experts etc.);
- Submissions (official submissions grouped by year and date – NIR, CRF, SEF, XML, cross-cutting information);
- Inventory Reviews (EC and UNFCCC review information, questions, answers, communication, review reports etc.);
- Backup (backup files of CRF).

In order to fill the gaps in archive, EPA developed checklists and documentation quality protocols for each CRF category and performed comprehensive quality checks over the each CRF category to identify missing references and documentation in the existing GHG inventory archive. According to the checklists results, sectoral experts provided missing references and documentation to the EPA, though all relevant GHG inventory material was collected, systematized, compiled and arranged according to the archive management system. Archive information includes:

- Disaggregated EFs used, including references to the IPCC document for default factors or to published references or other documentation.

- Activity data or sufficient information to enable activity data to be traced to the referenced source.
- Worksheets and interim calculations for source category estimates and aggregated estimates and any recalculations of previous estimates.
- QA/QC plans and outcomes of QA/QC procedures (external and internal reviews, checklists, documentation quality protocols).
- Data on key source identification, uncertainty assessment.
- Official Lithuania's GHG inventory submissions.

In addition to the main archive, sectoral experts have archives located in their own facilities. Original National Forest Inventory data is archived in the State Forest Service.

1.6.3 Quality Assurance

Quality assurance includes an objective review to assess the quality of the inventory, and also to identify areas where improvements could be made. The objective in QA implementation is to involve reviewers that can conduct an unbiased review of the inventory. In general, reviewers that have not been involved in preparing the inventory should be used. Preferably these reviewers would be independent experts from other agencies or a national or international expert or group not closely connected with national inventory compilation.

As the coordinating institution, EPA is also responsible for establishing a quality assurance system comprising review procedures which are conducted by personnel not directly involved in the inventory compilation/development. Its responsibilities include:

- Identification and prioritization of sets of data for review based on key category and uncertainty analysis,
- Identification of review personnel,
- Conclusions and corrective actions based on the review results.

A basic review of the draft GHG emission and removal estimates and the draft report takes place before the final submissions to the EC and UNFCCC secretariat (January to March) by the involved institutions on GHG inventory preparation process: the final draft of the NIR is coordinated with the Climate Change Policy Division at MoE, National Climate Change Committee, the relevant departments of the Ministry of Environment (e.g. Department of Waste, Department of Water, Department of Forestry and others) and it's subordinated institutions (e. g. Environmental Protection Agency, Lithuanian Environmental Investment Fund who is administrator of the National GHG Registry, etc.) before the submission to the European Commission and the UNFCCC secretariat. Received corrections are incorporated into the NIR.

Each year, the European Commission performs quality checks of the EU member states GHG inventories. The corrections are elaborated in Lithuania's GHG inventory in response to EC quality checks and comments. In 2012 technical review of the GHG emission inventory of Lithuania took place to support the determination of annual emission allocations under EU Decision 406/2009/EC. The technical review of the 2012 GHG inventory estimates of Lithuania for the years 2005, 2008, 2009 and 2010 was performed by a Technical Expert Review Team (TERT) under service contract to the Directorate General for Climate Action of the European Commission. Number of TERT recommendations were taken into account and resulting recalculations were performed in 2012 as well as 2013 GHG inventory submissions: estimation of emissions from lime production in the sugar factories, recalculation of emissions from N-fixing crops taking into account data on lucerne and clover, revision of emissions estimates associated with the Crop residues category, recalculation of emissions of F-gases.

UNFCCC reviews performed by the ERTs help to fulfill requirements of the Quality Assurance of the Lithuania's GHG inventory. UNFCCC review reports indicate issues where inventory needs improvements. GHG Inventory Expert team shall take into consideration recommendations provided by the ERT to ensure that all estimates or explanations as indicated by the ERT are corrected and included into NIR the next submissions.

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

Uncertainty estimation was performed using Tier 1 approach of *IPCC 2000*. Quantitative uncertainties assessment was carried out for the emission level 2012 and for 1990-2012 (1995-2011 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 Good Practice Guidance* with uncertainties based on expert judgment, consultation with statistical office. Tier 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 GPG 2000 equation 6.3. Results of combined uncertainty analysis including and excluding LULUCF are sorted descending to identify the biggest sectorial uncertainty in the inventory (Annex II tables 2-3, 2-4).

Excluding and including LULUCF five first subcategories with the biggest sectorial uncertainty were:

1. 6A Solid Waste
2. 1A1 Energy industries, biomass
3. 4D1 Direct Soil Emissions
4. 4D2 Pasture Range and Paddock
5. 4D3 Indirect Soil Emissions

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

Overall uncertainty

The total national GHG emission including LULUCF in the year 2012 is estimated with an uncertainty of ±43,0% and the trend of GHG emission 1990-2012 has been estimated to be ±8,5%.

The total national GHG emission excluding LULUCF in the year 2012 is estimated with an uncertainty of ±11,5% and the trend of GHG emission 1990-2012 has been estimated to be ±2,5%.

Comparing to the previous submission uncertainties have decreased. Changes of uncertainties are related to reevaluated uncertainties in the scope of implemented studies in energy sector and waste sectors. To achieve more reliable results, it is necessary to gather more relevant uncertainty data concerning both the activity data and the emission factors. As soon as more precise uncertainty estimates appear, they will be included in to calculations.

1.8 Completeness and Time-Series Consistency

Lithuania's GHG emission inventory includes all the major emission/removal sources identified by the IPCC Good Practice Guidance 2000 with some exceptions reported as "not estimated" (NE) (see Table 1-6), which suppose to 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 1990-2012.

Table 1-6. Summary of completeness of GHG inventory

IPCC source and sink categories	CO_2	CH_4	N_2O	HFCs	PFC	SF_6
1 Energy						
A Fuel combustion	√	√	√			
1 Energy industries	√	√	√			
2 Manufacturing industries and construction	√	√	√			
3 Transport	√	√	√			
4 Other sectors	√	√	√			
5 Other	√/IE/NE/NO	√/IE/NE/NO	√/IE/NE/NO			
B Fugitive emissions from fuels						
1 Solid fuels	NO	NO	NO			
2 Oil and natural gas	√	√	√			
C Memo items						
1 International Bunkers	√	√	√			
2 Multilateral Operations	NO	NO	NO			
3 CO_2 emissions from biomass	√					
2 Industrial processes						
A Mineral products	√	NA/NE/NO	NA/NE/NO			

	B Chemical industry	√	√	√	NO	NO	NO
	C Metal production	√	NO	NO	NO	NO	NO
	D Other production	√					
	E Production of halocarbons and SF_6				NO	NO	NO
	F Consumption of halocarbons and SF_6				√	NA/NO	√
	G Other production	NA	NA	NA	NA	NA	NA
3	**Solvent and other product use**	√		√			
4	**Agriculture**						
	A Enteric fermentation		√				
	B Manure management		√	√			
	C Rice cultivation		NO				
	D Agricultural soils		NA/NE	√			
	E Prescribed burning of savannas		NO	NO			
	F Field burning of agricultural residues		NO	NO			
	G Other		NO	NO			
5	**Land use, land use change and forestry**						
	A Forest land	√	√	√			
	B Cropland	√	√	√			
	C Grassland	√	√	√			
	D Wetlands	√	NE/NO	√			
	E Settlements	√/NE/NO	NE	NE			
	F Other land	√/NE/NO	NE/NO	NE/NO			
	G Other	NE	NE	NE			
6	**Waste**						
	A Solid waste disposal on land	NA	√				
	B Wastewater handling		√	√			
	C Waste incineration	√	NA	√			
	D Other	NA	NA	NA			
7	**Other**	NA	NA	NA	NA	NA	NA

√ – Emissions of the gas are covered under the source category
NA – Emissions of the gas 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 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 greenhouse gas emissions

Total GHG emissions amounted to 21622,3 Gg CO_2 eqv. excluding LULUCF and 13545,7 Gg CO_2 eqv. including LULUCF in 2012. The greenhouse gases include CO_2, CH_4, N_2O, HFCs, PFCs and SF_6. The emissions of GHG expressed in Gg CO_2 eqv. in 2012 have decreased by 55,6% comparing to the base year excluding LULUCF and by 69,5% including LULUCF. Figure 2-1 shows the estimated total greenhouse gas emissions in CO_2 eqv. from 1990 to 2012.

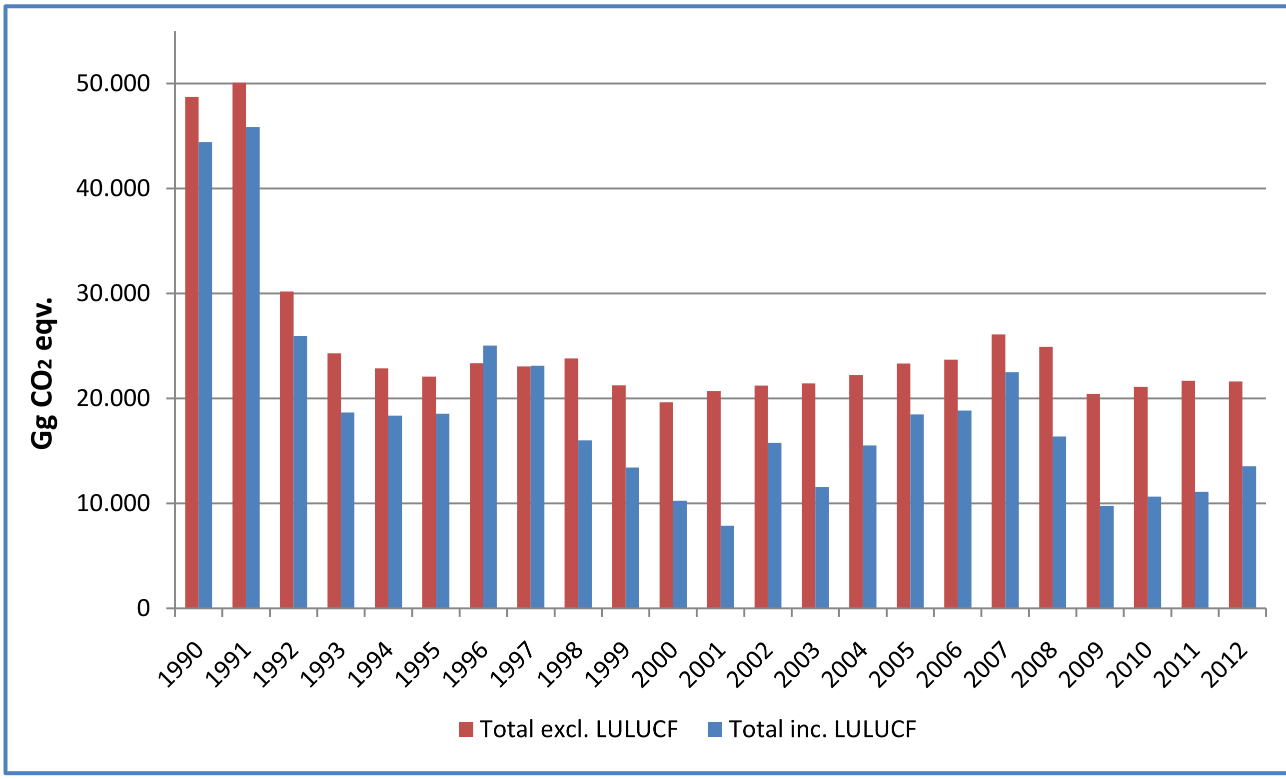

Figure 2-1. Emission trends for aggregated greenhouse gases in 1990-2012, Gg CO_2 eqv.

The most important greenhouse gas is CO_2, it contributed 65,6% to the total national GHG emissions expressed in CO_2 eqv. in 2012, followed by N_2O (19,2%) and CH_4 (14,1%). PFCs, HFCs and SF_6 amounted together to 1,1% of the total greenhouse gas 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 economical crisis and the slight growth of GDP in 2011 was observed 5,9% and in 2012 – 3,5%. These fluctuations were reflected in the country's emissions of greenhouse gases.

2.2 Description and interpretation of emission trends by gas

Carbon dioxide

The most important greenhouse gas in Lithuania is CO_2. The share of CO_2 from the total greenhouse gas emissions (excl. LULUCF) is varying from 59% to 75,6% during the time-period. CO_2 emissions have decreased by 60,4% since 1990. In 2012, the actual CO_2 emission (incl. LULUCF) was 80,7% lower than the emission in 1990. Between 1990 and 2000 greenhouse gas emissions decreased significantly as a consequence of the decline in industrial production and associated fuel consumption. Once the economy start grow again, emission rose but this was in part compensated by reductions achieved through energy efficiency and measures taken to reduce emissions. Comparing with 2011 CO_2 emissions increased by 77,6% including LULUCF or 1,1% excluding LULUCF.

The largest source of CO_2 emissions is energy sector which contributes around 79,8% of all CO_2 emissions. Compared to 2011 CO_2 emissions from energy sector decreased by 0,01%.

Figure 2-2 shows the distribution of CO_2 emissions in 2012 by the main sectors and subsectors.

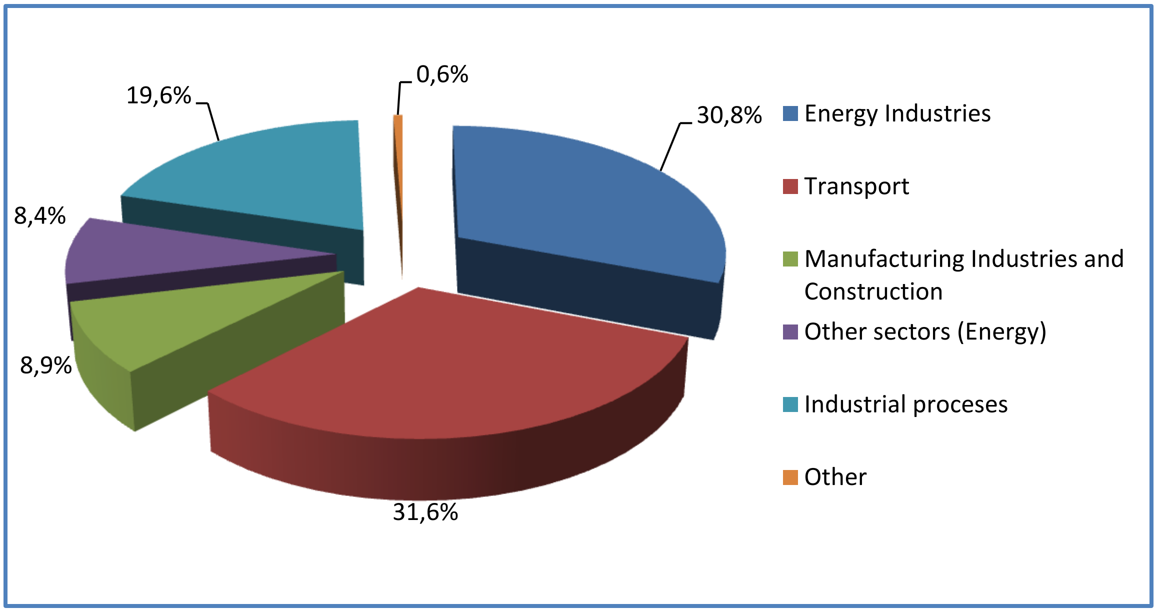

Figure 2-2. Distribution of CO_2 emissions by the main sectors and subsectors in 2012, %

Nitrous oxide

N_2O is the second most important GHG accounting for 19,2% in the total national greenhouse gas emissions (excl. LULUCF). Agriculture is the main source of N_2O emissions which contributed 81,3% to the total N_2O emissions in 2012. Particularly these are emissions from agricultural soils – contributing for 74,9% of the total N_2O emisions, and manure management which accounts for 6,4% in the total N_2O emissions.

N_2O emission from agriculture sector have increased by 2,4% comparing with 2011. The increase was in agricultural soils subsector as emissions from crop residue have increased because of a higher yield harvested during 2012.

The second significant source of N_2O emissions is nitric acid production. It contributes 14,2% to the total N_2O emissions. 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 dropped drastically and continue to decrease. Figure 2-3 shows the distribution of N_2O emissions in 2012 by the main sectors and subsectors.

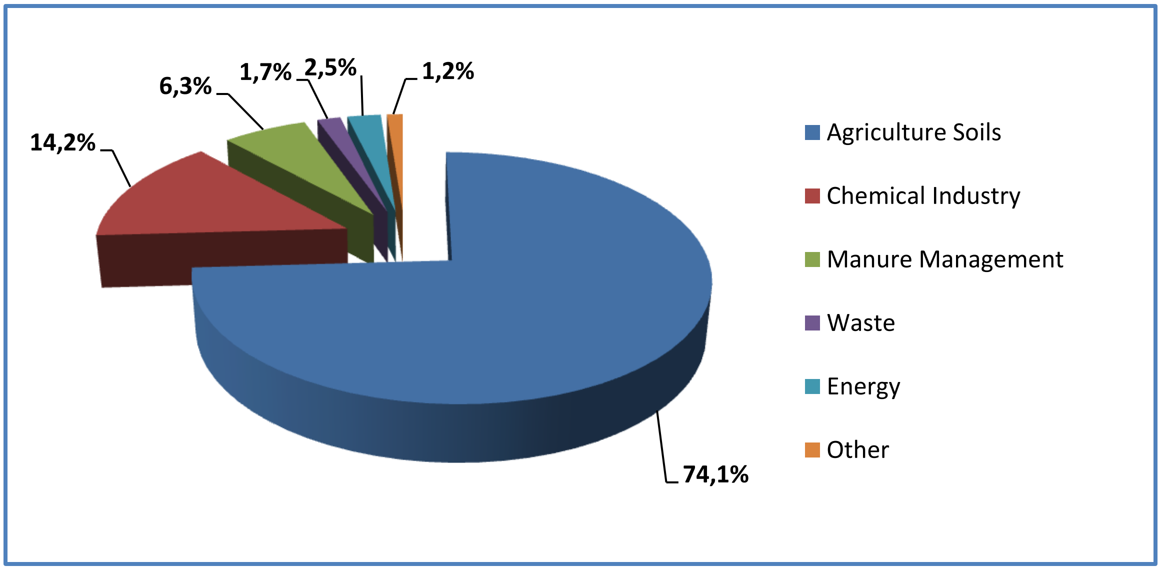

Figure 2-3. Distribution of N_2O emissions by the main sectors and subsectors in 2012, %

Methane

The largest sources of CH_4 emissions are: agriculture sector, contributing with 55,4%, waste sector – 29,2% and oil and natural gas sector – 8,5% from the total CH_4 emissions in 2012 (Figure 2-4). The emission of CH_4 from agriculture derives from enteric fermentation and manure management contributing with 38,8% and 16,6% of the total national CH_4 emission (excl. LULUCF).

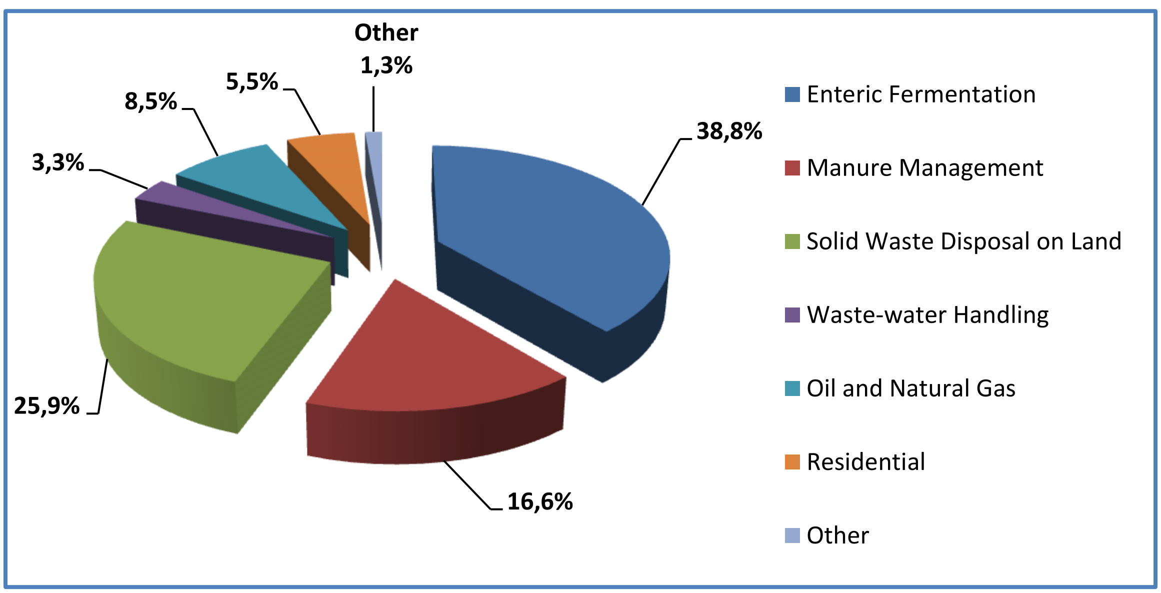

Figure 2-4. Distribution of CH4 emissions by the main sectors and subsectors in 2012, %

The emission of CH_4 has decreased by 46,9% from 1990 to 2012 (excl. LULUCF). The emissions of CH_4 mainly decreased due to reduction of livestock population.

HFCs and SF_6

The F-gases contribute 1,1% to the total national greenhouse gas emissions. The emissions of F-gases have increased during 1995-2012. A key driver behind the trend has been the substitution of ozone depleting substances (ODS) by F-gases in many applications. Figure 2-5 shows the trend of F-gases emissions during the period 1995-2012.

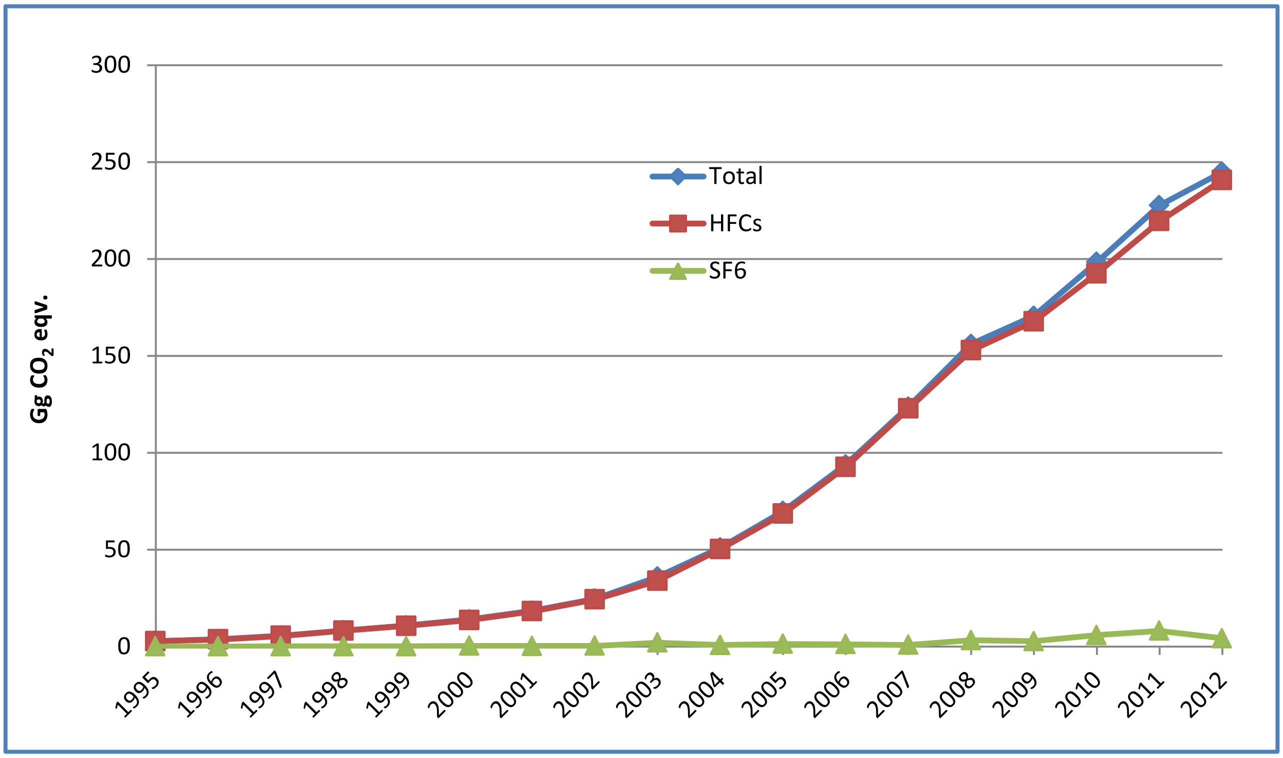

Figure 2-5. Emission trends for F-gases for the period 1995-2012, Gg CO_2 eg.

2.3 Description and interpretation of emission trends by category

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

The energy sector is the most significant source of greenhouse gas emissions in Lithuania with 55% share of the total emissions (excl. LULUCF) in 2012. The emissions from energy include CO_2, CH_4 and N_2O emissions.

Emissions of total greenhouse gases from the energy sector have decreased by 2,7 times from 32653,2 Gg CO_2 eqv. in 1990 to 11885,3 Gg CO_2 eqv. in 2012 (Figure 2-6). 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 greenhouse gas emission in energy sector was increasing about 2,5% per annum. The global economic recession has impact on greenhouse gas 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.

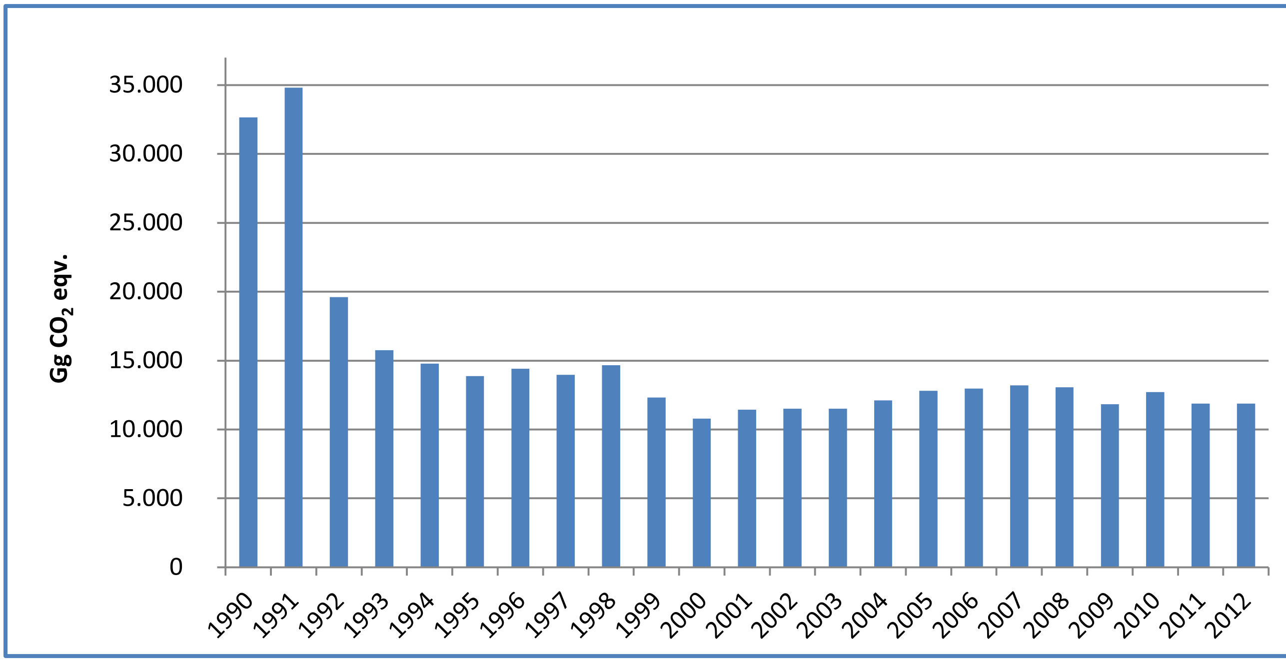

Figure 2-6. Trend of greenhouse gas emissions in energy sector during the period 1990-2012, Gg CO_2 eqv.

During the period 1990-2012 the share of transport sector significantly increased. In 1990, transport sector accounted for 22,9% of total greenhouse gas emission in energy sector whereas in 2012 – 38,2%. This growth is influenced by the rapid increase of the density of transport routes and the number of road vehicles.

The increase of greenhouse gas 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 greenhouse gas emissions from this subsector was increasing by average 3% per annum.

Industrial processes

The emissions from industrial processes (referred to as non-energy related ones) amount to 16,8% of the total emissions (excl. LULUCF) in 2012. The emissions from industrial processes includes CO_2, N_2O and F-gases emissions. Emissions of total greenhouse gases from the industrial processes sector have decreased by 1,2 times from 4457,7 Gg CO_2 eqv. in 1990 to 3626,9 Gg CO_2 eqv. in 2012 (Figure 2-7).

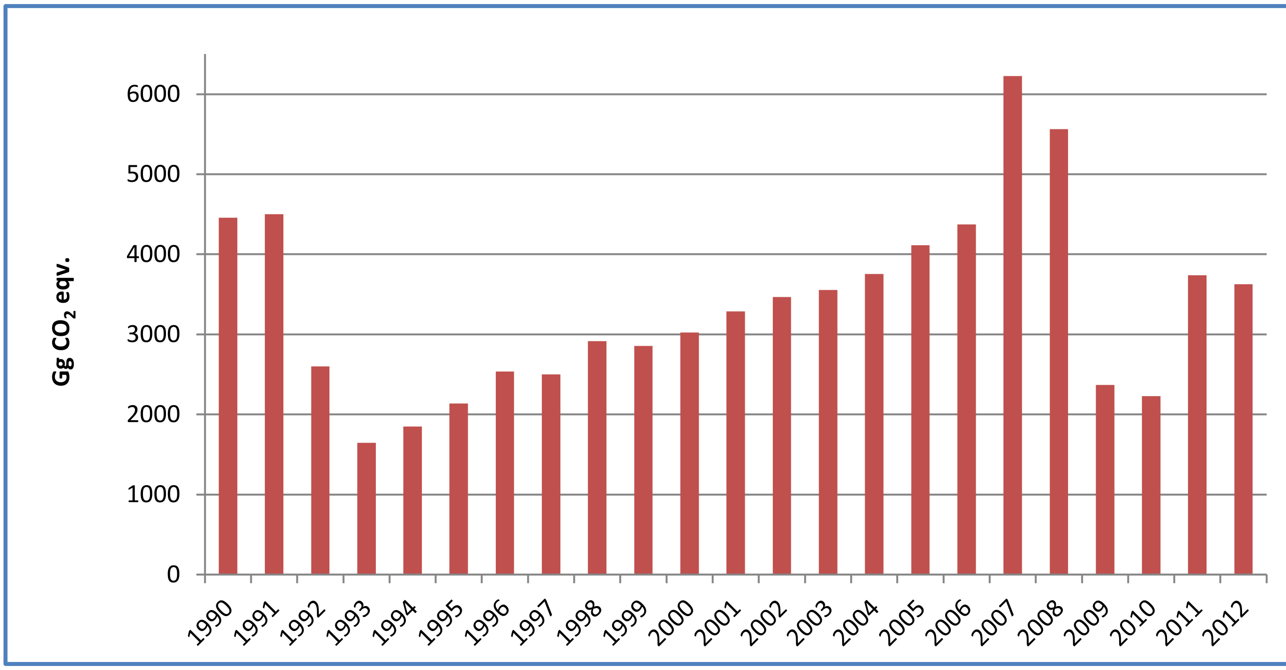

Figure 2-7. Trend of greenhouse gas emissions in industrial processes sector during the period 1990-2012, Gg CO_2 eqv.

CO_2 emissions from ammonia production contributing 10,7% to the total GHG national emissions (excl. LULUCF). The lowest emission of CO_2 was in 1993 due to decrease of the ammonia production and the peak of CO_2 emissions was in 2007 when the ammonia production increased. In 2012 ammonia and nitric acid production capacity have increased slightly, however emissions from nitric acid production have decreased because the single producer of ammonia and nitric acid AB "Achema" have finished the project ("*Nitrous Oxide Emission Reduction Project at GP Nitric Acid Plant in AB Achema Fertiliser Factory*") of catalyst installation in 2012. Emissions from ammonia production have increased very slightly in 2012.

Nitric acid production is the single source of N_2O emissions in industrial processes sector and accounts for 2,8% in the total GHG emission (excl. LULUCF). 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 of catalyst installation have been finished. Comparing with 2011 N_2O emissions decreased by 32,6%.

Solvents and other product use

The use of solvents in industries and households contribute 0,4% of the total greenhouse gas emission (excl. LULUCF). The emissions from solvents and other product use in 2012 include CO_2 and N_2O emissions. The emissions of total GHG from the solvents and other product use sector have decreased by 2,4 times from 197,52 Gg CO_2 eqv. in 1990 to 83,74 Gg CO_2 eqv. in 2012 (Figure 2-8). The reduction is due to the population decrease. The main source of CO_2 emissions is paint application contributing 51,6% to the total solvent and other product use CO_2 emissions. Domestic solvent use is the second important source of CO_2 emissions (20,7%) in solvent use sector.

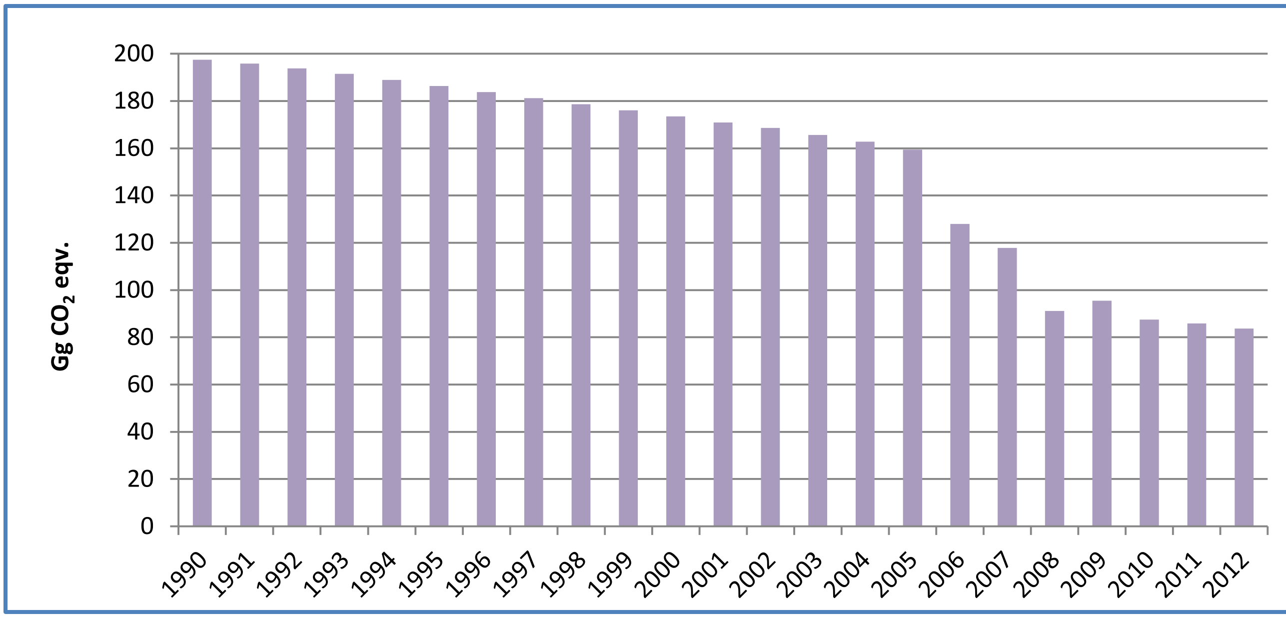

Figure 2-8. Trend of greenhouse gas emissions in solvents and other product use sector during the period 1990-2012, Gg CO_2 eqv.

Agriculture

Agriculture sector is the second most important source of greenhouse gas emissions in Lithuania contributing 23,4% to the total GHG emission (excl. LULUCF). The emissions from agriculture sector in 2012 include CH_4 and N_2O emissions. Emissions of total greenhouse gases from the agriculture sector have decreased by 2 times from 10289,83 Gg CO_2 eqv. in 1990 to 5059,98 Gg CO_2 eqv. in 2012 (Figure 2-9).

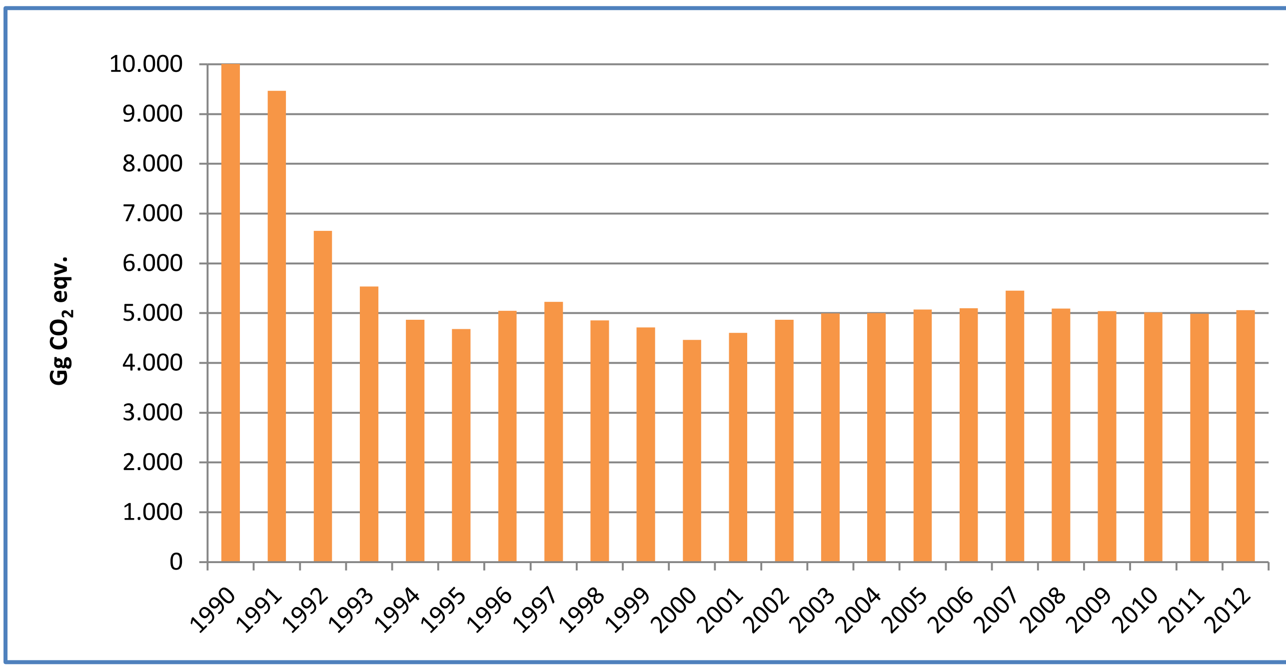

Figure 2-9. Trend of greenhouse gas emissions in agriculture sector during the period 1990-2012, Gg CO_2 eqv.

Agriculture sector is the most significant source of the CH_4 and N_2O emissions accounting for 55,4% and 81,3% in the total CH_4 and N_2O emissions, respectively. The emissions of CH_4 and N_2O from agriculture sector decreased by 60,8% and 43,6% compare to the base year, respectively.

The major part of the agricultural CH_4 emission originates from digestive processes. Enteric fermentation contributes 38,8%, manure management – 16,6% to the total national CH_4 emissions. The reduction of CH_4 emissions is caused by the decrease in total number of livestock population.

Agricultural soils are the most significant source of N_2O emissions accounting for 74,9% in the total national N_2O emissions. N_2O emission from atmospheric deposition and nitrogen leaching and run-off in 2012 decreased by 53,3% and 49,0% respectively comparing to the 1990 due to decrease of consumption of synthetic fertilizers and number of livestock population.

LULUCF

The Land Use, Land-Use Change and Forestry (LULUCF) sector for 1990-2012 as a whole acted as a CO_2 sink except in 1996 and 1997 when emission constituted to 1686,34 and 64,69 Gg CO_2 eqv. (Figure 2-10). 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 CO_2 balance from this sector.

The LULUCF sector during the period 2008-2012 removed from nearly 33,9% to 51,8% of the total CO_2 emissions in Lithuania. Largely this should be contributed to forest land.

Lower removals from LULUCF sector, comparing with 2011, has been mainly caused by decreased mean annual volume change from forest land (from 9,3 mill. m^3 in 2011 to 8,0 mill. m^3 in 2012). For instance, total removals in forest land in 2011 were 10574,6 Gg CO_2 and only 8076,6 Gg CO_2 were removed in 2012.

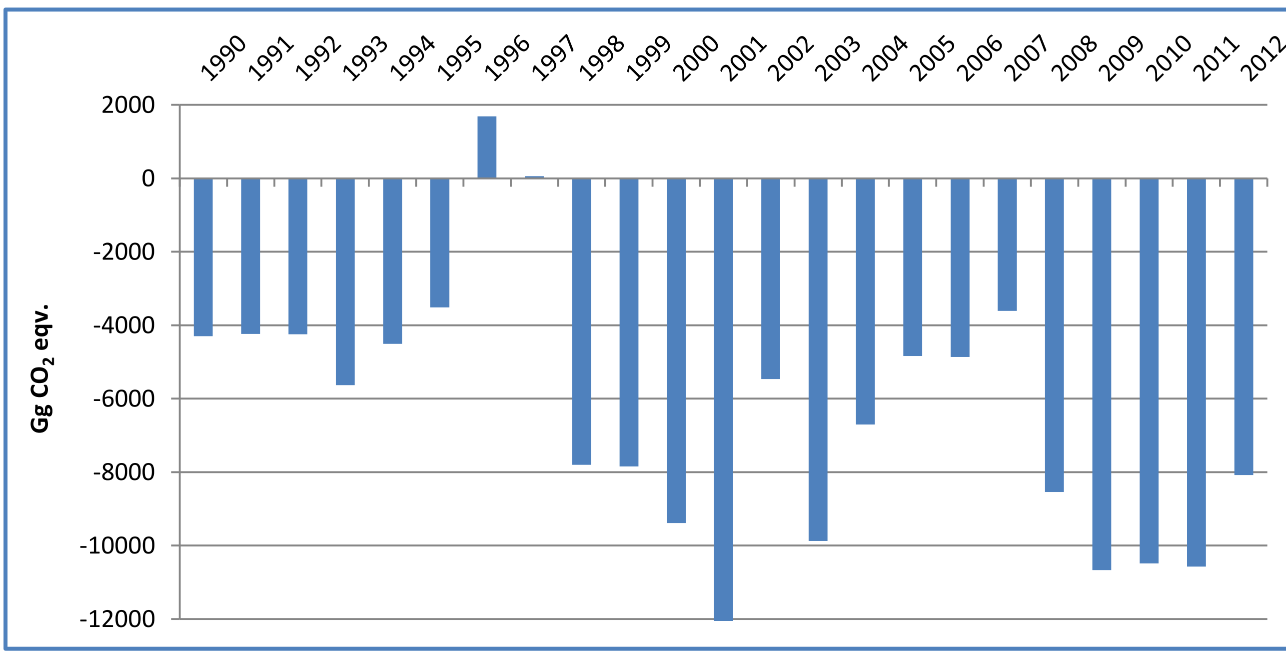

Figure 2-10. Lithuanian total greenhouse gases emissions/removals from LULUCF sector for the period 1990-2012, Gg CO_2 eqv.

Waste

The waste sector accounted for 4,5% of the total greenhouse gas emissions in 2012 (excl. LULUCF). The emissions from waste sector in 2012 included CO_2, CH_4 and N_2O emissions. Emissions of the total GHG from waste sector have decreased from 1122,51 Gg CO_2 eqv. in 1990 to 966,38 Gg CO_2 eqv. in 2012 (Figure 2-11).

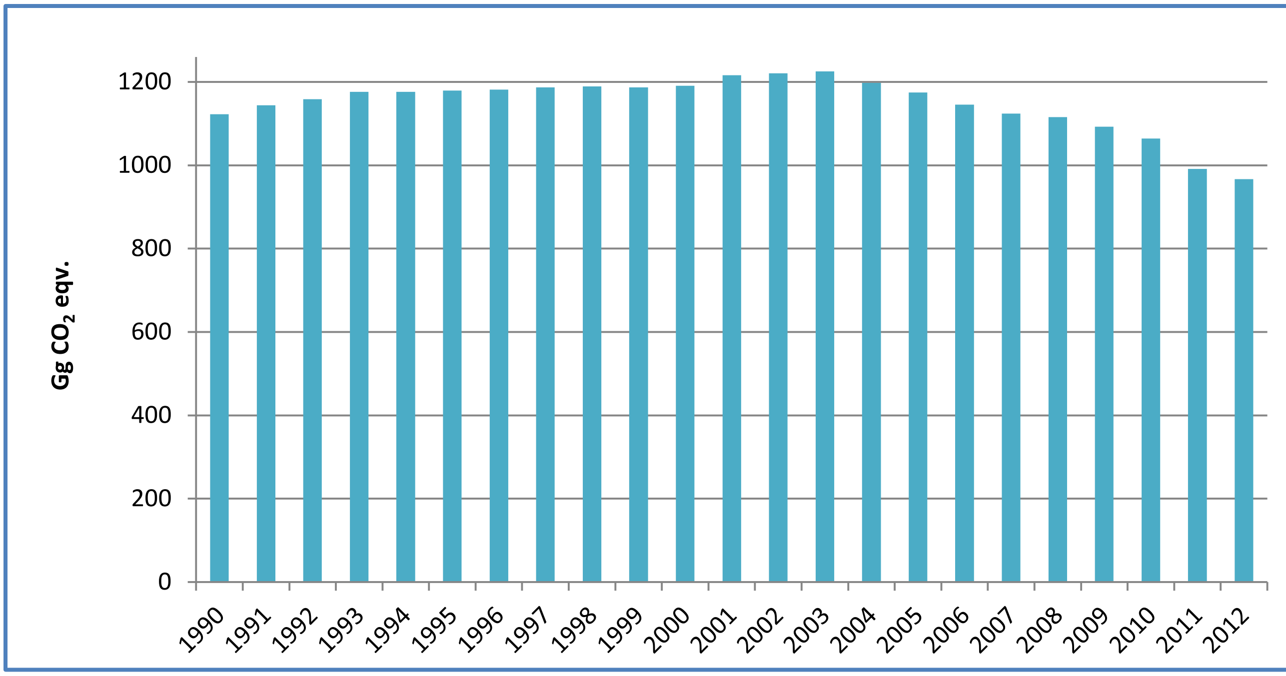

Figure 2-11. Trend of greenhouse gas emissions in waste sector during the period 1990-2012, Gg CO_2 eqv.

Solid waste disposal on land, including disposal of sewage sludge, was the most important source contributing from average 81,7% of the total greenhouse gas emissions in waste sector. The 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 over this waste to farmers for use in agriculture and greenhouse gas emissions have declined.

Total GHG emissions decreased approximately by 55,6% excluding LULUCF and by 69,5% including LULUCF compared to the base year. The trends of GHG emissions by sectors are presented in Table 1, expressed in CO_2 equivalent and taking into account GHG emissions/removals from LULUCF.

2.4 Description and interpretation of emission trends for indirect greenhouse gases and sulfur oxides

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 throught 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. NO_x 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 reports projections of the main pollutants.

The Informative Inventory Report (IIR) covering the inventory of air pollutant emissions from Lithuania is the source of data in this report (Figure 2-12). The report contains information on Lithuanian inventories for 1990-2012 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 2-12). 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 1995 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.

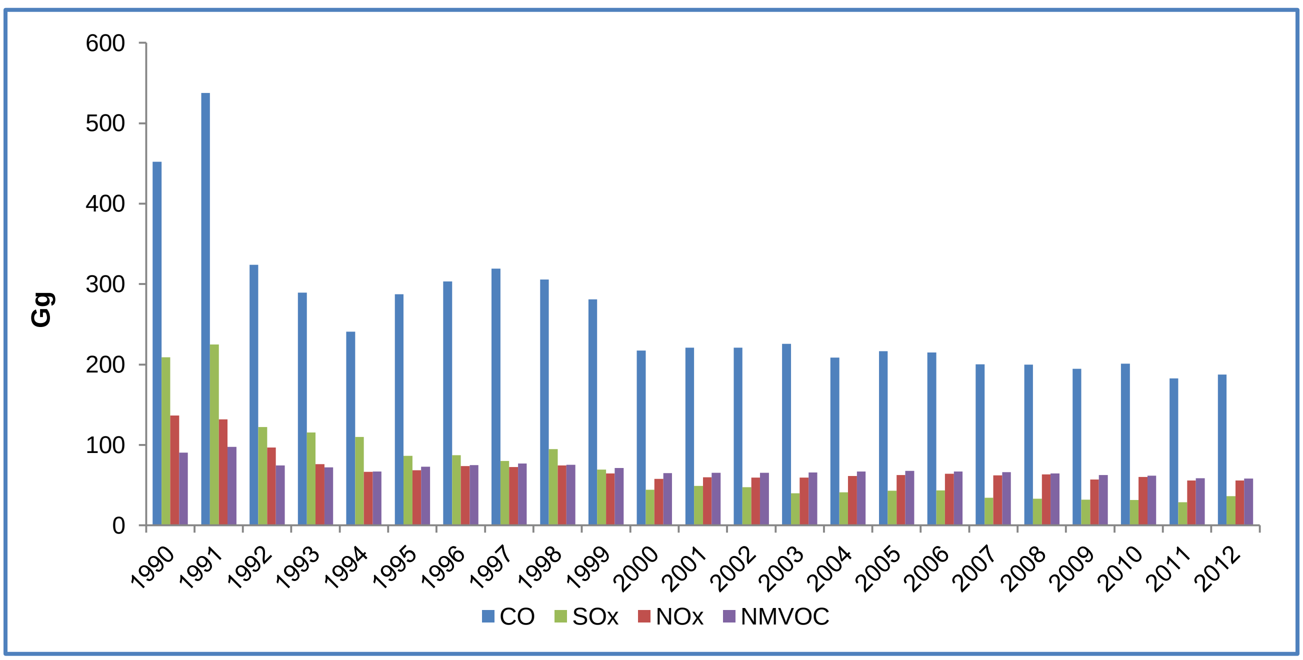

Figure 2-12. Development of non GHG gas and SO_2 emissions, 1990-2012 (*source:* LRTAP submission 2014)

A rapid decrease of indirect emissions followed the decline of the country economy in the 1990s. Since 2000, the GDP has been growing continuously. Table 2-1 present results from the Level Assessment of the key source for 2012.

Table 2-1. Key source analysis for the main pollutants in 2012

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 26,4%	1 A 4 b i Residential: Stationary plants 20,2%	1 A 2f i Stationary Combustion in manufacturing industries and construction 18,2%	1 B 2a iv Refining / storage 14,5%	1 A 1 b Petroleum refining 11,6%				**90,9**
NO_x	1 A3b iii Road transport: Heavy duty vehicles 31,6%	1 A 1 a Public electricity and heat production 18,4%	1 A 3 b i Road transport: Passenger cars 10,3%	1 A 4 b i Residential: Stationary plants 7,8%	1 A 3 c Railways 5,4%	1 B 2a iv Refining / storage 3,7%	1 A 3 a i International aviation (LTO) 2,9%		**80,1**
NMVOC	1 A 4 b i Residential: Stationary plants 26,2%	3 A 2 Industrial coating application 21,3%	3 D 2 Domestic solvent use 9,1%	2 D 2 Food and drink 7,4%	1 A 3 b i Road transport: Passenger cars 5,3 %	3 B 1 Degreasing 4,3%	3 D 1 3,3%	3 C 3 C Chemical products 3,0%	**79,9**
CO	1 A 4 b i Residential: Stationary plants 67,3%	1 A 3 b i Road transport: Passenger cars 16,6%							**83,9**

During the period 1990-2012, the emissions of sulphur dioxide has decreased by about 82,6%, from 209,1 Gg in 1990 to 36,4 Gg in 2012, 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 2012, the most significant sectoral source of SOx emissions was Electricity and heat production (26,4%), followed by emissions occurring from Residential: Stationary plants (20,2%) and in the Stationary Combustion in manufacturing industries and construction (18,2%) sectors (Table 2-1). A combination of measures has led to the reductions in SOx emissions in 1990-2012 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).

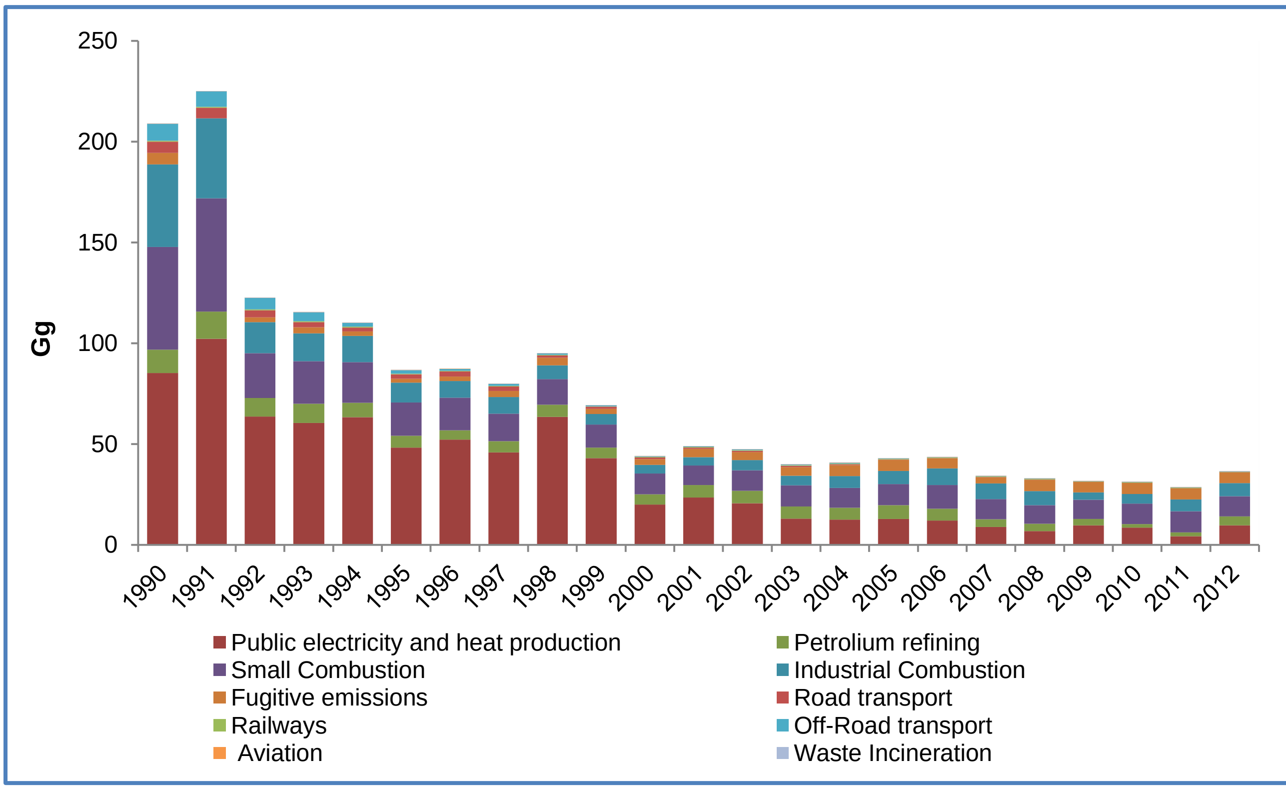

Figure 2.13. Emission trend for SOx by sectors, 1990-2012

Total nitrogen oxides emissions have decreased by 59,1%, from 136,5 Gg in 1990 to 55,8 Gg in 2012 (Figure 2-14). The Road transport (1A3bi-iii) and Energy industry (1A1) sectors are main sources of nitrogen oxides emissions ~50% in 1990 and 2012. 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 2-14).

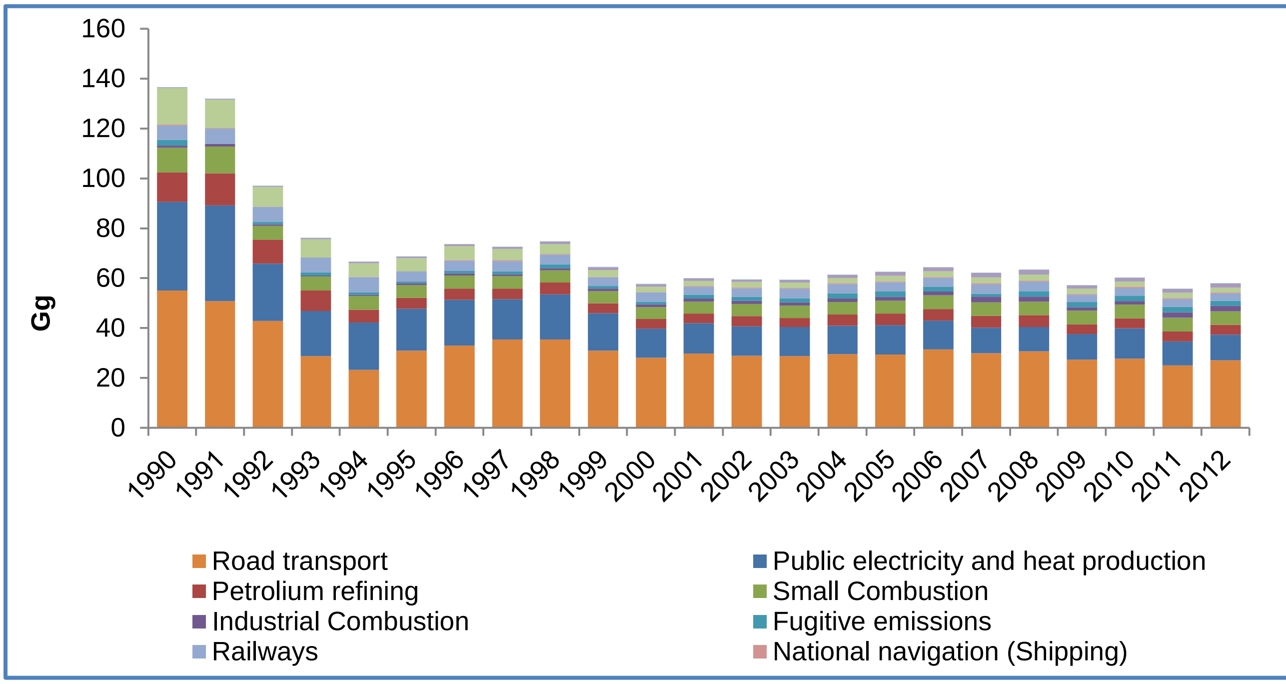

Figure 2-14. Emission trend for NOx by sectors, 1990-2012

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 fuelled 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, however, the amounts of NO_x jumped considerably in 1A1a sector, which was due to a larger use of gas in power plants following INNP closure.

The NMVOC emissions are determined mainly by Solvent and Other Product Use (3.A, 3.B, 3.C, 3.D) and Road Transport (1.A.3.b). The combined solvents (3.A-D) produced 45% of the 2012 total of NMVOC emissions in Lithuania having decreased by 19% between 1990 (32,2 Gg) and 2012 (26,0 Gg) (Figure 2-15)

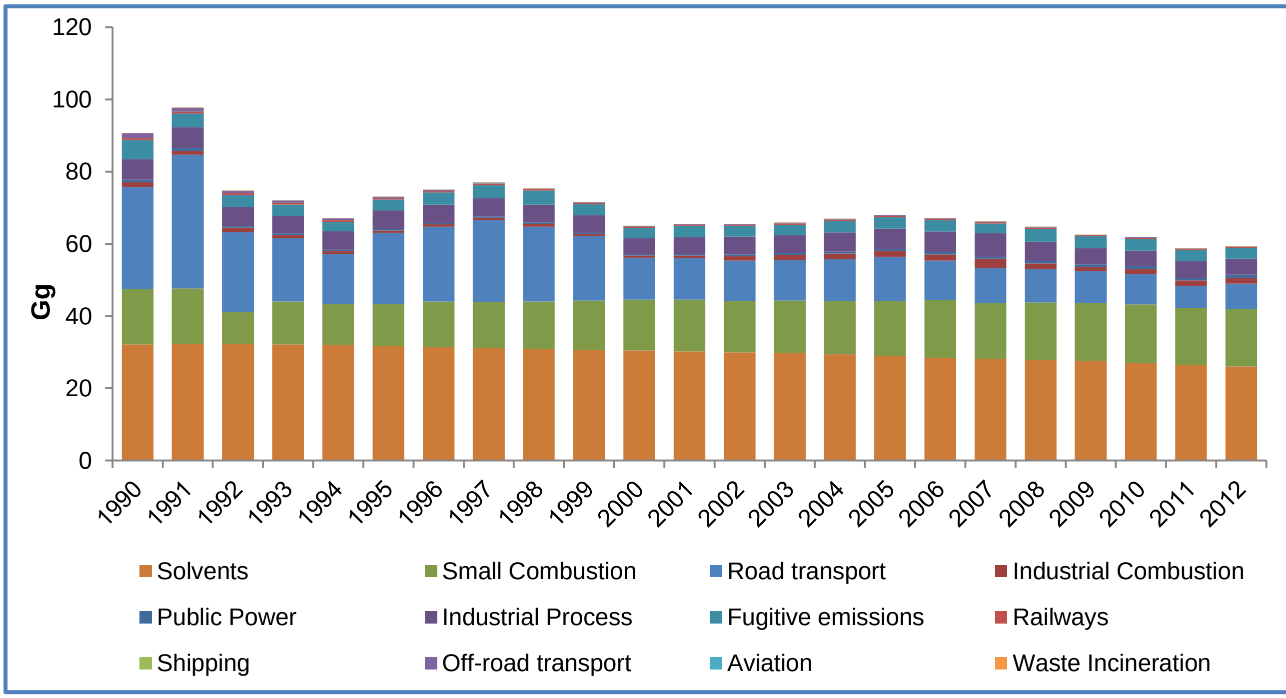

Figure 2-15. Emission trend for NMVOC by sectors, 1990-2012

Technological controls for volatile organic compounds (VOCs) 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 78% between 1990 (28,2 Gg) and 2012 (6,1 Gg), by contributing from 31% in 1990 to 11% of the national total in 2012. Combustion sources in the Residential (1.A.4.b) and Commercial/Institutional (1.A.4.a) combined sectors are another important sources, accounting for 8% of national total NMVOC emissions in 2012. 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 1990-2012 by 2,5 times. The total CO emission decreased from 452,1 Gg in 1990 to 187,5 Gg in 2012 (Figure 2-16).

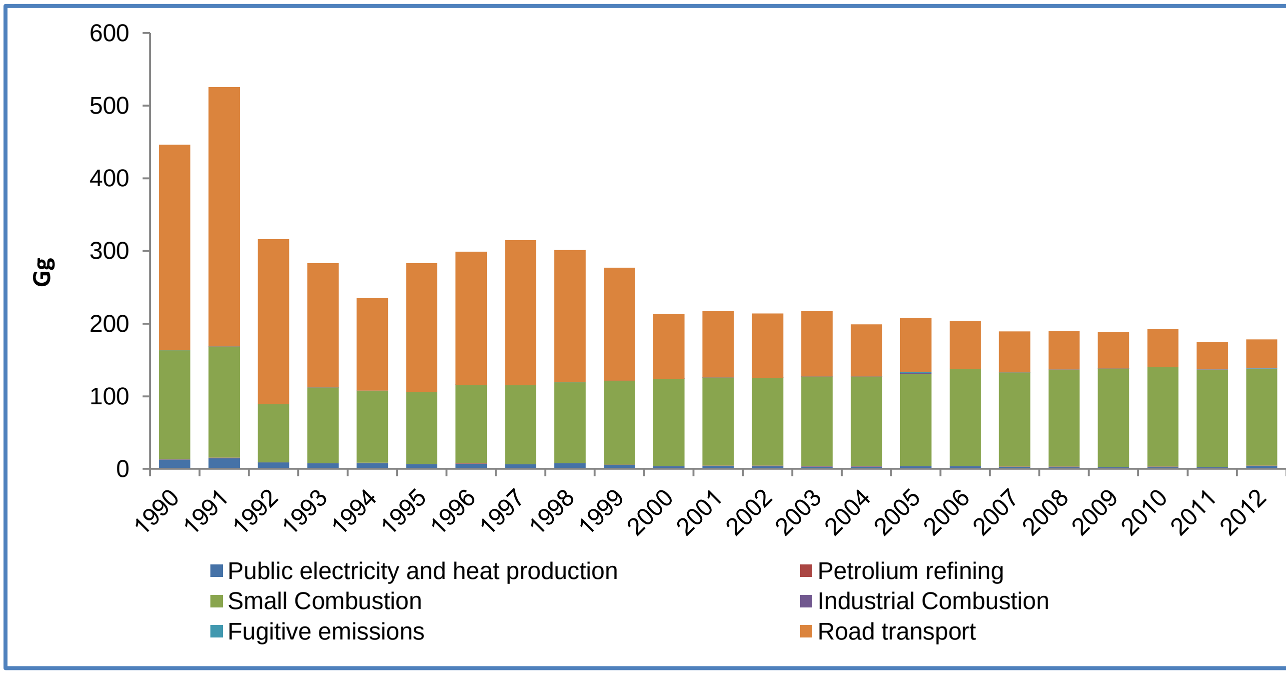

Figure 2-16. Emission trend for CO by sectors, 1990-2012

Carbon monoxide emissions, total 187 Gg (2012), originates generally from the Industrial combustion sector. This sector generated the biggest part of the total CO emissions – 75% (2012). Public Electricity and Heat Production (1.A.1.a) sector although contributing by only 4.2% of national total CO emissions in 2012, is continuing to grow indicating an increase by 17,0% between 1990 (4,56 Gg) and 2012 (5,34 Gg). 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).

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, 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 (2,9%). In 2009, GDP decreased by 14,8%. Since 2010 Lithuania's GDP has grown slightly by 1,4% in 2010, 6,0% in 2011 and 3,7% in 2012. Export has been the main driver of increased GDP during 2010–2012 (Statistics Lithuania, 2012).

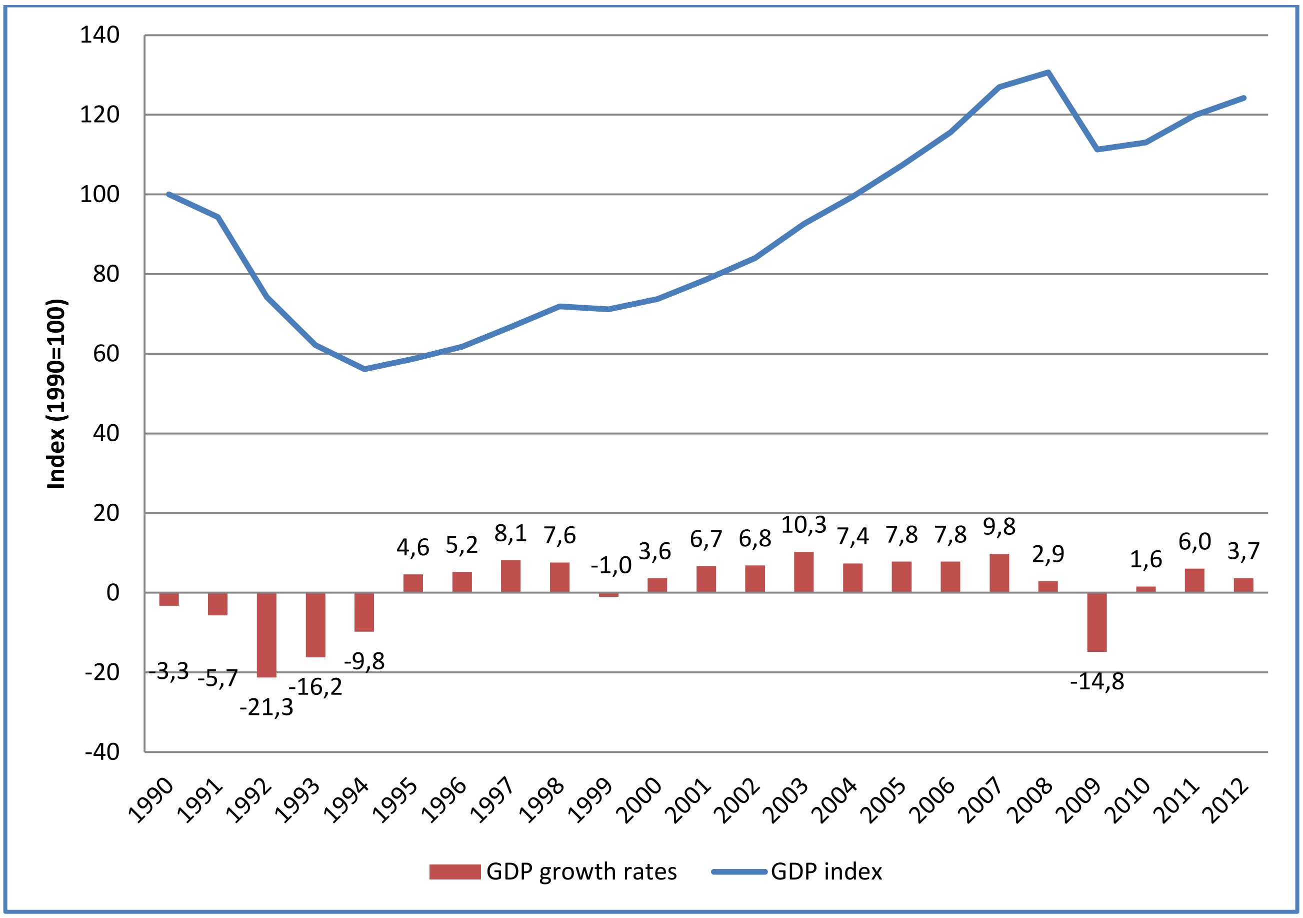

Figure 3-1. Changes of GDP annual growth rates and index in Lithuania

Dynamics of primary energy consumption in Lithuania during 1990-2012 is presented in Figure 3-2. Total primary energy consumption in 1990 amounted to 675,87 PJ (16,14 Mtoe) and in 2012 – 309,29 PJ (7,39 Mtoe). Oil and oil products were the most important fuel in Lithuania over previous decade. However, since 2000 their share in the primary energy balance has been fluctuating about

30% with the smallest portion of 23,9% in 2003 and the largest share of 39,1% in 2010. 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 27,8%, but in 2010 due to closure of Ignalina Nuclear Power Plant (NPP) the share of oil products increased to 39,1%. With reference to data of 2012, the share of oil and oil products was 37,1%.

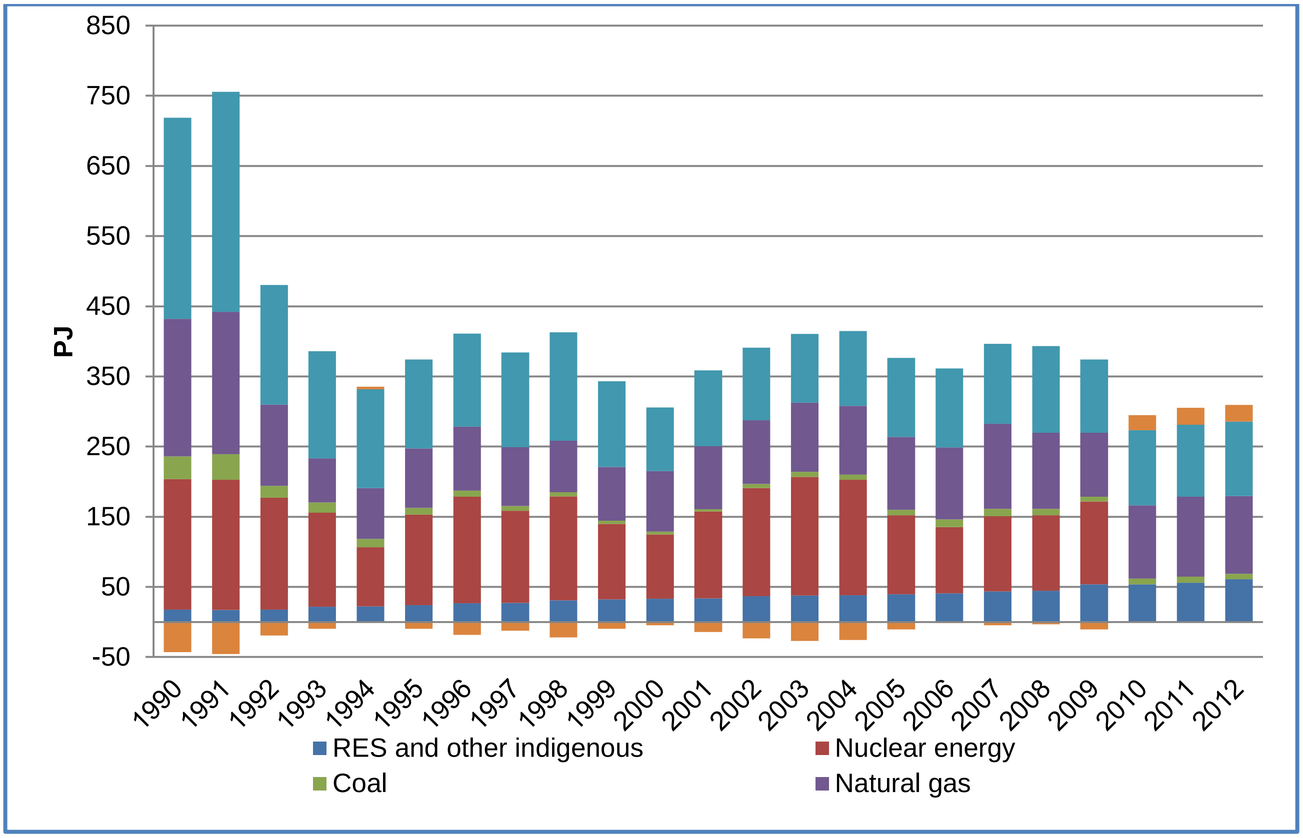

Figure 3-2. Primary energy consumption in Lithuania

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 30,5% in 2007. Total consumption of natural gas was decreasing 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 14,5 percentage points, i.e. from 24,4% in 2009 till 38,9% in 2012.

During the last decade the share of nuclear energy was very high and fluctuated about 30% with the lowest value of 26,1% in 2006 and the highest value of 41,1% 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 31,6%. 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 2011, share of electricity generated by all Lithuanian power plants was about 43% in the balance of gross consumption and 57% of electricity necessary to meet internal requirements was covered by electricity import, mostly from Russia.

Over the period 2000-2012 the share of coal in the primary energy balance was fluctuating about 2,0%, and in 2012 contribution of this fuel was 2,7%.

Comparison of the primary energy consumption structure in 1990 and in 2012 is presented in Figure 3-3.

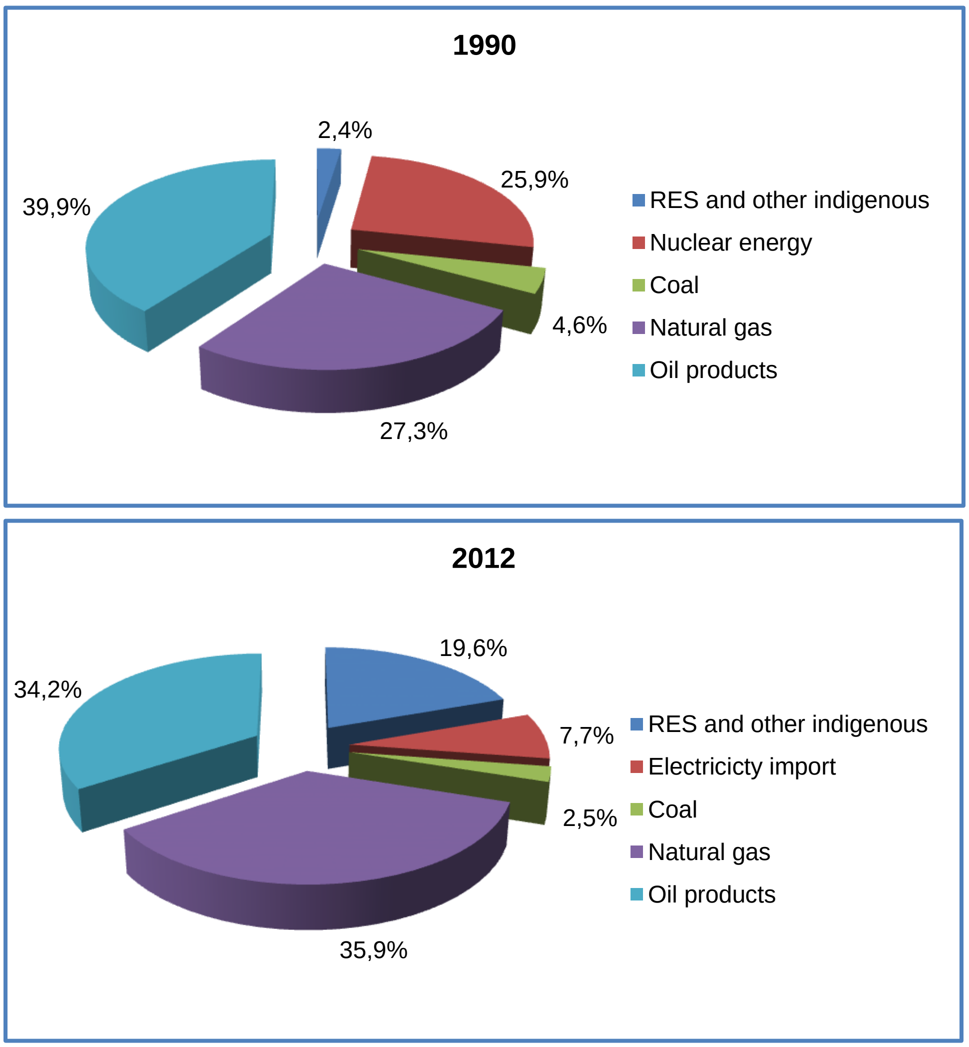

Figure 3-3. Structure of primary energy consumption in Lithuania

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. Nevertheless contribution of renewable energy sources into the country's primary energy balance during the period 1990-2012 was increasing (Statistics Lithuania, 2004, 2006-2012). During the period 1990-2012 primary energy supply from renewable sources increased by 3,6 times with an average annual growth of 6,0%. Primary supply from renewable energy sources reduced by 0,8% in 2011 due to consumption reduction of wood and agricultural waste, bioethanol, hydro and geothermal energy. 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 accounts for 86,1% in the balance of renewable energy sources. The second largest renewable energy source is liquid biomass. In 2012, a share of bioethanol and biodiesel was 5,4%. Hydro power is fluctuating and currently provides 3,1% in the balance of renewable energy sources.

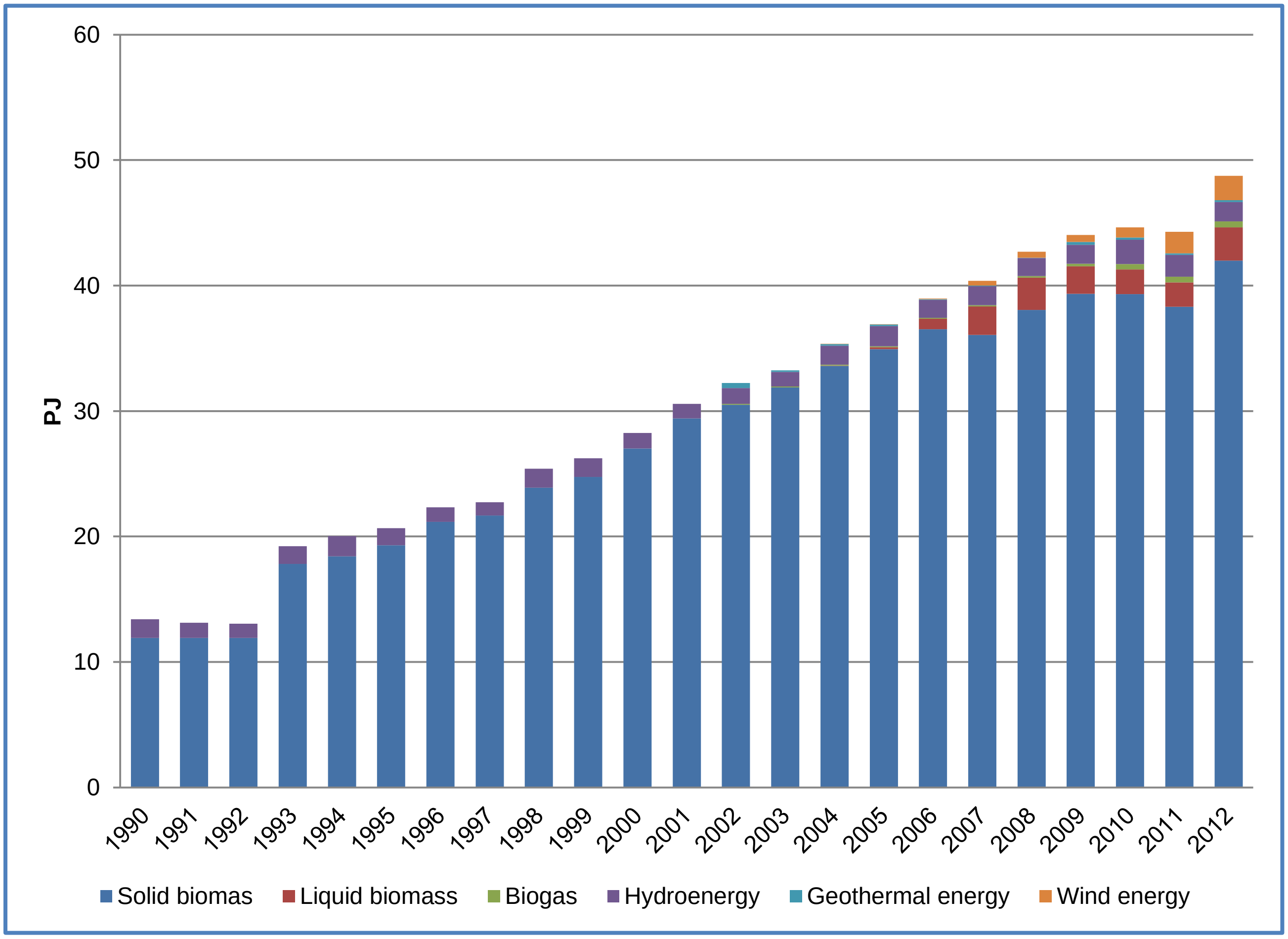

Figure 3-4. Consumption of renewable energy sources in Lithuania

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 71%. 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 (mostly from Russia).

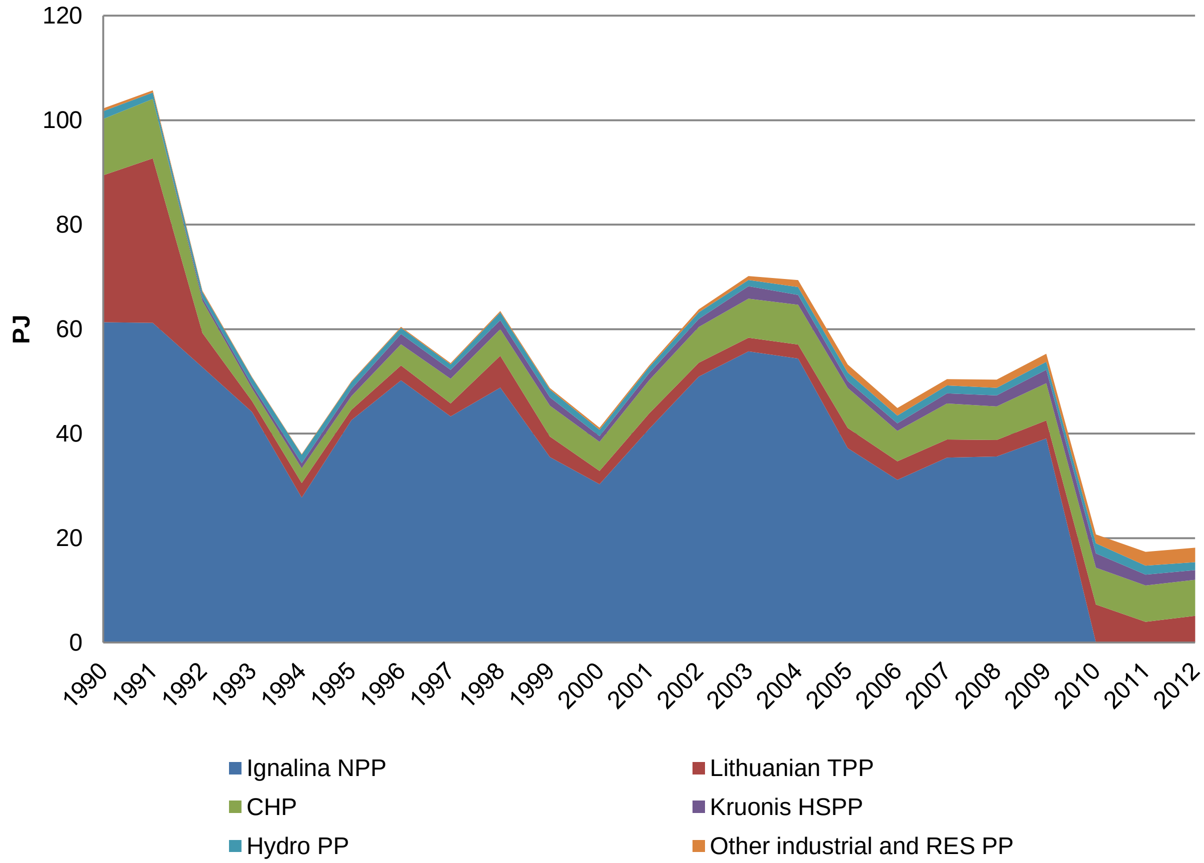

Figure 3-5. Structure of electricity generation in Lithuania

Taking into consideration 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 10,7% per year. Current electricity generation from renewable energy sources is still dominated by hydropower, generating about 36,4% of RES-E in 2012 and wind power, producing 46,5% of RES-E in 2012.

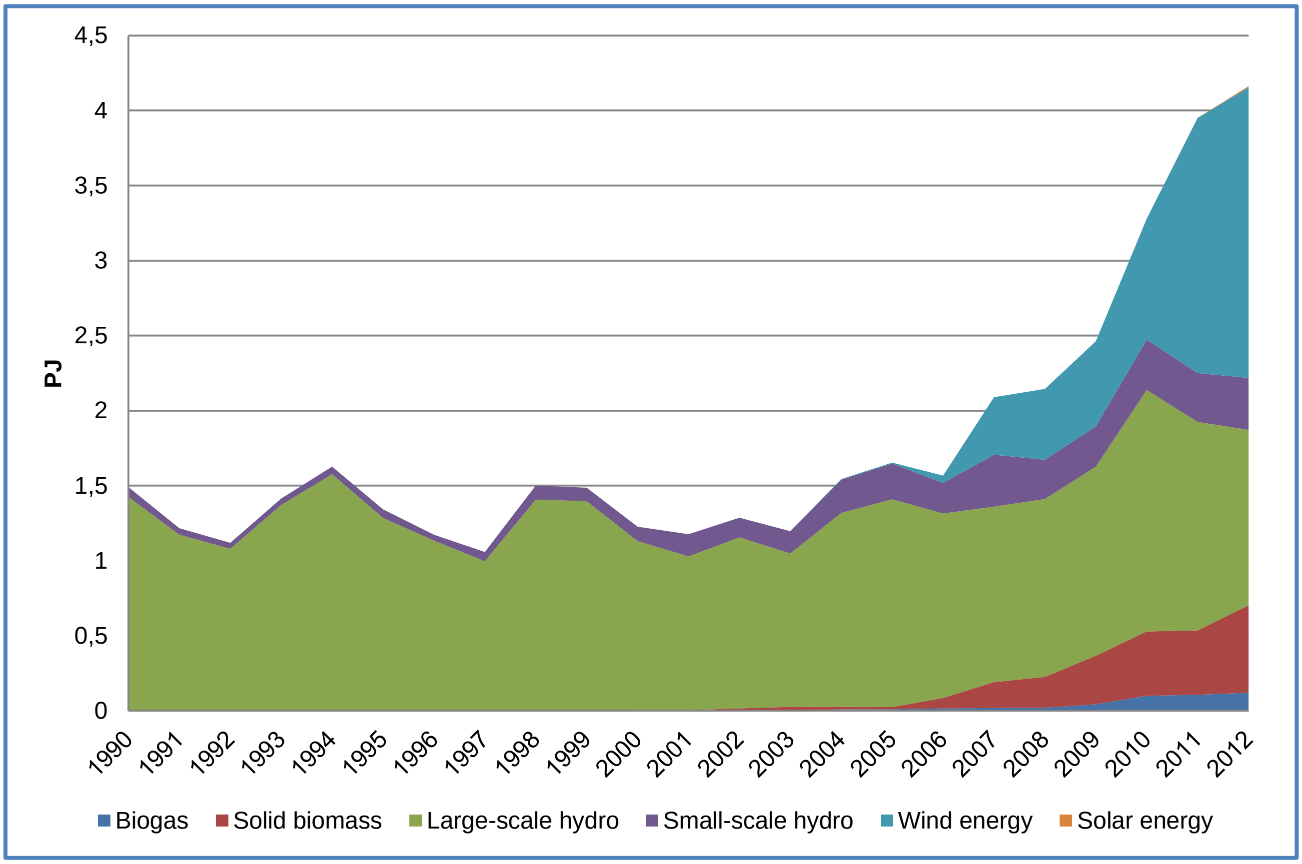

Figure 3-6. Green electricity production in Lithuania

Since 2006 the role of new renewable energy sources is growing rapidly in the Lithuanian electricity market. In 2012, about 46,5% of green electricity was covered by wind energy, 14,0% by biomass and about 2,9% by biogas. With reference of data 2012, there was produced 8 TJ (2,3 GWh) of solar electricity. Solar electricity contribution to the structure of RES-E was minor – 0,2% in 2012.

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 2000-2008 by 4,0% per annum, and in 2008 it was 205,3 PJ (4,9 Mtoe) (Statistics Lithuania, 2004, 2006, 2010). During this period the final energy consumption was increasing in all sectors of the national economy.

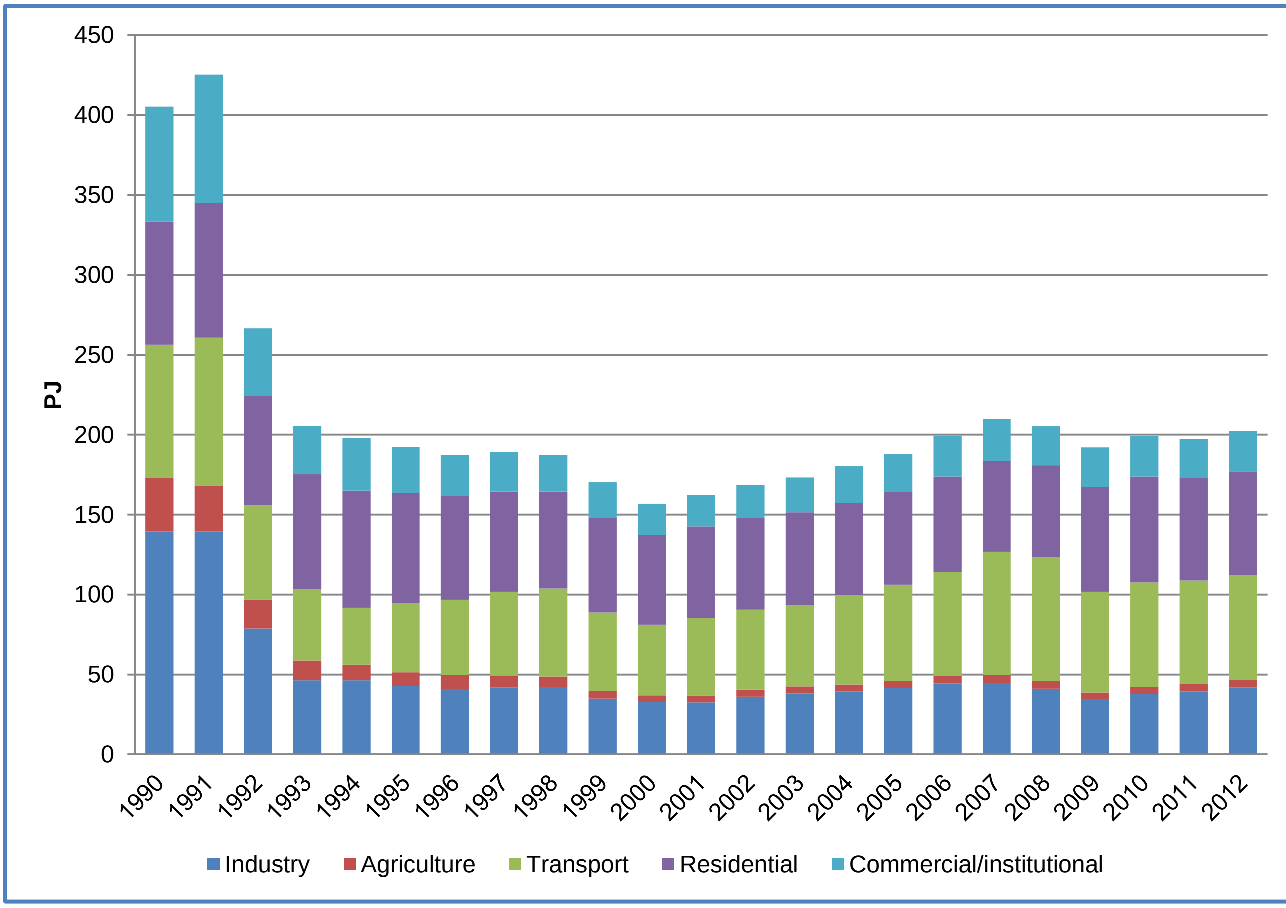

Figure 3-7. Final energy consumption in Lithuania

In 2009, total final energy consumption was by 6,4% 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 3,7% in 2010. However, in 2011 the final energy consumption reduced by 0,86% and amounted to 197,39 PJ (4,72 Mtoe). This decrease was mainly caused by reduced energy consumption in transport, residential and commercial/institutional sectors. Final energy consumption in industry increased by 5,1% in 2011 due to growing activities of Lithuanian manufacturing sector. In 2012 the final energy consumption increased by 2,6% and amounted to 202,5 PJ (4,84 Mtoe).

Several emission sources in the Energy Sector are key categories. Key categories in 2012 by level (L) and trend (T), excluding LULUCF are listed in Table 3-1.

Table 3-1. Key category from Energy Sector in 2012 by Level and Trend excluding LULUCF

IPCC source categoty	Gas	Identification criteria	Approach used
1.AA.1.A Public electricity and heat production, gaseous fuel	CO_2	Level	Tier 1 / Tier 2
		Trend	Tier 1
1.AA.1.A Public electricity and heat production, liquid fuel	CO_2	Level	Tier 1
		Trend	Tier 1 / Tier 2

1.AA.1.B Petroleum refining, liquid fuel	CO_2	Level	Tier 1
		Trend	Tier 1 / Tier 2
1.AA.2 Manufacturing industries and construction, gaseous fuels	CO_2	Level	Tier 1
		Trend	Tier 1
1.AA.2 Manufacturing industries and construction, liquid fuels	CO_2	-	-
		Trend	Tier 1 / Tier 2
1.AA.2 Manufacturing industries and construction, solid fuels	CO_2	Level	Tier 1
		Trend	Tier 1 / Tier 2
1.AA.3.B Road transportation, diesel	CO_2	Level	Tier 1 / Tier 2
		Trend	Tier 1 / Tier 2
1.AA.3.B Road transportation, gasoline	CO_2	Level	Tier 1
		Trend	Tier 1
1.AA.3.B Road transportation, LPG	CO_2	Level	Tier 1
		Trend	Tier 1
1.AA.3.C Railways	CO_2	Level	Tier 1
		-	-
1.AA.3.E Off-road vehicles and machinery	CO_2	Level	Tier 1
		Trend	Tier 1 / Tier 2
1.AA.4 Other sectors, biomass	CH_4	Level	Tier 2
		Trend	Tier 1 / Tier 2
1.AA.4 Other sectors	N_2O	-	-
		Trend	Tier 2
1.AA.4.A Commercial/Institutional	CO_2	Level	Tier 1
		Trend	Tier 1 / Tier 2
1.AA.4.B Residential	CO_2	Level	Tier 1
		Trend	Tier 1
1.B. Fugitive Emissions from Fuels	CH_4	Level	Tier 1
		Trend	Tier 1

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)
  - Other (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 III includes summary of study on "Determination of national GHG emission factors for energy sectors" (fuel combustion) performed by Lithuanian Energy Institute in August 2012.

In the Energy sector emissions of CO_2 contribute about 95% of total greenhouse gas emissions CO_2 eqv. in 2012. Trends of total GHG emissions calculated as CO_2 equivalents from the energy sector are presented in Figure 3-8. Total greenhouse gases (GHG) from the energy sector have decreased by almost 2,7 times from 32653,2 Gg CO_2 eqv. in 1990 to 11876,1 Gg CO_2 eqv. in 2012. 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 2,2% 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 GHG increase by 7,9% in 2010. In 2011, total GHG emissions in Energy sector decreased by 7,5%. 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.

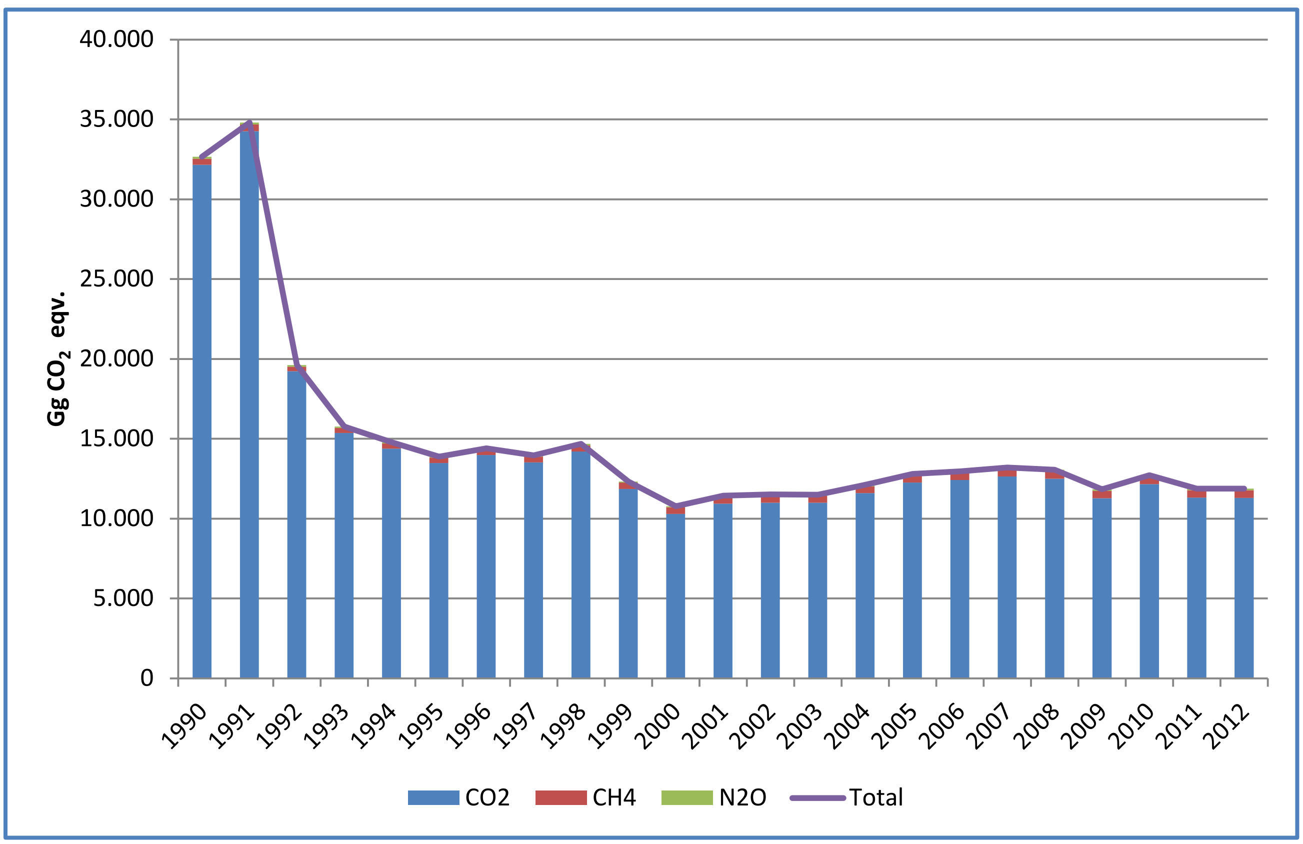

Figure 3-8. Total GHG emission from the Energy Sector (CRF 1), Gg CO_2 eqv.

Changes in structure of GHG emissions in energy sector showed in Figure 3-9. Historically the 1.A.1 Energy industries accounted for the largest share of GHG emission from Energy Sector. In 2012 this source category amounted about 37,1% of total GHG emission from energy sector. During the period 1990-2012 the share of transport sector increased significantly. In 1990 transport sector accounted for 22,9% of total GHG emission from Energy Sector and in 2012 - 38,2%. In 2012 transport accounted the largest share of GHG emission from Energy sector.

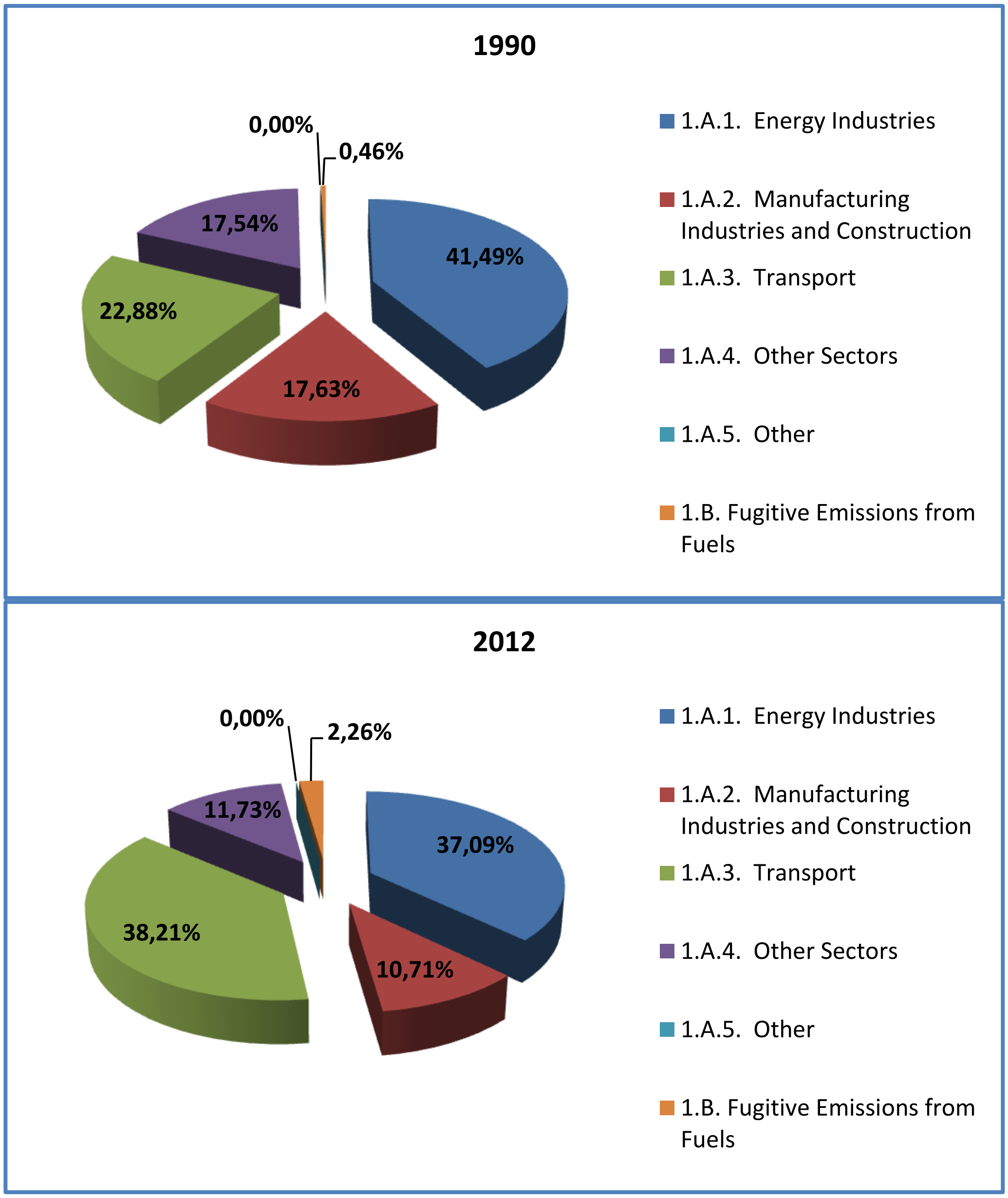

Figure 3-9. Structure of GHG emission from Energy Sector in 1990 and 2012

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%. Growing activities in the Manufacturing industries and construction sector stipulated increase in GHG emissions during 2009-2012. GHG emissions from Transport sector in 2012 increased by 0,5%. 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 5,1% due to implemented energy eficiency measures and incresed share of biomas 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 2,6% per annum. In 2012 fugitive emissions accounted 269,0 Gg CO_2 eqv.

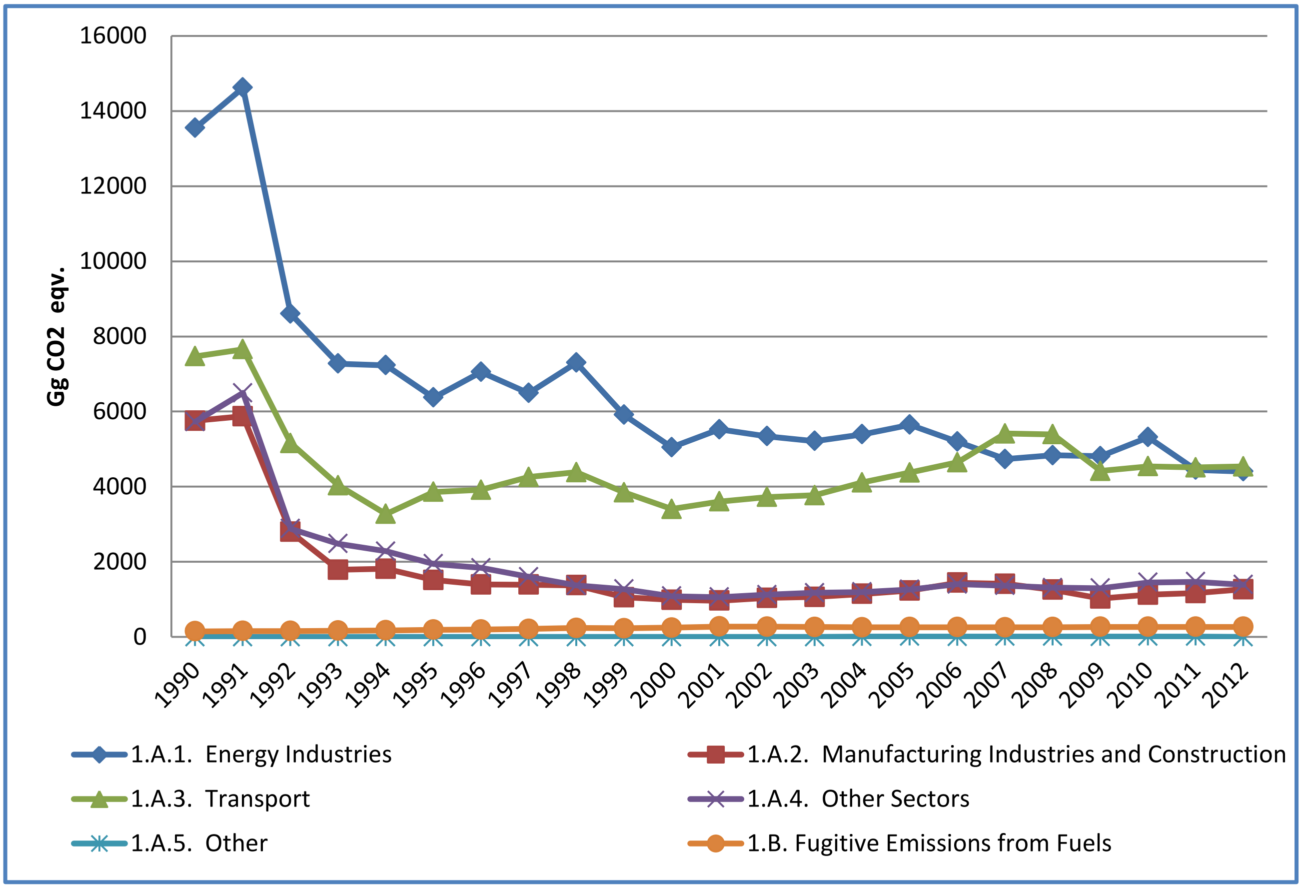

Figure 3-10. Total GHG emissions from the different subsectors within the Energy Sector, (CRF 1), Gg CO_2 eqv.

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.

Differences between sectoral and reference approach were estimated for fuel consumption and CO_2 emissions. Figure 3-11 shows comparison of CO_2 emissions estimates for the two approaches for the period 1990–2012.

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

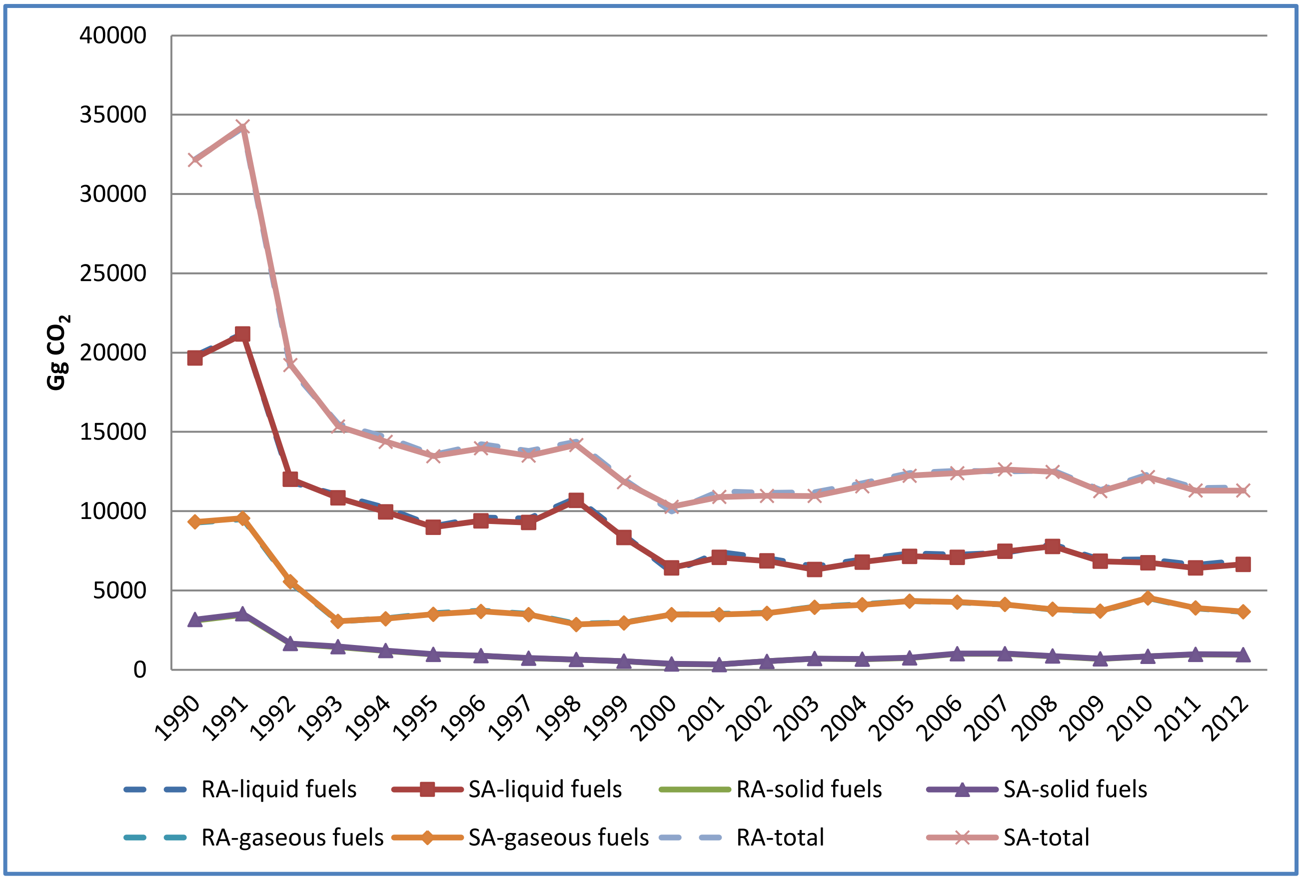

Figure 3-11. Comparison of CO_2 emissions between sectoral and reference approach

Figure 3-11 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

Year	Reference approach					Sectoral approach				
	Liquid, Gg CO_2	Solid, Gg CO_2	Gaseous, Gg CO_2	Other, Gg CO_2	Total, Gg CO_2	Liquid, Gg CO_2	Solid, Gg CO_2	Gaseous, Gg CO_2	Other, Gg CO_2	Total, Gg CO_2
1990	19814	3102	9283	-	32199	19669	3164	9322	-	32154
1991	21204	3466	9499	-	34169	21170	3535	9557	-	34261
1992	11844	1626	5489	-	18959	12019	1654	5548	-	19220
1993	11008	1435	3051	-	15494	10836	1461	3053	-	15350
1994	10213	1195	3248	-	14656	9950	1215	3214	-	14379
1995	9046	959	3559	-	13564	8989	974	3504	-	13467
1996	9609	882	3728	-	14219	9392	891	3677	-	13961
1997	9548	723	3522	-	13793	9281	734	3480	-	13495

1998	10835	631	2910	-	14377	10675	642	2857	-	14174
1999	8483	535	2975	-	11993	8329	544	2959	-	11832
2000	6143	367	3484	-	9993	6427	372	3478	-	10278
2001	7417	328	3516	-	11262	7082	334	3477	-	10892
2002	7037	533	3577	-	11147	6864	539	3560	-	10964
2003	6519	699	3977	-	11195	6312	706	3942	-	10960
2004	6964	670	4127	-	11760	6795	680	4098	-	11573
2005	7333	742	4334	-	12409	7154	755	4333	-	12242
2006	7265	1006	4250	18	12539	7086	1023	4267	19	12395
2007	7374	1004	4101	21	12501	7469	1019	4120	22	12630
2008	7897	850	3798	19	12565	7782	866	3817	19	12484
2009	6944	682	3686	17	11329	6842	694	3704	17	11257
2010	6966	833	4507	18	12324	6747	848	4529	18	12143
2011	6611	962	3871	21	11466	6414	980	3891	21	11305
2012	6890	943	3647	22	11503	6649	960	3665	23	11296

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 fuels, %	Total, %
1990	0.74	-1.95	-0.42	-	0.14
1991	0.16	-1.95	-0.61	-	-0.27
1992	-1.45	-1.68	-1.06	-	-1.36
1993	1.59	-1.82	-0.06	-	0.94
1994	2.65	-1.66	1.04	-	1.92
1995	0.64	-1.56	1.58	-	0.72
1996	2.31	-1.01	1.38	-	1.85
1997	2.88	-1.44	1.20	-	2.21
1998	1.50	-1.68	1.85	-	1.43
1999	1.84	-1.62	0.54	-	1.36
2000	-4.43	-1.41	0.17	-	-2.77
2001	4.74	-1.63	1.14	-	3.39
2002	2.52	-1.19	0.48	-	1.67
2003	3.28	-0.93	0.89	-	2.15
2004	2.49	-1.46	0.69	-	1.62
2005	2.51	-1.73	0.03	-	1.37

2006	2.53	-1.75	-0.41	-1,00	1.16
2007	-1.27	-1.51	-0.46	-1,00	-1.03
2008	1.48	-1.81	-0.50	-1,00	0.64
2009	1.49	-1.71	-0.49	-1,00	0.64
2010	3.24	-1.77	-0.49	-1,00	1.49
2011	3.08	-1.79	-0.49	-1,00	1.42
2012	3.63	-1.75	-0.50	-1,00	1.83

In reference approach emissions are estimated by subtracting 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.

3.2.2 International bunker fuels

GHG emissions and activity data from navigation assigned to international bunkers are presented in the following Table 3-4.

Table 3-4. GHG emissions and activity from 1.C1.B International bunkers-marine 1990-2012

Year	CO_2, Gg	CH_4, Gg	N_2O, Gg	Activity data, TJ
1990	302,2	0,019	0,002	3894
1991	498,3	0,032	0,004	6422
1992	925,1	0,060	0,007	11921
1993	510,8	0,033	0,004	6583
1994	482,8	0,031	0,004	6222
1995	448,5	0,029	0,003	5780
1996	417,4	0,027	0,003	5379
1997	192,3	0,012	0,001	2496
1998	158,1	0,010	0,001	2094
1999	229,5	0,015	0,002	3019
2000	292,6	0,019	0,002	3828
2001	314,9	0,021	0,002	4112
2002	348,9	0,023	0,003	4554
2003	348,2	0,023	0,003	4532
2004	360,1	0,023	0,003	4692
2005	456,8	0,030	0,004	5933
2006	437,8	0,028	0,003	5681
2007	380,7	0,025	0,003	4944
2008	285,9	0,019	0,002	3722
2009	406,9	0,026	0,003	5285
2010	445,0	0,029	0,003	5781
2011	452,4	0,029	0,004	5883
2012	384,5	0,025	0,003	5006

Tier 2 is used for CO_2 emissions estimates and Tier 1 for CH_4 and N_2O for International bunkers. 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 3-5. Country specific CO_2 emission factor and IPCC default values of CH_4 and N_2O has been used.

Table 3-5. Emission factors used for International bunkers

	CO_2, t/TJ	CH_4, t/TJ	N_2O, t/TJ
Marine			
Gas/diesel oil	72,89	0,005	0,0006
Residual fuel oil	77,60	0,005	0,0006
Aviation			
Jet kerosene	72,24	0,0005	0,002

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.C1.A International bunkers aviation 1990–2012

Year	CO_2, Gg	CH_4, Gg	N_2O, Gg	Activity data, TJ
1990	399,3	0,003	0,011	5527
1991	480,5	0,003	0,013	6652
1992	194,7	0,001	0,005	2695
1993	107,9	0,001	0,003	1494
1994	114,6	0,001	0,003	1586
1995	118,0	0,001	0,003	1634
1996	96,7	0,001	0,003	1338
1997	90,8	0,001	0,003	1257
1998	81,8	0,001	0,002	1133
1999	76,1	0,001	0,002	1053
2000	70,2	0,000	0,002	972
2001	93,6	0,001	0,003	1295
2002	83,4	0,001	0,002	1155
2003	93,5	0,001	0,003	1294
2004	104,4	0,001	0,003	1445
2005	138,9	0,001	0,004	1923
2006	158,1	0,001	0,004	2189
2007	198,1	0,001	0,005	2742
2008	229,4	0,002	0,006	3176
2009	109,9	0,001	0,003	1522
2010	145,3	0,001	0,004	2012
2011	166,9	0,001	0,005	2311
2012	190,3	0,001	0,005	2634

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 2001. Since 2001 Statistics Lithuania distinguishes aviation fuel consumption between domestic and international flights, however for 1990-2000 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 is used for domestic purposes and thus all the rest (gasoline type jet fuel and 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 aviation are presented in Table 3-5.

In this category following recalculations has been done:

- correction of activity data (jet kerosene) based on the newest information provided by the Lithuanian Statistics in November 2013.

Impact of these recalculations is presented in Table 3-7.

Table 3-7. Impact of recalculation on GHG emissions from 1.C1 International bunkers

Year	Submission 2013, Gg CO_2 eqv.	Submission 2014, Gg CO_2 eqv.	Absolute difference, Gg CO_2 eqv.	Relative difference, %
2000	367.8	364.6	-3.2	-0.9
2001	415.2	410.4	-4.7	-1.1
2004	468.2	466.7	-1.5	-0.3
2005	598.8	598.6	-0.2	-0.04

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 3-12). In 2012, natural gas amounted about 60,3% and refinery feedstocks - 30,6% in the structure of feedstocks and non-energy use of fuels. In this submission the data on sulphur (from oil) are updated for the whole time series based on the newest information provided by the Statistics Lithuania in November 2013.

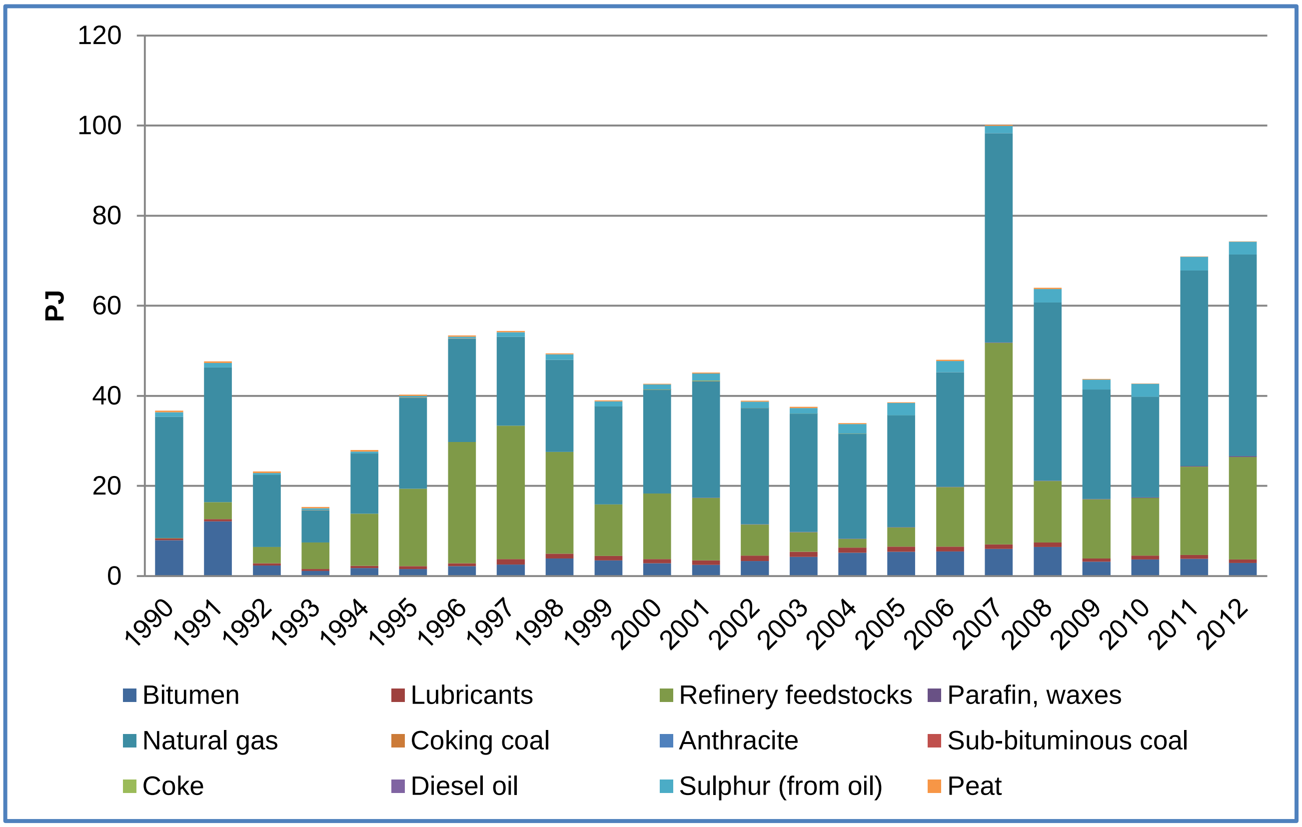

Figure 3-12. Feedstocks and non energy use of fuels in Lithuania

The natural gas is used for ammonia production in the AB Achema which is a single ammonia production company in Lithuania. 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 amounts of non-emitted CO_2 were calculated in accordance with the methodology provided in 1996 IPCC Guidelines. The amounts of non-emitted CO_2 are reported in CRF 1.AD Feedstocks and non-energy use and linked to the CRF 1.AB Fuel Combustion - Reference Approach as carbon stored.

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 3-8 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 3-8. 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 Biomass	+	+	+
1.A.1.a Other fuels	NO	NO	NO
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 Biomass	+	+	+
1.A.1.b Other fuels	NO	NO	NO
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 Biomass	+	+	+
1.A.1.c Other fuels	NO	NO	NO
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 Biomass	NO	NO	NO
1.A.2.a Other fuels	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	+	+	+
1.A.2.b Gaseous fuels	+	+	+
1.A.2.b Biomass	NO	NO	NO
1.A.2.b Other fuels	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 Biomass	+	+	+
1.A.2.c Other fuels	NO	NO	NO
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 Biomass	+	+	+
1.A.2.d Other fuels	NO	NO	NO
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 Biomass	+	+	+
1.A.2.e Other fuels	NO	NO	NO
1.A.2.f Other			
1.A.2.e Liquid fuels	+	+	+
1.A.2.e Solid fuels	+	+	+
1.A.2.e Gaseous fuels	+	+	+
1.A.2.e Biomass	+	+	+
1.A.2.e Other fuels	+	+	+
1.A.3.a Civil Aviation			
1.A.3.a Aviation Gasoline	+	+	+
1.A.3.a Jet Kerosene	+	+	+
1.A.3.b Road Transportation			
1.A.3.b Gasoline	+	+	+
1.A.3.b Diesel Oil	+	+	+
1.A.3.b LPG	+	+	+
1.A.3.b Natural Gas	+	+	+
1.A.3.b Biomass	+	+	+

1.A.3.b Other 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 Other Fuels	NO	NO	NO
1.A.3.d Navigation			
1.A.3.d Liquid Fuels	+	+	+
1.A.3.d Solid Fuels	NO	NO	NO
1.A.2.d Gaseous fuels	NO	NO	NO
1.A.3.d Other Fuels	NO	NO	NO
1.A.3.e Other			
1.A.3.d Liquid Fuels	+	+	+
1.A.3.d Solid Fuels	NO	NO	NO
1.A.2.d Gaseous fuels	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 Biomass	+	+	+
1.A.4.a Other fuels	NO	NO	NO
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 Biomass	+	+	+
1.A.4.b Other fuels	NO	NO	NO
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 Biomass	+	+	+
1.A.4.c Other fuels	NO	NO	NO
1.A.5 Other			
1.A.5 Liquid fuels	+	+	+
1.A.5 Solid fuels	NO	NO	NO
1.A.5 Gaseous fuels	NO	NO	NO
1.A.5 Biomass	NO	NO	NO
1.A.5 Other fuels	NO	NO	NO

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

3.2.6.1 Source category description

During last two decades 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 47% of the overall available electrical capacity is covered by this power plant. Characteristics of the Lithuanian power plants in 2012 are presented in Table 3-9.

Table 3-9. Characteristics of the Lithuanian power plants in 2012 (Energy in Lithuania, 2012)

Power plant	Fuel	Available capacity, MW
Lithuanian TPP	Residual fuel oil, natural gas, orimulsion	1304 (1884*)
Vilnius CHP	Residual fuel oil, natural gas	303
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	**-**	**3294 (3874*)**

* – 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 2012, 42,1% of heat supplied to district heating systems was produced at Combined Heat and Power plants (CHP) and 35,9% - at heat only boilers and 22% - at geothermal and other plants.

Natural gas is the main fuel used in the district heating sector. In 2012 natural gas covered about 68,2% of fuel consumption. Since 2000 the share of renewable energy increased significantly from 2% in 2000 to 27,2% in 2012 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 in public power and heat plants.

3.2.6.2 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, CH_4 and N_2O were calculated applying Tier 1 or Tier 2 (as presented in Table 3-10).

Emission factors and methods

Emission factors and methods used in the calculations of emissions from Public Electricity and Heat Production (1.A.1.a) are presented in Table 3-10.

Table 3-10. Emission factors and methods for category Public Electricity and Heat Production (1.A.1.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
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	3,0	D	T1	0,6	D	T1
Not liquefied petroleum gas	56,33	PS	T3	3,0	D	T1	0,6	D	T1
Orimulsion	81,74	PS	T3	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
Emulsified vacuum residue	79,41	PS	T3	3,0	D	T1	0,6	D	T1

Peat	104,34	CS	T2	1,0	CS	T2	1,5	CS	T2
Coking coal	94,90	CS	T2	1,0	D	T1	1,4	D	T1
Sub-bituminous coal	96,00	PS	T3	1,0	D	T1	1,4	D	T1
Anthracite	106,55	PS	T3	1,0	D	T1	1,4	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
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; D - default emission factors (1996 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.

1996 IPCC default emission factors were used for CH_4 and N_2O emissions estimation, except biogas, peat and used tires (industrial waste). 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 3-11. 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 3-12. 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 2005-2012 are provided in the Annex III. The entire time series (1990-2012) 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 Public electricity and heat production is provided in Figure 3-13.

As it is seen from Figure 3-13, during the latter ten years the consumption of fuels in Public electricity and heat production was rather stable – about 67 PJ a year. However, in 2011 fuel consumption reduced by 18,9% in comparison to 2010. This is mainly due to reduction of natural

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

gas consumption. Natural gas combustion volumes reduced by 17,5% in 2011. Consumption of fuels in Public electricity and heat production increased by 4,3% in 2012 and amounted 63,7 PJ.

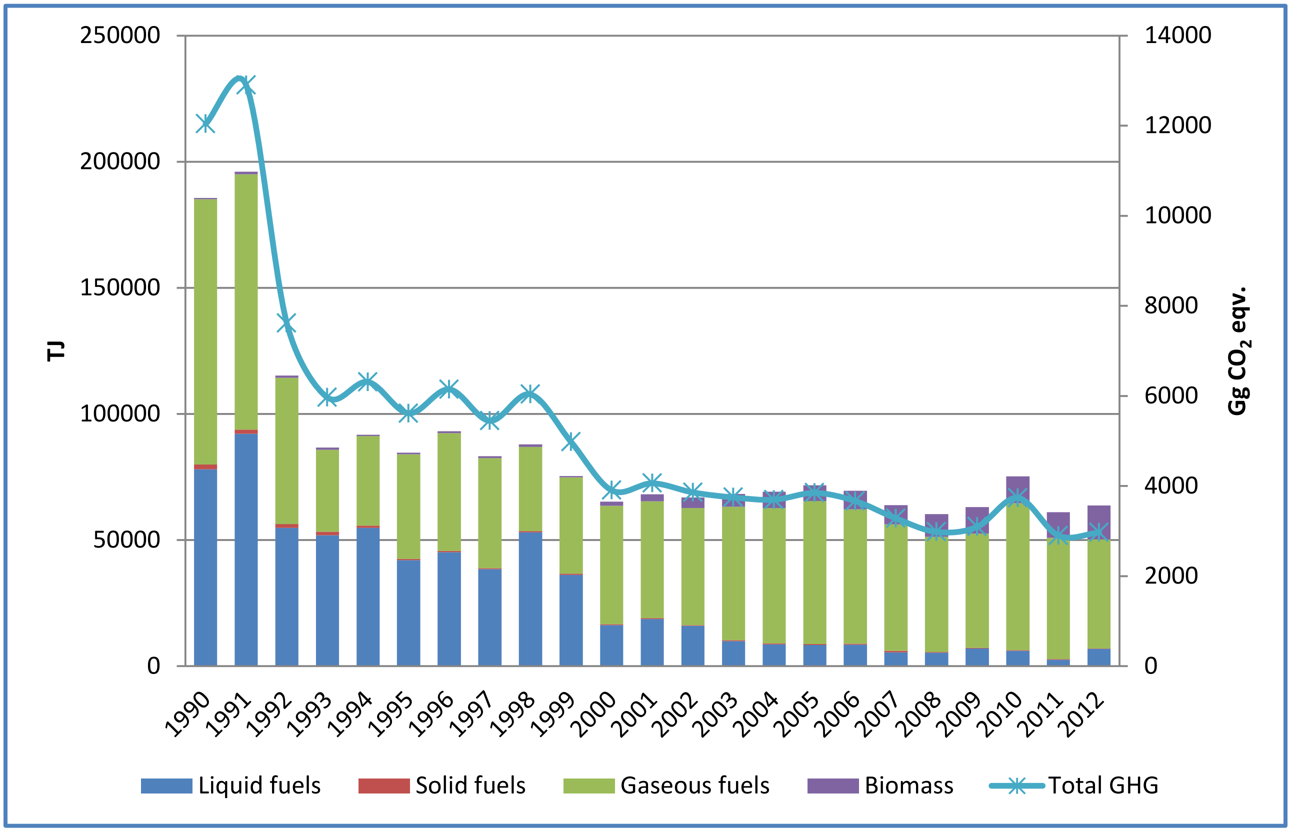

Figure 3-13. Tendencies of fuel consumed and GHG emissions in Public Electricity and Heat Production (1.A.1.a)

Natural gas dominates in the structure of total fuel combusted for Public Electricity and Heat Production. In 2012 natural gas accounted 67,9%. This is by 10,7 percentage points less than in 2011. The share and volume of liquid fuels drastically reduced since 1990s and in 2011 accounted only 3,9% in structure of fuel combusted. However, in 2012 consumption of residual fuel oil increased by 2,7 times. This caused structural changes in fuel consumption: the share of liquid fuels increased till 10,7%. Since 2000 wood/wood waste started to be widely used for Public Electricity and Heat Production. During a last decade the share of biomass increased from 2,5% (2000) till 20,9% (2012).

Total GHG emissions from Public Electricity and Heat Production reduced by 4 times since 1990.

3.2.6.3 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 ±50% 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 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 in search for outliers.

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

3.2.6.5 Source-specific recalculations

Following recalculations in this category has been done taking into account ERT recommendations:

- dissagregation of activity data for anthracite, coking coal and sub-bituminous since 2000 based on the newest information provided by Lithuanian Statistics in November 2013;
- correction of CO_2 plant specific emission factor for not liquefied petroleum gas based on EU ETS data.

Impact of these recalculations on GHG emissions from 1.A.1.a Public Electricity and Heat Production sector is presented in Table 3-13.

Table 3-13. Impact of recalculation on GHG emissions from 1.A.1a Public Electricity and Heat Production

Year	Submission 2013, Gg CO_2 eqv.	Submission 2014, Gg CO_2 eqv.	Absolute difference, Gg CO_2 eqv.	Relative difference, %
2000	3903,6	3903,3	-0,3	-0,01
2001	4062,4	4060,6	-1,8	-0,04
2002	3859,4	3857,8	-1,6	-0,04
2003	3748,1	3746,4	-1,7	-0,05

2004	3697,7	3696,2	-1,5	-0,04
2005	3847,8	3845,9	-1,9	-0,05
2006	3667,8	3665,9	-1,9	-0,05
2007	3283,0	3281,2	-1,8	-0,05
2008	2982,2	2980,9	-1,3	-0,04
2009	3093,6	3093,5	-0,1	0,00
2010	3737,8	3736,9	-0,9	-0,02
2011	2899,5	2900,3	0,8	0,03

3.2.6.6 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.

3.2.7 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 kerosine, gas/diesel oil, residual fuel oil, LPG and non-liquefied petroleum gas used in Lithuania are produced by the oil refinery UAB ORLEN Lietuva. Imports of the fuels specified above comprise only a minor fraction of the fuels used in Lithuania.

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 3-14) 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 3-14.

Table 3-14. 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
Residual fuel oil	80,81	PS	T3	3,0	D	T1	0,6	D	T1

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

LPG	65,42	CS	T2	3,0	D	T1	0,6	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	56,33	PS	T3	3,0	D	T1	0,6	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; D - default emission factors (1996 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 3-14.

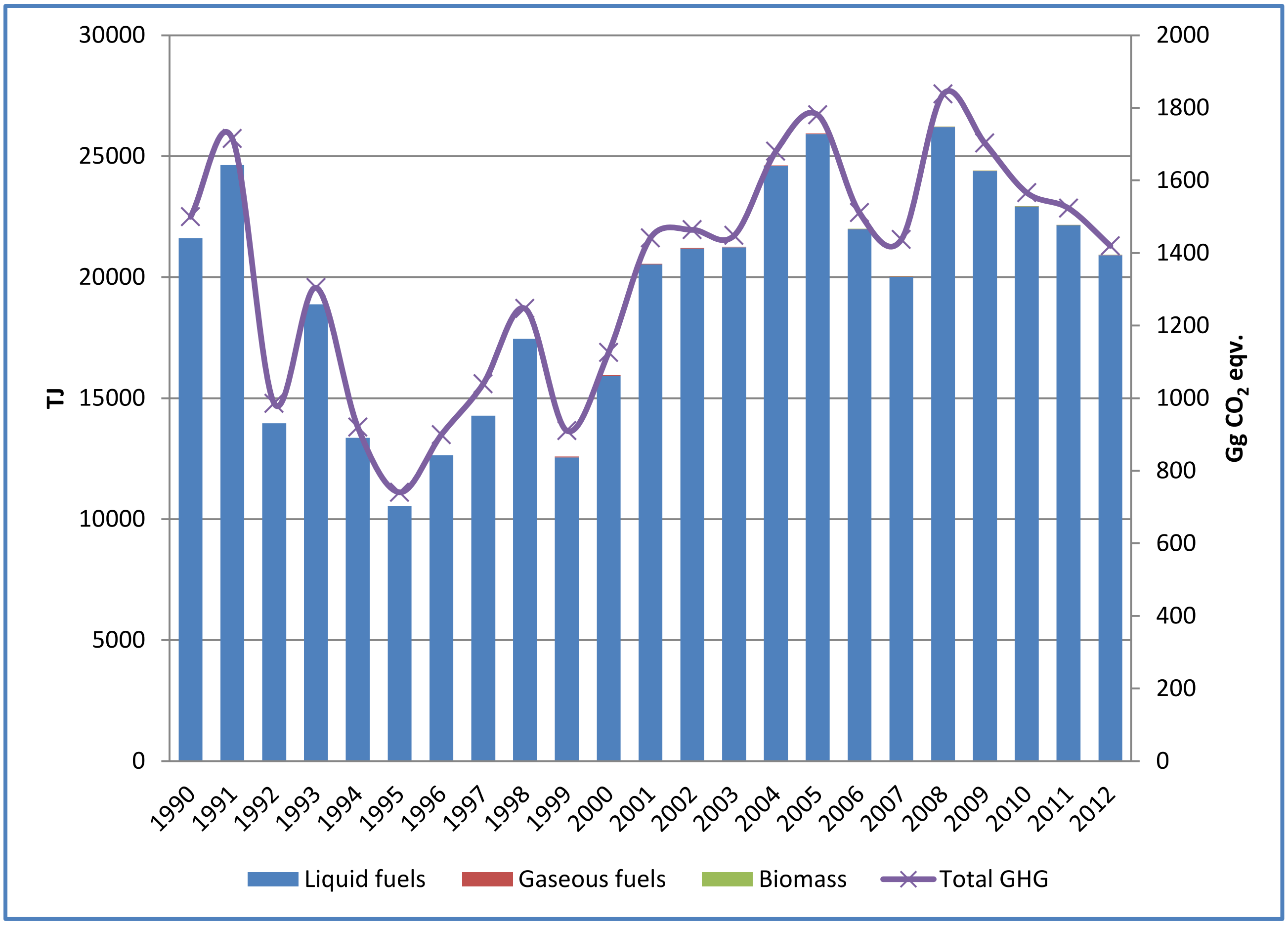

Figure 3-14. Tendencies of fuel consumed and total GHG emissions in Petroleum refinery during 1990-2012

As it is seen from Figure 3-14, liquid fuels are mainly used in Lithuanian Petroleum Refinery industry. Liquid fuels accounted 99,9% of fuel structure in 2012. Historically, non liquefied petroleum gas made more than 50% of total fuel consumed in petroleum refinery. With reference to data of 2012, there was consumed 20,9 PJ, from which non liquefied petroleum gas accounted 62,7%, residual fuel oil – 20,8%, petroleum coke – 16,4%.

Total GHG emissions from Petroleum Refinery in 2012 were below 1990 level by 5%.

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 ±50% 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 recalculations

Following recalculations in this category has been done:

- correction of CO_2 plant specific emission factors for residual fuel oil and not liquefied petroleum gas based on EU ETS data.

Impact of these recalculations on GHG emissions from 1.A.1.b Petroleum Refining are presented in Table 3-15.

Table 3-15. Impact of recalculation on GHG emissions from 1.A.1b Petroleum Refining

Year	Submission 2013, Gg CO_2 eqv.	Submission 2014, Gg CO_2 eqv.	Absolute difference, Gg CO_2 eqv.	Relative difference, %
1990	1501,4	1499,4	-2,0	-0,13
1991	1717,8	1715,0	-2,8	-0,16
1992	987,5	985,5	-2,0	-0,20
1993	1306,2	1304,4	-1,8	-0,14
1994	921,1	920,0	-1,1	-0,12
1995	741,5	740,7	-0,9	-0,12
1996	900,4	899,3	-1,1	-0,12
1997	1040,8	1039,3	-1,5	-0,14
1998	1248,1	1246,8	-1,3	-0,10
1999	911,5	910,1	-1,4	-0,15
2000	1126,8	1125,8	-1,0	-0,09
2001	1442,7	1441,6	-1,1	-0,08
2002	1464,6	1463,6	-1,0	-0,07
2003	1448,3	1447,9	-0,4	-0,03
2004	1680,4	1679,9	-0,4	-0,03
2005	1781,3	1780,5	-0,8	-0,04
2006	1511,5	1510,8	-0,7	-0,05

2007	1438,6	1436,6	-2,0	-0,14
2008	1839,3	1837,7	-1,6	-0,09
2009	1703,6	1702,3	-1,3	-0,08
2010	1566,3	1566,1	-0,2	-0,01
2011	1523,4	1523,1	-0,3	-0,02

3.2.7.6 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.

3.2.8.2 Methodological issues

CO_2 emissions were calculated applying Tier 2, CH_4 and N_2O were calculated applying Tier 1 (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 calculations of emissions from Manufacture of Solid Fuels and other Energy Industries (1.A.1.c) are presented in Table 3-16.

Table 3-16. Emission factors and methods for category Manufacture of Solid Fuels and other Energy Industries (1.A.1.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
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
LPG	65,42	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
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 (1996 IPCC); T1 - Tier 1; T2 - Tier 2.

Activity data

For calculation of GHG emissions in category Manufacture of Solid Fuels and other Energy Industries (1.A.1.c) 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 and other Energy Industries are presented in Figure 3-15.

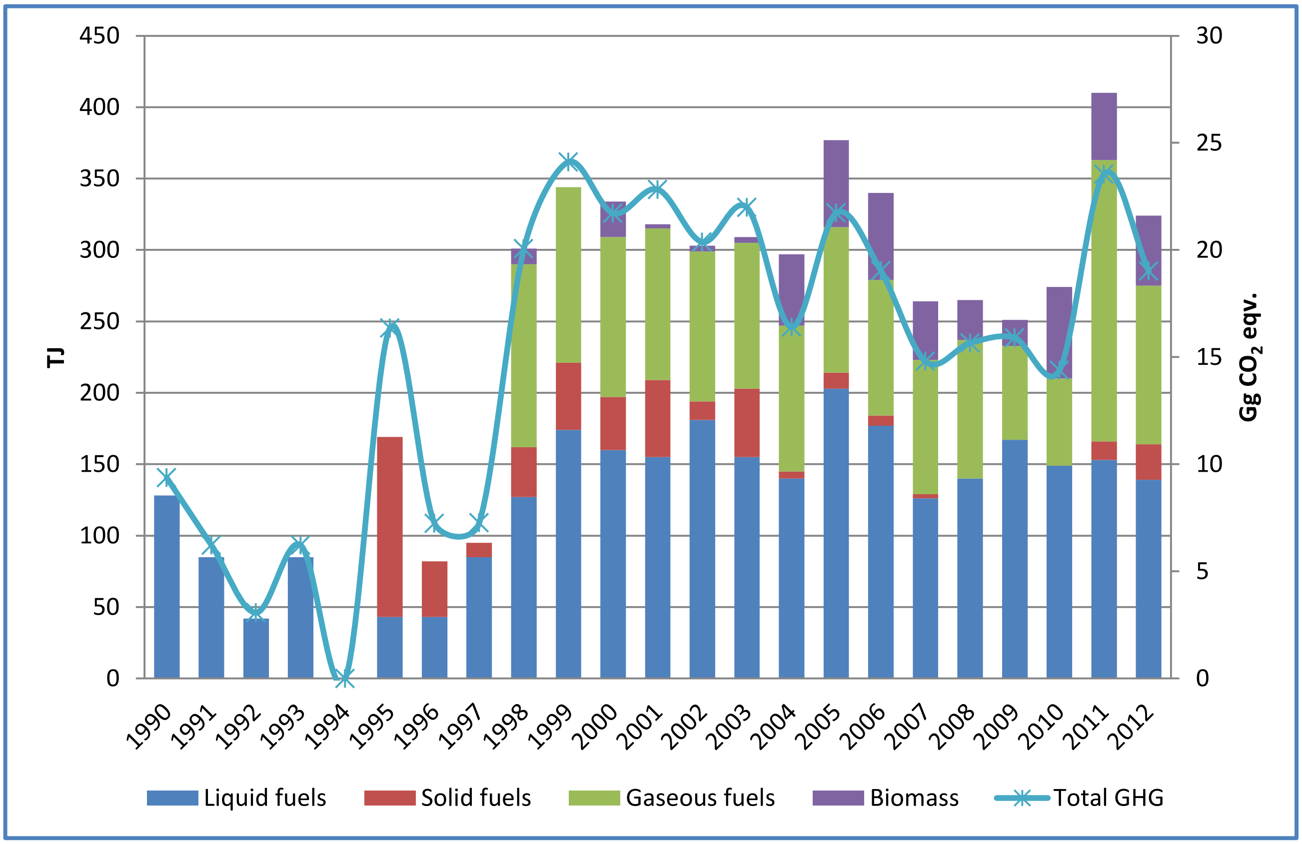

Figure 3-15. Tendencies of fuel consumption and total GHG emissions in Manufacture of Solid Fuels and other Energy Industries during 1990-2012

As it is seen from Figure 3-15, fuel consumption in Manufacture of Solid Fuels and other Energy Industries reduced during 2007-2010. Natural gas consumption increased by more than 3 times, therefore total fuel consumption in Manufacture of Solid Fuels and other Energy Industries increased by 50,0% till 410 TJ in 2011. In 2012, consumption of fuel in Manufacture of Solid Fuels and other Energy Industries reduced by 21% and accounted 324 TJ. With reference to data of 2012, natural gas accounted 34,3%, liquid fuels – 42,9%, biomass – 15,1% and solid fuels 7,7% of structure.

In 2012, total GHG emissions from Manufacture of Solid Fuels and other Energy industries were about 2 times higher than in 1990.

3.2.8.3 Uncertainties and time-series consistency

Uncertainty in activity data in Manufacture of Solid Fuels and 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 ±50% 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 and 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.

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

3.2.8.5 Source-specific recalculations

Following recalculations in this category has been done:

- corrections of activity data of motor gasoline and peat based on the newest statistical information provided by Lithuanian Statistics in November 2013.

Impact of these recalculations on GHG emissions from 1.A.1.c Manufacture of Solid Fuels and other Energy Industries is presented in Table 3-17.

Table 3-17. Impact of recalculation on GHG emissions from 1.A.1.c Manufacture of Solid Fuels and other Energy Industries

Year	Submission 2013, Gg CO_2 eqv.	Submission 2014, Gg CO_2 eqv.	Absolute difference, Gg CO_2 eqv.	Relative difference, %
1999	24,0	24,1	0,1	0,43
2005	21,6	21,7	0,1	0,34

3.2.8.6 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)

GHG emissions from Non-Ferrous Metals industry was accounted for the first time in the 2012 submission as the Lithuanian Statistics provided data for this category only for 2010-2011 period. Non-ferrous metals industry accounts very small share in Lithuanian manufacturing industries therefore since 2012 the Lithuanian Statistics again includes activity data under Other non specified industries (CRF 1.A.2.f).

3.3.2.1 Methodological issues

CO_2 emissions were calculated applying Tier 2, CH_4 and N_2O were calculated applying Tier 1 (as presented in Table 3-19) 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-Ferrous Metals industries (1.A.2.b) are presented in table 3-18.

Table 3-18. Emission factors and methods for category Non-Ferrous Metals industries (1.A.2.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
Coke	109,11	CS	T2	10,0	D	T1	1,4	D	T1
Peat	104,34	CS	T2	2,0	CS	T2	1,5	CS	T2
Natural gas	55,23	CS	T2	5,0	D	T1	0,1	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 (1996 IPCC); T1 - Tier 1; T2 - Tier 2.

Activity data

For calculation of GHG emissions in category Non-Ferrous Metals industries (1.A.2.b) 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 on November 2013. In the delivered data Lithuanian Statistics provided information about energy consumption in Non-Ferrous Metals industries for 2010 and 2011. Activity data are provided below in the Table 3-19.

Table 3-19. Energy consumption by fuel type in Non-Ferrous Metals industries, TJ

Year	Coke	Peat	Natural gas	Total
2010	28	0	0	**28**
2011	0	3	48	**51**

3.3.2.2 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.

Uncertainties of CO_2 emission factors for solid fuels (peat and coke) and gaseous fuels (natural gas) are ±7%. Uncertainties of 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 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.

3.3.2.3 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.

3.3.2.4 Source-specific recalculations

No recalculations have been done for the sector.

3.3.2.5 Source-specific planned improvements

Source-specific improvements are not planned.

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

3.3.3.1 Source category description

The chemical industry is one of the largest manufacturing industries in Lithuania. It produces a number of different products such as chemicals, plastics, solvents, petrochemical products, cosmetics etc. During the latter decade it has been noticed an intensive development of this industry. According to the data of 2012, chemical industry has created 11,2% of the total value added created in a manufacturing industry. This has been by 7,3% more than in 2011. The historical data has disclosed that since 1995 value added created in chemical industry has had a tendency to grow by 8,3% a year. 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 10,3% in 2008 (compared to value in 2007) and exceeded by 2,8% pre-crisis (2007) level in 2011. 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 3-21) 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 3-20.

Table 3-20. 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	2,0	D	T1	0,6	D	T1
LPG	65,42	CS	T2	2,0	D	T1	0,6	D	T1
Gasoil	72,89	CS	T2	2,0	D	T1	0,6	D	T1
Sub-bituminous coal	96,00	CS	T2	10,0	D	T1	1,4	D	T1
Natural gas	55,23	CS	T2	5,0	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 (1996 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 3-21.

Table 3-21. Energy consumption by fuel type in Chemicals industries, TJ

Year	RFO	LPG	Gasoil	Sub-bituminous 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	72,0	0,0	0,0	2,5	190,9	1,6	0,0	**267,0**
2002	66,7	0,7	0,0	2,0	251,0	0,7	0,0	**321,1**
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	3,0	0,0	**1864,0**
2005	0,0	6,9	0,0	0,4	2019,0	0,4	0,0	**2026,6**
2006	23,0	8,0	0,0	0,0	3419,0	2,0	0,0	**3452,0**
2007	0,0	21,3	0,0	0,3	2399,0	0,3	0,0	**2420,9**
2008	0,0	22,0	0,0	0,0	2438,0	0,0	0,0	**2460,0**
2009	0,0	16,0	0,0	0,0	3470,0	2,0	0,0	**3488,0**
2010	47,0	17,0	0,0	0,0	3284,0	0,0	94,0	**3442,0**
2011	0,0	4,0	0,0	0,0	2756,0	0,0	31,0	**2791,0**
2012	0,0	27,0	0,0	0,0	3696,0	0,0	52,0	**3775,0**

Tendencies of fuel consumption and total GHG emissions in Chemical industries are presented in Figure 3-16.

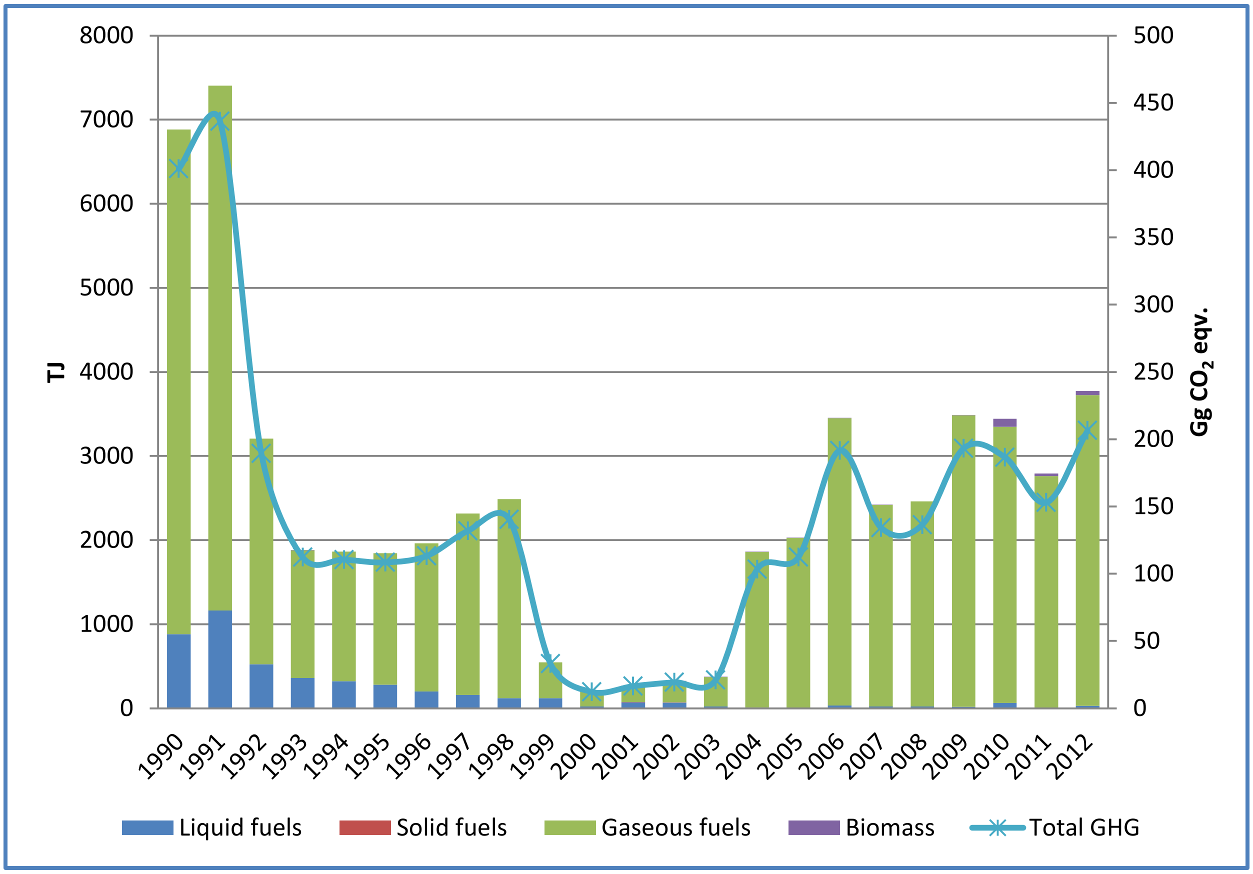

Figure 3-16. Tendencies of fuel consumption and total GHG emissions in Chemical industries during 1990-2012

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 3-16). Since 2002, when economy has started to grow at very fast rates, energy consumption in Chemical industries began to increase by 49,8% per year. During 2008-2009, the growth rates of fuel consumption in Chemical industries went slow and 1,3% fuel consumption decrease has been noticed in 2010. In 2011 energy consumption in Chemical industries further reduced. The reduction rate was 18,9%. With reference to data of 2012, fuel consumption in Chemical industries significantly increased (by 35,3%) and amounted 3,8 PJ.

In 2012, total GHG emissions from Chemical industries were about 2 times lower than in 1990 and amounted 206,4 Gg 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 ±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 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 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 recalculations

Following recalculations in this category has been done:

- correction of activity data of residual fuel oil, LPG, gasoil, sub-bituminous coal, natural gas and wood/wood waste consumption based on the newest statistical information provided by Lithuanian Statistics in November 2013.

Impact of these recalculations on GHG emissions from 1.A.2.c Chemical industries is presented in Table 3-22.

Table 3-22. Impact of recalculation on GHG emissions from 1.A.2.c Chemical industries

Year	Submission 2013, Gg CO_2 eqv.	Submission 2014, Gg CO_2 eqv.	Absolute difference, Gg CO_2 eqv.	Relative difference, %
1999	32,96	32,98	0,02	0,06
2000	12,13	12,14	0,01	0,08
2001	16,47	16,42	-0,05	-0,30
2002	19,27	19,33	0,06	0,31
2003	21,27	21,16	-0,11	-0,52

3.3.3.6 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 an important branch of manufacturing industry in Lithuania. With reference to data of 2012, value added created by Pulp, Paper and Print industries made 10,3% in the structure of manufacturing industry. This is by 0,4 percentage points less than in 2011. The Pulp, Paper and Print industries has been growing by 12,3% in 1995-2007, and the growth rates have been by 3,8 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 food processing, beverage and tobacco, as well chemical and furniture production) with the lowest decline rates. The decline rate of value added in this industry has been 18,0% in 2009. Value added of Pulp, Paper and Print industries exceeded the pre-crisis level by 13,9% in 2011 and by 19,0% in 2012.

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 3-24) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Pulp, Paper and Print industries (1.A.2.c) is presented in Table 3-23.

Table 3-23. 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	2,0	D	T1	0,6	D	T1
Residual fuel oil	77,60	CS	T2	2,0	D	T1	0,6	D	T1
LPG	65,42	CS	T2	2,0	D	T1	0,6	D	T1
Coke	109,11	CS	T2	10,0	D	T1	1,4	D	T1
Coking coal	94,90	CS	T2	10,0	D	T1	1,4	D	T1
Sub-bituminous coal	96,00	CS	T2	10,0	D	T1	1,4	D	T1
Anthracite	106,55	CS	T2	10,0	D	T1	1,4	D	T1
Peat	104,34	CS	T2	2,0	CS	T2	1,5	CS	T2

Natural gas	55,23	CS	T2	5,0	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 (1996 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 3-24.

Table 3-24. Energy consumption by fuel type in Pulp, paper and print industries, TJ

Year	Gas-oil	RFO	LPG	Coke	Coking coal	An-thra-cite	Sub-bitu-mi-nous coal	Peat	Na-tural gas	Other solid bio-mass	Wood/ wood waste	Total
1990	0,0	2087,3	0,0	0,0	0,0	0,0	0,0	0,0	4555,0	0,0	243,0	**6885,3**
1995	0,0	721,0	0,0	0,0	75,4	0,0	0,0	0,0	1200,0	0,0	289,0	**2285,4**
2000	4,2	211,9	47,0	0,0	17,6	0,0	0,0	0,0	1450,1	0,0	467,0	**2197,8**
2001	6,0	127,9	9,3	0,0	0,0	0,0	12,0	0,0	1594,1	0,0	995,5	**2744,8**
2002	1,0	140,4	13,0	0,0	0,0	0,0	0,0	0,0	1873,0	0,0	1914,3	**3941,7**
2003	0,0	119,9	9,3	0,0	0,0	0,0	0,0	0,0	1507,1	0,0	2264,8	**3901,1**
2004	0,0	139,9	14,0	0,0	0,0	0,0	0,0	0,0	1290,0	0,0	2251,0	**3694,9**
2005	2,6	147,5	7,4	0,0	0,0	0,0	11,9	1,4	1495,0	0,0	2081,5	**3747,3**
2006	1,0	119,9	10,0	0,0	0,0	0,0	10,0	4,0	1282,0	0,0	1990,0	**3416,9**
2007	0,6	69,0	19,2	0,0	0,0	0,0	2,9	11,1	1598,0	0,0	2204,7	**3905,5**
2008	0,0	18,0	17,0	0,0	0,0	0,0	3,0	12,0	2207,0	0,0	2103,0	**4360,0**
2009	1,0	23,0	11,0	0,0	0,0	2,0	0,0	6,0	1650,0	4,0	1701,0	**3398,0**
2010	0,0	31,0	22,0	0,0	0,0	0,0	0,0	1,0	2116,0	0,0	2033,0	**4203,0**
2011	20,0	0,0	9,0	0,0	0,0	0,0	0,0	0,0	1570,0	1,0	1944,0	**3544,0**
2012	17,0	0,0	7,0	0,0	0,0	0,0	0,0	0,0	1174,0	0,0	2338,0	**3536,0**

Tendencies of fuel consumption and total GHG emissions in Pulp, Paper and Print industries are presented in Figure 3-17.

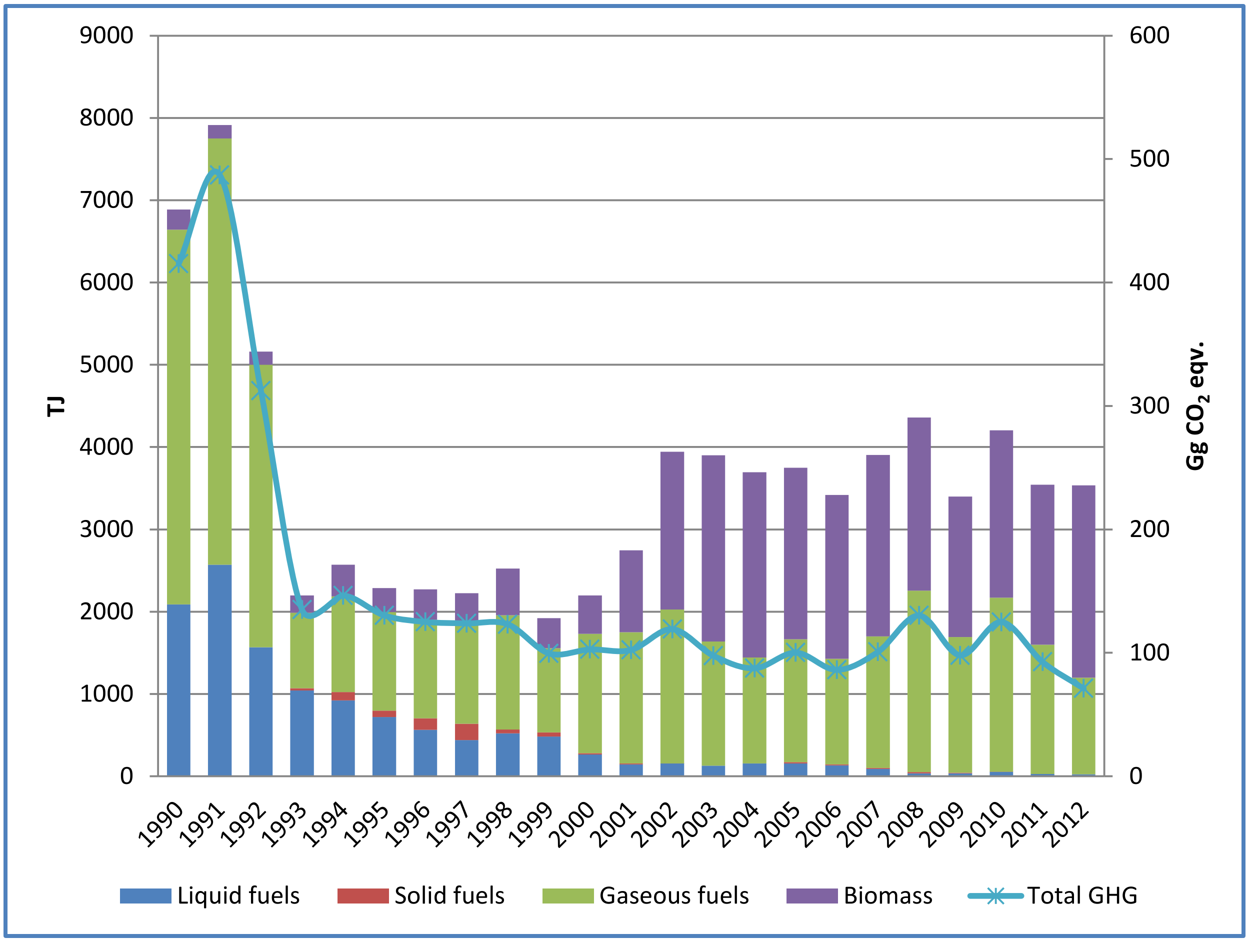

Figure 3-17. Tendencies of fuel consumption and total GHG emissions in Pulp, Paper and Print industries during 1990-2012

Historically natural gas was the main fuel used in Pulp, Paper and Print industries. In 2012, the share of natural gas was 33,2%. This is by 11,1 percentage points less than in 2011. During 2000-2007 biomass consumption started to increase at 24,8% per annum (Figure 3-17). Since 2007 consumption of biomass was developing impermanently. Thus, in 2012, the share of biomass accounted 66,1%, natural gas - 33,2% in the structure of fuel used in Pulp, Paper and Print industries.

In 2012, total GHG emissions from Pulp, Paper and Print industries were even 5,8 times lower than in 1990 and amounted 71,1 Gg 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 ±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 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 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 recalculations

Following recalculations in this category has been done:

- corrections of activity data of residual fuel oil, LPG, gasoil, natural gas, peat, coke and wood/wood waste consumption based on the newest statistical information provided by Lithuanian Statistics in November 2013;
- dissagregation of activity data for anthracite, coking coal and sub-bituminous since 2000 based on the newest information provided by Lithuanian Statistics in November 2013.

Impact of these recalculations on GHG emissions from 1.A.2.d Pulp, paper and print industries is presented in Table 3-25.

Table 3-25. Impact of recalculation on GHG emissions from 1.A.2.d Pulp, Paper and Print industries

Year	Submission 2013, Gg CO_2 eqv.	Submission 2014, Gg CO_2 eqv.	Absolute difference, Gg CO_2 eqv.	Relative difference, %
1997	123,76	123,84	0,08	0,06
1999	99,52	99,55	0,03	0,03
2000	102,75	102,73	-0,03	-0,03
2001	102,25	102,29	0,04	0,04
2002	119,18	119,13	-0,05	-0,04
2003	97,67	97,62	-0,05	-0,05
2004	87,45	87,44	-0,01	-0,01
2005	100,05	100,12	0,07	0,07
2006	85,83	86,15	0,32	0,37
2007	100,73	100,72	-0,01	-0,01
2008	130,09	130,19	0,10	0,08
2009	97,87	97,97	0,10	0,1
2011	92,68	92,61	-0,07	-0,08

3.3.4.6 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 19,5% (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 22,2% of total value added in manufacturing industry.

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 3-27) 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 3-26.

Table 3-26. 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	2,0	D	T1	0,6	D	T1
Residual fuel oil	77,60	CS	T2	2,0	D	T1	0,6	D	T1
LPG	65,42	CS	T2	2,0	D	T1	0,6	D	T1
Gasoil	72,89	CS	T2	2,0	D	T1	0,6	D	T1

Peat	104,34	CS	T2	2,0	CS	T2	1,5	CS	T2
Coking coal	94,90	CS	T2	10,0	D	T1	1,4	D	T1
Sub-bituminous coal	96,00	CS	T2	10,0	D	T1	1,4	D	T1
Anthracite	106,55	CS	T2	10,0	D	T1	1,4	D	T1
Coke	109,11	CS	T2	10,0	D	T1	1,4	D	T1
Natural gas	55,23	CS	T2	5,0	D	T1	0,1	D	T1
Wood/ wood waste	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 (1996 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 3-27.

Table 3-27. Energy consumption by fuel type in Food Processing, Beverages and Tobacco industries, TJ

Year	Sha-le oil	RFO	LPG	Gasoil	Peat	Coking coal	An-thra-cite	Sub-bitu-mi-nous coal	Coke	Na-tural gas	Wood and wood waste	Bio-gas	Total
1990	0,0	2247,8	0,0	0,0	0,0	351,7	0	0,0	0,0	8498,0	36,0	0,0	11133,5
1995	0,0	1605,6	0,0	0,0	0,0	150,7	0	0,0	0,0	2077,0	57,0	0,0	3890,3
2000	0,0	1567,2	121,4	3,0	0,0	67,8	0	0,0	105,5	2890,2	77,0	0,0	4832,1
2001	0,0	1120,0	59,6	0,0	0,0	0,0	0	37,7	99,6	2987,3	42,6	0,0	4346,8
2002	0,0	875,6	64,0	4,3	0,8	0,0	0	61,3	98,0	3792,0	49,4	0,0	4945,3
2003	0,0	677,0	74,3	29,5	1,5	0,0	0	40,9	105,5	4025,5	71,3	0,0	5025,5
2004	5,0	587,7	102,0	47,1	1,5	0,0	0	34,1	76,2	3711,0	112,0	0,0	4676,5
2005	13,0	334,2	157,5	148,4	5,5	0,0	0	49,6	63,6	3694,0	297,3	0,0	4763,2
2006	40,0	291,9	210,0	89,8	1,5	0,0	0	40,9	61,5	3865,0	140,0	5,0	4745,6
2007	22,0	379,2	237,3	51,7	2,1	0,0	0	36,0	60,4	4214,0	82,2	13,0	5097,9
2008	27,0	274,0	205,0	92,0	2,0	0,0	0	32,0	29,0	3932,0	102,0	10,0	4705,0
2009	0,0	233,0	186,0	73,0	1,0	36,0	0	7,0	45,0	3644,0	78,0	18,0	4321,0
2010	0,0	212,0	192,0	94,0	15,0	3,0	0	38,0	54,0	4005,0	93,0	10,0	4716,0
2011	0,0	268,0	194,0	86,0	9,0	29,0	18	9,0	49,0	4297,0	88,0	10,0	5057,0
2012	0,0	243,0	221,0	121,0	11,0	29,0	24	2,0	44,0	4422,0	63,0	0,0	5180,0

Tendencies of fuel consumption and total GHG emissions in Food processing, beverages and tobacco industries are presented in Figure 3-18.

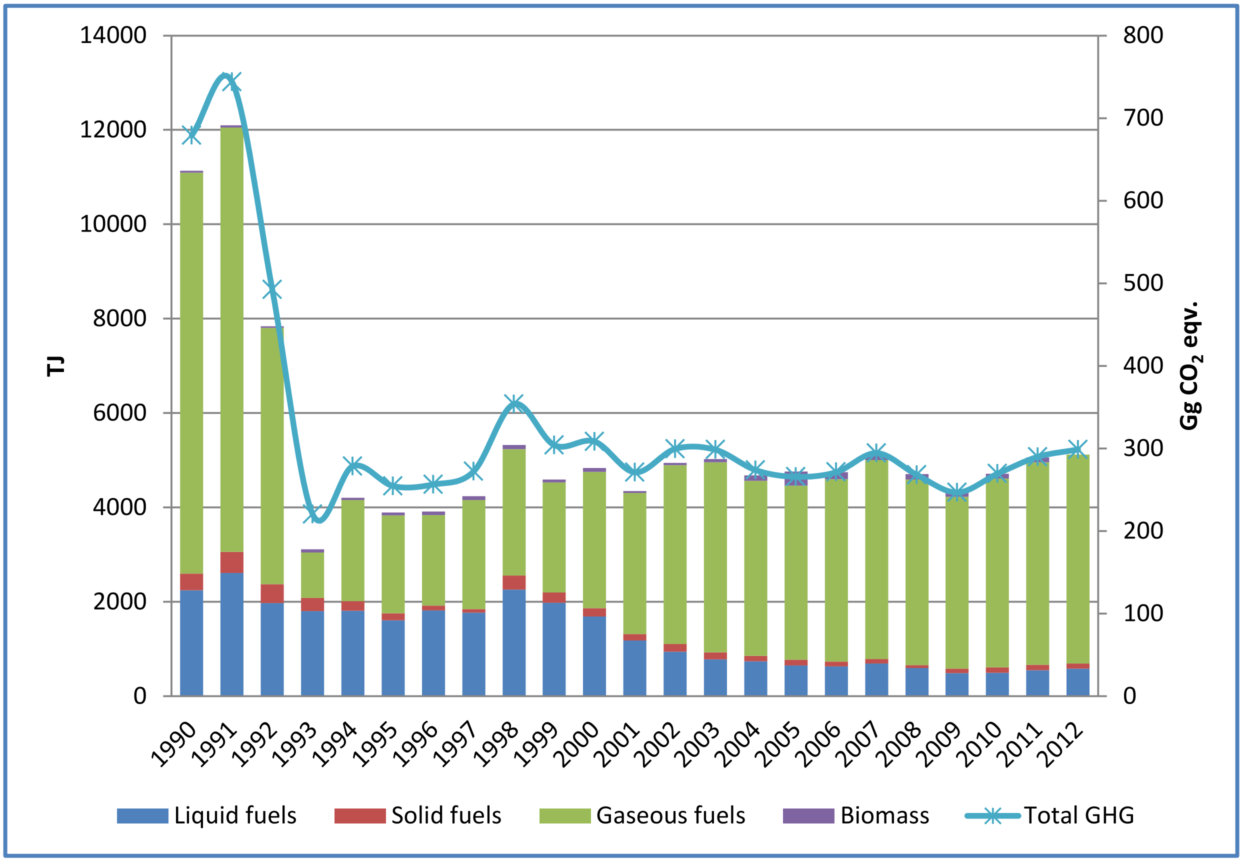

Figure 3-18. Tendencies of fuel consumption and total GHG emissions in Food Processing, Beverages and Tobacco industries during 1990-2011

Fuel consumed in Food Processing, Beverages and Tobacco industries has become more diversified in 2012 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, wood/wood waste and biogas penetrate the market (Figure 3-18). The share of residual fuel oil in the structure of energy consumed in industry has reduced from 41,3% (1995) till 4,7% (2012). The share of natural gas has a tendency to increase, i.e. it has increased by 32,0 percentage points during 1995-2012.

In 2012, total GHG emissions from Food Processing, Beverages and Tobacco industries were 2,3 times lower than in 1990 and amounted 298,7 Gg 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 ±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 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 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 recalculations

Following recalculations in this category has been done taking into account ERT recommendations:

- corrections of activity data of residual fuel oil, LPG, gasoil, peat, coke, natural gas and wood/wood waste consumption based on the newest statistical information provided by Lithuanian Statistics in November 2013;
- dissagregation of activity data for anthracite, coking coal and sub-bituminous since 2000 based on the newest information provided by Lithuanian Statistics in November 2013.

Impact of these recalculations on GHG emissions from 1.A.2.e Food Processing, Beverages and Tobacco industries is presented in Table 3-28.

Table 3-28. Impact of recalculation on GHG emissions from 1.A.2.e Food Processing, Beverages and Tobacco industries

Year	Submission 2013, Gg CO_2 eqv.	Submission 2014, Gg CO_2 eqv.	Absolute difference, Gg CO_2 eqv.	Relative difference, %
1993	220,4	220,5	0,05	0,02
1994	278,6	278,6	0,01	0,00
1995	254,5	254,46	-0,06	-0,02
1996	256,38	256,37	-0,01	0,00
1997	272,25	272,29	0,04	0,01
1998	353,75	353,68	-0,07	-0,02
1999	304,02	303,96	-0,06	-0,02
2000	308,32	308,38	0,06	0,02
2001	271,06	271,13	0,07	0,03
2002	299,97	299,47	-0,50	-0,17
2003	298,76	298,42	-0,34	-0,11
2004	274,14	273,75	-0,39	-0,14
2005	267,39	265,65	-1,74	-0,65
2006	271,69	271,29	-0,40	-0,15
2007	294,65	294,37	-0,28	-0,10
2008	270,50	267,98	-2,52	-0,93
2009	246,89	246,74	-0,15	-0,06
2010	269,75	269,35	-0,40	-0,15
2011	289,47	289,85	0,38	0,13

3.3.5.6 Source-specific planned improvements

Source-specific improvements are not planned.

3.3.6 Other Industries (CRF 1.A.2.f)

3.3.6.1 Source category description

Other non-specified industries in Lithuania include the following activities:

- manufacturing of textile goods;
- sewing of goods;
- production of leather and its products;
- manufacturing of wood and its products, excluding production of furniture;
- production of medicine industry goods and pharmaceutical preparations;
- manufacturing of rubber and plastic goods;
- manufacturing of other non-metalic mineral products;
- manufacturing of basic metals;
- manufacturing of metal goods, excluding machines and equipments;
- manufacturing of computers, electronic and optical goods;
- manufacturing of electrical goods;
- manufacturing of other machines and equipment;
- manufacturing of motor vehicle and trailers;

- manufacturing of other vehicles and equipment;
- manufacturing of furniture;
- manufacturing of other goods;
- construction.

Other non-specified industries in Lithuania have accounted 45,6% of value added in 2012. Textile goods industry is the largest industry prescribed to other non-specified industries and the third largest (after food processing, beverages and tobacco and pulp, paper and print) manufacturing industry in Lithuania. Since 1999 its structural share has been reducing from 21,4% (1999) till 7,5% (2012). Rubber and plastic goods industry has been an advanced branch of manufacturing industry in Lithuania during 1995-2008 in terms of growth rates of value added created and trade (Kaunas Technology University). During 1995-2006 added value created in this industry increased by 11,2% a year. During 2007-2009, a decrease of activities was fixed in the industry (value added was decreasing by 22,3% a year). Since 2010 volume of value added is increasing by 17,0% a year.

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 3-30) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Other industries (1.A.2.f) are presented in the Table 3-29.

Table 3-29. Emission factors and methods for category Other 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	2,0	D	T1	0,6	D	T1
LPG	65,42	CS	T2	2,0	D	T1	0,6	D	T1
Gasoil	72,89	CS	T2	2,0	D	T1	0,6	D	T1
Jet kerosene	72,24	CS	T2	2,0	D	T1	0,6	D	T1
Petroleum coke	94,06	CS	T2	2,0	D	T1	0,6	D	T1
Peat	104,34	CS	T2	2,0	CS	T2	1,5	CS	T2
Coking coal	94,90	CS	T2	10,0	D	T1	1,4	D	T1
Sub-bituminous coal	96,00	PS	T3	10,0	D	T1	1,4	D	T1

Anthracite	106,55	PS	T3	10,0	D	T1	1,4	D	T1
Coke	109,11	CS	T2	10,0	D	T1	1,4	D	T1
Natural gas	55,23	CS	T2	5,0	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
Used tires (industrial waste)	85,03	PS	T3	30	CS	T2	4,0	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; D - default emission factors (1996 IPCC); T1 - Tier 1; T2 - Tier 2; T3 - Tier 3.

Activity data

For calculation of GHG emissions in category Other 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 3-30.

Table 3-30. Energy consumption by fuel type in Other industries, TJ

Year	Resi-dual fuel oil	LPG	Gasoil	Jet kero-sene	Petro-leum coke	Peat	Coking coal	Anthra-cite	Sub-bitumi-nous coal	Coke	Natural gas	Wood / wood waste	Other solid bio-mass	Biogas	Total
1990	39819,2	92,0	0,0	0,0	0,0	169,4	1456,9	0,0	0,0	0,0	18041,0	225,0	0,0	0,0	**59803,5**
1995	9113,0	46,0	0,0	0,0	0,0	232,7	502,3	0,0	0,0	0,0	4295,0	515,0	0,0	0,0	**14703,9**
2000	3824,1	106,5	7,0	10,0	0,0	43,4	66,0	0,0	5,0	240,3	4020,2	771,0	0,0	0,0	**9093,5**
2001	3761,0	174,0	0,0	5,0	0,0	35,2	0,0	0,0	59,0	204,0	4317,9	891,4	0,0	0,0	**9447,5**
2002	2084,2	170,3	12,8	5,0	0,0	12,0	102,0	0,0	1638,3	204,0	4244,0	1371,9	47,3	0,0	**9891,8**
2003	711,0	152,0	83,0	5,0	0,0	15,9	414,5	690,0	1882,1	254,9	4509,2	1745,1	83,5	0,0	**10546,2**
2004	1155,0	155,0	105,0	0,0	17,0	13,0	580,3	95,5	2296,6	283,0	4514,0	1858,0	90,8	0,0	**11163,2**
2005	1334,3	134,4	278,6	0,0	46,0	8,9	0,0	0,0	3014,9	470,8	4925,0	1812,8	40,9	0,0	**12066,5**
2006	895,5	157,0	171,0	0,0	325,0	9,5	125,6	0,0	4288,3	655,0	4500,0	1686,0	10,3	1,0	**12824,2**
2007	129,8	140,1	177,1	0,0	793,0	13,2	0,0	0,0	4586,2	649,7	4263,0	1410,2	76,0	0,0	**12238,3**
2008	224,0	181,0	174,0	0,0	218,0	10,0	301,0	75,0	3712,0	458,0	3426,0	1245,0	19,0	0,0	**10043,0**
2009	91,0	135,0	140,0	0,0	685,0	6,0	1204,0	370,0	686,0	276,0	2200,0	975,0	4,0	0,0	**6772,0**
2010	80,0	164,0	173,0	0,0	111,0	23,0	2857,0	7,0	171,0	391,0	2596,0	937,0	11,0	0,0	**7521,0**
2011	93,0	100,0	157,0	0,0	0,0	56,0	3732,0	73,0	8,0	473,0	2843,0	1140,0	6,0	0,0	**8681,0**
2012	184,0	97,0	165,0	0,0	13,0	67,0	4331,0	0,0	18,0	510,0	2846,0	1156,0	6,0	0,0	**9393,0**

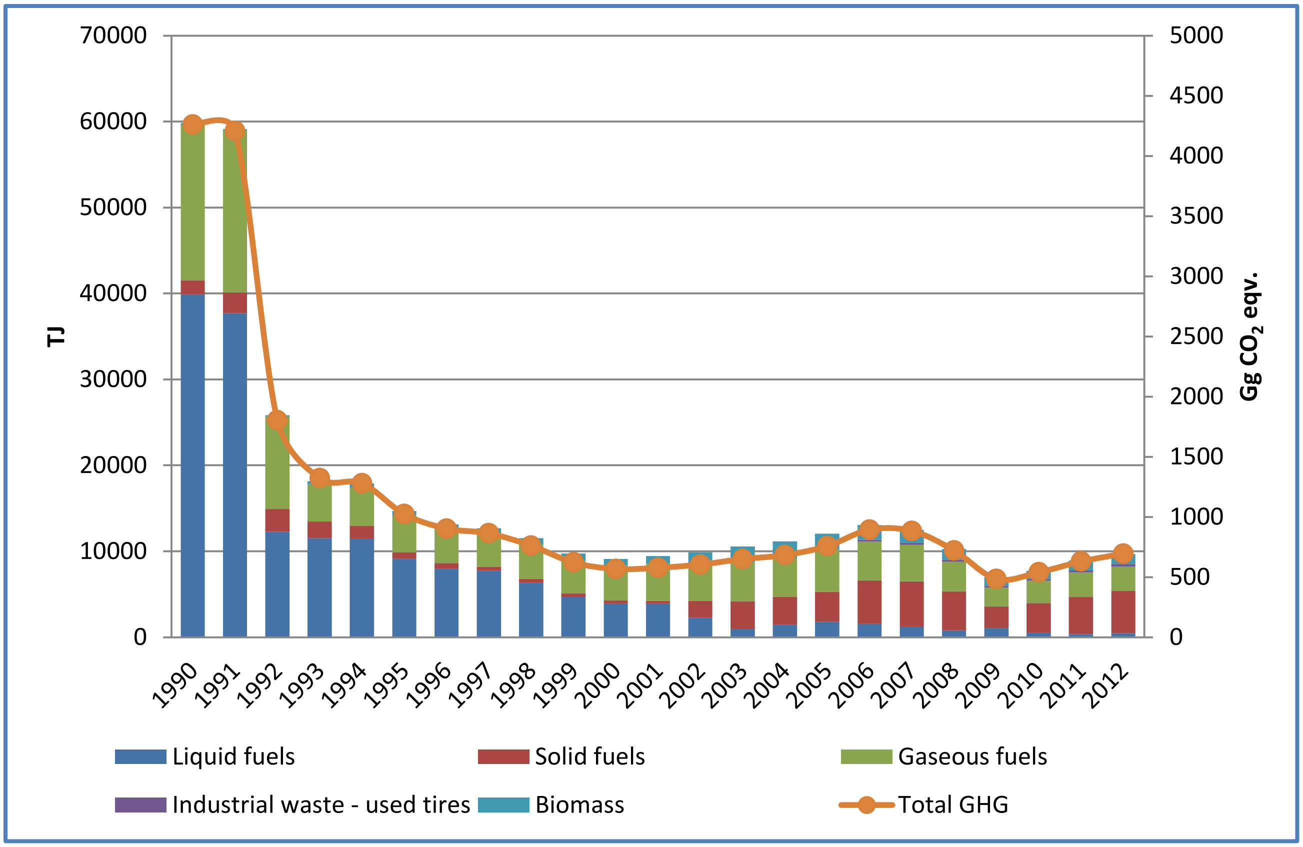

Figure 3-19. Tendencies of fuel consumption and total GHG emissions in Other industries during 1990-2012

In Other Industries sector the largest reductions have been noticed in residual fuel oil consumption during the period 1990-2012 (Table 3-31). The share of residual fuel oil has decreased from 66,6% (1990) till 2,0% (2012). Although, volume of natural gas has been reducing, however its share has remained rather stable during 1990-2012 (Figure 3-19). It has accounted about 30-40% in the structure. During the period of rapid economic development coal has rapidly penetrated the market, i.e. the share has increased from 19,8% (2002) till 44,4% (2008). In 2009 consumption of coal has reduced by 36,5% till 2,5 PJ. With reference to data 2012, the share of coal has been 51,0% in fuel structure. The share of wood/wood waste fluctuates around 14% in the structure of fuel consumption during 2002-2012.

In 2012, total GHG emissions from Other industries were even 6 times lower than in 1990 and amounted 695,3 Gg CO_2 eqv.

3.3.6.3 Uncertainties and time-series consistency

Uncertainty in activity data in Other 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 ±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 Other 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 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 recalculations

Following recalculations in this category has been done taking into account ERT recommendations:
- corrections of activity data of residual fuel oil, gasoil, LPG, peat, coke, natural gas, wood/wood waste and other solid biomass consumption based on the newest statistical information provided by Lithuanian Statistics in November 2013;
- dissagregation of activity data for anthracite, coking coal and sub-bituminous since 2000 based on the newest information provided by Lithuanian Statistics in November 2013.

Impact of these recalculations on GHG emissions from 1.A.2.f Other industries is presented in Table 3-31.

Table 3-31. Impact of recalculation on GHG emissions from 1.A.1.f Other industries

Year	Submission 2013, Gg CO_2 eqv.	Submission 2014, Gg CO_2 eqv.	Absolute difference, Gg CO_2 eqv.	Relative difference, %
1990	4261,38	4261,32	-0,06	0,00
1991	4206,62	4206,49	-0,13	0,00
1992	1803,14	1803,24	0,10	0,01
1993	1322,52	1322,51	-0,01	0,00
1994	1280,02	1280,02	0,00	0,00
1995	1023,42	1023,41	-0,01	0,00
1996	903,14	903,07	-0,07	-0,01
1997	863,54	863,49	-0,05	-0,01
1998	760,73	760,67	-0,06	-0,01
1999	624,44	621,40	-3,04	-0,49
2000	567,50	567,58	0,08	0,01
2001	578,09	577,01	-1,08	-0,19
2002	618,93	604,05	-14,88	-2,40

2003	658,68	649,92	-8,76	-1,33
2004	702,61	682,97	-19,64	-2,80
2005	783,81	757,49	-26,32	-3,36
2006	933,01	893,76	-39,25	-4,21
2007	925,68	883,81	-41,87	-4,52
2008	752,02	721,22	-30,80	-4,10
2009	485,31	483,48	-1,83	-0,38
2010	540,97	539,38	-1,59	-0,29
2011	628,64	629,40	0,76	0,12

3.3.6.6 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 3-32. 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 3-32. 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.c *Railways*	Railway transport operated by diesel locomotives	
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 3-33).

Table 3-33. GHG emissions (Gg) by subcategories from 1.A.3 Transport sector in 1990 – 2012

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*		
	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
1990	9,02380	0,00006	0,00025	5247,15	1,69	0,13	349,972	0,024	0,003	15,4855	0,0011	0,0001	85,4960	0,0077	0,0002	1678,609	0,115	0,014
1991	8,66260	0,00006	0,00024	5818,71	2,01	0,18	371,652	0,025	0,003	9,2913	0.0011	0,0001	82,2927	0,0075	0,0001	1260,662	0,086	0,010
1992	8,22978	0,00006	0,00023	3713,65	1,28	0,11	359,275	0,025	0,003	3,0614	0,0002	0,0000	47,2217	0,0043	0,0001	962,441	0,066	0,008
1993	7,93958	0,00006	0,00022	2763,11	0,97	0,08	353,069	0,024	0,003	3,0614	0,0002	0,0000	26,4552	0,0024	0,0000	834,938	0,057	0,007
1994	7,43514	0,00005	0,00021	2071,29	0,79	0,06	374,800	0,026	0,003	3,0614	0,0002	0,0000	28,8853	0,0026	0,0001	751,261	0,052	0,006
1995	7,07394	0,00005	0,00020	2769,67	0,97	0,08	241,573	0,017	0,002	3,0614	0,0002	0,0000	33,7455	0,0031	0,0001	757,231	0,052	0,006
1996	6,71212	0,00005	0,00019	3050,41	0,99	0,08	251,471	0,017	0,002	15,5256	0,0011	0,0001	37,8326	0,0034	0,0001	506,493	0,035	0,004
1997	6,49416	0,00005	0,00018	3444,72	1,1	0,10	240,974	0,017	0,002	15,5985	0,0011	0,0001	35,5129	0,0032	0,0001	459,836	0,032	0,004
1998	6,20458	0,00004	0,00017	3645,30	1,06	0,10	233,175	0,016	0,002	10,8606	0,0007	0,0001	27,5045	0,0025	0,0000	407,286	0,028	0,003
1999	5,84276	0,00004	0,00016	3243,84	0,95	0,10	206,570	0,014	0,002	9,2570	0,0006	0,0001	31,2602	0,0028	0,0001	298,749	0,020	0,002
2000	5,48156	0,00004	0,00015	2860,00	0,73	0,09	217,941	0,015	0,002	8,9796	0,0006	0,0001	38,3296	0,0035	0,0001	229,342	0,016	0,002
2001	5,98228	0,00004	0,00017	3137,58	0,75	0,10	191,482	0,013	0,002	10,4374	0,0007	0,0001	18,6677	0,0017	0,0000	192,226	0,013	0,002
2002	8,07724	0,00006	0,00022	3238,40	0,74	0,10	206,716	0,014	0,002	11,8811	0,0008	0,0001	20,7113	0,0019	0,0000	191,714	0,013	0,002
2003	2,65924	0,00002	0,00007	3282,37	0,76	0,10	226,688	0,016	0,002	13,06615	0,0009	0,0001	17,7841	0,0016	0,0000	181,727	0,012	0,001
2004	4,03180	0,00003	0,00011	3610,30	0,78	0,11	225,740	0,015	0,002	16,9975	0,0012	0,0001	17,8393	0,0016	0,0000	184,570	0,013	0,002
2005	1,79794	0,00001	0,00005	3832,05	0,81	0,12	228,437	0,016	0,002	16,78354	0,0012	0,0001	35,7338	0,0032	0,0001	204,689	0,014	0,002
2006	2,08690	0,00005	0,00006	4093,12	0,78	0,14	217,650	0,015	0,002	19,09023	0,0013	0,0002	60,3112	0,0055	0,0001	193,098	0,013	0,002
2007	3,89104	0,00011	0,00012	4839,15	0,70	0,17	226,032	0,016	0,002	17,82755	0,0012	0,0001	63,2384	0,0057	0,0001	192,149	0,013	0,002
2008	4,39238	0,00011	0,00013	4816,61	0,70	0,18	228,437	0,016	0,002	18,91619	0,0013	0,0002	55,4509	0,0050	0,0001	197,034	0,014	0,002
2009	2,58948	0,00006	0,00008	3965,41	0,62	0,12	175,009	0,012	0,001	16,45206	0,0011	0,0001	56,0585	0,0051	0,0001	151,182	0,010	0,001
2010	1,65036	0,00002	0,00005	4070,18	0,58	0,13	185,141	0,013	0,002	19,7532	0,0014	0,0002	56,7764	0,0051	0,0001	156,648	0,011	0,001
2011	1,86708	0,00003	0,00005	4038,18	0,52	0,12	193,013	0,013	0,002	16,3274	0,0011	0,0001	47,6083	0,0043	0,0001	164,812	0,011	0,001
2012	1,65036	0,00003	0,00005	4042,75	0,51	0,12	180,840	0,012	0,001	14,9425	0,0010	0,0001	73,4559	0,0067	0,0001	173,266	0,012	0,001

Fuel combustion emissions in 1.A.3 *Transport* sector accounted for 101750 and 65059 TJ in 1990 and 2012, respectively. The sectors emissions decreased from 7470 in 1990 to 4538 Gg CO_2 equivalent in 2012. In 2012 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 2012 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.

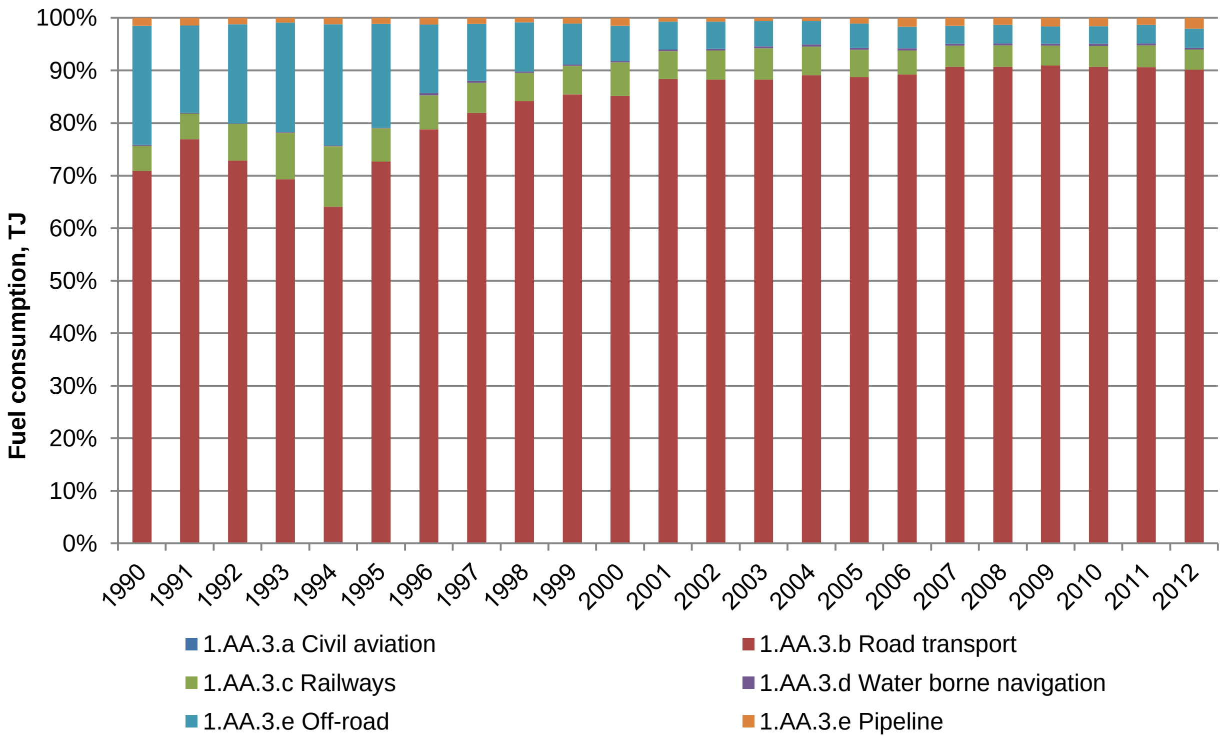

Figure 3-20. Fuel consumption distribution in Transport sector

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 9,1 Gg (CO_2 equivalent) in 1990 (Figure 3-22 and Table 3-34).

Figure 3-21. 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 3-34[4].

Table 3-34. 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

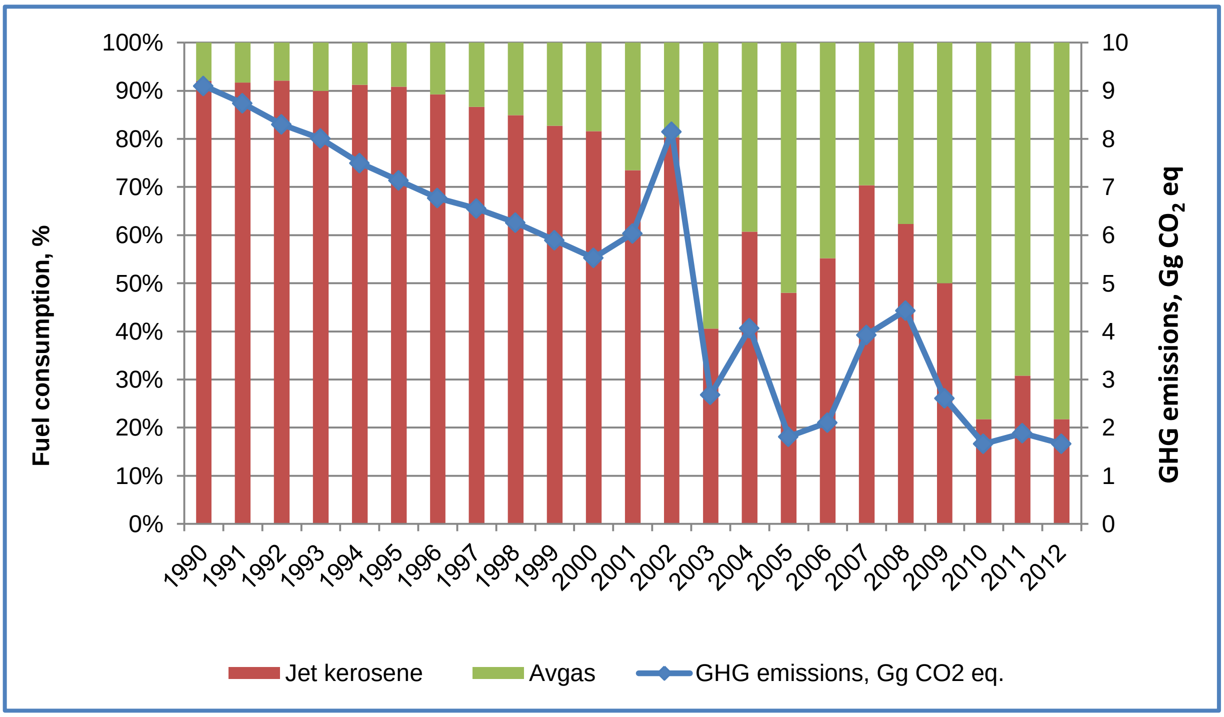

Figure 3-22. Trend of GHG emissions in Civil Aviation sector

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 (Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual (Vol. 3) p. 1.95) 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 2011 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% 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 (Figure 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 types. Apart from this level of further detail according to aircraft type, the algorithms are the same as for the Tier 1 approach:

[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.

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

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, fore ach 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 is used for domestic purposes and thus all the rest (gasoline type jet fuel and kerosene type jet fuel) is used for international flights – the latter could therefore be considered as aviation bunkers. Data on jet fuel (kerosene and aviation gasoline) split between domestic and international aviation is available only from 2001. 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 1990-2000 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).

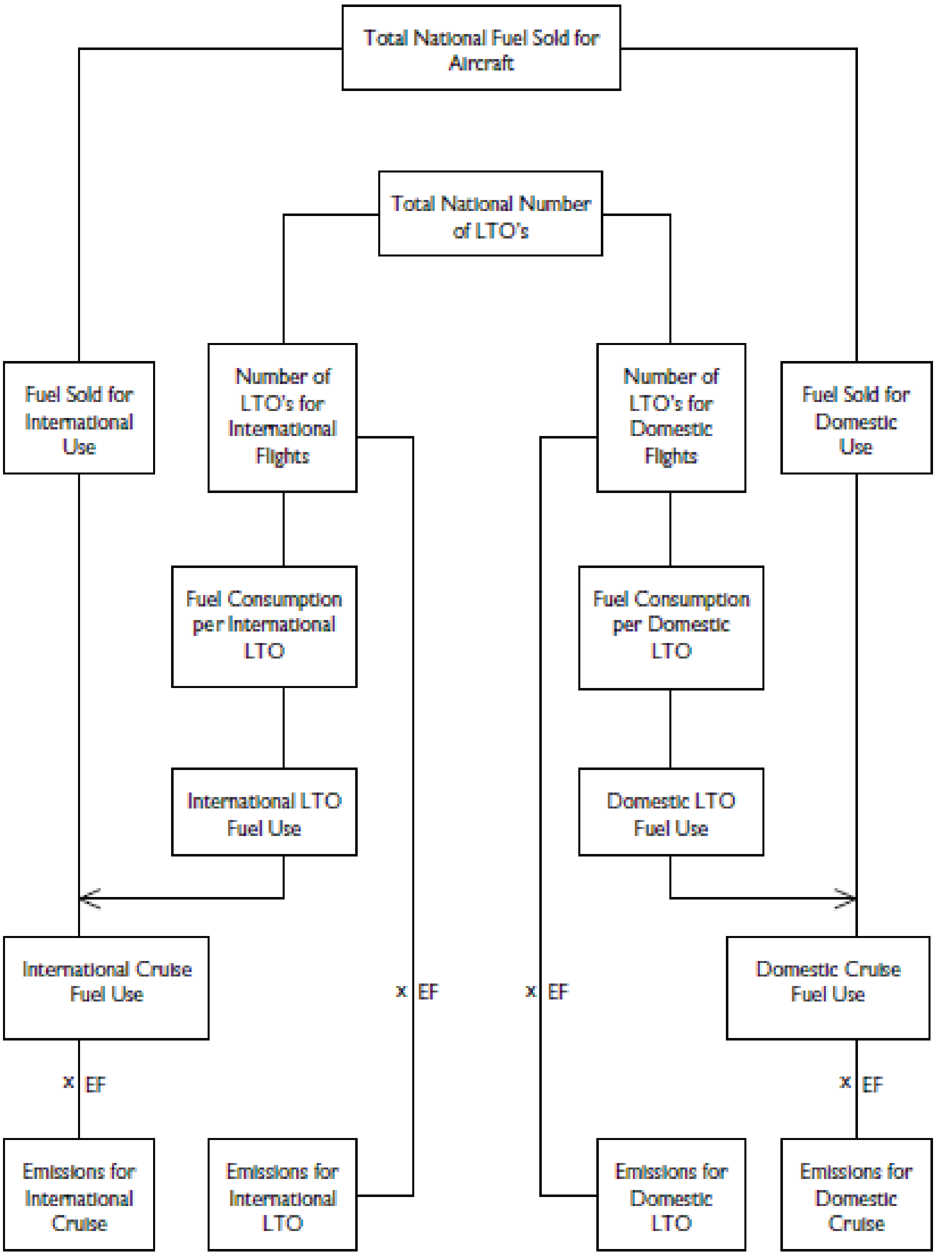

Figure 3-23. Estimation of Aircraft Emissions with the Tier 2 Method

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 alghoritm and surrogate data was used as parameters for comparison (for example Average length of carriage per tonne, km) (Figure 3-24).

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

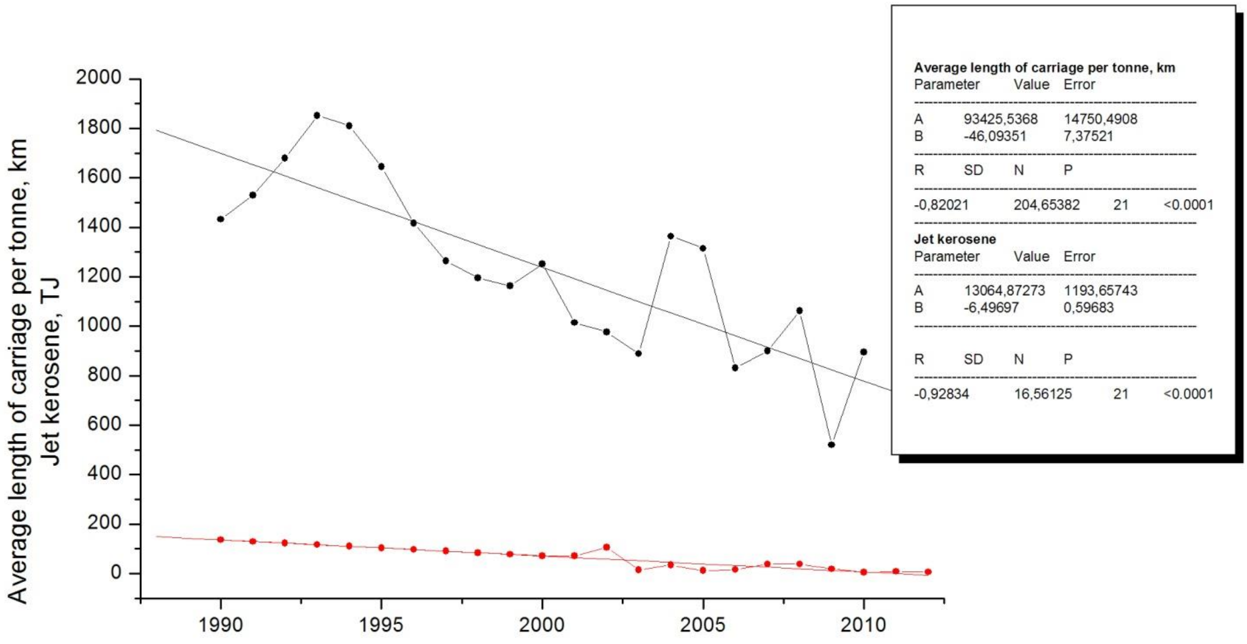

Figure 3-24. The intercomparison between surrogate data and trend of civil aviation emissions

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, therefore GHG emissions are reported for 2001-2012.

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 2006-2011 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 3-35. 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 3-35. CO_2, CH_4 and N_2O emission factors for Civil aviation sector used in the Lithuanian GHG inventory

Fuel	Emission factor [kg/GJ]	Source / Comments
CO_2 emission factors		
Aviation gasoline	71,62	Country specific EF based on "Greenhouse gas emissions characteristics of national energy sector" study, 2012
Jet kerosene	72,24	Country specific EF based on producer data (research protocols of UAB ORLEN Lietuva Quality Research Center)
CH_4 emission factors		
Aviation gasoline	0,5	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual. Table 1-7. p. 1.35
Jet kerosene	0,5	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual. Table 1-7. p. 1.35
N_2O emission factors		
Aviation gasoline	2	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual. Table 1-8. p. 1.36
Jet kerosene	2	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual. Table 1-8. p. 1.36

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%) 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% for N_2O. 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 were done.

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 (1,289 km/km²) network (2012). There are 5,8 km of roads per 1,000 of population in Lithuania and 331 km of state roads per 1,000 km^2 of its territory. At the end of 2012, the length of roads amounted to 82,9 thous. km and, compared to 2011, increased by 1,5%; the length of E-roads amounted to 1642 km, 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, light duty vehicles, heavy duty trucks, buses, motorcycles, mopeds) (Table 3-36). 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.

24,4 % motorcycles, 14,9 % of passenger cars, 19,3 % of buses, 28,1 % of lorries and 67,3 % of road tractors were produced up to 10 years ago.

Table 3-36. 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	45,6	1671,1	163,9	1880,6
2009	51,4	1695,3	159,7	1906,4

2010	56,3	1691,9	147,2	1895,4
2011	63,8	1747,6	193,6	2005,0
2012	66,8	1797,721	196,2	2060,7

*Number of re-registered motorcycles

Greenhouse gas emissions from road transport decreased by 23,1% to 4,1 Tg CO_2 eqv. during 1990 – 2012, that was 71,3% and 90,2% of the sector’s emissions, respectively. GHG emissions from road transport comparing with 2011 increased by 0,1% in 2012. This increase is primarily caused by a 10,6% decrease (1148 TJ) in gasoline fuel and liquefied petroleum gases – 5,7% (390 TJ) consumption by road transportation, while consumption of diesel oil increased by 1562 TJ. The lowest emission level in the road transportation was achieved in 1994 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 Figure 3-25.

Table 3-37. 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	15580	31753	9810	72	589
2007	18858	38798	9708	200	1762
2008	18631	39697	8615	334	1916
2009	15364	32128	7681	584	1581
2010	12405	36892	7275	436	1454
2011	10804	38491	6790	397	1481
2012	9656	40053	6400	365	2168

*Carbon from biofuel is reported as a memo item but not included in national CO2 totals, as required by the IPCC Guidelines.

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 3-38[8].

Table 3-38. 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

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 (Figure 3-13). 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 3-36). 90% of the fuel in transportation sector is consumed by road transport.

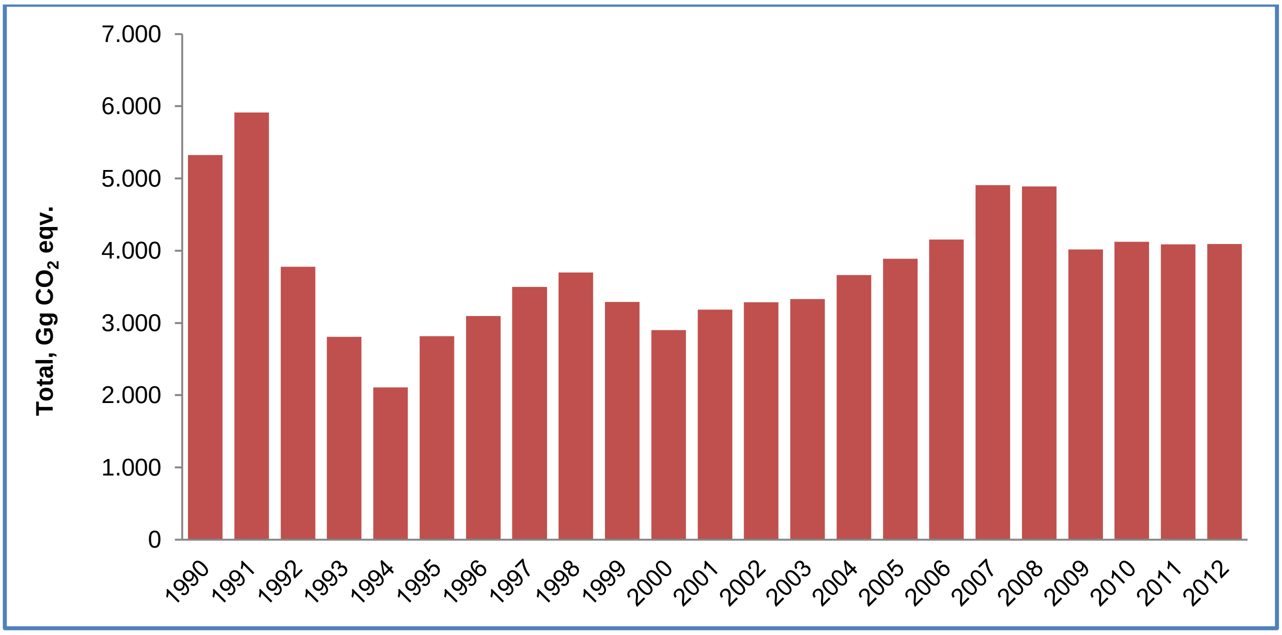

Figure 3-25. Development of greenhouse-gas emissions from road transport, Gg CO_2 eqv. in 1990-2012

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

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

[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.

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. 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. The number of petrol engines (all vehicles) has dropped between 1990 and 2012 (-54%), while the number of diesel engines has more than doubled from ~116 to 736 thousands for the same period.

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 (v10.0) 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:

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

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.

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

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:

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

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):

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

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:

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

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 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 v9.0). 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 3-39.

Table 3-39. Emission factors for Road transportation sector used in the Lithuanian GHG inventory

Fuel	Emission factor [kg/GJ]	Source / Comments
CO_2 emission factors		
Motor gasoline	72,97	Country specific EF based on producer data (research protocols of UAB ORLEN Lietuva Quality Research Center)
Gas/Diesel oil	72,89	Country specific EF based on producer data (research protocols of UAB ORLEN Lietuva Quality Research Center)
LPG	65,42	Country specific EF based on producer data (research protocols of UAB ORLEN Lietuva Quality Research Center)
Biodiesel	70,8	2006 *IPCC Guidelines*
Bioethanol	70,8	2006 *IPCC Guidelines*
CH_4 emission factors		
Biodiesel	10,0	2006 *IPCC Guidelines*
Bioethanol	10,0	2006 *IPCC Guidelines*
N_2O emission factors		
Biodiesel	0,6	2006 *IPCC Guidelines*
Bioethanol	0,6	2006 *IPCC Guidelines*

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%. 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.

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 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%.

Following in-country review ERT 2012 recommended providing justification of gasoline N_2O IEF fluctuation 2006-2008. Over 1990-2011 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 (Figure 3-26) since a regression line of nitrous oxide emission factors against mileage for passenger vehicles yielded a slight not significant slope (Barton and Simpson, 1994):

$$EF_{N2O} = (a \times Mj,k + b) \times EF_{BASE,} \qquad (2)$$

where,

a, b, EF_{BASE} depend on technology level for gasoline PCs & LCVs

[10] IPCC GPG 2000. Energy. P. 2-49.

a, b depend on fuel sulfur content

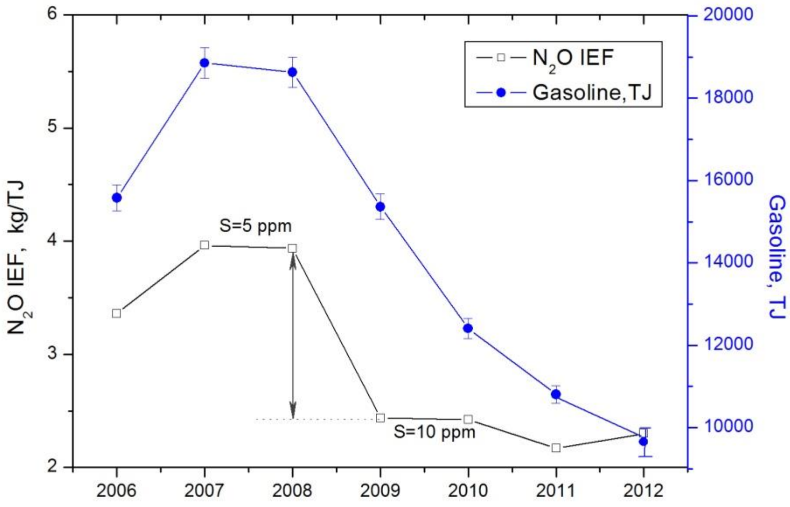

Figure 3-26. Dynamic of Implied Emission Factors of N_2O for gasoline

The fuel consumption slightly decreased in 2007-2012, 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

CO_2, CH_4 and N_2O emissions from *Road Transportation* have been recalculated in this submission (Table 3-41) with respect to the new fuel consumption activity data (Table3-40).

Table 3-40. Revised activity data for Road transport, TJ

Fuel Type	Year	Submission 2013	Submission 2014
Gasoline	2005	14686	14685
Diesel oil	2011	37613	38491
LPG	2010	7681	7275
	2011	7554	6790

[11] TNO, 2002; Riemersma et al., 2003

Table 3-41. Recalculated GHG emissions from Road Transportation

Year	Submission 2013 Gg CO_2 eqv.	Submission 2014 Gg CO_2 eqv.	Absolute difference	Relative difference %
2005	3886,46	3886,36	-0,10	-0,003
2010	4141,58	4122,38	-19,20	-0,464
2011	4055,11	4087,46	32,35	0,798

3.4.2.6 Source-specific planned improvements

No source-specific improvements are planed.

3.4.3 Railways (CRF 1.A.3.c)

3.4.3.1 Source category description

In 2012, the operational length of railways amounted to 1767.6 km. The length of electrified lines remained unchanged (122 km).

Emissions of railway transportation comprise railway transport operated by diesel locomotives. In 2011 electric locomotives run only 0,7% of railway transportation in Lithuania. In 2012, compared to 2011, the number of railway vehicles decreased: that of locomotives – by 4,5, wagons – by 1,1, coaches (including diesel and electric railcars) – 2,2%. 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 (Figure 3-27).

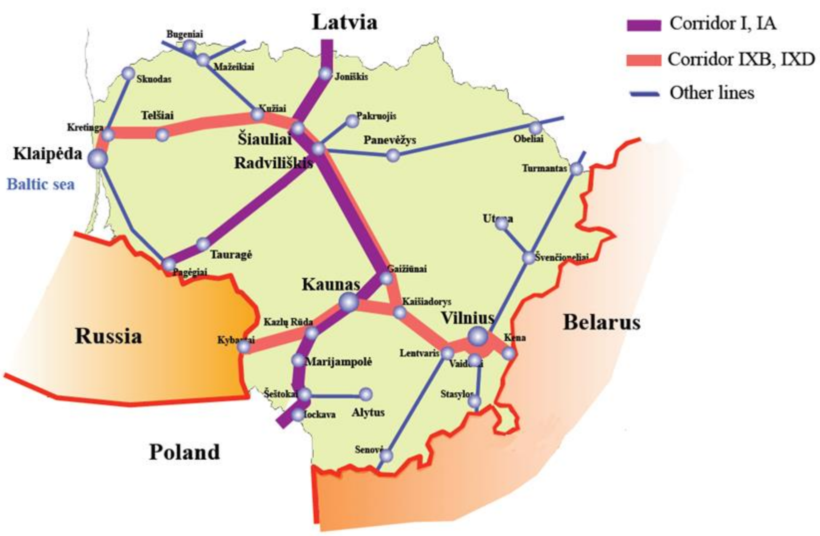

Figure 3-27. Lithuanian railways network

This sector concerns the movement of goods or people mostly by diesel locomotives. Most locomotives (79,7%), 88,4% of coaches (including diesel and electric railcars) and 91,3% of wagons were produced 15 years ago or even earlier.

In 2012, goods transport by rail amounted to 49,4 million tonnes, which is by 5,6% less than in 2011. National goods transport by rail amounted to 14,9 million tonnes, which is by 1% less than in 2011; international goods transport by rail amounted to 34,5 million tonnes, which is by 7,5% less than in 2011. In 2012, 33,8% of all the goods carried by rail (16,7 million tonnes) were coke and refined petroleum products. Chemicals, chemical products and man-made fibres, rubber and plastic products, nuclear fuel carried by rail amounted to 13,3 million tonnes, or 27%, metal ores and other mining and quarrying products, peat, uranium and thorium – 4,5 million tonnes, or 9% of all the goods carried by rail.

The major proportion of goods was carried from Belarus (66,1%) and Russia (24,1%). Most goods from Lithuania were carried to Latvia (23,9%), Belarus (20,2%), and Ukraine (16,5%). Fuel consumption 1990-2012 for railways, based on energy statistics from Statistics Lithuania is shown in Figure 3-28.

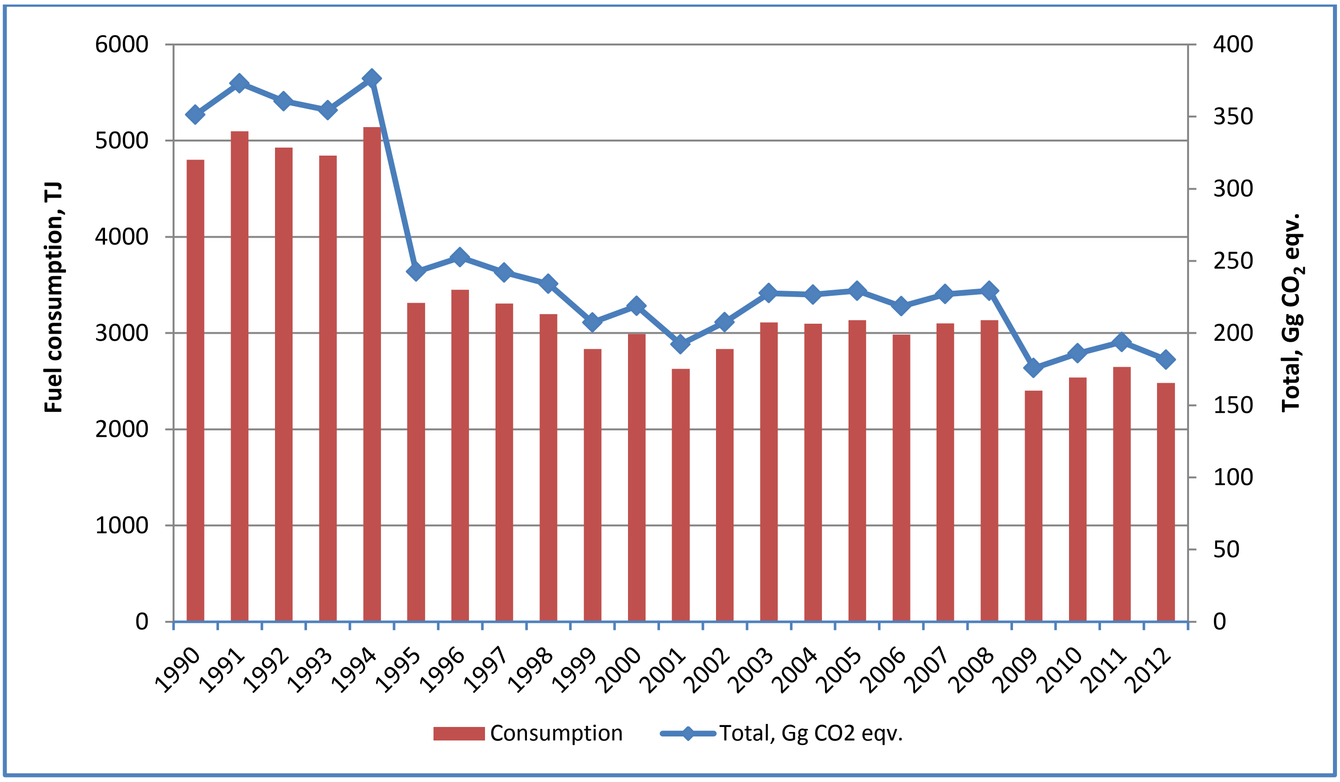

Figure 3-28. Trend of GHG emissions in *Railways* sector

The trend of Gg CO_2 eqv. 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.

3.4.3.2 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 (Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual). 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):

$$Emission = \sum_j (Fuel_j \cdot EF_j)\,. \tag{6}$$

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 3-42.

Table 3-42. Emission factors for Railways sector used in the Lithuanian GHG inventory

Fuel	Emission factor [kg/GJ]	Source / Comments
CO_2 emission factor		
Diesel oil	72,89	Country specific EF based on producer data (research protocols of UAB ORLEN Lietuva Quality Research Center)
CH_4 emission factor		
Diesel oil	5,0	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. 1.35. TABLE 1-7.
N_2O emission factor		
Diesel oil	0,6	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. 1.36. TABLE 1-8.

Emissions from electricity used in electric trains are not included in this category, but in category 1.A 1. Emissions of railway transportation were 0,18 Tg (CO_2 eqv.) in 2012, it was only 4,0% of the *Transport* sector emissions. The emissions were 0,35 Tg (CO_2 eqv.) in 1990. Substantial decrease from the year 2008 is caused by the ongoing economic depression.

3.4.3.3 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.

3.4.3.4 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.

3.4.3.5 Source-specific recalculations

No source-specific recalculations were done.

3.4.3.6 Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

3.4.4 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 2012. Transport of goods by inland waterways amounted to 1049,5 thous. tonnes in 2012. In 2012, compared to 2011, passenger transport by inland waterways increased by 2,8%.

As seen in Figure 3-29 fuel consumption decreased by 3,6% between 1990 and 2012. This decrease is obviously due to the impact of the decreased fuel consumption in inland waterways.

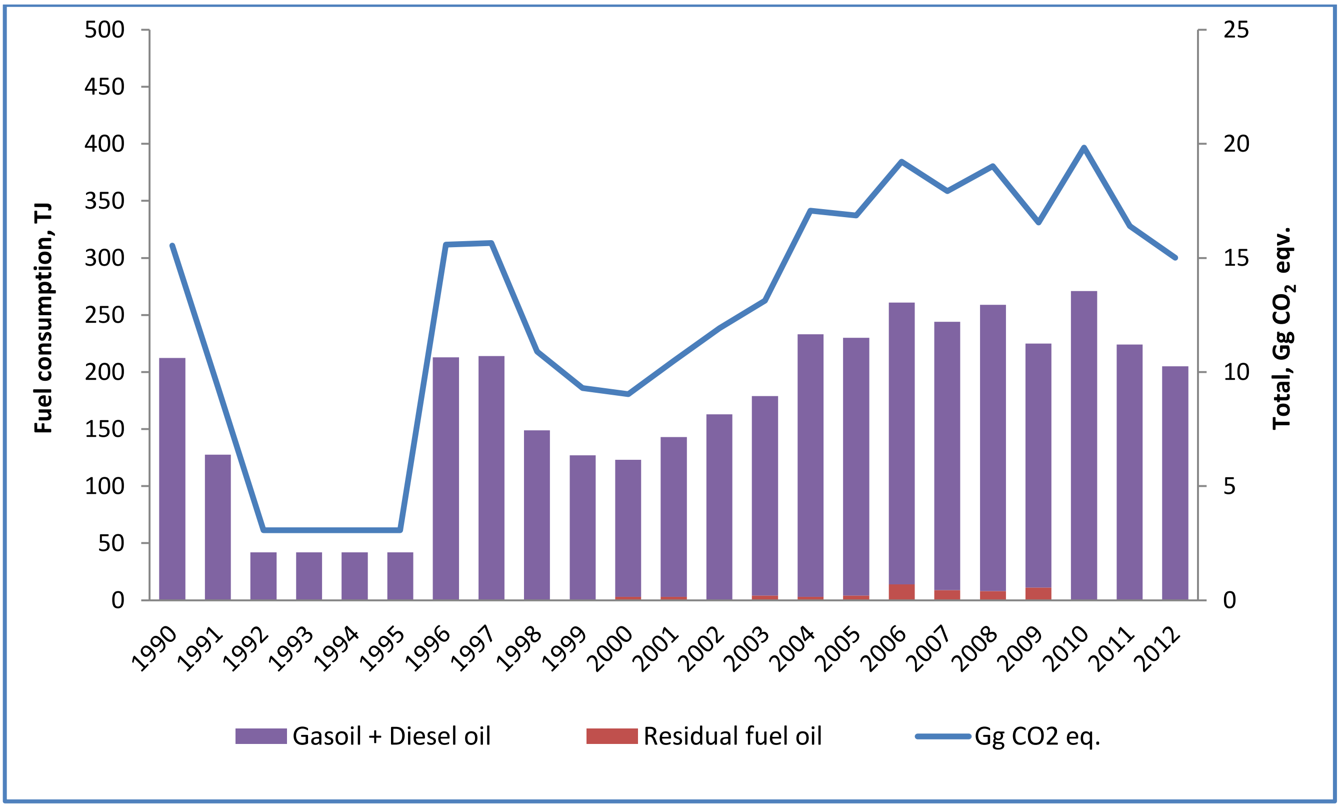

Figure 3-29. Trend of GHG emissions in *Water navigation* sector

3.4.4.1 Source category description eqv.

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 0,015 Tg (CO_2 eqv.) in 2012, it was ~0,4% of the sector's emissions. Emissions were 0,016 Tg (CO_2 eqv.) in 1990.

3.4.4.2 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:

$$Emission = \sum (FuelConsumed_{ab} \cdot EF_{ab}) \,. \tag{7}$$

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 3-43.

Table 3-43. Emission factors for Water-borne navigation sector used in the Lithuanian GHG inventory

Fuel	Emission factor [kg/GJ]	Source / Comments
CO_2 emission factors		
Residual Fuel Oil	77,60	Country specific EF based on “Greenhouse gas emissions characteristics of national energy sector” study, 2012
Gasoil and Diesel oil	72,89	Country specific EF based on producer data (research protocols of UAB ORLEN Lietuva Quality Research Center)
CH_4 emission factors		
Residual Fuel Oil	5,0	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. 1.35. TABLE 1-7.
Gasoil and Diesel oil	5,0	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. 1.35. TABLE 1-7.
N_2O emission factors		
Residual Fuel Oil	0,6	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. 1.36. TABLE 1-8.
Gasoil and Diesel oil	0,6	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. 1.36. TABLE 1-8.

3.4.4.3 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 ± 140% and CH_4 ± 50% (2006 *IPCC Guidelines*).

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

No source-specific recalculations were done.

3.4.4.6 Source-specific planned improvements

No source-specific improvements are under active consideration at the moment.

3.4.5 Other (CRF 1.A.3.e; 1.A.5.b)

3.4.5.1 Natural gas transportation in pipelines (1.A.3.e)

In Lithuania, natural gas is transported via gas transmission and distribution systems (Figure 3-30) 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 3-44).

Table 3-44. 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

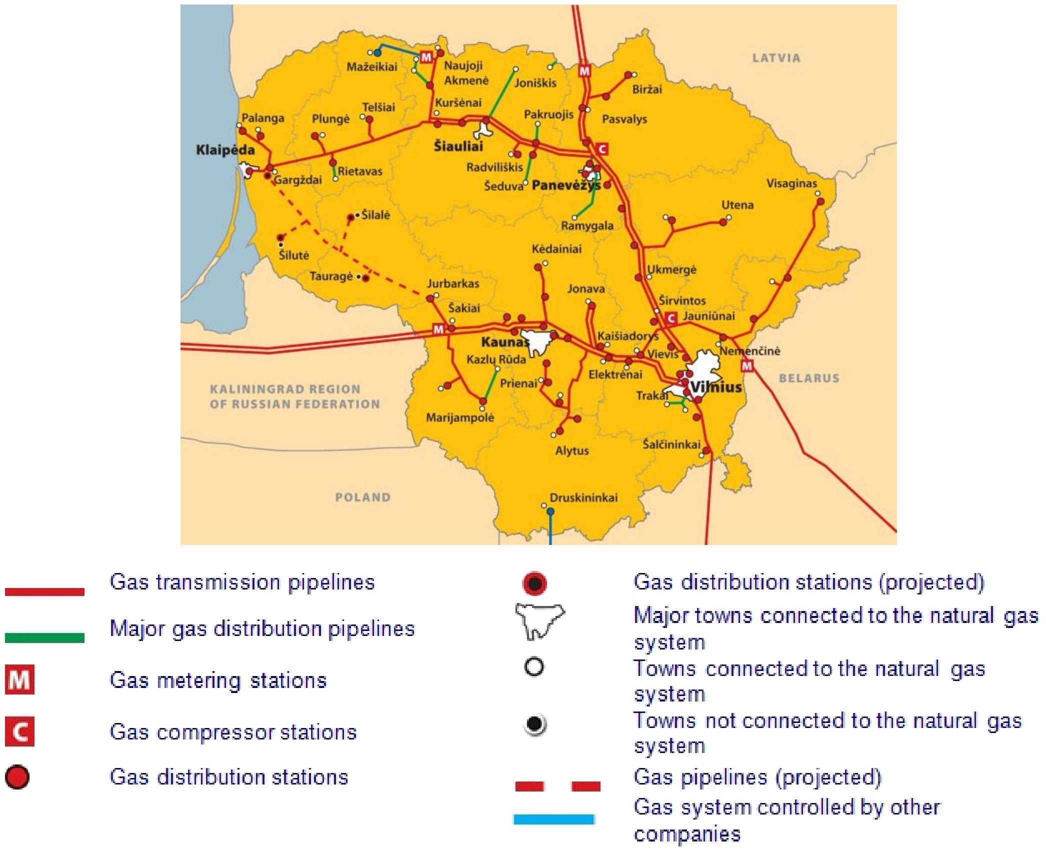

Figure 3-30. Gas distribution network in Lithuania

3.4.5.1.1 Source category description (1.A.3.e)

Transport via pipelines includes transport of gases via pipelines.

3.4.5.1.2 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 3-45.

Table 3-45. CO_2 emission factor for Natural gas transportation in pipelines sector used in the Lithuanian national GHG inventory

Fuel	Emission factor, kg/GJ	Source / Comments
CO_2 emission factor		
Natural gas	55,23	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
CH_4 emission factor		
Natural gas	5,0	*Revised 1996 IPCC Guidelines*
N_2O emission factor		
Natural gas	0,1	*Revised 1996 IPCC Guidelines* and *2006 IPCC Guidelines*

3.4.5.1.3 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*).

3.4.5.1.4 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.

3.4.5.1.5 Source-specific recalculations

Country specific CO_2 emission factor for natural gas based on study on "Determination of national GHG emission factors for energy sector" was applied (Table 3-46).

Table 3-46. Recalculated GHG emissions from Natural gas transportation in pipelines

Year	Submission 2013, Gg CO_2 eqv.	Submission 2014, Gg CO_2 eqv.	Absolute difference, Gg CO_2 eqv.	Relative difference, %
1990	88,3	85,7	-2,6	-2,9
1991	85,0	82,5	-2,5	-2,9
1992	48,8	47,3	-1,5	-3,1
1993	27,3	26,5	-0,8	-2,9
1994	29,8	29,0	-0,8	-2,7
1995	34,8	33,8	-1,0	-2,9
1996	39,1	37,9	-1,2	-3,1
1997	36,7	35,6	-1,1	-3,0
1998	28,4	27,6	-0,8	-2,8
1999	32,3	31,3	-1,0	-3,1
2000	39,6	38,4	-1,2	-3,0
2001	19,3	18,7	-0,6	-3,1
2002	21,4	20,8	-0,6	-2,8
2003	18,4	17,8	-0,6	-3,3

2004	18,4	17,9	-0,5	-2,7
2005	36,9	35,8	-1,1	-3,0
2006	62,3	60,5	-1,8	-2,9
2007	65,3	63,4	-1,9	-2,9
2008	57,3	55,6	-1,7	-3,0
2009	57,9	56,2	-1,7	-2,9
2010	58,6	56,9	-1,7	-2,9
2011	49,2	47,7	-1,5	-3,0

3.4.5.1.6 Source-specific planned improvements

No improvements are planned.

3.4.5.1.7 Off-road vehicles and other machinery (1.A.3.E)

3.4.5.1.8 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*).

3.4.5.1.9 Methodological issues

Revised 1996 IPCC 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 3-47.

Table 3-47. Emission factors for Off-road vehicles and other machinery sector used in the Lithuanian national GHG inventory

Fuel	Emission factor, kg/TJ	Source / Comments
CO_2 emission factors		
Motor gasoline	72,97	Country specific EF based on producer data (research protocols of UAB ORLEN Lietuva Quality Research Center)
Diesel oil	72,89	Country specific EF based on producer data (research protocols of UAB ORLEN Lietuva Quality Research Center)
CH_4 emission factors		

Motor gasoline	5	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual. Table 1-7. p. 1.35
Diesel oil	5	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual. Table 1-7. p. 1.35
N_2Oemission factors		
Motor gasoline	0,6	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. 1.36. TABLE 1-8.
Diesel oil	0,6	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. 1.36. TABLE 1-8.

3.4.5.1.10 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.

3.4.5.1.11 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.

3.4.5.1.12 Source-specific recalculation

Following recalculations in this category has been done taking into account corrections of activity data of diesel oil based on the newest statistical information provided by Lithuanian Statistics in November 2013. Impact of these recalculations on GHG emissions from Off-road transportation are presented in Table 3-48.

Table 3-48. Recalculated GHG emissions from Off-road transportation

Year	Submission 2012 Gg CO_2 eqv.	Submission 2013 Gg CO_2 eqv.	Absolute difference	Relative difference %
1990	1772,4	1685,3	-87,1	-4,9
1991	1343,4	1265,7	-77,7	-5,8
1992	1006,7	966,3	-40,4	-4,0
1993	869,4	838,3	-31,1	-3,6
1994	822,7	754,3	-68,4	-8,3
1995	775,8	760,3	-15,5	-2,0
2005	206,5	205,5	-1,0	-0,5
2006	194,4	193,9	-0,5	-0,3
2007	193,2	192,9	-0,3	-0,2
2008	198,1	197,8	-0,3	-0,2
2009	152,3	151,8	-0,5	-0,3

2010	157,6	157,3	-0,3	-0,2
2011	166,1	165,5	-0,6	-0,4

3.4.5.1.13 Source-specific planned improvements

No improvements are planned.

3.4.5.2 Military aviation (1.A.5.b)

3.4.5.2.1 Source category description

Military activity is defined here as those activities using fuel purchased by or supplied to the military authorities of the country.

3.4.5.2.2 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 3-35. 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.

Emission factors

Emission factors used in the calculation of emissions from *Civil aviation* transportation are presented in Tables 3-36 – 3-38.

3.4.5.2.3 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.

3.4.5.2.4 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.

3.4.5.2.5 Source-specific recalculation

No source-specific recalculations were done.

3.4.5.2.6 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 69,2% (2009). In 2012 the share of value added in commercial / institutional sector reduced till 65,0%. Retail, wholesale trade, transport, accommodation and catering services' sector is the largest sector prescribed to this category. With reference to data of 2012, it created 32,9% 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 3-64) 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 3-49.

Table 3-49. 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	10,0	D	T1	0,6	D	T1
Gasoil	72,89	CS	T2	10,0	D	T1	0,6	D	T1
Peat	104,34	CS	T2	10,0	CS	T2	1,4	CS	T2
Coking coal	94,90	CS	T2	10,0	D	T1	1,4	D	T1
Anthracite	106,55	CS	T2	10,0	D	T1	1,4	D	T1

Sub-bituminous coal	96,00	CS	T2	10,0	D	T1	1,4	D	T1
Lignite	101,20	CS	T2	10,0	D	T1	1,4	D	T1
Natural gas	55,23	CS	T2	5,0	D	T1	0,1	D	T1
Wood/ wood waste	109,90	CS	T2	300,0	D	T1	4,0	D	T1
Other solid biomass	109,90	CS	T2	300,0	D	T1	4,0	D	T1
Charcoal	109,90	CS	T2	200,0	D	T1	1,0	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 (1996 IPCC); T1 - Tier 1; T2 - Tier 2.

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 3-30.

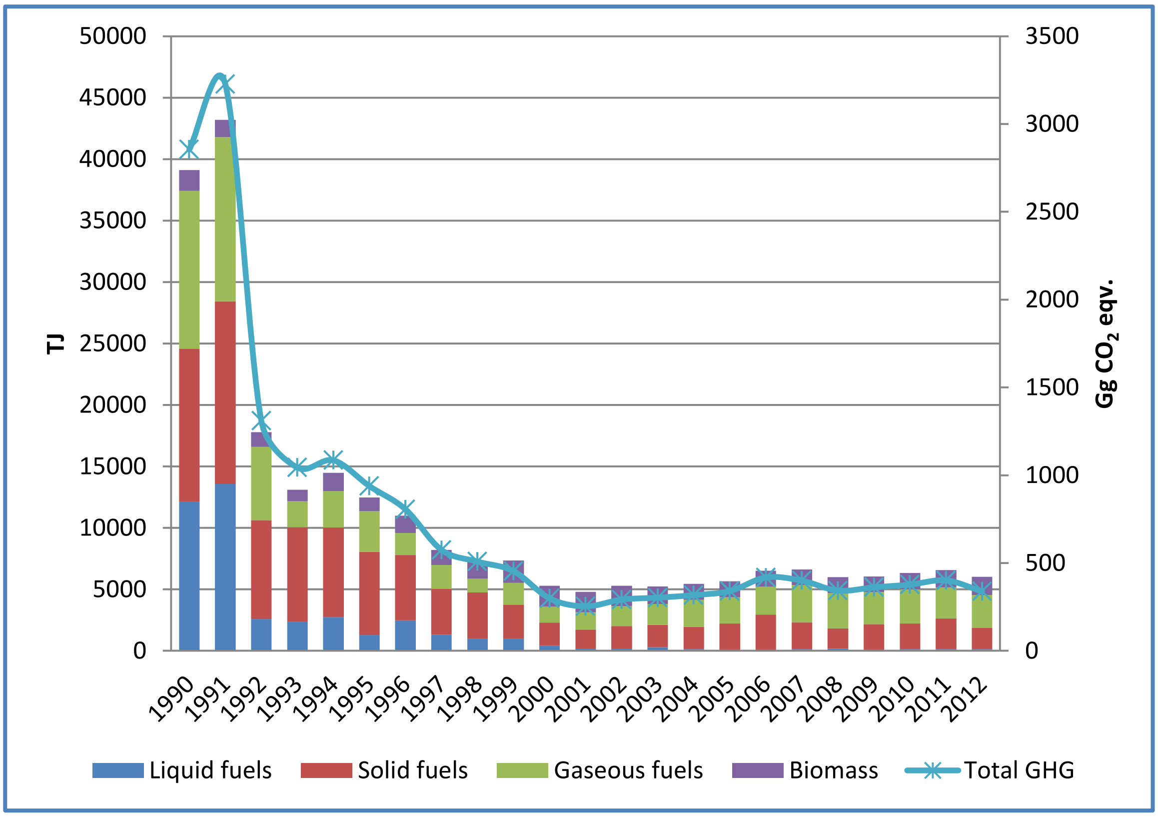

Figure 3-31. Tendencies of fuel consumption in Commercial / institutional sector during 1990-2012

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 (2008-2009) fuel consumption volumes was further reduced by 4,8% a year. In 2012 there was consumed 6,01 PJ of fuel in Commercial / institutional sector. This was 8,5% less than in 2011. In 2012, natural gas accounted 44,1% of fuel structure, solid fuels – 29,1%, biomass – 24,6% and liquid fuels – 2,2%.

In 2012, total GHG emissions from Commercial / institutional sector were even 8,4 times lower than in 1990 and amounted 338,5 Gg CO_2 eqv.

3.5.1.3 Uncertainties and time-series consistency

Uncertainty in activity data in Commercial/ institutional 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 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 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 recalculations

Following recalculations in this category has been done taking into account ERT recommendations:

- corrections of activity data of lignite and charcoal consumption based on the newest statistical information provided by Lithuanian Statistics in November 2013;
- dissagregation of activity data for anthracite, coking coal and sub-bituminous since 2000 based on the newest information provided by Lithuanian Statistics in November 2013.

Impact of these recalculations on GHG emissions from 1.A.4.a Commercial/institutional sector is presented in Table 3-50.

Table 3-50. Impact of recalculation on GHG emissions from 1.A.4.a Commercial/institutional sector

Year	Submission 2013, Gg CO_2 eqv.	Submission 2014, Gg CO_2 eqv.	Absolute difference, Gg CO_2 eqv.	Relative difference, %
2000	315,4	298,5	-16,9	-5,4
2001	267,2	253,5	-13,7	-5,1
2002	308,5	292,0	-16,5	-5,3
2003	319,6	303,0	-16,6	-5,2
2004	333,2	317,2	-16,0	-4,8
2005	358,5	340,2	-18,3	-5,1
2006	442,9	417,8	-25,1	-5,7
2007	418,4	399,8	-18,6	-4,4
2008	354,5	342,9	-11,6	-3,3
2009	373,1	361,7	-11,4	-3,1
2010	389,7	377,2	-12,5	-3,2
2011	401,8	401,1	-0,7	-0,2

3.5.1.6 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 2012 – 66,6 m^2. With reference to data of 2012, 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 3-67) 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 3-51.

Table 3-51. 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	10,0	D	T1	0,1	D	T1
Gasoil	72,89	CS	T2	10,0	D	T1	0,6	D	T1
Peat	104,34	CS	T2	300,0	CS	T2	1,4	CS	T2
Coking coal	94,40	CS	T2	300,0	D	T1	1,4	D	T1
Anthracite	106,55	CS	T2	300,0	D	T1	1,4	D	T1
Sub-bituminous coal	96,00	CS	T2	300,0	D	T1	1,4	D	T1
Lignite	101,20	CS	T2	300,0	D	T1	1,4	D	T1
Natural gas	55,23	CS	T2	5,0	D	T1	0,1	D	T1
Wood/ wood waste	109,90	CS	T2	300,0	D	T1	4,0	D	T1
Other solid biomass	109,90	CS	T2	300,0	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 (1996 IPCC); T1 - Tier 1; T2 - Tier 2.

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.

Tendencies of fuel consumption and total GHG emissions in Residential sector are presented in Figure 3-31.

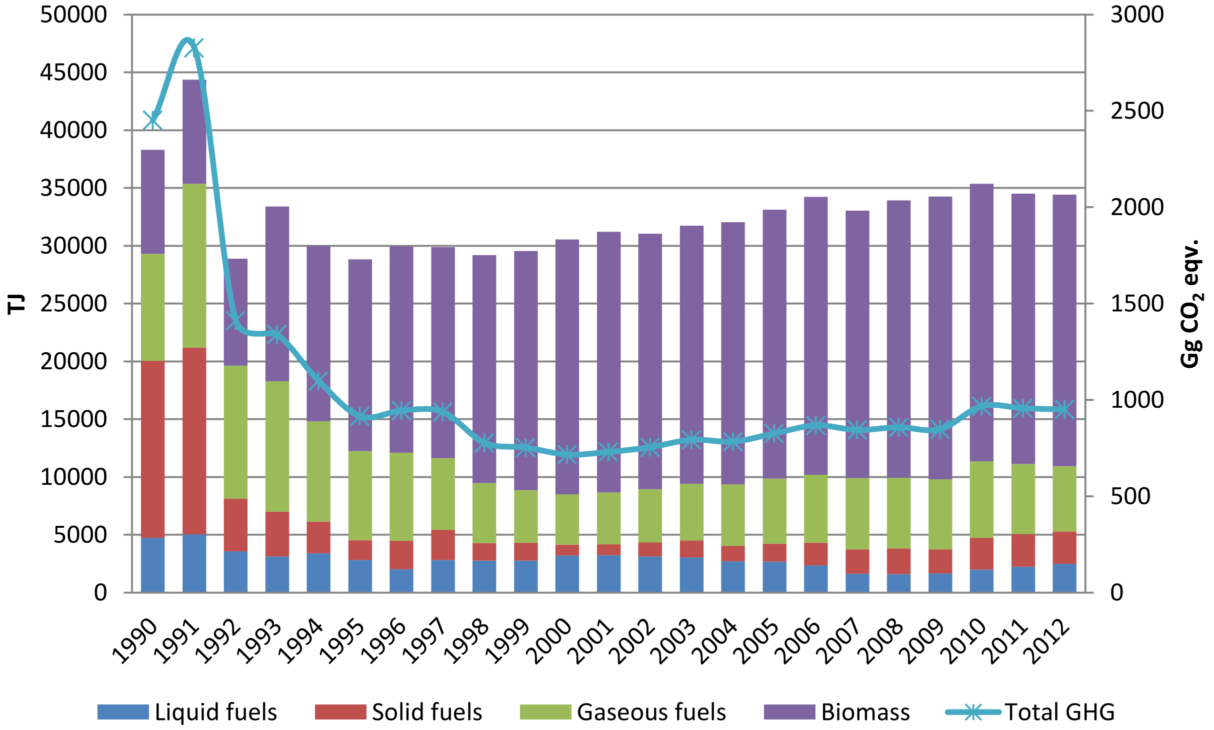

Figure 3-32. Tendencies of fuel consumption in Residential sector during 1990-2012

As it is seen from Figure 3-17, biomass dominates in the structure of fuel consumed in Residential sector. Biomass accounted 68,2%, natural gas - 16,5%, solid fuels - 8,1% of fuel structure in 2012. The share of liquid fuels is increasing during last three years and with reference to data of 2012, there were consumed 2,5 PJ (7,2% of fuel structure) of liquid fuels.

In 2012, total GHG emissions from Residential sector were 2,6 times lower than in 1990 and amounted 950,0 Gg CO_2 eqv.

3.5.2.3 Uncertainties and time-series consistency

Uncertainty in activity data in Residential 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 (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 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 recalculations

Following recalculations in this category has been done:

- corrections of activity data of LPG consumption based on the newest statistical information provided by Lithuanian Statistics in November 2013;
- dissagregation of activity data for anthracite, coking coal and sub-bituminous since 2000 based on the newest information provided by Lithuanian Statistics in November 2013.

Impact of these recalculations on GHG emissions from 1.A.4.b Residential sector is presented in Table 3-52.

Table 3-52. Impact of recalculations on GHG emissions from 1.A.4.b Residential sector

Year	Submission 2013, Gg CO_2 eqv.	Submission 2014, Gg CO_2 eqv.	Absolute difference, Gg CO_2 eqv.	Relative difference, %
2000	722,5	716,1	-6,4	-0,9
2001	736,2	729,6	-6,6	-0,9
2002	762,5	753,9	-8,6	-1,1
2003	803,2	792,9	-10,3	-1,3
2004	792,5	783,1	-9,4	-1,2
2005	835,9	825,8	-10,1	-1,2
2006	881,5	867,3	-14,2	-1,6
2007	859,9	843,6	-16,3	-1,9
2008	871,7	857,6	-14,1	-1,6
2009	859,1	847,5	-11,6	-1,4
2010	966,3	967,4	1,1	0,1
2011	930,9	956,5	25,6	2,8

3.5.2.6 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 7,2% in 2011. With reference to data of 2012, this sector created 4,0% of total GDP. This is only by 0,2 percentage points more than in 2011.

3.5.3.2 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 3-68) 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/fisheries sector (1.A.4.c) are presented in Table 3-53.

Table 3-53. Emission factors and methods for category Agriculture/forestry/fisheries sector (1.A.4.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
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	10,0	D	T1	0,6	D	T1
Gasoil	72,89	CS	T2	10,0	D	T1	0,6	D	T1
Peat	104,34	CS	T2	300,0	CS	T2	1,4	CS	T2
Coking coal	94,90	CS	T2	300,0	D	T1	1,4	D	T1
Anthracite	106,55	CS	T2	300,0	D	T1	1,4	D	T1
Sub-bituminous coal	96,00	CS	T2	300,0	D	T1	1,4	D	T1
Natural gas	55,23	CS	T2	5,0	D	T1	0,1	D	T1
Wood/ wood waste	109,90	CS	T2	300,0	D	T1	4,0	D	T1
Other solid biomass	109,90	CS	T2	300,0	D	T1	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 (1996 IPCC); T1 - Tier 1; T2 - Tier 2.

Activity data

For calculation of GHG emissions in category Agriculture/forestry/fisheries sector (1.A.4.c) 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/fisheries sector are presented in Figure 3-32.

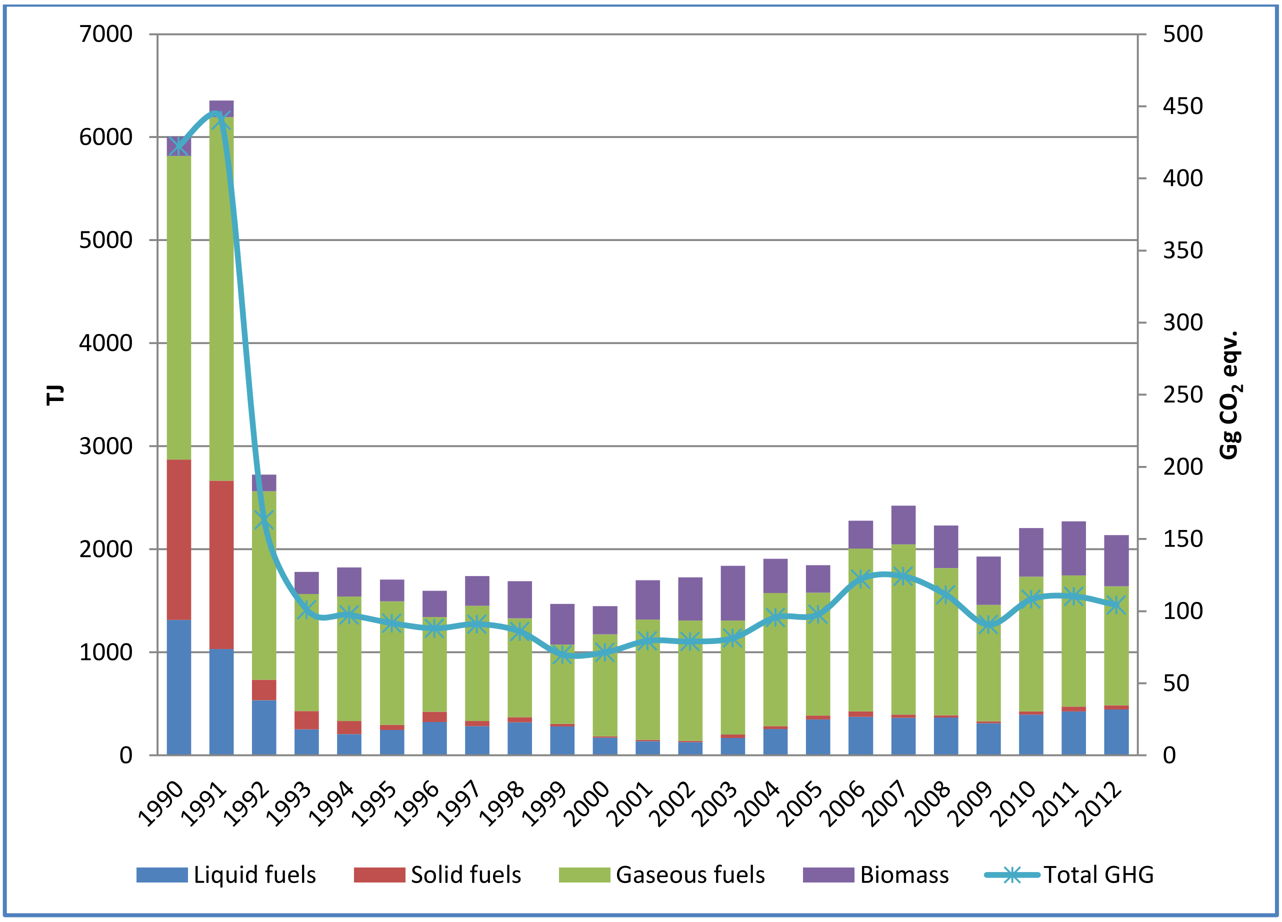

Figure 3-33. Tendencies of fuel consumed and total GHG emissions in Agriculture/forestry/fisheries sector during 1990-2012

Figure 3-32 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/fisheries sector reduced by 11,7%. In 2010 fuel consumption increased by 9,4%. In 2012, natural gas made the largest share in the structure of fuel – 54,1%. The share of biomass was 23,2%, liquid fuel – 20,9% and solid fuel – 1,8%.

In 2012, total GHG emissions from Agriculture/forestry/fisheries sector were 4 times lower than in 1990 and amounted 104,2 Gg CO_2 eqv.

3.5.3.3 Uncertainties and time-series consistency

Uncertainty in activity data in Agriculture/forestry/fisheries 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/fisheries 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.

3.5.3.4 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.

3.5.3.5 Source-specific recalculations

Following recalculations in this category has been done:

- corrections of activity data of biogas consumption based on the newest statistical information provided by Lithuanian Statistics in November 2013;
- dissagregation of activity data for anthracite, coking coal and sub-bituminous since 2000 based on the newest information provided by Lithuanian Statistics in November 2013.

Impact of these recalculations on GHG emissions from 1.A.4.c Agriculture/forestry/fisheries sector is presented in Table 3-54.

Table 3-54. Impact of recalculations on GHG emissions from 1.A.4.c Agriculture/forestry/fisheries sector

Year	Submission 2013, Gg CO_2 eqv.	Submission 2014, Gg CO_2 eqv.	Absolute difference, Gg CO_2 eqv.	Relative difference, %
2000	71,44	71,35	-0,09	-0,13
2001	79,49	79,40	-0,09	-0,11
2002	79,08	78,90	-0,18	-0,23
2003	81,66	81,29	-0,37	-0,45
2004	95,85	95,67	-0,18	-0,19
2005	98,07	97,70	-0,37	-0,38
2006	122,65	122,20	-0,45	-0,37
2007	124,34	124,15	-0,19	-0,15
2008	111,47	111,28	-0,19	-0,17
2009	90,69	90,61	-0,08	-0,09
2010	108,23	108,18	-0,05	-0,05

3.5.3.6 Source-specific planned improvements

Source-specific improvements are not planned.

3.5.4 Other stationary (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, Gg;

$A_{industry segment}$ - activity value, units of activity;

$EF_{industry segmentl}$ - emission factor, Gg/unit of activity.

Emissions from natural gas distribution were calculated by using emission factors provided in the IPCC GPG 2000-table 3-28 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".

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.

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. As country-specific emission factors are not available, emissions of CH_4 and CO_2 from natural gas distribution and transmission were calculated using default emission factors provided in IPCC GPG 2000.

Table 3-55. Emission factors for fugitive emissions from oil and natural gas systems (1.B.2), kg/TJ

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
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
Oil production	Conventional oil	Fugitives	1,45E-03	2,7E-04	0	Gg per 10^3 m^3 conventional oil production
		Venting	138,1E-05	1,2E-05	0	Gg per 10^3 m^3 conventional oil production
		Flaring	13,75E-05	6,7E-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

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 transmission and distribution pipelines from UAB Lietuvos dujos (http://www.dujos.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.

CO_2, CH_4 and N_2O emission factors used in estimation of emissions were taken from IPCC GPG 2000 so uncertainty was assigned as very high about 50% according IPCC GPG 2000.

[12] http://www.stat.gov.lt

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 recalculations

No recalculations have been done for the sector in this submission.

3.6.2.6 Source-specific planned improvements

Source-specific improvements are not planned.

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 2012 the Fund provided information on verified CO_2 emissions for 96 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 3-56.

Table 3-56. Comparison of the verified CO_2 emissions and NIR (sectoral approach), 2012

	Verified CO_2 emissions, Gg	Calculated CO_2 emissions, Gg	Absolute difference, Gg	Relative difference, %
1.AA.1.A Public Electricity and Heat Production	2643.87	2938.08	294.2	10.0
1.AA.1.B Petroleum Refining	1731.63	1414.45	-317.2	-22.4
1.AA.2.C Chemicals	312.97	205.90	-107.1	-52.0
1.AA.2.D Pulp, Paper and Print	34.96	66.54	31.6	47.5

[13] http://www.laaif.lt/index.php?-130096284

1.AA.2.E Food Processing, Beverages and Tobacco	50.81	297.81	247.0	82.9
1.AA.2.F Other	912.59	688.95	-223.6	-32.5
1.AA.4.C Agriculture/ Forestry/ Fisheries	31.17	99.84	68.7	68.8
Total	5717.99	5711.57	-6.4	-0.1

Total CO_2 emissions calculated in NIR sectoral approach are only 0,1% lower 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.

4 INDUSTRIAL PROCESSES (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 87% of the total industrial production (excluding construction) in 2012 (Figure 4-1).

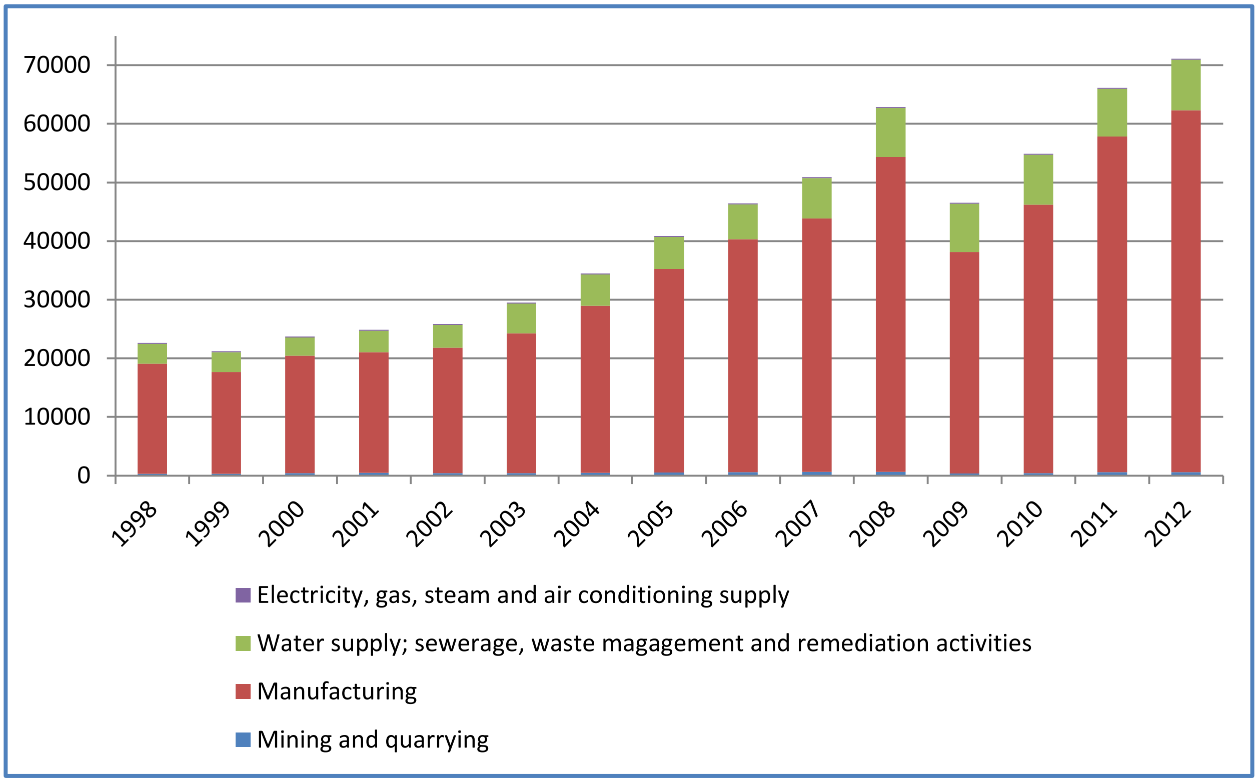

Figure 4-1. Industrial production at constant prices (except construction) in millions Litas

Four most important sectors within Manufacturing cumulatively produced 74% of production:

- Manufacture of refined petroleum products (34%);
- Manufacture of food products and beverages (18%);
- Manufacture of wood products and furniture (10%);
- Manufacture of chemicals and chemical products (12%).

Share of the main sectors in production of manufacturing products in Lithuania is presented in Figure 4-2.

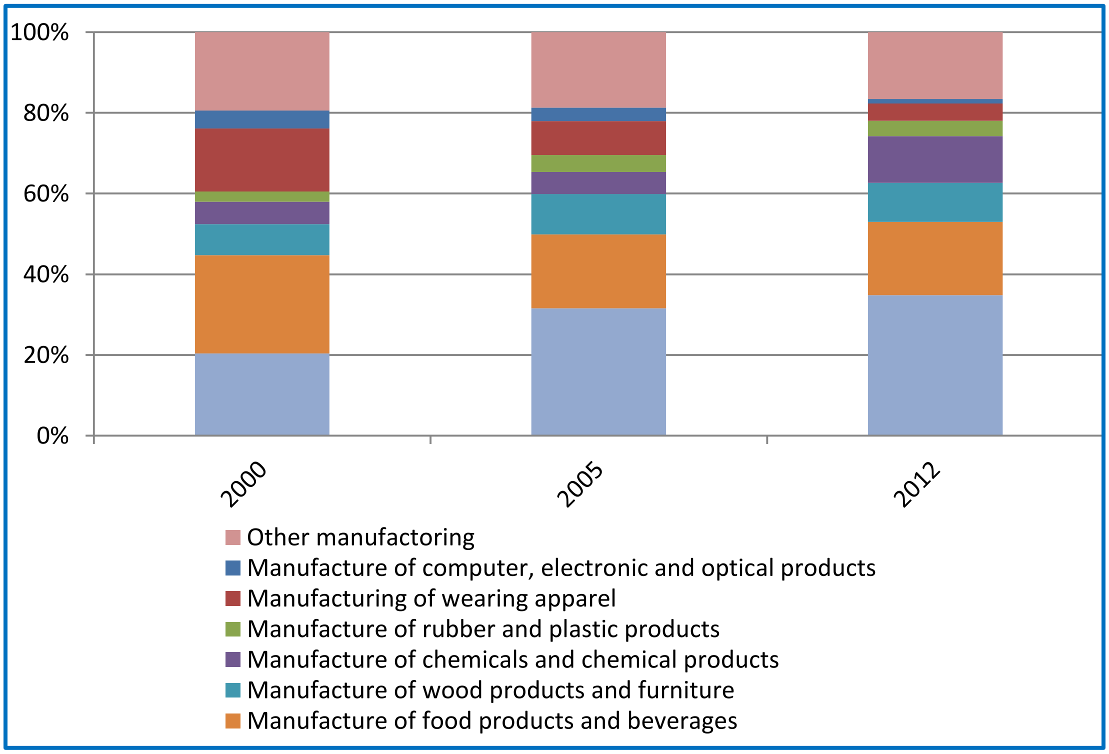

Figure 4-2. Share of the main sectors in production of manufacturing products in Lithuania

Greenhouse gas emissions from Industrial processes contributed 16,8 % to the total anthropogenic greenhouse gas emissions in Lithuania in 2012, totalling 3626,9 Gg CO_2 eqv. (Figure 4-3.).

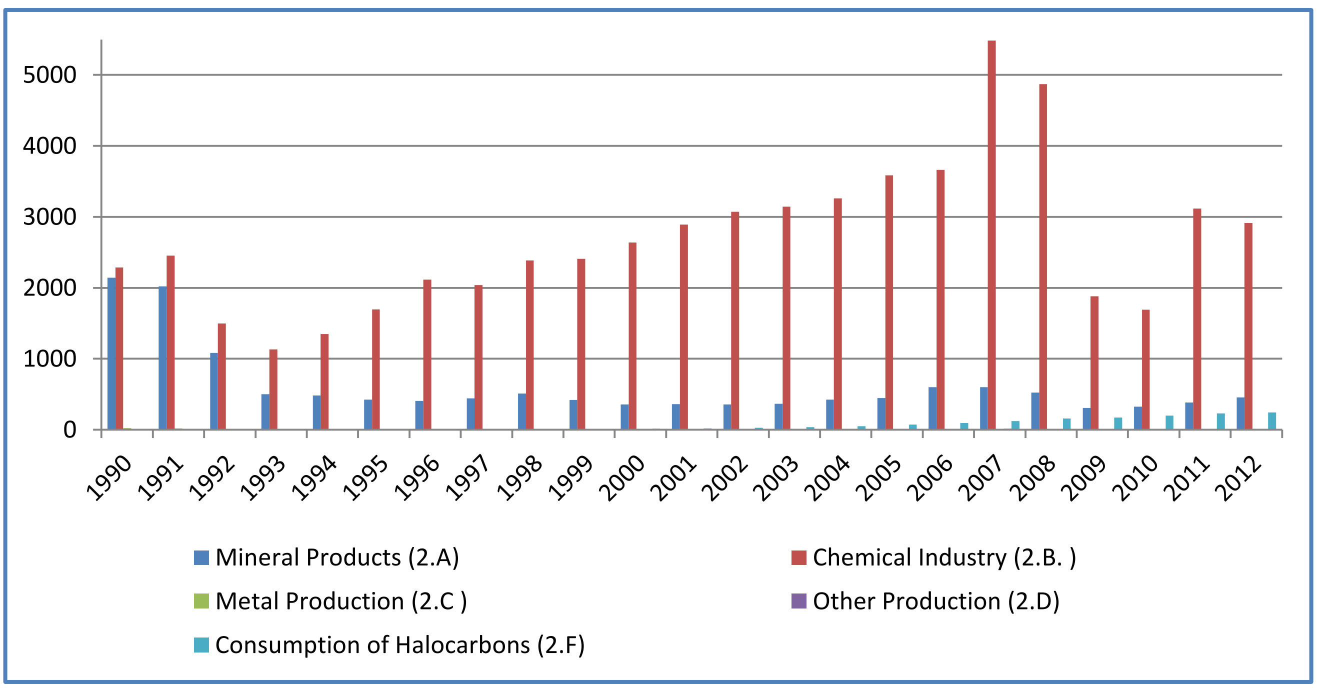

Figure 4-3. GHG emissions from industrial processes in 1990-2012, Gg CO_2 eqv.

Lithuanian greenhouse gas emissions from Industrial processes consist from the following emission categories:

- Mineral products (CRF 2.A) include CO_2 emissions from:

- cement production (CRF 2.A.1);
- lime production (CRF 2.A.2);
- limestone and dolomite use (CRF 2.A.3);
- soda ash use (CRF 2.A.4.2);
- asphalt roofing (CRF 2.A.5);
- road paving with asphalt (CRF 2.A.6);
- other: glass (CRF 2.A.7.1), mineral wool, bricks and tiles production.

- Chemical industry (CRF 2.B) include:
  - CO_2 emissions from ammonia production (CRF 2.B.1) and methanol production (CRF 2.B.5.5);
  - N_2O emissions from nitric acid production (CRF 2.B.2);
  - CH_4 emissions from methanol production (CRF 2.B.5.5).
- Metal production (CRF 2.C) include CO_2 emissions from coke used in blast furnaces (CRF 2.C.1.2).
- Other production (CRF 2.D) include:
  - SO_2 emissions from pulp production (CRF 2.D.1); NMVOC and CO_2 emissions from food and drink production (CRF 2.D.2).
- Consumption of halocarbons and SF_6 (CRF 2.F) covers emissions of F-gases from:
  - refrigeration and air conditioning equipment (CRF 2.F.1);
  - foam blowing (CRF 2.F.2);
  - fire extinguishers (CRF 2.F.3);
  - metered dose inhalers (CRF 2.F.4);
  - other applications using ODS substitutes (CRF 2.F.6);
  - semiconductor manufacture (CRF 2.F.7);
  - electrical equipment (CRF 2.F.8);
  - other (CRF 2.F.9).

Several emission sources in the Industrial processes sector are key categories. The key categories in 2012 by level and trend, excluding LULUCF are listed in Table 4-1.

Table 4-1. Key category from Industrial processes in 2012 by Level and Trend excluding LULUCF

IPCC source category	Gas	Identification criteria	Approach used
2.A.1 Cement Production	CO_2	Level	Tier 1
		Trend	Tier 1
2.A.7 Bricks and Tiles (decarbonizing)	CO_2	Level	-
		Trend	Tier 1
2.B.1 Ammonia Production	CO_2	Level	Tier 1 / Tier 2
		Trend	Tier 1 / Tier 2
2.B.2 Nitric Acid Production	N_2O	Level	Tier 1 / Tier 2
		Trend	Tier 1
2.F.1 Refrigeration and Air Conditioning Equipment	HFC	Level	Tier 1
		Trend	Tier 1 / Tier 2

4.2 Mineral Products (CRF 2.A)

CO_2 emissions from cement and lime production and from limestone and dolomite use as well as emissions from soda ash use, asphalt roofing, road paving with asphalt and other production are reported in this category (Table 4-2). Cement production is a key source category in Lithuanian GHG inventory. Soda ash is not produced in Lithuania. Limestone and dolomite use comprises the use in the production of iron, bricks and tiles, and mineral wool. Emissions from glass production are reported under their own source category (2.A.7.1).

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	Limestone and dolomite use	CO_2
2.A.4	Soda ash use	CO_2
2.A.5	Asphalt roofing	CO_2
2.A.6	Road paving with asphalt	CO_2
2.A.7	Other production (glass, mineral wool, bricks and tiles)	CO_2

In the production of cement, CO_2 is emitted when an intermediate product - clinker is produced. In that process limestone is heated to a high temperature, which results in emissions, as the main component of limestone, calcium carbonate, breaks down and calcinates into calcium oxide and carbon dioxide. Limestone also contains small amounts of magnesium carbonate ($MgCO_3$), which will calcinate in the process causing CO_2 emissions. CO_2 emissions from lime production and limestone and dolomite use are also due to calcination of calcium and magnesium carbonates at high temperatures.

In addition, carbon dioxide is released when soda ash (Na_2CO_3), is heated to high temperatures. Emissions of the category Mineral products were 48,0% of the emissions of the Industrial processes sector in 1990 and 12,5% in 2012. Amount of emissions were 2141,7 Gg CO_2 eqv. in 1990 and 454,68 Gg CO_2 eqv. in 2012 (Figure 4-4, 4-5).

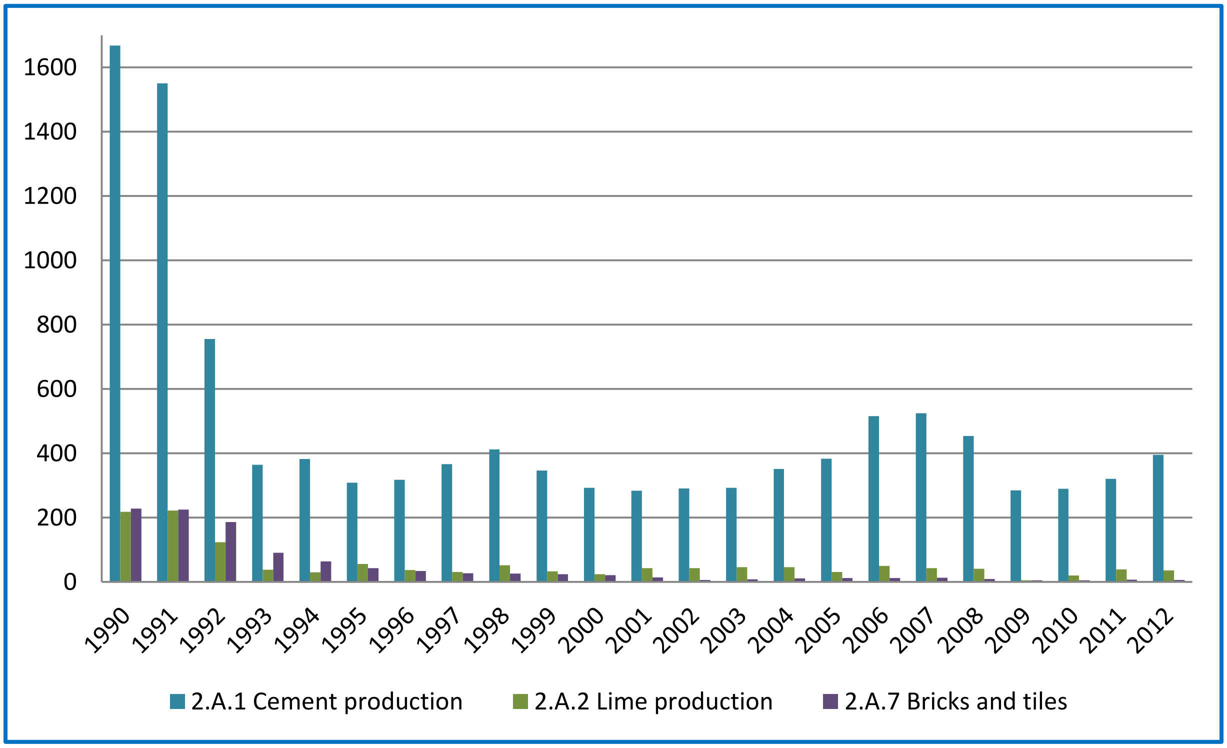

Figure 4-4. Greenhouse gas emission from Mineral products, Gg CO_2 eqv. in 1990-2012: production of cement, lime and bricks and tiles

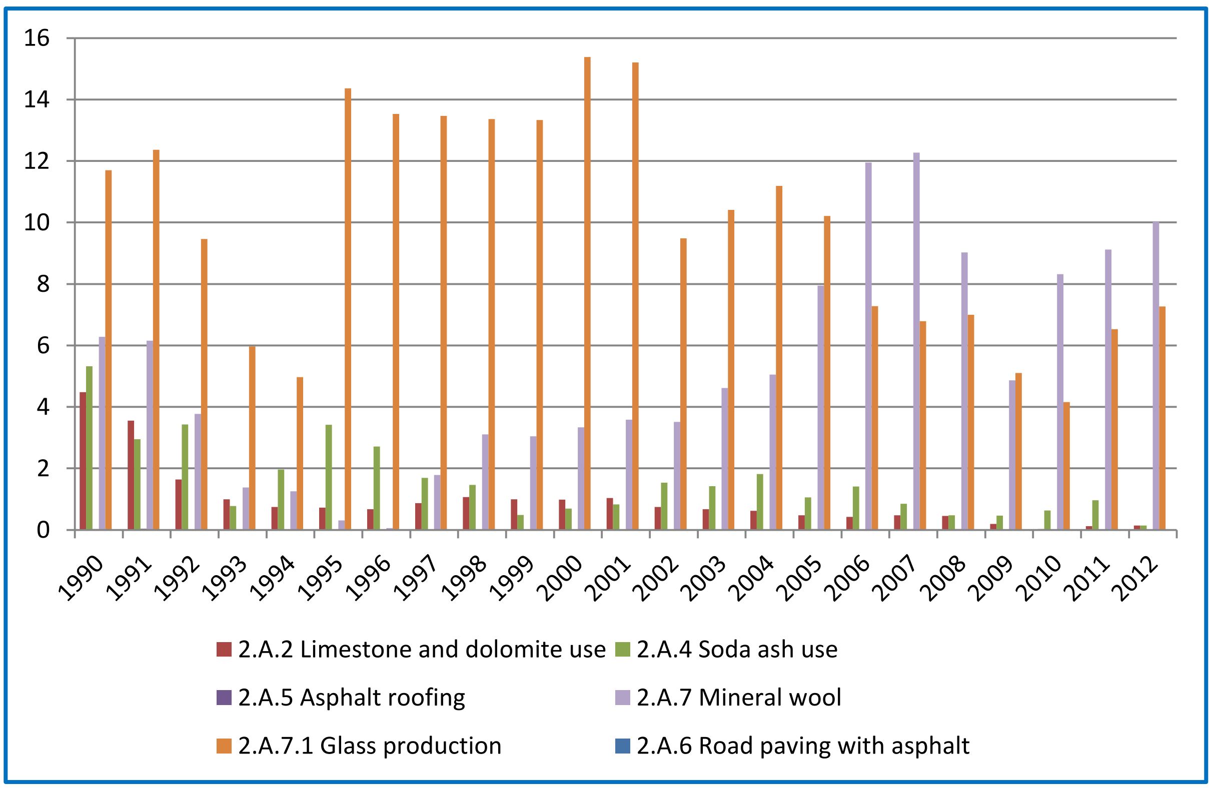

Figure 4-5. Greenhouse gas emission from Mineral products, Gg CO_2 eqv. in 1990-2012: limestone and dolomite use, soda ash use, asphalt roofing, glass and mineral wool production

Cement production is the biggest source of greenhouse gas emissions in the Mineral products category, being 395,2 Gg in 2012 (86,9%). Emissions from cement production were 37,4% in 1990 and 10,9 % in 2012 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 Source Category Description

Category 2.A.1 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. The conversion of the lime into cement clinker then results in the release of further CO_2.

Cement is produced in a single company - AB Akmenės Cementas, which is situated in the North Western part of Lithuania. The factory was constructed in soviet times (1947-1974), cement produced in the factory was exported to other Republics of USSR, Hungary, Cuba and Yugoslavia. The total nominal capacity of the plant is about 5 million tonnes cement per year. The data on clinker production and composition were provided by the AB Akmenės Cementas. Activity data is collected on company level.

Since the opening of the factory cement has been produced using wet production technology. In 2006 the company has made a strong innovation step and decided to build new 4500 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 k tonnes 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.

The production of cement is highly dependent on the construction market. Impressive increase of annual added value in construction sector was observed in 2006 and 2007 - 21.0% and 21.2% accordingly. In 2008 this factor decreased to 1.2%. The construction and real estate sector development in 2008 was strongly adjusted by the slowed down growth of economy and real estate market. In 2010, the construction works of residential buildings has decreased by half in comparison with 2005. However, since 2011 the results for housing and construction are significantly positive. Construction works of residential buildings in 2012 increased by 38 % in comparison with 2010.

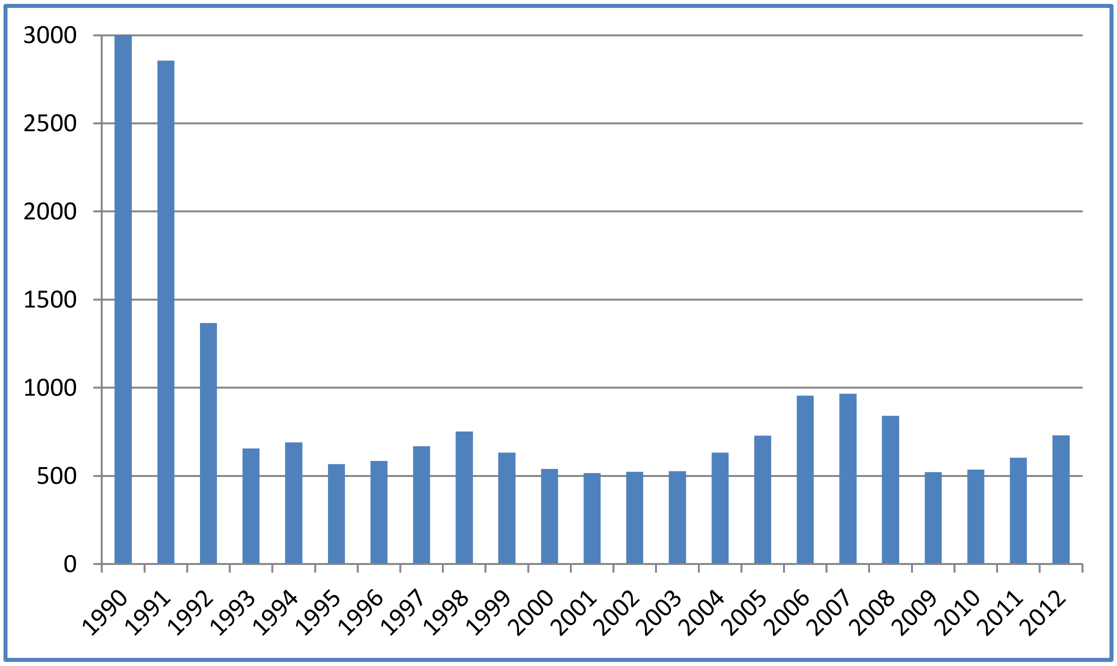

Figure 4-6. Clinker production, k tonnes in 1990-2012

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 AB Akmenės Cementas, 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, Gg;

CKD - cement kiln dust generation, Gg;

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 2005-2012 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 (Gg/year) from Cement production

Year	Emission	CKD fraction
1990	1668,1	1,3 %
1991	1550,0	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 %

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% (1990 to 2009), the average value being 64,2%, standard deviation 0,8%.

Data on MgO content in clinker were available only for the period 2000 to 2009 (provided by the producer). MgO content fluctuated in the range from 3,33% to 4,13%, average value was 3,84%, standard deviation 0,27%. 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 - 2012. 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 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.

As the producer reports CO_2 emissions for EU ETS, it was decided to perform a quality control quality by comparing the two estimates (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, Gg	383,4	516,4	523,8	454,1	283,7
CO_2 emissions EU ETS, Gg	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 2005-2012 are consistent.

4.2.1.5 Source-specific recalculations

No source-specific recalculations were done.

4.2.1.6 Source-specific planned improvements

No source-specific improvements have been planned.

4.2.2 Lime Production (CRF 2.A.2)

4.2.2.1 Source 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 - 2012. The fraction of hydrated lime fluctuated from 0% to 4%.

[14] http://db1.stat.gov.lt/statbank/default.asp?w=1440

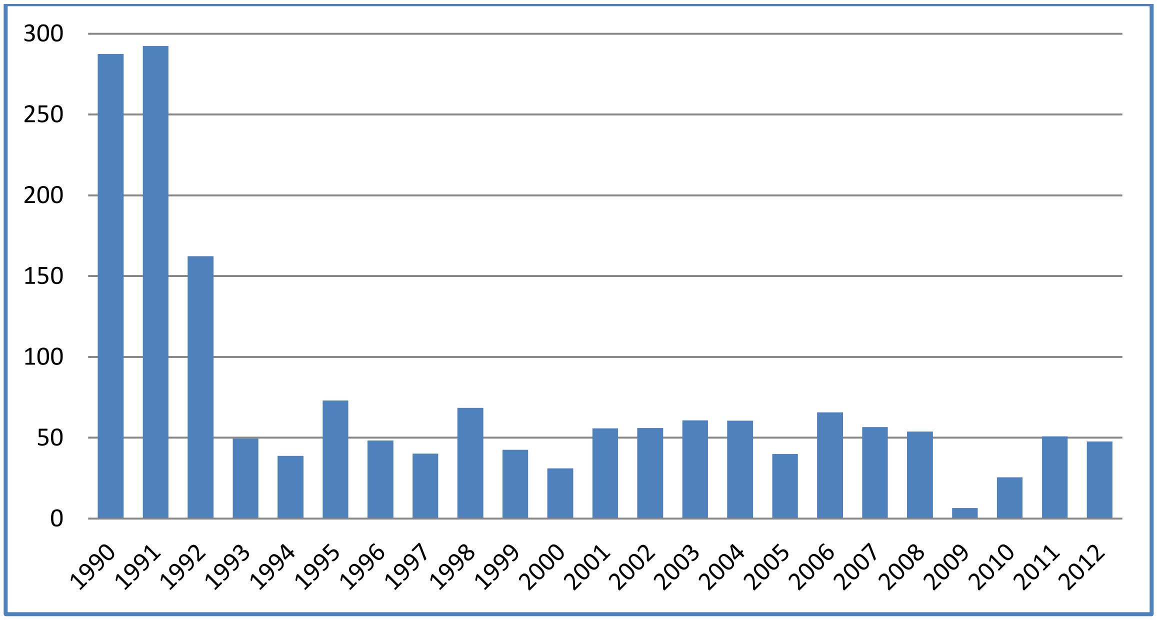

Figure 4-7. Lime production, Gg in 1990-2012 in Lithuania

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 statistics therefore the quantities of the lime produced were obtained directly from the sugar producing companies for the years 1990-2012.

4.2.2.2 Methodological issues

CO_2 emission from lime production was calculated by Tier 2 method using production data provided by Statistics Lithuania and limestone composition data provided by AB Naujasis Kalcitas. According to the data provided by AB Naujasis Kalcitas 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 1999-2012 and it was assumed that during 1990-2001 there was no hydrated lime production. Hydrated lime data were converted to quicklime using default water content correction factor 0,28 (IPCC GPG 2000, p. 3.22-23).

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.

CO_2 emission was calculated using the following equation:

$$Emission = LP \times (C_{CaO} \times (MCO_2/M_{CaO}) + C_{MgO} \times (MCO_2/M_{MgO}))$$

where:
LP - lime production, Gg;
C_{CaO} and C_{MgO} - CaO and MgO fractions in lime;
MCO_2, M_{CaO}, M_{MgO} - molecular weights of CO_2, CaO and MgO.

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 1990-2012.

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 carbonisation 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.

It is assumed that around 90% of the lime used was precipitated as $CaCO_3$ in the carbonation process[15]. 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, Gg	Amount of lime produced, Gg	CO_2 from lime production, Gg	Precipitated share of lime, %	Precipitated amount of lime, Gg	Reported activity data (lime), Gg	Reported CO_2 emissions, Gg
1990	34,2	17,6	13,8	90%	15,8	1,8	1,4
1991	29,0	14,9	11,7	90%	13,4	1,5	1,2
1992	25,6	13,2	10,3	90%	11,8	1,3	1,0
1993	27,5	14,1	11,1	90%	12,7	1,4	1,1
1994	21,5	11,0	8,7	90%	9,9	1,1	0,9
1995	24,2	12,4	9,8	90%	11,2	1,2	1,0
1996	24,8	12,7	10,0	90%	11,5	1,3	1,0
1997	21,5	11,0	8,7	90%	9,9	1,1	0,9
1998	23,7	12,2	9,6	90%	11,0	1,2	1,0
1999	21,7	11,2	8,8	90%	10,1	1,1	0,9
2000	17,3	8,9	7,0	90%	8,0	0,9	0,7
2001	15,1	7,8	6,1	90%	7,0	0,8	0,6
2002	17,7	9,1	7,1	90%	8,2	0,9	0,7
2003	15,7	8,1	6,3	90%	7,3	0,8	0,6
2004	15,4	7,9	6,2	90%	7,1	0,8	0,6
2005	14,7	7,6	5,9	90%	6,8	0,8	0,6
2006	12,6	6,5	5,1	90%	5,8	0,6	0,5
2007	14,1	7,2	5,7	90%	6,5	0,7	0,6
2008	9,1	4,7	3,7	90%	4,2	0,5	0,4
2009	18,8	9,7	7,6	90%	8,7	1,0	0,8
2010	19,2	9,9	7,8	90%	8,9	1,0	0,8

[15] This assumption is supported by the NIR Sweden 2010

2011	22,4	11,5	9,0	90%	10,3	1,1	0,9
2012	29,19	15,01	11,79	90%	13,51	1,50	1,18

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, Gg/year

Year	Reported CO_2 emissions from lime production, Gg	Reported CO_2 emissions from sugar industry, Gg	Total CO_2 emissions, Gg
1990	216,4	1,4	217,8
1991	220,4	1,2	221,5
1992	121,9	1,0	122,9
1993	36,4	1,1	37,5
1994	28,5	0,9	29,3
1995	54,3	1,0	55,3
1996	35,6	1,0	36,6
1997	29,6	0,9	30,5
1998	51,0	1,0	51,9
1999	31,4	0,9	32,3
2000	22,8	0,7	23,5
2001	41,7	0,6	42,3
2002	41,7	0,7	42,5
2003	45,3	0,6	46,0
2004	45,3	0,6	45,9
2005	29,7	0,6	30,3
2006	49,2	0,5	49,8
2007	42,3	0,6	42,9
2008	40,3	0,4	40,7
2009	4,2	0,8	5,0
2010	18,6	0,8	19,4
2011	37,6	0,9	38,5
2012	34,92	1,18	36,1

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 5%;
- Combined uncertainty is 7,1%.

CO_2 emission was calculated using production data provided by Statistics Lithuania and limestone composition data provided by AB Naujasis Kalcitas. 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 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.

In addition, source category-specific quality control procedures have been carried out in this submission. Emission data for years 2009-2012 have been verified with EU ETS data. The calculated emissions are significantly higher than reported in EU ETS for all four years (17% in 2009, 27% in 2010, 25% in 2011 and 27% in 2012). 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. The default EFs used in the EU ETS are lower than EFs used in GHG inventory.

4.2.2.5 Source-specific recalculations

No source-specific recalculations were done.

4.2.2.6 Source-specific planned improvements

No source-specific improvements have been planned.

4.2.3 Limestone and Dolomite Use (CRF 2.A.3)

4.2.3.1 Source Category Description

Specific CO_2 emissions caused by thermal degradation of limestone and dolomite are covered in sections dealing with cement, lime, glass, mineral wool, brick and tile production. This section covers limestone flux use in iron foundries. Consumption of limestone flux in iron foundries was calculated as one tenth of iron production according to the information provided by the foundries.

4.2.3.2 Methodological issues

CO_2 emission was calculated by Tier 2 method. Iron production data provided by Statistics Lithuania. Consumption of limestone flux in iron foundries was calculated as one tenth of iron production in accordance with the information provided by the foundries. CO_2 emissions were calculated from material mass balance assuming that all carbon contained in raw materials (limestone) used as flux was released to the atmosphere as CO_2.

CO_2 emission was calculated using the following equation:

$$Emission = LC \times (C_{CaO} \times (MCO_2/M_{CaCO3}) + C_{MgO} \times (MCO_2/M_{MgCO3}))$$

where:
LC - lime consumption, Gg;
C_{CaO} and C_{MgO} - CaO and MgO fractions in lime;

MCO_2, M_{CaCO3}, M_{MgCO3} - molecular weights of CO_2, $CaCO_3$ and $MgCO_3$.

Estimated CO_2 emissions from lime and dolomite use are provided in Table 4-7.

Table 4-7. Estimated CO_2 emissions from lime and dolomite use, Gg/year

Year	Emission
1990	4,5
1991	3,6
1992	1,6
1993	1,0
1994	0,7
1995	0,7
1996	0,7
1997	0,9
1998	1,1
1999	1,0
2000	0,98
2001	1,04
2002	0,74
2003	0,67
2004	0,62
2005	0,48
2006	0,42
2007	0,48
2008	0,46
2009	0,19
2010	0,03
2011	0,13
2012	0,14

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:

- Limestone and dolomite use was evaluated for iron production. It was assumed that uncertainty of limestone and dolomite use activity data is 10%.
- Emission factor uncertainty is assumed to be 5%;
- Combined uncertainty is 11,2%.

Iron production data was provided by Statistics Lithuania. Data is consistent over the time-series.

4.2.3.4 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.

4.2.3.5 Source-specific recalculations

No source-specific recalculations were done.

4.2.3.6 Source-specific planned improvements

No source-specific improvements have been planned.

4.2.4 Soda Ash Use (CRF 2.A.4)

4.2.4.1 Source Category Description

CO_2 emissions from soda ash consumed in glass production is covered under CRF 2.A.7. This chapter covers other uses of soda ash. The data on overall use of soda ash were obtained from the publications of Statistics Lithuania[16]. In 2010 the Statistics Lithuania has stopped the collection of statistical data on the overall use of soda ash. Therefore for the years 2010 – 2012 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:

- AB Guartis (former Warta Glass Panevėžys) 1999-2012. 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 2004-2012. 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 4-8.

[16] Statistic Lithuania publication "Raw Materials"

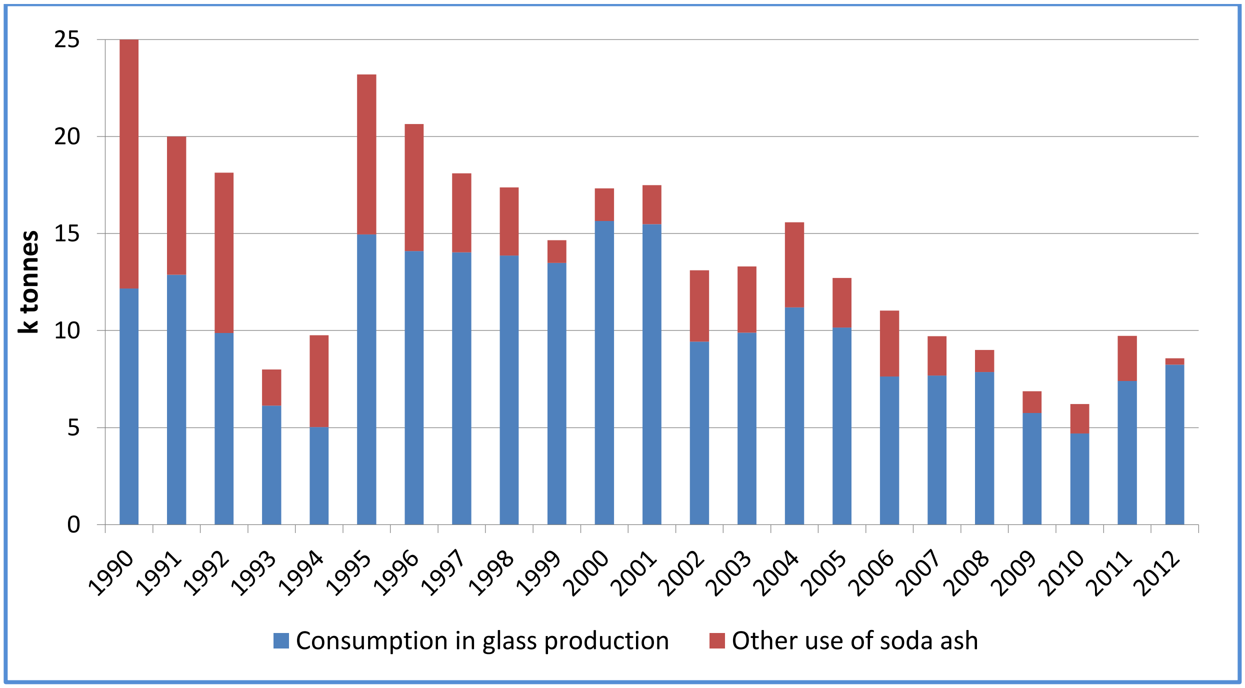

Figure 4-8. Evaluated use of soda ash in 1990-2012

4.2.4.2 Methodological issues

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:

$$Emission = SA \times MCO_2/M_{Na2CO3},$$

where:

SA - other use of soda ash, Gg;
MCO_2 and M_{Na2CO3}- molecular weights of CO_2 and Na_2CO_3.

Estimated CO_2 emissions from other use of soda ash are provided in Table 4-8.

Table 4-8. Estimated CO_2 emissions from soda ash use, Gg/year

Year	CO_2 emission, Gg
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

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:

- 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 10%.
- Emission factor uncertainty is assumed to be 5%;
- Combined uncertainty is 11,2%.

Data on overall use of soda ash were taken from the publications of Statistics Lithuania[17]. Data on overall use of soda ash was not available for 2010-2012 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.7).

4.2.4.4 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.

4.2.4.5 Source-specific recalculations

Soda ash use was recalculated for the years 2010 and 2011 due to change of activity data. Data on overall soda ash use for period 1990-2009 was taken from Statistic Lithuania. The collection of this data was stopped in 2010, therefore the data for 2010 and 2011 was extrapolated in the previous submission. In this submission for the years 2010 – 2012 overall soda ash use is determined via balancing (import minus export).

[17] Statistic Lithuania publication "Raw Materials"

Table 4-9. Impact of recalculation on CO_2 emissions

Year	Submission 2013, Gg	Submission 2014, Gg	Absolute difference, Gg	Relative difference, %
2010	0,47	0,63	0,16	34
2011	0,47	0,96	0,49	105

4.2.4.6 Source-specific planned improvements

No source-specific improvements have been planned.

4.2.5 Asphalt Roofing (CRF 2.A.5)

4.2.5.1 Source Category Description

UAB Mida LT is a single company in Lithuania producing asphalt roofing materials. The company started operation in 2001 after reorganisation 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 2001-2012 (Table 4-10). The production of roll roofing materials has decreased by 95 % compared to 2011, this is due to the import of the cheaper production from other countries.

Table 4-10. Production of asphalt roofing materials in Lithuania 2001-2012 (thous m^2)

Year	Bitumen tiles	Roll roofing materials
2001	253	2087
2002	403	3352
2003	975	5526
2004	1,67	6124
2005	3157	4488
2006	2356	4322
2007	3842	5948
2008	3451	6424
2009	367	0
2010	3681	477
2011	3265	573
2012	3737	29

According to the producer, asphalt roofing materials were also produced in 1990-2000 prior to reorganisation 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 4-9.

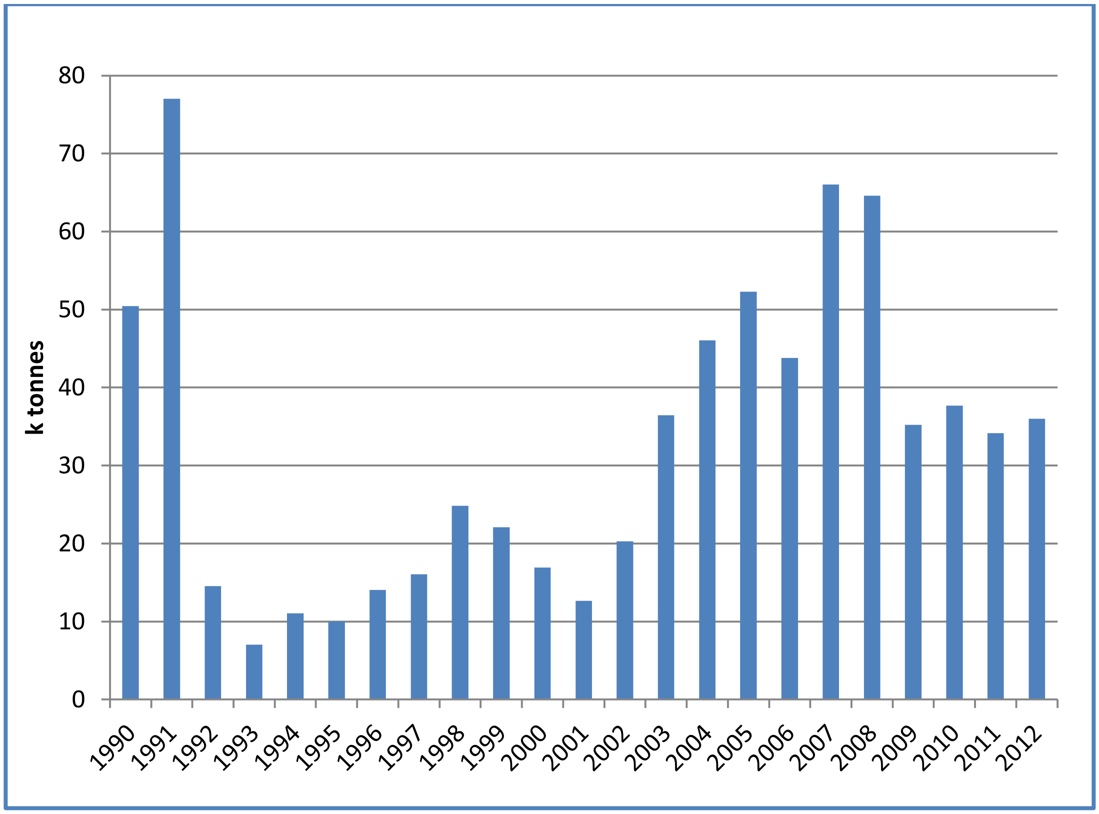

Figure 4-9. Production of asphalt roofing in 1990-2012

4.2.5.2 Methodological issues

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 0,16 kg NMVOC per tonne product was used (Revised IPCC Guidelines 1996, Table 2-3, p. 2-13).

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 4-11.

Table 4-11. Estimated NMVOC and CO_2 eq emissions from asphalt roofing production

Year	NMVOC, Gg	CO_2 eq, Gg
1990	0,0081	0,0237
1991	0,0123	0,0361

1992	0,0023	0,0068
1993	0,0011	0,0033
1994	0,0018	0,0052
1995	0,0016	0,0047
1996	0,0022	0,0066
1997	0,0026	0,0075
1998	0,0040	0,0117
1999	0,0035	0,0104
2000	0,0027	0,0079
2011	0,0020	0,0059
2002	0,0032	0,0095
2003	0,0058	0,0171
2004	0,0074	0,0216
2005	0,0084	0,0245
2006	0,0070	0,0206
2007	0,0106	0,0310
2008	0,0103	0,0303
2009	0,0056	0,0165
2010	0,0060	0,0177
2011	0,0055	0,0160
2012	0,0058	0,0169

4.2.5.3 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 2001-2012. Production of the asphalt roofing materials in 1990-2000 was estimated based on annual average use of bitumen.

4.2.5.4 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.

4.2.5.5 Source-specific recalculations

No source-specific recalculations were done.

4.2.5.6 Source-specific planned improvements

No source-specific improvements have been planned.

4.2.6 Road paving with asphalt (CRF 2.A.6)

4.2.6.1 Source category Description

According to the data published in the European Asphalt Pavement Association publication "Asphalt in figures"[18] there were 20 companies in the asphalt industry in 2012 in Lithuania. In the same publication the data on consumption of bitumen in the road industry is also available for the years 2007-2012. Statistics Lithuania collects data on production of bitumen (data available for 2002-2012), 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[19]. Consumption of bitumen in road industry is provided in Figure 4-10.

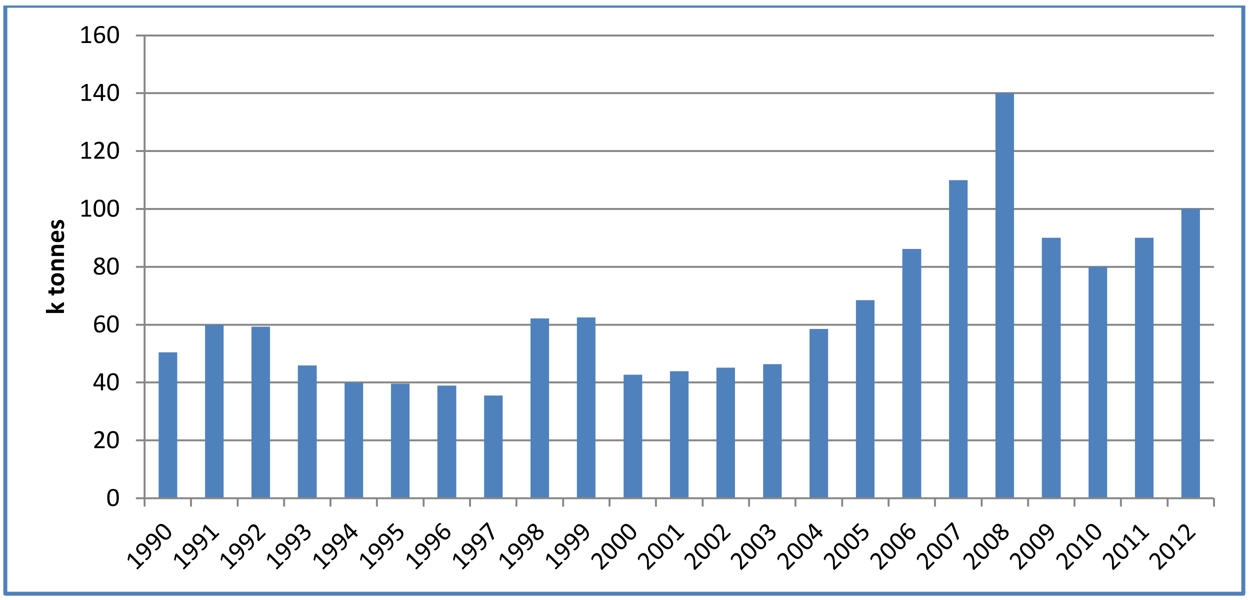

Figure 4-10. Consumption of bitumen in 1990-2012

4.2.6.2 Methodological issues

NMVOC emissions from road paving with asphalt are calculated based on annual consumption of bitumen. NMVOC emission was calculated using default emission factor 0,023 kg/tonne of asphalt (Revised IPCC Guidelines 1996, Table 2-4, p. 2-14).

[18] http://www.eapa.org/asphalt.php

[19] VĮ Transporto ir kelių tyrimo institutas „2002-2015 metų Lietuvos Respublikos valstybinės reikšmės kelių priežiūros ir plėtros programa", I tomas, Kaunas 2001

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 4-12.

Table 4-12. Estimated NMVOC and CO_2 eq emissions from road paving with asphalt

Year	NMVOC, Gg	CO_2 eq, Gg
1990	0,001	0,002
1991	0,001	0,002
1992	0,001	0,002
1993	0,001	0,002
1994	0,001	0,002
1995	0,001	0,002
1996	0,001	0,001
1997	0,001	0,001
1998	0,001	0,002
1999	0,001	0,002
2000	0,001	0,002
2001	0,001	0,002
2002	0,001	0,002
2003	0,001	0,002
2004	0,001	0,002
2005	0,002	0,003
2006	0,002	0,003
2007	0,003	0,004
2008	0,003	0,005
2009	0,002	0,003
2010	0,002	0,003
2011	0,002	0,003
2012	0,002	0,004

4.2.6.3 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 10%.
- Emission factor uncertainty is assumed to be 25%;
- Combined uncertainty is 26,9%.

4.2.6.4 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.

4.2.6.5 Source-specific recalculations

Data on NMVOC and CO_2 emissions from road paving with asphalt are reported for the first time in Lithuanian inventory.

4.2.6.6 Source-specific planned improvements

No source-specific improvements have been planned.

4.2.7 Other (CRF 2.A.7)

Other production under the Mineral products covers production of glass, mineral wool and bricks and tiles.

4.2.7.1 Glass Production (CRF 2.A.7.1)

4.2.7.1.1 Source Category Description

There were three glass production plants in Lithuania. One of them (AB Ekranas producing cathode ray tubes) got bankrupt in 2006 and currently there are only two plants in operation.

AB Guartis (former Warta Glass Panevėžys) is the largest overall glass producer manufacturing 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. The production of glass increased by more than 60 % in 2012, it is due to modernization of container glass production line (the company installed a new more powerful and more economical glass melting furnace and purchased equipment to produce thin-walled bottles).

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 1990-2012 is shown in Figure 4-11.

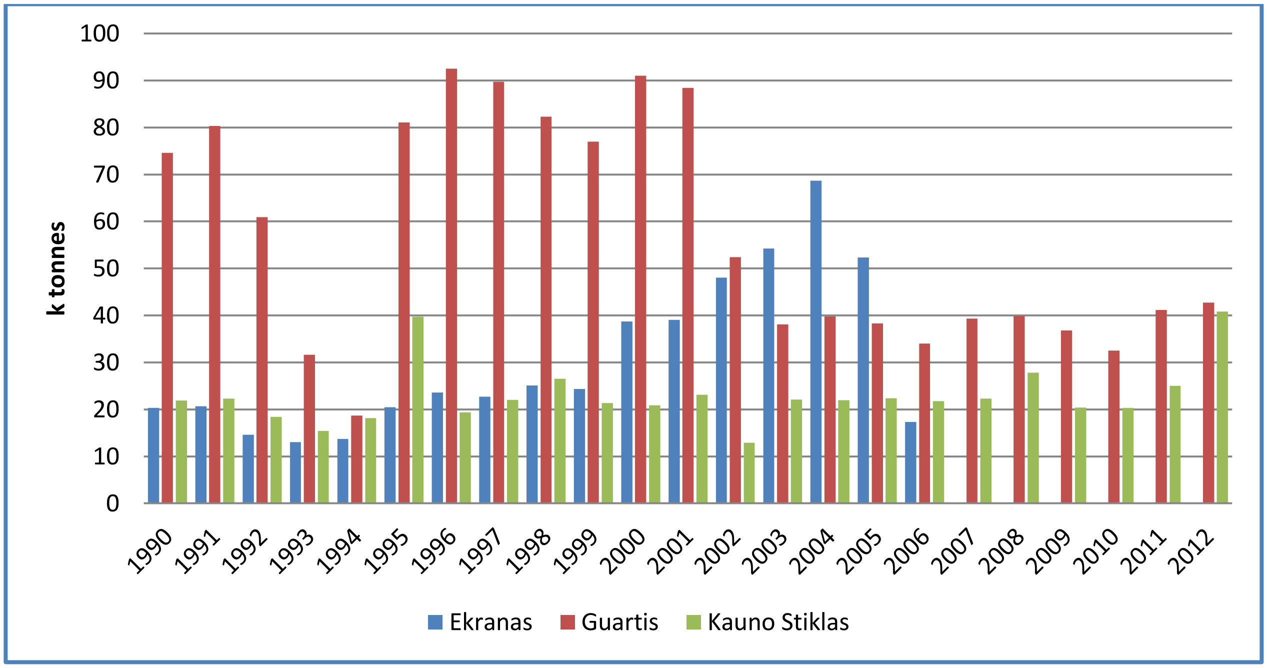

Figure 4-11. Glass production

4.2.7.1.2 Methodological issues

CO_2 emissions were calculated using the following equation (2006 IPCC Guidelines for National Greenhouse Gas Inventories):

$$CO_2\ Emissions = \sum(M_i \times EF_i \times F_i) + M_c \times EF_c$$

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
Mi - mass of the carbonate i consumed, tonnes;
Fi - 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;
Mc - 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 Guidelines for National Greenhouse Gas Inventories (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, K2 CO_3, Ba CO_3, Ca CO_3, Sr CO_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 Guartis (former Warta Glass Panevėžys)

CO_2 emissions were calculated using plant specific data provided by the production company:

- Glass production data is available for 1990-2012 (tonnes of glass produced).
- Data on cullet use is available for the period 1999-2012.
- 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 2005-2012.

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 1990-2012 (tonnes of glass produced).
- Data on cullet use is available for the period 2004-2012;
- 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 2007-2012.

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 4-13. CH_4 and N_2O emissions from glass production were not estimated due to lack of IPCC methodology.

Table 4-13. Estimated CO_2 emissions from glass production, Gg/year

Year	CO_2 emission, Gg
1990	11,70
1991	12,36
1992	9,47
1993	5,96
1994	4,96
1995	14,36
1996	13,53
1997	13,47

1998	13,37
1999	13,33
2000	15,38
2001	15,20
2002	9,48
2003	10,41
2004	11,18
2005	10,22
2006	7,28
2007	6,79
2008	7,00
2009	5,10
2010	4,16
2011	6,53
2012	7,29

4.2.7.1.3 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 (1999-2012). 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.

4.2.7.1.4 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.

Source category-specific quality control procedures have been carried out in this submission. Emission data for years 2007-2012 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 4-14 below:

Table 4-14. Estimated CO_2 emissions (Gg/year) from glass production. Comparison of GHG inventory and EU ETS data.

EU ETS, Gg CO_2	2007	2008	2009	2010	2011	2012
Kauno stiklas	2,67	2,95	1,60	1,26	2,45	3,43
Guartis	4,13	4,04	3,51	2,90	4,10	3,84

Glass production, total	6,79	7,00	5,11	4,16	6,55	7,28
CRF, Gg CO_2						
Kauno stiklas	2,66	2,97	1,60	1,26	2,45	3,43
Guartis	4,12	4,03	3,51	2,90	4,08	3,84
Glass production, total	6,79	7,00	5,10	4,16	6,53	7,29
EU ETS/ CRF						
Kauno stiklas	100,02%	99,50%	100,03%	100,13%	100,03%	100,03%
Guartis	100,12%	100,28%	100,05%	99,93%	100,48%	100,04%
Glass production, total	100,08%	99,95%	100,04%	99,99%	100,31%	100,04%

4.2.7.1.5 Source-specific recalculations

No source-specific recalculations were done.

4.2.7.1.6 Source-specific planned improvements

No source-specific improvements have been planned.

4.2.7.2 Mineral Wool Production

4.2.7.2.1 Source Category Description

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 1998-2012 were provided by the UAB Paroc company.

Mineral wool production during 1990- 2012 is shown in Figure 4-12.

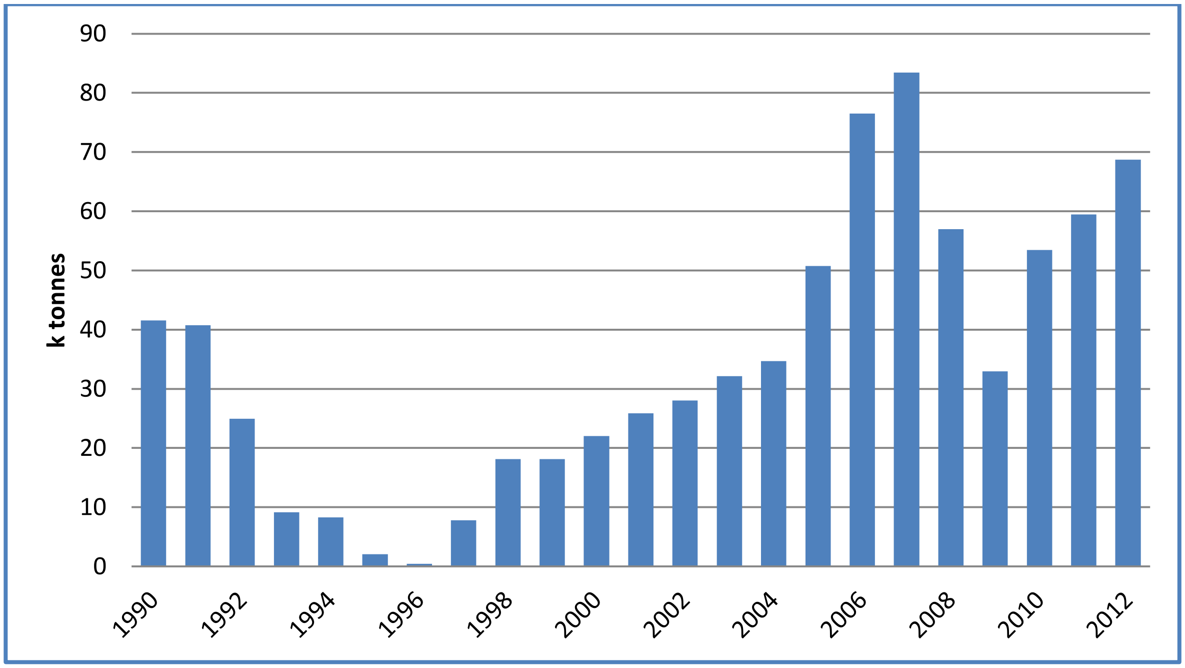

Figure 4-12. Mineral wool production in 1990-2012

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 (1997-2012).

4.2.7.2.2 Methodological issues

CO_2 emissions from mineral wool production were calculated using data provided by the production company UAB Paroc.

The production company has provided data on:

- total production 1998 – 2012;
- dolomite consumption 1997 – 2012;
- CO_2 emission factors (t CO_2/t dolomite) 2008 – 2012.

Difference in emission factor for dolomite is due to moisture of the raw material.

CO_2 emissions in 1997-2012 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 4-15.

Table 4-15. Estimated CO_2 emissions from mineral wool production, Gg/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

4.2.7.2.3 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 1998-2012 were provided by the producer company. Activity data is not available for the period 1990-1997 and was extrapolated.

4.2.7.2.4 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.

Source 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 2008-2012 have been verified with ETS data and the correspondence between these data is 100%.

4.2.7.2.5 Source-specific recalculations

No source-specific recalculations were done.

4.2.7.2.6 Source-specific planned improvements

No source-specific improvements have been planned.

4.2.7.3 Bricks and Tiles Production

4.2.7.3.1 Source Category Description

Data on ceramic bricks, tiles and vitrified clay pipes production were taken from Statistics Lithuania publications[20]. 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 metres. Recalculation of data to mass units was made by applying average conversion factors based on information provided by the largest ceramic bricks and pipes producer in Lithuania AB Palemono Keramika[21]. 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 kilometres 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 metres 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 AB Palemono Keramika). Ceramics production in Lithuania in 1990-2012 is provided in Figure 4-13.

[20] http://db1.stat.gov.lt/statbank/default.asp?w=1440
[21] http://www.palemonokeramika.lt/

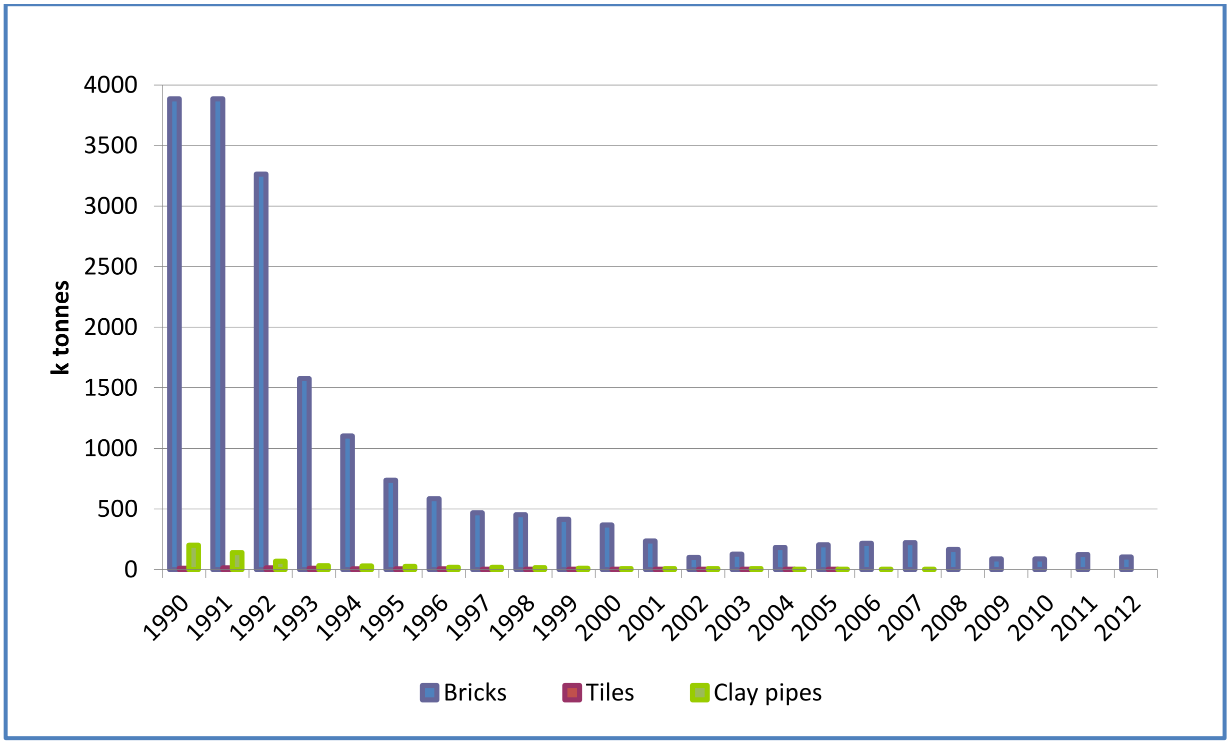

Figure 4-13. Production of ceramic products in 1990-2012

4.2.7.3.2 Methodological issues

CO_2 emissions from ceramics production were calculated from material balance based on CaO and MgO contents in the product provided by the AB Palemono Keramika. 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, Gg;
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 4-16.

Table 4-16. Estimated CO_2 emissions from briks and tiles production, Gg/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

4.2.7.3.3 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[22]. 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 metres. Recalculation of data to mass units was made. Vitrified clay pipes production data in Statistics Lithuania publications are provided in thousands of kilometres 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 metres from 1990 to 2001 and in tile units from 2002. These data were converted to weight units.

4.2.7.3.4 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.

[22] http://db1.stat.gov.lt/statbank/default.asp?w=1440

4.2.7.3.5 Source-specific recalculations

No source-specific recalculations were done.

4.2.7.3.6 Source-specific planned improvements

No source-specific improvements have been planned.

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 4-17).

Table 4-17. 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.5.5	Methanol	CO_2, CH_4

Ammonia and nitric acid production are key sources of this source category in Lithuanian inventory. Adipic acid, carbides, carbon black, dichloroethylene and styrene are not produced in Lithuania.

Emissions of chemical industry in 2012 were 2915,5 Gg CO_2 eqv., and it was 80% 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 2319,17 Gg in 2012. Emissions of N_2O from nitric acid production were 1,92 Gg in 2012. 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 Source Category Description

AB Achema 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 800-1000 °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 1360 t/day; after reconstruction (in 1995) it reached 1560 t/day or 569400 t/year.
- AM-80 unit – project capacity is 1560 t/day or 569400 t/year.
- Total ammonia capacity is 1138800 t/year.

Ammonia production and natural gas consumption data (Figure 4-14) were provided by AB Achema company. Other fuels are not used in the ammonia production process. At the production plant, the natural gas is measured at the entrance point to the ammonia production unit, the flows for heating and ammonia production process are not separately measured.

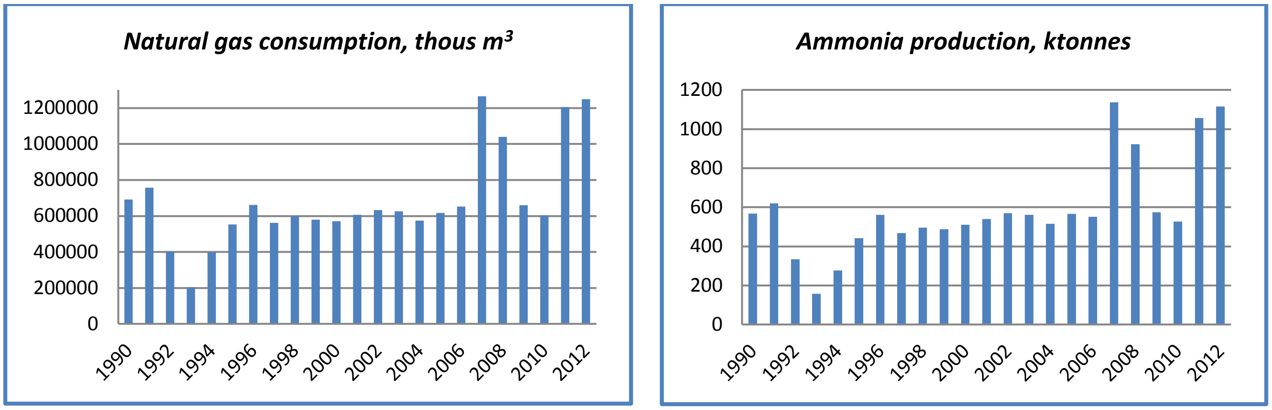

Figure 4-14. Natural gas consumption and ammonia production

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 2012 ammonia production has increased by 100% as compared to 2010.

4.3.1.2 Methodological issues

The CO_2 emissions were calculated using Tier 3 method (2006 IPCC Guidelines, page 3.13) and based on the following data provided by producer:

- annual production of ammonia;
- data on natural gas consumption;
- lower calorific values (annual average) of natural gas;
- country specific emission factor.

CO_2 emissions were calculated using the following equation:

$$CO_2 \ emitted = TFR \times Cv \times 4{,}186 \times 10^{-9} \times EF$$

Where:
TFR_{NG} – Total fuel requirements for ammonia production (= total consumption of natural gas, thousand m^3). This includes the natural gas used for heating as well as ammonia production process;
Cv – lower calorific value of the natural gas (kcal/m^3);
$4{,}186 \times 10^{-9}$ – conversion factor TJ/kcal;

EF – Country specific CO_2 emission factor for natural gas (tCO_2/TJ). Constant emission factor 55,23 tCO_2/TJ is used over the whole time series. Justification of the country specific emission factor for natural gas is provided in NIR Energy chapter.

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 AB „Lietuvos dujos". Calorific value of supplied natural gas is measured twice per month at Lithuania's natural gas supplier (AB "Lietuvos dujos") laboratory.

The same company produces urea and dry ice. In estimating CO_2 emissions from ammonia production, no account was taken for intermediate binding of CO_2 in downstream manufacturing processes and products (Revised 1996 IPCC Reference Manual p. 2.16).

Ammonia production (k tonnes/year), estimated CO_2 emissions (Gg/year) and implied emission factor (t CO_2 per tonne of ammonia produced) are provided in Table 4-18.

Table 4-18. Ammonia production (k tonnes/year), estimated CO_2 emissions and implied emission factor (t CO_2 per tonne of ammonia produced), Gg/year

Year	Ammonia production, k tonnes	Emission, Gg/year	Implied emission factor, t CO_2 per tonne of ammonia produced
1990	568,4	1291,5	2,27
1991	619,6	1407,2	2,27
1992	334,0	747,2	2,24
1993	157,9	377,9	2,39
1994	277,2	743,5	2,68
1995	442,3	1017,3	2,30
1996	560,6	1208,4	2,16
1997	467,3	1034,9	2,21
1998	495,6	1102,1	2,22
1999	487,3	1067,1	2,19
2000	509,9	1055,5	2,07
2001	540,1	1131,6	2,10
2002	568,6	1168,9	2,06
2003	561,2	1155,5	2,06
2004	515,2	1063,1	2,06
2005	565,5	1141,8	2,02
2006	551,1	1208,1	2,19
2007	1137,6	2339,8	2,06
2008	921,9	1925,1	2,09
2009	574,4	1223,1	2,13
2010	527,2	1115,3	2,12
2011	1056,0	2231,1	2,11
2012	1115,9	2319,2	2,08

Variations in implied emission factor (t CO_2 per tonne of ammonia) are due to:

- Calorific value of the natural gas – variation is in the range of 1,2% from the 1990-2012 average;
- Stability of the production process and operation schedule of the production line. If the production process is not stable and/ or ammonia production has to be stopped and restarted again, share of natural gas used for thermal processes increases and thus higher values of EF (t CO_2 per tonne of ammonia) are obtained.

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 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 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.

4.3.1.5 Source-specific recalculations

No source-specific recalculations were done.

4.3.1.6 Source-specific planned improvements

No source-specific improvements have been planned.

4.3.2 Nitric Acid Production (CRF 2.B.2)

4.3.2.1 Source Category Description

Nitric acid is produced by AB Achema which is the single nitric acid producer in Lithuania. According to information provided by AB Achema, 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 NOx in a reactor. Grande Paroisse (GP) unit uses a dual-pressure scheme (medium/high). Gaseous emissions from GP are cleaned from NOx in the reactor using a DeNOx technology.

Capacities:
At present AB Achema 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 1080 thous t/year. Capacity of GP unit is 360 thous t/year. Total nitric acid production capacity is 1440 thous t/year.

Information on nitric acid production units operated during 1990-2012 period in AB Achema is provided in Table 4-19.

Table 4-19. Nitric acid production units in AB Achema in 1990-2011

Nitric acid production unit	1990-2002	2003	2004	2005-2008	2009-2012
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 4-15) were provided by AB Achema.

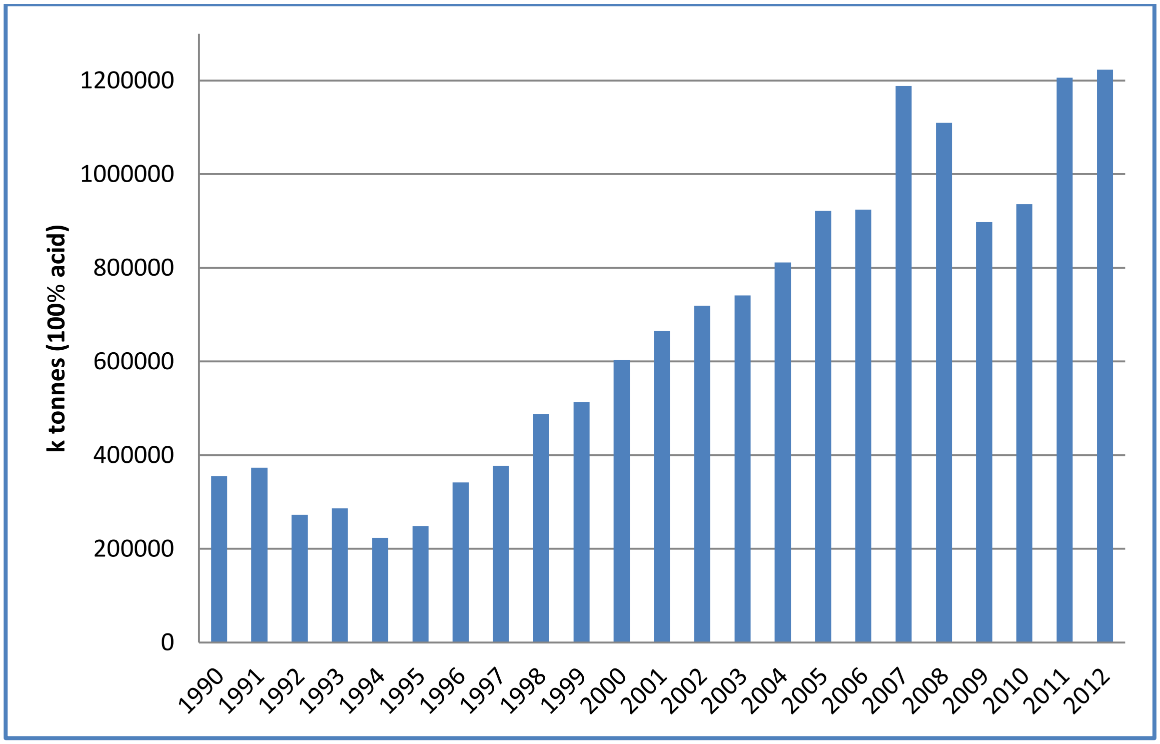

Figure 4-15. Nitric acid production in 1990-2012

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 (2009-2012);
- Production unit specific N_2O emission factors (Table 4-18):
  - Prior to installation of catalyst (2007-2008 monitoring campaign data);
  - After installation of catalyst (2009 - 2012);

For the years 2009-2012 production unit specific N_2O emission factors were obtained from the producer (Table 4-20). The emission factors were measured and registered in automated monitoring system (AMS) by AB Achema.

Table 4-20. 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
UKL-1	9,63	1,72	1,86	1,87	1,62
UKL-2	9,51	1,43	1,42	1,65	1,71
UKL-3	5,45	2,22	2,92	2,16	1,32
UKL-4	7,73	1,88	2,4	1,68	0,77
UKL-5	6,61	2,07	1,87	1,69	1,43
UKL-6	10,34	3,73	3,51	2,65	2,48
UKL-7	9,09	2,70	1,54	1,16	1,64

UKL-8	6,96	2,35	1,58	1,50	1,18
UKL-9	not operational	4,81	4,84	6,65	1,66
GP	8,83	1,17	0,96	2,32	1,63

* 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;
- 2009-2001: 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 2009-2012 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 4-21.

Table 4-21. Estimated emissions of N_2O from nitric acid production, Gg/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

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 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.

Plant specific emission factors were compared with IPCC GPG default factors. The plant specific EFs used for GHG inventory calculations are in the range of EFs provided in Table 3.8 (IPCC 2000 Guidance page 3.35), both for plants without abatement measures installed and for plants using catalytic reduction. Since 2007, plant specific EFs 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 Source-specific recalculations

No source-specific recalculations were done.

4.3.2.6 Source-specific planned improvements

No source-specific improvements have been planned.

4.3.3 Methanol Production (CRF 2.B.5)

4.3.3.1 Source 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 74000 t/year.

Methanol production data (Figure 4-16) 1990-2008 were obtained from Statistics Lithuania publications[23]. 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 is no plans to renew methanol production in the future.

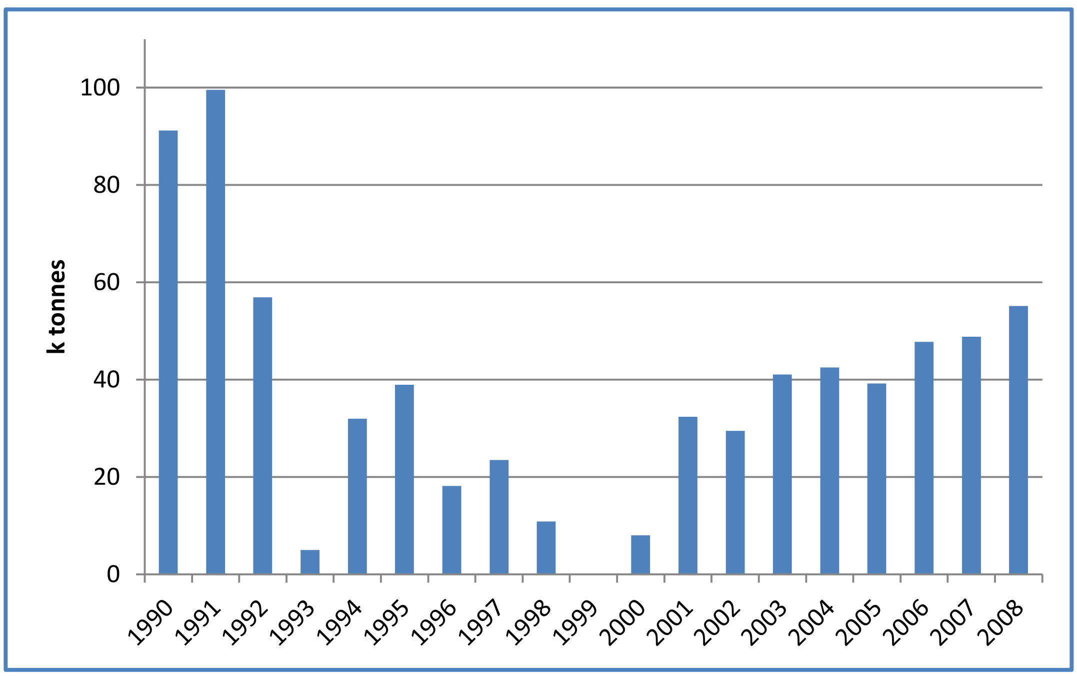

Figure 4-16. Methanol production

[23] http://db1.stat.gov.lt/statbank/default.asp?w=1440

4.3.3.2 Methodological issues

CH_4 emissions were calculated from methanol production data using emission factor 2 kg CH_4 per tonne of produced methanol taken from the Revised 1996 IPCC Guidelines (Table 2-9, p. 2.22). Estimated emissions of CH_4 (Gg/year) from methanol production are provided in Table 4-22.

CO_2 emissions were calculated from methanol production data using default emission factor 0,67 tonne CO_2 per tonne of produced methanol taken from the IPCC 2006 Guidelines (Table 3.12, p. 3.73). Estimated emissions of CO_2 (Gg/year) from methanol production are provided in Table 4-22.

Table 4-22. Estimated emissions of CH_4 and CO_2 from methanol production

Year	CH_4, Gg	CO_2, Gg
1990	0,182	61,1
1991	0,199	66,7
1992	0,114	38,1
1993	0,010	3,4
1994	0,064	21,4
1995	0,078	26,1
1996	0,036	12,2
1997	0,047	15,7
1998	0,022	7,3
1999	NO	NO
2000	0,016	5,4
2001	0,065	21,7
2002	0,059	19,9
2003	0,082	27,5
2004	0,085	28,5
2005	0,078	26,3
2006	0,096	32,0
2007	0,098	32,7
2008	0,110	36,9
2009	NO	NO
2010	NO	NO
2011	NO	NO
2012	NO	NO

4.3.3.3 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 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 – 2012.

4.3.3.4 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.

4.3.3.5 Source-specific recalculations

Data on CO_2 emissions from methanol production are reported for the first time in Lithuanian inventory.

4.3.3.6 Source-specific planned improvements

No source-specific improvements have been planned.

4.4 Metal production (CRF 2.C)

In Lithuanian GHG inventory this category includes non-fuel emissions of CO_2 from pig iron production (Table 4-23). There are two facilities producing cast iron in blast furnaces in Lithuania. There were one facility using electric arc furnace for cast iron production, but it went bankrupt in 2010. Only scrap metal is used as a raw material.

Table 4-23. Reported emissions under the subcategory Metal production

CRF	Source	Emissions reported
2.C.1.2	Pig iron production	CO_2

There are no key sources in this source category. Steel, sinter, coke, ferroalloys and aluminium are not produced in Lithuania. Emissions from metal production in 2012 were 3,05 Gg 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 Source Category Description

There are two facilities producing cast iron in blast furnace in Lithuania. There were one facility using electric arc furnace for cast iron production, but it went bankrupt in 2010. Only scrap metal is used as raw material.

1990-2009 data on the total cast iron production were provided by Statistics Lithuania[24]. Since 2010 the data on cast iron production in blast furnace is obtained from the facilities. The data on

[24] http://db1.stat.gov.lt/statbank/default.asp?w=1440

coke consumption for whole period were obtained from the plants. Variations of cast iron production are shown in Figure 4-17.

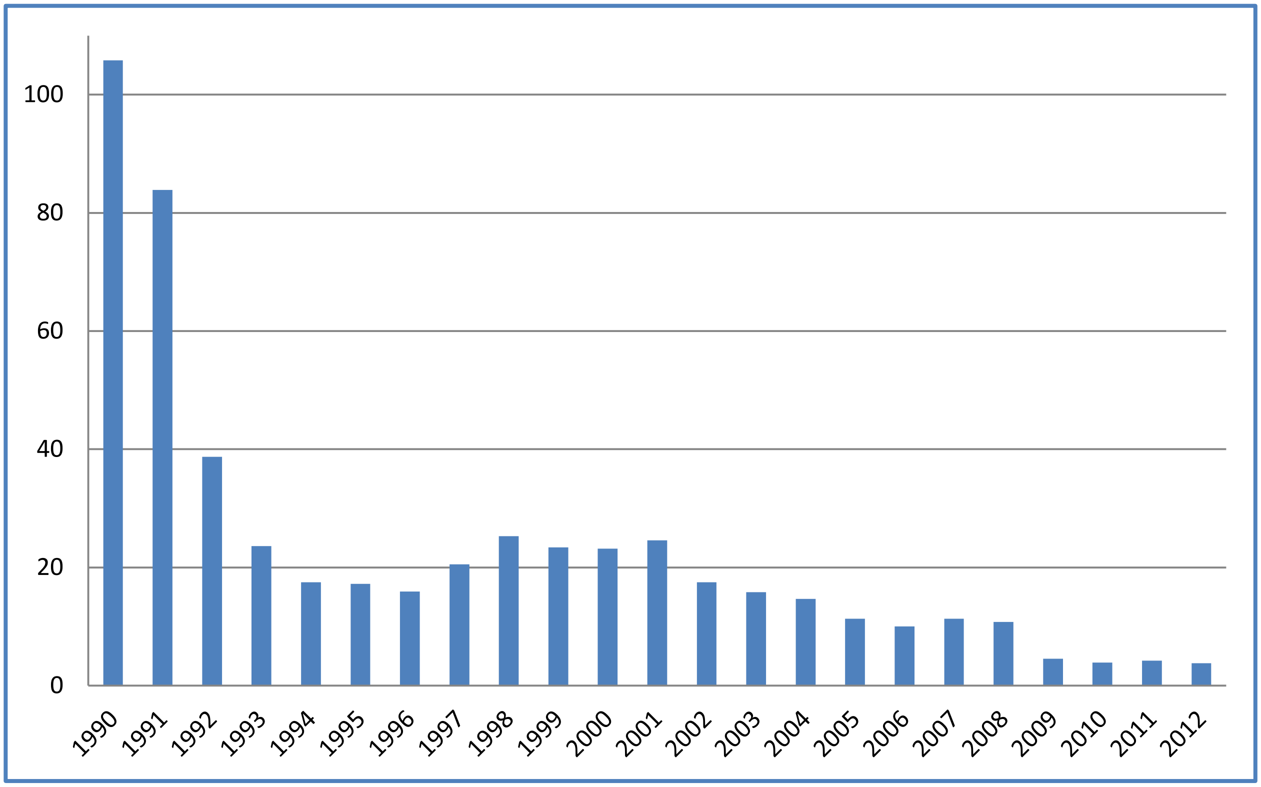

Figure 4-17. Cast iron production, k tonnes

4.4.1.2 Methodological issues

CO_2 emissions from blast furnaces were calculated from coke consumption using default emission factor 3.1 tonnes CO_2 per tonne coke (Revised 1996 IPCC Guidelines. Table 2-12, p. 2.26).

Revised 1996 IPCC Guidelines do not provide emission factor for electric arc furnaces. Therefore emission factor 0,08 tonne CO_2 per tonne of steel produced is provided in 2006 IPCC Guidelines was used for evaluation of CO_2 emissions from electric arc furnace.

Estimated CO_2 emissions from cast iron production are shown in Table 4-24.

Table 4-24. Estimated CO_2 emissions from Iron and Steel production, Gg/year

Year	Emission
1990	21,2
1991	17,0
1992	8,4
1993	6,2
1994	5,8
1995	5,0
1996	5,5
1997	6,0
1998	6,6
1999	7,0
2000	7,5
2001	7,8
2002	7,5
2003	7,0
2004	7,0
2005	7,2
2006	6,9
2007	6,5
2008	4,8
2009	4,0
2010	4,1
2011	3,7
2012	3,1

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 were taken from Statistics Lithuania and data on cast iron production in blast furnaces were provided by the production companies. Uncertainty of the activity data is assumed to be 4%;
- In Lithuania cast iron is produced only from iron scrap while default emission factors are established for production from iron ores. Emission factor uncertainty is assumed to be 10%;
- Combined uncertainty is 10,8%.

Data is consistent over the time-series.

4.4.1.4 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.

4.4.1.5 Source-specific recalculations

No source-specific recalculations were done.

4.4.1.6 Source-specific planned improvements

No source-specific improvements have been planned.

4.5 Other production (CRF 2.D)

In Lithuanian inventory this category includes non-fuel emissions of SO_2 from paper and pulp production and NMVOC and CO_2 emissions from food and drink production (Table 4-25). Pulp was produced in Lithuania in 1990-1993 in a single paper mill AB Klaipėdos kartonas. 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. Pulp is not produced in Lithuania since 1993.

NMVOC emissions from food and drink production are calculated based on data from Statistics Lithuania.

Table 4-25. Reported emissions under the subcategory Other production

CRF	Source	Emissions reported
2.D.1	Pulp and Paper	SO_2
2.D.2	Food and Drink	NMVOC, CO_2

There are no key sources in this category. Emissions from other production were 8,86 Gg CO_2 eqv. in 2012 and it was 0,2% of industry sector's emissions.

4.5.1 Pulp and paper (CRF 2.D.1)

4.5.1.1 Source Category Description

Paper is produced in two companies in Lithuania. Pulp was produced in AB Klaipėdos kartonas company from 1990 to 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. Data on the pulp production was provided by AB Klaipėdos kartonas. Variations of pulp production in 1990-1993 are shown in Figure 4-18.

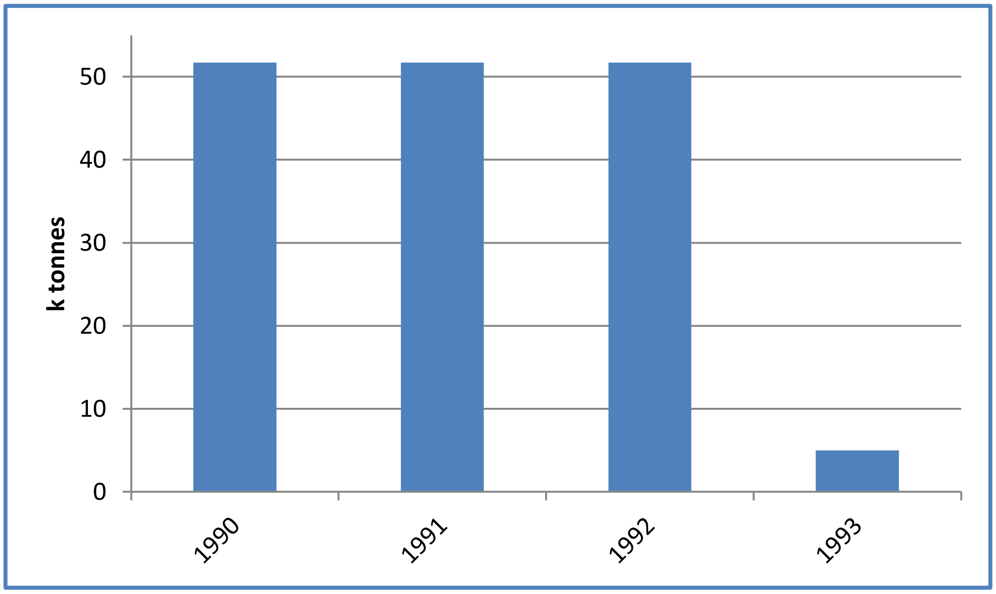

Figure 4-18. Pulp production

4.5.1.2 Methodological issues

Emissions of SO_2 from pulp and paper manufacturing were calculated using IPCC simple methodology (Revised 1996 IPCC Guidelines, p. 2.39-2.40). AB Klaipėdos kartonas used acid sulphite pulping process for production of pulp. SO_2 emissions were calculated from pulp production data using default emission factor 30 kg SO_2 per tonne of dried pulp (Revised 1996 IPCC Guidelines, Table 2-23, p. 2.40). Estimated SO_2 emissions from pulp production are shown in Table 4-26.

Table 4-26 Estimated SO_2 emissions from pulp and paper production, Gg/year

Year	Emission
1990	1,55
1991	1,55
1992	1,55
1993	0,15
1994-2012	NO

4.5.1.3 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 companies and covers period 1990-1993. Production of pulp was stopped in 1993.

4.5.1.4 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.

4.5.1.5 Source-specific recalculations

No source-specific recalculations were done.

4.5.1.6 Source-specific planned improvements

No source-specific improvements have been planned.

4.5.2 Food and drink (CRF 2.D.2)

4.5.2.1 Source Category Description

Data on production of food and drink products were taken from Statistics Lithuania publications[25]. Data is available for 2000-2012. 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 4-27).

Table 4-27. Total annual production of beverages, thousand decaliters in 2000-2012

Year	Spirits and liqueurs	Grape wine	Fruit and berry wine	Sparkling grape wine	Beer
2000	854	169	1245	234	21049
2001	899	127	889	302	21935
2002	908	203	872	269	26885
2003	932	140	890	215	26417
2004	1068	249	983	267	26898
2005	1230	463	1055	322	28946
2006	1519	388	1161	409	29340
2007	1853	342	1374	544	28564
2008	1546	297	1371	538	29685
2009	1038	246	1233	294	27623
2010	893	290	1370	434	29182
2011	932	175	1421	437	30511
2012	917	225	1434	423	28406

Note: Spirits and liqueurs are expressed as 100% alcohol

Average for the period 2000-2011 was used to estimate production of beverages for the period 1990-1999.

Data on production of the following products was used for greenhouse gas emission inventory: meat and meat sub products, food fish and marine products, sugar, confectionery products, bread and pastry products and prepared mixed animal feeds (Table 4-28).

[25] http://db1.stat.gov.lt/statbank/default.asp?w=1440

Table 4-28. Total annual production of food products, k tonnes in 2000-2012

Year	Meat and meat sub products	Food fish and marine products	Sugar	Confectionery products	Bread and pastry products	Prepared mixed animal feeds
2000	79	52	127	44	180	265
2001	71	66	109	41	189	254
2002	83	59	138	43	187	277
2003	106	58	132	41	178	282
2004	118	64	133	45	186	360
2005	159	73	125	47	193	394
2006	165	64	97	50	183	454
2007	186	64	125	51	173	483
2008	173	65	70	49	169	350
2009	155	64	107	45	158	380
2010	182	76	104	47	158	433
2011	180	67	135	52	150	426
2012	193	76	141	50	144	453

Average for the period 2000-2011 was used to estimate food production for the period 1990-1999.

4.5.2.2 Methodological issues

NMVOC emissions from food and drink production are calculated based on total annual production data (Revised 1996 IPCC Guidelines, p. 2.41-2.42). NMVOC emissions were calculated using default emission factors (Revised 1996 IPCC Guidelines, Table 2-24, p. 2.41, Table 2-25, p.2.42). Emission factors are provided in Table 4-29.

Table 4-29. 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	Meat and meat sub products	0,3
	Food fish and marine products	
Sugar	Sugar	10,0
Cakes, biscuits and breakfast cereals	Confectionery products	1,0
Bread	Bread and pastry products	8,0
Animal Feed	Prepared mixed animal feeds	1,0

Estimated NMVOC emissions from food and drink production were converted to CO_2 equivalent using factor of 1,91 tonne CO_2 per t NMVOC (factor for ethanol). Estimated NMVOC and CO_2 eqv. emissions from food and drink production are shown in Table 4-30.

Table 4-30. Estimated NMVOC and CO_2 eqv. emissions from food and drink production, Gg/year

Year	NMVOC	CO_2 eqv.
1990	4,9	9,3
1991	4,9	9,3
1992	4,9	9,3
1993	4,9	9,3
1994	4,9	9,3
1995	4,9	9,3
1996	4,9	9,3
1997	4,9	9,3
1998	4,9	9,3
1999	4,9	9,3
2000	4,4	8,4
2001	4,4	8,4
2002	4,7	9,0
2003	4,6	8,8
2004	5,0	9,5
2005	5,3	10,1
2006	5,4	10,3
2007	6,1	11,7
2008	5,0	9,5
2009	4,5	8,6
2010	4,3	8,3
2011	4,6	8,8
2012	4,6	8,9

4.5.2.3 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.

4.5.2.4 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.

4.5.2.5 Source-specific recalculations

No source-specific recalculations were done.

4.5.2.6 Source-specific planned improvements

No source-specific improvements have been planned.

4.6 Production of Halocarbons and SF6 (CRF 2.E)

Fluorinated gases, monitored under the UNFCCC, are not produced in Lithuania and national consumption is covered only by import.

4.7 Consumption of Halocarbons and SF6 (CRF 2.F)

Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) are used as alternatives to chlorofluorocarbons (CFCs), ozone depleting substances being phased out under the Montreal Protocol. Emissions of HFCs and SF_6 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 and SF_6 emission 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 (Study 2012). The project was financed from the national sources. The study covered CRF sections 2.F.1-2.F.9. The results of the study were used for the preparation of the present report.

The share of GHG emissions from the consumption of halocarbons and SF_6 is steadily increasing. In 2012 the emissions were estimated at 244,8 Gg CO_2 equivalent (or 6,8% from the aggregated emissions from Industrial processes).

Based on the current knowledge, the major source of GHG emissions in the sub-sector "Consumption of Halocarbons and SF6" is mobile air conditioning (CRF 2.IIA.F.1.6), which accounts for approximately 41,3% of the emissions (as CO_2 equivalent). Transport Refrigeration (CRF 2.IIA.F.1.3) and Commercial Refrigeration (CRF 2.IIA.F.1.2) account for 25,6% and 16,2% of the 2012 emissions respectively (as CO_2 equivalent).

Only subcategory Refrigeration and Air Conditioning Equipment (CRF 2.F.1) is the key category in 2012 by level and trend.

Estimated emissions from consumption of halocarbons and SF_6 in 1993-2012 are shown in Figure 4-19.

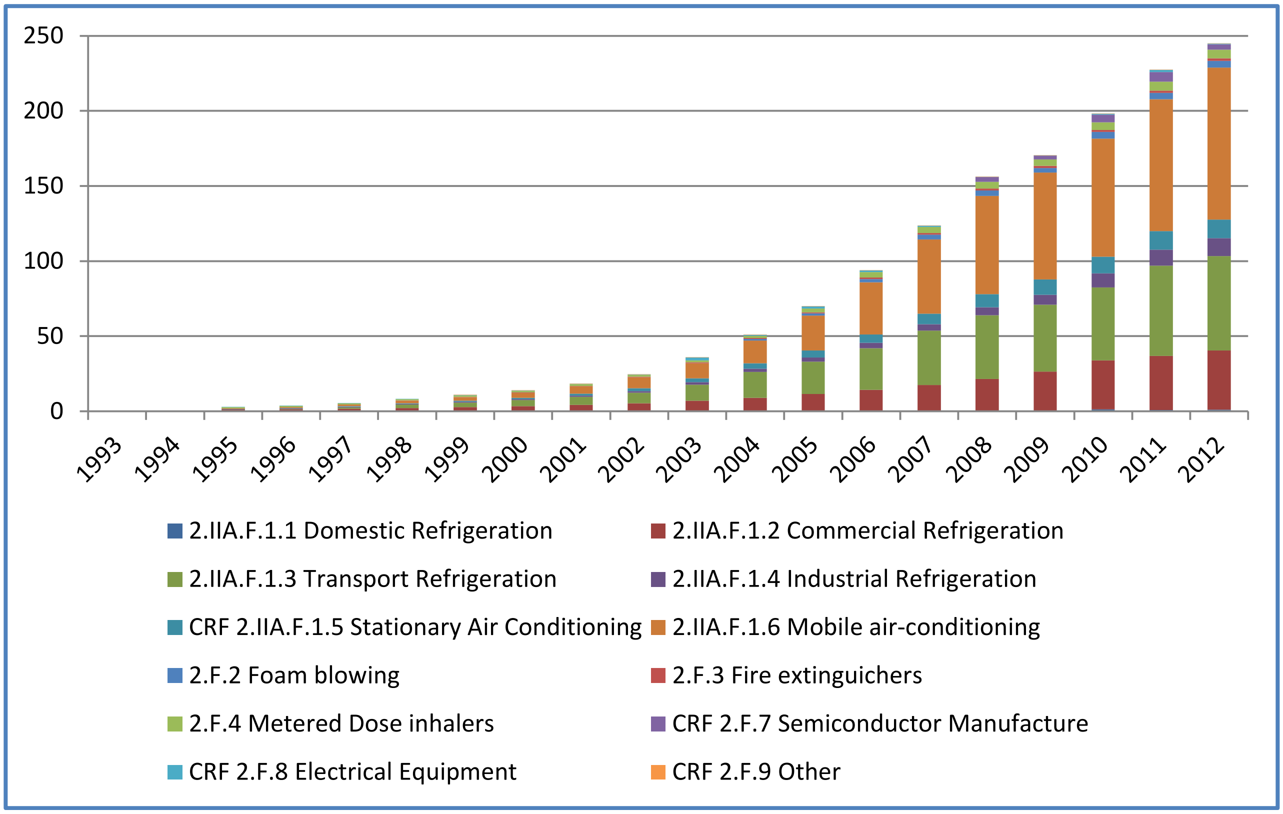

Figure 4-19. Estimated emissions from consumption of Halocarbons and SF_6 in 1993-2012.

4.7.1 Refrigeration and air conditioning equipment (CRF 2.F.1)

This section covers emissions of halocarbons from domestic, commercial, transport and industrial refrigeration, stationary and mobile air-conditioning.

4.7.1.1 Domestic Refrigeration (CRF 2.IIA.F.1.1)

There is only one company manufacturing domestic refrigerators in Lithuania, joint-stock company AB Snaigė. 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 AB Snaigė 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.

Following the data of AB Snaigė:

- 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 HFC due to the charging process of new equipment were calculated using the following equation (2006 IPCC Guidelines, p. 7.50):

$$E_{charge,\,t} = M_t \times k$$

Where:

$E_{charge,\,t}$ – emission during system manufacture/assembly in year t, tonnes

M_t – amount of HFC charged into new equipment in year t, tonnes;

k – emission factor of assembly losses of the HFC charged into new equipment, %.

Estimates demonstrated in Figure 4-20.

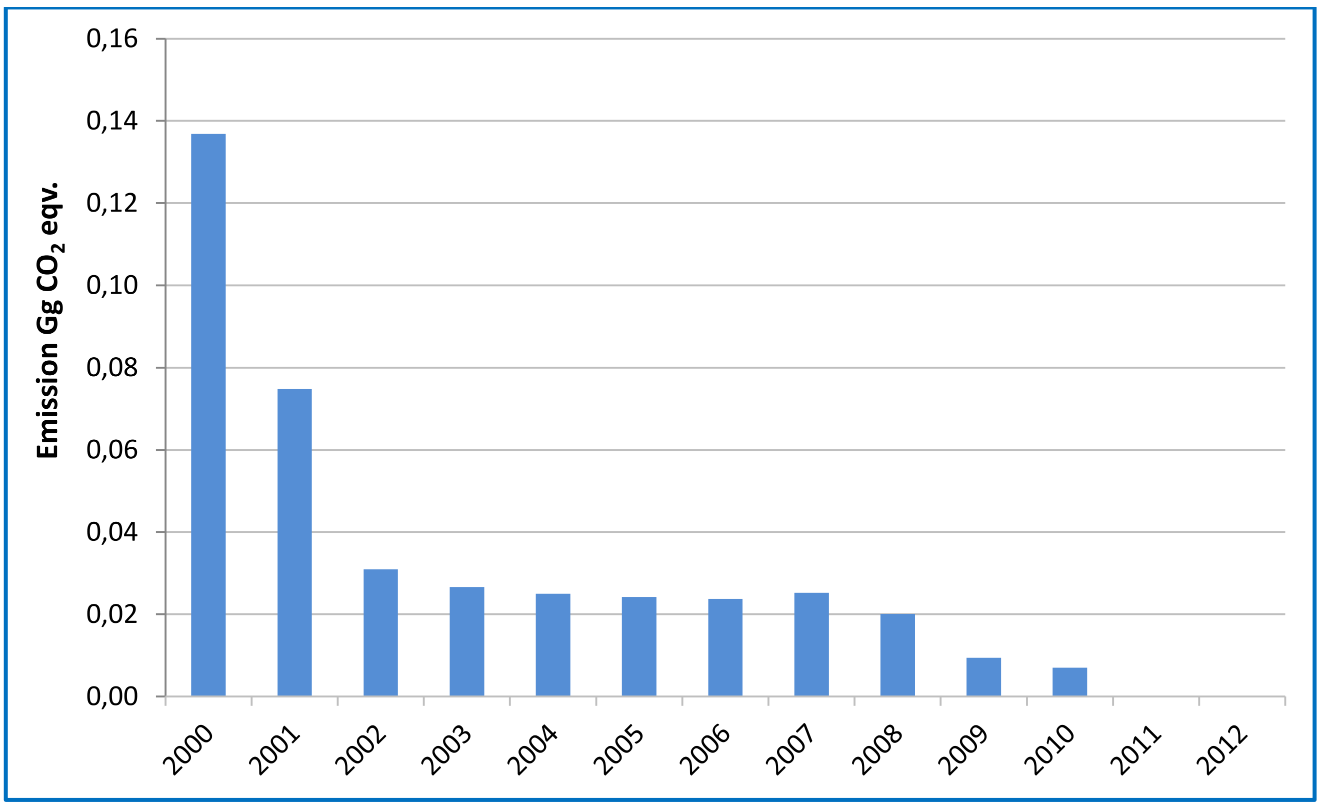

Figure 4-20. Fluorinated gas emissions during the initial charging of refrigerant into domestic refrigerators manufactured by AB Snaigė for 2000-2012

The largest amounts of fluorinated gases (0.14 Gg CO_2-equivalent) 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.

Domestic (household) refrigeration: refrigerators and freezers

The predominant refrigerant in domestic refrigeration equipment is R-134a, a small number of the appliances are also filled with the refrigerant R-152a. 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.

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.

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 (renewed in this submission from 2001);
- 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-152a 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, p. 7.52);
- 30% of refrigerators operating in 1995-2012 were filled with HFC-134a. The same assumption is applied to freezers;
- 7% of refrigerators operating in 1995-2012 were filled with HFC-152a. 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, p 7.50):

$$E_{lifetime,\,t} = B_t \; x \; x$$

where:
$E_{lifetime, t}$ – amount of HFCs banked in existing systems in year *t*, tonnes;
B_t – amount of HFCs banked in existing systems in year *t*, tonnes;
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 2012 was 19% of all gases subject to disposal and in 2012 – 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 2011 was 58% of all gases subject to disposal and in 2012 m – 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):

$$E_{end\text{-}of\text{-}life,\,t} = M_{t\text{-}d} \; x \; p \; x \; (1\text{-}\eta_{rec,d})$$

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:

$$E_{total,\,t} = E_{charge,\,t} + E_{lifetime,\,t} + E_{end\text{-}of\text{-}life,\,t}$$

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.

Estimates of fluorinated gas emissions from domestic refrigerators and freezers in Lithuania for 1995-2012 are demonstrated in Figures 4-21 and 4-22 below.

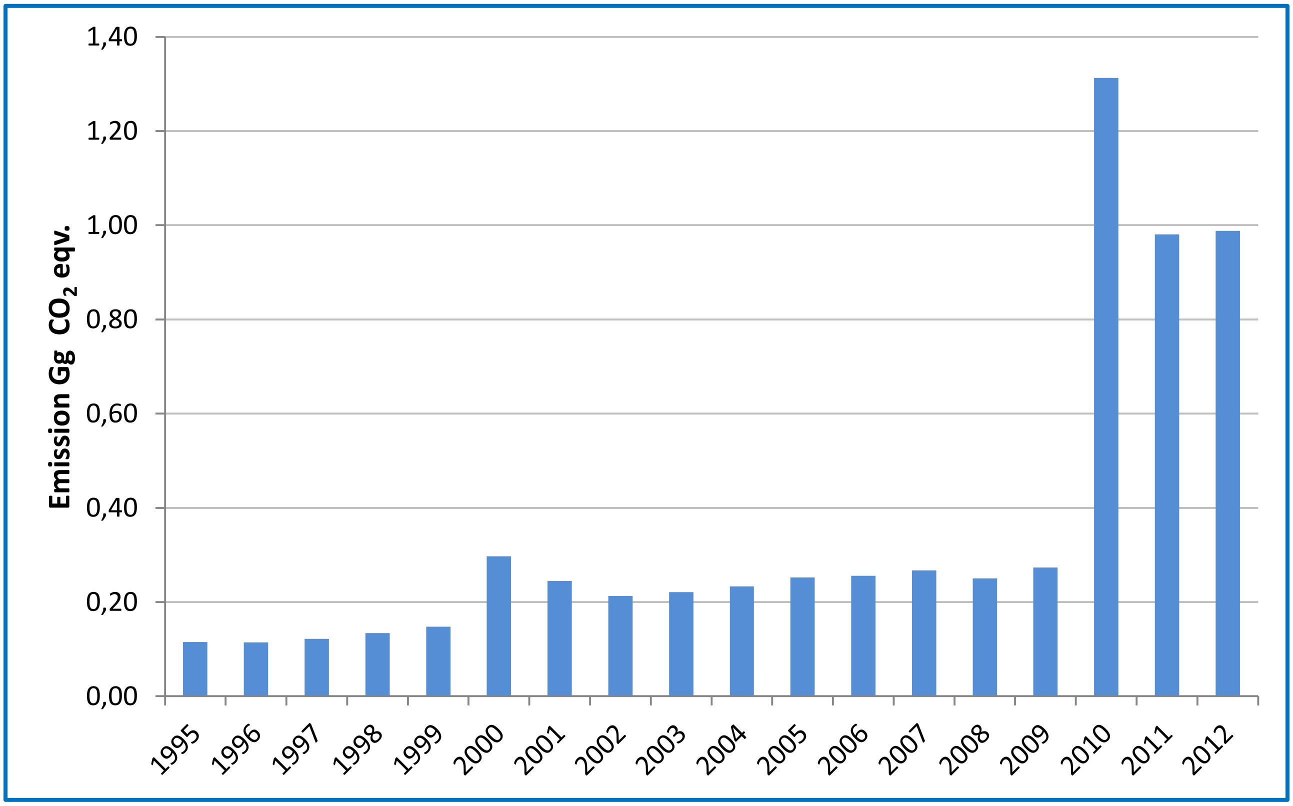

Figure 4-21. Fluorinated gas emissions from domestic refrigerators in Lithuania for 1995-2012

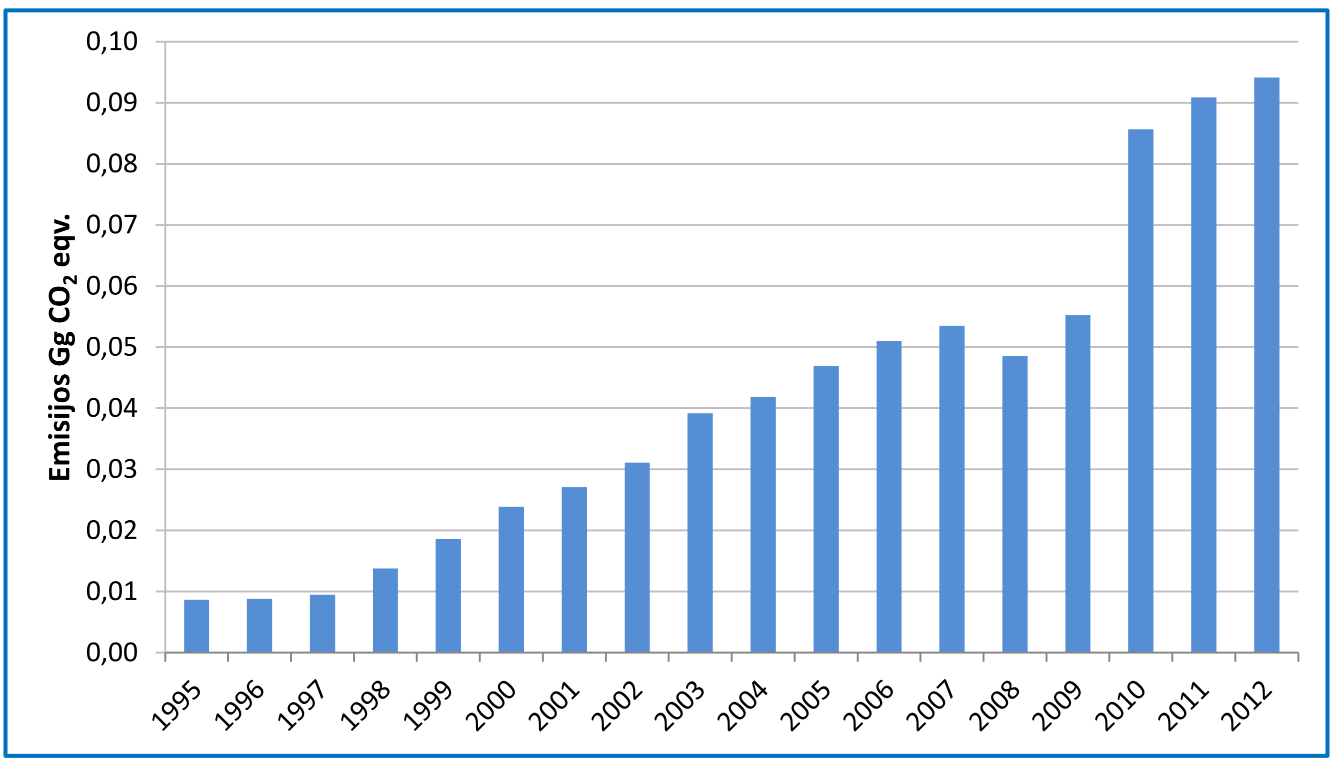

Figure 4-22. Fluorinated gas emissions from domestic freezers in Lithuania for 1995-2012

Estimated total emissions of fluorinated gases from domestic refrigeration are provided in Table 4-31. It is important to note that total fluorinated gas emissions from domestic refrigeration were recalculated because of revised number of inhabitants in Lithuania obtained from Statistics Lithuania.

Table 4-31. Total fluorinated gas emissions from domestic refrigeration for 1995-2012.

Year	Emissions form manufacturing Gg CO_2 eqv.	Emissions from operation (refrigerators) Gg CO_2 eqv.	Emissions from operation (freezers) Gg CO_2 eqv.	Emissions from disposal Gg CO_2 eqv.	Total, Gg CO_2 eqv.
1995	NO	0,11	0,01	NO	0,12
1996	NO	0,11	0,01	NO	0,11
1997	NO	0,11	0,01	NO	0,12
1998	NO	0,12	0,01	NO	0,13
1999	NO	0,13	0,02	NO	0,15
2000	0,14	0,14	0,02	NO	0,30
2001	0,07	0,14	0,03	NO	0,24
2002	0,03	0,15	0,03	NO	0,21
2003	0,03	0,16	0,04	NO	0,24
2004	0,03	0,17	0,04	NO	0,25
2005	0,02	0,18	0,05	NO	0,25
2006	0,02	0,18	0,05	NO	0,25
2007	0,03	0,19	0,05	NO	0,27
2008	0,02	0,18	0,05	NO	0,25
2009	0,01	0,21	0,05	NO	0,27
2010	0,01	0,22	0,06	1,03	1,32
2011	NO	0,23	0,06	0,69	0,98
2012	NO	0,24	0,06	0,69	0,99

Fluorinated gas emissions has increased since 2010 as a result of inclusion of emissions at the time of disposal of equipment in 2010 and since then.

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 4-32.

Table 4-32. 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.IIA.F.1.1 Domestic refrigeration					28
Domestic refrigerators	10	20	10	20	31
Domestic freezers	10	20	10	20	31

4.7.1.2 Commercial Refrigeration (CRF 2.IIA.F.1.2)

A survey of fluorinated gas use in commercial and industrial refrigeration in Lithuania was conducted in 2008 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 4-33.

Table 4-33. 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 2012 results, and the assessment of EPA database in 2012 it was assumed (table 4-34) that annual change of F-gases use was:

Table 4-34. Assumed annual change of F-gases used comparing with previous year

F-gases	2011	2012
HFC-32	5%	5%
HFC-125	10%	10%
HFC-134a	20%	20%
HFC-143a	10%	10%

The following groups of fluorinated gas use in commercial refrigeration were estimated:

- skating rinks;
- supermarkets;
- other retail enterprises;
- storage facilities.

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 2012 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.).

Estimates of fluorinated gas emission from commercial refrigeration (supermarkets, shops, skating rinks) are demonstrated in Figure 4-23 below.

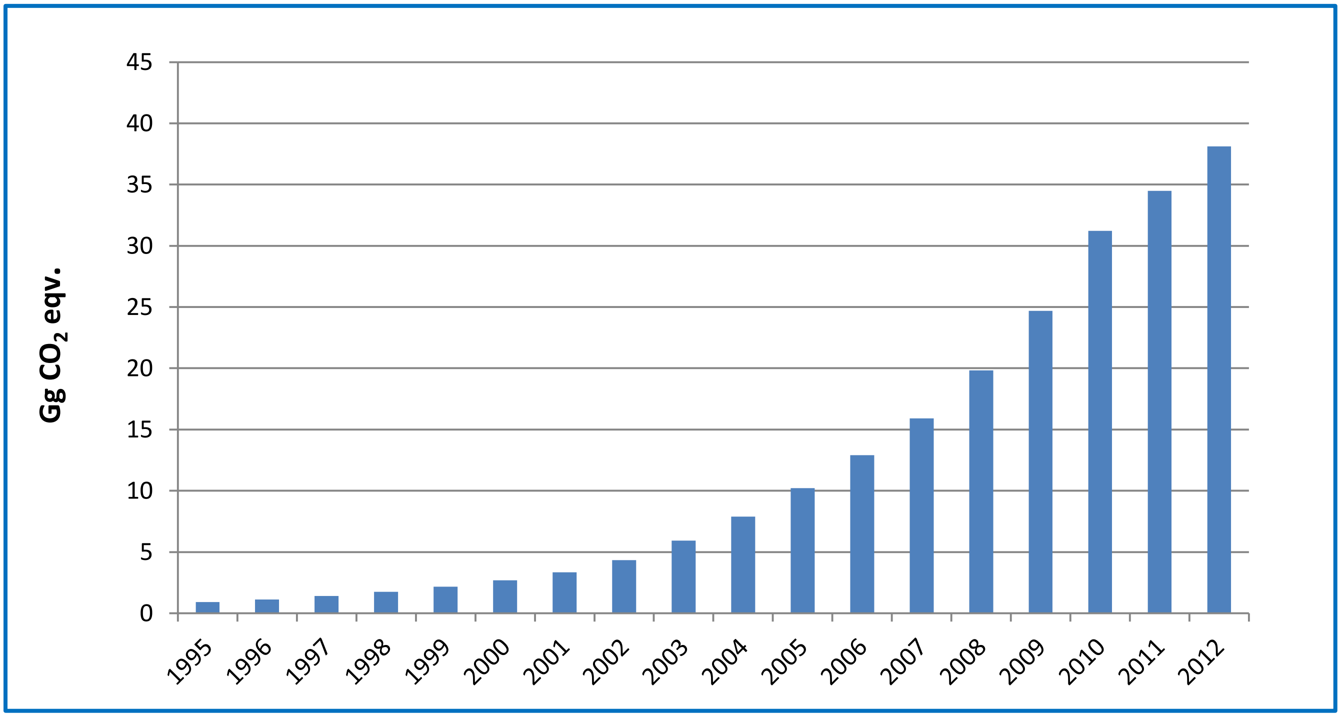

Figure 4-23. Fluorinated gas emissions from commercial refrigeration (supermarkets, shops, skating rinks)

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 company data (UAB Kalnapilio-Tauro grupe, AB Volfas Engelman, TUB Rinkuskiai, UAB Svyturio-Utenos alus, Coca Cola HBC Lietuva, AB Kauno Alus) 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: data source: drink producers);
- emissions at system disposal is 10% (data source: EMP);
- since coolers delivered are already charged with refrigerant by producers, the emission factor during the initial charging was not assessed;
- 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.

Emissions of HFCs from drink coolers were calculated using the following equation (2006 IPCC Guidelines, 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, tonnes;*
$E_{end\text{-}of\text{-}life,\ t}$ – 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, tonnes;*
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:

$$E_{end\text{-}of\text{-}life,\ t} = M_{t\text{-}d}\ x\ p\ x\ (1\text{-}\eta_{rec,\ d})$$

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 emissions from drink coolers air-conditioning systems are demonstrated in Figure 4-24 below.

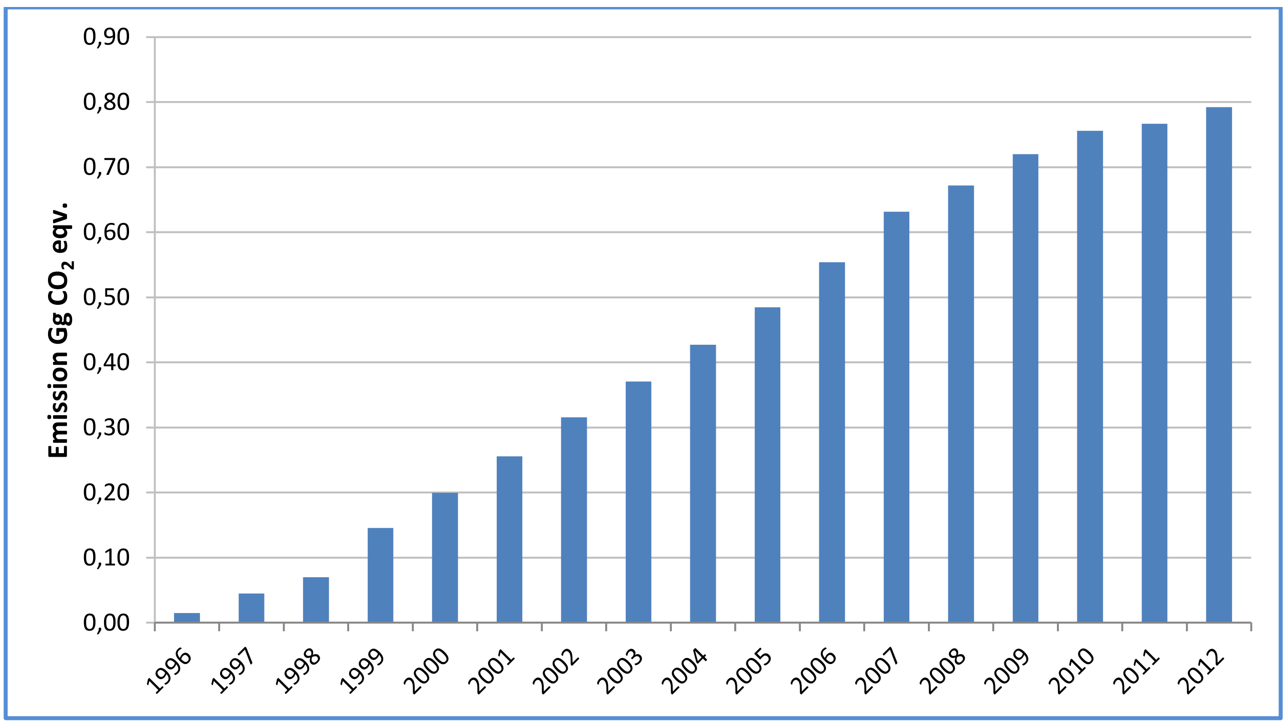

Figure 4-24. Fluorinated gas emissions from drink coolers for 1996-2012

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 2006-2012.

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);
- 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;
- emissions at system disposal – 10% (data source: UAB EMP);
- 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 equipment in accommodation and catering businesses were calculated using the equations provided in the 2006 IPCC Guidelines, 7.49 p., Tier 2a.

Estimates of fluorinated gas emissions from commercial refrigeration equipment in accommodation and catering businesses are demonstrated in Figure 4-25 below.

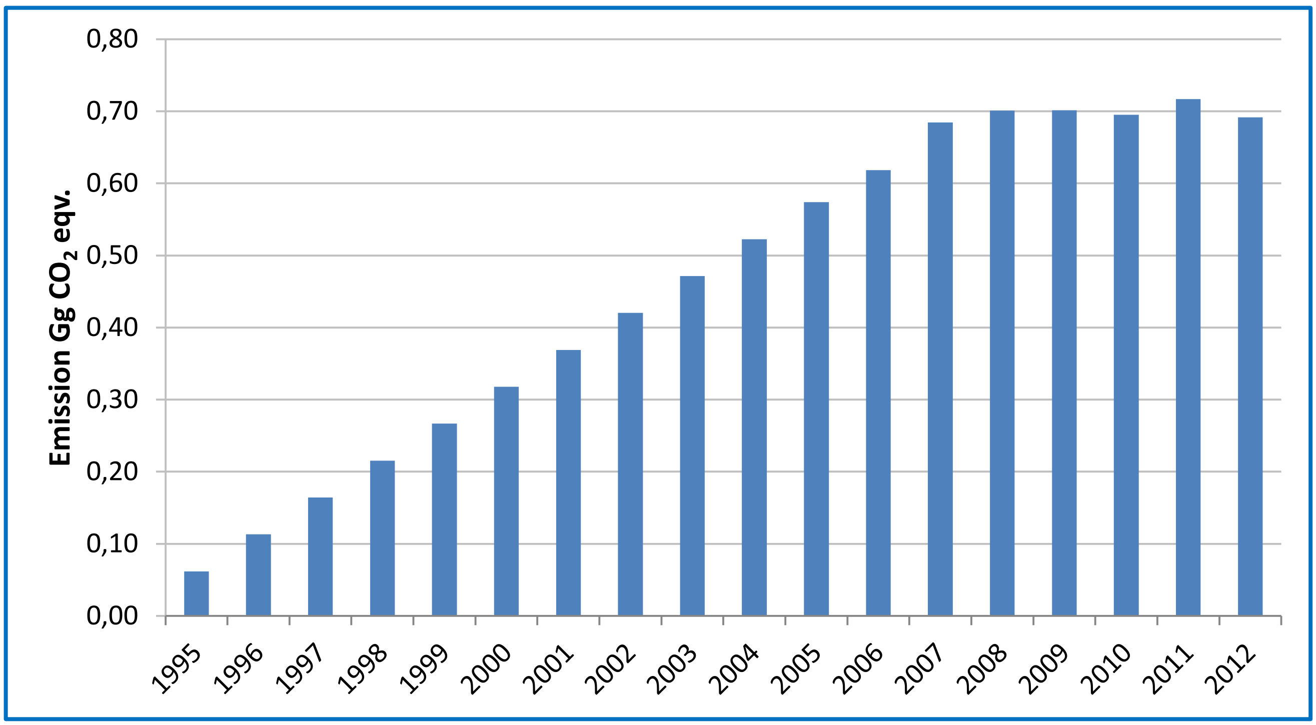

Figure 4-25. Fluorinated gas emissions from commercial refrigeration in accommodation and catering businesses for 1995-2012

Emissions from the commercial refrigeration equipment initial charging and decommissioning were recalculated taking into account the following assumptions:

Based on Study 2012 „Analysis of the use of fluorinated GHG in Lithuania in 1990-2011" results, it was considered that the lifetime of the commercial refrigeration equipment (in supermarkets, shops, accommodation and catering business) is 15 years and the lifetime of drink coolers is 10 years, which is in the range of lifetime values provided in IPCC GPG (10-15 years) and 2006 IPCC Guidelines (10-20 years). Taking into account that HFCs have been used in commercial refrigeration in Lithuania since 1995 (except HFC-32, which was started to use since 2001), end-of-life emissions were estimated for years 2010-2012 (from commercial refrigeration equipment) and 2006-2012 (from drink coolers).

Emissions during the initial charging of commercial refrigeration in accommodation and catering business and drink coolers were estimated for all time series, using emission factor 3 % based on expert judgement and 2012 study on F-gases results. Emissions during the initial charging of commercial refrigeration in supermarkets, shops, skating rinks are estimated using EF 4 %.

In 2013, in response to ERT remark in Saturday paper, emissions from end-of-life commercial refrigeration equipment were estimated using equation 3.43, p. 3.102 provided in 2000 IPCC GPG:

Disposal Emissions = (HFC and PFC Charged in year t-n) x (y/100) x (1-z/100) – (Amount of Intentional Destruction)

where:
y= Percentage of initial charge remaining in equipment at the time of disposal;
z= Recovery efficiency at the time of disposal. If any chemical is recycled during disposal, the percentage should be subtracted from the total. If there is no recycling, this term will be zero.

90% of initial charge remaining factor at the time of disposal (y) was taken from 1996 IPCC Revised Guidelines. According to the Guidelines, "If country specific data are not available, 90 percent of that initially charged may be assumed for calculation purposes (y in Equation 2 represents 90 per cent)"(p. 2.57 of 1996 IPCC Guidelines). This value is the maximum value of the best estimates (expert judgement) range given in 2000 IPCC GPG, Table 3.2.2, p. 3.106.

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 commercial refrigeration equipment are usually extracted before decommissioning and reused in other systems. 90 percent recovery efficiency at disposal value is also maximum value of the best estimates (expert judgement) range given in 2000 IPCC GPG, Table 3.2.2, p. 3.106.

Amount of intentional destruction is considered to be zero, as F-gases destruction is not taking place in Lithuania.

The total emissions of fluorinated gases from commercial refrigeration are provided in Table 4-35. It is important to stress that total emissions of fluorinated gases from commercial refrigeration were recalculated considering the ERT remarks in "Potential Problems and Further Questions from the ERT formulated in the course of the 2013 review of the greenhouse gas inventories of Lithuania submitted in 2013" and taking into account updated data from TUB "Rinkuskiai" and newly obtained data from AB "Kauno alus" (emissions from drink coolers).

Table 4-35. Total emissions of fluorinated gases from commercial refrigeration for 1995-2012

Year	Emissions from commercial refrigeration (supermarkets, shops, skating rinks), Gg CO_2 eqv.	Emissions from drink coolers, Gg CO_2 eqv.	Emissions from commercial refrigeration in accommodation and catering businesses, Gg CO_2 eqv.	Total emissions from commercial refrigeration, Gg CO_2 eqv.
1995	0,90		0,06	0,96
1996	1,12	0,01	0,11	1,24
1997	1,40	0,05	0,16	1,61
1998	1,74	0,07	0,22	2,03
1999	2,16	0,15	0,27	2,58
2000	2,68	0,20	0,32	3,20
2001	3,34	0,26	0,37	3,97
2002	4,33	0,32	0,42	5,07
2003	5,92	0,37	0,47	6,76
2004	7,89	0,43	0,52	8,84
2005	10,21	0,49	0,57	11,27
2006	12,91	0,56	0,62	14,09
2007	15,90	0,64	0,68	17,22
2008	19,83	0,68	0,70	21,21
2009	24,68	0,72	0,70	26,10
2010	31,21	0,76	0,70	32,67
2011	34,50	0,78	0,72	35,99
2012	38,12	0,79	0,69	39,60

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 equipment

Emission source	Input data UN, %	EF during operation UN, %	Input data UN, %	Recovery EF UN, %	Total emission UN, %
CRF 2.IIA.F.1.2 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

4.7.1.3 Transport Refrigeration (CRF 2.IIA.F.1.3)

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 2012 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 (2009-2012) 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.

The emission calculation methodology which was applied is provided below.

Refrigerated road vehicles: refrigerated trucks, refrigerated vans, 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%). Fluorinated gas emissions from this 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 1992-2012 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 1993-2012. 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, tonnes;*
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 residual charge in the system being disposed is 70%;
- 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):

$$E_{end\text{-}of\text{-}life,\ t} = M_{t\text{-}d} \times p \times (1-\eta_{rec,\ d})$$

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, %.

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 4-26 below.

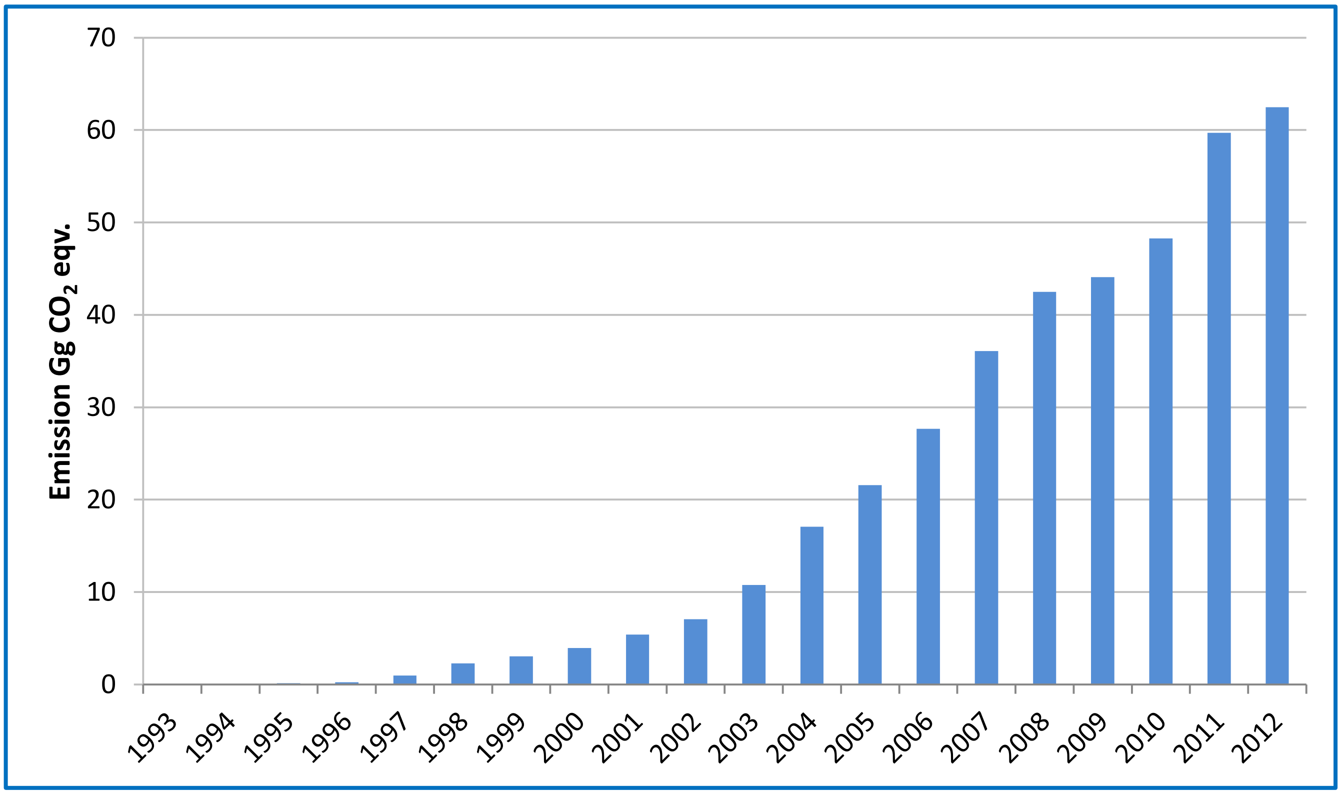

Figure 4-26. Fluorinated gas emissions from refrigerated road vehicles for 1993-2012

Trains – 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 2006-2012 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 15 kg;
   - the emission factor during the operation of the equipment (which is fairly new) is 10%.
2. Other assumptions:
   - 80% of all freight wagons are charged with the refrigerant R-134a;
   - 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, tonnes;*
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, 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, %.

Estimates of fluorinated gas emissions from freight wagons are demonstrated in Figure 4-27 below.

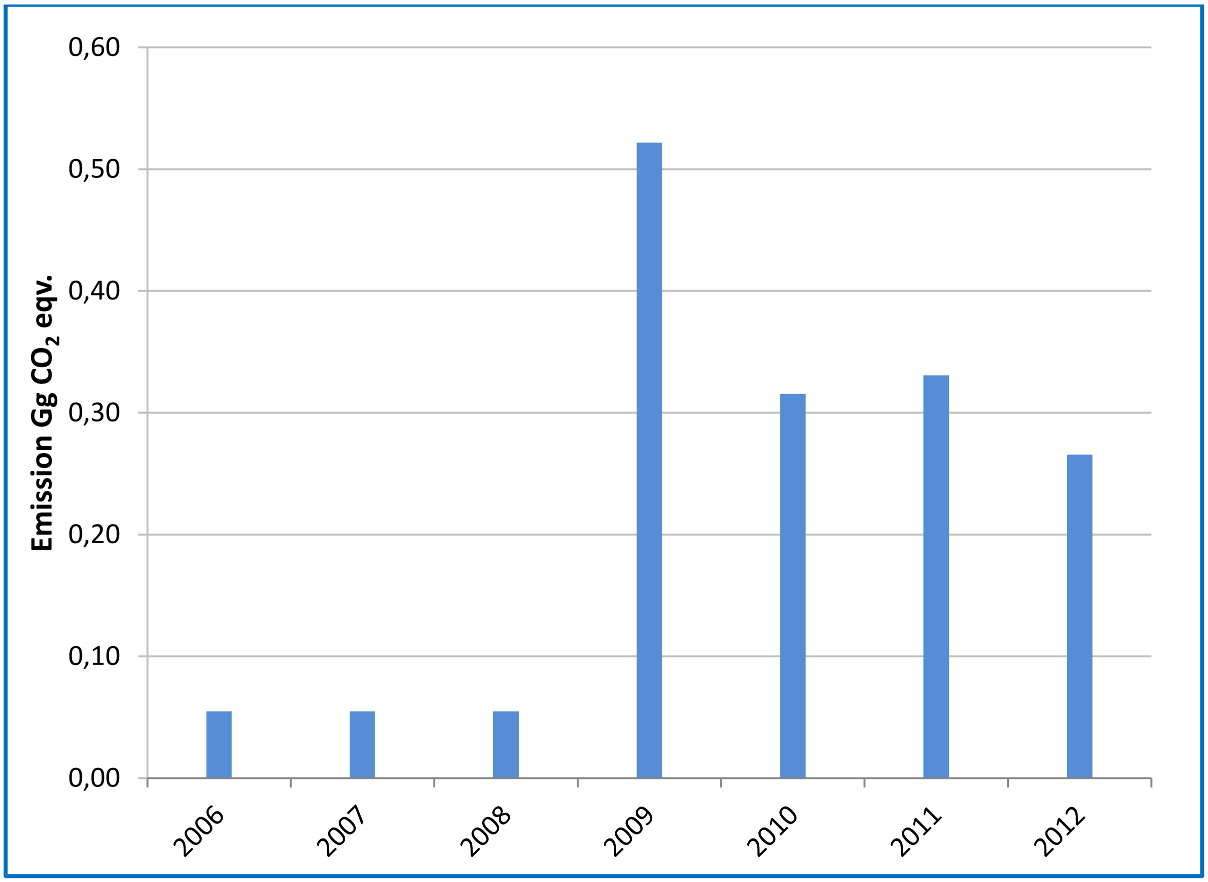

Figure 4-27. Fluorinated gas emissions from freight wagons for 2006-2012

As seen in Figure 4-27 emissions over the period of 2009-2012 were higher than in the period of 2006-2008. 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 4-37.

Table 4-37. Total fluorinated gas emissions from transport refrigeration for 1993-2012

Year	Emissions from refrigerated road vehicles, Gg CO_2 eqv.	Emissions from refrigerated rail vehicles, Gg CO_2 eqv.	Total HFC emissions in sub-category, Gg CO_2 eqv.
1993	0,01	NO	0,01
1994	0,04	NO	0,04
1995	0,11	NO	0,11
1996	0,24	NO	0,24
1997	0,96	NO	0,96
1998	2,27	NO	2,27
1999	3,05	NO	3,05
2000	3,95	NO	3,95
2001	5,41	NO	5,41
2002	7,06	NO	7,06
2003	10,77	NO	10,77
2004	17,08	NO	17,08
2005	21,58	NO	21,58
2006	27,68	0,05	27,73
2007	36,09	0,05	36,14
2008	42,49	0,05	42,54
2009	44,09	0,52	44,61
2010	48,26	0,32	48,58
2011	59,70	0,33	60,03
2012	62,49	0,27	62,76

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 2000-2012 is provided by Statistics Lithuania is presented in Table 4-38.

Table 4-38. Reefer vessels registered in Lithuania in 2000-2012

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Annual number of reefer vessels registered in Lithuania	20	20	23	17	18	16	18	19	13	12	11	9	5

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.

State enterprise Klaipėda State Seaport Authority, on the basis of the data of the Port Control Department, provided information on reefers calling Klaipėda State Seaport from 2002 to 2011 (Table 4-39).

Table 4-39. Reefer vessels calling Klaipėda State Seaport in 2002-2011

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Annual number of reefer vessels with the Lithuanian flag calling Klaipėda Seaport	9	7	10	11	2	8	5	1	0	3
Total annual number of reefer vessels	260	316	304	315	237	254	227	192	202	192
Difference in per cent	3,46	2,22	3,29	3,49	0,84	3,15	2,20	0,52	0,00	1,56

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 4-40.

Table 4-40. Uncertainty (UN) estimates of fluorinated gas emissions in the sub-category of commercial refrigeration in 2012

Emission source	Input data UN, %	EF during operation UN, %	Input data UN, %	Recovery EF UN, %	Total emission UN, %
CRF 2.IIA.F.1.3 Refrigeration in vehicles					31
Refrigerated road vehicles	10	20	10	20	31
Refrigerated rail vehicles	5	5	5	5	7

4.7.1.4 Industrial Refrigeration (CRF 2.IIA.F.1.4)

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 2012 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.

In response to ERT remark in Saturday paper on potential underestimation concerning decommissioned equipment emissions in Industrial refrigeration subcategory, HFC emissions from this subsector were recalculated. Emissions from industrial refrigeration decommissioning were estimated for 2010-2012 and taking into account that HFCs have been used in industrial refrigeration in Lithuania since 1995, end-of-life emissions were estimated for 2010 - 2012 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 IPCC GPG (10-15 years) and 2006 IPCC Guidelines (10-20 years).

Emissions from end-of-life industrial refrigeration equipment were estimated using equation 3.43, p. 3.102 provided in 2000 IPCC GPG:

Disposal Emissions = (HFC and PFC Charged in year t-n) x (y/100) x (1-z/100) – (Amount of Intentional Destruction)

According to the 1996 IPCC Guidelines, p. 2.57 and 2000 IPCC GPG, Table 3.2.2, p. 3.106 and national experts judgement, 90 % of initial charge remaining factor at the time of disposal (y) was assumed.

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 percent recovery efficiency at disposal value is also maximum value of the best estimates (expert judgement) range given in 2000 IPCC GPG, Table 3.2.2, p. 3.106.

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 JSC 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.

Estimations of fluorinated gas emissions from industrial refrigeration are demonstrated in Figure 4-28 below.

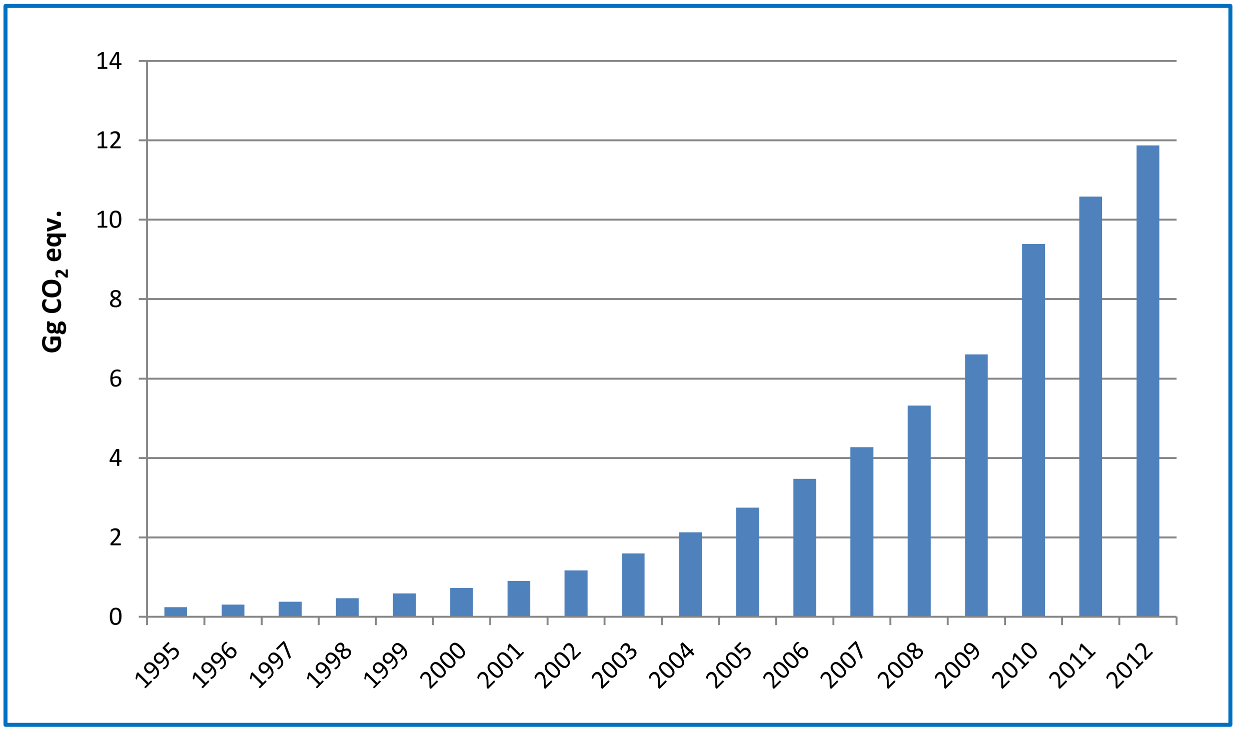

Figure 4-28. Fluorinated gas emissions from industrial refrigeration for 1995-2012, Gg CO_2 eqv.

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 4-41.

Table 4-41. 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.IIA.F.1.4 Industrial refrigeration	30	15	30	15	47

4.7.1.5 Stationary Air-Conditioning (CRF 2.IIA.F.1.5)

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 2012 are deemed to be annual recharge amounts in air-conditioning systems;
- the amount of gases contained in air-conditioning systems in 2012 = 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, 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, tonnes;*
x – emission factor of HFCs for each sub-application bank during operation, accounting for average annual leakage and average annual emission during servicing, %.

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.

In response to ERT remark in Saturday paper on potential underestimation concerning decommissioned equipment emissions in Stationary air conditioning (A/C) subcategory, HFC emissions from this subsector were recalculated. 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 IPCC GPG (10-15 years) and 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 - 2012 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 2000 IPCC GPG, Table 3.22, p. 3.106).
- Emissions from end-of-life stationary A/C equipment were estimated using equation 3.43, p. 3.102 provided in 2000 IPCC GPG:

Disposal Emissions = (HFC and PFC Charged in year t-n) x (y/100) x (1-z/100) – (Amount of Intentional Destruction)

Data on HFC charged in year t-n is based on study „Analysis of the use of fluorinated GHG in Lithuania in 1990-2011", which was carried out in 2012, results.

90 % of initial charge remaining factor at the time of disposal was taken from 1996 IPCC Revised Guidelines. According to the Guidelines, "If country specific data are not available, 90 percent of that initially charged may be assumed for calculation purposes (y in Equation 2 represents 90 per cent)"(p. 2.57 of 1996 IPCC Guidelines). This value is the maximum value of the best estimates (expert judgement) range given in 2000 IPCC GPG, Table 3.2.2, p. 3.106.

Recovery efficiency at disposal (*z*) value 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. 80 percent recovery efficiency at disposal value is also maximum value of the best estimates (expert judgement) range given in 2000 IPCC GPG, Table 3.2.2, p. 3.106.

Amount of intentional destruction is considered to be zero, as F-gases destruction is not taking place in Lithuania.

Estimates of fluorinated gas emissions from stationary air-conditioning systems are demonstrated in Figure 4-29 below.

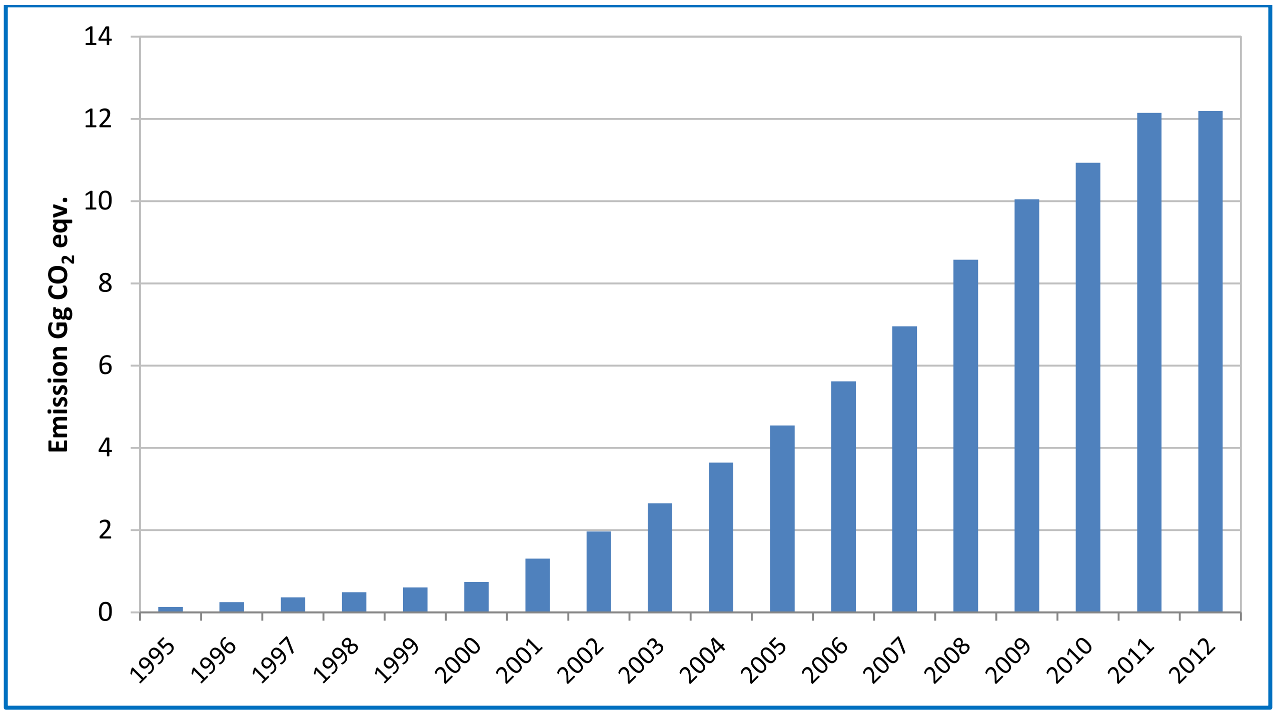

Figure 4-29. Fluorinated gas emissions from stationary air conditioning for 1995-2012

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 2010-2011 and 511 – in 2012;
- 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 and by Lithuanian Geothermal Association. The total number of heat-pumps installed is 1865 in 2009, 2221 in 2010 is provided by EurObserv'ER in SYSTÈMES SOLAIRES le journal des énergies renouvelables N° 205 – 2011/ BAROMÈ T R E POMP E S À CHAL EUR – EUROBSERV'ER and in in the Study carried out by EurObser'ER in 2013 (Observatoire des énergies renouvelables) (http://www.eurobserv-er.org/pdf/baro218_en.asp). According Lithuanian Geothermal Association the number of ground source heat pump systems in Lithuania is growing and reached 4387 in 2012, with 511 newly installed.

Following the data provided by private liability companies UAB Vilpra and UAB Geoterminio šildymo sistemos 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, p. 7.50, Tier 2a):

$$E_{charge,\,t} = M_t \times k$$

where:

$E_{Charge,\,t}$ –emissions during system manufacture/assembly in year *t, tonnes;*

M_t – amount of HFCs charged into new equipment in year *t, tonnes;*

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, tonnes;*
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 2005-2012 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 4-30 below.

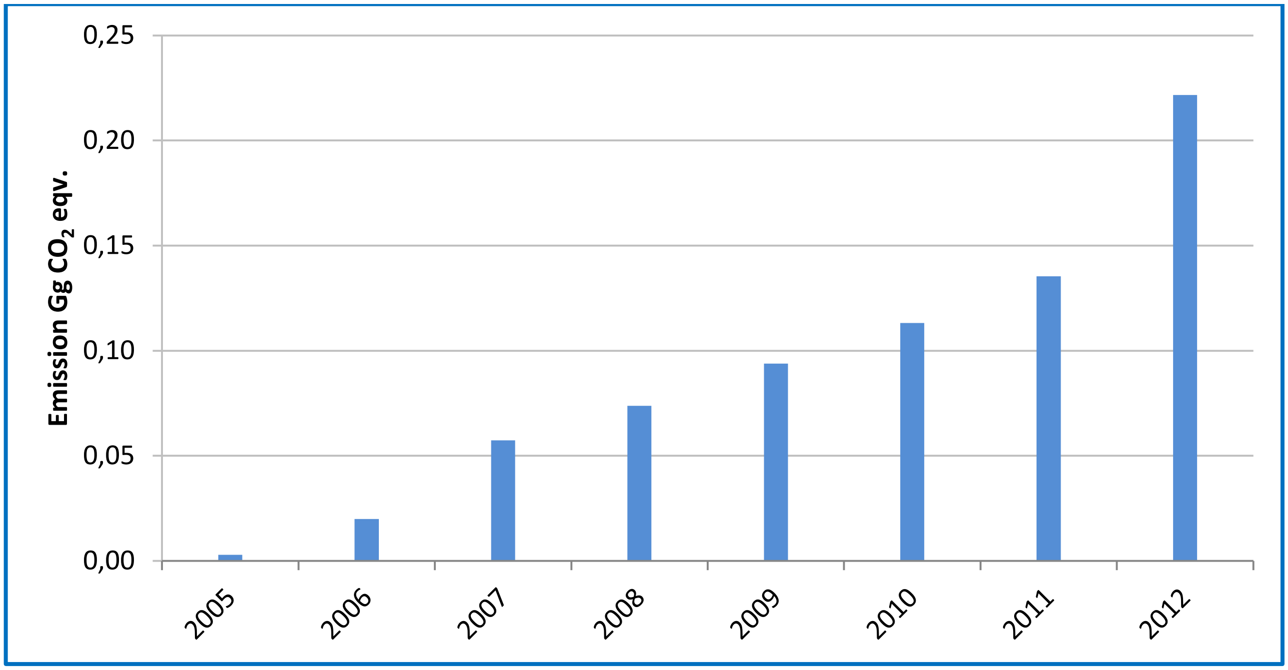

Figure 4-30. Fluorinated gas emissions from heat pumps for 2005-2012

Estimates of total fluorinated gas emissions from stationary air conditioning and heat pumps are provided in Table 4-42. 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 4-42. Total HFC emissions from stationary air conditioning and heat pumps for the period 1995-2012

Year	Emissions from stationary air conditioning, Gg CO_2 eqv.	Emissions from heat pumps, Gg CO_2 eqv.	Total HFC emissions, Gg CO_2 eqv.
1995	0,13	NO	0,13
1996	0,25	NO	0,25
1997	0,37	NO	0,37
1998	0,48	NO	0,48

1999	0,60	NO	0,60
2000	0,74	NO	0,74
2001	1,30	NO	1,30
2002	1,96	NO	1,96
2003	2,65	NO	2,65
2004	3,64	NO	3,64
2005	4,54	0,00	4,54
2006	5,62	0,02	5,64
2007	6,96	0,06	7,02
2008	8,58	0,07	8,65
2009	10,05	0,09	10,14
2010	10,93	0,11	11,04
2011	12,14	0,14	12,28
2012	12,19	0,22	12,41

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 stationary air conditioning

Emission source	Input data UN, %	EF during operation UN, %	Input data UN, %	Recovery EF UN, %	Total emission UN, %
CRF 2.IIA.F.1.5 Stationary air conditioning					35
Air-conditioning and ventilation equipment	30	20	-	-	36
Heat pumps	20	20	-	-	28

4.7.1.6 Mobile Air-Conditioning (CRF 2.IIA.F.1.6)

Road vehicles with air conditioning: passenger vehicles, buses, 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%).

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 1991-2012 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 1993-2012. 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 4-44).

Table 4-44. 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%

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, p. 7.50, Tier 2a):

$$E_{lifetime,\,t} = B_t \times x$$

where:
B_t – amount of HFCs banked in existing systems in year *t, tonnes;*
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, p. 7.51):

$$E_{end\text{-}of\text{-}life,\,t} = M_{t-d} \times p$$

where:

$M_{t\text{-}d}$ – 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, %.

There are calculated emissions from disposal passenger car (M1) and buses ≤ 5 t (M2) with air-conditioning systems filled with HFC-134a in this report. Air-conditioning systems of freight vehicles are also filled with HFC-134a gases, but their lifetime is 20-22 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 4-31 below.

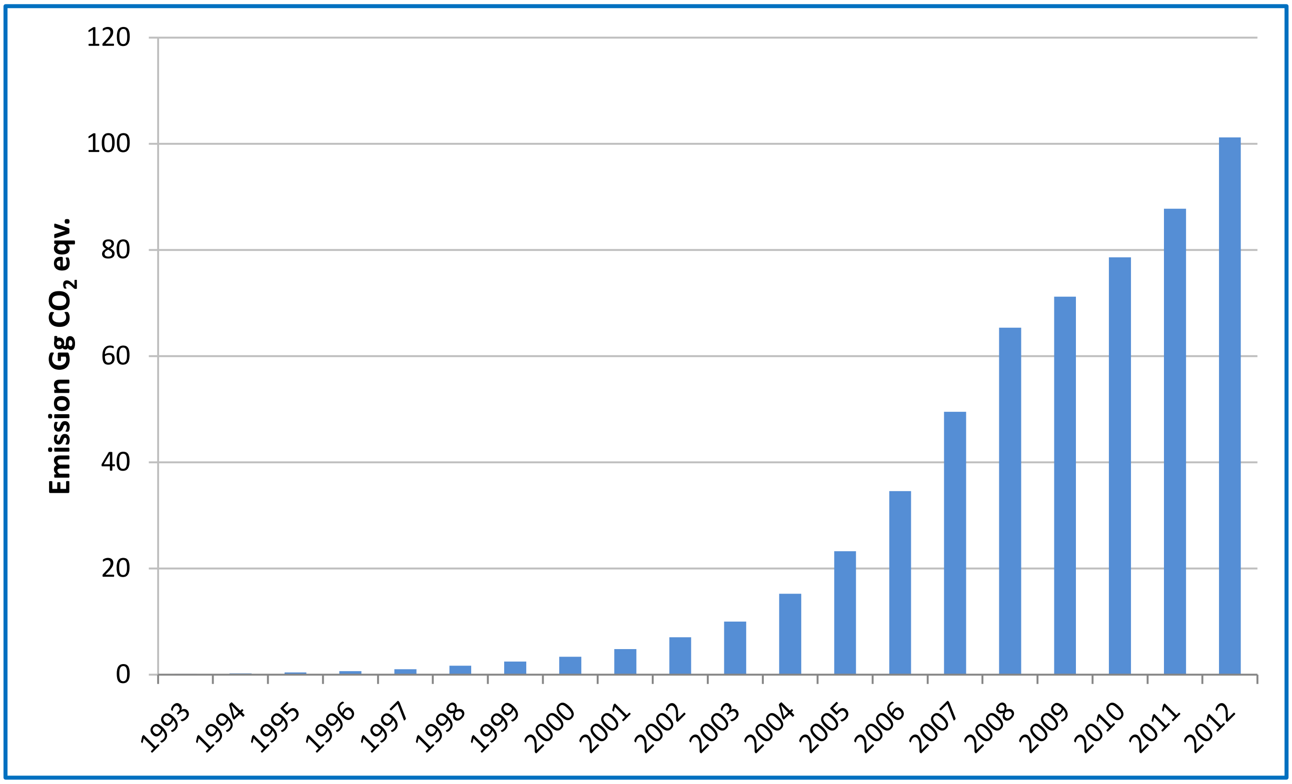

Figure 4-31. Fluorinated gas emissions from vehicles with air conditioning for 1993-2012

Trains – passenger carriages

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.

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, tonnes;*
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 4-32 below.

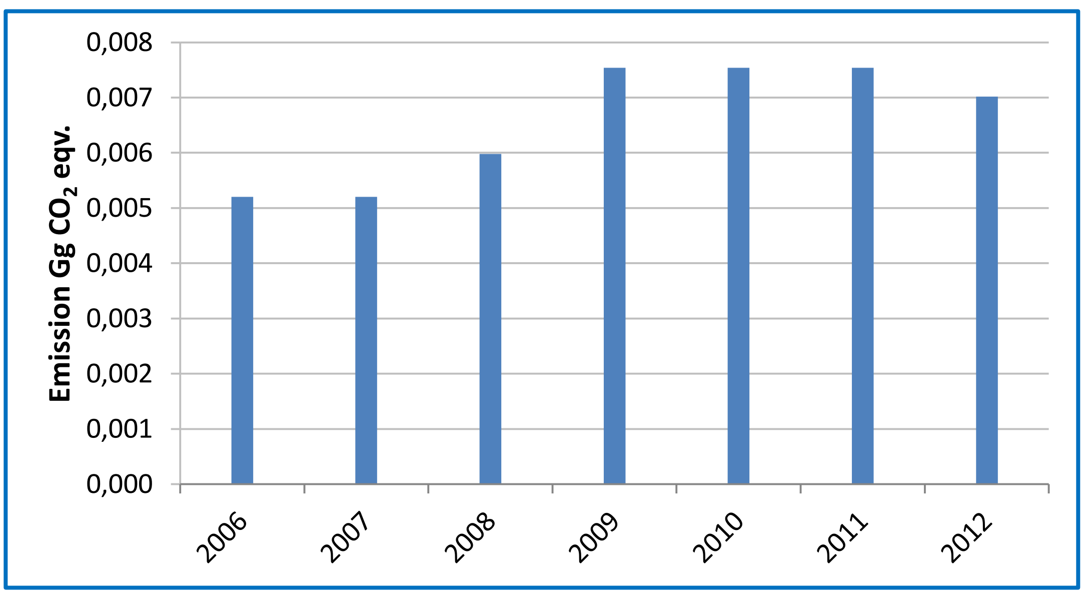

Figure 4-32. Fluorinated gas emissions from passenger carriages for 2006-2012

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 4-45.

Table 4-45. Total HFC emissions from mobile air conditioning for the period 1993-2012

Year	Emissions from vehicles with air conditioning, Gg CO_2 eqv.	Emissions from rail vehicles with air conditioning, Gg CO_2 eqv.	Total emissions, Gg CO_2 eqv.
1993	0,09	NO	0,09
1994	0,23	NO	0,23
1995	0,43	NO	0,43
1996	0,64	NO	0,64
1997	1,02	NO	1,02
1998	1,67	NO	1,67
1999	2,45	NO	2,45
2000	3,34	NO	3,34
2001	4,78	NO	4,78
2002	7,05	NO	7,05
2003	9,99	NO	9,99
2004	15,21	NO	15,21
2005	23,25	NO	23,25
2006	34,58	0,005	34,59
2007	49,48	0,005	49,49
2008	65,34	0,006	65,35
2009	71,16	0,008	71,17
2010	78,58	0,008	78,59
2011	87,75	0,008	87,76
2012	101,19	0,007	101,20

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 4-46.

Table 4-46. Uncertainty (UN) estimates of fluorinated gas emissions in the sub-categoryof mobile air conditioning

Emission source	Input data UN, %	EF during operation UN, %	Input data UN, %	Recovery EF UN, %	Total emission UN, %
CRF 2.IIA.F.1.6 Mobile air conditioning					31
Air-conditioning equipment in road vehicles	10	20	10	20	31
Air-conditioning equipment in rail vehicles	5	5	-	-	7

4.7.2 Foam Blowing(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.

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 2012. 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-365 mfc, HFC-134a, HFC-245fa, HFC-227ea). According to the data provided by UAB Termomontazas, actual amounts of F-gases used for the foam blowing constitute 7.5% of the foam material by weight.

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 2004-2012 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-365 mfc, 7% HFC-227ea;
   Variant II: 95% HFC-365 mfc, 5% HFC-245 fa;
   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, p. 7.33, Tier 2a):

$$Emissions_t = M_t \ x \ EF_{FYL} \ + \ Bank_t \ x \ EF_{AL}$$

where:
M_t – total HFCs used in manufacturing new closed-cell foam in year *t*, tones
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*, tones
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 2004-2012.

Estimations of fluorinated gas emissions from closed cell foam are demonstrated in Figure 4-33 below.

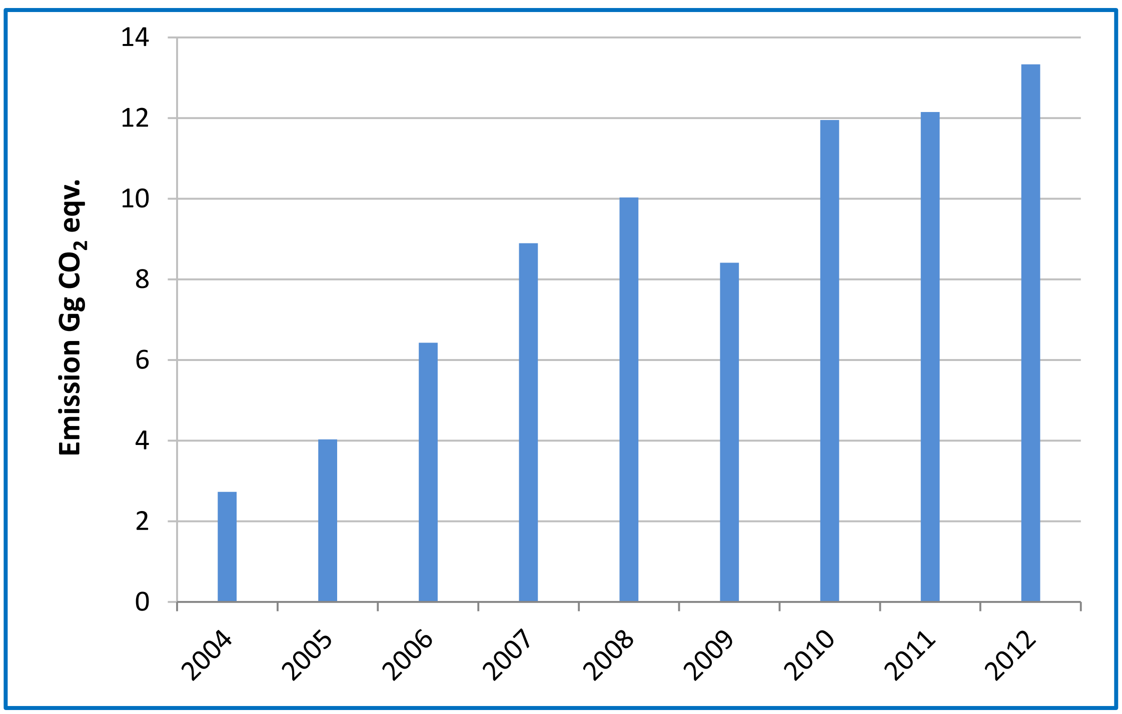

Figure 4-33. Emissions from closed cell foam for 2004-2012

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 4-47.

Table 4-47. Total HFC emissions from foam blowing for the period 2004-2012

Year	Emissions from foam blowing, Gg CO_2 eqv.
2004	2,73
2005	4,03
2006	6,43
2007	8,90
2008	10,03
2009	8,41
2010	11,95
2011	12,15
2012	12,20

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 4-48.

Table 4-48. 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

4.7.3 Fire Extinguishers (CRF 2.F.3)

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 1000 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%).

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 2000-2012 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 2012;
- 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 2000-2012);
- 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, p. 7.61):

$$Emissions_t = Bank_t \ x \ EF$$

where:
$Bank_t$ - bank of agent in fire protection equipment in year *t*, tones;
EF - fraction of agent in equipment emitted each year.

Estimates of fluorinated gas emissions from fire protection systems are demonstrated in Figure 4-34 below.

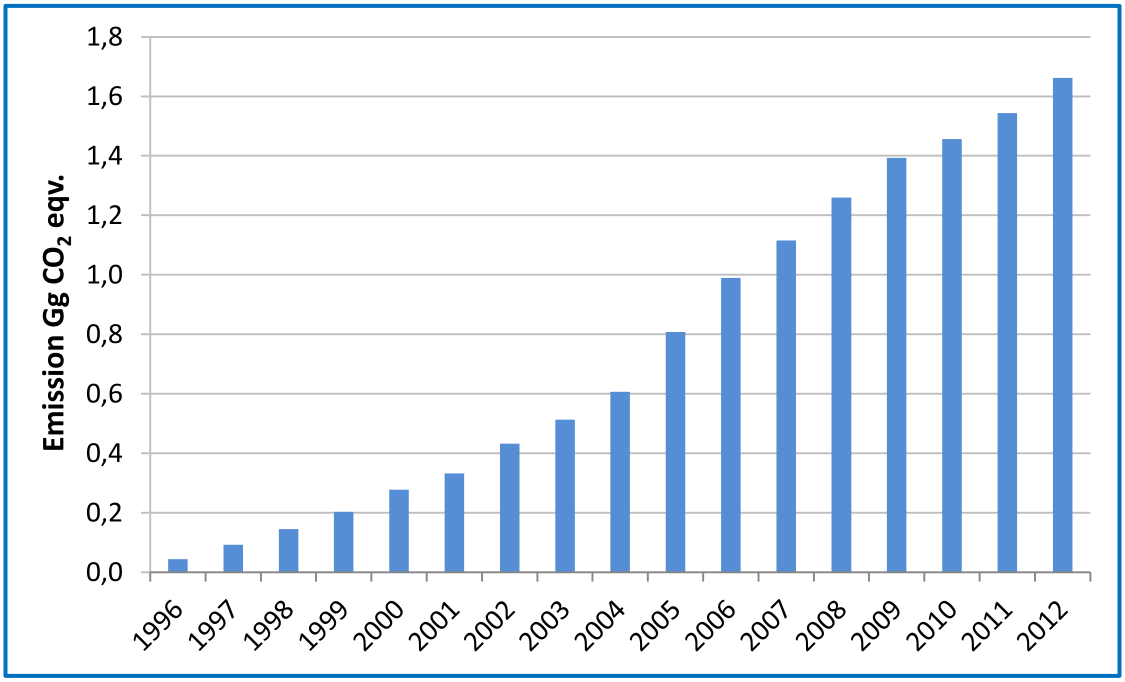

Figure 4-34. Fluorinated gas emissions from fire protection systems for 1996-2012

Emissions were estimated for the period 1996-2012 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 4-49.

Table 4-49. Total HFC emissions from fire protection systems for the period 1996-2012

Year	Emissions from fire protection systems, Gg CO_2 eqv.
1996	0,04
1997	0,09
1998	0,15
1999	0,20
2000	0,28
2001	0,33
2002	0,43
2003	0,51
2004	0,61
2005	0,81
2006	0,99
2007	1,11
2008	1,26
2009	1,39
2010	1,46
2011	1,54
2012	1,66

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 4-50.

Table 4-50. Uncertainty (UN) estimates of fluorinated gas emissions in the sub-category of fire extinguishers

Emission source	Input data UN, %	EF during operation UN, %	Total emission UN, %
CRF 2.F.3 Fire extinguishers	20	20	28

4.7.4 Aerosols/Metered Dose Inhalers (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.

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 2004-2012. 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.

Emissions of HFCs from metered dose inhalers were calculated using the following equation (2006 IPCC Guidelines, 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*, tonnes
S_{t-1} – quantity of HFCs contained in aerosol products sold in year *t-1*, tonnes
EF – emission factor (fraction of chemical emitted during the first year).

Estimates of fluorinated gas emissions from metered dose inhalers are demonstrated in Figure 4-35 below.

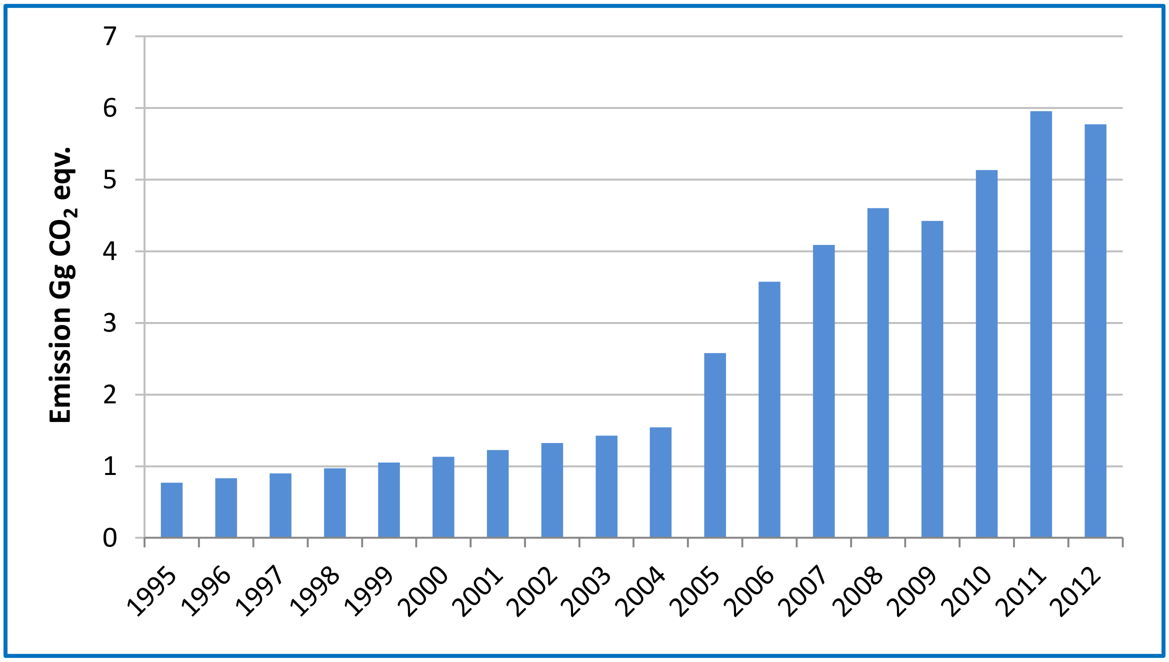

Figure 4-35. Fluorinated gas emissions from metered dose inhalers for 1995-2012

Estimates of HFC emissions from metered dose inhalers are presented in Table 4-51.

Table 4-51. Total HFC emissions from metered dose inhalers for the period 1995-2012

Year	Emissions from metered dose inhalers, Gg CO_2 eqv.
1995	0,77
1996	0,83
1997	0,90
1998	0,97
1999	1,05
2000	1,13
2001	1,22
2002	1,32
2003	1,43
2004	1,54
2005	2,58
2006	3,58
2007	4,09
2008	4,60
2009	4,42
2010	5,13
2011	5,96
2012	5,77

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 4-52. 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 Aerosols/Metered dose inhalers	5	5	7

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" (1995-2010) are used.

4.7.6 Other Applications Using ODS Substitutes (CRF 2.F.6)

SF_6 emissions from semiconductor production is not accurring in Lithuania so for the category "CRF 2.F.6. Other Applications Using ODS Substitutes" notation key "NO" is used.

4.7.7 Semiconductor Manufacture (CRF 2.F.7)

There is one company in Lithuania, UAB Vilniaus Ventos puslaidininkiai, which produces semiconductors, and this company was contacted for necessary data. The company said that the SF_6 gas has been used only since 2008 and atmosphere emissions are estimated at 50%. SF_6 emissions were estimated for the period 2008-2012. Since it is the only company in Lithuania which produces semiconductors, and the production depends on economic situation as whole and production demand, fluctuations of the emissions occur.

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*, tonnes
C_i - emission factor during production.

Estimates of SF_6 emissions from semiconductor manufacture are demonstrated in Figure 4-36 below.

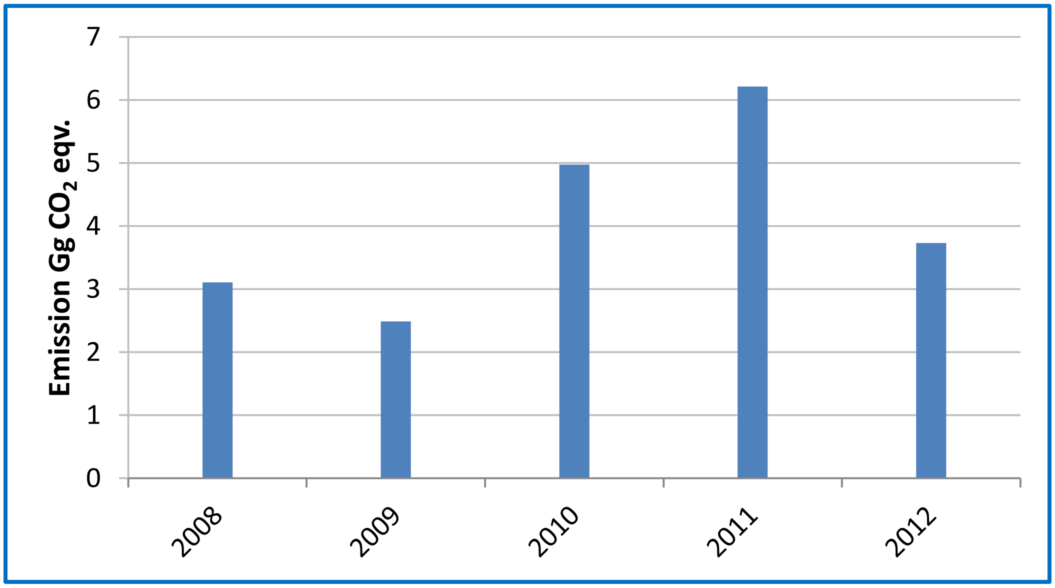

Figure 4-36. SF_6 emissions from semiconductor manufacture for 2008-2012

Estimates of fluorinated gas emissions from semiconductor manufacture are presented in Table 4-53.

Table 4-53. Total HFC emissions from semiconductor manufacture for the period 2008-2012

Year	Emissions from semiconductor manufacture, Gg CO_2 eqv.
2008	3,11
2009	2,49
2010	4,97
2011	6,21
2012	3,73

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 4-54.

Table 4-54. 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.F.7 Semiconductor manufacture	5	5	7

4.7.8 Electrical Equipment (CRF 2.F.8)

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).

Following the 2000 IPCC Guidelines, emissions were estimated using Tier 3a method (on the basis of the data directly obtained from each company) for the period 1995-2012 (first operating losses were registered in 1995).

Estimates of SF_6 emissions in the sub-category of electrical equipment are demonstrated in Figure 4-37 below.

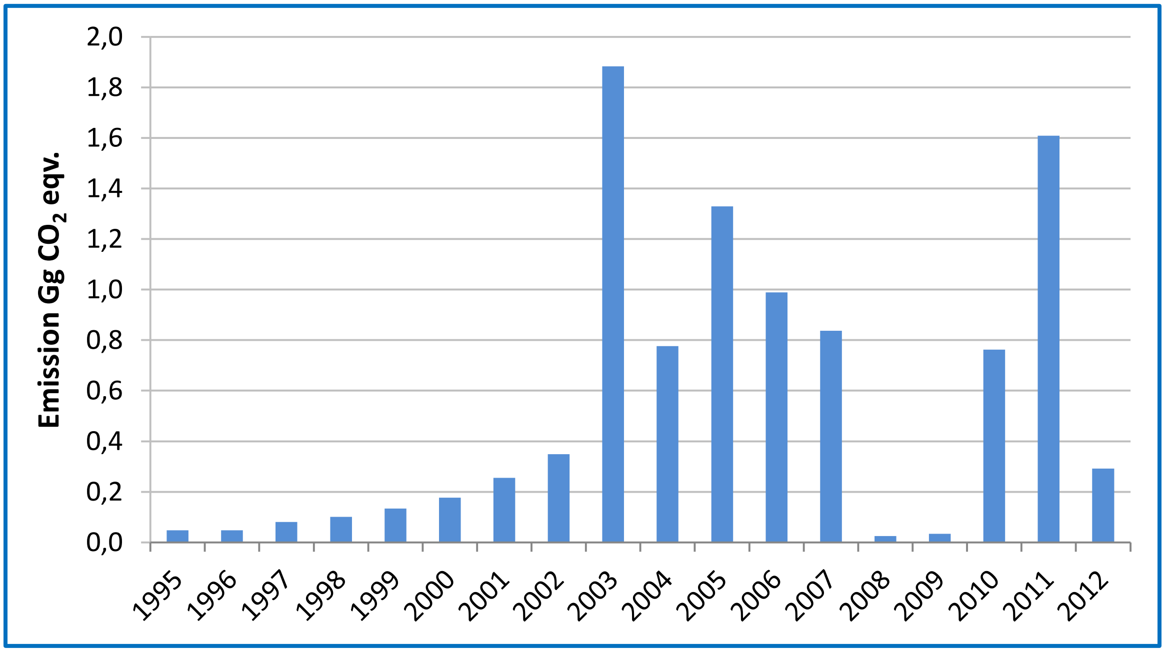

Figure 4-37. SF_6 emissions from electrical equipment for 1995-2012

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 4-55. Total SF_6 emissions from electrical equipment for the period 1995-2012

Year	Emissions from electrical equipment, Gg CO_2eqv.
1995	0,05
1996	0,05
1997	0,08
1998	0,10
1999	0,13
2000	0,18
2001	0,26
2002	0,35
2003	1,88
2004	0,78
2005	1,33
2006	0,99
2007	0,84
2008	0,03
2009	0,03
2010	0,76
2011	1,61
2012	0,29

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 4-56.

Table 4-56. Uncertainty (UN) estimatesof 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.F.8 Electrical equipment	5	5	7

4.7.9 Other (CRF 2.F.9)

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 SF6 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 4-38 below.

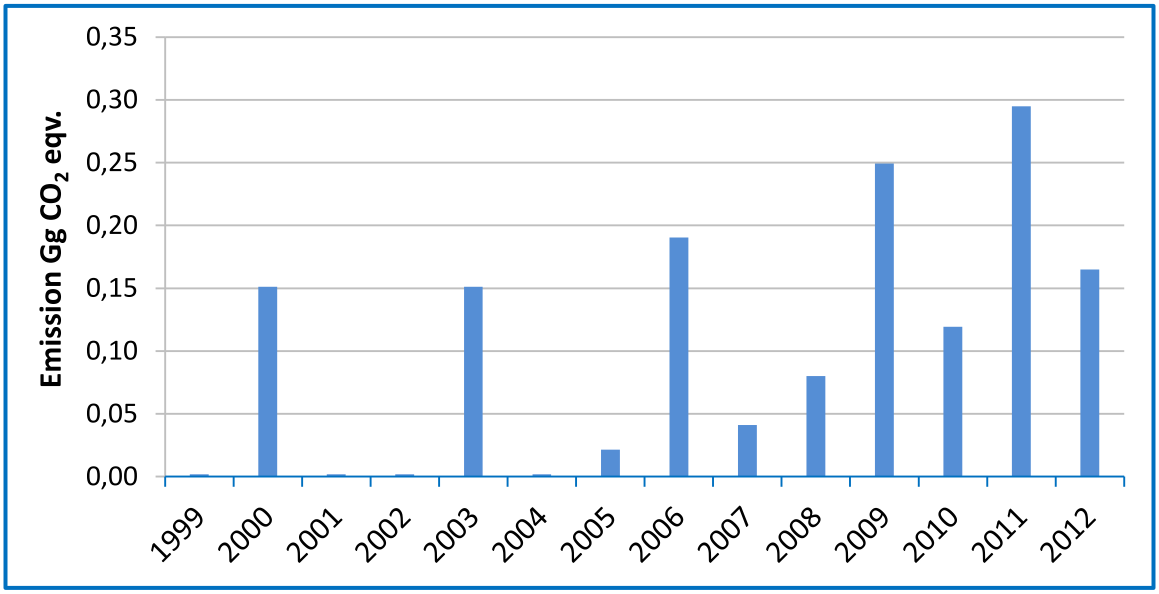

Figure 4-38. SF_6 emissions from accelerators (in radiation therapy facilities) for 1999-2012

Estimates of SF_6 emissions from accelerators (in radiation therapy facilities) are presented in Table 4-57.

Table 4-57. Total HFC emissions from fire from accelerators (in radiation therapy facilities) for the period 1999-2012

Year	Emissions from accelerators (in radiation therapy facilities), Gg CO_2 eqv.
1999	0,002
2000	0,151
2001	0,002
2002	0,002
2003	0,151
2004	0,002
2005	0,021
2006	0,190
2007	0,041
2008	0,080
2009	0,249
2010	0,119
2011	0,295
2012	0,165

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 4-58.

Table 4-58. 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.F.9 Other	5	5	7

4.7.10 Source-specific recalculations

Domestic refrigeration (CRF 2.IIA.F.1.1)

HFC emissions from domestic refrigeration were recalculated (Table 4-59) for the period 2001-2011 based on the updated information provided by Statistics Lithuania:

- the number of inhabitants in Lithuania;
- the average size of households in Lithuania;
- the percentage of households using domestic refrigerators.

Table 4-59. Reported in previous submission and recalculated fluorinated gas emissions from domestic refrigeration (Gg CO_2 eqv.)

Year	Previous submission	This submission	Absolute difference	Relative difference, %
2001	0,25	0,25	0,00	-0,21
2002	0,21	0,21	0,00	-0,64
2003	0,22	0,22	0,00	-0,99
2004	0,24	0,23	0,00	-1,52
2005	0,26	0,25	-0,01	-2,44
2006	0,26	0,26	-0,01	-3,33
2007	0,28	0,27	-0,01	-3,89
2008	0,26	0,25	-0,01	-4,39
2009	0,28	0,27	0,00	-1,12
2010	1,32	1,31	0,00	-0,27
2011	0,98	0,98	0,00	-0,39

Commercial refrigeration (CRF 2.IIA.F.1.2)

Emissions were recalculated for the period 2001-2011, based on updated data from TUB "Rinkuskiai" and newly obtained data from AB "Kauno alus" (table 4-60).

Table 4-60. Reported in previous submission and recalculated fluorinated gases emissions from commercial refrigeration, Gg CO_2 eqv.

Year	Previous submission	This submission	Absolute difference	Relative difference, %
2001	3,97	3,97	0,00	0,02
2002	5,06	5,06	0,00	0,05
2003	6,77	6,77	0,00	0,03
2004	8,84	8,84	0,00	0,03
2005	11,27	11,27	0,00	0,04
2006	14,09	14,09	0,00	0,03
2007	17,21	17,22	0,01	0,04
2008	21,20	21,21	0,01	0,03
2009	26,10	26,11	0,01	0,03
2010	32,66	32,67	0,01	0,03
2011	35,98	35,99	0,01	0,03

Potential emissions from refrigeration and air conditioning equipment (CRF 2.F.1)

As it was done recalculations for domestic and commercial refrigeration due to updated information provided by Statistics Lithuania and stock company, potential emissions from refrigeration and air conditioning equipment were changed too. Impact of these recalculations is demonstrated in table 4- 61 below.

Table 4-61. Reported in previous submission and recalculated potential fluorinated gases emissions (Gg CO_2 eqv.) from refrigeration and air conditioning equipment

Year	Previous submission	This submission	Absolute difference	Relative difference, %
1993	0,64	0,64	0,00	0,00
1994	0,95	0,95	0,00	0,00
1995	61,15	61,38	0,22	0,36
1996	10,43	10,46	0,03	0,28
1997	17,32	17,63	0,31	1,79
1998	24,94	24,81	-0,13	-0,52
1999	26,96	27,62	0,66	2,44
2000	31,10	31,68	0,58	1,87
2001	44,61	45,07	0,47	1,04
2002	57,38	57,91	0,53	0,92
2003	80,90	81,47	0,56	0,70
2004	130,49	131,13	0,64	0,49
2005	161,90	162,38	0,49	0,30
2006	209,34	209,98	0,64	0,31
2007	256,90	258,07	1,17	0,45
2008	264,46	266,10	1,63	0,62

2009	221,49	224,91	3,42	1,54
2010	263,80	265,91	2,11	0,80
2011	206,21	217,67	11,46	5,56

Transport refrigeration (CRF 2.IIA.F.1.3)

Emissions of HFC-134a from disposal of refrigerated freight wagons for the period 2009-2012 are reported for the first time, based on newly obtained data from AB Lietuvos geležinkeliai.

Industrial refrigeration (CRF 2.IIA.F.1.4)

No source-specific recalculations were done.

Stationary air-conditioning (CRF 2.IIA.F.1.5)

Emissions of HFC-32, HFC-125, HFC-134A and HFC-125 were recalculated for the 2011, based on the more accurate data acquired of installed heat pumps (information according to Study carried out by EurObser'ER in 2013).

Table 4-62. Reported in previous submission and recalculated fluorinated gas emissions from heat pumps, Gg CO_2 eqv.

Year	Previous submission	This submission	Absolute difference	Relative difference, %
2011	0,13	0,14	0,01	6,23

Mobile air-conditioning (CRF 2.IIA.F.1.6)

No source-specific recalculations were done.

Foam blowing (CRF 2.F.2)

No source-specific recalculations were done.

Fire extinguishers (CRF 2.F.3)

No source-specific recalculations were done.

Aerosols/ Metered Dose Inhalers (CRF 2.F.4)

No source-specific recalculations were done.

Semiconductor manufacture (CRF 2.F.7)

No source-specific recalculations were done.

Electrical equipment (CRF 2.F.8)

No source-specific recalculations were done.

Other (CRF 2.F.9)

No source-specific recalculations were done.

4.7.11 Source-specific planned improvements

The new EU Regulation on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006 is expected to come 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.

In early 2014 Ministry of Environment initiated a study on F-gases regulation review where necessary legislative, administrative, reporting system improvement measures to be proposed in order to effectively implement the requirements of the abovementioned Regulation. In the scope of this study also analysis of new F-gases (such as NF_3 etc.) use in Lithuania will be performed and methodological changes of Lithuania's F-gases emissions estimates applying IPCC 2006 Guidelines will be discussed.

5 SOLVENT AND OTHER PRODUCTS USE (CRF 3)

Solvent and other products use contribute a small amount to the total GHG emissions in Lithuania. Share to the total emission was only 0,4% in 2012 (excl. LULUCF). Indirect CO_2 emission from NMVOC for the following CRF categories was estimated:

- Paint application (CRF 3.A)
- Degreasing and dry cleaning (CRF 3.B)
- Other (CRF 3.D) (includes emissions from the use of N_2O for anaesthesia, emissions from use of glues and adhesives, graphic arts, domestic solvent use).

The inventory of NMVOC emissions from the solvent and other product 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.

5.1 Paint Application, Degreasing and Dry Cleaning, Other (CRF 3.A, 3.B & 3.D)

5.1.1 Source Category Description and Methodological issues

NMVOC emissions were calculated according to EMEP/CORINAIR methodology simpler approach based on per capita data for several source categories. Default per capita emission factors proposed in EMEP/CORINAIR guidebook were used, multiplying them by the number of inhabitants (Table 5-1).

Table 5-1. NMVOC emission factors

Sub-sectors	NMVOC emission factors, kg/cap/year
Paint application	4,50
Industrial degreasing	0,85
Dry cleaning	0,31
Graphic arts	0,65
Glues and adhesives	0,60
Domestic solvent use	1,80

Emissions were calculated using annual average population data provided by the Statistics Lithuania. It was assumed that the average carbon content is 85 percent by mass for all categories under sector of solvents and other products use. CO_2 emissions from solvent and other product use were calculated using the equation below.

$$\textit{Emission } CO_2 = \textit{Emission NMVOC} \times 0{,}85 \times 44/12$$

N_2O emissions from N_2O used in anaesthesia were estimated taking into account amount of N_2O sold in Lithuania. Following the 2006 IPCC Guidelines, it was assumed that 100% of N_2O sold for anaesthesia was emitted to the air, therefore activity data is equal to estimated emissions. The data 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. Other sources of N_2O emissions were not estimated. According to information gained from one of the leading N_2O selling company, the import of N_2O for non-medical use is negligibly small as compared to amounts sold for medical purposes.

CO_2, N_2O and NMVOC emissions (Gg) from solvents and other products use is presented in Table 5-2.

Table 5-2. CO_2, N_2O and NMVOC emissions (Gg) from solvents and other products use for the period 1990-2012

Year	CO_2 emission	NMVOC emission	N_2O emission
1990	100,42	32,22	0,31
1991	100,59	32,27	0,31
1992	100,48	32,24	0,30
1993	100,00	32,09	0,30
1994	99,31	31,87	0,29
1995	98,55	31,62	0,28
1996	97,80	31,38	0,28
1997	97,09	31,15	0,27
1998	96,38	30,93	0,27
1999	95,70	30,71	0,26
2000	95,03	30,49	0,25
2001	94,25	30,24	0,25
2002	93,50	30,00	0,24
2003	92,74	29,76	0,24
2004	91,71	29,42	0,23
2005	90,22	28,95	0,22
2006	88,80	28,49	0,13
2007	87,75	28,15	0,10
2008	86,85	27,87	0,01
2009	85,89	27,56	0,03
2010	84,11	26,99	0,01
2011	82,23	26,38	0,01
2012	81,13	26,03	0,01

5.1.2 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%.

5.1.3 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.

5.1.4 Source specific recalculation

The following recalculations were done:

- NMVOC and CO_2 emissions from Paint application, Industrial degreasing, Dry cleaning, Graphic arts, Glues and adhesives and Domestic solvent use were recalculated for the period 2001-2011 due to updated population data by Statistics Lithuania.

Table 5-3. CO_2 and NMVOC emissions recalculations, Gg

Year	Previous submission	This submission	Difference	Previous submission	This submission	Difference
	CO_2	CO_2		NMVOC	NMVOC	
2001	94,2	94,3	0,03	30,2	30,2	0,01
2002	93,4	93,5	0,06	30,0	30,0	0,02
2003	92,7	92,7	0,09	29,7	29,8	0,03
2004	91,6	91,7	0,13	29,4	29,4	0,04
2005	90,0	90,2	0,21	28,9	29,0	0,07
2006	88,5	88,8	0,27	28,4	28,5	0,09
2007	87,5	87,8	0,28	28,1	28,1	0,09
2008	86,6	86,9	0,24	27,8	27,9	0,08
2009	85,7	85,9	0,17	27,5	27,6	0,05
2010	84,0	84,1	0,07	27,0	27,0	0,02
2011	82,3	82,2	0,07	26,4	26,4	0,02

5.1.5 Planned improvements

No planned improvements are under the consideration.

6 AGRICULTURE (CRF 4)

6.1 Overview of the sector

Greenhouse gas (GHG) emissions from agriculture sector in Lithuania include: CH_4 emissions from enteric fermentation of domestic livestock; CH_4 and N_2O emissions from manure management; direct and indirect N_2O emissions from agricultural soils. Direct N_2O emissions from agricultural soils include emissions from synthetic fertilizers, manure applied to soils, biological nitrogen fixation of N-fixing crops, crop residues, cultivation of organic soils and sewage sludge application. Indirect N_2O emission sources include emissions from atmospheric deposition and from nitrogen leaching. Rice is not cultivated and savannas do not exist in Lithuania, therefore reported as "NO" in CRF tables. Field burning of agricultural residues is prohibited by the legislation[26] and reported as "NO". For agriculture sector twelve relevant categories were evaluated as the key categories (Table 6-1).

Table 6-1. Key category from Agriculture in 2012 by Level and Trend excluding LULUCF

IPCC source categoty	Gas	Identification criteria	Approach used
4.A Enteric Fermentation, cattle	CH_4	Level	Tier 1 / Tier 2
		Trend	Tier 1 / Tier 2
4.B Manure Management, cattle	CH_4	Level	Tier 1 / Tier 2
		-	-
4.B Manure Management, swine	CH_4	Level	Tier 1 / Tier 2
		Trend	Tier 1
4.B Manure Management	N_2O	Level	Tier 1 / Tier 2
		Trend	Tier 1 / Tier 2
4.D.1.1 Direct Soil Emissions Synthetic N fertilizers	N_2O	Level	Tier 1 / Tier 2
		Trend	Tier 1 / Tier 2
4.D.1.2 Direct Soil Emissions Manure fertilizers	N_2O	Level	Tier 1 / Tier 2
		Trend	Tier 2
4.D.1.4 Direct Soil Emissions Crop residues	N_2O	Level	Tier 1 / Tier 2
		Trend	Tier 1 / Tier 2
4.D.1.5 Direct Soil Emissions Cultivation of histosols	N_2O	Level	Tier 1 / Tier 2
		Trend	Tier 1 / Tier 2
4.D.2 Pasture, Range and Paddock Manure	N_2O	Level	Tier 1 / Tier 2
		Trend	Tier 2
4.D.3 Indirect Emissions	N_2O	Level	Tier 1 / Tier 2
		Trend	Tier 1 / Tier 2

Emissions were evaluated using methodology of *Revised 1996 IPCC Guidelines*, *IPCC Good Practice Guidance 2000* and *IPCC Guidelines for National Greenhouse Gas Inventories 2006*.

5059,98 Gg CO_2 eqv. of GHG emissions in Lithuania originated from agriculture sector in 2012. The major part of GHG emissions – 61,4%, is related to the agricultural soils (Figure 6-1).

[26] 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

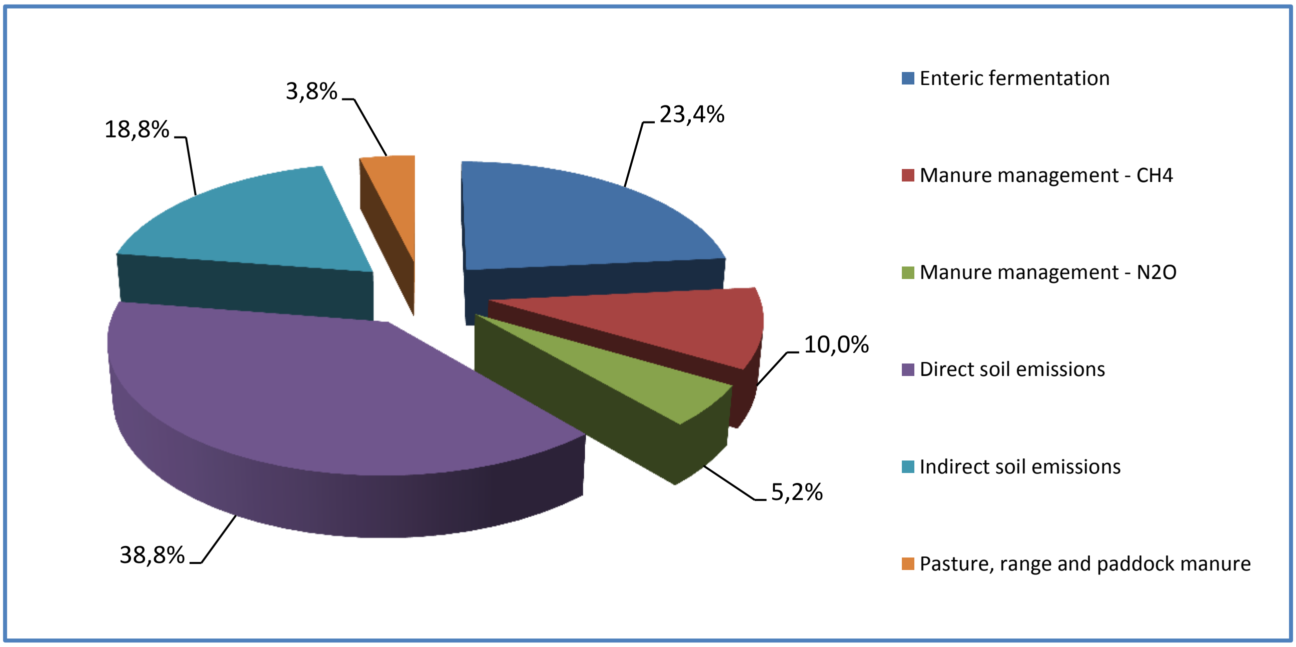

Figure 6-1. The share of aggregated emissions by categories from key sources within the sector in 2012, %

In 2012 N_2O emissions contributed 66,6% of the total GHG emission from the agriculture sector. The major part of CH_4 emissions from agriculture sector originates from digestive processes. This subsector constituted more than 70% of the total CH_4 emissions comprising from agriculture sector. From 1990 to 2012 emissions from agriculture sector have decreased by 50,8% (Figure 6-2, Table 6-2).

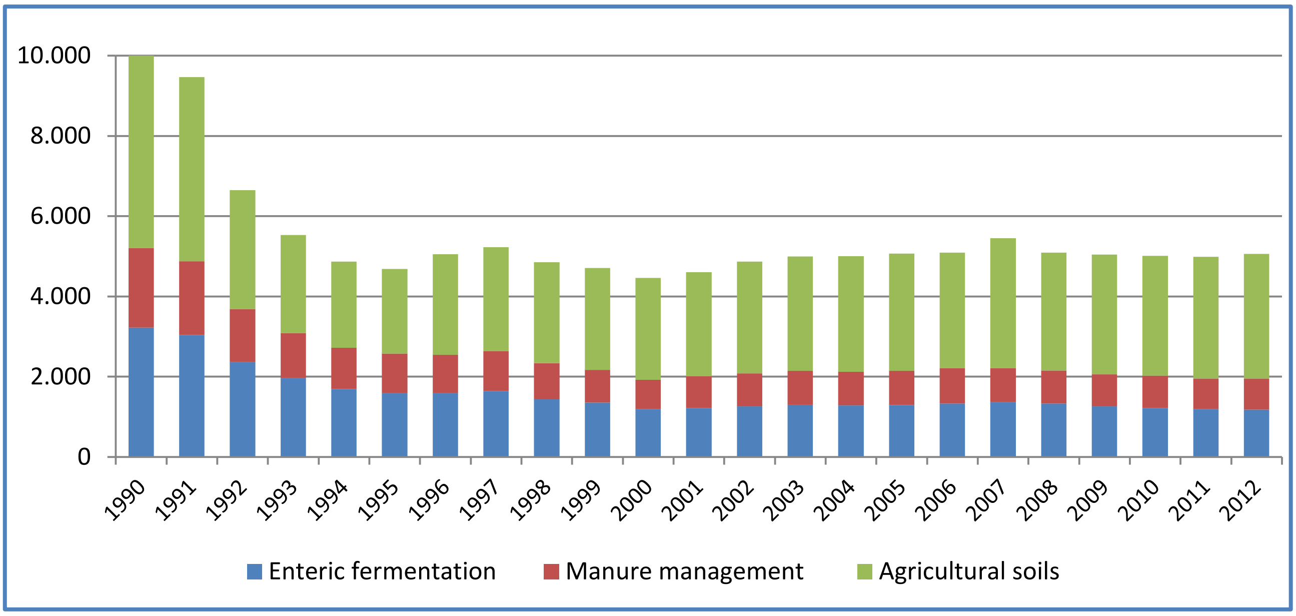

Figure 6-2. Aggregated emissions by categories within the agriculture sector during the period 1990-2012, Gg CO_2 eqv.

missions 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. Traditionally, Lithuania grew grain (wheat, rye, barley, and feed grains), potatoes, flax and sugar beets, developed dairy farming, meat production, and food processing. Crops accounted for one-third and livestock for two-thirds 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, to reestablish private ownership and management in the agriculture sector. The laws were provided for 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 smallholdings, averaging 8,8 ha in size, often not large enough to be economically viable.

Table 6-2. GHG emissions from agriculture sector by sources during the period 1990-2012, Gg CO_2 eqv.

Year	Enteric fermentation	Manure management		Agricultural soils			Total
				Direct	Pasture, range and paddock	Indirect	
	CH_4	CH_4	N_2O	N_2O	N_2O	N_2O	
1990	3226,5	1093,8	885,3	2702,3	493,2	1888,7	**10289,8**
1991	3041,6	1017,4	819,0	2458,1	465,0	1662,6	**9463,7**
1992	2372,0	709,2	607,1	1607,5	365,3	991,1	**6652,2**
1993	1974,4	619,9	495,7	1387,3	310,5	744,3	**5532,2**
1994	1693,1	604,1	421,4	1262,6	269,1	618,0	**4868,2**
1995	1592,1	598,8	390,3	1259,9	253,1	589,3	**4683,4**
1996	1592,4	567,7	383,4	1508,8	255,6	741,9	**5049,8**
1997	1641,6	607,2	392,3	1555,2	264,2	765,3	**5225,9**
1998	1440,3	560,8	340,4	1550,6	235,2	726,3	**4853,7**
1999	1355,2	499,9	317,0	1576,8	219,1	742,3	**4710,4**
2000	1193,9	453,6	280,2	1606,6	203,1	724,7	**4462,2**
2001	1221,4	503,4	283,4	1638,6	205,2	752,9	**4604,9**
2002	1259,8	534,0	291,9	1753,4	211,1	819,4	**4869,5**
2003	1302,5	544,3	303,4	1786,7	219,9	838,1	**4995,0**
2004	1284,9	539,6	299,8	1814,6	219,2	843,9	**5001,9**
2005	1289,8	555,0	304,6	1842,1	219,5	859,8	**5070,7**
2006	1331,9	564,0	312,2	1781,8	225,7	879,7	**5095,3**
2007	1362,8	532,4	313,3	2001,9	225,5	1013,3	**5449,3**
2008	1332,1	527,3	298,3	1826,2	218,1	891,7	**5093,7**
2009	1264,3	511,7	281,0	1870,7	206,5	908,4	**5042,6**
2010	1225,7	525,4	275,2	1858,0	199,4	930,5	**5014,3**
2011	1200,8	495,7	263,6	1898,3	194,7	933,9	**4986,8**
2012	1185,1	506,8	263,2	1963,7	191,4	949,8	**5060,0**

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 constantly increasing. In 1996-1997 dairy cattle productivity in the private farms was about 3296-3301 kg per cow and reached 3444 kg in 1998, but in 1999 felt down to 3223 kg and was lower than in agricultural companies and enterprises (3266 kg). The producer purchase prices of the 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 6-3. Data provided by Statistics Lithuania.

Table 6-3. Milk yield average per cow, kg

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Milk yield, kg	3734	3481	3080	2910	2925	3010	3093	3205
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Milk yield, kg	3384	3228	3673	3903	4003	4015	4176	4312
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	
Milk yield, kg	4484	4708	4778	4811	4901	5026	5227	

Climatic conditions

Lithuanian climate belongs to Atlantic forest area in the continental southwest region. Except the Baltic coastal region which is closer to climate of Western Europe and can be attributed to individual Southern Baltic climate region. More detailed information on climatic conditions and temperature is presented in the Introduction (see Section 1.1.1).

Precipitation

Average annual rainfall in 1991-2006 comparing with 1961-1990 in western and central part of Lithuania decreased by 12-56 mm, and in the South and the North-East part of Lithuania increased by 20-66 mm. In 2008 annual rainfall (697 mm) was close to the climatic standards of 1961-1990, which was 675 mm. 60-65% of the annual rainfall comes from April to October. Each summer very strong falls occur with 30 mm of rainfall per day. An average number of days with snow cover comparing the periods 1961-1990 and 1991-2006 decreased by 4-10 days. However, the maximum snow thickness increased by 0,8-2,0 cm. This relates to increasing precipitation in the cold period and more frequent snowfalls in the recent years.[27]

Year 2010 was particularly rainy – 849 mm which is 126 % of climatic normal. The most humid was warm period of the year. In 2011 summer rainfall significantly exceeded the average multi-annual rainfall: fell 347 mm – 155 % of climatic normal (climatic normal – 223 mm). Lithuania is an excess irrigation area with increasing recurrence of summer drought (year 1992, 1994, 2002, 2006). Due to the climate change, precipitation patterns in Lithuanian territory are changing differently – in some places it is increasing, elsewhere decreasing (however, these changes are not very large). But there is the tendency that precipitation is increasing in Lithuania during the cold season and decline in the warm season. The share of liquid precipitation in the cold period is increasing.[28]

[27] Lithuania's Fifth National Communication under the United Nations Framework Convention on Climate Change. Vilnius, January 2010

[28] Lithuania's Sixth National Communication under the United Nations Framework Convention on Climate Change. Vilnius, January 2014

6.2 Enteric fermentation (CRF 4.A)

6.2.1 Source category description

This chapter describes estimation of the CH_4 emissions from enteric fermentation. CH_4 emission from enteric fermentation of domestic livestock includes emissions from cattle (dairy cattle, 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. According to *Revised 1996 IPCC*[29], the relevant quantities are considered as negligible and are not calculated, however population of poultry is presented in Table 6-4 as it is used for calculations in subsector Manure management. Activity data have been obtained from Statistics Lithuania (agriculture section)[30] and from the register of Agricultural Information and Rural Business Centre (AIRBC)[31]. Animal population numbers used in the inventory are presented in Table 6-4. In general the number of dairy cattle in 2012 decreased by 61,2% comparing with 1990. In the same time non-dairy cattle population decreased by 75,2%, population of horses decreased by 63,1%, swine population – by 66,9%. The number of sheep population increased by 38,8%, goats - by 161,5%. Generally decline of the livestock population was caused by the changes in the economy due to collapse of the Soviet Union.

Table 6-4. Data on livestock population used in GHG inventory, thous. heads

Year	Dairy cattle	Non-dairy cattle	Sheep	Goats	Horses	Swine	Rabbits	Nutria	Fur-bearing animals	Poultry
1990	842,0	1479,5	56,5	5,2	79,9	2435,9	73,4	17,3	158,2	16815
1991	831,9	1364,7	58,1	6,3	82,6	2179,8	73,7	17,1	155,9	16994
1992	737,8	963,2	51,7	8,8	79,7	1359,8	83,5	13,3	146,1	8259
1993	678,1	706,2	45,0	10,4	81,3	1196,2	92,8	10,3	99,5	8728
1994	614,9	537,5	40,0	12,4	78,2	1259,8	88,0	10,0	94,7	8849
1995	586,0	479,1	32,3	14,6	77,6	1270,0	84,3	8,9	90,0	8444
1996	589,9	464,2	28,2	16,9	81,4	1127,6	93,9	7,1	93,4	7775
1997	615,3	452,7	24,0	18,5	78,5	1205,2	119,3	4,8	90,5	7423
1998	541,0	386,7	15,8	23,7	74,3	1167,7	102,5	3,5	45,6	6749
1999	494,3	403,5	13,8	24,7	74,9	936,1	85,4	2,2	41,8	6373
2000	438,4	309,9	11,5	23,0	68,4	867,6	82,3	2,2	44,8	5577
2001	441,8	309,9	12,3	23,7	64,5	1010,8	74,1	2,0	51,6	6576
2002	443,3	335,8	13,6	22,0	60,7	1061,0	74,6	1,6	60,5	6848
2003	448,1	364,0	16,9	27,2	63,6	1057,4	98,3	1,5	92,3	8067
2004	433,9	358,1	22,2	26,9	63,6	1073,3	96,6	1,4	131,5	8419
2005	416,5	383,8	29,2	22,0	62,6	1114,6	99,9	1,7	172,2	9397
2006	399,0	439,8	36,6	20,8	60,9	1127,1	103,5	2,9	172,7	9440
2007	398,0	436,1	52,0	19,7	55,9	923,2	102,1	1,7	161,0	9875
2008	393,6	379,4	53,7	16,6	54,4	897,1	103,5	1,3	175,2	9108
2009	371,9	359,2	54,2	14,7	49,0	928,2	107,5	1,3	120,1	9309
2010	354,7	353,0	55,8	16,0	44,7	929,4	103,5	1,4	175,7	9466
2011	342,8	355,2	60,2	15,0	36,4	790,3	98,1	0,3	193,1	8921
2012	326,3	366,3	78,4	13,6	29,5	807,5	99,5	0,6	305,1	9086

[29] *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*
[30] Statistics Lithuania. Available from: *http://www.stat.gov.lt/en/*
[31] State enterprise Agricultural Information and Rural Business Centre. Available from: *http://www.vic.lt/*

The population of sheep in the past few years increased due to promotion of farming in poorer lands. CH_4 emissions are primarily related to cattle, which, in 2012 contributed 95,8% of the total emission from enteric fermentation. In 2012 dairy cattle produced 63,3% and non-dairy cattle –32,4% of CH_4 emissions from enteric fermentation. The share of other livestock emissions to the total enteric fermentation emissions was small. Emission from swine made 1,5%, horses – 0,9%, sheep and goats – 1,6% of the total emission from enteric fermentation.

CH_4 emission from enteric fermentation comprised around 70% of the total CH_4 emission from livestock and 23,6 % of the total emissions from agriculture sector. In 2012, comparing with 2011, CH_4 emission from enteric fermentation decreased by 1,3%. During the period 1990-2012 CH_4 emission from enteric fermentation decreased by 63,3% (Table 6-5).

Table 6-5. CH_4 emissions from enteric fermentation by livestock categories during the period 1990-2012, Gg

Year	Cattle		Sheep	Goats	Horses	Swine	Rabbits, nutria and fur-bearing animals
	Dairy	Non-dairy					
1990	76,35	72,50	0,66	0,03	1,44	2,60	0,07
1991	73,37	66,88	0,68	0,03	1,49	2,33	0,07
1992	62,15	47,20	0,60	0,04	1,43	1,45	0,07
1993	56,01	34,61	0,54	0,05	1,46	1,28	0,07
1994	50,92	26,34	0,49	0,06	1,41	1,35	0,06
1995	49,06	23,48	0,39	0,07	1,40	1,36	0,06
1996	49,92	22,75	0,34	0,08	1,47	1,20	0,07
1997	52,79	22,19	0,30	0,09	1,41	1,30	0,08
1998	47,46	18,19	0,19	0,12	1,34	1,22	0,07
1999	42,65	19,18	0,16	0,12	1,35	1,02	0,06
2000	39,82	14,58	0,14	0,12	1,23	0,91	0,05
2001	41,07	14,54	0,14	0,12	1,16	1,07	0,05
2002	41,64	15,80	0,16	0,11	1,09	1,14	0,05
2003	42,29	17,07	0,19	0,14	1,14	1,12	0,07
2004	41,75	16,69	0,26	0,13	1,14	1,14	0,07
2005	40,60	18,00	0,34	0,11	1,13	1,16	0,08
2006	39,63	20,96	0,41	0,10	1,10	1,14	0,08
2007	40,55	21,66	0,55	0,10	1,01	0,96	0,08
2008	41,70	19,07	0,58	0,08	0,98	0,95	0,08
2009	39,51	18,15	0,59	0,07	0,88	0,92	0,08
2010	37,92	17,89	0,61	0,08	0,80	0,98	0,08
2011	36,98	17,89	0,66	0,07	0,65	0,84	0,08
2012	35,74	18,31	0,84	0,07	0,53	0,85	0,09

The overall reduction of CH_4 emission was caused by decrease in total number of livestock (excluding sheep, goats, rabbits and minks). In case of dairy cattle the attrition of animals was partly counterbalanced by an increase in productivity of animals resulting in higher emission per animal.

6.2.2 Methodological issues

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 with other livestock population. Cattle are a key source due to the contribution to the total greenhouse gas emissions. Therefore the Tier 2 method was used for estimation of CH_4 emissions from enteric fermentation of dairy and non-dairy cattle. Tier 2 method was also used for CH_4 emission estimation from enteric fermentation of sheep and swine (Table 6-6). For estimation of CH_4 emission from enteric fermentation of goats, horses, rabbits, nutria and fur-bearing animals (minks, foxes and polar foxes) the Tier 1 method was used.

Table 6-6. Methods and emission factors 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
Non-dairy cattle	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
Non-dairy cattle*	To 8 months	Bulls		Tier 2	CS
		Heifers		Tier 2	CS
	From 8 to12 months	Bulls		Tier 2	CS
		Heifers		Tier 2	CS
	From 1 to 2 years old	Bulls		Tier 2	CS
		Heifers		Tier 2	CS
	2 years old and older	Bulls		Tier 2	CS
		Heifers		Tier 2	CS
Sheep	Mature ewes and ewe lambs 1 and more years			Tier 2	CS
	Lambs to 12 months			Tier 2	CS
Sheep*	Mature sheep			Tier 2	CS
	Ewe lambs			Tier 2	CS
	Baa-lambs to 8 months			Tier 2	CS
	Rams			Tier 2	CS
Goats				Tier 1	IPCC
Horse				Tier 1	IPCC
Swine	Sows			Tier 2	CS
	Piglets < 2 months (< 20 kg)			Tier 2	CS
	Growing pigs (20-110 kg)			Tier 2	CS
	Pigs > 110 kg (8 months and >)			Tier 2	CS

	Boars	Tier 2	CS
	Gilts for breeding	Tier 2	CS
Rabbits		Tier 1	Russian emission factor
Nutria		Tier 1	Russian emission factor
Fur-bearing animals		Tier 1	Norwegian emission factor

** Since 2007 activity data was collected from the register of Agricultural Information and Rural Business Centre*

Characterisation of animal populations

CH_4 emission calculations are based on the number of livestock population. Data on livestock number is provided by the Register of Agricultural Information and Rural Business Centre (AIRBC) and Statistics Lithuania. During the period 1990-2006 the number of livestock was obtained from the database of Statistics Lithuania (as of 1st of January). Starting with 2007 data on the average annual number of cattle and sheep are provided by the AIRBC.

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. The Register on livestock of AIRBC in cooperation with The State Food and Veterinary Service implements animal registration and identification system, in which all the changes between the animal subcategories are registered every month. Therefore it is assumed that data on animal population in the Register is more accurate than data provided in the database of Statistics Lithuania.

In Lithuanian inventory livestock category "cattle" (CRF 4.A) consists of "dairy cattle" and "non-dairy cattle". Calculating CH_4 emissions "dairy cattle" are taken in general, not dividing in to smaller sub-categories.

"Non-dairy cattle" sub-category includes purebred and hybrid suckling cows used for meat production. For the period 1990-2006 sub-category "Non-dairy" cattle consists of 11 subcategories according to database of Statistics Lithuania:

- calves less than 1 year old for slaughter,
- bulls less than 1 year old for breeding,
- heifers less than 1 year old for breeding,
- bulls from 1 to 2 years old,
- heifers from 1 to 2 years old for slaughter,
- heifers from 1 to 2 years old for breeding,
- bulls 2 years old and older,
- heifers 2 years old and older for slaughter,
- heifers 2 years old and older for breeding,
- other cows.

For the period 1990-1996 not all information on relevant 11 sub-categories was available in the database of Statistics Lithunia. At that period the only available data was on division to such 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 subsequent years division to sub-categories.

For the period 2007-2012 sub-category of "Non-dairy cattle" consists of 9 relevant sub-categories from the Registy of AIRBC:

- suckling cows,
- bulls to 8 months,
- heifers to 8 months,
- bulls from 8 to 12 months,
- heifers from 8 to 12 months,
- bulls from 1 to 2 years old,
- heifers from 1 to 2 years old,
- bulls 2 years old and older,
- heifers 2 years old and older.

The total number of cattle is given in Table 6-4, the number of non-dairy cattle by sub-categories in Tables 6-7 and 6-8.

Table 6-7. The number of non-dairy cattle by sub-categories in Lithuania during the period 1990-2006, 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			Dairy cattle for slaughter
		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	-	164,6	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	-	105,5	15,0	92,1	70,0	19,4	82,1	17,3	7,3	36,5	7,7
1998	-	113,5	13,1	80,8	53,8	14,1	64,0	11,9	4,5	24,1	6,9
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

Table 6-8. The number of non-dairy cattle by sub-categories in Lithuania during the period 2007-2012, thous. heads

Year	Cattle sub-categories								
	Suckling cows	Cattle to 8 months		Cattle from 8 to12 months		Cattle from 1 to 2 years old		Cattle 2 years old and older	
		Bulls	Heifers	Bulls	Heifers	Bulls	Heifers	Bulls	Heifers
2007	12,3	53,0	70,5	26,4	36,9	58,1	104,5	16,6	45,6
2008	14,9	49,6	70,2	20,8	33,6	41,4	92,7	11,9	44,1
2009	16,9	46,0	64,4	20,5	33,4	39,0	89,6	9,9	39,5
2010	19,1	45,9	64,6	19,5	30,7	38,1	86,9	9,1	39,2
2011	21,4	46,3	68,1	19,3	32,4	37,9	86,4	7,3	36,2
2012	24,6	48,3	73,0	19,3	35,0	37,6	91,7	5,3	31,5

Other important parameter used in CH_4 emission calculation from enteric fermentation is average weight of cattle. Average weight of dairy cattle is required in order to calculate the gross energy intake during the period 1990-2008. The average weight of Lithuanian black-and-white and Lithuanian red dairy cattle, has been calculated on the basis of expert judgement; the average weight of the other breeds of dairy cattle has been calculated using the available literature sources. Data on the average weight of dairy cattle is presented in Table 6-9.

Table 6-9. The average weight of dairy cattle during the period 1990-2012, kg

Year	1990	1991	1992	1993	1994	1995	1996	1997
Weight, kg	575,0	575,9	576,8	577,7	578,6	579,5	580,5	581,4
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Weight, kg	582,3	583,2	584,1	585,0	585,9	586,8	587,7	588,6
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	
Weight, kg	589,5	590,5	591,4	592,3	593,2	594,1	595,0	

Average weight of non-dairy cattle is calculated in accordance with average weight of each non-dairy cattle sub-category proportionally to its number of population:

$$m_{average} = (\sum m_i * population_i)/population_{total}$$

where:
$m_{average}$ – average weight of non-dairy cattle, kg;
m_i – average weight of each non-dairy cattle sub-category (excluding mature cows and bulls over 2 years), kg/day;
$population_i$ – population of each non-dairy cattle sub-category (excluding mature cows and bulls over 2 years), thous. heads;
$population_{total}$ – total population of non-dairy cattle sub-category (excluding mature cows and bulls over 2 years), thous. heads.

Data on average weight of each non-dairy cattle sub-category was based on national references and expert judgment[32]. Data on average weight of non-dairy cattle is presented in Table 6-10 below.

[32] Gyvulininkystės žinynas. Baisogala, Institute of Animal Science of LVA, 2007

Table 6-10. The average weight of non-dairy cattle during the period 1990-2012, kg

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Weight, kg	331,0	331,0	331,0	331,0	331,0	331,0	331,0	331,0
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Weight, kg	312,0	315,3	312,3	312,2	313,4	314,1	312,1	313,6
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	
Weight, kg	319,3	319,3	322,4	323,9	326,2	321,7	316,3	

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:

$$w_{average} = (\sum w_i * population_i)/population_{total}$$

where:
$w_{average}$ – average weight gain of non-dairy cattle, kg/day;
w_i – average weight gain of each non-dairy cattle sub-category (excluding mature cows and bulls over 2 years), kg/day;
$population_i$ – population of each non-dairy cattle sub-category (excluding mature cows and bulls over 2 years), thous. heads;
$population_{total}$ – total population of non-dairy cattle sub-category (excluding mature cows and bulls over 2 years), thous. heads.

The average weight gain of non-dairy cattle for 2012 was estimated to be 0,7 kg/day.

The total number and number by sub-categories of swine used in 1990-2012 are presented in Tables 6-4 and 6-11. Information on swine population by sub-categories are obtained from the database of Statistics Lithuania.

Table 6-11. The number of swine by sub-categories in Lithuania during the period 1990-2012, thous. heads

Year	**Swine sub-categories**					
	Sows	**Piglets till 2 months (20 kg)**	**Growing pigs (20-110 kg)**	**Boars**	**Pigs > 8 months**	**Gilts for breeding**
1990	173,4	450,2	1564,7	8,1	186,8	52,8
1991	155,1	402,9	1400,2	7,3	167,1	47,2
1992	96,8	251,3	873,4	4,5	104,3	29,5
1993	85,1	221,1	768,4	4,0	91,7	25,9
1994	89,7	232,8	809,2	4,2	96,6	27,3
1995	90,4	234,7	815,8	4,2	97,4	27,5
1996	80,3	208,4	724,3	3,8	86,5	24,4
1997	92,2	220,5	759,5	4,5	94,6	33,8
1998	76,8	232,8	743,0	4,0	85,7	25,4
1999	63,2	159,4	608,2	3,9	79,8	21,6
2000	59,3	160,2	544,6	3,1	71,2	17,2
2001	73,7	188,5	653,1	3,6	69,7	22,2
2002	76,2	181,2	704,7	3,5	76,1	19,3
2003	78,6	194,3	691,4	2,2	75,3	15,6
2004	80,0	199,0	703,9	2,0	72,7	15,7

2005	82,4	222,0	720,4	1,9	71,5	16,4
2006	81,9	249,8	711,1	2,0	66,6	15,6
2007	62,3	191,5	578,0	1,3	70,7	19,3
2008	65,2	162,9	595,8	1,2	59,1	12,9
2009	67,9	229,0	559,5	1,4	55,0	15,4
2010	67,8	171,9	617,6	1,4	56,5	14,3
2011	53,1	138,6	528,2	1,1	54,1	15,2
2012	51,7	140,4	553,6	0,9	49,0	11,8

The average weight of swine is estimated based on the same methodology as for average weight of non-dairy cattle.

Table 6-12. The average weight of swine during the period 1990-2012, kg

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Weight, kg	70,3	70,3	70,3	70,3	70,3	70,3	70,3	70,7
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Weight, kg	68,3	71,7	69,9	69,5	70,3	71,4	70,8	69,4
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	
Weight, kg	67,7	67,8	68,8	67,0	67,9	68,3	66,7	

The total number and the number by sub-categories of sheep population for the period 1990-2012 is reported in Tables 6-4 and 6-13. For the period 1990-2006 the number of sheep was obtained form the database of Statistics Lithuania (as of 1st of January). For the period 2007-2012 the average annual number of sheep population by sub-categories is obtained from the Register of AIRBC.

The collection of data on population of sheep from different sources for the periods 1990-2006 and 2007-2012 is applied for the same reason as for the cattle.

The data basis of the Register of Agricultural Information and Rural Business Center provides data on mature sheep and other male and female sheep. In assumption that the birth rate of male and female lambs is almost equal and baa-lambs are kept up to 8 months old for meat while almost all of the ewe lambs are left for breeding, and there is 1 ram needed for the 25-30 ewes mating, the number of various age groups sheep was calculated. Population of sheep for the period 1990-2012 is presented in Table 6-13.

Table 6-13. The number of sheep by sub-categories in Lithuania during the period 1990-2012, thous. heads

Year	Sheep sub-category					
	Mature sheep and ewe over 1 years*	Lambs to1 years*	Mature sheep**	Ewe lambs**	Baa-lambs to 8 month**	Rams**
1990	36,2	20,3	-	-	-	-
1991	36,9	21,2	-	-	-	-
1992	32,7	19,0	-	-	-	-
1993	30,7	14,3	-	-	-	-
1994	27,4	12,6	-	-	-	-
1995	21,5	10,8	-	-	-	-
1996	19,6	8,6	-	-	-	-
1997	17,8	6,2	-	-	-	-
1998	10,6	5,2	-	-	-	-
1999	8,7	5,1	-	-	-	-
2000	7,5	4,0	-	-	-	-
2001	7,7	4,6	-	-	-	-
2002	8,4	5,2	-	-	-	-
2003	10,3	6,6	-	-	-	-
2004	14,4	7,7	-	-	-	-
2005	18,5	10,7	-	-	-	-
2006	21,6	15,0	-	-	-	-
2007	-	-	22,0	17,6	11,4	0,9
2008	-	-	23,4	18,2	11,2	0,9
2009	-	-	24,3	18,3	10,6	1,0
2010	-	-	25,0	19,4	10,3	1,0
2011	-	-	27,0	21,4	10,8	1,1
2012	-	-	33,0	28,8	15,4	1,3

* *Activity data was collected from the database of Statistics Lithuania*
** *Activity data was collected from the register of Agricultural Information and Rural Business Centre*

Calculation of CH_4 emission factors for cattle, swine and sheep

CH_4 emissions from enteric fermentation were calculated using the following equation[33]:

$$CH_4 \text{ emission} = EF \times Population / (10^6 \text{ kg/Gg})$$

where:
EF – emission factor for each animal category, kg/head/yr;
Population – the number of head in the defined livestock population.

National emission factors for dairy and non-dairy cattle were calculated in accordance with the Tier 2 methodology provided in *IPCC GPG 2000*[34]:

$$EF = (GE \times Ym \times 365 \text{ days/yr}) / 55.65 \text{ MJ/kg } CH_4$$

[33] *IPCC GPG 2000*. Agriculture. Eq. 4.12, p. 4.25
[34] *IPCC GPG 2000*. Agriculture. Eq. 4.14, p. 4.26

where:
EF – emission factor, kg CH_4/head/yr;
GE – gross energy intake of the sub-category, MJ/head/day;
Ym – methane conversion rate ((percentage of gross energy that is converted to methane) (assumed to be 6%)). CH_4 conversion factor for calves up to ten[35], lambs up to five[36] and piglets up to five-seven[37] days of age, consuming only milk was assumed to be zero.
To estimate the EF from dairy cattle in the period 1990-2006 gross energy (GE) was calculated using equation[38]:

$$GE = (NE_m + NE_a + NE_l + NE_p) / (NE_{ma}/DE) / (DE/100)$$

where:
NE_m – Net energy required by the animal for maintenance, MJ/head/day;
NE_a – Net energy for animal activity, MJ/head/day;
NE_l – Net energy for lactation, MJ/head/day;
NE_p – Net energy required for pregnancy, MJ/head/day;
NE_{ma}/DE – ratio of net energy available in a diet for maintenance to digestible energy consumed;
NE_{ga}/DE – ratio of net energy available for growth in a diet to digestible energy consumed;
DE – digestible energy expressed as a percentage of gross energy.

The main sources of activity data used in CH_4 emission factor calculation from dairy cattle were: weight, feeding situation, milk production, fat content of milk, percentage of pregnant females, and feed digestibility.

Feeding data in 1990-2007 was obtained from the tables reported by the *IPCC GPG 2000*, milk production and fat content of milk were obtained from statistical databases. During the time-period 2008-2012 to estimate the EF for dairy cattle gross energy was calculated on the basis of amount of feed which are fed for cattle[39]. Average milk yield per cow are given in Table 6-14.

Table 6-14. Average milk yield (kg/head/day) and fat content of milk (%) during the period 1990-2012

Year	Milk yield (kg/head/day)	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	8,44	4,13
2000	10,06	4,13
2001	10,69	4,08
2002	10,97	4,06
2003	11,00	4,11

[35] Gyvulininkystės žinynas. Baisogala, Institute of Animal Science of LVA, 2007, p.104
[36] Zapasnikienė, B. *Mitybos normos avims ir ožkoms*. 2 lentelė, p. 11
[37] Gyvulininkystės žinynas. Baisogala, Institute of Animal Science of LVA, 2007, p. 281
[38] *IPCC GPG 2000*. Agriculture. Eq. 4.11, p. 4.20
[39] Studija "Lietuvos mėšlo tvarkymo sistemose susidarančių metano ir azoto suboksido kiekio tyrimai ir įvertinimas". 2012

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

To estimate the EF from dairy cattle in the period 2008-2012 and non-dairy cattle in the period 1990-2012 gross energy of feed was calculated using equation[40]:

$$Gross\ energy\ (MJ/kg\ feed) = 0.0239 \times CP + 0.0398 \times C_{Fat} + 0.0201 \times C_{Fibre} + 0.0175 \times NFE$$

where:
CP – crude protein, g/kg in dry matter;
C_{Fat} – crude fat, g/kg in dry matter;
C_{Fibre} – crude fibre, g/kg in dry matter;
NFE – nitrogen-free extracts, g/kg in dry matter.
GE (MJ/head/day) was estimated by multiplying GE per kg of every feed from amount of the necessary feed in dry matter, then making GE sums and calculating the amount per day:

$$GE_{(MJ/head/day)} = GE_{(MJ/kg\ feed)} \times (F_{quantity} \times dry\ matter/kg\ feed) / 365$$

where:
$GE_{(MJ/kg\ feed)}$ – the amount of gross energy, MJ/kg feed;
$F_{quantity}$ x dry matter/kg feed – the amount of forage, necessary during a year, kg (counting as dry matter).

The average daily feed intake for each subcategory of non-dairy cattle was calculated on the basis of feed accumulation standards indicated in the national reference book of livestock production[41]. according to national zoo-technical activity data –-weight and weight gain.

Most frequently used feedstuffs were included in calculation, namely, hay from cultivated meadows and pastures with different nutritive values, also clover and cereal grass hay, straw from different crops, cultivated meadow grass and silage from maize and perennial wilted grass, root-crops, grass from cultivated meadows and pastures with different nutritive values, also leguminous green feeds, concentrates with respect to the composition of every different type of feed, milk and milk replacers. Average diet nutrition indicators for dairy cattle used to calculate gross energy are presented in Table 6-15.

Table 6-15. Average diet nutrition indicators for dairy cattle used to calculate gross energy during the period 2008-2012, MJ

	2008	**2009**	**2010**	**2011**	**2012**
during the lactation period					
crude protein	2166,3	2173,9	2189,5	2212,0	2251,9
crude fat	451,9	453,4	456,7	461,0	469,7
crude fibre	3744,8	3757,7	3784,7	3823,8	3892,7

[40] Kulpys H., Šeškevičienė J., Jeroch H. *Žemės ūkio gyvulių ir paukščių mitybos fiziologinės reikmės*. Kaunas, 2004, p. 30
[41] Gyvulininkystės žinynas. Baisogala, Institute of Animal Science of LVA, 2007, p. 616

nitrogen-free extracts	7588,8	7615,1	7670,1	7748,8	7888,4
during the dry period					
crude protein	1727,5				
crude fat	380,3				
crude fibre	3318,4				
nitrogen-free extracts	5807,2				

Average gross energy intake for dairy cattle are presented in Table 6-16.

Table 6-16. Calculated average gross energy intake for dairy cattle during the period 1990-2012, MJ/head/day

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
GE	230,4	224,1	214,1	209,9	210,4	212,7	215,0	218,0
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
GE	222,9	219,3	230,8	236,2	238,7	239,8	244,5	247,7
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	
GE	252,4	258,9	269,2	270,0	271,7	274,1	278,4	

Average diet nutrition indicators for dairy cattle used to calculate gross energy are presented in Table 6-17.

Table 6-17. Average diet nutrition indicators for non-dairy cattle used to calculate gross energy, MJ

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Crude protein	1028,8	1028,8	1028,8	1028,8	1028,8	1028,8	1028,8	1028,8
Crude fat	236,4	236,4	236,4	236,4	236,4	236,4	236,4	236,4
crude fibre	1711,3	1711,3	1711,3	1711,3	1711,3	1711,3	1711,3	1711,3
Nitrogen-free extracts	3271,0	3271,0	3271,0	3271,0	3271,0	3271,0	3271,0	3271,0
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Crude protein	997,0	1005,3	994,4	991,7	991,7	987,2	981,5	985,3
Crude fat	231,3	232,8	231,0	230,2	230,4	229,5	228,5	229,4
Crude fibre	1630,5	1643,4	1636,1	1635,2	1648,6	1647,6	1638,4	1647,9
Nitrogen-free extracts	3143,1	3181,7	3139,9	3130,2	3130,6	3118,8	3097,9	3122,3
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	
Crude protein	994,8	984,3	994,2	997,3	998,7	990,9	979,3	
Crude fat	231,4	227,8	231,5	232,3	232,8	231,9	230,4	
Crude fibre	1684,2	1789,5	1809,5	1828,7	1833,1	1824,1	1816,1	
Nitrogen-free extracts	3169,1	3326,4	3371,9	3383,6	3397,5	3375,1	3340,6	

Average gross energy intake for non-dairy cattle subcategories are given in Tables 6-18 and 6-19.

Table 6-18. Calculated average gross energy intake for non-dairy cattle subcategories in 1990-2006, 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	131,4
	Heifers for breeding	137,3
Cattle 2 years old and older	Bulls	177,3
	Heifers for slaughter	171,2
	Heifers for breeding	171,2
Dairy cattle for slaughter		192,6

Table 6-19. Calculated average gross energy intake for non-dairy cattle subcategories in 2007-2012, MJ/head/day

Cattle sub-categories		Gross Energy
Suckling cows		221,4
Cattle to 8 months	Bulls	84,2
	Heifers	70,4
Cattle from 8 to12 months	Bulls	134,9
	Heifers	106,2
Cattle from 1 to 2 years old	Bulls	181,5
	Heifers	137,3
Cattle 2 years old and older	Bulls	177,3
	Heifers	171,2

Pasture-cowshed time estimations are based on the data of the national zoo-technical activity data[42,43].

Values of CH_4 emission factors estimated for enteric fermentetion of dairy cattle using country specific data and Tier 2 method are presented in Table 6-20.

Table 6-20. Calculated emission factors used for calculation of CH_4 emission from enteric fermentation of dairy cattle during the period 1990-2012, kg CH_4/head/year

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
EF	90,68	88,20	84,24	82,59	82,81	83,72	84,62	85,81
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
EF	87,73	86,29	90,84	92,96	93,92	94,37	96,21	97,48
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	
EF	99,33	101,89	105,93	106,25	106,91	107,86	109,54	

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 6-3).

[42] Gyvulininkystės žinynas. Mokslas, Vilnius, 1976, p. 98-99
[43] Tarvydas V. ir kt. *Šėrimo normos, pašarų struktūra ir sukaupimas galvijams*, Vilnius, 1995, p. 4

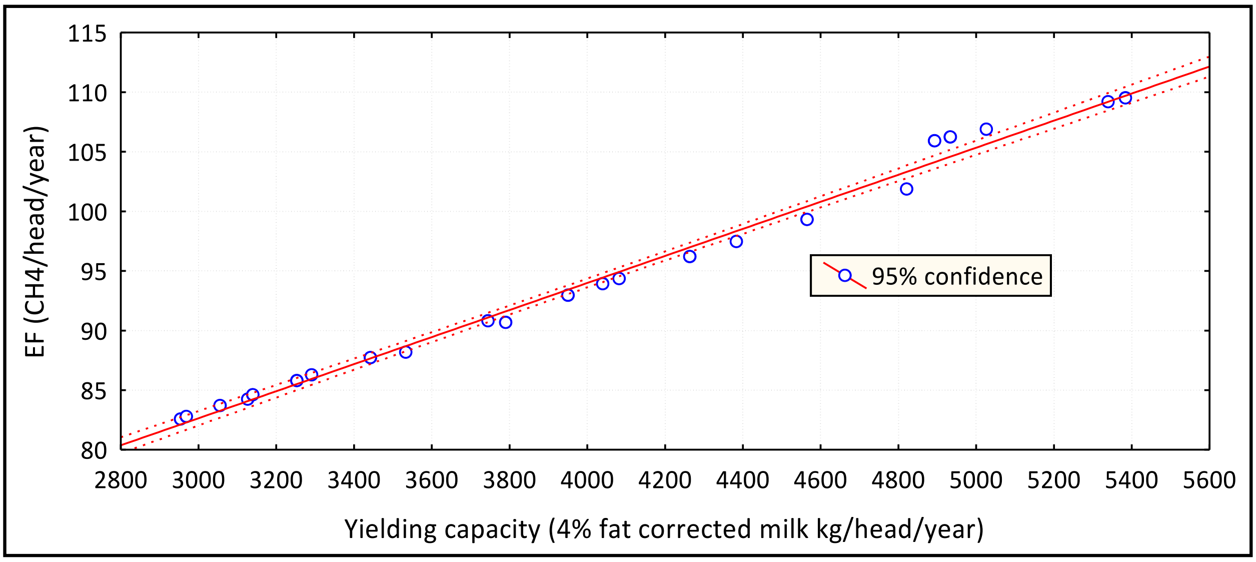

Figure 6-3. Correlation between yielding capacity (4% fat corrected milk, kg/head/year) and EF (CH_4/head/year) in 1990-2012

EF of CH_4 during the period 1990-1993 has decreased due to the reduced productivity of dairy cattle. In time period 1994-1998 EF has increased but 1999 EF has decreased again as productivity of milk per head has decreased. Estimated emission factors of the relevant sub-categories of non-dairy cattle are presented in Tables 6-21 and 6-22.

Table 6-21. Calculated emission factors used for calculation of CH_4 emission from enteric fermentation of non-dairy cattle sub-categories during the period 1990-2006, kg CH_4/head/year

Cattle sub-categories		Emission Factor
Suckling cows		87,13
Cattle less than 1 year old	For slaughter	34,75
	Bulls for breeding	38,43
	Heifers for breeding	30,08
Cattle from1 to 2 years old	Bulls	71,43
	Heifers for slaughter	51,71
	Heifers for breeding	54,03
Cattle 2 years old and older	Bulls	69,75
	Heifers for slaughter	67,37
	Heifers for breeding	67,37
Dairy cattle for slaughter		75,79

Table 6-22. Calculated emission factors used for calculation of CH_4 emission from enteric fermentation of non-dairy cattle sub-categories during the period 2007-2012, kg CH_4 /head/year

Non-dairy cattle sub-categories		Emission Factor
Suckling cows		87,10
Cattle to 8 months	Bulls	32,23
	Heifers	26,95
Cattle from 8 to 12 months	Bulls	53,09
	Heifers	41,79
Cattle from 1 to 2 years old	Bulls	71,43
	Heifers	54,03
Cattle 2 years old and older	Bulls	69,75
	Heifers	67,37

Calculated emission factors for non-dairy cattle vary across the years due to the changes in allocation of subcategories, population size and feed consumption (Table 6-23).

Table 6-23. Calculated emission factors used for calculation of CH_4 emission from enteric fermentation of non-dairy cattle during the period 1990-2012, kg CH_4/head/year

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
EF	49,00	49,00	49,00	49,00	49,00	49,00	49,00	49,00
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
EF	47,04	47,52	47,05	46,93	47,05	46,91	46,62	46,91
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	
EF	47,66	49,66	50,26	50,54	50,68	50,36	49,98	

Calculating emission factors used for calculation of CH_4 emission from enteric fermentation of non-dairy cattle it was determined that weaning age of calves is up to ten days [44]. At this age they are nourished by milk only and CH_4 conversion factor was assumed to be zero.

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. Most frequently used feedstuffs also were used for calculations: barley, wheat, triticale, dried pulses, rapeseed cake, soybean meal, milk replacers, fish meal and oil.

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 6-24.

Table 6-24. Average diet nutrition indicators for swine used to calculate gross energy, g/day

	In average			
	crude protein	**crude fat**	**crude fibre**	**nitrogen-free extracts**
Sows	387,46	117,29	175,43	1513,52
Piglets	38,77	10,61	6,42	113,39
Growing pigs	245,21	64,89	83,66	1090,08
Boars	365,69	83,05	172,61	1367,21
Pigs >8 month	428,70	104,35	131,92	1725,64
Pigs for breed	428,70	82,50	131,92	1725,64

Calculated average gross energy intakes and emission factors in relevant sub-category of swine are given in Table 6-25.

Table 6-25. Calculated average gross energy intake (MJ/head/day) and emission factors (kg CH_4/head/year) used for calculation of CH_4 emission from enteric fermentation of swine during the period 1990-2012

Swine sub-category	**GE (MJ/head/day)**	**EF (kg CH_4/head/year)**
Sows	43,9	1,73
Piglets <2 month (<20 kg)	3,5	0,14
Growing pigs (20-110 kg)	29,2	1,15
Pigs > 110 kg (8 month and>)	47,3	1,86

[44] Gyvulininkystės žinynas. Baisogala, Institute of Animal Science of LVA, 2007, p.104

Gilts for breeding	46,4	1,93
Boars	39,4	1,55

Calculated average gross energy and emission factors for swine are presented in Table 6-26.

Table 6-26. Calculated average gross energy intake (MJ/head/day) and emission factors of CH_4 emission from enteric fermentation of swine (kg CH_4/head year) during the period 1990-2012

Year	GE	EF
1990	27,28	1,07
1991	27,28	1,07
1992	27,28	1,07
1993	27,28	1,07
1994	27,28	1,07
1995	27,28	1,07
1996	27,28	1,07
1997	27,56	1,08
1998	26,77	1,05
1999	27,79	1,09
2000	27,29	1,05
2001	27,13	1,06
2002	27,50	1,08
2003	27,13	1,06
2004	27,02	1,06
2005	26,59	1,04
2006	25,89	1,01
2007	26,61	1,04
2008	27,05	1,06
2009	25,30	0,99
2010	26,89	1,05
2011	27,26	1,07
2012	27,03	1,06

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 [45]. 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 years due to the changes of allocation of sub-categories, population and feed consumption.

Determining CH_4 emission from sheep, gross energy was calculated using the same methodology as for cattle, based on the feed accumulation standards.

Calculated average gross energy intakes for sheep are presented in Tables 6-27 and 6-28. Calculated emission factors for sheep sub-categories are given in Tables 6-29 and 6-30.

[45] Gyvulininkystės žinynas. Baisogala, Institute of Animal Science of LVA, 2007, p. 281

Table 6-27. Calculated gross energy intake for sheep sub-categories during the period 1990-2006, MJ/head/day

Mature sheep and ewe over 1 year	Lambs to 1 year
32,79	14,87

Table 6-28. Calculated gross energy intake for sheep sub-categories during the period 2007-2012, MJ/head/day

Mature sheep	Ewe lambs for breeding	Baa-lambs to 8 months	Rams
34,66	21,82	11,93	36,44

Equation 4.14 from *IPCC GPG 2000* assumes an emission factor for the period of 365 days.

The life span of baa-lambs is shorter than 1 year and in most cases they are slaughtered after 8 months. Therefore CH_4 emission factors for baa-lamb sub-category in 2007-2012 was calculated for 240 days period .

Table 6-29. Calculated emission factors for sheep sub-categories during the period 1990-2006, kg CH_4/head/year

Mature sheep and ewe over 1 year	Lambs to 1 year
15,05	5,77

Table 6-30. Calculated emission factors for sheep sub-categories during the period 2007-2012, kg CH_4/head/year

Mature sheep	Ewe lambs for breeding	Baa-lambs to 8 months	Rams
15,91	8,59	3,09	16,73

Calculated average gross energy intake and average emission factors of CH_4 emission from enteric fermentation of sheep are given in Table 6-31.

Table 6-31. Calculated average gross energy intake (MJ/head/day) and emission factors of CH_4 emission from enteric fermentation of sheep (kg CH_4/head year) during the period 1990-2012

Year	GE (MJ/head/day)	EF (kg CH4/head/year)
1990	26,35	11,72
1991	26,25	11,67
1992	26,20	11,64
1993	27,10	12,10
1994	27,15	12,13
1995	26,80	11,95
1996	27,33	12,22
1997	28,15	12,65
1998	26,89	12,00
1999	26,17	11,62
2000	26,56	11,83
2001	26,09	11,58
2002	25,94	11,51
2003	25,79	11,43

2004	26,56	11,83
2005	26,21	11,65
2006	25,43	11,24
2007	25,33	10,58
2008	25,59	10,73
2009	25,91	10,91
2010	26,02	10,97
2011	26,06	11,00
2012	25,52	10,69

Calculating emission factors used for calculation of CH_4 emission from enteric fermentation of sheep it was determined that weaning age of lambs is up to five[46] days. At this age they are nourished by milk only and CH_4 conversion factor was assumed to be zero.

Calculated emission factors for sheep vary across the time period due to the changes of allocation of sub-categories in population and feed consumption.

Calculation of CH_4 emission factors from other animals

Comparing with cattle contribution of other livestock to the whole CH_4 emission from enteric fermentation is much smaller, therefore, CH_4 emission from enteric fermentation of goats and horses are estimated using Tier 1 method. Considering the rather small numbers of these animals the default emission factors pursuant to *Revised 1996 IPCC Guidelines*[47] were used. As no default IPCC or national emission factors for fur-bearing animals, rabbits and nutria are available, the Norwegian[48] emission factor for fur-bearing animals and Russian[49] emission factors for rabbits and nutria were used in calculations (Table 6-32).

Table 6-32. Default emission factors for each animal category used for calculation of CH_4 emission from enteric fermentation, kg CH_4/head/year

Animal category	EF (kg CH_4 / head /year)	Emission factor
Goat	5,0	IPCC default
Horse	18,0	IPCC default
Rabbits	0,59	Russian emission factor
Nutria	0,35	Russian emission factor
Fur-bearing animals	0,1	Norwegian emission factor

6.2.3 Uncertainties and time-series consistency

Uncertainties of CH_4 emissions from enteric fermentation are caused by the uncertainty of number of animals, weight of animals and emission factors uncertainty.

Activity data uncertainty

For the period 1990-2012 activity data, excluding data on number of cattle and sheep (this data since 2007 is being collected from the Register of AIRBC), was collected from Statistics Lithuania.

[46] Zapasnikienė, B. *Mitybos normos avims ir ožkoms*. 2 lentelė, p. 11
[47] *Revised 1996 IPCC*. Workbook. Vol. 2, Agriculture, Table 4-2, p. 4.3
[48] Greenhouse gas emission in Norway 1990-2011, National inventory report, 2013, p. 238, Table 6.3
[49] Национальный доклад о кадастре антропогенных выбросов из источников и абсорбции поглотителями парниковых газов не регулируемых Монреальским протоколом за 1990-2011 гг. Москва, 2013. Часть 1, С. 175, Таблица 6.5

Data provided by Statistics Lithuania is collected by applying continuous accountability for agriculture companies and applying sampling methods for farmers and households. The object of research is about 10 000 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 thous. heads, or if the population of cattle is smaller than 500 thous. heads, 5% accuracy requirements are applied according to the regulation of the European Community No. 1165/2008 on the data accuracy requirements.

Since becoming a member state of the European Union the registration and marking of animals with ear pins and individual ID numbers is obligatory in Lithuania. Therefore, for the last years (2007-2012) the data on number of cattle and sheep are obtained from the register of AIRBC. The precision of calculated emissions is influenced by the fact that it is impossible to divide the dairy cattle into sub-category. The weight of cattle for meat and their weight gain is established only in accordance with conclusions of experts and the indices of registers, therefore the data can be more uncertain as it is based on expert judgement.

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 for the 1990-1996 period estimates.

Overall uncertainty for activity data for enteric fermentation is assumed to be ±3%.

Emission factors uncertainty

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 ±50%[50],[51]. Emission factors estimated using the Tier 2 method are likely to be in the order of ±20%[52].

In order to increase the herd of sheep almost all ewe-lambs are grown for breed. However, since part of the ewe-lambs are slaughtered for meet, uncertainty of emission factors may be up to ±4%.

6.2.4 Source-specific QA/QC and verification

General QC procedures were applied for estimates from enteric fermentation. Furthermore, emission factors were compared with IPCC defaults and with emission factors of neighbouring countries. (Tables 6-33, 6-34 and 6-35).

Comparing results obtained in 2011 it can be seen that CH_4 emission factor from enteric fermentation of dairy cattle category is approximately comparable to Belarus EFs (Table 6-33). Estonia and Latvia showed higher emission factors, however Estonia also showed higher productivity of cattle.

[50] *IPCC GPG 2000.* Agriculture, p. 4.27
[51] *IPCC Guidelines 2006*. Emissions from livestock and manure management, p. 10.33
[52] *IPCC GPG 2000.* Agriculture, p. 4.28

Table 6-33. Comparison of EF and other parameter for CH_4 emission calculation from enteric fermentation of dairy cattle

Country	EF (kg CH_4/head/year)	Milk yield (kg/head/day)	Average weight (kg)	Average GE intake (MJ/head/day)
Belarus	107,26	12,28	550	272,56
Estonia	128,28	19,64	547,36	327,18
Latvia	117,82	13,87	550	299,40
Lithuania (in 2012)	109,54	14,32	595,00	278,36
Poland	98,79	13,04	500	251,05
Revised 1996 IPCC[53] (Western Europe)	100	11,51	550	254,7

Emission factor of non-dairy cattle in Lithuanian is similar to the corresponding EF results for Belarus, Latvia and Poland (Table 6-34). Besides, those countries indicated similar gross energy intake as well. Also Belarus and Poland indicates similar average weight of animals of non-dairy cattle sub-category.

Table 6-34. Comparison of EF and other parameter for CH_4 emission calculation from enteric fermentation of non-dairy cattle

Country	EF (kg CH_4/head/year)	Average weight (kg)	Average gross energy intake (MJ/head/day)
Belarus	51,40	313,65	130,60
Latvia	52,16	500	132,54
Lithuania (in 2012)	49,98	316,28	127,69
Poland	49,55	321,63	125,90
Revised 1996 IPCC[54] (Western Europe)	48	-	-

The level of Lithuanian emission factor for swine is higher than corresponding results of Estonia and lower than Denmark and Germany (Table 6-35). Estonia also indicated lower gross energy intake and lower average weight of swine. However Denmark indicated considerably high gross energy intake and high average weight of swine. The level of German emission factor for swine is considerably higher than corresponding factor of Lithuania while weight and gross energy of swine is slightly higher. Belarus, Latvia and Poland used IPCC default emission factor.

Table 6-35. Comparison of EF and other parameter for CH_4 emission calculation from enteric fermentation of swine

Country	EF (kg CH_4/head/year)	Average weight (kg)	Average gross energy intake (MJ/head/day)
Belarus	1,5	NA	NE
Denmark	1,11	107,0	40,41
Estonia	0,99	44,54	25,11
Germany	1,17	68,95	29,65
Latvia	1,50	NA	NA
Lithuania (in 2012)	1,06	66,71	27,03

[53] *Revised 1996 IPCC*. Agriculture. Reference manual. Vol. 1.Table 4-4, p. 4.11; Vol. 2. Table A-1, p. 4.31; Table B-1, p. 4.39
[54] *Revised 1996 IPCC*. Agriculture. Reference manual. Vol. 1. Table 4-4, p. 4.11

Poland	1,50	82	NA
Revised 1996 IPCC[55] (developed countries)	1,5	-	-

6.2.5 Source-specific recalculations

In order to increase consistency of used methodologies for calculation of emission from enteric fermentation, the following recalculations have been made during this submission:

- Gross energy intake for dairy cattle for the period 1991-2012 was recalculated due to recalculation of weight of dairy cattle (Table 6-36).
- Emission from sheep for 2011 were recalculated due to correction of CH_4 emission factors for baa-lambs.

The changes of CH_4 emission factors and emissions from enteric fermentation are given in Tables 6-36 and 6-37.

Table 6-36. Comparison of calculated gross energy (MJ/head/day) and CH_4 emission factors (kg CH_4/head/year) from enteric fermentation for dairy cattle in previous and in this submission

Year	Previous submission		This submission		Relative difference, %
	Gross energy (MJ/head/day)	CH_4 emission factors (kg CH_4/head/year)	Gross energy (MJ/head/day)	CH_4 emission factors (kg CH_4/head/year)	
1990	230,42	90,68	230,42	90,68	0,00
1991	223,96	88,14	224,12	88,20	0,07
1992	213,73	84,11	214,05	84,24	0,15
1993	209,39	82,40	209,87	82,59	0,23
1994	209,78	82,55	210,42	82,81	0,31
1995	211,95	83,41	212,75	83,72	0,38
1996	214,06	84,24	215,02	84,62	0,45
1997	216,92	85,36	218,04	85,81	0,52
1998	221,65	87,23	222,93	87,73	0,58
1999	217,82	85,72	219,26	86,29	0,66
2000	229,22	90,21	230,82	90,84	0,70
2001	234,47	92,27	236,23	92,96	0,75
2002	236,75	93,17	238,67	93,92	0,81
2003	237,72	93,55	239,79	94,37	0,87
2004	242,24	95,33	244,48	96,21	0,92
2005	245,30	96,53	247,70	97,48	0,98
2006	249,84	98,32	252,40	99,33	1,02
2007	256,19	100,82	258,91	101,89	1,06
2008	260,73	102,61	269,19	105,93	3,24
2009	261,50	102,91	269,99	106,25	3,25
2010	263,11	103,54	271,68	106,91	3,25
2011	268,71	105,75	274,08	107,86	3,28

[55] *Revised 1996 IPCC*. Agriculture. Reference manual. Vol. 1. Table 4-3, p. 4.10

Table 6-37. Reported in previous submission and recalculated CH_4 emissions from enteric fermentation during the period 1990-2011, Gg

Year	Previous submission	This submission	Absolute difference	Relative difference, %
1990	153,65	153,65	0,00	0,00
1991	144,79	144,84	0,05	0,03
1992	112,86	112,95	0,09	0,08
1993	93,89	94,02	0,13	0,14
1994	80,47	80,62	0,15	0,19
1995	75,63	75,81	0,18	0,24
1996	75,61	75,83	0,22	0,29
1997	77,90	78,17	0,27	0,35
1998	68,31	68,59	0,28	0,41
1999	64,25	64,53	0,28	0,44
2000	56,58	56,85	0,27	0,48
2001	57,86	58,16	0,30	0,52
2002	59,66	59,99	0,33	0,55
2003	61,66	62,03	0,37	0,60
2004	60,80	61,19	0,39	0,64
2005	61,03	61,42	0,39	0,64
2006	63,02	63,43	0,41	0,65
2007	64,47	64,90	0,43	0,67
2008	62,12	63,43	1,31	2,11
2009	58,96	60,20	1,24	2,10
2010	57,17	58,37	1,20	2,10
2011	56,46	57,65	1,19	2,11

6.2.6 Source-specific planned improvements

The collection of more accurate data on cattle weight are planned.

6.3 Manure management (CRF 4.B)

6.3.1 Manure management - CH_4 emission (CRF 4.B(a))

6.3.1.1 Source 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. Lithuania's climate conditions are described in Section 1.1.1.

Calculations of GHG emission from manure management were performed using the same livestock population data as described in section "Enteric fermentation" (see Section 6.2). The information on manure management systems have been provided by the Water Research Institute of the University of Agriculture of the Republic of Lithuania, also data of manure management systems use in Lithuania were collected during the experts investigation.

Calculated emissions

Total CH_4 emissions from manure management of domestic livestock contributed 10,1% of the total agricultural emissions or 30,0% of the total CH_4 emissions in 2012. In 2012, comparing with 2011, CH_4 emissions from manure management increased by 2,2%. In 2012 the highest CH_4 emission from manure management systems among different categories of domestic animals was determined in swine breeding category (Table 6-38). The use of anaerobic digester for biogas-treatment in 2004-2011 slightly reduced CH_4 emissions. In 2012 the biogas treatment plant has stopped operating.

Table 6-38. CH_4 emission from manure management by animal category during the period 1990-2012, Gg

Year	Dairy cattle	Non-dairy cattle	Sheep	Goats	Horses	Swine	Poultry	Fur-bearing animals, rabbits and nutria
1990	11,05	9,17	0,014	0,001	0,11	30,30	1,31	0,125
1991	10,90	8,71	0,014	0,001	0,11	27,25	1,33	0,124
1992	9,47	6,33	0,013	0,001	0,11	17,09	0,64	0,115
1993	8,75	4,77	0,011	0,001	0,11	15,11	0,68	0,082
1994	8,16	3,73	0,010	0,001	0,11	15,99	0,69	0,078
1995	8,05	3,42	0,008	0,002	0,11	16,20	0,66	0,074
1996	8,38	3,40	0,007	0,002	0,11	14,45	0,61	0,076
1997	9,07	3,40	0,006	0,002	0,11	15,68	0,58	0,074
1998	8,34	2,86	0,004	0,003	0,10	14,83	0,53	0,042
1999	7,66	3,10	0,003	0,003	0,10	12,40	0,50	0,037
2000	7,30	2,39	0,003	0,003	0,10	11,34	0,43	0,039
2001	7,69	2,43	0,003	0,003	0,09	13,20	0,51	0,042
2002	7,96	2,69	0,003	0,003	0,08	14,11	0,53	0,048
2003	8,24	2,94	0,004	0,003	0,09	13,94	0,63	0,072
2004	8,30	2,92	0,005	0,003	0,09	13,62	0,66	0,098
2005	8,23	3,24	0,007	0,003	0,09	14,01	0,73	0,126
2006	8,18	3,85	0,009	0,002	0,08	13,86	0,74	0,128
2007	8,53	4,22	0,012	0,002	0,08	11,63	0,77	0,119
2008	8,93	3,73	0,013	0,002	0,08	11,52	0,71	0,128
2009	8,62	3,63	0,013	0,002	0,07	11,22	0,73	0,091
2010	8,42	3,65	0,013	0,002	0,06	12,01	0,74	0,129
2011	8,35	3,72	0,015	0,002	0,05	10,63	0,70	0,139
2012	8,21	3,88	0,019	0,002	0,04	11,06	0,71	0,216

Comparing to 1990 CH_4 emissions from manure management decreased by 53,7% in 2012 (Figure 6-4).

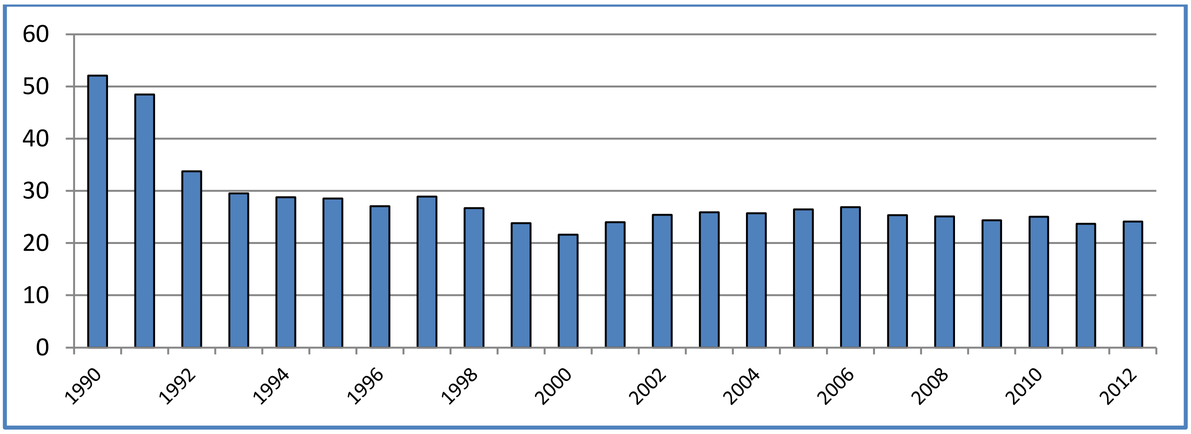

Figure 6-4. CH_4 emission from manure management during the period 1990-2012, Gg

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.

6.3.1.2 Methodological issues

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 of these livestock categories.

The summary of methods that were used for calculation of CH_4 emission from manure management are presented in Table 6-39.

Table 6-39. Methods and emission factors used for estimation of 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 1996
Horses	Tier 1	IPCC 1996
Swine	Tier 2	CS
Poultry	Tier 1	IPCC 1996
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

Characterization of manure management systems

Assumption on manure remaining on pasture was based on grazing time of dairy and non-dairy cattle. Bulls, partly calves and cows for slaughter, normally are kept in stalls all the time. 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[56, 57]. For cattle category, the average duration of grazing on pasture periods and the average time spent in milking stalls are used to divide excrement into pasture and stable portions.

In 2012 data about manure management systems were updated[58]. It was found that during the stable period 39,4% of cow manure goes to the solid manure management systems and 20,6% goes to the liquid manure management systems. About 40% of cow manure stays in the pastures.

In the other cattle categories, 46%, 24,3% and 1,8% of manure goes to solid, liquid and deep bedding manure management systems respectively. 27,9% of manure stays in the pastures.

The most widely used system in swine farms is the liquid manure management system, which accounts for 86,7% of total manure management systems. 11,1% of manure is managed as solid manure including 2,2% manure managed in pits below confinements as deep bedding. However, pits below animal confinements are not included in CRF reporter. Therefore, this type of swine manure management system is reported as "Other manure management system". In mid 2011 was stopped processing of slurry in biogas plants.

When the number of small farmers who use solid manure management technologies relatively decreases, the number of animals kept in the bigger herds, where the liquid manure management technologies are used, relatively increases. Therefore it is highly likely that the part of liquid manure management system increased in 2012, thus, based on this assumption, the data on manure management systems in categories of cattle and swine was 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 manure management systems were taken as default values from the *IPCC GPG 2000*[59] (Table 6-39). Data on manure management used in calculations for dairy cattle, non-dairy cattle and swine are provided in Figures 6-5, 6-6 and 6-7.

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[56] Gyvulininkystės žinynas. Mokslas: Vilnius, 1976, p. 98-99

[57] Tarvydas, V. ir kt. *Šėrimo normos, pašarų struktūra ir sukaupimas galvijams*. Vilnius, 1995, p. 4

[58] Studija "Lietuvos mėšlo tvarkymo sistemose susidarančių metano ir azoto suboksido kiekio tyrimai ir įvertinimas". 2012

[59] *IPCC GPG 2000*. Agriculture. Table 4.10-4.11, p. 4.36-4.37

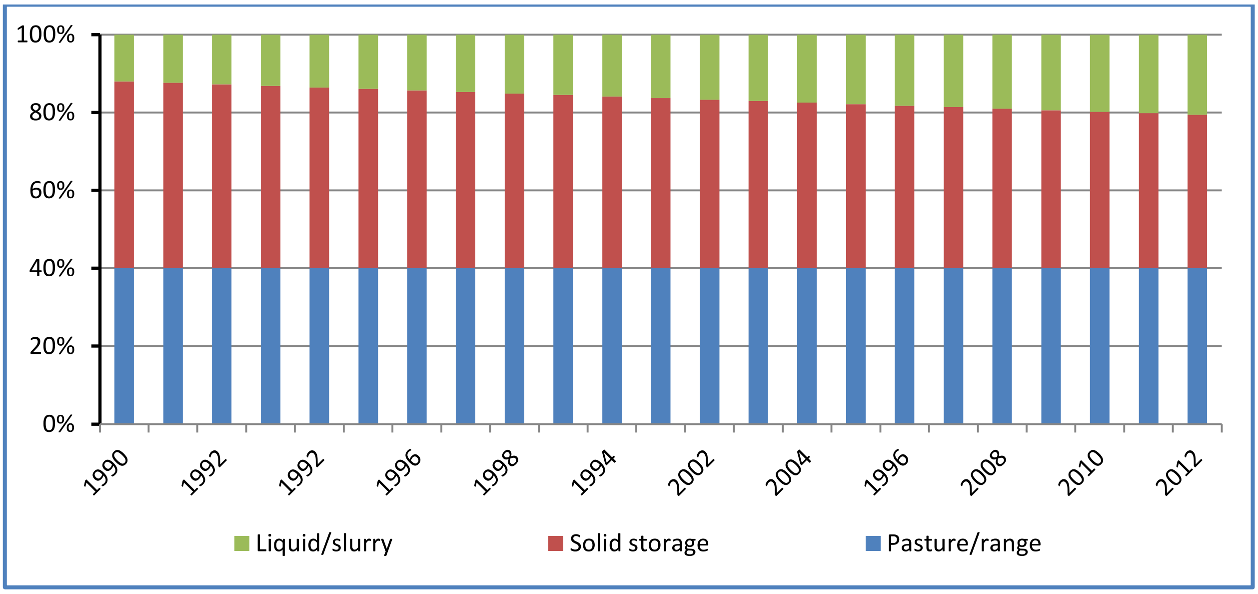

Figure 6-5. Data on manure management systems for dairy cattle, %

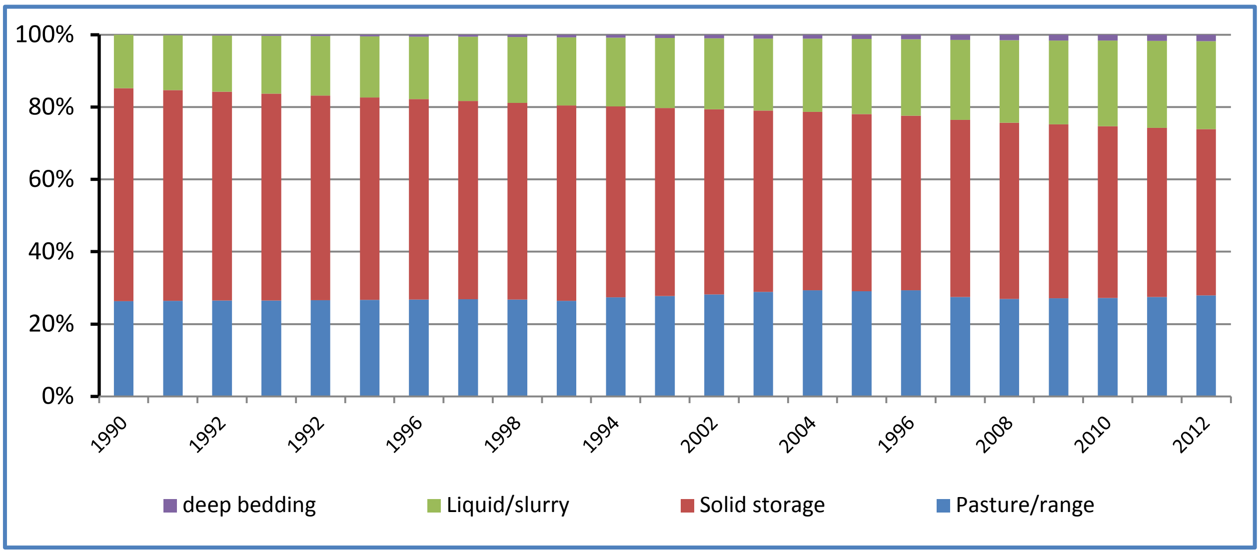

Figure 6-6. Data on manure management systems for non-dairy cattle, %

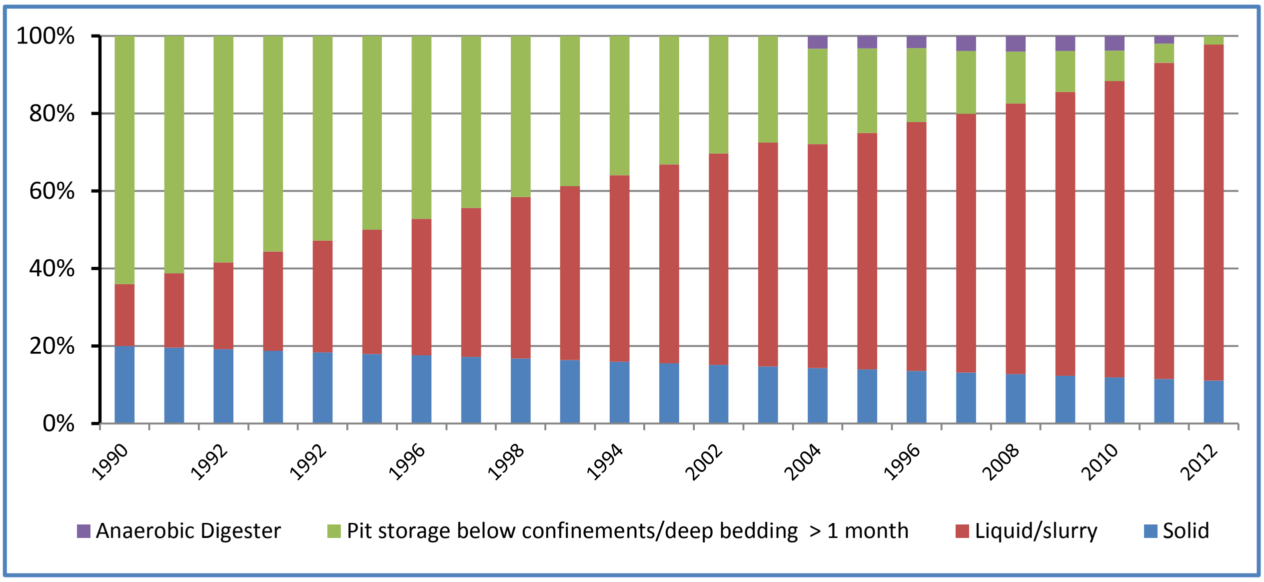

Figure 6-7. Data on manure management systems for swine, %

Calculation of CH_4 emissions

CH_4 emissions from manure management were calculated using the following equation:[60]

$$CH_{4\ EMISSIONS} = EF \times Population / (10^6\ kg/Gg)$$

where:
EF – emission factor for defined livestock population, kg/head/year;
Population – the number of head in the defined livestock population.

CH_4 emissions from horses, goats, poultry, rabbits, nutria and fur-bearing animals were calculated using Tier 1 method. Default IPCC emission factors for each relevant livestock category are used to calculate emissions from manure (Table 6-40).

Table 6-40. Emission factors used for calculation of CH_4 emission from manure management, kg CH_4/head/year[61, 62]

Animal category	Emission Factor
Goats	0,12
Horses	1,39
Poultry	0,078
Rabbits	0,08
Nutria	0,68
Fur-bearing animals	0,68

Methane emission factors for cattle, swine and sheep were determined using the fallowing equation:[63]

$$EF = VS \times 365\ days/year \times B_0 \times 0.67\ kg/m^3 \times \Sigma MCF \times MS$$

where:
EF – annual emission factor for defined livestock population, kg;
VS – daily VS excreted for an animal within defined population, kg;
B_0 – maximum CH_4 producing capacity for manure produced by an animal within defined population, m^3/kg of VS;
MCF – methane conversion factor for each manure management system;
MS – fraction of animal species/category manure handled using manure system.

The VS excretion rate, calculated for dairy and non-dairy cattle, sheep and swine were estimated from feed intake levels [64]:

$$VS = GE \times (1\ kg\text{-}dm/18.45\ MJ) \times (1 - DE/100) \times (1 - ASH/100)$$

where:
GE – estimated daily average feed intake, MJ/day;
DE – digestible energy of the feed, %;
ASH – ash content of manure, %.

[60] *IPCC GPG 2000*. Agriculture. Eq. 4.15, p. 4.30
[61] *Revised 1996 IPCC* . Agriculture. Workbook. Vol. 1, Table 4-4, p. 4.6
[62] *IPCC 2006 Guidelines*. Table 10.16, p. 10.41
[63] *IPCC GPG 2000*. Agriculture. Eq. 4.17, p. 4.34
[64] *IPCC GPG 2000*. Agriculture. Eq. 4.16, p. 4.31

Gross energy consumption values for dairy cattle, non-dairy cattle, swine and sheep were used the same as calculated in section 6.2 „Enteric fermentation" (CRF 4.A). 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) is provided in *IPCC GPG 2000*[65] and *Revised 1996 IPCC*[66] respectively.

The following table shows the applicable distributions for the various manure management systems. Calculated daily VS excretions for dairy cows, other cattle, swine and sheep are shown in Table 6-41.

Table 6-41. Daily VS excretions for dairy, non-dairy cattle, swine and sheep, kg-dm/day

Year	**Cattle**		**Swine**	**Sheep**
	Dairy	**Non-dairy**		
1990	4,02	2,19	0,36	0,53
1991	3,91	2,19	0,36	0,52
1992	3,74	2,19	0,36	0,52
1993	3,66	2,19	0,36	0,54
1994	3,67	2,19	0,36	0,54
1995	3,71	2,19	0,36	0,53
1996	3,75	2,19	0,36	0,55
1997	3,81	2,19	0,37	0,56
1998	3,89	2,11	0,36	0,54
1999	3,83	2,13	0,37	0,52
2000	4,03	2,11	0,36	0,53
2001	4,12	2,10	0,36	0,52
2002	4,17	2,11	0,37	0,52
2003	4,19	2,10	0,36	0,51
2004	4,27	2,09	0,36	0,53
2005	4,32	2,10	0,35	0,52
2006	4,41	2,13	0,34	0,51
2007	4,52	2,21	0,35	0,51
2008	4,70	2,24	0,36	0,51
2009	4,71	2,25	0,34	0,52
2010	4,74	2,26	0,36	0,52
2011	4,78	2,25	0,36	0,52
2012	4,86	2,23	0,36	0,51
Revised 1996 IPCC[67] (Western Europe)	5,1	2,7	0,5	0,4

Calculated VS value shown in Table 6-37 is lower than the default values shown in the IPCC methodology for cattle and swine, however this value for sheep in our calculation is higher.

Methane producing capacities B_0 (0,24 m^3 CH_4/kg VS for dairy cows, 0,45 for swine) were also taken from *IPCC GPG 2000*. Value of Methane producing capacities B_0 = 0,17 ± 0,02 m^3 CH_4/kg

[65] *IPCC GPG 2000*. Agriculture. Tables 4-10, 4.11, p. 4.31-4.32
[66] *Revised 1996 IPCC*. Agriculture. Reference Manual. Vol. 3,Table B-7, p.4.47
[67] *Revised 1996 IPCC*. Agriculture. Reference Manual. Vol. 3,Tables B-3, B-4, B-6,B-7, p. 4.43, 4.44, 4.46, 4.47

VS for non-dairy cattle, comparable to the value indicated in the *IPCC GPG 2000* we determined in our study in 2012[68]. Default values of MCF provided in the IPCC guidelines was used (Table6-42).

Table 6-42. Methane conversion factors (MCF) for manure management systems, %[69]

Animal waste management system (AWMS)				
Solid storage	**Pit storage below confinements > month**	**Liquid/slurry**	**Pasture/range and paddock**	**Anaerobic lagoon**
1	39	39	1	0

Animal manure treatment in a biogas device has reduced emission of CH_4. In our estimations it was considered that all biogas was collected and digested in the anaerobic digester, therefore, amount of CH_4 used as fuel was not included into the total emission.

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 6-43). Methane conversion factor for slurry manure is higher than solid manure MCF.

Table 6-43. Calculated emission factors used for calculation of CH_4 emission from manure management for dairy cattle, kg CH_4/head/year

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
EF	13,12	13,10	12,84	12,91	13,26	13,73	14,21	14,74
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
EF	15,41	15,49	16,65	17,40	17,95	18,39	19,13	19,75
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	
EF	20,51	21,44	22,70	23,17	23,73	24,36	25,16	

Tables 6-44, 6-45, 6-46 and 6-47 shows the changes in emission factors for non-dairy cattle, swine and sheep.

[68] Studija "Lietuvos mėšlo tvarkymo sistemose susidarančių metano ir azoto suboksido kiekio tyrimai ir įvertinimas". 2012 m./*Revised 1996 IPCC*. Agriculture. Reference Manual. Vol. 3, Table B-4, p. 4.44

[69] *IPCC GPG 2000*. Agriculture. Table 4.10, p. 4.36

Table 6-44. Calculated emission factors used for calculation of CH_4 emission from manure management for non-dairy cattle sub-categories during the period 1990-2006, kg CH_4/head/year

Year	Non-dairy cattle	EF by cattle sub-categories										
		Suckling cows	Cattle less than 1 year old			Cattle from1 to 2 years old			Cattle 2 years old and older			Dairy cattle for slaughter
			For slaughter	Bulls for breeding	Heifers for breeding	Bulls	Heifers for slaughter	Heifers for breeding	Bulls	Heifers for slaughter	Heifers for breeding	
1990	6,20	-	4,66	6,26	3,17	11,33	5,30	5,54	11,06	6,91	6,91	10,97
1991	6,38	-	4,78	6,47	3,27	11,69	5,46	5,71	11,42	7,11	7,11	11,30
1992	6,57	-	4,90	6,67	3,36	12,06	5,62	5,87	11,78	7,32	7,32	11,63
1993	6,76	-	5,01	6,87	3,46	12,43	5,78	6,04	12,14	7,53	7,53	11,96
1994	6,94	-	5,13	7,08	3,55	12,79	5,94	6,21	12,49	7,74	7,74	12,29
1995	7,13	-	5,24	7,28	3,65	13,16	6,10	6,37	12,85	7,95	7,95	12,62
1996	7,32	-	5,36	7,48	3,74	13,53	6,26	6,54	13,21	8,16	8,16	12,95
1997	7,50	-	5,47	7,69	3,84	13,89	6,42	6,71	13,57	8,36	8,36	13,28
1998	7,40	-	5,59	7,89	3,94	14,26	6,58	6,88	13,93	8,57	8,57	13,62
1999	7,69	-	5,71	8,09	4,03	14,63	6,74	7,04	14,29	8,78	8,78	13,95
2000	7,70	16,67	5,82	8,29	4,13	15,00	6,90	7,21	14,64	8,99	8,99	14,28
2001	7,85	17,08	5,94	8,50	4,22	15,36	7,06	7,38	15,00	9,20	9,20	14,61
2002	8,00	17,48	6,05	8,70	4,32	15,73	7,22	7,54	15,36	9,41	9,41	14,94
2003	8,08	17,89	6,17	8,90	4,41	16,10	7,38	7,71	15,72	9,61	9,61	15,27
2004	8,16	18,30	6,28	9,11	4,51	16,46	7,54	7,88	16,08	9,82	9,82	15,60
2005	8,43	18,70	6,40	9,31	4,61	16,83	7,70	8,04	16,44	10,03	10,03	15,93
2006	8,76	19,11	6,51	9,51	4,70	17,20	7,86	8,21	16,79	10,24	10,24	16,26

Table 6-45. Calculated emission factors used for calculation of CH_4 emission from manure management for non-dairy cattle sub-categories during the period 2007-2012, kg CH_4/head/year

Year	EF by cattle sub-categories									
	Non-dairy cattle	Cattle sub-category								
		Suckling cows	To 8 months		From 8 to12 months		From 1 to 2 years old		2 years old and older	
			Bulls	Heifers	Bulls	Heifers	Bulls	Heifers	Bulls	Heifers
2007	9,67	19,52	8,15	4,30	13,06	6,48	17,56	8,38	17,15	10,45
2008	9,83	19,92	8,32	4,38	13,33	6,61	17,93	8,55	17,51	10,66
2009	10,09	20,33	8,49	4,47	13,60	6,74	18,30	8,71	17,87	10,86
2010	10,34	20,73	8,66	4,55	13,87	6,87	18,66	8,88	18,23	11,07
2011	10,48	21,14	8,83	4,64	14,15	7,00	19,03	9,05	18,59	11,28
2012	10,59	21,55	9,00	4,72	14,53	7,19	19,40	9,21	18,94	11,49

Table 6-46. Calculated emission factors used for calculation of CH_4 emission from manure management for swine during the period 1990-2012, kg CH_4/head/year

Year	1990	1991	1992	1993	1994	1995	1996	1997
EF	12,44	12,50	12,57	12,63	12,69	12,75	12,82	13,01
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
EF	12,70	13,25	13,07	13,06	13,30	13,18	12,69	12,57
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	
EF	12,30	12,59	12,84	12,09	12,92	13,45	13,70	

Table 6-47. Calculated emission factors used for calculation of CH_4 emission from manure management for sheep during the period 1990-2011, kg CH_4/head/year

Year	1990	1991	1992	1993	1994	1995	1996	1997
EF	0,244	0,243	0,243	0,251	0,252	0,248	0,253	0,261
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
EF	0,249	0,243	0,246	0,242	0,240	0,239	0,246	0,243
Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	
EF	0,236	0,235	0,237	0,240	0,241	0,242	0,237	

Emission factor for non-dairy cattle and swine has also increased as a result of increasing number of housing types of animals when solid manure management was replaced by slurry-based system. Calculated emission factors for sheep vary throughout the years due to the changes in livestock population distribution through sub-categories.

6.3.1.3 Uncertainties and time-series consistency

CH_4 emission from manure management was calculated based on activity data and emission factors. Overall uncertainties result from animal number inaccuracy (Chapter 6.2.3), data of manure management systems and emission factors. However, the data on excretion and distribution of manure among the management systems are less reliable.

2006 IPCC Guidelines 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 is estimated to be ±30%. Improvements achieved by Tier 2 methodologies are estimated to reduce uncertainty ranges in emission factors to ±20%. The uncertainty of the manure management system usage data can be 10% or less[70].

Uncertainties in estimates of B_0 from cattle and swine are ±15%[71]. In study on experimental research and evaluation of country specific methane producing capacity (B_0) in Lithuania uncertainty of B_0 from non dairy cattle was estimated ±12%[72]. Overall uncertainty for B_0 ±14,5%. Overall uncertainty for activity data assumed to be ±17,65%.

6.3.1.4 Source-specific QA/QC and verification

QA/QC includes checking of activity data, emission factors and methods applied. If errors are found they are corrected. These activities are implemented every year in preparation of agriculture inventory. In addition, emission factors were compared with EF of other countries'.

Data in Table 6-48 shows that Lithuania uses significantly higher emission factors for calculation of emission from manure management than neighbouring countries. While these countries use MCF 10% for the calculation of emission from liquid/slurry most often, Lithuania uses MCF 39%[73].

Table 6-48. Comparison of EF (kg CH_4/head/yr) and GE intake (MJ/head/day) for CH_4 emission calculation from manure management of cattle, swine and sheep

		Belarus	Estonia	Latvia	Lithuania	Poland
Dairy cattle	EF	5,14	10,32	11,83	25,16	13,73
	GE intake	272,56	327,18	299,40	278,36	251,05
Non-dairy cattle	EF	2,79	-	3,01	10,59	2,69
	GE intake	130,60	-	132,54	127,69	125,90
Swine	EF	4,60	1,98	4,0	13,70	5,75
	GE intake	NE	25,11	NA	27,03	NA
Sheep	EF	0,19	0,19	0,19	0,24	0,17
	GE intake	NE	20,0	NA	25,52	18,06

6.3.1.5 Source-specific recalculations

In order to ensure consistency of methodologies used to estimate CH_4 emission from manure management, the following recalculations have been made:

- Due to update of manure management systems for swine recalculations were made in this submission in 2011 (Table 6-49);
- Due to updated of average weight for the period 1991-2011 and gross energy data for dairy cattle for the period 2008-2011 emissions of CH_4 were recalculated.

[70] *IPCC 2006 Guidelines*. Emissions from Livestock and Manure management, p. 10.48
[71] *IPCC 2006 Guidelines*. Emissions from Livestock and Manure management, Table 10A-4, p. 10.77
[72] Studija "Lietuvos mėšlo tvarkymo sistemose susidarančių metano ir azoto suboksido kiekio tyrimai ir įvertinimas". 2012 m.
[73] *IPCC GPG 2000*. Agriculture. Tables 4-10, p. 4.31

Table 6-49. Comparison of recalculated CH_4 emission factors from manure management for cattle, swine and sheep in previous and this submission for 2011, kg CH_4/head/year

Year	Dairy cattle			Swine		
	Previous submission	This submission	Relative difference, %	Previous submission	This submission	Relative difference, %
2011	23,88	24,36	2,01	13,03	13,45	3,22

The results of recalculated CH4 emissions during the period 1990-2011 are given in Table 6-50.

Table 6-50. Reported in previous submission and recalculated CH_4 emissions from manure managementin 1990-2011, Gg

Year	Previous submission	This submission	Absolute difference	Relative difference, %
1990	52,08	52,08	0,00	0,00
1991	48,44	48,45	0,01	0,02
1992	33,76	33,77	0,01	0,03
1993	29,50	29,52	0,02	0,07
1994	28,74	28,77	0,03	0,10
1995	28,48	28,51	0,03	0,11
1996	27,00	27,03	0,03	0,11
1997	28,87	28,91	0,04	0,14
1998	26,66	26,71	0,05	0,19
1999	23,76	23,81	0,05	0,21
2000	21,55	21,60	0,05	0,23
2001	23,92	23,97	0,05	0,21
2002	25,37	25,43	0,06	0,24
2003	25,85	25,92	0,07	0,27
2004	25,62	25,69	0,07	0,27
2005	26,35	26,43	0,08	0,30
2006	26,78	26,86	0,08	0,30
2007	25,26	25,35	0,09	0,36
2008	24,83	25,11	0,28	1,13
2009	24,10	24,37	0,27	1,12
2010	24,75	25,02	0,27	1,09
2011	23,11	23,61	0,50	2,16

6.3.1.6 Source-specific planned improvements

Collection of more accurate data on manure storage systems used in Lithuanian agriculture will be proceed.

6.3.2 Manure management - N_2O emission (CRF 4.B(b))

6.3.2.1 Source 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 of manure, type of manure storage system, duration of time manure is stored, climatic condition during the storage. N_2O is the most potent agricultural greenhouse gas with warming potential 310 times greater than that of CO_2.

The emission of N_2O is calculated based on the amount of nitrogen excretion per animal and animal waste management system. The emission estimates from manure deposits on grass are described in the section "Pasture, range and paddock manure" (see Section 6.5.2).

N_2O emissions from manure management were 263,17 Gg CO_2 eqv. or 5,2% of the total agriculture emissions in 2012. In 2012, comparing with 1990, N_2O emissions from manure management decreased by 70,3% (Figure 6-8). Calculated N_2O emissions from different manure management systems are presented in Table 6-51.

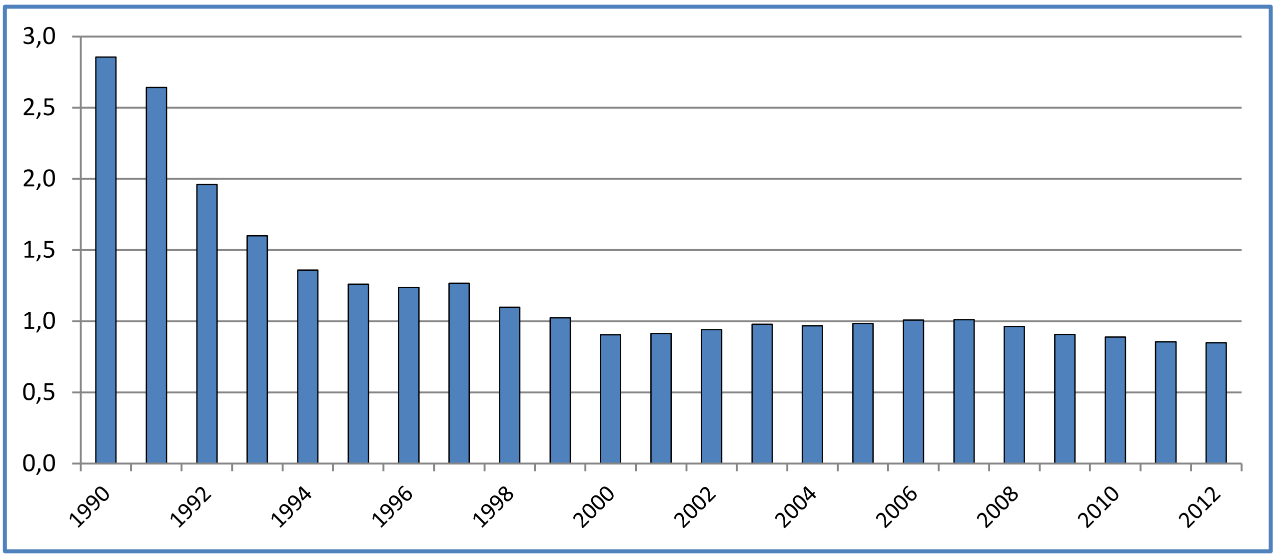

Figure 6-8. Nitrous oxide emission from manure management during the period 1990-2012, Gg

Table 6-51. Calculated N_2O emissions for different manure management systems, Gg

Year	AWMS			
	Liquid system	Solid storage and dry lot	Anaerobic digester	Other systems
1990	0,04	2,73	-	0,08
1991	0,04	2,52	-	0,08
1992	0,03	1,88	-	0,04
1993	0,03	1,53	-	0,04
1994	0,03	1,29	-	0,04
1995	0,03	1,19	-	0,04
1996	0,03	1,17	-	0,04
1997	0,03	1,20	-	0,04
1998	0,03	1,04	-	0,03
1999	0,02	0,97	-	0,03
2000	0,02	0,86	-	0,03
2001	0,02	0,86	-	0,03
2002	0,03	0,88	-	0,03
2003	0,03	0,92	-	0,03
2004	0,03	0,90	0,0006	0,03
2005	0,03	0,91	0,0006	0,04
2006	0,03	0,94	0,0006	0,04

2007	0,03	0,94	0,0006	0,04
2008	0,03	0,90	0,0006	0,03
2009	0,03	0,84	0,0006	0,03
2010	0,03	0,82	0,0006	0,03
2011	0,03	0,79	0,0003	0,03
2012	0,03	0,79	-	0,03

6.3.2.2 Methodological issues

To estimate N_2O emissions from manure management the Tier 1 method was used. To estimate N_2O emissions from manure management entails multiplying the total amount of N excretion (from all livestock categories) in each type of manure management system by an emission factor for that type of manure management system. Emissions are then summed over all manure management systems.

Activity data

The data on population of livestock were obtained from the Register of Agricultural Information and Rural Business Centre (2007-2012) and from the database of Statistics Lithuania (1990-2012). More detailed information on livestock population and distribution of livestock sub-categories is provided in section 6.2.1.

Fractions of the total annual excretion of livestock managed in specific manure management systems are presented in Figure 6-5, Figure 6-6, Figure 6-7 in the above mentioned section "Manure management – CH_4 emission (CRF 4.B(a))" and in Table 6-52.

Table 6-52. Percentage of manure production per animal waste management systems, %

Year	Solid storage and dry lot	Liquid system	Pasture, range and paddock	Other systems
Sheep				
1990-2012	54,8		45,2	
Goats				
1990-2012	54,8		45,2	
Horses				
1990-2012			92	8
Poultry				
1990-2012		28	1	71
Rabbits				
1990-2012	100			
Fur-bearing animals				
1990-2006	100			
2007	93	7		
2008	85	15		
2009-2012	78	22		
Nutria				
1990-2012	100			

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[74]:

$$(N_2O\text{-}N)(mm) = \Sigma_{(S)} ((\Sigma_{(T)} (N_{(T)} \times Nex_{(T)} \times MS_{(T,S)})) \times EF_{3(S)})$$

where:
$(N_2O\text{-}N)(mm)$ – N_2O-N emissions from manure management in the country (kg N_2O-N/yr);
$N_{(T)}$ – 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/yr);
$MS_{(T,S)}$ – Fraction of total annual excretion for each livestock species/category T that is managed in manure management system S in the country;
$EF_{3(S)}$ – N_2O emission factor for 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.

Conversion of $(N_2O\text{-}N)(mm)$ emission to $N_2O(mm)$ emission for reporting purposes is performed by using the following equation:

$$N_2O(mm) = (N_2O\text{-}N)\ (mm) \times 44/28$$

For calculation of total nitrogen excretion IPCC default annual average nitrogen excretion rates for each animal category were used (Table 6-53).

Table 6-53. Default N excretion values for livestock categories, kg N/head/yr[75,76]

Animal category	Nitrogen excretion
Sheep, goats	16
Horses	25
Poultry	0,6
Rabbits	8,1
Minks, nutria	4,59
Foxes, polar foxes	12,09

The annual amount of N excretion per head for dairy cattle was calculated on the total annual N intake and total annual N retention of the animal[77]. The annual amount of N excretion per head for non-dairy cattle and swine was calculated on the total annual N intake and total annual N retention for productivity of the animal. Annual average N intake per head for cattle and swine were calculated in accordance with the tables[78] of forage sustenance and ration. The difference between intake and retention is N excretion (Table 6-54). The emission factors for each manure management system were taken from IPCC Guidelines (Table 6-55).

[74] *IPCC GPG 2000*. Agriculture. Eq. 4.18, p. 4.42
[75] *Revised 1996 IPCC*. Agriculture. Workbook. Vol. 1, Table 4-6, p. 4.10.
[76] *2006 IPCC Guidelines*. Table 10.19, p. 10.59.
[77] *IPCC GPG 2000*. Agriculture. Eq. 4.19, p. 4.45.
[78] Gyvulininkystės žinynas. Baisogala, Institute of Animal Science of LVA. 2007, p. 584-601.

Table 6-54. N excretion factors used in the estimates of N_2O emissions from cattle and swine, kg N/head/yr

Animal category	Dairy cattle	Non-dairy cattle	Swine
1990	82,50	52,56	11,05
1991	79,13	52,56	11,05
1992	73,77	52,56	11,05
1993	72,61	52,56	11,05
1994	72,61	52,56	11,05
1995	72,84	52,56	11,05
1996	73,95	52,56	11,05
1997	75,43	52,56	11,21
1998	77,92	50,58	10,77
1999	75,93	51,05	11,29
2000	83,90	50,42	11,09
2001	84,60	50,27	10,95
2002	85,79	50,29	11,05
2003	86,33	50,06	10,90
2004	88,74	49,70	10,83
2005	90,56	49,85	10,66
2006	92,71	50,27	10,14
2007	96,05	49,92	10,80
2008	97,84	50,42	10,80
2009	98,13	50,36	10,22
2010	98,75	50,49	10,72
2011	99,62	49,96	10,91
2012	101,18	49,23	10,71

Table 6-55. Default emission factors for N_2O estimation from manure management, kg N_2O-N/kg nitrogen excreted [79]

Manure management system	Emission factor
Pasture/range/paddock	0,02
Solid storage and dry lot	0,02
Liquid system, pits below confinements	0,001
Other management systems:	
For swine	0,001
For sheep, goats, horses and poultry	0,005

6.3.2.3 Uncertainties and time-series consistency

N_2O emission from manure management was calculated based on the livestock population. N excretion and N emission factors related to manure management systems. *IPCC GPG 2000* (Table 4.12) refers that uncertainty range for the default emission factors for N_2O from manure management is estimated to be -50%/+100%[80]. The uncertainty of nitrogen excretion for

[79] *Revised 1996 IPCC*. Agriculture. Workbook. Vol. 1, Table 4-8, p. 4.14
[80] *IPCC GPG 2000*. Agriculture. Table 4.13, p. 4.43

categories of livestock is ±28%. The uncertainties associated with the N excretion rates related with the N intake and N retention of animals may be as low as ±25%[81]. Overall uncertainty for activity data assumed to be ±28%.

6.3.2.4 Source-specific QA/QC and verification

QA/QC includes checking of activity data, emission factors and methods applied. These activities are implemented every year in preparation of agriculture inventory. If errors are found they are corrected. Comparing the results obtained in 2011 it can be seen that gross energy consumption in dairy cattle category occupied an intermediate position between Belarus and Latvia, while Lithuania shows higher N_{ex} rate (Table 6-56).

Table 6-56. Comparison of GE (MJ/head/day) and N excretion (kg N/head/yr) values for N_2O emission calculation from manure management of cattle and swine

Country	Dairy cattle		Non-dairy cattle		Swine	
	Nex	GE	Nex	GE	Nex	GE
Belarus	77,09	272,56	36,56	130,60	10,10	NE
Denmark	138,47	341,13	44,11	130,24	7,98	40,41
Estonia	116,14	327,18	-	-	10,49	25,11
Latvia	70,0	299,40	50,0	132,54	10,0	NA
Lithuania (in 2012)	101,18	278,36	49,23	127,69	10,71	27,03
Poland	86,70	251,05	57,81	125,90	13,56	NA

In non-dairy cattle sub-category the levels of gross energy intakes are similar to those of Belarus and Denmark, however N_{ex} rates in these countries are lower. Poland shows slightly lower GE value, but a a higher value of N_{ex}.

In swine category the level of gross energy intakes and N_{ex} rates in Lithuania are similar to those of Estonia.

6.3.2.5 Source-specific recalculations

N_2O emission was recalculated due to updated of gross energy intake and protein consumption for the period 1990-2011 and N retention for dairy cattle according to *IPCC GPG 2000*[82] metodology for entire time series (Table 6-57). Similarly N_2O emission was recalculated due to updated data for manure management system for swine in 2011.

Table 6-57. Comparison of recalculated N_2O emission from manure management in previous and this submission for the period 1990-2011, Gg

Year	Previous submission	This submission	Absolute difference	Relative difference, %
1990	2,86	2,86	0,00	0,00
1991	2,64	2,64	0,00	0,00
1992	1,96	1,96	0,00	0,00
1993	1,60	1,60	0,00	0,00
1994	1,36	1,36	0,00	0,00
1995	1,26	1,26	0,00	0,00

[81] *IPCC GPG 2000*. Agriculture, p. 4.46
[82] *IPCC GPG 2000*. Agriculture. Eq. 4,19, p. 4.45.

1996	1,22	1,24	0,02	1,64
1997	1,27	1,27	0,00	0,00
1998	1,10	1,10	0,00	0,00
1999	1,02	1,02	0,00	0,00
2000	0,90	0,90	0,00	0,00
2001	0,92	0,91	-0,01	-1,09
2002	0,94	0,94	0,00	0,00
2003	0,98	0,98	0,00	0,00
2004	0,97	0,97	0,00	0,00
2005	0,98	0,98	0,00	0,00
2006	1,01	1,01	0,00	0,00
2007	1,01	1,01	0,00	0,00
2008	0,96	0,96	0,00	0,00
2009	0,90	0,91	0,01	1,11
2010	0,89	0,89	0,00	0,00
2011	0,87	0,85	-0,02	-2,3,

6.3.2.6 Source-specific planned improvements

Collection of more accurate data on manure utilization and appliance to biogas plants in Lithuania is planned. Additional data should enable better and more reliable judgments on N_2O emissions from manure management.

6.4 Rice cultivation (CRF 4.C)

Rice is not cultivated in Lithuania, emissions are reported as „NO" in CRF reporter.

6.5 Agricultural soils (CRF 4.D)

This source category includes direct and indirect nitrous oxide (N_2O) emissions from agricultural soils and emissions from manure deposited on pastures (Table 6-58). Agricultural soils represent a large source of N_2O emissions. N_2O emission from agricultural soils contributed 66,6% of the total GHG emission from agriculture sector. N_2O emissions from Agricultural soils subsector were also identified as a key category (see Table 6-1).

Table 6-58. N_2O emissions from agricultural soils during the period 1990-2012, Gg

Year	Direct soil emissions	Pasture manure	Indirect emissions
1990	8,72	1,59	6,09
1991	7,93	1,50	5,36
1992	5,19	1,18	3,20
1993	4,48	1,00	2,40
1994	4,07	0,87	1,99
1995	4,06	0,82	1,90
1996	4,87	0,82	2,39
1997	5,02	0,85	2,47
1998	5,00	0,76	2,34
1999	5,09	0,71	2,39
2000	5,18	0,66	2,34
2001	5,29	0,66	2,43
2002	5,66	0,68	2,64

2003	5,76	0,71	2,70
2004	5,85	0,71	2,72
2005	5,94	0,71	2,77
2006	5,75	0,73	2,84
2007	6,46	0,73	3,27
2008	5,89	0,70	2,88
2009	6,03	0,67	2,93
2010	5,99	0,64	3,00
2011	6,12	0,63	3,01
2012	6,33	0,62	3,06

6.5.1 Direct emissions from agricultural soils (CRF 4.D.1)

6.5.1.1 Source 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 to agricultural land as soil amendment. A major direct source of N_2O is the use of synthetic fertilizer (Figure 6-9). Similarly the use of animal manure as fertilizer can lead to substantial emissions of N_2O from agricultural soils.

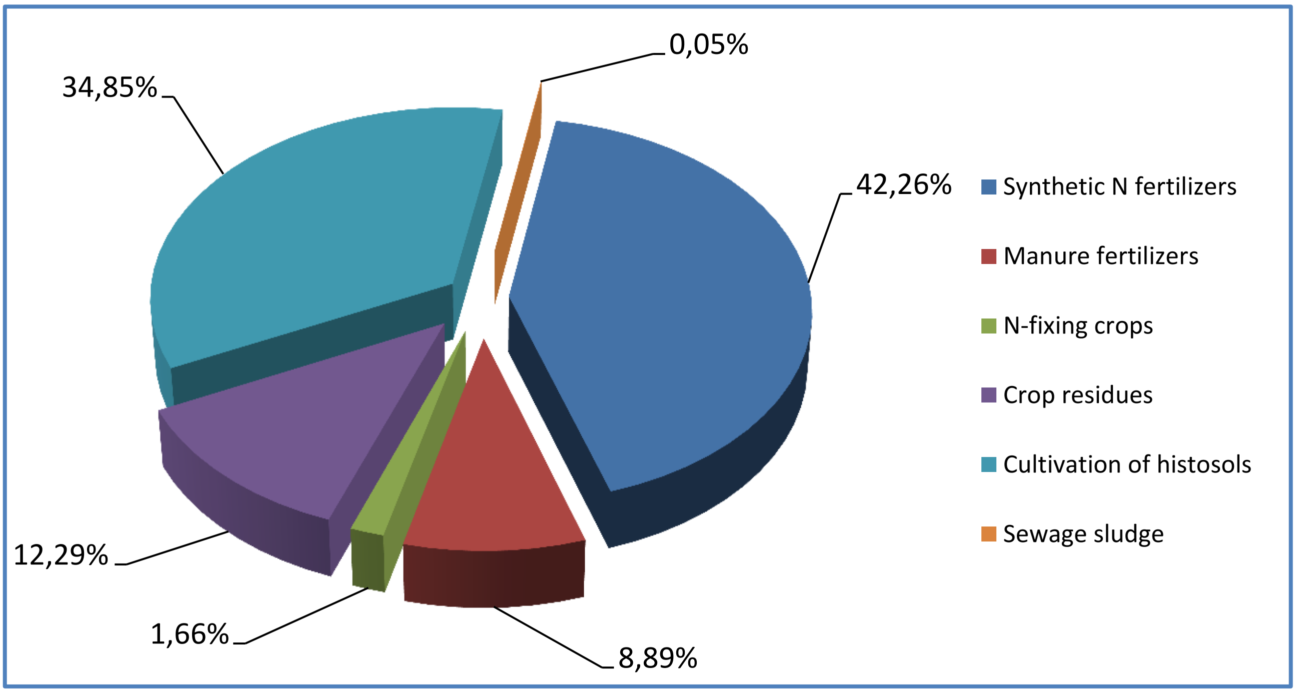

Figure 6-9. The share of direct N_2O emissions from agricultural soils in 2012, %

As shown in Figure 6-9 the biggest share of N_2O emissions in 2012 were from application of synthetic fertilizers and cultivation of histosols. The share of N_2O emissions from synthetic N fertilizers took more than 42% ant N_2O emissions from cultivation of histosols took almost 35% of the total N_2O emissions from direct emissions from agricultural soils subsector.

The biggest influence on variation of N_2O emission from agricultural soils in 1990-2012 was the usage of nitric fertilizers and soil nitrogen mineralization due to cultivation of organic soils including grasslands. Emissions of N_2O from sewage sludge as fertilizer amounted to 0,003 Gg N_2O in 2012 and contributed only 0,05% of total N_2O emissions from Direct soil emissions (CRF 4.D.1).

Table 6-59 presents direct N_2O emissions from agricultal soils subsector for the period 1990-2012 by each source category.

Table 6-59. Direct N_2O emissions from agricultural soils by source category during the period 1990-2012, Gg

Year	Synthetic N fertilizers	Manure fertilizers	N-fixing crops	Crop residues	Cultivation of histosols	Sewage sludge
1990	4,33	1,59	0,39	0,46	1,94	0,002
1991	3,61	1,48	0,38	0,47	1,99	0,002
1992	1,67	1,03	0,18	0,26	2,04	0,003
1993	1,02	0,86	0,17	0,34	2,09	0,001
1994	0,73	0,77	0,15	0,27	2,14	0,005
1995	0,71	0,73	0,15	0,28	2,19	0,010
1996	1,40	0,70	0,18	0,37	2,21	0,006
1997	1,43	0,72	0,19	0,42	2,25	0,008
1998	1,47	0,64	0,17	0,41	2,30	0,006
1999	1,66	0,59	0,13	0,34	2,35	0,006
2000	1,73	0,52	0,13	0,37	2,42	0,006
2001	1,80	0,55	0,12	0,32	2,49	0,006
2002	2,03	0,58	0,13	0,37	2,54	0,006
2003	2,05	0,60	0,13	0,39	2,59	0,006
2004	2,07	0,61	0,13	0,43	2,61	0,007
2005	2,10	0,63	0,16	0,42	2,62	0,007
2006	2,16	0,64	0,11	0,30	2,54	0,004
2007	2,72	0,64	0,14	0,49	2,45	0,012
2008	2,26	0,61	0,14	0,51	2,35	0,013
2009	2,40	0,59	0,15	0,60	2,28	0,013
2010	2,53	0,59	0,10	0,51	2,27	0,005
2011	2,60	0,56	0,10	0,60	2,25	0,007
2012	2,68	0,56	0,11	0,78	2,21	0,003

Comparing with 2011 N_2O emissions from Crop residue have increased by 30%. This increase was caused by a higher yield harvested in 2012. The harvest of wheat increased by 60,4%, triticale – 83,5%, rye – 84,2%, oats – 27,2%, sugar beet – 14,3% in 2012 comparing with 2011. Year of 2012 were favorable for agriculture crops because of a good climatic conditions.

6.5.1.2 Methodological issues

Nitrogen inputs to soils from the main sources were calculated using *IPCC GPG 2000* Tier 1a methods.

Direct N_2O emissions from agricultural soils have been calculated using the following equation[83]:

[83] *IPCC GPG 2000*. Agriculture. Eq. 4.20, p. 4.54

$$N_2O_{DIRECT} – N = ((F_{SN} + F_{AM} + F_{BN} + F_{CR} + F_{SL}) \times EF_1) + F_{OS} \times EF_2$$

where:
N_2O_{DIRECT} – N – emission of N_2O in units of nitrogen;
F_{SN} – annual amount of synthetic fertilizer nitrogen applied to soils adjusted to account for the amount that volatilizes as NH_3 and NO_x;
F_{AM} – annual amount of animal manure nitrogen intentionally applied to soils adjusted to account for the amount that volatilizes as NH_3 and NO_x;
F_{BN} – amount of nitrogen fixed by N-fixing crops cultivated annually;
F_{CR} – amount of nitrogen in crop residues returned to soils annually;
F_{SL} - annual amount of sewage sludge fertilizer nitrogen applied to soils adjusted to account for the amount that volatilizes as NH_3 and NO_x;
F_{OS} – area of organic soils cultivated annually;
EF_1 – emission factor for emissions from N inputs (kg N_2O-N/kg N input);
EF_2 – emission factor for emissions from organic soil cultivation (kg N_2O-N/ha/yr).

Conversion of N_2O-N emissions to N_2O emissions for reporting purposes is performed by using the following equation[84]:

$$N_2O = N_2O\text{-}N \times 44/28$$

Synthetic N fertilizers (F_{SN}) (CRF 4.D.1.1)

Data about consumption of synthetic fertilizers were collected from different sources:

- for the period 1990-1994 data was obtained from Statistics Lithuania;
- for the period 1995-2006 from International Fertilizer Industry Association (IFA)[85];
- for the period 2007-2011 from UAB Agrochema.

Note: at the time when NIR was being prepared the data for consumption of synthetic N fertilizers in Lithuania was not available. Basing on expert judgement the total amount of nitrogen fertilizers consumed was assumed to be around 3% higher than in 2011.

Synthetic Fertilizer Nitrogen, adjusted for Volatilization (F_{SN}) was estimated by determining the total amount of synthetic fertilizer consumed annually (N_{FERT}), and then adjusting this amount by the fraction that volatilizes as NH_3 and NO_x ($Frac_{GASF}$)[86]:

$$F_{SN} = N_{FERT} \times (1 - Frac_{GASF})$$

where:
N_{FERT} – total use of synthetic fertilizer, kg N/yr;
$Frac_{GASF}$ – fraction of total synthetic fertilizer nitrogen that is emitted as $NOx+NH_3$, kg N/kg N.

$$N_2O_{DIRECT} = F_{SN} \times EF_1 \times 44/28$$

To calculate annual amount of synthetic fertilizer nitrogen applied to soils default factors from *Revised 1996 IPCC* were used (Table 6-60).

[84] *IPCC GPG 2000.* Agriculture, p. 4.54
[85] International Fertilizer Industry Association (IFA). Available from: *http://www.fertilizer.org/*
[86] *IPCC GPG 2000*. Agriculture. Eq. 4.22, p. 4.56

Table 6-60. Default factors used for estimation of synthetic fertiliser nitrogen[87]

Factor	Unit
EF_1	0,0125 kg N_2O-N/kg N
$Frac_{GASF}$	0,1 kg NH_3-N + NO_x-N/kg of synthetic fertilizer nitrogen applied

N_2O emission from Synthetic N fertilizer application to soil has decreased by 40% in 2011 comparing with the base year (Figure 6-10).

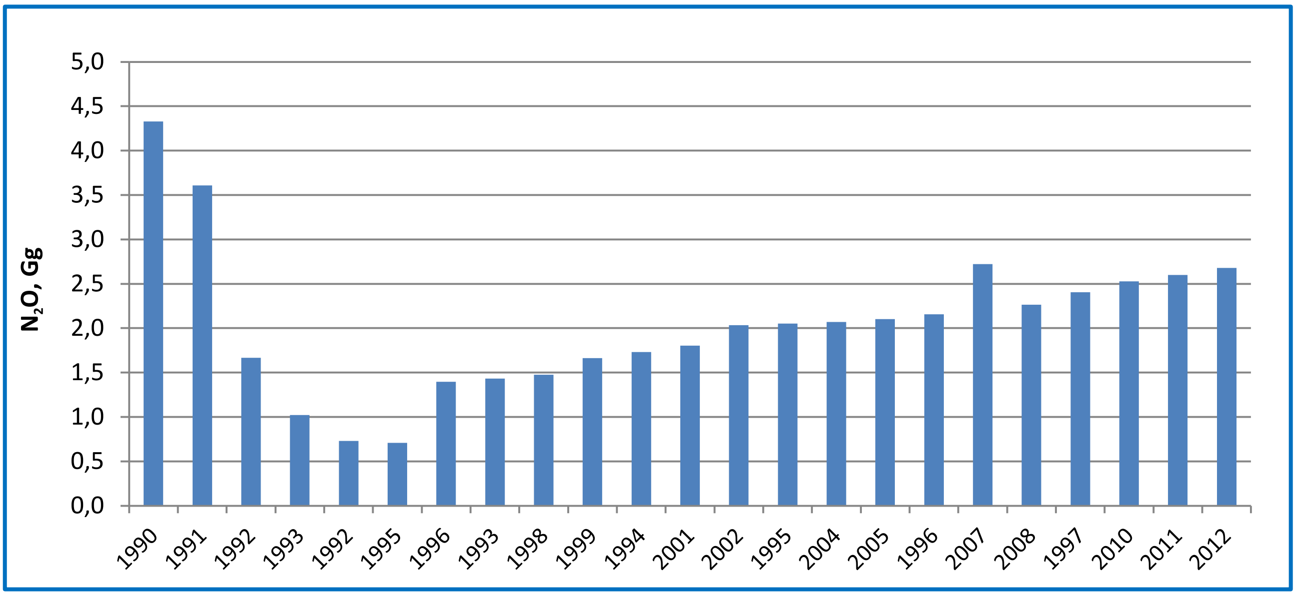

Figure 6-10. N_2O emission from Synthetic N fertilizers during the period 1990-2012, Gg

Animal manure applied to soils (CRF 4.D.1.2)

The main activity data for this source is number of livestock population. Data about livestock population were taken from Statistics Lithuanian and the Register of Agricultural Information and Rural Business Center. Information about distribution between manure management systems was taken from the Water Research Institute of the University of Agriculture of the Republic of Lithuania, also from the investigations made in previous years.

Animal manure nitrogen (F_{AM}) emits from agricultural soil through manure application to fields as organic fertilizer and animal pastures by grazing of animals. N_2O emissions were estimated by determining the total amount of animal manure nitrogen produced annually and then adjusting this amount to account for the animal manure that is volatilized as NH_3 and NO_x ($Frac_{GASM}$)[88]:

$$F_{AM} = \Sigma_T (N_{(T)} \times Nex_{(T)}) \times (1 - Frac_{GASM}) [1 - Frac_{FUEL\text{-}AM} + Frac_{PRP}]$$

where:
$N_{(T)}$ – number of head of livestock category T;
$Nex_{(T)}$ – annual average N excretion per head of category T (kg N/animal/yr);
$Frac_{FUEL}$ – fraction of livestock nitrogen excretion contained in animal manure that is burned for fuel;
$Frac_{PRP}$ (or $Frac_{GRAZ}$) – animal manure, deposited onto soils by grazing livestock.

[87] *Revised 1996 IPCC*. Reference Manual, Agriculture, p. 4.89, 4.94
[88] *IPCC GPG 2000*. Agriculture. Eq. 4.23, p. 4.56

This country specific value was calculated according to *Revised 1996 IPCC* methodology[89]:

$$Frac_{PRP} = N_{past} / N_{total}$$

N_{past} – amount of N from manure per animal waste management systems - pasture range and paddock 4.D.2, wich was applied tosoils (Gg/yr);
N_{total} – amount of N from manure per all animal waste management systems in Lithuania (Gg/yr).

$$N_{total} = N_L + N_S + N_{past} + N_{oth}$$

where:
N_L – amount of N from manure per animal waste management systems - liquid system (Gg/yr);
N_S – amount of N from manure per animal waste management systems - solid storage and drylot (Gg/yr);
N_{oth} – amount of N from manure per animal waste management systems – other system (Gg/yr).

$$N_2O_{DIRECT} = F_{AM} \times EF_1 \times 44/28$$

To calculate annual amount of Animal manure nitrogen (F_{AM}) applied to soils *Revised 1996 IPCC* default factors were used (Table 6-61, 6-62).

Table 6-61. Default factors used in estimation of N_2O emission from animal manure applied to soils[90]

Factor	Unit
$Frac_{GASM}$	0,2 kg NH_3-N + NOx-N/kg of N excreted by livestock
N_2O EF	0,0125 kg N_2O-N/kg N
$Frac_{FUEL}$	0,0 kg N/kg nitrogen excreted[91]

The background data used for calculation of fraction of animal manure that is deposited onto soils by grazing livestock ($Frac_{PRP}$) is provided in the Figures 6-4, 6-5, 6-6 (percentage of manure production per animal waste management systems), Tables 6-49 and 6-50 (N excretion values) and Tabale 6-51 (default emission factors for N_2O estimation from manure management).

The fraction of livestock nitrogen that was excreted and deposited on soil during grazing ($Frac_{PRP}$) is presented in Table 6-62.

Table 6-62. Fraction of livestock nitrogen excreted and deposited on soil during grazing in Lithuania ($Frac_{PRP}$)

Year	Fraction excreted on pasture
1990	0,268
1991	0,270
1992	0,289
1993	0,292
1994	0,287
1995	0,286
1996	0,294
1997	0,294

[89] *Revised 1996 IPCC*. Reference Manual, Agriculture, Table 4-21, p. 4.101
[90] *Revised 1996 IPCC*. Reference Manual, Agriculture, Table 4-18, p 4.89; Table 4-19, p. 4.94
[91] *Revised 1996 IPCC*. Workbook, Agriculture, Table 4-17, p. 4.35

1998	0,295
1999	0,296
2000	0,304
2001	0,296
2002	0,294
2003	0,293
2004	0,293
2005	0,287
2006	0,288
2007	0,289
2008	0,291
2009	0,289
2010	0,283
2011	0,287
2012	0,282

N_2O emission from Manure fertilizer application to soil has decreased by 64,6% in 2012 comparing with 1990 (Figure 6-11). This decrease is associated with reduction of livestock population.

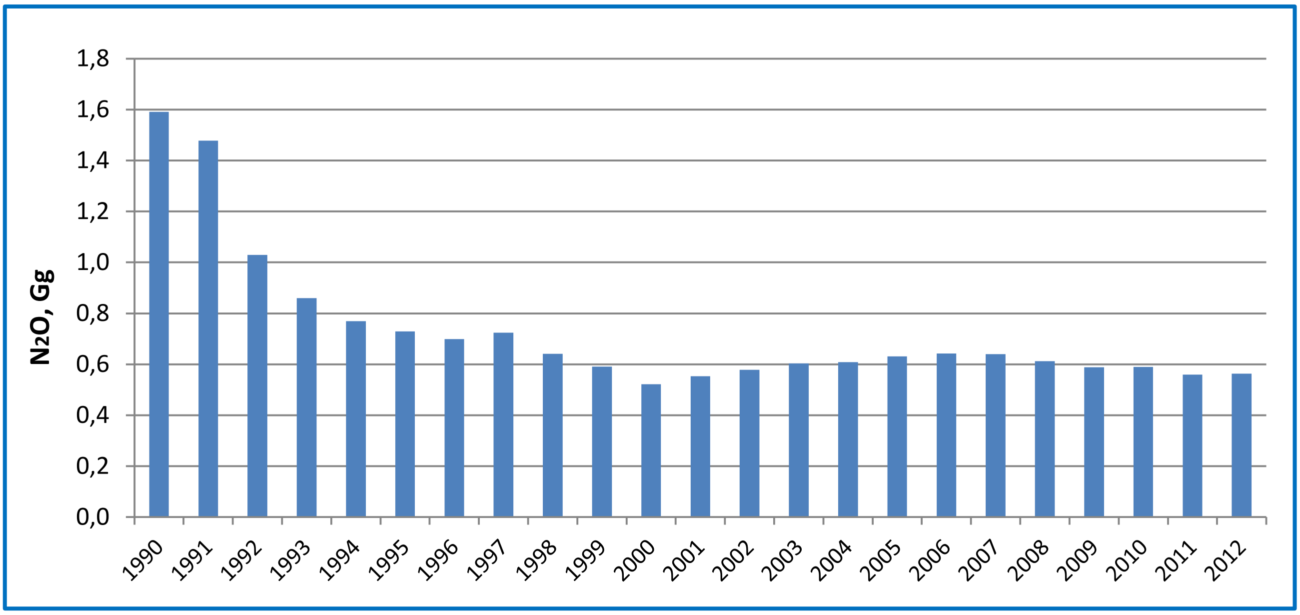

Figure 6-11. Nitrous oxide emission from Manure fertilizers during the period 1990-2012, Gg

N-fixing crops (CRF 4.D.1.3)

The main activity data that was used for calculation of N_2O emissions – harvested crops (thous. tonnes) by type of crop. This data was provided by database of Statistics Lithuania.

The main crops that were taken in to account and amount of harvest ($Crop_{BF}$) are presented in Table 6-63.

Table 6-63. Harvested crops in Lithuania during the period 1990-2012, thous. tonnes

Year	Harvested crops								
	Peas	Beans	Lupine	Vetches	Grain legume mixtures	Lucerne hay	Lucerne silase	Clover-grass mixture hay	Clover and their mixture silase
1990	113,5	4,6	1,8	65,2	15,1	10,7	187,6	499,1	1476,3
1991	103,3	3,7	1,3	70,6	15,3	10,1	177,5	472,3	1396,9
1992	13,9	0,1	0,2	10,5	2,8	7,8	137,4	365,7	1081,7
1993	11,1	1,2	1,0	17,4	4,6	6,4	111,9	297,6	880,3
1994	13,9	9,0	0,4	20,1	0,0	5,3	93,1	247,8	732,9
1995	21,4	2,7	1,0	18,2	4,2	4,9	86,1	229,0	677,3
1996	40,1	6,9	3,1	26,5	10,8	4,8	85,2	226,6	670,3
1997	65,6	4,5	2,6	2,9	30,8	4,9	86,3	229,6	679,2
1998	72,5	5,5	1,8	19,6	4,7	4,3	75,0	199,5	590,0
1999	46,5	1,9	0,8	11,5	3,1	4,1	72,5	193,0	570,9
2000	49,7	2,7	1,6	16,8	2,2	3,4	60,5	160,9	475,9
2001	30,0	4,1	1,5	14,3	2,3	3,5	60,7	161,6	478,0
2002	37,0	4,0	1,7	15,3	4,9	3,6	63,0	167,5	495,5
2003	21,6	4,5	2,8	4,2	15,4	3,5	67,4	191,6	517,8
2004	22,0	5,3	2,8	2,0	25,4	5,0	67,8	183,7	404,6
2005	21,1	5,8	4,9	4,5	22,6	3,0	54,9	279,1	434,1
2006	15,8	3,0	4,8	1,5	9,8	2,3	59,2	176,4	440,9
2007	24,2	2,7	7,9	3,3	18,3	3,5	69,9	183,9	583,4
2008	29,1	4,3	7,3	1,6	20,0	6,0	74,4	162,3	568,1
2009	50,3	5,1	10,6	1,5	18,2	4,2	56,8	138,9	732,2
2010	42,5	5,0	6,8	3,1	12,7	1,6	56,8	50,8	305,7
2011	47,5	7,4	6,5	3,2	13,4	2,4	56,8	46,6	400,9
2012	48,4	10,3	5,1	3,2	12,9	2,4	52,3	46,9	394,5

To estimate the amount of nitrogen that is fixed by N-fixing crops cultivated annually (F_{BN}) the following equation has been used[92]:

$$F_{BN} = \sum_i [Crop_{BFi} \cdot (1 + Res_{BFi}/Crop_{BFi}) \cdot Frac_{DMi} \cdot Frac_{NCRBFi}]$$

where:
$Crop_{BF}$ – production of pulses, kg dry biomass/yr;
$Res_{BF}/Crop_{BF}$ – residue to crop product mass ratio specific to each type;
$Frac_{DM}$ – the fraction of dry matter in the aboveground biomass of each crop type
$Frac_{NCRBF}$ – fraction of nitrogen in N-fixing crop, kg N/kg of dry biomass.

Crops that were used for forage amount of nitrogen that is fixed was assessed using the following equation[93]:

$$F_{BN} = \sum_i (Crop_{BFi} \cdot Frac_{DMi} \cdot Frac_{NCRBFi})$$

[92] *IPCC GPG 2000*. Agriculture. Eq. 4.26, p. 4.57
[93] *IPCC GPG 2000*. Agriculture. Eq. 4.27, p. 4.57

This equation is being used because such crops as alfalfa where the entire plant is harvested as product $Res_{BF}/Crop_{BF}$ will be equal 0[94].

Total emissions of N_2O from N-fixing crops are calculated using the following equation:

$$N_2O_{DIRECT} = F_{BN} \times EF_1 \times 44/28$$

These equations represents Tier 1b method which requires country specific values and default factors for each crop type. Table 6-64 represents the main factors that were used in calculations. These values mainly represents country specific data, some used factors are taken from *IPCC GPG 2000* and *Revised 1996 IPCC*, and some from other countries.

Table 6-64. Factors used for the calculation of nitrogen content in crop residues returned to soils[95,96,97,98,99,100]

Crop type	Factor		
	$Res_{BF}/Crop_{BF}$	$Frac_{DM}$	$Frac_{NCRBF}$
Peas	1,5	0,87	0,0142
Beans	2,1	0,87	0,0230
Lupine	2,1	0,89	0,0230
Vetches	2,1	0,85	0,0230
Grain legume mixtures	2,1	0,87	0,0230
Lucerne hay	0,0	0,86	0,0180
Lucerne silase	0,0	0,36	0,0300
Clover-grass mixtures hay	0,0	0,86	0,0150
Clover and their mixtures silase	0,0	0,345	0,0052

Emission factor (EF_1) that was used for calculation of N_2O emission – 0,0125 kg N_2O-N/kg N[101].

Crop residue (CRF 4.D.1.4)

The annual production of residue N is also estimated using Tier 1b method. The amount of nitrogen returning to soils annually through incorporation of crop residues (F_{CR}) were estimated by determining the total amount of crop residue N produced (from both non-nitrogen-fixing crops (Table 6-65 and 6-66) and N-fixing crops (Table 6-63)). For calculations the following equation was used[102]:

$$F_{CR} = \sum_i [(Crop_{0i} \cdot Res_{0i}/Crop_{0i} \cdot Frac_{DMi} \cdot Frac_{NCROi}) \cdot (1 - Frac_{BURNi} - Frac_{FUEL-CRi} - Frac_{CNST-CRi} - Frac_{FODi})] + \sum_j \left[\left(Crop_{BFj} \cdot Res_{BFj}/Crop_{BFj} \cdot Frac_{DMj} \cdot Frac_{NCRBFj}\right) \cdot \left(1 - Frac_{BURNj} - Frac_{FUEL-CRj} - Frac_{CNST-CRj} - Frac_{FODj}\right)\right]$$

where:
$Crop_0$ and *$Crop_{BF}$* – production of non-N-fixing crops, kg dry biomass/yr;
$Res_0/Crop_0$ and *$Res_{BF}/Crop_{BF}$* – the residue to crop product mass ratio;

[94] *IPCC GPG 2000*. Agriculture, p. 4.57
[95] *Revised 1996 IPCC*. Reference Manual. Agriculture, Table 4-19, p. 4.94
[96] Gyvulininkystės žinynas. Baisogala, Institute of Animal Science of LVA. 2007
[97] *IPCC GPG 2000*. Agriculture, Table 4.16, p. 4.58
[98] National Inventory Report of Hungary, 2011. Table 6.20, p. 132
[99] National Inventory Report of Estonia, 2012. Table 6.53, p. 251
[100] National Inventory Report of Denmark, 2009, Table 6.25, p. 271
[101] *Revised 1996 IPCC*. Reference Manual. Agriculture, Table 4-18, p. 4.89
[102] *IPCC GPG 2000*. Agriculture. Eq. 4.29, p. 4.59

$Frac_{DM}$ – the dry matter content of the aboveground biomass;
$Frac_{NCR0}$ and $Frac_{NCRBF}$ – the nitrogen content of the aboveground biomass, kg N/kg of dry biomass;
$Frac_{BURN}$ – the fraction of residue burned in the field before and after harvest;
$Frac_{FUEL-CR}$ – the fraction of residue used as fuel;
$Frac_{CNST-CR}$ – the fraction of residue used for construction;
$Frac_{FOD}$ – the fraction of residue used as fodder, N/kg crop-N.
Non of the harvested crops used in calculations were burned in field, used as fuel or material for construction therefore indicated as 0 in equation. Some of the crops were used for fodder.

Table 6-65. Harvested crop yield by type in Lithuania during the period 1990-2012, thous. tonnes

Year	Harvested crop yield						
	Wheat	**Triticale**	**Rye**	**Barley**	**Oats**	**Other cereals**	**Buckwheat**
1990	1183,7	0,0	470,2	1196,4	195,7	18,7	0,2
1991	854,9	0,0	344,8	1699,2	232,9	21,3	0,2
1992	833,8	0,0	342,4	955,1	50,9	15,2	0,2
1993	890,6	39,3	434,1	1207,9	77,7	21,6	1,3
1994	549,4	50,6	313,0	1090,5	69,0	25,5	0,2
1995	637,3	46,6	239,3	891,5	66,7	24,5	0,6
1996	936,2	77,6	286,8	1176,6	101,6	34,8	1,5
1997	1127,4	114,1	348,2	1193,5	111,7	46,9	3,5
1998	1031,0	94,9	348,7	1104,3	97,2	32,7	8,0
1999	870,9	85,1	260,9	741,6	67,1	14,2	8,6
2000	1237,6	130,9	311,4	859,6	82,9	19,8	14,7
2001	1076,3	143,8	231,1	776,2	84,3	19,8	12,7
2002	1217,6	145,3	170,2	871,1	97,5	18,5	10,6
2003	1204,1	214,2	147,1	899,8	114,6	28,6	14,7
2004	1430,2	263,4	140,6	859,8	117,7	31,6	13,0
2005	1379,4	201,1	108,3	948,3	114,1	39,0	15,7
2006	809,8	110,4	90,0	743,8	62,8	27,0	8,9
2007	1390,7	227,6	165,2	1013,7	119,5	52,6	20,9
2008	1722,5	311,0	204,9	970,4	140,8	19,2	20,9
2009	2100,2	426,0	207,9	858,2	142,5	33,2	14,7
2010	1710,4	258,4	87,0	550,0	93,9	34,6	14,0
2011	1869,3	237,0	85,0	759,8	128,5	47,0	26,0
2012	2998,9	434,8	156,6	741,9	163,5	50,0	30,6

Table 6-66. Harvested crop yield by type in Lithuania during the period 1990-2012 thous. tonnes

Year	Harvested crop yield						
	Maize for grain	**Linseed**	**Sugar beet**	**Rape seed**	**Potatoes**	**Vegetables**	**Feed beet**
1990	0,0	10,2	718,1	28,0	1531,1	295,0	2678,8
1991	0,0	10,2	811,2	12,5	1508,3	398,4	2446,0
1992	0,0	3,1	621,5	7,6	1079,2	259,8	1417,6
1993	0,0	1,2	855,3	3,1	1772,6	376,0	1998,3
1994	0,0	3,5	461,5	13,2	1096,4	282,6	1324,7
1995	0,0	6,5	692,4	18,9	1593,5	368,7	2188,9
1996	0,0	3,2	795,5	22,6	2044,3	432,6	1718,4
1997	0,0	2,9	1001,9	37,2	1829,8	415,0	1829,7
1998	0,0	2,7	949,2	71,9	1849,2	436,9	2026,0
1999	0,0	3,7	869,9	115,1	1708,1	325,1	1573,3

2000	0,0	2,7	881,6	81,0	1791,6	329,4	1399,4
2001	0,0	0,9	880,4	64,8	1054,4	322,0	1382,9
2002	8,3	2,7	1052,4	105,6	1531,3	290,0	1136,2
2003	8,7	2,7	977,4	119,5	1445,2	549,3	944,7
2004	3,0	1,8	904,9	204,7	1021,4	379,4	385,3
2005	4,9	2,0	798,5	201,2	894,7	369,2	375,7
2006	4,7	0,7	717,1	169,6	457,1	225,5	195,5
2007	26,0	0,3	799,9	311,9	576,1	281,9	164,6
2008	32,0	0,2	339,1	330,2	716,4	310,4	134,3
2009	23,8	0,2	682,0	415,8	662,5	321,7	113,3
2010	47,5	0,2	706,7	416,7	476,9	188,6	40,8
2011	71,9	0,4	877,8	484,3	587,7	315,0	50,5
2012	78,8	0,2	1003,0	632,9	549,9	307,4	48,6

The values that were used for calculations are presented in Table 6-67. These factors represents country specific values, IPCC default values and values of other countires`.

Table 6-67. Factors used for calculation of the nitrogen content in crop residues returned to soils[103,104,105,106,107]

Crop type	Factor			
	$Res_0/Crop_0$	$Frac_{DM}$	$Frac_{NCR0}$	$Frac_{FOD}$
Wheat	1,3	0,850	0,0028	0,07
Triticale	1,3	0,880	0,0028	0,07
Rye	1,6	0,850	0,0048	0,00
Barley	1,2	0,853	0,0043	0,07
Oats	1,3	0,860	0,0070	0,07
Other cereals	1,3	0,850	0,0150	0,07
Buckwheat	1,3	0,850	0,0150	0,00
Maize for grain	1,0	0,860	0,0081	0,00
Linseed	1,0	0,910	0,0150	0,00
Sugar beet	0,3	0,230	0,0228	0,00
Rapeseed	2,1	0,880	0,0150	0,00
Potatoes	0,4	0,220	0,0110	0,00
Vegetables	0,8	0,200	0,0150	0,00
Feed beet	0,3	0,120	0,0228	0,70

For calculation of N_2O emissions the same emission factor of 0,0125 N_2O-N/kg N was used as for N-fixing crops.

Cultivation of histosols (CRF 4.D.1.5)

For assessment of organic soils (histosols)[108] data of the National Forest Inventory was used: area of cropland and grassland (Chapter 7) and percentage of organic soils in these land use categories. NFI provided that area of organic soils in croplands is 0,7% and area of organic soils in grasslands – 10,5%. According to *IPCC 2003* Cropland land use category consist of arable land

[103] *Revised 1996 IPCC*. Agriculture, Table 4-18 and 4-19, p. 4.89, 4.94
[104] Gyvulininkystės žinynas. Baisogala, Institute of Animal Science of LVA. 2007
[105] *IPCC GPG 2000*. Agriculture, Table 4.16, p. 4.58
[106] National Inventory Report of Hungary, 2011. Table 6.20, p. 132
[107] National Inventory Report of Austria, 2011. Table 196, p. 293
[108] Lietuvos pelkių ekonominis vertinimas. Ataskaita, Aplinkos apsaugos politikos centras, 2010

and orchards and berry plantations. To estimate N_2O emissions from cultivation of histosols only arable land was used. To identify total arable land area the area of orchards and berry plantations were eliminated. This data was obtained from the register of Agriculture Information and Rural business center.

N_2O emissions from histosols are based on the area with organic soils multiplied by the emission factor and conversion of N_2O-N to N_2O emissions:

$$N_2O_{Direct} = Area \times EF_2 \times 44/28$$

where:
EF_2 – 8 kg N_2O-N/ha/year[109].
Area – total are of organic soils in Lithuania, ha.

Sewage Sludge applied to soils (CRF 4.D.1.6)

Sewage sludge from wastewater treatment plants is used as soil amendment in Lithuania. According to national waste database – sewage sludge with recovery code R10 is being treated as useful amendment for agricultural soil[110]. Sewage sludge corresponding to this code is a municipal sewage sludge is used for land treatment that results in benefit to agriculture or ecological improvement.

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 in Lithuania. As a result, it was decided to use interpolation for to fill the gaps of data for the period 2000-2003. It was assumed that annual amount of sewage sludge in 1990 is similar to that of 1991.

To calculate the nitrogen input from application of sewage sludge the data of nitrogen concentration (%) was used. This data was obtained from Environmental Protection Agency. 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 2010-2012 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 2010-2012 the arithmetic average value of the years 2004-2009 was used (3,75%).

Note: at the time of NIR preparation activity data for sewage sludge applied to soil was preliminar as data processing takes several months and this data might be updated. This information be checked before next submission and might be changed if necessary.

The following equation was used for calculation of nitrogen input from sewage sludge application to agricultural soils:[111]

$$N_{SEWSLUDGE} = S_{SLUDGE} * S_N/100$$

109 *IPCC GPG 2000*. Agriculture. Table 4-16, p. 4.60
110 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
111 National Inventory Report of Poland, 2012, p. 141

where:
$N_{SEWSLUDGE}$ – annual amount of nitrogen intentionally input to agricultural soils by sewage sludge application, Gg N/year;
S_{SLUDGE} – annual amount of sewage sludge applied to agricultural soils, Gg/year;
S_N – nitrogen content in dry matter, %.

Sewage sludge fertilizer nitrogen, adjusted for volatilization (F_{SL}) was estimated by determining the total amount of sewage sludge fertilizer consumed annually ($N_{SEWSLUDGE}$), and then adjusting this amount by the fraction that volatilizes as NH_3 and NO_x ($Frac_{GASF}$)[112,113]:

$$F_{SL} = N_{SEWSLUDGE} \times (1 - Frac_{GASF})$$

where:
$Frac_{GASF}$ – fraction of total sludge nitrogen that is emitted as NO_x+NH_3, kg N/kg N.

$$N_2O_{DIRECT} = F_{SL} \times EF_1 \times 44/28$$

EF_1 – emission factor.

To calculate annual amount of sewage sludge fertiliezer nitrogen applied to soils default factors from *IPCC GPG 2000* were used:

Table 6-68. Default factors used for estimation of sewerage sludge fertiliser nitrogen[114]

Factor	Unit
EF_1	0,0125 kg N_2O-N/kg N
$Frac_{GASF}$	0,2 kg NH_3-N + NO_x-N/kg of sewage sludge fertilizer nitrogen applied

In Lithuania application of sewage sludge as fertilizer is relatively small. Emissions of N_2O from this subcategory amounted to 0,003 Gg N_2O in 2012 and contributed only 0,05% of N_2O emissions from category direct soil emissions (Figure 6-12).

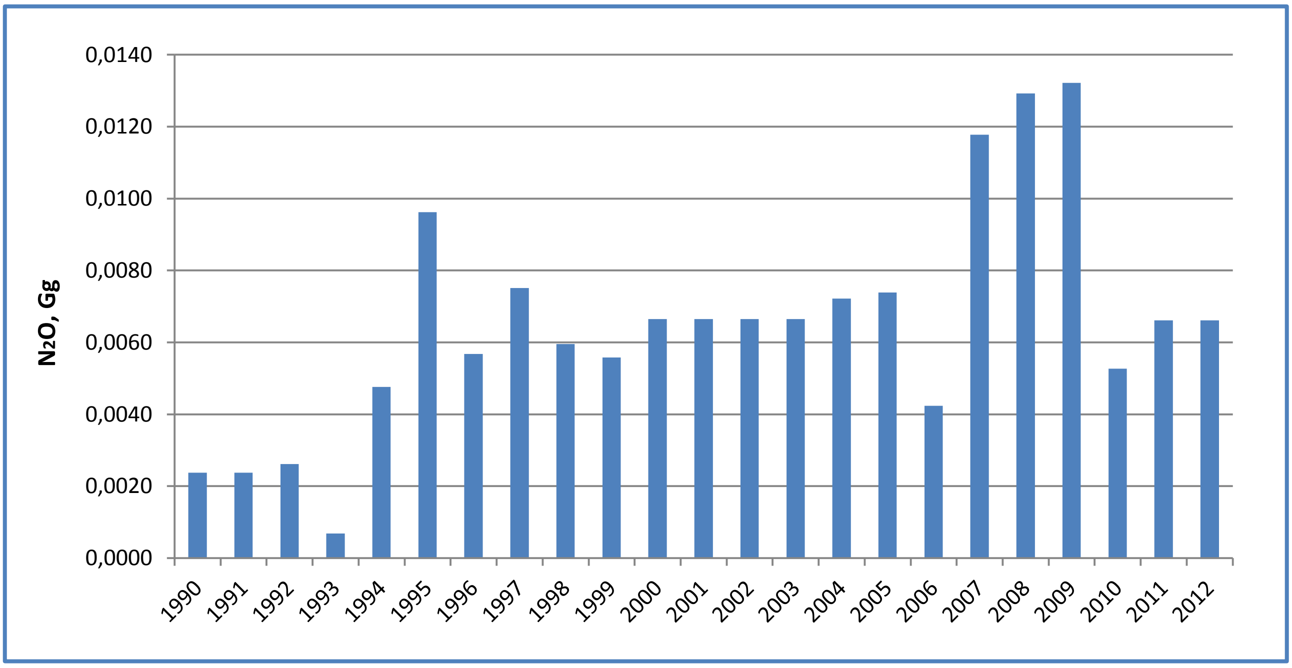

Figure 6-12. N_2O emission from sewage sludge N fertilizers during the periods 1990-2012, Gg

[112] National Inventory Report of Estonia, 2012, Eq. 6.29, p. 256
[113] *IPCC GPG 2000*. Agriculture, Eq. 4.22, p. 4.56
[114] *IPCC GPG 2000*. Agriculture. Eq. 4.20, p. 4.54, Table 4.17, p. 4.60

6.5.1.3 Uncertainties and time-series consistency

Uncertainties in estimates of direct emissions of N_2O from agricultural soils were caused by uncertainties related to the activity data and emission factors. Based on expert judgement, N_2O emission factors uncertainty was assumed to be ±100%, activity data uncertainty ±20%.

6.5.1.4 Source-specific QA/QC and verification

A sector specific QA/QC includes the QC measures outlined in QA/QC plan. These measures are implemented every year during the agricultural inventory. If errors or inconsistencies are found they are documented and corrected.

6.5.1.5 Source-specific recalculations

Recalculations of direct N_2O emission from agricultural soils were performed in this submission due to:

- Recalculations in manure management – N_2O subsector what caused recalculations in subsector animal manure applied to soils (4.D.1.2);
- Following the recommendations of ERT during centralized review 2013 recalculations were performed in subsector sewage sludge using $Frac_{GAZF}$ value 0,2 instead of 0,1 (4.D.16). Also recalculations were performed for the quantity of sewage sludge that was used as amendment to agricultural soils – inaccuracies in data gaps during the period 2000-2003 were corrected.

The relative difference comparing previous and this submission did not exeede more than 0,2% decrease of emissions in subsector direct emissions from agriculture soils.

6.5.1.6 Source-specific planned improvements

No improvements are planned.

6.5.2 Pasture, range and paddock manure (CRF 4.D.2)

6.5.2.1 Source category description

In 2012 N_2O emission from pasture, range and paddock manure during the time-period decreased by 61,2% since 1990 due to decrease of livestock population (Figure 6-13).

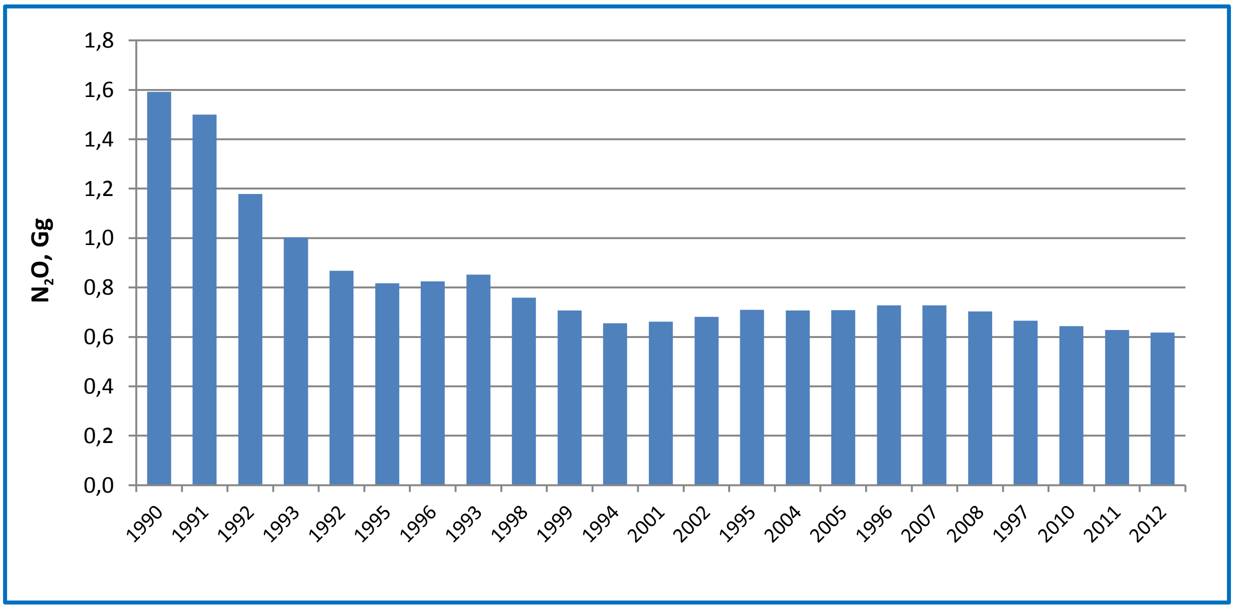

Figure 6-13. N_2O emission from Pasture, range and paddock manure during the period 1990-2012, Gg

6.5.2.2 Methodological issues

Direct N_2O emissions from pasture, range and paddock manure were calculated according to the same methodology as used for estimation of N_2O emissions from manure management (see Chapter Manure management – N_2O emissions (CRF 4.B (b))).

6.5.2.3 Uncertainties and time-series consistency

Uncertainties in estimates of emission of N_2O from pasture, range and paddock manure are caused by uncertainties related to the activity data and emission factor. Based on expert judgement, N_2O emission factor uncertainty was assumed to be ±100%, activity data uncertainty ±20%.

6.5.2.4 Source-specific QA/QC and verification

Source specific QA/QC includes checking of activity data based on Tier 1 method according to QA/QC plan.

6.5.2.5 Source-specific recalculations

N_2O emissions from pasture, randge and paddock manure (4.D.2) were recalculated due to recalculations made in subsector manure management – N_2O (4.B.(b)), but relative difference between this and previous submission was minor. The relative difference between previous and this submission did not exeede more than 1,5%.

6.5.2.6 Source-specific planned improvements

No improvements are planned.

6.5.3 Agricultural soils (CRF 4.D.3) – indirect emissions

6.5.3.1 Source category description

Indirect N_2O emissions from agricultural soils consists of emissions from leaching and runoff of the applied or deposited on soils nitrogen and atmospheric deposition on soils of NO_X and ammonium.

Figure 6-14 shows total emission of N_2O from indirect emissions of agricultural soils and distribution between two subcategories – atmospheric deposition (4.D.3.1) and nitrogen leaching and run-off (4.D.3.2).

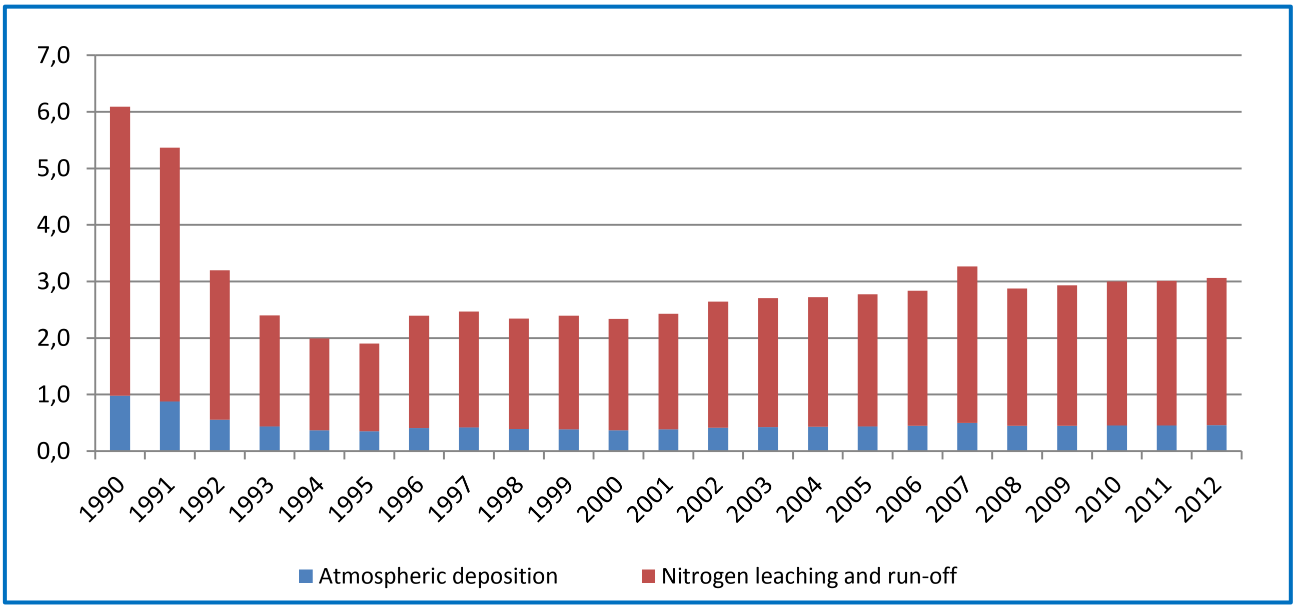

Figure 6-14. Indirect N_2O emissions from agricultural soils during the period 1990–2012, Gg

The total indirect N_2O emissions from agricultural soils were 3,06 Gg in 2012. N_2O emission from atmospheric deposition and nitrogen leaching and run-off in 2012 decreased by 53,3% and 49% respectively comparing to 1990 due to decrease of consumption of synthetic fertilizers and number of livestock population (Figure 6-14).

6.5.3.2 Methodological issues

Activity data used to estimate indirect N_2O emissions from agricultural soils were amount of nitrogen applied to soils from synthetic fertilizers, animal manure and sewage sludge fertilizers excreted. Amount of sewage sludge (R10) and nitrogen (N) concentration in sludge were used for calculations same as were used in the Sewage Sludge applied to soils (CRF 4.D.1.6)[115].

Atmospheric deposition (4.D.3.1)

Atmospheric deposition in our calculations includes the emission from livestock manure, use of synthetic fertilizers and sewage sludge applied to agricultural soils.

Tier 1b method and equation 4.32 were used for estimating emissions of N_2O from atmospheric deposition:[116]

[115] *IPCC GPG 2000*. Agriculture. Footnote 21, p. 4.70
[116] *IPCC GPG 2000*. Agriculture. Eq. 4-32, p. 4.70

$$N_2O_{(G\text{-}SOIL)}\text{-}N = \{(N_{FERT} * Frac_{GASF}) + [(\Sigma T(N_{(T)} * Nex_{(T)}) + N_{SEWSLUDGE}] * Frac_{GASM}\} * EF_4$$

where:
$N_2O_{(G\text{-}SOIL)}$ – N_2O produced from atmospheric deposition of N, Gg N/yr;
N_{FERT} – total amount of synthetic nitrogen fertilizer applied to soils, Gg N/yr;
$Frac_{GASF}$ – fraction of synthetic N fertiliser that volatilises as NH_3 and NO_x, kg NH_3-N and NO_x-N/kg of N input;
$\Sigma_T(N_{(T)} * Nex_{(T)})$– total amount of animal manure nitrogen excreted in a country, Gg N/yr;
$N_{SEWSLUDGE}$ – annual amount of nitrogen intentionally used to agricultural soils by sewage sludge application, Gg N/year;
$Frac_{GASM}$ – fraction of animal manure N that volatilises as NH_3 and NO_x, kg NH_3-N and NO_x-N/kg of N excreted;
EF_4 – emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, kg N_2O-N/kg NH_3-N and NO_x-N emitted.

Conversion of N_2O-N emissions to N_2O emissions is performed by the following equation:

$$N_2O = N_2O\text{-}N \times 44/28$$

Table 6-69. IPCC default factors used in estimation of indirect N_2O emissions from atmospheric deposition[117]

Factor	Unit
N_2O EF	0,01 kg N_2O-N/kg NH_4-N & NO_x-N deposited
$Frac_{GASF}$	0,1 kg NH_3-N + NO_x-N/kg of synthetic fertilizer N applied
$Frac_{GASM}$	0,2 kg NH_3-N + NO_x-N/kg of N excreted by livestock

Leaching and runoff (4.D.3.2)

Part of the nitrogen is lost from agricultural soils through leaching and runoff, and gets to the groundwater, rivers and wetlands resulting in biogenic production of N_2O. *Tier 1b* method was used for estimation of N_2O emissions from leaching and runoff:[118]

$$N_2O_{(L\text{-}SOIL)}\text{-}N = [N_{FERT} + (\Sigma_T(N_{(T)} * Nex_{(T)}) + N_{SEWSLUDGE}] * Frac_{LEACH} * EF_5$$

where:
$N_2O_{(L\text{-}SOIL)}$ – N_2O-N emissions produced from leaching and runoff of N, Gg N/yr;
N_{FERT} – total amount of synthetic nitrogen fertilizer applied to soils, Gg N/yr;
$\Sigma_T(N_{(T)} * Nex_{(T)})$ – total amount of animal manure nitrogen excreted in a country, Gg N/yr;
$N_{SEWSLUDGE}$ – annual amount of nitrogen intentionally used to agricultural soils by sewage sludge application, Gg N/year;
$Frac_{LEACH}$ – fraction of nitrogen applied on soils that leaches as NH_3 and NO_x, kg NH_3-N and NO_x-N/kg of N excreted;
EF_5 – emission factor for leaching and runoff, kg N_2O-N/kg N leaching and runoff.

Conversion of N_2O–N emissions to N_2O emissions is performed by the following equation:

$$N_2O = N_2O\text{–}N \times 44/28$$

[117] *Revised 1996 IPCC*. Agriculture, p. 4.94, 4.105
[118] *IPCC GPG 2000*. Agriculture, Eq. 4-34, p. 4.71; National Inventory Report of Poland, 2012. p. 144; National Inventory Report of Estonia, 2012, Eq. 6-32, p. 264

Table 6-70. IPCC default factors used in the estimation of indirect N_2O emissions from nitrogen leaching and run- off[119]

Factor	Unit
N_2O EF	0,025 kg N_2O-N/kg N
$Frac_{LEACH}$	0,3 kg NH_3-N + NO_x-N/kg of synthetic fertilizer N applied

6.5.4 Uncertainties and time-series consistency

Information about emission factors, leaching and volatilization fractions are sparse and highly variable. Expert judgment indicates that emission factor uncertainties are at least in order of magnitude and volatilization fractions of about ±100%, activity data uncertainty ±20%.

6.5.5 Source-specific QA/QC and verification

Source specific QA/QC includes checking of activity data based on Tier 1 method according to QA/QC plan.

6.5.6 Source-specific recalculations

Recalculations in the subsector "Indirect emissions from agricultural soils" are related to N_2O emission recalculations made in manure management subsector. Relative difference between emissions calculated in this submission and presented in previous submission are not very significant. The relative difference between previous and this submission was very small and varied from -0,7% to 0,1%.

6.5.7 Source-specific planned improvements

No improvements are planned.

6.6 Prescribed burning of savannas (CRF 4.E)

Savannas do not exist in Lithuania.

6.7 Field burning of agricultural residues (CRF 4.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)[120], therefore emission from field burning of agricultural residues is reported as "NO".

[119] *Revised 1996 IPCC*. Agriculture, p. 4.105-4.106

[120] 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

7 LAND USE, LAND USE CHANGE AND FORESTRY (CRF Sector 5)

7.1 Overview of LULUCF

Land Use, Land Use Change and Forestry (LULUCF) sector in Lithuania has been acting as a sink during two periods of time: 1990 – 1995 and 1998 – 2012 (Figure 7-1). 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.

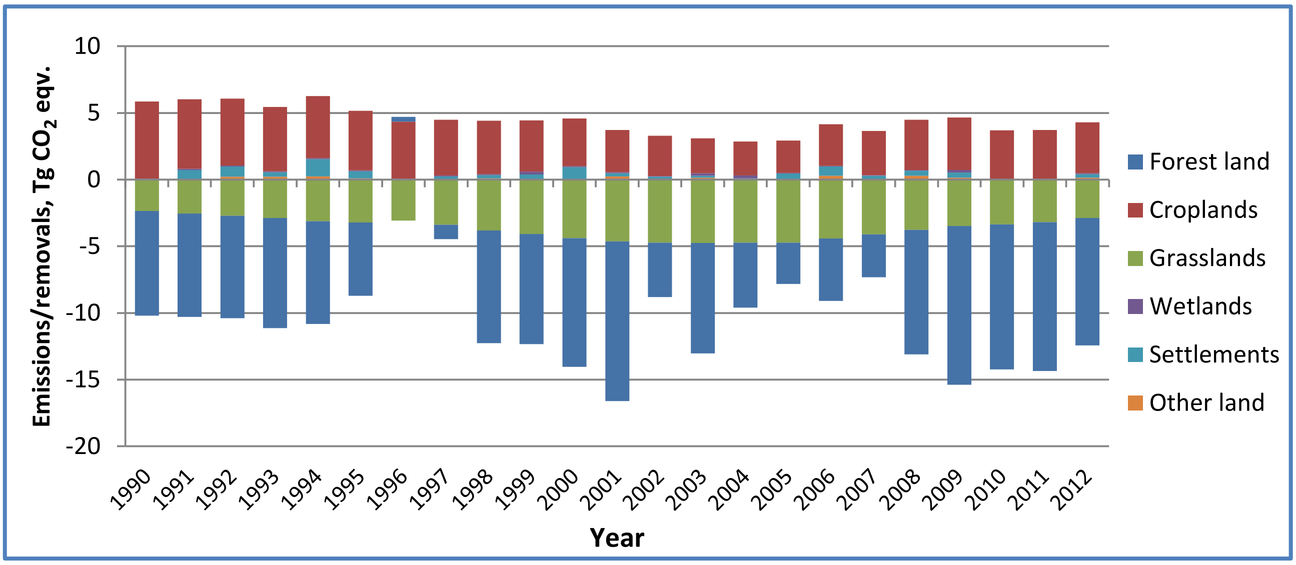

Figure 7-1. Net CO_2 eqv. emissions and removals from LULUCF sector in 1990 – 2012 by land use category. The possitive values shows emisions and negative – removals

Lithuania has improved its reporting system of greenhouse gases from LULUCF sector substantially since 2011 and has a clear subordination among data providers and executors. There are several organizations and activities responsible for provision of the official data related to Land Use Land Use Change and Forestry reporting in Lithuania. These organizations and activities are presented below:

- **National Land Service** (NLS) under the Ministry of Agriculture[121] 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 data associated with registered areas of forest land and detail information about all forest holdings regardless their ownership[122].

- **National Forest Inventory** (NFI) executed by State Forest Service provides objective and known accuracy data associated with forest land, forest land use and forest resources (growing stock volume, annual increment, fellings, dead wood and etc.). Information for this dataset is collected by using unique sampling technique since 1998. Data presented by NFI is used for monitoring and reporting of land use and land use changes under the

[121] *Available from: http://www.nzt.lt/go.php/lit/English*
[122] *Available from: http://www.amvmt.lt*

Convention requirements as a continuation of the implemented Studies (*see Chapter 7.1.1. 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 statistical databases on their website[123].
- Statistical data about Lithuanian forests and forestry are published in annual reports "**Forest assessment**", annual publications "**Lithuanian Statistical Yearbook of Forestry**", periodical publications of NFI[124] and National forest resources assessment (FRA) reports[125].
- **National Land Service** publishes annual statistical information on all land use categories in Lithuania in publication "Land Fund of the Republic of Lithuania"[126].

Several legal acts were adopted or amended during 2011-2012 in order to establish connections between different institutions, providing data for greenhouse gas accounting in LULUCF sector and to increase consistency, completeness and transparency of the methods and approaches used for reporting:

- **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.

Following the requirements of *Good Practice Guidance for Land Use, Land-Use Change and Forestry 2003*, (*IPCC 2003*) provision of official statistics has been improved substantially, and

[123] *Available from: http://www.stat.gov.lt/en/*
[124] *Available from: http://www.amvmt.lt*
[125] *Available from: http://www.fao.org/forestry/fra/en/*
[126] *Available from: www.zis.lt/download.php/fileid/77*

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 special studies;
2) Since 2012 all data concerning land use, land use changes is based on direct annual field measurements executed by NFI.

Above mentioned data sources that have been used for determination of the total land area and to monitor changes reported in the previous submissions, were not harmonised between themselves and data presented not always was precise or did not fulfil the requirements of the United Nations Framework Convention on Climate Change (UNFCCC). Most of results were fragmented and did not cover the required 1990-2011 period. Due to different inventory methodologies and the definitions of land use categories for each inventory, the presented results did not complied each other. Furthermore, land use definitions used by the statistics, on which basis land area was estimated, did not comply with the *IPCC 2003* (Table 7-5). For instance, meadows and natural pastures were assigned to croplands in national definition, though it comes under grassland category under *IPCC 2003* 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 required time period of 1990 – 2011. 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 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 7-2).

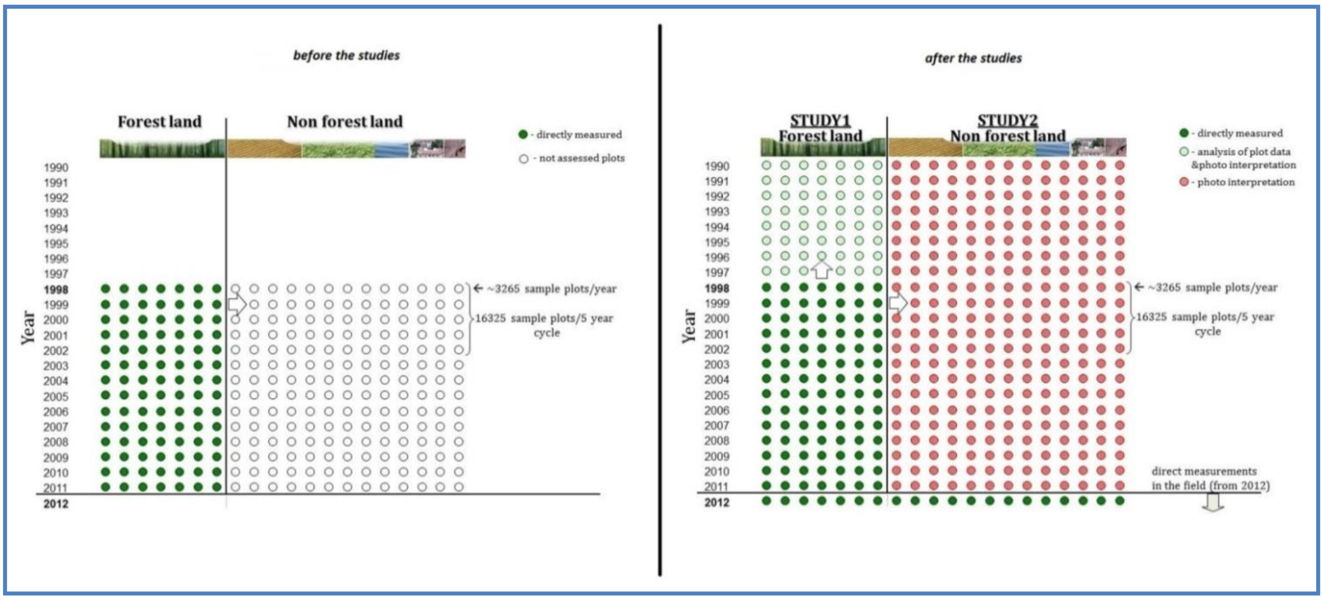

Figure 7-2. Data owned for the assessment of land-use changes before the studies (NFI data since 1998) and assessment of the land-use changes on NFI sample plots grid after implementation of the studies for the period of 1990-2011. Filled dots represent data that was owned before/after the studies.

Furthermore, with the help of GIS techniques, analysing historical datasets of Lithuanian State Forest Cadastre, aerial photography archives, provided by State Land Fund and other available material, wall-to-wall areas of Afforestation, Reforestation and Deforestation activities were mapped, identified and classified during the *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 01.01.2013. According to NFI data, total land area is 6530 thous. ha. Forest land occupy 33,5%, croplands – 32,2%, grasslands – 23,6%, wetlands – 5,2%, settlements – 5,2% and other land – 0,2% of the total land area in Lithuania (Figure 7-3).

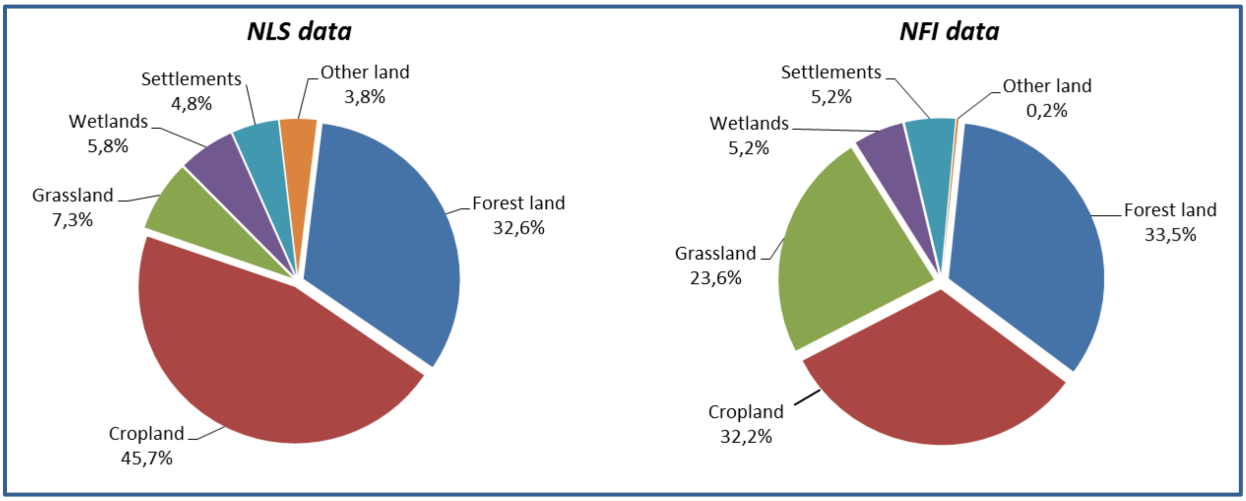

Figure 7-3. Comparison of land-use categories presented by NLS and latest NFI data (*Study-1, Study-2 data was used up to 2011*). 01.01.2013

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 of distribution of total land area among relevant land use categories is used.

Several emission sources in the LULUCF sector are identified as key categories. They are listed in Table 7-1 (including LULUCF, by Level and Trend assessment).

Table 7-1. Key category from LULUCF in 2012 by Level and Trend

IPCC source categoty	Gas	Identification criteria	Approach used
5.A.1 Forest Land remaining Forest Land	CO_2	Level	Tier 1 / Tier 2
		Trend	Tier 1 / Tier 2
5.A.2 Land Converted to Forest Land	CO_2	Level	Tier 1 / Tier 2
		Trend	Tier 1 / Tier 2
5.B Cropland	CH_4	Level	Tier 1 / Tier 2
		Trend	Tier 1 / Tier 2
5.C Grassland	CO_2	Level	Tier 1 / Tier 2
		Trend	Tier 1 / Tier 2
5.E Settlements	CO_2	Level	Tier 1 / Tier 2
		Trend	Tier 1 / Tier 2
5.F Other land	CO_2	Level	-
		Trend	Tier 2

7.1.1 Study "Forest land changes in Lithuania during 1990 – 2011" *(Study-1)*

The *Study-1* was carried out by the team of specialists of Aleksandras Stulginskis University (former Lithuanian University of Agriculture) together with NFI specialists 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 prepared report[127].

The *Study-1* was splitted 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* and the requirements of UNFCCC on the unique permanent sample plots grid of National Forest Inventory 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 7-7).
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 least 50 years (R2), but ceased to be forest on 31 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 for storing 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 State Forest Cadastre 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*. All available auxiliary data sets (such as State Forest Cadastre data, maps from previous stand-wise forest

[127] *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.*

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: State Forest Cadastre, 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[128], other projects done by the contractors. The main data source used was the geographic data from the State Forest Cadastre. 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 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 newly 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-out on a 10-years cycle base, 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. First, 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 National Paying Agency 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.

[128] *Available from: http://earthexplorer.usgs.gov/*

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 off all, deforestation accounted in the SFC were 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 State Forest Cadastre 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 for storing 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 7-2) for the period 1990-2011 which fits the requirements of *IPCC 2003*. 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.

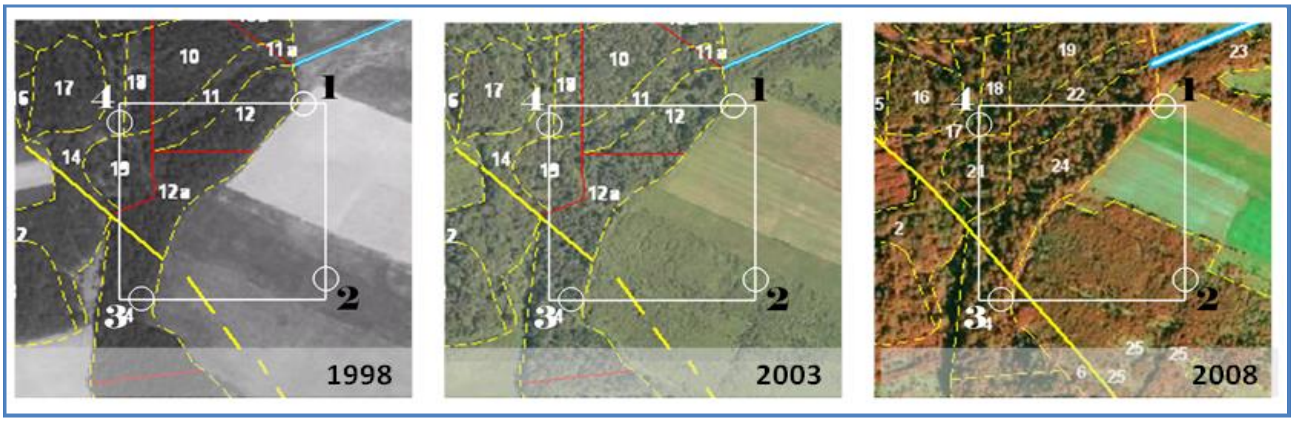

Figure 7-4. Land use changes according to NFI data

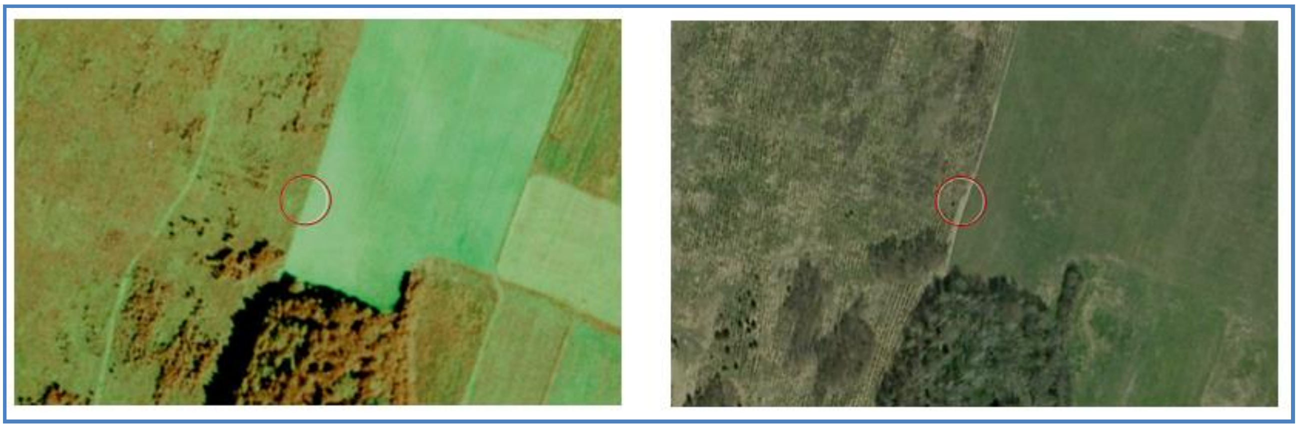

Figure 7-5. Grassland converted to Forest Land

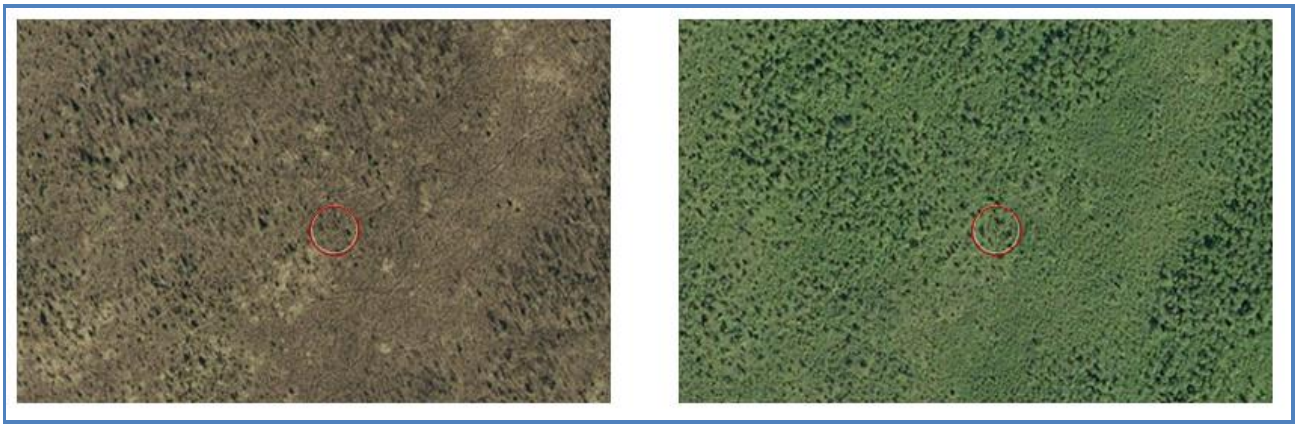

Figure 7-6. Wetland converted to Forest Land

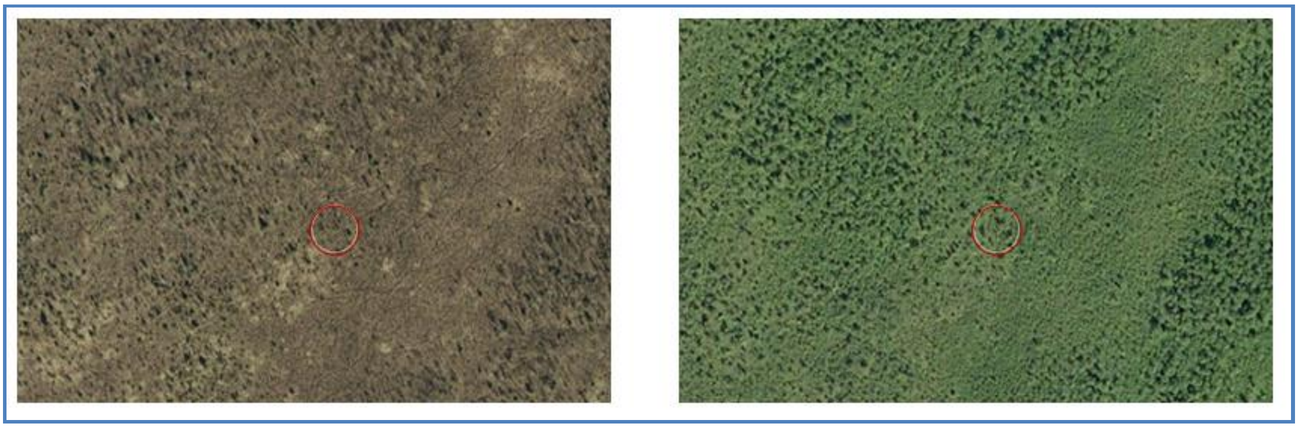

Figure 7-7. Wetland converted to Forest Land

7.1.2 Study "Changes of areas of Croplands, Grasslands, Wetlands, Settlements and Other lands in Lithuania during 1990-2011" (*Study-2*)

The *Study-2* was carried out by the specialists of State Land Fund. 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*.

Annual identification of different land categories was carried out on 16325 systematically distributed sample plots available from Lithuanian National Forest Inventory 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 performed:

- 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 orthophotomaps 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 National Forest Inventory sample plots grid and statistical data provided by Land Fund together with digital orthophotomaps, 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 7-2). 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 material is presented in Figure 7-8. The same tract of sample plots is depicted in every photo but in different time periods and was assessed by SLF specialists.

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 7-8. 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[129].

As the result of *Study-1* and *Study-2* which are based on point sampling method (NFI permanent sample plots) land transition matrix was compiled for each year for the period of 1990-2011. Since 2012 land use transition matrix is prepared using NFI data (Table 7-2; Annex VI).

Table 7-2. Yearly land transition matrix for 2012, ha (01.01.2012 - 01.01.2013)

Land category	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	**Final**	**Net change**
Forest land	2173205	1997	8787	799	0	0	2184788	**11583**
Cropland	0	2083337	30335	0	0	0	2113692	**30355**
Grassland	0	5192	1527355	0	0	0	1532547	**5192**
Wetlands	0	0	0	342297	0	0	342297	**0**
Settlements	0	0	799	0	341897	0	342696	**799**
Other land	0	0	399	0	0	13580	13979	**399**
Initial	**2173205**	**2090527**	**2090527**	**343096**	**341897**	**13580**	**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 7-3.

Table 7-3. Reported emissions/removals and calculation methods for LULUCF sector

CRF category	**Stock change reported**	**Emission / removal reported**	**Methods / Tiers used**
5.A	carbon/CO_2	CO_2; N_2O; CH_4	T1; T2
5.B	carbon/CO_2	CO_2; N_2O; CH_4	T1
5.C	carbon/CO_2	CO_2; N_2O; CH_4	T1
5.D	carbon/CO_2	CO_2	T1
5.E	carbon/CO_2	CO_2	T1
5.F	carbon/CO_2	CO_2	T1

Reconciliation of the executed studies

Both studies were launched in order to recover land use data until 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 lacking data for the period of 1990-1997 as it is required by UNFCCC and Kyoto Protocol for GHG reporting.

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

[129] *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.*

plots assignment to different land use categories. Connecting element for both studies was uniform National Forest Inventory 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.

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 State Forest Cadastre 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 State Forest Service 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 State Forest Service. 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 7-9.

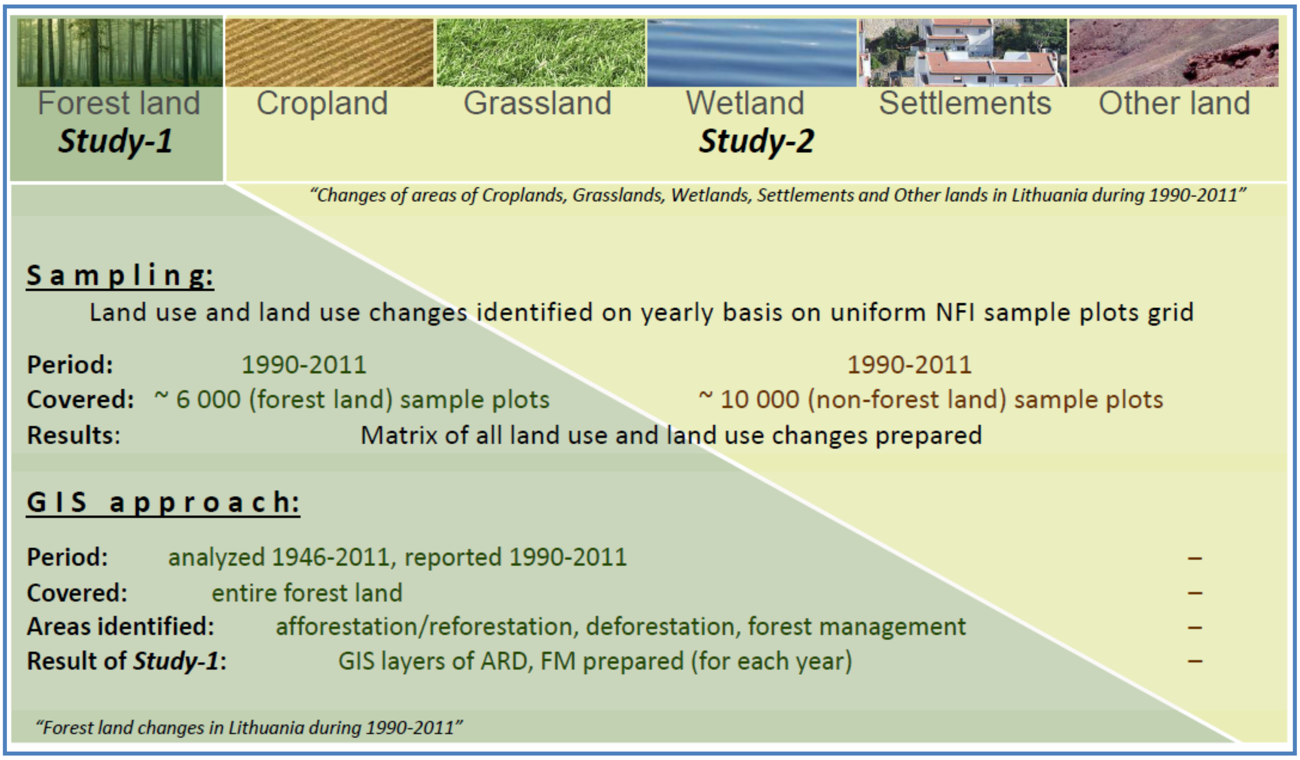

Figure 7-9. Studies on land use changes in 1990-2011

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 7.1*), setting the rules, and also obliging, forest owners and managers to register newly afforested, reforested and deforested areas to State Forest Cadastre, which will serve as the main data provider for ARD areas identification reported under the Kyoto Protocol starting with 2012.

7.1.3 National definitions for all categories used in the inventory

The land areas used in the inventory are consistent with those defined in *IPCC 2003*. The national classification of land-use areas was adjusted to the requirements of *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 (Table 7-5).

Forest land is defined according to Law on Forests of the Republic of Lithuania[130]. 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 7-4).

Table 7-4. 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.

Wetlands. 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.

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

[130] *Available from: http://www3.lrs.lt/pls/inter3/dokpaieska.showdoc_l?p_id=437404&p_query=&p_tr2=2*

only used for householders' meanings. Only the areas of settlements remaining settlements and lands converted to settlements are reported. Settlements are managed land.

<u>*Other land.*</u> 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 7-5. National definitions for land use categories and relevant land use category defined in IPCC 2003

<table>
<tr><th colspan="11">National definitions for land use categories and subcategories</th></tr>
<tr><th colspan="3">Agricultural land</th><th rowspan="2">Forest land</th><th rowspan="2">Roads</th><th rowspan="2">Settlements</th><th rowspan="2">Water bodies</th><th colspan="4">Other land</th></tr>
<tr><th>Arable land</th><th>Orchards and berry plantations</th><th>Meadows and natural pastures</th><th>Swamps (bogs)</th><th>Trees and bushes plantations in urban areas</th><th>Disturbed land</th><th>Unmanaged land</th></tr>
<tr><th colspan="11">Relevant category in IPCC 2003</th></tr>
<tr><td colspan="2">Cropland</td><td>Grassland</td><td>Forest land</td><td colspan="2">Settlements</td><td colspan="2">Wetlands</td><td>Settlements</td><td colspan="2">Other land</td></tr>
</table>

Information on extension of unmanaged forest and grassland

According to the Annex to 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 land and grasslands in Lithuania are managed and there is no unmanaged forest land or grasslands.

7.1.4 Land use changes

Forest coverage in Lithuania remains continuously increasing during the last decades (Figure 7-11). Natural and human induced afforestation increased forest land area by 123,4 thous. ha since 1990 (Table 7-7). Comparing with 1946, forest area increased more than one third and in some counties forest expansion almost doubled.

Declared croplands area in Lithuania was decreasing since 1990 to 2005. This is closely connected with 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 7-6. National land use data for 1990-2012, thous. ha[131]

Years	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	Total
1990	2061,4	2426,0	1307,7	363,1	324,3	47,5	6530
1991	2068,6	2386,5	1350,0	357,9	325,5	41,5	6530
1992	2074,6	2346,6	1392,0	356,3	327,1	33,6	6530
1993	2079,7	2311,0	1431,5	354,7	325,9	27,2	6530
1994	2082,5	2269,5	1473,0	354,7	329,1	21,2	6530
1995	2084,9	2233,1	1513,4	354,7	328,7	15,2	6530
1996	2090,1	2215,9	1527,4	352,7	327,5	15,2	6530
1997	2093,7	2183,6	1555,7	352,7	329,1	15,2	6530
1998	2097,3	2134,5	1600,4	352,3	330,3	15,2	6530
1999	2100,1	2088,5	1643,2	351,5	331,5	15,2	6530
2000	2105,7	2029,4	1697,1	348,7	334,3	14,8	6530
2001	2108,9	1967,5	1755,8	348,3	335,1	14,4	6530
2002	2113,3	1918,8	1799,4	349,1	335,9	13,6	6530
2003	2118,9	1876,8	1836,5	348,3	335,9	13,6	6530
2004	2126,9	1854,9	1850,9	347,9	336,3	13,2	6530
2005	2134,9	1835,3	1862,5	347,1	337,9	12,4	6530
2006	2142,1	1893,2	1796,2	345,5	339,9	13,2	6530
2007	2150,4	1952,7	1729,5	343,9	340,7	12,8	6530
2008	2157,2	2026,6	1647,2	343,9	341,5	13,6	6530
2009	2160,0	2080,5	1589,3	344,7	341,9	13,6	6530
2010	2166,4	2084,9	1579,7	343,5	341,9	13,6	6530
2011	2173,2	2090,5	1567,7	343,1	341,9	13,6	6530
2012	2184,8	2113,7	1532,5	342,3	342,7	14,0	6530

[131] *Data used: Forest Land – Study-1; Cropland, Grassland, Wetland, Settlement, Other Land – Study-2.*

Table 7-7. Land use changes between 1990 and 2012

Land use	1990	2012	LUC	Activity data provider
	thous. ha			
Forest Land (FL)	2061,4	2184,8	123,4	*Study-1*
Cropland (CL)	2426,0	2113,7	-312,3	*Study-2*
Grassland (GL)	1307,7	1532,5	224,8	*Study-2*
Wetland (WL)	363,1	342,3	-20,8	*Study-2*
Settlements (SL)	324,3	342,7	18,4	*Study-2*
Other Land (OL)	47,5	14,0	-33,5	*Study-2*

7.1.5 GHG sinks and releases

Annual CO_2 emissions and removals for the period 1990-2012 are provided in Table 7-8 (evaluated net CO_2 emissions and removals in LULUCF sector). LULUCF sector in Lithuania has continuously been CO_2 sink with the only emissions of 1639,2 $GgCO_2$ in 1996 and 15,1 $GgCO_2$ in 1997. Removals were ranging from -3565,9 $GgCO_2$ to -12889,3 $GgCO_2$ during the accounting period. In average -6411,6 $GgCO_2$ are removed every year. Removal of CO_2 mainly corresponds to forest land with the smaller share from grasslands.

Table 7-8. Evaluated CO_2 emissions and removals in LULUCF sector, Gg

Year	Forest land	Croplands	Grasslands	Wetlands	Settlements	Other land	Total
1990	-7831,6	5777,3	-2362,4	72,7	NE, NO	NE, NO	-4344,0
1991	-7768,2	5211,9	-2538,2	72,7	732,4	NE, NO	-4289,4
1992	-7664,1	5033,0	-2720,0	72,7	768,6	209,9	-4299,9
1993	-8241,8	4825,6	-2885,8	63,3	349,0	209,9	-5679,7
1994	-7695,7	4642,5	-3119,6	75,3	1291,7	248,4	-4557,5
1995	-5500,0	4449,5	-3219,7	74,9	524,6	104,8	-3565,9
1996	349,3	4281,7	-3066,6	74,7	NE, NO	NE, NO	1639,2
1997	-1086,8	4167,1	-3376,2	67,1	243,9	NE, NO	15,1
1998	-8454,4	4007,1	-3819,7	68,0	243,9	104,8	-7850,3
1999	-8265,4	3850,6	-4079,7	211,1	383,4	NE, NO	-7900,0
2000	-9645,5	3579,0	-4395,5	71,1	942,3	NE, NO	-9448,6
2001	-11991,3	3163,5	-4620,8	71,4	243,9	243,9	-12889,3
2002	-4076,8	3014,8	-4726,3	58,2	209,9	NE, NO	-5520,3
2003	-8273,1	2629,4	-4747,4	194,3	139,1	139,1	-9918,5
2004	-4860,1	2543,9	-4739,0	197,4	104,8	NE, NO	-6753,0
2005	-3085,9	2422,9	-4729,2	55,8	458,8	NE, NO	-4877,6
2006	-4695,2	3120,5	-4411,7	57,6	701,6	283,6	-4943,6
2007	-3219,2	3320,1	-4108,9	56,5	278,6	NE, NO	-3673,0
2008	-9320,2	3766,3	-3775,7	56,1	383,4	278,5	-8611,7
2009	-11899,4	3927,6	-3482,8	196,9	383,4	139,1	-10735,2
2010	-10871,3	3643,7	-3349,9	56,5	NE, NO	NE, NO	-10521,0
2011	-11168,0	3674,4	-3180,1	55,6	NE, NO	NE, NO	-10618,2
2012	-9538,1	3825,6	-2885,2	55,6	278,6	139,1	-8124,4

7.2 Forest land (CRF 5.A)

The definition of forest used in this submission is described in chapter 7.1.3 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.

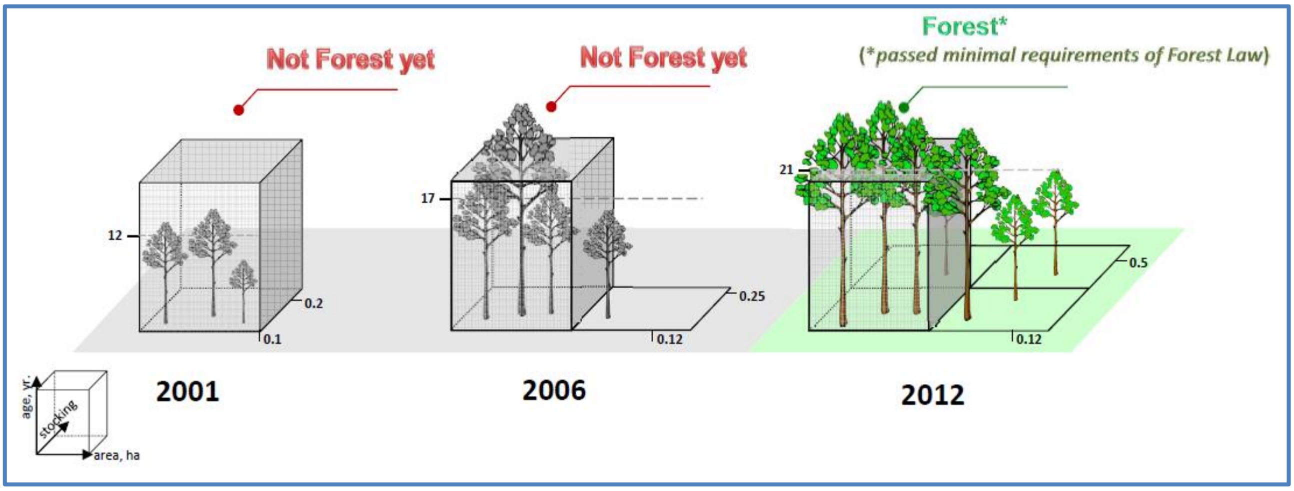

Figure 7-10. Definition of forest applied in Lithuania. Group of trees becomes forest only when reaching certain parameters

7.2.1 Source category description

Forest land area

Forest coverage in Lithuania was expanding continuously since 1948 (Figure 7-11). However data on forest coverage in Lithuania during inter-war period is very limited and the exact numbers are still unknown.

Expert judgement made by the authors of "The Chronicle of Lithuanian Forests. XX Century"[132] allows us to presume forest coverage to be around 21 percent 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 some 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 was existing 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" and being less than 10 ha were disregarded as well as those belonging to small farms and being less than 1 ha in size.

After restoration of independency in 1991, there were no legal obstacles for implementation of forest accounting. However, the land reform has been also started at that time, so the State Forest Inventory (SFI) has been suspended or even discontinued. In 1996, when the new cycle

[132] *Lietuvos Respublikos Aplinkos Ministerija, Miškų departamentas. Lietuvos miškų metraštis. XX amžius. Vilnius, 2003*

of SFI has been started there were found numerous areas of naturally afforested areas that were missing in the previous inventories or in State land accounting related documents.

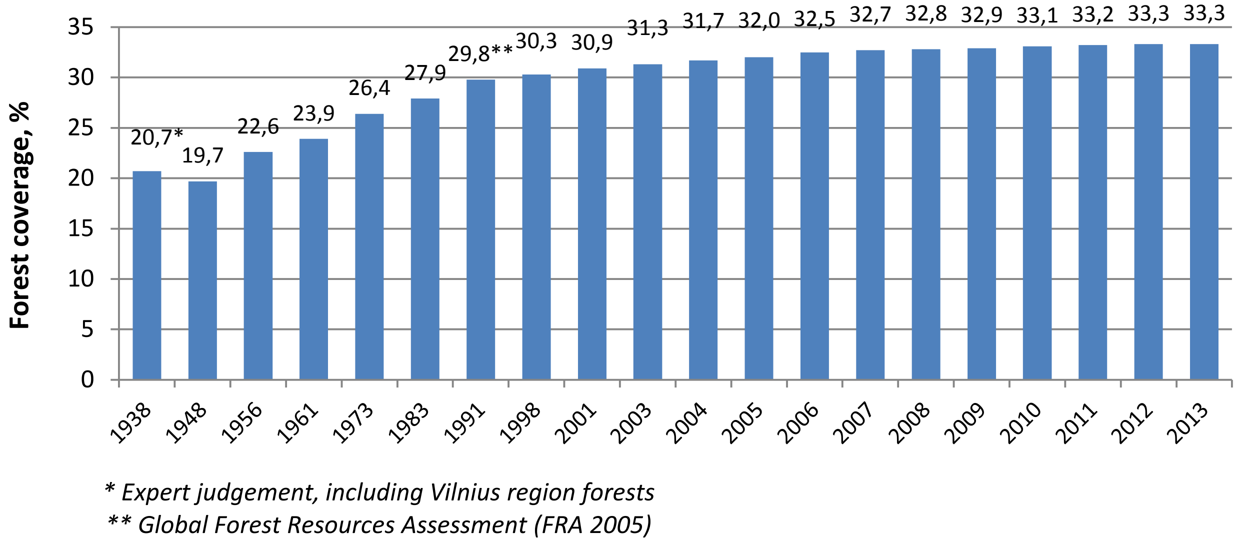

Figure 7-11. Forest coverage 1988-2013.01.01

According to the Lithuanian Statistical Yearbook of Forestry by 1st of January 2013, total forest land area in 2012 was 2173,0 thous. ha, covering 33,3% of the country's territory. The average forest area per capita increased from 0,57 ha to 0,68 ha. Around half of all forest land in Lithuania is of State importance – 1076,5 thous. ha. Around 810,3 thous. ha of private forests are registered 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 844,5 thous. ha. Since the 1st of January 2003, the forest land area has increased by 128,0 thous. ha corresponding to 2,0% of the total forest cover. During the same period, forest stands expanded by 104,0 thous. ha to 2055,0 thous. ha. Average annual increase in forest area is more than 5 thous. ha. Following prior official data of Forest Assessment[133] 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 January 2013 Forest Assessment that is based on data of State Forest Cadastre shows nearly the same forest coverage as the National Forest Inventory, which is based on permanent sample plots data (Figure 7-12).

[133] *Kuliešis, A., Vižlenskas, D., Butkus, A. et al. 2010. Forest Assessment. State Forest Service.*

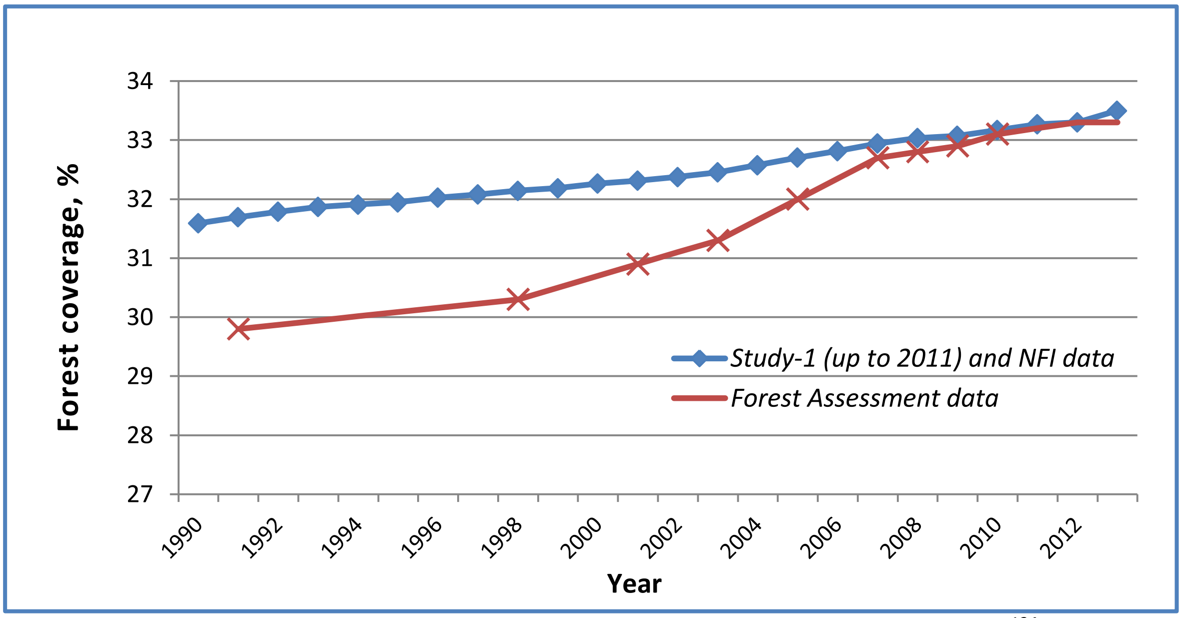

Figure 7-12. Changes in forest coverage in Lithuania 1990-2012, 2013.01.01[134]

All Lithuanian forests are distributed into four functional groups. In the beginning of 2013, 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): 266,8 thous. ha (12,3%); group III (protective forests): 331,2 thous. ha (15,2%); and group IV (exploitable forests): 1549,2 thous. ha (71,3%) (Figure 7-13).

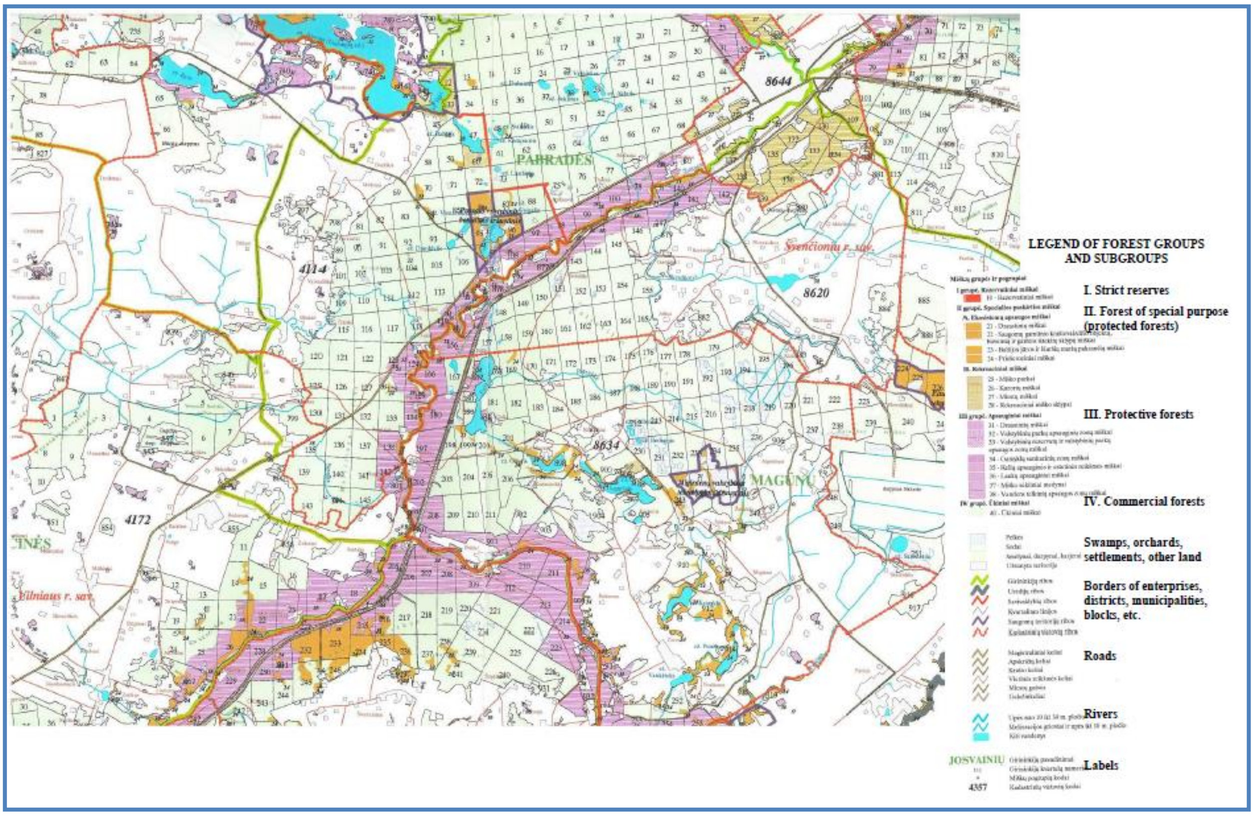

Figure 7-13. Scheme of forest distinguished by forest groups

[134] *Data from Study-1* and *Forest Assessment (2010)*.

Occupying 1152,9 thous. ha, coniferous stands prevail in Lithuania, covering 56,1% of the forest area (Figure 7-14). They are followed by softwood deciduous forests (825,4 thous. ha, 40,2%). Hardwood deciduous forests occupy 76,7 thous. ha (3,7%). Over the last ten years total area of softwood deciduous forests increased by 127,0 thous. ha. The area of hardwood deciduous has decreased by 15,9 thous. ha and coniferous forest by 7,1 thous. ha. Scots pine (*Pinus sylvestris*) occupies the biggest share in Lithuanian forests – 721,2 thous. ha. Compared to 2003, the area of pine expanded by 9,7 thous. ha. Norway spruce (*Picea abies*) covers 429,1 thous. ha, with a reduction of 16,2 thous. ha. Birch (*Betula pendula)* covers the largest area among deciduous trees. Since 2003, it has increased by 68,0 thous. ha and reached 460,2 thous. ha by 2012. Area of Black alder (*Alnus glutinosa*) increased by 25,0 thous. ha to the total of 144,5 thous. ha. The area of grey alder (*Alnus incana*) expanded by 5,4 thous. ha i.e. less than the black alder, reaching 127,4 thous. ha. The area of aspen (*Populus tremula*) stands expanded by 24,6 thous. to 81,9 thous. ha. Oak (*Quercus robur*) forests increased from 35,7 thous. ha to 41,9 thous. ha. The area of ash (*Fraxinus excelsior*) stands diminished by 44% to 29,0 thous. ha.

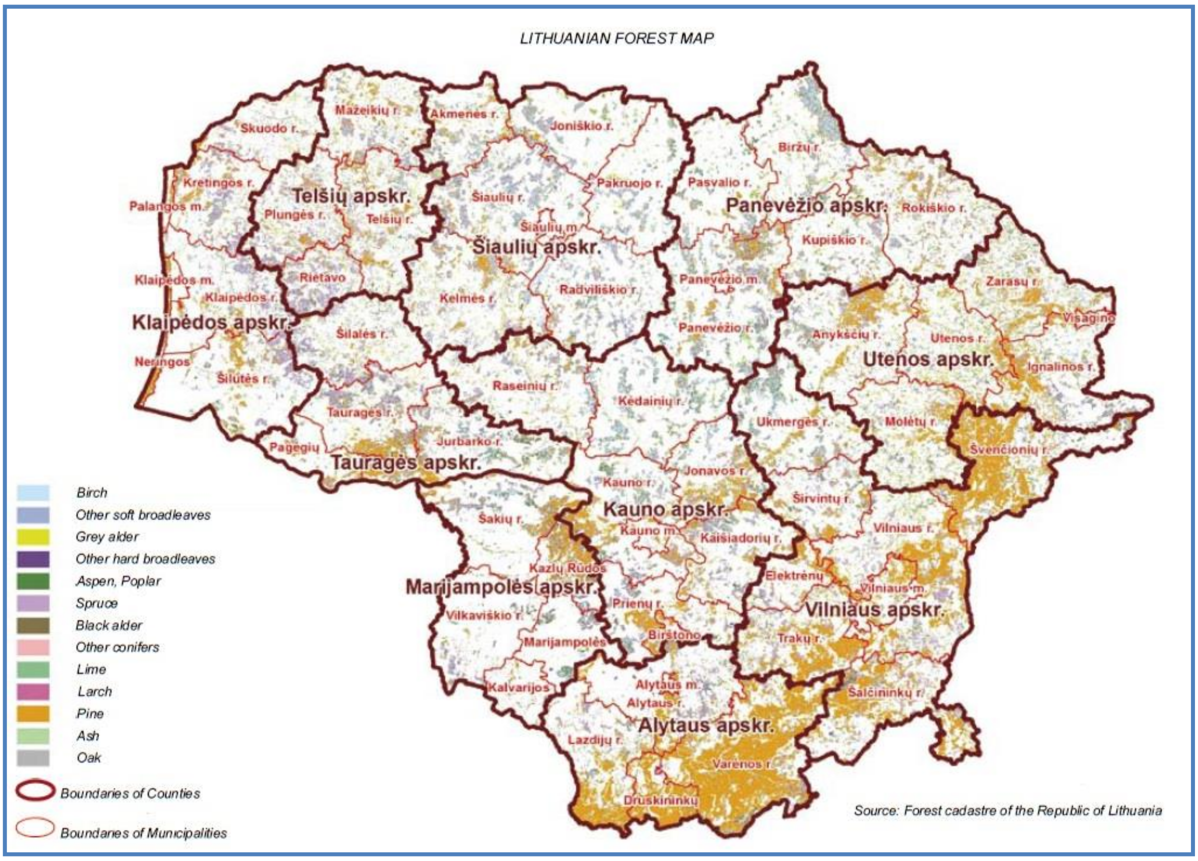

Figure 7-14. Lithuanian forest map by prevailing tree species

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 state 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, 1988-2001. The methods of Lithuanian forest inventory and management planning until 1966 were based on Russian forest inventory instructions adapted to the conditions of Lithuania. 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. Aerophotos 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 fellings, 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 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 independency, 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. Standwise Forest Inventory 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 200 000 - 250 000 ha what is 10% of the total forest land area of the country (Figure 7-15).

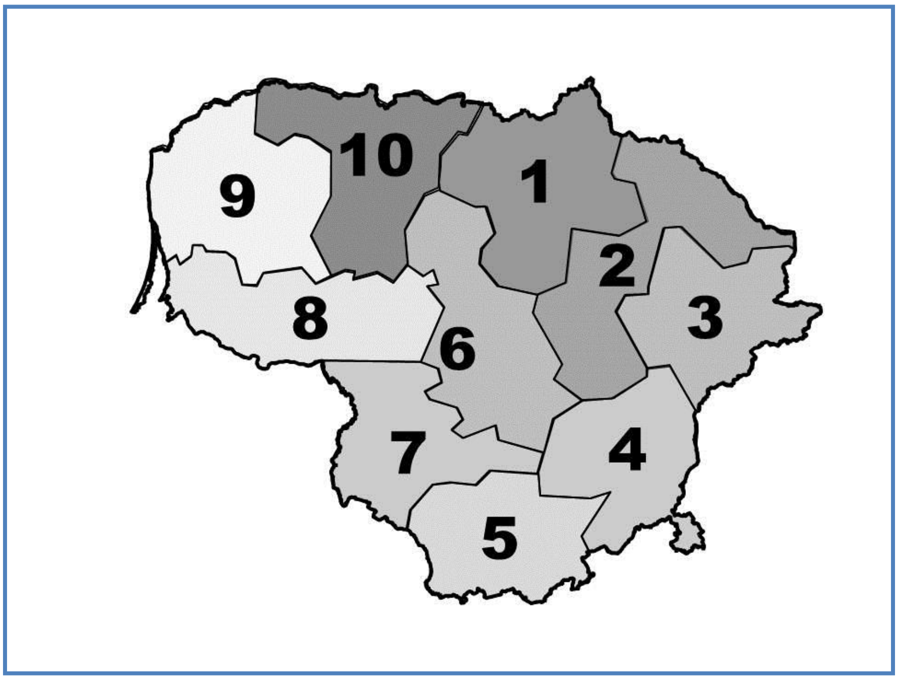

Figure 7-15. Execution of SFI over ten years period through the whole territory of Lithuania

Based on the inventory results forest management plans (Figure 7-16) are prepared for forest enterprises, state parks, recreational and protected areas. Some of the archived cartographical material owned by SFI is represented in figures below.

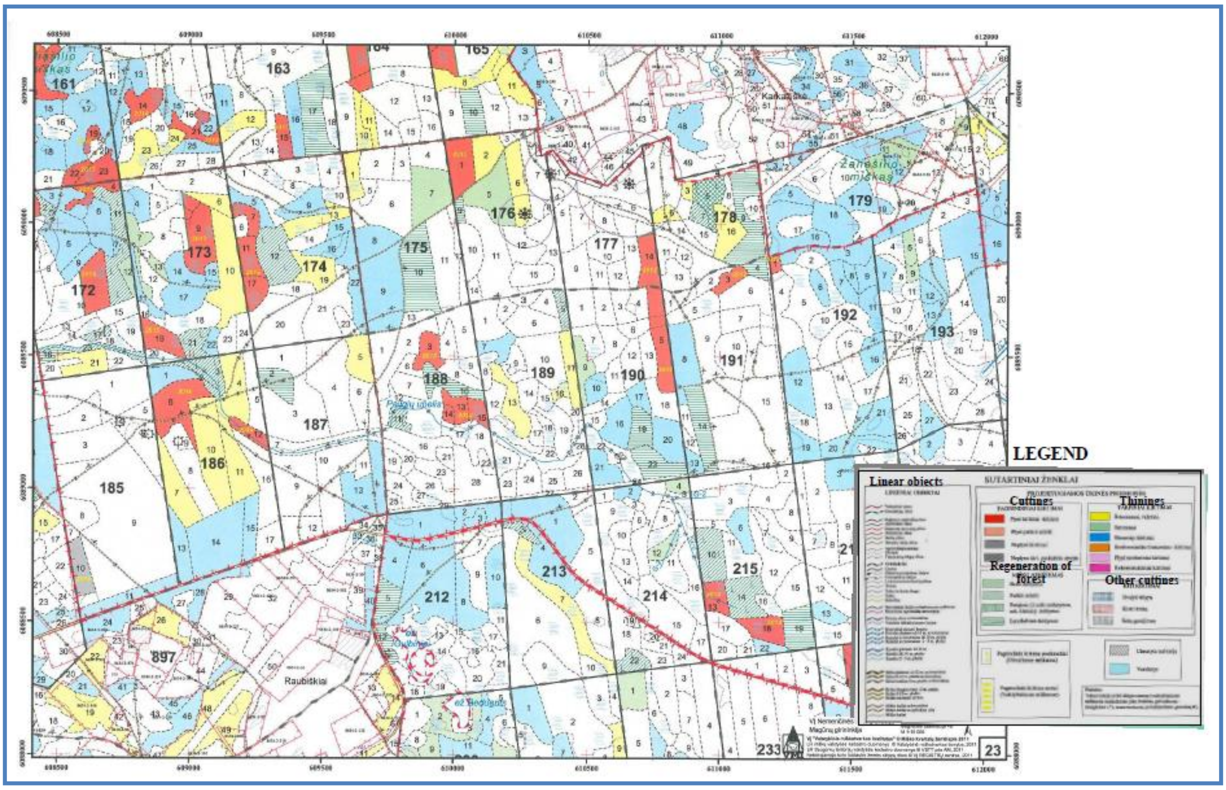

Figure 7-16. Forest management plan (planned forestry activities presented on scheme of forest blocks and compartments; S1:10 000)

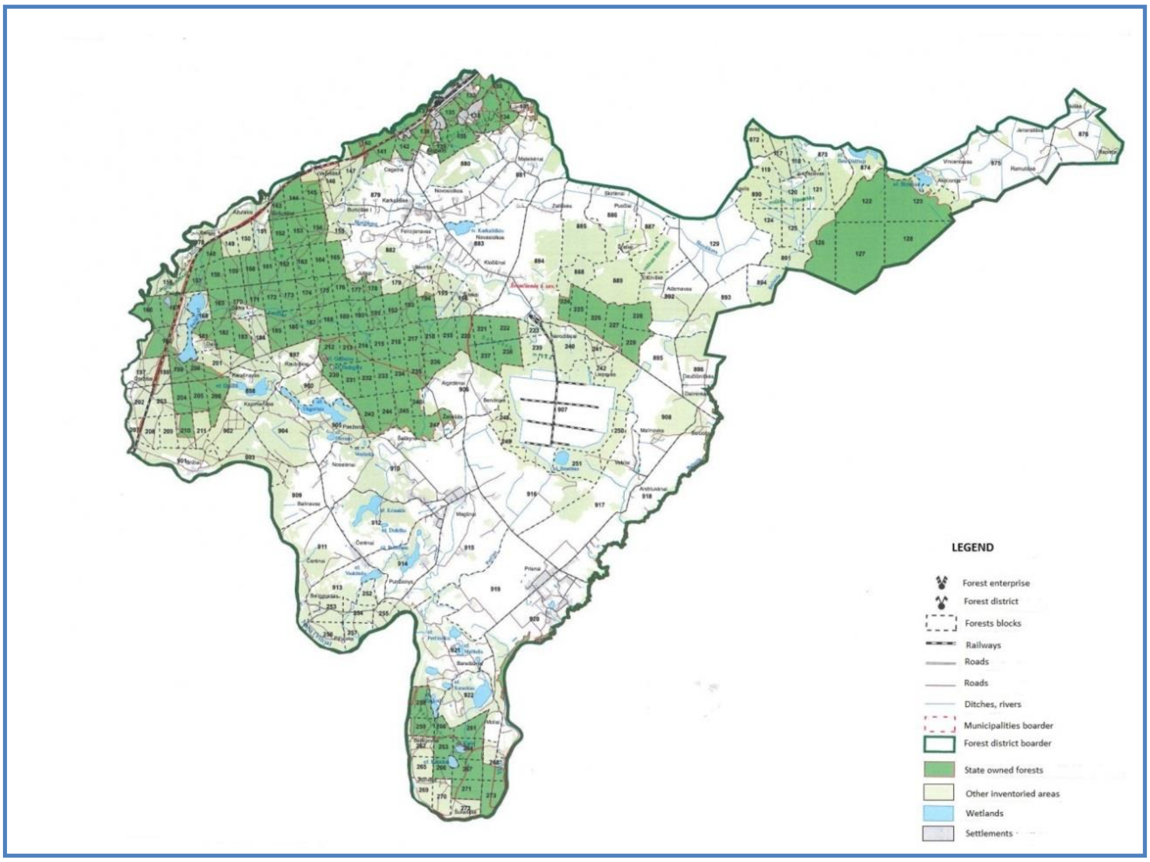

Figure 7-17. Scheme of the Forest District (S 1:10000)

National Forest Inventory

National Forest Inventory using sampling method as a comprehensive and continuous monitoring of all Lithuanian forests 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.[135].) and it is conducted by the State Forest Service 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.).

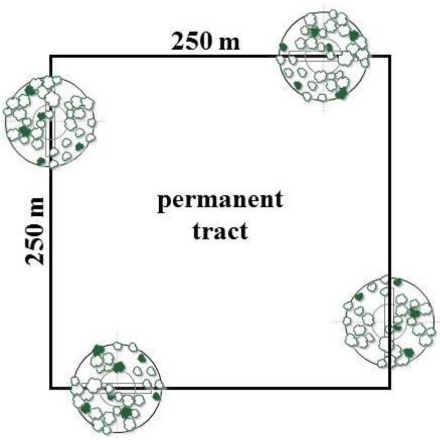

Figure 7-18. Tract of permanent sample plots

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 7-18) 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

[135] *Forest Law of the Republic of Lithuania. 10.04.2010. Nr. IX-240, Žin., 2001, Nr. 35-1161 (2001 04 25).*

monitoring of conversion amongst land use categories. The sample units are arranged to square shape clusters and include four permanent, regularly measured plots (Figure 7-19).

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.

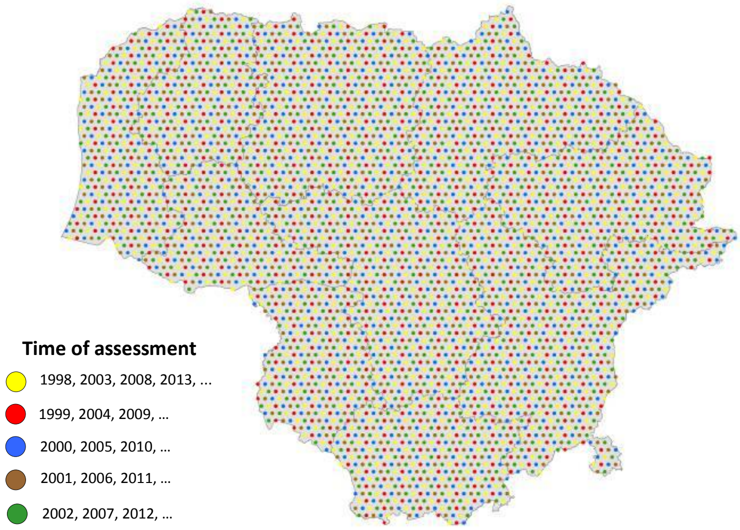

Figure 7-19. Distribution of NFI clusters of plots on Lithuanian territory

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[136] and renewed Regulations of National Forest Inventory[137] 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 Lithuanian State Forest Cadastre (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 standwise forest inventory data.

Primary tasks 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.

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[136] *Order of the Minister of Environment on Approval of Harmonised Principles for data collection and reporting on LULUCF. 12.01.2012. No. D1/27.*

[137] *Regulation of National forest inventory by sampling method. 08.11.2004. Order No D1-570. Adopted by the Minister of Environment of the Republic of Lithuania on 08 November 2004.*

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 bigger than 10 000 ha. Each forest tract smaller than 10 000 ha is subordinated to the district 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 an approach will gradually result in a stable system of block number, independent neither of administrative division of forests nor of ownership category. LSFC database is due to be 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.

Organic and mineral soils

NFI provides data on forest land distribution by forest soils (Table 7-9). According to NFI[138] 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 7-9. Forest land area by mineral and organic soils 1990-2012, 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

[138] *Lithuanian National Forest Inventory 2003 – 2007. Forest resources and their dynamics.*

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

Soils are classified by using Forest soils classification prepared by M. Vaičys[139]. 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 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 7-20.

[139] *M.Vaičys et al. 2006. Miško augaviečių tipai [en. Forest soil types. 2006]*

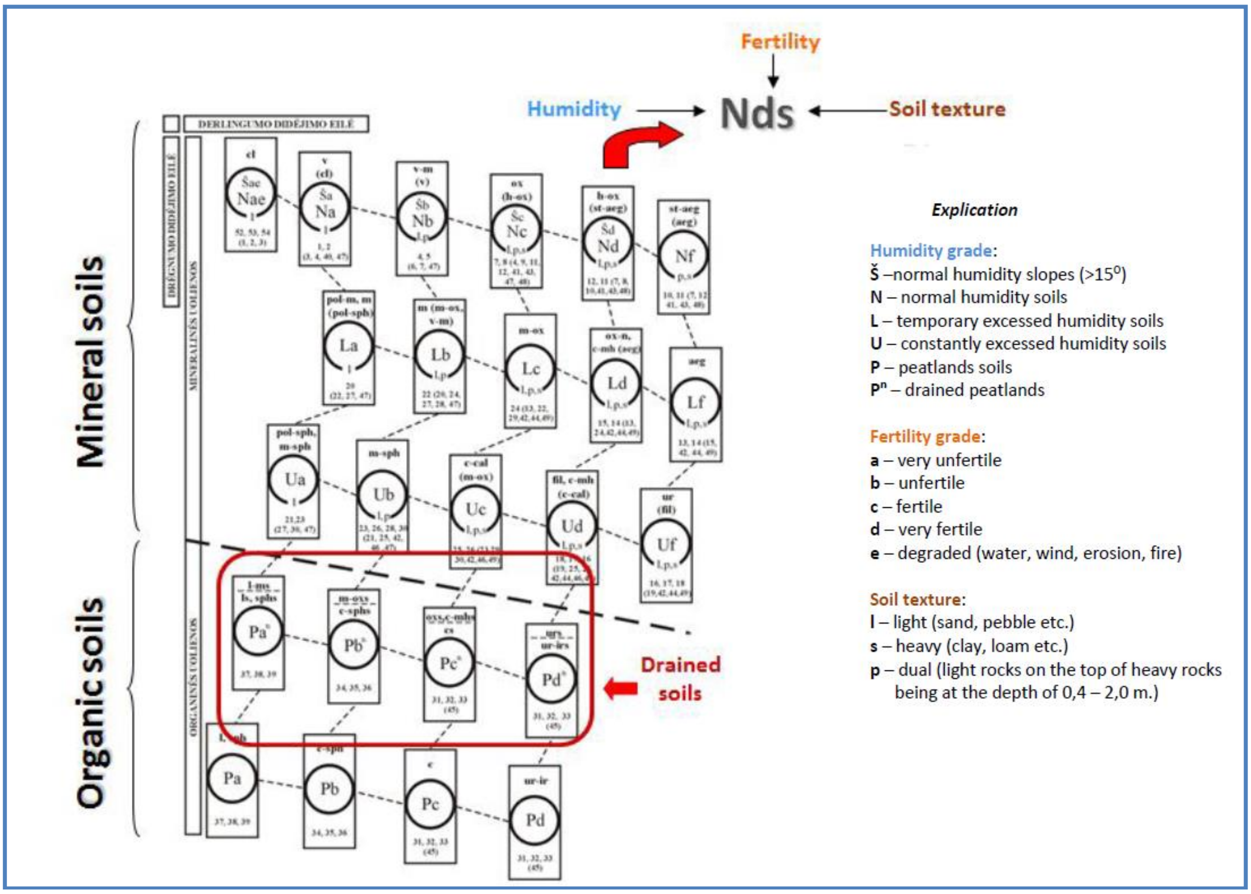

Figure 7-20. Classification of forest soil types

In this greenhouse gas 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 2003*, 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 was divided in two time series: 1990-2001 and 2002-2012.

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 7-10). Percentage of forest stands area from total forest land area varied from 96,5 to 97,0 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 elected 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 named time points.

Mean growing stock volume per hectare in stands for 1988 and 1999 was used from the research[140]. Forest stand yield was estimated based on Standwise Forest Inventory (SFI) data and data on fellings during 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 in 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[141]. Mean growing stock volume for 1997 was taken from Lithuanian forest statistics[142]. Data for the year 2000 presented from Lithuanian Statistical Yearbook of Forestry 2009[143]. 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[144] for 1988 and 1999 together with National forest inventory data for 2002, it was adjusted by 13%.

Total growing stock volume for the period of 2002-2012 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 7.2.1).

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[145].

Table 7-10. Growing stock volume identified according to *Study-1*, Forest assessment data and other research results

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

[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. In: Science and forestry on the eve of XXI century].*
[141]*Valstybinis miškotvarkos institutas. 1993 (1996) Lietuvos miško ištekliai. 1993 (1996). [en. Forest Inventory and Management Institute. Lithuanian Forest resources 1993 (1996)].*
[142] *Valstybinis miškotvarkos institutas.1998. Lietuvos miškų statistika. [en. Forest Inventory and Management Institute. Lithuanian Forest statistics. 1998].*
[143] *Valstybinė miškų tarnyba. Lietuvos miškų ūkio statistika. 2009. [en. State Forest Service. Lithuanian Statistical Yearbook of Forestry. 2009].*
[144]*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. In: Science and forestry on the eve of XXI century].*
[145] *Kuliešis, A., Kulbokas, G. 2008. Dubravos miško medynų pokyčiai nepalankių gamtinių veiksnių poveikio laikotarpiu. Miškininkystė, 2008, 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 1990-2011 was estimated (Table 7-11).

Table 7-11. Total growing stock volume estimated on growing stock volume analysis during 1988 – 2001 and NFI permanent sample plots data during 2002 – 2012

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

The figure below shows comparison between the total growing stock volumes declared in the earlier submission (04.11.2011) and estimated total growing stock volume, based on growing stock volume analysis during the period of 1988-2001 with NFI permanent sample plots data for 2002-2012.

Main differences of these two trends 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 forspruce stands[146]. 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).

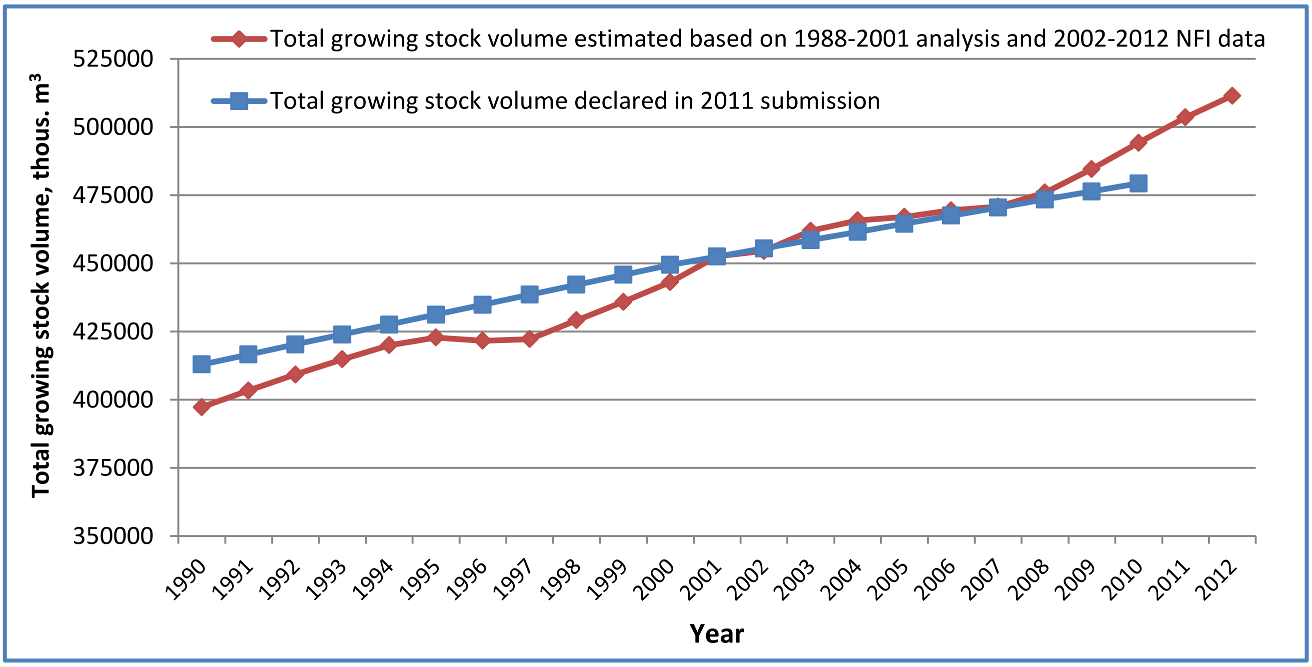

Figure 7-21. Comparison of total growing stock volume between estimated and submitted on 04.11.2011

In the Table 7-12, annual growing stock volume and growing stock volume changes by tree species is presented. The partition of total growing stock volume was made using NFI permanent sample plots data of tree species composition. For the period of 2002-2012 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 7-12. 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

[146] *Kuliešis A., Kulbokas G. Dubravos miško medynų pokyčiai nepalankių gamtinių veiksnių poveikio laikotarpiu. Miškininkystė, 2008, Nr. 2 (en. „Changes of Dubrava forest stands during the impact of adverse natural factors").*

Year	Growing stock volume			Annual change of growing stock volume		
	Coniferous	Deciduous	Total	Coniferous	Deciduous	Total
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

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 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[147].

For the period 2002-2012 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 7-13).

Table 7-13. Total and mean dead tree stems volume changes during 1990-2012

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

[147] *Kuliešis A., Kulbokas G. Dubravos miško medynų pokyčiai nepalankių gamtinių veiksnių poveikio laikotarpiu. Miškininkystė, 2008, Nr. 2 (en. „Changes of Dubrava forest stands during the impact of adverse natural factors").*

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
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

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 7-14). That is explained by spruce dieback, caused by the bark beetle *Ips Typographus*, when more than 13000 thous. m^3 of dead tree stems were accumulated in forests (Figure 7-22). Volume of dead tree stems was stabilized only after 1998.

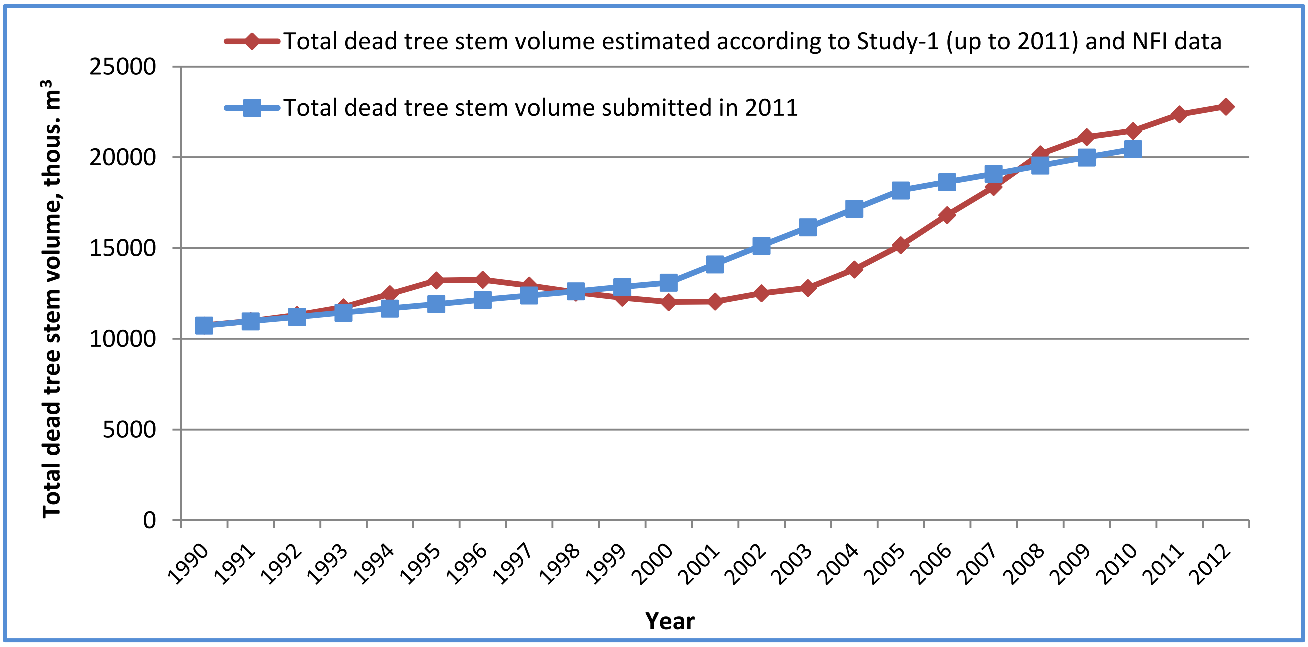

Figure 7-22. Comparison of total dead tree stems stock volume estimated according to *Study-1 (up to 2011)* and latest NFI data with earlier submitted data (2011.11.04)

Another steady increase of dead tree stems has started since 2001. Reasons for that are the following: storm damages in 2000-2005[148], low number of commercial thinnings, endorsed international environmental agreements committing to leave more deadwood in stands to maintain biodiversity (Natura 2000[149] etc.). In 2012 more than 10 m^3/ha of merchantable dead tree stems are accumulated in stands to decay, what is almost twice more if comparing with 1990.

Table 7-14. Total dead tree stems volume and their changes during 1990-2012, 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

[148] *Available from: http://www.msat.lt/lt/miskai/misku-bukle/vejo-pazeidimai-istorija-ir-prognoze/*
[149] *Available from: http://www.natura.org/sites.html*

Year	Dead tree stems volume			Annual change of dead tree stems volume		
	Coniferous	Deciduous	Total	Coniferous	Deciduous	Total
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	22799,9	91,6	341,6	433,2

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). Changes in total forest fellings (living trees) for the period of 1990-2012 are presented in the Figure 7-23.

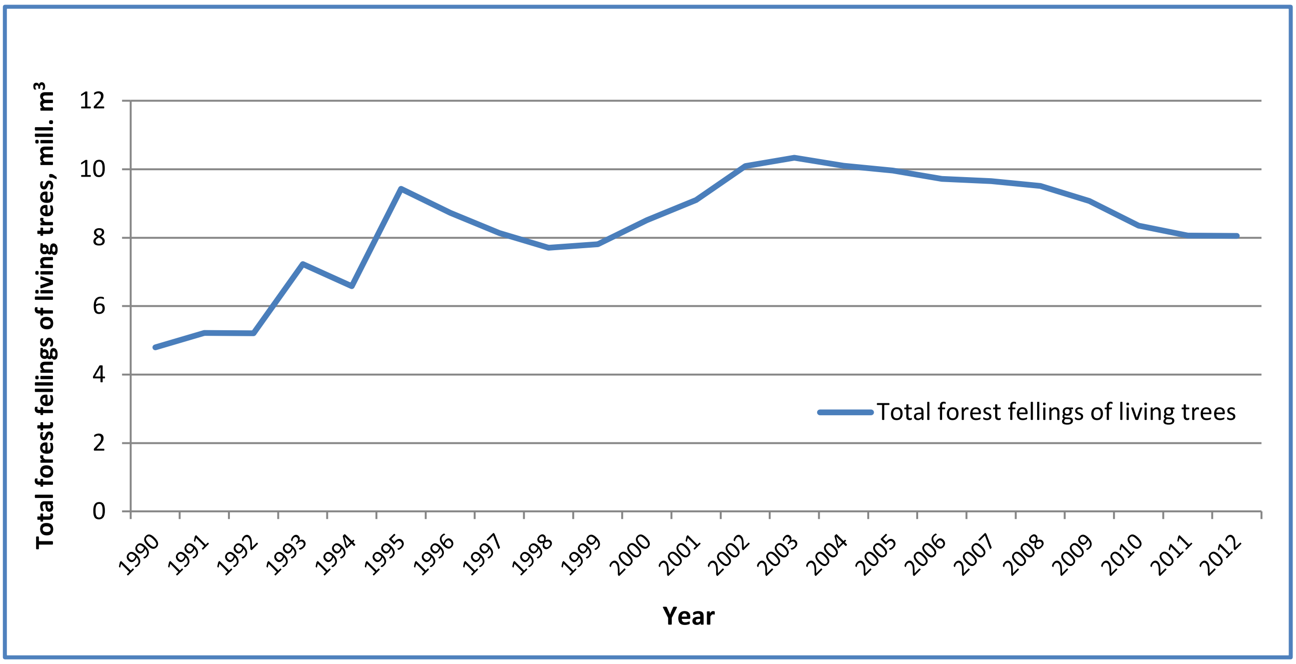

Figure 7-23. Total forest fellings (living trees) in all forests irrespectful of their ownership 1990-2012

Biomass burning

Data on areas affected by forest fires is provided by the Directorate General of State Forests. The Directorate General of State Forests 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 Directorate General of State Forests every year.

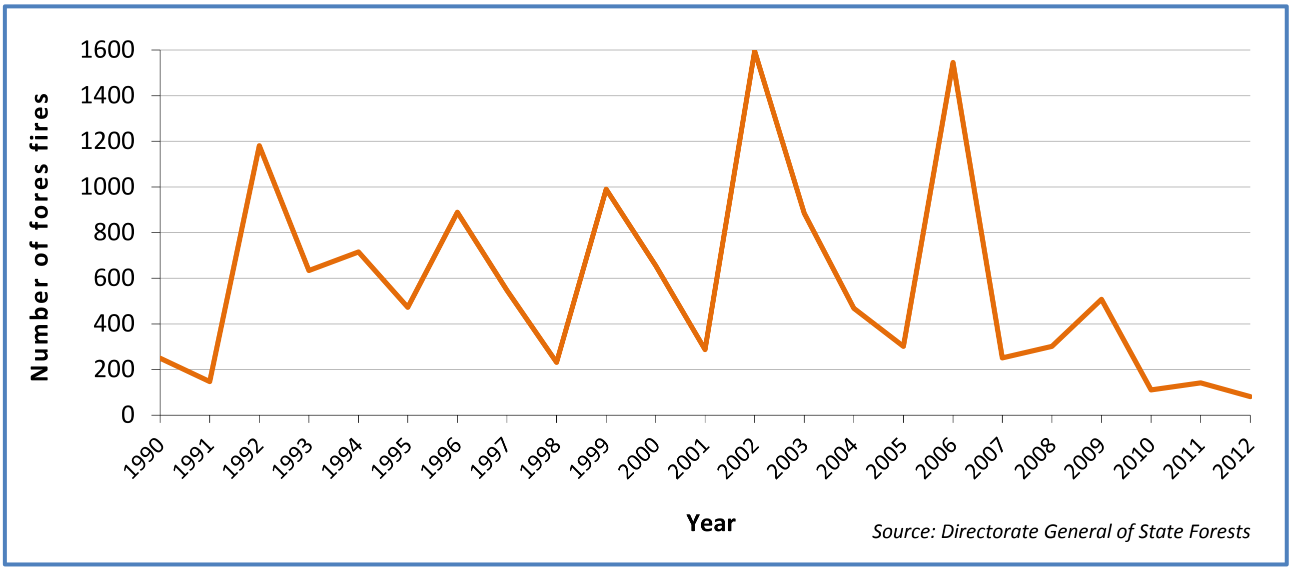

Figure 7-24. Number of forest fires in Lithuania during the period 1990-2012

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 7-25.

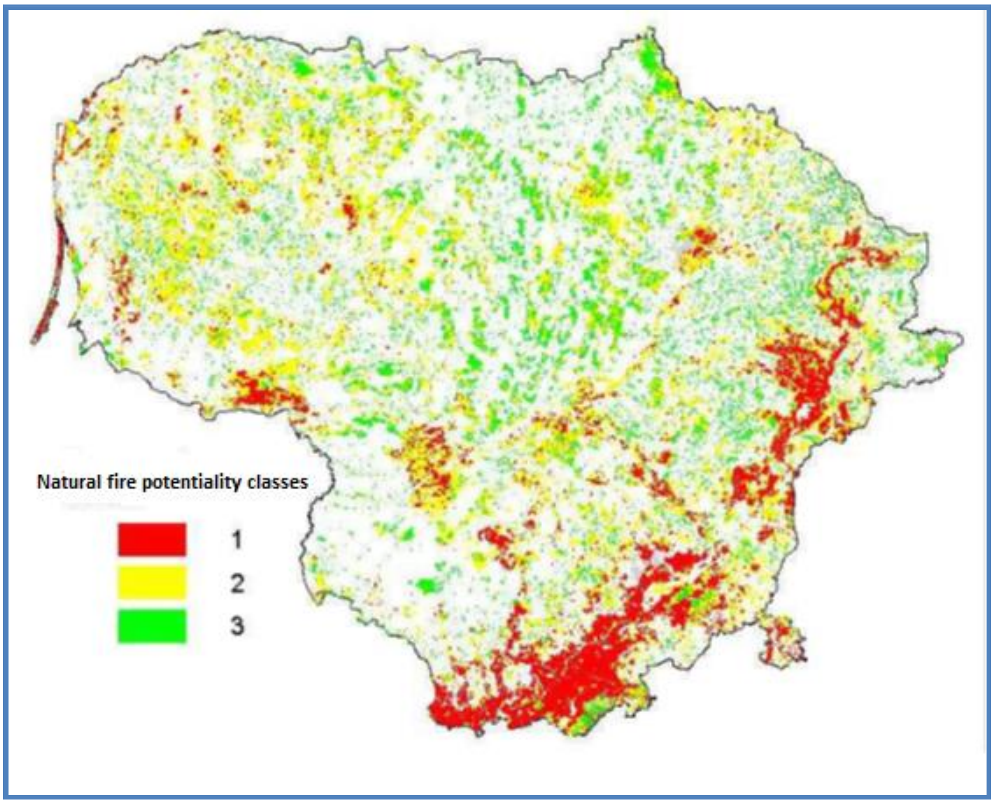

Figure 7-25. Lithuanian forests according to natural fire potentiality classes

Prescribed burning of forest biomass is not used in Lithuania.

Windbreaks and windfalls

Statistical Yearbook of Forestry provides data on windbreaks and windfalls. However, according to the data collection principles used by National Forest Inventory, 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[150].

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.

7.2.2 Methodological Issues

7.2.2.1 Forest land remaining Forest land

The greenhouse gas 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, 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 in *IPCC 2003* eqv. 3.2.1 (p. 3.23):

$$\Delta C = \Delta C_{LB} + \Delta C_{DOM} + \Delta C_{Soils}$$

where:
ΔC – annual change in carbon stock in total forest land, t C yr^{-1};
ΔC_{LB} – annual change in carbon stock in living biomass (includes above and below-ground biomass) in total forest land, t C yr^{-1};
ΔC_{DOM} – annual change in carbon stock in dead organic matter (includes dead wood and forest litter) in total forest land, t C yr^{-1};
ΔC_{Soils} – annual change in carbon stock in soils in total forest land, 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 2003*, 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 (*IPCC 2003* eqv. 3.2.3, p. 3.24):

$$\Delta C_{LB} = (C_{t2} - C_{t1})/(t_2 - t_1) \text{ and } C = (\Delta AGB + \Delta BGB) \times CF \text{ (\textit{modified eqv. 3.2.3})}$$

[150] *Ozolinčius R., Armolaitis K., Mikšys V., Varnagirytė-Kabašinskienė I. 2010. Recommendations for compensating wood ash fertilization (2nd revised edition).*

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;
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 (default = 0,5), t C $(tonne\ d.m.)^{-1}$.

Annual growing stock volume (GSV) change from 2003 for Forest land remaining forest land was estimated based on NFI data using the following steps:

1. Annual GSV change in all forest area (total forest management and afforested/reforested area) is estimated by sampling method. This estimation is based on the change of GSV on the same area (re-measured permanent sample plots data $V_{rem_{t2}} – V_{rem_{t1}}$) and adding GSV increment (ΔV_{new}) of first time measured permanent sample plots i.e. new afforested areas or other plots which have no re-measurement data;

2. Annual GSV change of afforested/reforested area is 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 of all forest annual GSV change (*step 1*) and annual GSV change of afforested/reforested area (*step 2*).

The equations presenting calculations on growing stock volume change in Forest land remaining Forest land are shown below:

$$\Delta FF_t = ((V_{rem_{t2}} - V_{rem_{t1}}) + \Delta V_{new}) - \Delta F2$$

where:
ΔFF_t – growing stock volume change for Forest land remaining Forest land for the defined year, m^3;
$V_{rem_{t1}}$ – growing stock volume calculated at time $t_{1,}$ m^3;
$V_{rem_{t2}}$ – growing stock volume calculated at time $t_{2,}$ m^3;
ΔV_{new} – growing stock volume change of the new measured sample plots, m^3;
ΔF2 – 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. Above-ground biomass is calculated by employing slightly modified eqv. 3.2.3, (p. 3.24) of *IPCC 2003*:

$$\Delta AGB = (\Delta GS) \times WD \times BEF$$

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 3A.1.9 of the *IPCC 2003* (p. 3.171). Density values for coniferous and deciduous were calculated as weighted average values related to growing stock volume (Table 7-15).

Above ground biomass was calculated for broadleaves and coniferous separately. For the period of 2002-2012 data of NFI was used, and for the period of 1990-2001 mean value for the known time period was used.

Table 7-15. 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 *IPCC 2003* in Table 3A.1.10 (p. 3.178), 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 eqv. 3.2.3 (p. 3.24) of the *IPCC 2003* 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 3A.1.8 (p. 3.168) of *IPCC 2003*: for coniferous – 0,26; for deciduous – 0,19:

$$\Delta BGB = \Delta AGB \times R$$

[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.
Усольцев В.А. 2003. Фитомасса лесов Северной Евразии. Предельная продуктивность и география. 405 с., Якатеринбург.

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 the *IPCC 2003* was used for estimation of carbon fraction (CF) in dry biomass matter.

Change in carbon stock in dead organic matter

For the greenhouse gas inventory Lithuania defines dead organic matter (*DOM*) as it is described in *IPCC 2003*, which provides two types of dead organic matter pools: dead wood and litter.

Annual change in carbon stocks in dead organic matter in Forest Land remaining Forest Land is calculated following the summarising 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 equation 3.2.10 (p. 3.32) of *IPCC 2003* has been used to calculate carbon stock change in dead organic matter:

$$\Delta C_{DOM} = \Delta C_{DW} + \Delta C_{DW_H}$$

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_{DW_H} – 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 3.2.12 (p. 3.34) of *IPCC 2003*:

$$\Delta C_{FF_{DW}} = [A \times (B_{t2} - B_{t1}) / T] \times CF$$

where:
$\Delta C_{FF_{DW}}$ – 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 (default = 0,5), tonnes C (tonne d.m.)$^{-1}$.

$$\Delta C_{FF_{DW}} = \Delta B / T \times CF$$

where:
$\Delta C_{FF_{DW}}$ – 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 (default = 0,5), tonnes C (tonne d.m.)$^{-1}$.

$$\Delta B = B_{t2} - B_{t1}$$

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.

$$AGB = V_{dw} \times WD \times BEF$$

where:
V_{dw} – available dead wood volume, m^3;
WD – basic wood density, t d. m. m^{-3};
BEF – biomass expansion factor.

$$BGB = AGB \times R$$

where:
AGB – above-ground biomass, t d. m.;
R – root-to-shoot ratio, dimensionless.

Change in carbon stock in soil organic matter

Carbon stock change in drained organic forest soils was calculated using equation 3.2.15 (p. 3.42) of *IPCC 2003*:

$$\Delta C_{FOS} = A_{Drainage} \times EF_{Drainage}$$

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 3.2.3 of the *IPCC* 2003 (p. 3.42) 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 equation 3a.2.1 is applied with a simple disaggregation of drained forest soils into “nutrient rich” and “nutrient poor” areas and default emission factors are used.

$$N_2O\ emisions_{FF} = \Sigma(A_{FF_{organic\ IJK}} \times EF_{FF_{drainage,\ organic\ IJK}}) + A_{FF_{mineral}} \times EF_{FF\ drainage,\ mineral} \times 44/28 \times 10^{-6}$$

where:
N_2O emisions $_{FF}$ – 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 7-9). 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. 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.

Biomass Burning

Data on areas affected by forest fires on areas under the category Forest land remaining Forest land is provided by the Directorate General of State Forests. 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 was calculated using equation 3.2.20 (p. 3.49) of *IPCC 2003*:

$$L_{fire} = A \times B \times C \times D \times 10^{-6}$$

where:
L_{fire} – quantity of GHG released due to fire, t of GHG;
A – area burnt, ha;
B – mass of 'available' fuel, kg d.m. ha^{-1};
C – combustion efficiency (or fraction of biomass combusted), dimensionless;
D – emission factor, g $(kg\ d.m.)^{-1}$.

Values of biomass stock were taken from the Table 3A.1.13 of the *IPCC 2003* (Annex 3A.1, p. 3.185). Mean value for wildfire of temperate forest is 19,8 t per ha.

Average values of emission factor D for CO_2, N_2O and CH_4 gases were calculated based on the values presented by *Delmas et al*. and *Kauffmann et al*. in the Table 3A.1.16 of the *IPCC 2003* (Annex 3A.1, p. 3.185) and are equal to:

CO_2 – 1555,5 g $(kg\ d.m.)^{-1}$;
N_2O – 8,05 g $(kg\ d.m.)^{-1}$;
CH_4 – 0,11 $(kg\ d.m.)^{-1}$.

[152] *Lithuanian National Forest Inventory 2003 – 2007. Forest resources and their dynamics*

7.2.2.2 Land converted to Forest land

Land use area calculations of Land converted to Forest land are further described in chapter 7.2.1. The total area of land converted to Forest land between 1990 and 2012 were computed by using sample plots data of National Forest Inventory.

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 7-16. Yearly land transition matrix for Croplands converted to Forest Land

Year of the conversion	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	0,0	399,4	399,4	1198,2	0,0	0,0	399,4	798,8	0,0	399,4	399,4	798,8	0,0	798,8	399,4	798,8	798,8	2795,9	1597,7	0,0	399,4	1997,1	1997,1
2	0,0	0,0	399,4	399,4	1198,2	0,0	0,0	399,4	798,8	0,0	399,4	399,4	798,8	0,0	798,8	399,4	798,8	798,8	2795,9	1597,7	0,0	399,4	1997,1
3	0,0	0,0	0,0	399,4	399,4	1198,2	0,0	0,0	399,4	798,8	0,0	399,4	399,4	798,8	0,0	798,8	399,4	798,8	798,8	2795,9	1597,7	0,0	399,4
4	399,4	0,0	0,0	0,0	399,4	399,4	1198,2	0,0	0,0	399,4	798,8	0,0	399,4	399,4	798,8	0,0	798,8	399,4	798,8	798,8	2795,9	1597,7	0,0
5	0,0	399,4	0,0	0,0	0,0	399,4	399,4	1198,2	0,0	0,0	399,4	798,8	0,0	399,4	399,4	798,8	0,0	798,8	399,4	798,8	798,8	2795,9	1597,7
6	0,0	0,0	399,4	0,0	0,0	0,0	399,4	399,4	1198,2	0,0	0,0	399,4	798,8	0,0	399,4	399,4	798,8	0,0	798,8	399,4	798,8	798,8	2795,9
7	0,0	0,0	0,0	399,4	0,0	0,0	0,0	399,4	399,4	1198,2	0,0	0,0	399,4	798,8	0,0	399,4	399,4	798,8	0,0	798,8	399,4	798,8	798,8
8	0,0	0,0	0,0	0,0	399,4	0,0	0,0	0,0	399,4	399,4	1198,2	0,0	0,0	399,4	798,8	0,0	399,4	399,4	798,8	0,0	798,8	399,4	798,8
9	0,0	0,0	0,0	0,0	0,0	399,4	0,0	0,0	0,0	399,4	399,4	1198,2	0,0	0,0	399,4	798,8	0,0	399,4	399,4	798,8	0,0	798,8	399,4
10	0,0	0,0	0,0	0,0	0,0	0,0	399,4	0,0	0,0	0,0	399,4	399,4	1198,2	0,0	0,0	399,4	798,8	0,0	399,4	399,4	798,8	0,0	798,8
11	0,0	0,0	0,0	0,0	0,0	0,0	0,0	399,4	0,0	0,0	0,0	399,4	399,4	1198,2	0,0	0,0	399,4	798,8	0,0	399,4	399,4	798,8	0,0
12	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	399,4	0,0	0,0	0,0	399,4	399,4	1198,2	0,0	0,0	399,4	798,8	0,0	399,4	399,4	798,8
13	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	399,4	0,0	0,0	0,0	399,4	399,4	1198,2	0,0	0,0	399,4	798,8	0,0	399,4	399,4
14	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	399,4	0,0	0,0	0,0	399,4	399,4	1198,2	0,0	0,0	399,4	798,8	0,0	399,4
15	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	399,4	0,0	0,0	0,0	399,4	399,4	1198,2	0,0	0,0	399,4	798,8	0,0
16	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	399,4	0,0	0,0	0,0	399,4	399,4	1198,2	0,0	0,0	399,4	798,8
17	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	399,4	0,0	0,0	0,0	399,4	399,4	1198,2	0,0	0,0	399,4
18	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	399,4	0,0	0,0	0,0	399,4	399,4	1198,2	0,0	0,0
19	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	399,4	0,0	0,0	0,0	399,4	399,4	1198,2	0,0
20	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	399,4	0,0	0,0	0,0	399,4	399,4	1198,2
	399,4	798,8	1198,2	2396,5	2396,5	2396,5	2795,9	3594,7	3594,7	3994,1	4393,5	5192,4	5192,4	5991,2	6390,6	7189,4	7988,3	10384,7	11982,4	11982,4	12381,8	13979,4	15577,1

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 7-26). 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 of Lithuania, stands are becoming forest when reaching certain requirements for forest (for instance 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 (Table 7-17).

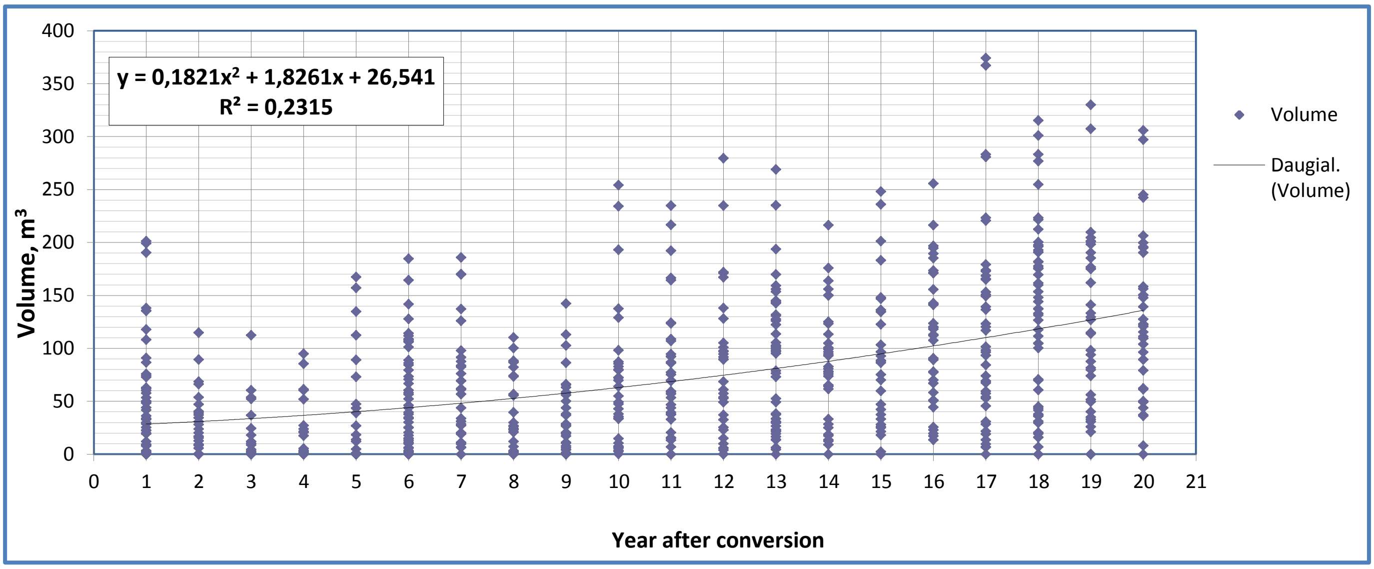

Figure 7-26. NFI data on growing stock volume of non-forest lands converted to forest land at the year of conversion to Forest land

Table 7-17. 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:

$$\Delta V = \sum [A_i (V_{t_2} - V_{t_1}))$$

where:
ΔV – GSV change on land converted to Forest land, m^3;
Ai – area according to land use category, ha;
V_{t_1} – GSV at time t_1, m^3;
V_{t_2} – 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 equation 3.2.25 (p. 3.53) of the *IPCC 2003*:

$$\Delta C_{LFLB} = \Delta C_{LFGROWTH} + \Delta C_{LFCONVERSION} - \Delta C_{LFLOSS}$$

where:
$\Delta C_{LF_{LB}}$ – annual change in carbon stocks in living biomass in land converted to forest land, tonnes C yr^{-1};
$\Delta C_{LF_{GROWTH}}$ – annual increase in carbon stocks in living biomass due to growth in land converted to forest land, tonnes C yr^{-1};
$\Delta C_{LF_{CONVERSION}}$ – annual change in carbon stocks in living biomass due to actual conversion to forest land, tonnes C yr^{-1};
$\Delta C_{LF_{LOSS}}$ – 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 3.2.26 (p. 3.53) of the *IPCC 2003*:

$$\Delta C_{LF_{CONVERSION}} = \sum_i [B_{AFTER_i} - B_{BEFORE_i}] \times \Delta A_{TO\_FOREST_i} \times CF$$

where:
$\Delta C_{LF_{CONVERSION}}$ – 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 (default = 0.5), tonnes C (tonnes d.m.)-1;
i – represent different types of land converted to forest.

B_{AFTER} value was modelled by using Figure 7-26.

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. Above-ground biomass is calculated by employing slightly modified eqv. 3.2.3, (p. 3.24) of *IPCC 2003*:

$$\Delta AGB = (\Delta GS) \times WD \times BEF$$

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 3A.1.9 of the *IPCC 2003*. Density values for coniferous and deciduous were calculated as weighted average values related to growing stock volume (Table 7-18).

Above ground biomass was calculated for broadleaves and coniferous separately. For the period of 2002-2012 data of NFI was used, and for the period of 1990-2001 mean value for the known time period was used.

Table 7-18. 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[153]). 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 2003* in Table 3A.1.10 (p. 3.178), what showing the consistency between the chosen methods.

[153] *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 eqv. 3.2.3 (p. 3.24) of the *IPCC 2003* 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 3.A.1.8 of *IPCC 2003* (p. 3.168): for coniferous – 0,26, for deciduous – 0,19.

$$\Delta BGB = \Delta AGB \times R$$

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 the *IPCC 2003* 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 3.2.1 of *IPCC 2003* (p. 3.36). 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 7-9). According to NFI[154] 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 equation 3.2.15 (p. 3.42) of *IPCC 2003*:

$$\Delta C_{FOS} = A_{Drainage} \times EF_{Drainage}$$

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}.

[154] *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 3.2.3 of the *IPCC* 2003 (p. 3.42) was used in calculations. Default $EF_{Drainage}$ for temperate forests is 0,68 tonnes C ha^{-1} yr^{-1}.

Biomass Burning

Data on areas affected by forest fires on areas under the category Forest land remaining Forest land is provided by the Directorate General of State Forests. 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 3.2.20 (p. 3.49) of *IPCC 2003*:

$$L_{fire} = A \times B \times C \times D \times 10^{-6}$$

where:
L_{fire} – quantity of GHG released due to fire, t of GHG;
A – area burnt, ha;
B – mass of 'available' fuel, kg d.m. ha^{-1};
C – combustion efficiency (or fraction of biomass combusted), dimensionless;
D – emission factor, g (kg d.m.)$^{-1}$.

Values of biomass stock were taken from the Table 3A.1.16 of the *IPCC 2003* (Annex 3A.1, p. 3.185). Mean value for biomass consumption used for wildfires of temperate forest is 19,8 t per ha.

Emission factor *D* is calculated as average of two values (1531 and 1580 g/kg) of CO_2 dry matter combusted, provided in Table 3A.1.16 of the *IPCC 2003* (Annex 3A.1, p. 3.185). The emission ratios of CH_4 (0,012) and N_2O (0,007) are taken from Table 3A.1.15 of the *IPCC 2003* (Annex 3A.1, p. 3.185).

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.

7.2.3 Quantitative overview of carbon emissions/removals from the sector

The area of total forest land area, Forest Land remaining Forest Land, and area of Land converted to Forest Land are provided in the Table 7-19 below.

Table 7-19. Forest land area changes during the period 1990-2012, 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

Carbon stock change in living biomass

Area and growing stock volume in Forest Land remaining Forest Land was increasing annually since 1990 to 2012 except 1996 when total growing stock volume resulted in losses comparing to previous years due to spruce dieback (Table 7-20). 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 7-19). The changes of growing stock volume are also related to area changes in Land converted to Forest Land.

Table 7-20. 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
2002	255503,7	191411,8	446915,5	1131,1	6541,8	7672,9	454588,4

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	
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

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 1990-2012. Living biomass losses of 881,4 thous. t d.m. were inventoried in 1996. The mean value of annual carbon stock change is about 1551,6 Gg. 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 165,0 and 203,5 Gg per year (Table 7-21).

Table 7-21. 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, Gg
	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, Gg	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, Gg	
1990	2977614,0	684382,9	3661996,9	1831,0	275130,8	54878,7	330009,4	165,0	1996,0
1991	2977614,0	684382,9	3661996,9	1831,0	291103,8	58064,7	349168,5	174,6	2005,6
1992	2872739,2	660445,6	3533184,8	1766,6	306716,1	61178,8	367894,9	183,9	1950,5
1993	2894495,5	660133,8	3554629,3	1777,3	310012,4	61836,3	371848,6	185,9	1963,2
1994	2617779,3	598111,7	3215891,0	1607,9	315250,6	62881,1	378131,7	189,1	1797,0
1995	1378175,7	317344,9	1695520,5	847,8	323506,1	64527,8	388033,9	194,0	1041,8
1996	-720025,8	-161798,5	-881824,3	-440,9	328590,0	65541,8	394131,9	197,1	-243,8
1997	202504,4	49566,6	252071,0	126,0	336133,1	67046,4	403179,6	201,6	327,6
1998	3616168,4	823742,3	4439910,7	2220,0	335572,9	66934,7	402507,6	201,3	2421,2
1999	3484203,6	795275,4	4279479,0	2139,7	338308,9	67480,4	405789,3	202,9	2342,6
2000	4061675,3	917182,8	4978858,0	2489,4	319123,5	63653,6	382777,1	191,4	2680,8
2001	4899240,7	1117092,6	6016333,3	3008,2	320906,7	64009,3	384916,0	192,5	3200,6
2002	1078213,1	244642,4	1322855,4	661,4	317687,6	63367,2	381054,8	190,5	852,0
2003	3001796,6	732817,6	3734614,2	1867,3	311445,7	62446,6	373892,3	186,9	2054,3
2004	1194533,6	302434,8	1496968,4	748,5	323144,5	64292,3	387436,7	193,7	942,2
2005	299881,8	72772,3	372654,1	186,3	330639,2	66039,8	396679,1	198,3	384,7
2006	856052,3	240145,3	1096197,5	548,1	330464,7	66205,5	396670,2	198,3	746,4
2007	248961,6	149967,7	398929,3	199,5	333599,1	66730,8	400329,9	200,2	399,6
2008	2875922,5	677706,3	3553628,8	1776,8	338799,8	68197,6	406997,3	203,5	1980,3
2009	4565867,0	1034717,9	5600584,9	2800,3	301820,1	60499,6	362319,8	181,2	2981,5
2010	4385346,8	1087249,9	5472596,7	2736,3	306965,9	60977,7	367943,6	184,0	2920,3

Year	Forest land remaining forest land				Land converted to forest land (≤ 20 years stands)				Total Carbon stock change, Gg
	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, Gg	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, Gg	
2011	4286352,8	998432,7	5284785,5	2642,4	300513,7	58985,7	359499,4	179,7	2822,1
2012	3763200,4	870697,7	4633898,0	2317,0	304211,4	59756,5	363967,9	182,0	3312,0

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 7-22 provides values of stock change in biomass and carbon stock change in dead wood. The data represent tendency of annual accumulation of dead wood in forest land since 1990 to 2012.

Table 7-22. 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, Gg
	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, Gg	Below-ground biomass stock change, t d. m	Carbon stock change, Gg	
1990	113525,0	28777,6	142302,6	71,2	114516,7	57,3	128,4
1991	113525,0	28777,6	142302,6	71,2	50101,0	25,1	96,2
1992	158305,2	40543,6	198848,8	99,4	38888,0	19,4	118,9
1993	204386,4	52606,8	256993,1	128,5	270068,5	135,0	263,5
1994	341035,7	88381,9	429417,5	214,7	134557,1	67,3	282,0
1995	354004,1	92899,4	446903,5	223,5	432061,9	216,0	439,5
1996	16484,2	3755,0	20239,2	10,1	238099,3	119,0	129,2
1997	-145492,0	-39304,8	-184796,8	-92,4	83978,9	42,0	-50,4
1998	-180532,4	-47308,0	-227840,4	-113,9	-37217,9	-18,6	-132,5
1999	-135537,3	-35527,1	-171064,4	-85,5	-36740,8	-18,4	-103,9
2000	-111199,6	-28370,9	-139570,5	-69,8	17416,1	8,7	-61,1
2001	9202,7	2065,9	11268,5	5,6	109745,1	54,9	60,5
2002	233351,6	52384,4	285736,1	142,9	219013,1	109,5	252,4
2003	158856,5	29166,7	188023,2	94,0	202707,3	101,4	195,4
2004	516464,4	114731,5	631195,8	315,6	111342,2	55,7	371,3
2005	698652,3	142763,9	841416,2	420,7	39812,7	19,9	440,6
2006	875186,9	179347,8	1054534,7	527,3	-22998,2	-11,5	515,8
2007	788122,3	171287,4	959409,7	479,7	-45155,5	-22,6	457,1
2008	928580,1	199631,3	1128211,4	564,1	-51402,5	-25,7	538,4
2009	491324,7	102736,1	594060,8	297,0	-84649,8	-42,3	254,7
2010	169483,7	39244,0	208727,7	104,4	-145745,6	-72,9	31,5
2011	464179,8	100715,2	564895,0	282,4	-142532,4	-71,3	211,2
2012	227766,8	46295,2	274062,0	137,0	-104541,3	-52,3	84,8

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 7.2.1.

Table 7-23. Annual carbon stock change 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 CO_2 emissions, Gg
			Area of drained organic soils , thous. ha						CO_2 emissions, Gg							
	Area of drained organic soils, thous. ha	CO_2 emissions, Gg	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

Biomass burning

The default mean burned biomass values per hectare were used. Carbon emissions are related with burned area (Table 7-24). The largest carbon emissions were observed in 1992 (29,9 $GgCO_2$) and in 2006 (36,9 $GgCO_2$). This is the result of repetitive draughts (1992, 1994, 2002, 2006)[155] 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 7-24. Annual carbon stock change due to biomass burning

Year	Area burned, ha	Burned biomass, t d.m.	CO_2 emissions, Gg
1990	134,0	2653,2	4,1
1991	64,0	1267,2	2,0
1992	971,0	19225,8	29,9
1993	355,0	7029,0	10,9
1994	355,0	7029,0	10,9
1995	355,0	7029,0	10,9
1996	355,0	7029,0	10,9
1997	355,0	7029,0	10,9
1998	54,0	1069,2	1,7
1999	342,9	6789,8	10,6
2000	327,1	6476,0	10,1
2001	111,1	2200,6	3,4
2002	746,4	14778,9	23,0
2003	436,2	8636,2	13,4
2004	253,2	5013,4	7,8
2005	50,8	1006,6	1,6
2006	1199,3	23746,1	36,9
2007	38,0	752,4	1,2
2008	112,4	2225,5	3,5
2009	315,3	6242,9	9,7
2010	21,5	425,7	0,7
2011	292,8	5797,4	9,0
2012	20,29	401,7	0,6

7.2.4 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

[155] *Lithuanian Hydrometeorological Service (available from: www.meteo.lt)*

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) 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 analysed 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 analysed 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:

$$Q_m = Q \times p_m \textit{ or } Q_m = K_m \times q_R;\ Q_m = \frac{q_m \times q_R}{500}$$

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:

$$p_m = \frac{Km}{K}$$

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:

$$P_{Q_m} = \sqrt{\frac{1-p_m}{(K-1)p_m}} \times 100$$

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 analysed 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 analysed 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 2003*, which is also known as simple error propagation method.

To estimate uncertainty of a product of several quantities eqv. 5.2.1 (p. 5.10) of *IPCC 2003* 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 2003* was used (eqv. 5.2.2; p. 5.11):

$$U_E = \frac{\sqrt{(U_E \times E_1)^2 + (U_2 \times E_2)^2 + \ldots.(U_n \times E_n)^2}}{| E_1 + E_2 + \cdots E_n|}$$

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 *IPCC 2003* (eqv. 5.2.2). 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%.

References for the uncertainties of values that were used in calculations are provided below:

Biomass:
1) D (wood density) – *IPCC 2003* Chapter 3 p. 3.31;
2) BEF – *IPCC 2003* Chapter 3 p. 3.31;
3) R (below ground biomass) – *IPCC 2003* Chapter 3 p. 3.31;
4) CF (carbon fraction) – *IPCC 2003* Chapter 5 p. 5.17

Dead wood:
1) D (wood density) – *IPCC 2003* Chapter 3 p. 3.31;
2) BEF – *IPCC 2003* Chapter 3 p. 3.31;
3) R (below ground biomass) – *IPCC 2003* Chapter 3 p. 3.31;
4) CF (carbon fraction) – *IPCC 2003* Chapter 5 p. 5.17

Litter:
1) Carbon in litter – *IPCC 2003* Chapter 3, p. 3.38

Organic soils (CO_2): EF (drainage) – *IPCC 2003* Chapter 3 p. 3.79 and p. 3.118
Organic soils (N_2O): EF_{ff} (drainage) – *IPCC 2003* Chapter 3, Appendix 3a.2, p 3.275, Table 3a.2.1

Forest fires: Coefficients – *IPCC 2003* Chapter 3, p 3.50

Table 7-25. Assessment 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	12,2
Emission factor	Forest Land remaining Forest land	$GgCO_2$	31,1
	Land converted to Forest Land	$GgCO_2$	38,4

7.2.5 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 & 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.

National Forest Inventory Dept. 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 & KP LULUCF data analysis, provision of methodological guidances and preparation of GHG reports.

Quality assurance and Quality control 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 2003*:

- **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 2003*.

7.2.6 Source-specific recalculations

Following ERT 2012 recommendations emissions from wildfires in Forest land were included into total emissions/removals from Forest land, as they were reported separately in the previous submissions and caused double-counting in this category. Since now these emissions are accounted correctly, and reported using IE notation key in the relevant CRF tables.

There were also minor re-estimations made in carbon stock changes in organic soils associated with conversions from Settlements and Other lands to Forest land.

The total difference between emission/removals from Forest land of this submission and submission of 2012, caused by recalculations associated with wildfires in Forest land and carbon stock changes in organic soils from conversions of Settlements and Other lands to Forest land, is presented in Table 7-26.

Table 7-26. Reported in previous submission and recalculated emission/removals from Forest land during the period 1990-2011

Year	Previous submission, Gg CO_2	This submission, Gg CO_2	Difference, Gg CO_2	Relative difference, %
1990	-7819,5	-7831,6	12,1	0,2
1991	-7757,3	-7768,3	11,0	0,1
1992	-7622,6	-7664,1	41,5	0,5
1993	-8219,2	-8241,8	22,6	0,3
1994	-7672,3	-7695,7	23,4	0,3
1995	-5476,5	-5500,0	23,5	0,4
1996	372,8	349,3	23,5	-6,3
1997	-1063,4	-1086,8	23,4	2,2
1998	-8437,6	-8454,4	16,8	0,2
1999	-8239,6	-8265,4	25,8	0,3
2000	-9617,5	-9645,5	28,0	0,3
2001	-11970,0	-11991,3	21,3	0,2
2002	-4036,0	-4076,8	40,8	1,0
2003	-8243,5	-8273,1	29,6	0,4
2004	-4836,2	-4860,1	23,9	0,5
2005	-3065,6	-3085,9	20,3	0,7
2006	-4639,5	-4695,2	55,7	1,2
2007	-3196,5	-3219,2	22,7	0,7
2008	-9295,3	-9320,2	24,9	0,3
2009	-11868,2	-11899,4	31,2	0,3
2010	-10854,5	-10871,3	16,8	0,2
2011	-11143,8	-11168,0	24,2	0,2

7.2.7 Source specific planned improvements

Following the recommendations of ERT 2012, Lithuania is planning to revise methodology used for estimation of country-specific mass values of available fuel for wildfires, including dead wood and litter.

7.3 Cropland (CRF 5.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, inspects, 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' meanings are included under *Settlements* category. All croplands are managed land.

7.3.1 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 7-27. Estimated carbon stocks under Cropland land use category

Land Use Category	Carbon stock change in living biomass	Carbon stock change in dead organic matter	Carbon stock change in soils	
			Mineral soils	Organic soils
Cropland remaining Cropland	√	NO	NO*	√
Land converted to Cropland	√	NO	√	√

**Assumed to be close to zero, therefore reported as NO*

Information on data sources used for calculations are presented in Table 7-28.

Table 7-28. Information on data sources used for estimation of cropland land area

Sources used	Source data used
Soviet kolkhoz'es land use plans	1990
Orthophoto maps	NLF: 1995-1998; 2005, 2009, 2010
Land areas and croplands declarations database	2010-2011

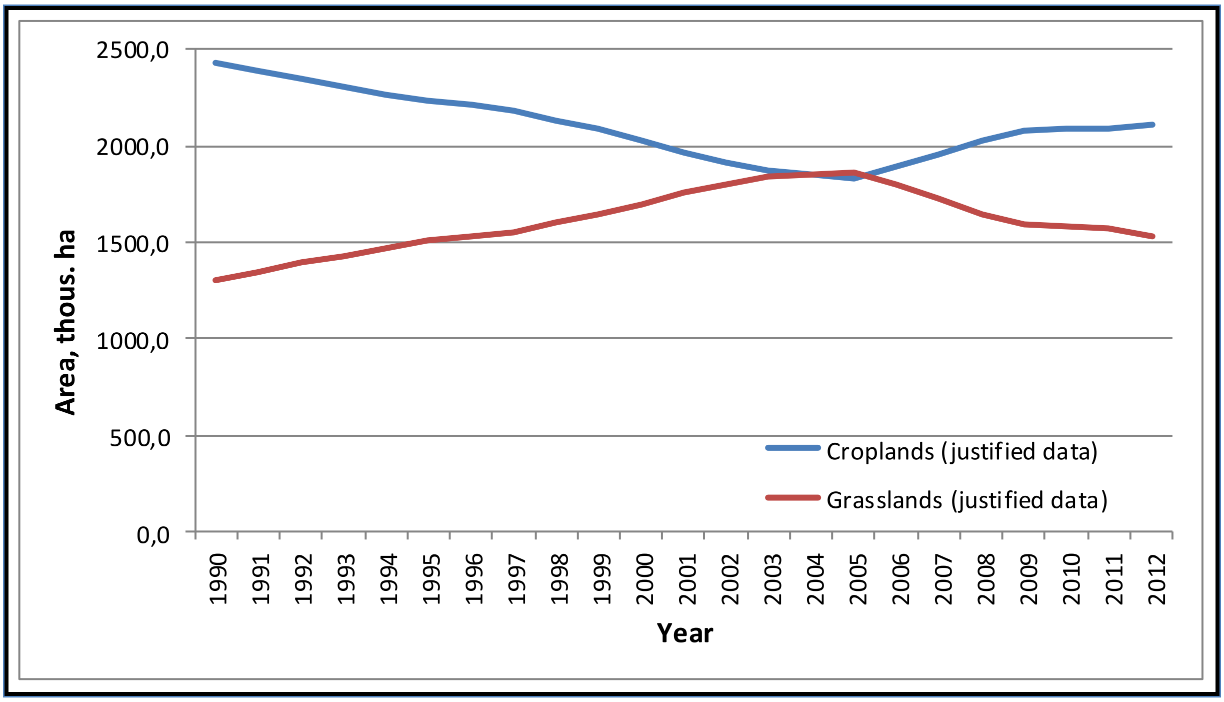

Figure 7-27. Comparison between estimated cropland and grassland area based on study and evened (data analysis techniques applied) data

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 7-27).

7.3.2 Methodological issues

7.3.2.1 Cropland remaining cropland

Areas continiously managed as Croplands and areas coverted to Croplands after 20 consecutive years followed conversion reported in the category Cropland remaining Cropland (CC). Emissions and removals reported from Cropland remaining Cropland (CC) include two subcategories of CO_2 emissions/removals:

- changes in carbon stocks in living biomass;
- changes in carbon stocks in soils.

The following equation was used for calculation of carbon stock changes (*IPCC 2003,* eqv. 3.3.1, p. 3.70):

$$\Delta Ccc = \Delta Ccc_{LB} + \Delta Ccc_{Soils}$$

where:
ΔCcc – annual change in carbon stocks in cropland remaining cropland, tonnes C yr^{-1};
ΔCcc_{LB} – annual change in carbon stocks in living biomass, tonnes C yr^{-1};
ΔCcc_{Soils} – annual change in carbon stocks in soils, tonnes C yr^{-1}.

To convert tonnes C to Gg CO_2, value is being multiplied by 44/12 and by 10^{-3}.

Change in carbon stocks in living biomass

The change in living biomass was 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 59 thous. ha in 2012. Major part of total horticultural area reported in the agricultural statistics is covering private gardens and small land plots at the summer houses containing fruit trees which, according to the *IPCC 2003*, must be reported in Settlements (Chapter 7.6). Therefore, Lithuania reports only perennial woody biomass accumulated in commercial orchards. Since 1999 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)[156]. Area of commercial orchards in 1990 obtained from scientific publication of Venskutonis[157]. 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.

Tier 1 method was chosen for calculations according to available activity data. Default factors were applied to nationally derived estimates of land areas. Default growth (2,1 tonnes C ha^{-1} yr^{-1}), 30 years harvest/maturity cycle and loss rates (63 tonnes C ha^{-1}) of aboveground woody biomass were employed from Table 3.3.2 of the *IPCC 2003* (p. 3.71).

For calculation of living biomass in perennial woody crops on cropland the following equation was used (*IPCC 2003,* eqv. 3.2.2, p. 3.24):

[156] *Available from: http://www.vic.lt/*
[157] *Venskutonis, Vladas. Sodininkystė. Vilnius 1999 [en. Horticulture]*

$$\Delta Ccc_{LB} = (\Delta Ccc_{G} - \Delta Ccc_{L})$$

where:
ΔCcc_{LB} – annual change in carbon stocks in living biomass (includes aboveground biomass) in cropland remaining cropland, tonnes C yr^{-1};
ΔCcc_{G} – annual increase in carbon stocks due to biomass growth, tonnes C yr^{-1};
ΔCcc_{L} – annual decrease in carbon stocks due to aboveground biomass loss, tonnes C yr^{-1}.

Using default harvest cycles in cropping containing perennial species indicated in Table 3.2.2 of *IPCC 2003*, 30 years harvest/maturity cycle matrix was prepared. Area was distributed equally in age classes since 1990. ΔCcc_{L} – was calculated considering decrease in area according to age classes and was assumed that all aboveground biomass is lost at the age of 30.

The sources of uncertainty when using *Tier 1* method include the degree of accuracy in land area estimates and default carbon accumulation and loss rates. Established values of uncertainties are provided in Table 7-30.

Change in carbon stocks in soils

CO_2 emissions or removals from soils include these carbon stocks: mineral soils, CO_2 emissions from organic soils (i.e. peat soils) and emissions of CO_2 from liming of agricultural soils. According to *IPCC 2003*, carbon stocks are measured to a default depth of 30 cm and do not include C in surface residue (i.e. dead organic matter) or changes in inorganic carbon (i.e. carbonate minerals).

The change in organic carbon stocks in soils has been estimated using the following equation (*IPCC 2003*, eqv. 3.3.2, p. 3.74):

$$\Delta Ccc_{Soils} = \Delta C_{CCMineral} - \Delta C_{CCOrganic} - \Delta C_{CCLime}$$

where:
$\Delta C_{CCSoils}$ – annual change in carbon stocks in soils in cropland remaining cropland, tonnes C yr^{-1};
$\Delta C_{CCMineral}$ – annual change in carbon stocks in mineral soils, tonnes C yr^{-1};
$\Delta C_{CCOrganic}$ – annual carbon emissions from cultivated organic soils (estimated as net annual flux), tonnes C yr^{-1};
ΔC_{CCLime} – annual C emissions from agricultural lime application, tonnes C yr^{-1}.

Mineral soils

According to the report of available soil data in Lithuania[158] HAC soils (*Albeluvisols*, *Luvisols*, *Cambisols*) occupy 70% of cropland area, sandy soils (*Arenosols*) – 12%, spodic soils (*Podzols*) – 11%, wetland soils (*Gleysols*) – 5,3%.

Default reference soil organic carbon stocks (SOC_{REF}) in tones C per ha for 30 cm layer corresponding to cold temperate moist climate region were taken from *IPCC 2003* Table 3.3.3 (p. 3.76). Reference carbon content of HAC soils reported as 95 tonnes C per ha, sandy soils have 71 tonnes C per ha, spodic soils have 115 tonnes C per ha and wetland soils have 87 tonnes C per ha.

Carbon stock change in mineral soils was calculated using the following equation (*IPCC 2003,* eqv. 3.3.3, p. 3.75):

[158] *Buivydaite, V.V. 2005. Soil Survey and Available Soil Data in Lithuania. ESB-RR9, p. 211-223*

$$\Delta C_{CCMineral} = [(SOC_0 - SOC_{(0-T)}) \times A] / T$$

$$SOC = SOC_{REF} \times F_{LU} \times F_{MG} \times F_I$$

where:
SOC – soil organic carbon stock, tonnes C ha^{-1};
SOC_{REF} – the reference carbon stock, tonnes C ha^{-1};
T – inventory time period, years (default is 20 year);
A – land area of each parcel, ha;
F_{LU} – stock change factor for land use or land-use change type, dimensionless;
F_{MG} – stock change factor for management regime, dimensionless;
F_I – stock change factor for input of organic matter, dimensionless.

Relative stock change factors (F_{LU}, F_{MG}, and F_I) for different management activities on cropland were taken from *IPCC 2003* Table 3.3.4 (p. 3.77).

Croplands in Lithuania represent area that has been continuously managed over 20 years, to predominantly annual crops. GPG revised F_{LU} factor for temperate wet climatic conditions is 0,71, error range ±12%. Conservation reserves having different F_{LU} factor started to be accounted by National Land Service since 2002. Though, such areas increased by ~15% since 2002, still remains negligible (<1 thous. ha) and therefore not included into calculations.

Main tillage practice is full tillage, described as substantial soil disturbance with full inversion and frequent tillage operations and little part of the surface covered by residues at planting time. GPG revised F_{MG} factor for temperate wet climatic conditions is 1,0, error NA. Area under reduced tillage has been growing in the period 1999-2004 (Šiuliauskas, Liakas. 2005)[159]. Statistics for such land accounting is not available, therefore not included into calculations.

Croplands in Lithuania mainly have medium residue return when all crop residues are returned to the field, either removal of residues compensated by organic matter supplements from green manure or other manures. Corresponding to *IPCC 2003* revised F_I factor for such input in temperate wet climatic conditions is 1,0 (error NA).

Organic soils

Using data presented by National Forest Inventory permanent sample plots measured in 2012, referring to 0,7% of organic soils from the total croplands area, it was assumed that this value is equally correct to croplands remaining croplands and to lands converted to croplands.

Tier 1 approach was used in order to calculate carbon stock change in organic soils (*IPCC 2003,* eqv. 3.3.5, p. 3.79). Default emission factors (*IPCC 2003* Table 3.3.5, p. 3.79) were used along with area estimates for cultivated organic soils in cold temperate climate region present in Lithuania (*IPCC 2003,* eqv. 3.3.5, p. 3.79). Default emission factor for cold temperate regions – 1 tonne C ha^{-1} yr^{-1}.

$$\Delta C_{CC_{Organic}} = \sum_c (A \times EF)_c$$

where:
$\Delta C_{CC_{Organic}}$ – CO_2 emissions from cultivated organic soils in croplands remaining croplands, tonnes C yr^{-1};

[159] *Šiuliauskas A.,Liakas V. Beplūgė žemdirbystė Lietuvos ūkiuose / Žemės ūkis. 2005. Nr. 2. –P.4-5. [en. Ploughless agriculture in Lithuanian farms]*

A – land area of organic soils in climate type *c*, ha;
EF – emission factor for climate type *c*, (*IPCC 2003* Table 3.3.5, p. 3.79), tonnes C ha^{-1} yr^{-1}.

Liming

Naturally acid soils cover ~41% of agricultural land in Lithuania. Following the introduction of large-scale agricultural technologies (1965-1990) the extent of acid soils was successfully reduced to 18,7% nationwide (Marcinkonis *et al.* 2011)[160]. It was succeeded due to intensive long-term liming, with applications of dust limestone to 160.000-200.000 ha per year from 1976, with average application rate of 4,5 t ha^{-1} $CaCO_3$ (Knasys, 1985)[161]. Main liming agent was dust limestone produced by AB „Akmenės cementas".

However, as a result of political and economical changes in Lithuania since 1991 and the repeal of state support, the extent of liming decreased, falling from 14.400 to 4.000 ha per year between 1993 and 1996. Since 1997 liming of acid soils has virtually ceased, except on large farms using various liming agents, but reliable statistical data on liming of such agricultural land in Lithuania is not available. The overview of annual application rates and annual C emissions are presented in Table 7-29. Drastic reduction in liming was also confirmed by two dolomite quarries which are the main suppliers of dolomite based liming agents in Lithuania, both companies are not producing dolomite for soil liming for the last 10 years. AB "Naujasis kalcitas" being subsidiary company of AB „Akmenės cementas" which nowadays produces limestone based soil liming agents, reports 4000-6000 tonnes annual limestone sales in recent years. Eventhough liming has decreased dramatically nowadays comparing to 1990 but the long-term effect of previous large scale liming is still visible allowing producing reasonable yields on acidified areas even today. This is also supported by farming practice growing acidity tolerant plants. The subsidiary schemes supporting liming of farmlands not implemented in Lithuania therefore liming of soils remains negligible.

Table 7-29. Annual amount of limestone and dolomite used for liming in 1990-2012, tonnes

Reporting year			**± change 1990-2012**
1990	**1996**	**2012**	
Annual application in tones of $CaCO_3$			
900000	18000	6000	-894000
Annual C emissions from agricultural lime application. tonnes C yr^{-1}			
108000	2160	720	-107280

The *Tier 1* method was used to estimate CO_2 emissions from liming of croplands. The following equation was used for calculation of annual C emissions from agricultural lime application (*IPCC 2003* eqv. 3.3.6, p. 3.42):

$$\Delta C_{CCLime} = M_{Limestone} \times EF_{Limestone}$$

where:
ΔC_{CCLime} – annual C emissions from agricultural lime application, tonnes C yr^{-1};
$M_{Limestone}$ – annual amount of calcium limestone or dolomite, tonnes yr^{-1};
$EF_{Limestone}$ – emission factor, tonnes C (tonne limestone or dolomite)$^{-1}$.

[160] *Marcinkonis, S., Booth C.A., Fullen M.A., Tripolskaja, L. (2011). Soil acidity indices in East Lithuania. Communications in Soil Science and Plant Analysis. Volume 42, Issue 13 pp. 1565-1580*
[161] *Knašys V. Dirvožemių kalkinimas. Vilnius: Mokslas. 1985, 262 p. [en. Soil liming]*

Overall emission factor of 0,12 has been used to estimate CO_2 emissions, without differentiating between variable compositions of lime material. Tonnes of C converted to $GgCO_2$ by multiplying conversion factor by 44/12 and 10^{-3}.

Due to dramatically reduced liming annual CO_2 emissions in recent years founded to be ~150 times lower comparing with 1990. CO_2 emission in recent years from agricultural lime application were ~2,64 Gg CO_2 eqv.

7.3.2.2 Land converted to Cropland

The cumulative areas over a 20-year transition period reported in Figure 7-28. For each year, the cumulative total area reported under Land converted to Cropland (LC) 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. Regarding information obtained from NFI, during the last decades there have been no conversions of Forest land to Cropland. CO_2 and N_2O emissions and removals are reported from Land converted to Cropland (LC) using *Tier 1* method.

The following equation was used for calculation of total change in carbon stocks in Land converted to Cropland (*IPCC 2003* eqv. 3.3.7, p. 3.83):

$$\Delta C_{LC} = \Delta C_{LCLB} + \Delta C_{LCSoils}$$

where:
ΔC_{LC} - total change in carbon stocks in land converted to cropland, tonnes C yr^{-1};
ΔC_{LCLB} - change in carbon stocks in living biomass in land converted to cropland, tonnes C yr^{-1};
$\Delta C_{LCSoils}$ - change in carbon stocks in soil in land converted to cropland, tonnes C yr^{-1};
To convert tonnes C to Gg CO_2, value multiplied by 44/12 and by 10^{-3}.

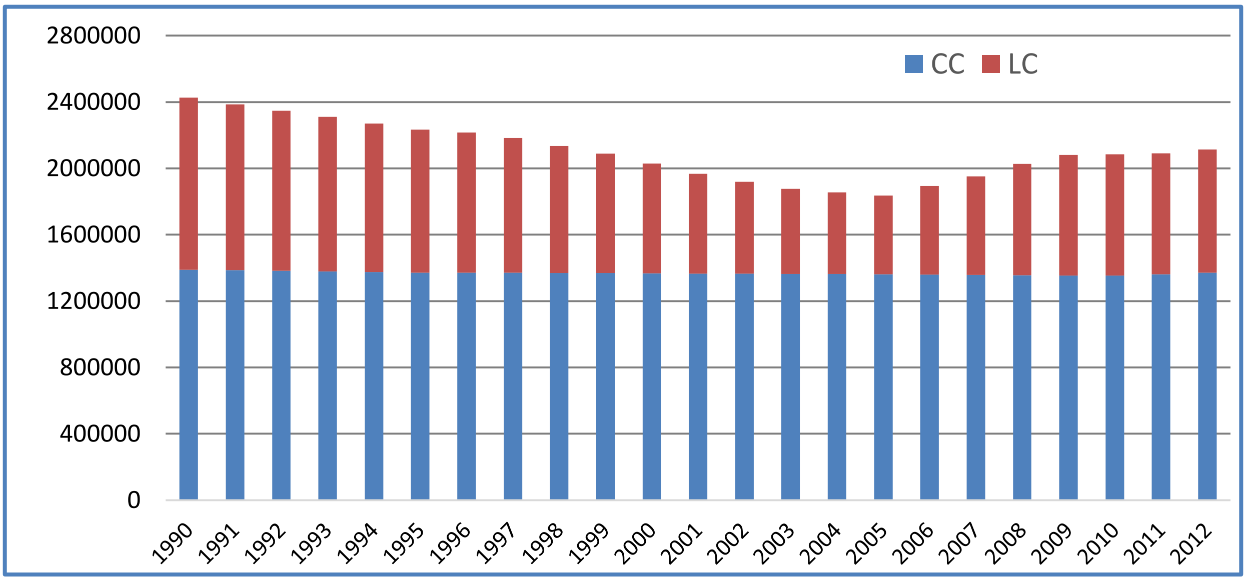

Figure 7-28. Cropland area changes during the period 1990-2012, ha

Change in carbon stock in living biomass

Tier 1 was used to estimate annual change in carbon stocks in living biomass on Land converted to Cropland. The default assumption for *Tier 1* is that all carbon in biomass is lost to the atmosphere through decay processes either on- or off-site. As such, *Tier 1* calculations do not differentiate immediate emissions from burning and other conversion activities. The following equation was used for calculation (*IPCC 2003* eqv. 3.3.8, p. 3.85):

$$\Delta C_{LCLB} = A_{Conversion} \times (L_{Conversion} + \Delta C_{Growth})$$

$$L_{Conversion} = C_{After} - C_{Before}$$

where:
ΔC_{LCLB} - annual change in carbon stocks in living biomass in land converted to cropland, tonnes C yr^{-1};
$A_{Conversion}$ - annual area of land converted to cropland, ha yr^{-1};
$L_{Conversion}$ - carbon stock change per area for that type of conversion when land is converted to cropland, tonnes C ha^{-1};
ΔC_{Growth} - changes in carbon stocks from one year of cropland growth, tonnes C ha^{-1};
C_{After} - carbon stocks in biomass immediately after conversion to cropland, tonnes C ha^{-1};
C_{Before} - carbon stocks in biomass immediately before conversion to cropland, tonnes C ha^{-1}.

It is assumed that for conversions from grasslands to croplands all biomass is cleared when preparing a site for cropland use, thus, no data available for conversions from other land uses to croplands. The default for C_{After} is 0 tonnes C ha^{-1}. Default 2,4 tonnes d.m. ha^{-1} estimate for C_{Before} has been used (*IPCC 2003* Table 3.4.2, p. 3.109). It was also assumed that changes in carbon stocks from one year of cropland growth are equal to zero, because considering cropland management practice, biomass stock from one year is marginal. Default 5,0 tonnes C ha^{-1} carbon stock in biomass present on Land converted to Cropland (ΔC_{Growth}) has been used (*IPCC 2003* Table 3.3.8, p. 3.88).

Change in carbon stock in soils

Tier 1 was used to estimate annual change in carbon stocks in soils on Land converted to Cropland. For calculation the following equation was used (*IPCC 2003* eqv. 3.3.12, p. 3.89):

$$\Delta C_{LCSoils} = \Delta C_{LCMineral} - \Delta C_{LCOrganic} - \Delta C_{LCLiming}$$

where:
$\Delta C_{LCSoils}$ – annual change in carbon stocks in soils in land converted to cropland, tonnes C yr^{-1};
$\Delta C_{LCMineral}$ – change in carbon stocks in mineral soils in land converted to cropland, tonnes C yr^{-1};
$\Delta C_{LCOrganic}$ – annual C emissions from cultivated organic soils converted to cropland (estimated as netannual flux), tonnes C yr^{-1};
$\Delta_{CLCLiming}$ – annual C emissions from agricultural lime application on land converted to cropland, tonnes C yr^{-1}.

Calculation of carbon stocks in mineral soils on Lands converted to Cropland were based on same methodological approaches as for Cropland remaining Cropland described in more details in chapter 7.3.2.1.

Tier 1 approach was used in order to calculate carbon stock change in organic soils. Default 1 tonne C ha^{-1} yr^{-1} emission factor (*IPCC 2003* Table 3.3.5, p. 3.79) was used along with area estimates for Wetlands converted to Cropland in cold temperate climate region which is common for Lithuania (*IPCC 2003* eqv. 3.3.5, p. 3.79). Area of organic soils was assumed to be 0,7% of all conversions to Croplands.

All carbon emission from lime application reported in Cropland remaining Cropland category, therefore CO_2 emissions from liming reported to be zero in Land converted to Cropland.

7.3.3 Non-CO_2 greenhouse gas emissions

In Lithuania there is no controlled burning of Cropland, emissions of non-CO_2 only results from wildfires. Emissions from Cropland category were estimated employing the following equation: (*IPCC 2006* eqv. 2.27, p. 2.42):

$$L_{fire} = A \times M_b \times C_f \times G_{ef} \times 10^{-3}$$

where:
L_{fire} – amount of greenhouse gas emissions from fire, tonnes of each GHG e.g., CH_4, N_2O, etc.;
A – area burnt, ha;
M_b – mass of fuel available for combustion, tonnes ha^{-1}. This includes biomass, ground litter and dead wood. When *Tier 1* methods are used then litter and dead wood pools are assumed zero, except where there is a land-use change;
C_f – combustion factor, dimensionless (Table 2.6, *IPCC 2006*);
G_{ef} – emission factor, g kg^{-1} dry matter burnt (Table 2.5, *IPCC 2006*).

Note: Where data for M_B and C_f was not available, a default value for the amount of fuel actually burnt (the product of M_B and C_f) was used (Table 2.4, IPCC 2006).

Activity data on Cropland area burnt was obtained from statistics of Fire and rescue department[162]. Conversion of GHG emissions to CO_2 Gg has been made by multiplying certain amount of gases in tonnes by:

- For CH_4 multiplied by 16/12/1000.
- For CO multiplied by 28/12/1000.
- For N_2O multiplied by 44/28/1000.
- For NO multiplied by 46/14/1000.

Cropland wildfires are infrequent and emissions normally are small, in recent years emissions were accounted for about 2,49-3,24 Gg CO_2.

Agriculture section already addresses the following non-CO_2 emission sources:
- N_2O emissions from application of mineral and organic fertilizers, organic residues and biological nitrogen fixation and N_2O emissions from cultivation of organic soils reported as part of the Chapter 6 - Agriculture (CRF sector 4).

7.3.4 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 2003*. The uncertainty rates in the activity data and the emission factors used in the estimates are reported in Table 7-30.

Table 7-30. Estimated values of uncertainties for Cropland

Input	Uncertainties, %	References
Activity data		
Cropland area	±2,2	*Study 2*
Emission factors		
G (biomass accumulation)	±75	*IPCC 2003*, p. 3.71

[162] *Fire and Rescue Department under the Ministry of the Interior of the Republic of Lithuania. Available from: http://www.vpgt.lt/*

L (biomass loss)	±75	*IPCC 2003*, p. 3.71
SOC_{REF}	±95	*IPCC 2003*, p. 3.76
F_{LU} F_{MG} F_I	NA	*IPCC 2003*, p. 3.77
EF (organic soils)	±90	*IPCC 2003*, p. 3.79

7.3.5 Source-specific QA/QC and verification

The QC/QA includes the QC activities described in the *IPCC 2003*. Activity data and emission values are compared with emission values of other countries. If errors were found they were corrected.

7.3.6 Source-specific recalculations

The overall emissions in category have decreased by 0-1% comparing with 2013 inventory. This is due to recalculations made in subsector Other land converted to Cropland, also there were calculations including evaluation of carbon stock gain of mineral soil. Some inacuracies in activity data where corrected, organic soils now accounts for 0,7% of Cropland area (instead of 0,8 % used in previous submission). The total difference between emission/removals from Cropland of this submission and submission of 2013 is presented in Table 7-31.

Table 7-31. Reported in previous submission and recalculated emission/removals from Cropland during the period 1990-2011

Year	Previous submission, $GgCO_2$ eqv.	This submission, $GgCO_2$ eqv.	Absolut difference, $GgCO_2$ eqv.	Relative difference, %
1990	5772,1	5777,3	5,2	0,1
1991	5211,8	5211,9	0,1	0,0
1992	5042,9	5033,0	-9,9	-0,2
1993	4855,2	4825,6	-29,6	-0,6
1994	4682,0	4642,5	-39,5	-0,8
1995	4494,0	4449,5	-44,5	-1,0
1996	4326,4	4281,7	-44,7	-1,0
1997	4211,9	4167,1	-44,8	-1,1
1998	4052,2	4007,1	-45,1	-1,1
1999	3891,0	3850,6	-40,4	-1,0
2000	3619,6	3579,0	-40,6	-1,1
2001	3199,6	3163,5	-36,1	-1,1
2002	3046,2	3014,8	-31,4	-1,0
2003	2661,1	2629,4	-31,7	-1,2
2004	2575,6	2543,9	-31,7	-1,2
2005	2449,9	2422,9	-27	-1,1
2006	3147,1	3120,5	-26,6	-0,8
2007	3346,4	3320,1	-26,3	-0,8
2008	3792,3	3766,3	-26	-0,7
2009	3953,3	3927,6	-25,7	-0,7
2010	3669,4	3643,7	-25,7	-0,7
2011	3700,0	3674,4	-25,6	-0,7

7.3.7 Source-specific planned improvements

Estimations of CO_2 emissions from liming of cropland will be improved, more liming agents will be included with specific emission factors. Living biomass activity data for Croplands is planned to be upgraded with short rotation woody crops (Salix plantations).

Following the recommendations of ERT 2012, Lithuania plans to revise reference carbon stocks with country-specific values and implement more detailed stratification of management systems.

7.4 Grassland (CRF 5.C)

7.4.1 Source category description

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 ground vegetation, still remain grasslands. All grasslands are managed land. Only emissions from organic soils have been estimated under category Grassland remaining Grassland, assuming that there is no carbon stock change in living biomass and no liming of natural grasslands and pastures was applied during the last decades. Estimated carbon stocks are presented in the table below.

Table 7-32. Estimated carbon stocks under Grassland land use category

Land Use Category	Carbon stock change in living biomass	Carbon stock change in dead organic matter	Carbon stock change in soils	
			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*

Two source categories are accounted under this category: emissions from Grassland remaining Grassland and emissions from Land converted to Grassland.

7.4.2 Methodological issues

7.4.2.1 Grassland remaining Grassland

Areas continiously managed as a Grassland and areas coverted to Grassland after 20 consecutive years followed conversion reported in the category Grassland remaining Grassland (GG). Emissions and removals reported from Grassland remaining Grassland include two subcategories of CO_2 emissions/removals:

- changes in carbon stocks in living biomass;
- changes in carbon stocks in soils.

The total annual carbon stock change in GG category was estimated as the sum of annual estimates of carbon stock changes in each carbon pool – living biomass and soils – as shown in equation below (*IPCC 2003* eqv. 3.4.1, p. 3.105):

$$\Delta C_{GG} = \Delta C_{GGLB} + \Delta C_{GGSoils}$$

where:
ΔC_{GG} – annual change in carbon stocks in Grassland remaining Grassland, tonnes C yr^{-1};
ΔC_{GGLB} – annual change in carbon stocks in living biomass in Grassland remaining Grassland, tonnes C yr^{-1};
$\Delta C_{GGSoils}$ – annual change in carbon stocks in soils in Grassland remaining Grassland, tonnes C yr^{-1}.

To convert tonnes C to Gg CO_2 values are multiplied by 44/12 and by 10^{-3}.

Change in carbon stocks in living biomass

Grassland management practices in Lithuania mainly are static. Default *Tier 1* method was used assuming that there is no carbon stocks change in living biomass. Because *Tier 1* method does not assume any change in grassland biomass, it is not relevant to develop activity data and uncertainty estimates for *Tier 1*.

Change in carbon stocks in soils

Carbon stock changes (CO_2 emissions or removals) for mineral and organic soils (i.e. peat soils) are considered. Liming was not applied for natural grasslands and pastures during the last decades. Carbon emission from grassland lime application in the early 90's was reported together with cropland lime application in subcategory 5.B.1, therefore CO_2 emissions from liming reported to be zero in grasslands to avoid double counting and reported as NO.

For carbon stock changes in mineral soils, the *IPCC 2003* define soil carbon stocks as organic carbon incorporated into mineral soil horizons to a depth of 30 cm and do not include C in surface residue (i.e. dead organic matter) or changes in inorganic carbon (i.e. carbonate minerals).

The change in organic carbon stocks in soils has been estimated using the following equation (*IPCC 2003* eqv. 3.4.7, p. 3.111):

$$\Delta C_{GGSoils} = \Delta C_{GGMineral} – \Delta C_{GGOrganic} – \Delta C_{GGLiming}$$

where:
$\Delta C_{GGSoils}$ – annual change in carbon stocks in soils in grassland remaining grassland, tonnes C yr^{-1};
$\Delta C_{GGMineral}$ – annual change in carbon stocks in mineral soils in grassland remaining grassland, tonnes C yr^{-1};
$\Delta C_{GGOrganic}$ – annual change in carbon stocks in organic soils in grassland remaining grassland (estimated as net annual flux), tonnes C yr^{-1};
$\Delta C_{GGLiming}$ – annual C emissions from lime application to grassland, tonnes C yr^{-1}.

Mineral Soils

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%.

Annual rates of emissions by source or removals by sinks were calculated as the difference in stocks (over time) divided by the inventory time period. The default time period is 20 years. Carbon stock change in mineral soils was calculated using the following equation (*IPCC 2003* eqv. 3.4.8, p. 3.112):

$$\Delta C_{GGMineral} = [(SOC_0 - SOC_{(0-T)}) \times A] / T$$

$$SOC = SOC_{REF} \times F_{LU} \times F_{MG} \times F_I$$

where:
$\Delta C_{GGMineral}$ – annual change in carbon stocks in mineral soils, tonnes C yr^{-1};
SOC_0 – soil organic carbon stock in the inventory year, tonnes C ha^{-1};
$SOC_{(0-T)}$ – soil organic carbon stock T years prior to the inventory, tonnes C ha^{-1};
T – inventory time period, years (default is 20 years);
A – land area of each parcel, ha;
SOC_{REF} – the reference carbon stock, tonnes C ha^{-1} (*IPCC 2003* Table 3.4.4, p. 3.117);
F_{LU} – stock change factor for land use or land-use change type, dimensionless (*IPCC 2003* Table 3.4.5, p. 3.118);
F_{MG} – stock change factor for management regime, dimensionless (*IPCC 2003* Table 3.4.5, p. 3.118);
F_I – stock change factor for input of organic matter, dimensionless (*IPCC 2003* Table 3.4.5, p. 3.118).

Default reference soil organic carbon stocks (SOC_{REF}) were taken from *IPCC 2003* Table 3.4.4 (p. 3.117). For cold temperate moist climate region, HAC soils with 95 tonnes C per ha for 30 cm layer, sandy soils - 71 tonnes C per ha for 30 cm layer, spodic soils - 115 tonnes C per ha for 30 cm layer and wetland soils - 87 tonnes C per ha for 30 cm layer. The average value obtained from the values given above was calculated as 93,88 tonnes C per ha for 30 cm layer.

Relative stock change factors (F_{LU}, F_{MG} and F_I) for grassland management were taken from *IPCC 2003* Table 3.4.5 (p. 3.118).

All grasslands (excluding those on organic soils) are assigned a base or (land use) F_{LU} factor of 1 (error NA).

It was assumed that carbon inputs and losses in mineral soil balance in Grassland remaining Grassland category is equal one to another and therefore net changes are close to zero (reported as NO). Carbon inputs and losses from mineral soil are calculated for Land converted to Grassland category only.

Grasslands in Lithuania mainly represents non-degraded and sustainably managed grasslands, but without significant management improvements during the last decades. According to *IPCC 2003* revised default F_{MG} factor in all climatic conditions is 1,0 (error NA).

Nominal level input (applied only to improved grassland) used. According to *IPCC 2003* revised F_I factor for improved grassland where no additional management is applied is equal to 1,0 (error NA).

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 and reported as NO.

Organic soils

The activity data 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% of the total land area.

Tier 1 is used to estimate annual C emissions. Area of grassland organic soils under cold temperate regime was multiplied by the default emission factor using the fallowing equation (*IPCC 2003* eqv. 3.4.10, p. 3.114):

$$\Delta C_{GGOrganic} = \Sigma_c (A \times EF)_c$$

where:
$\Delta C_{GGOrganic}$ – CO_2 emissions from cultivated organic soils in grassland remaining grassland, tonnes C yr^{-1};
A – land area of organic soils in climate type *c*, ha;
EF – emission factor for climate type *c*, tonnes C ha^{-1} yr^{-1}.

Emission factor of 0,25 tonnes C ha^{-1} yr^{-1} for a cold temperate regime has been used for calculations (*IPCC 2003* Table 3.4.6 p. 3.118). Tonnes of C were converted to $GgCO_2$ multiplying conversion factor by 44/12 and 10^{-3}.

7.4.2.2 Land Converted to Grassland

The cumulative areas of grassland over a 20-year transition period reported in Figure 7-29. 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.

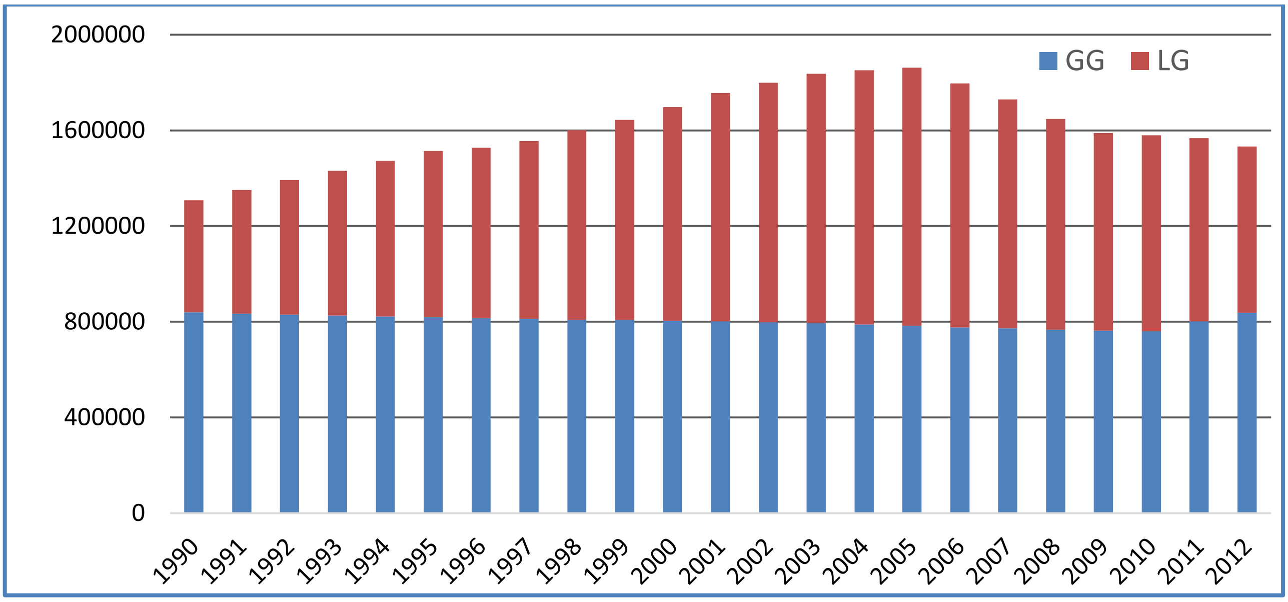

Figure 7-29. Grassland area changes during the period 1990-2012, ha

Based on information obtained from *Study-1* and *Study-2* during the last decades there have been no conversions of Forest land to Grasslands. Emissions and removals from Land converted to Grassland reported using *Tier 1* method including two subcategories of CO_2 emissions/removals:

- changes in carbon stocks in living biomass;
- changes in carbon stocks in soils.

The following equation was used for calculation of total change in carbon stocks in Land converted to Grassland (*IPCC 2003* eqv. 3.4.12, p. 3.120):

$$\Delta C_{LG} = \Delta C_{LGLB} + \Delta C_{LGSoils}$$

where:
Δ_{CLG} – total change in carbon stocks in land converted to grassland, tonnes C yr^{-1};
ΔC_{LGLB} – change in carbon stocks in living biomass in land converted to grassland, tonnes C yr^{-1};
$\Delta C_{LGSoils}$ – change in carbon stocks in soils in land converted to grassland, tonnes C yr^{-1}.

To convert tonnes of C to Gg CO_2, values are multiplied by 44/12 and by 10^{-3}.

Change in carbon stock in living biomass

Tier 1 is used to estimate annual carbon stocks change in living biomass from Land converted to Grassland. The default assumption for *Tier 1* is that all carbon in biomass is lost to the atmosphere through decay processes either on- or off-site. As such, *Tier 1* calculations do not differentiate immediate emissions from burning and other conversion activities. Equation used for calculation (*IPCC 2003* eqv. 3.4.13, p. 3.122):

$$\Delta C_{LGLB} = A_{Conversion} \times (L_{Conversion} + \Delta C_{Growth})$$

$$L_{Conversion} = C_{After} - C_{Before}$$

where:
ΔC_{LGLB} – annual change in carbon stocks in living biomass in land converted to grassland, tonnes C yr^{-1};
$A_{Conversion}$ – annual area of land converted to grassland from some initial use, ha yr^{-1};
$L_{Conversion}$ – carbon stock change per area for that type of conversion when land is converted to grassland, tonnes C ha^{-1};
ΔC_{Growth} – carbon stocks from one year of growth of grassland vegetation after conversion, tonnes C ha^{-1};
C_{After} – carbon stocks in biomass immediately after conversion to grassland, tonnes C ha^{-1};
C_{Before} – carbon stocks in biomass immediately before conversion to grassland, tonnes C ha^{-1}.

It is assumed that all biomass is cleared when preparing a site for grassland use, thus, the default value C_{After} is 0 tonnes C ha^{-1}. Default estimate of 10,0 tonnes d.m. ha^{-1} for C_{Before} has been used (*IPCC 2003* Table 3.4.8, 3.124). Default value of 13,6 tonnes d.m. ha^{-1} carbon stock in biomass after one year (ΔC_{Growth}) for cold temperate wet climate zone has been used (*IPCC 2003* Table 3.4.9, 3.125).

Change in carbon stock in soils

Tier 1 method is used to estimate annual carbon stocks change in soils for Land converted to Grassland. The following equation was used for calculation (*IPCC 2003* eqv. 3.4.17, p. 3.126):

$$\Delta C_{LGSoils} = \Delta C_{LGMineral} - \Delta C_{LGOrganic} - \Delta C_{LGLime}$$

where:
$\Delta C_{LGSoils}$ – annual change in stocks in soils in Land converted to Grassland, tonnes C yr^{-1};
$\Delta C_{LGMineral}$ – change in carbon stocks in mineral soils in Land converted to Grassland, tonnes C yr^{-1};
$\Delta C_{LGOrganic}$ – annual C emissions from organic soils converted to Grassland (estimated as net annual flux), tonnes C yr^{-1};
ΔC_{LGLime} – annual C emissions from agricultural lime application on Land converted to Grassland, tonnes C yr^{-1}.

Calculation of carbon stocks in mineral soils in Land converted to Grassland is based on the same methodological approaches as for Grassland remaining Grassland detailed in section 7.4.2.1.

Annual rates of emissions by source or removals by sinks in croplands converted to grasslands were calculated as the difference in stocks (over time) divided by the inventory time period. The default time period is 20 years. Carbon stock change in mineral soils was calculated using the following equation (*IPCC 2003* eqv. 3.4.8, p. 3.112):

$$\Delta C_{GGMineral} = [(SOC_0 - SOC_{(0-T)}) \times A] / T$$

$$SOC = SOC_{REF} \times F_{LU} \times F_{MG} \times F_I$$

where:
$\Delta C_{GGMineral}$ – annual change in carbon stocks in mineral soils, tonnes C yr^{-1};
SOC_0 – soil organic carbon stock in the inventory year, tonnes C ha^{-1};
$SOC_{(0-T)}$ – soil organic carbon stock T years prior to the inventory, tonnes C ha^{-1};
T – inventory time period, years (default is 20 years);
A – land area of each parcel, ha;
SOC_{REF} – the reference carbon stock, tonnes C ha^{-1} (Table 3.4.4 of *IPCC 2003*);
F_{LU} – stock change factor for land use or land-use change type, dimensionless (*IPCC 2003* Table 3.4.5, p. 3.118);
F_{MG} – stock change factor for management regime, dimensionless (*IPCC 2003* Table 3.4.5, p. 3.118);
F_I – stock change factor for input of organic matter, dimensionless (*IPCC 2003* Table 3.4.5, p. 3.118).

Default reference soil organic carbon stocks (SOC_{REF}) were taken from *IPCC 2003* Table 3.4.4 (p. 3.117). For cold temperate moist climate region, HAC soils with 95 tonnes C per ha for 30 cm layer, sandy soils - 71 tonnes C per ha for 30 cm layer, spodic soils - 115 tonnes C per ha for 30 cm layer and wetland soils - 87 tonnes C per ha for 30 cm layer. The average value obtained from the values given above was calculated as 93,88 tonnes C per ha for 30 cm layer.

Tier 1 approach was used in order to calculate carbon stock change in organic soils. Default emission factor of 0,25 tonnes C yr^{-1} (*IPCC 2003* Table 3.4.6, p. 3.118) was used along with area estimates for Wetlands converted to Grasslands in cold temperate climate region present in Lithuania (*IPCC 2003* eqv. 3.4.10, p. 3.114). Area of organic soils was determined using data of NFI 2012 (10,5%) and was distributed to all conversions of grasslands.

All carbon emissions from lime application reported in Cropland remaining Cropland category, therefore CO_2 emissions from liming assumed to be zero in Land converted to Grassland and reported as NO.

7.4.3 Non-CO_2 greenhouse gas emissions

Non-CO_2 greenhouse gas emissions resulting from fire in Grassland category were calculated employing the same methodology used for calculation of non-CO_2 GHG emissions in Cropland category (Section 7.3.3).

The following non-CO_2 greenhouse gas emissions already reported in the Agriculture section:

- N_2O emissions from application of mineral and organic fertilizers, organic residues and biological nitrogen fixation in managed grassland;

- CH_4 emissions from grazing livestock.

7.4.4 Uncertainty assessment

The activity data was obtained from The National Land Service (NLS) and national Nature Heritage Fund (NHF). The emission factors were employed from *IPCC 2003*. The uncertainty rates in the activity data and the emission factors used in the estimates are reported in Table 7-33.

Table 7-33. Estimated values of uncertainties for Grassland

Input	Uncertainties, %	References
Activity data		
Grassland area	±1,2	*Study 2*
Emission factors		
SOC_{REF}	±95	*IPCC 2003*, p 3.117
F_{LU} F_{MG} F_I	NA	*IPCC 2003*, p 3.118
EF (organic soils)	±90	*IPCC 2003*, p 3.118

7.4.5 Source-specific QA/QC and verification

The QC/QA includes the QC activities described in the *IPCC 2000*. Activity data and emission values are compared with emission values of other countries. If errors were found they were corrected.

7.4.6 Source-specific recalculation

The overall sink in category has increased by 0-2% comparing with 2013 inventory. This is due to recalculations made in subsector Other land converted to Grassland, there were gain of mineral soil carbon stocks included in to the calculations.

The total difference between emission/removals from Grassland in this submission and submission of 2013 is presented in Table 7-34.

Table 7-34. Reported in previous submission and recalculated emission/removals from Grassland during the period 1990-2011

Year	Previous submission, $GgCO_2$ eqv.	This submission, $GgCO_2$ eqv.	Absolut difference, $GgCO_2$ eqv.	Relative difference, %
1990	-2362,4	-2362,4	0,0	0,0
1991	-2531,3	-2538,2	-6,9	0,3
1992	-2699,4	-2720,0	-20,6	0,8
1993	-2837,7	-2885,8	-48,1	1,7
1994	-3057,7	-3119,6	-61,9	2,0
1995	-3151,0	-3219,7	-68,7	2,2
1996	-2997,8	-3066,6	-68,8	2,3
1997	-3307,4	-3376,2	-68,8	2,1
1998	-3751,0	-3819,7	-68,7	1,8
1999	-4017,9	-4079,7	-61,8	1,5
2000	-4333,6	-4395,5	-61,9	1,4
2001	-4565,8	-4620,8	-55	1,2
2002	-4678,1	-4726,3	-48,2	1,0

2003	-4699,2	-4747,4	-48,2	1,0
2004	-4690,9	-4739,0	-48,1	1,0
2005	-4687,9	-4729,2	-41,3	0,9
2006	-4370,4	-4411,7	-41,3	0,9
2007	-4067,7	-4108,9	-41,2	1,0
2008	-3734,5	-3775,7	-41,2	1,1
2009	-3441,6	-3482,8	-41,2	1,2
2010	-3308,6	-3349,9	-41,3	1,2
2011	-3138,9	-3180,1	-41,2	1,3

7.4.7 Source-specific planned improvements

Uncertainty assessment of emissions from grassland will be improved.

7.5 Wetland (CRF 5.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 (*Taminskas et al, 2011*)[163]

Data on wetland area were taken from the *Study-2*. The area includes two categories reported in the statistics – water bodies and swamps (bogs). Figure 7-30 shows comparison between data used for greenhouse gas estimations (*Study-1* and *Study-2*) and data provided by Lithuanian Inland Water Register. The difference between these two data sources is marginal.

CO_2 emissions associated with peat extraction were evaluated.Extracted peat is mostly used for production of organic fertilizers or fuel. Extent of such production is available from Statistics Lithuania[164].

In 2011 inland waters (lakes, rivers etc.) constituted to 196,0 (*Study-2* data) thous. ha, what is 57% of the total wetlands area. During the *Study-2* there was no differentiation for wetlands into managed and unmanaged categories. Only natural rivers, lakes, ponds and peat lands were estimated.

[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.*

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

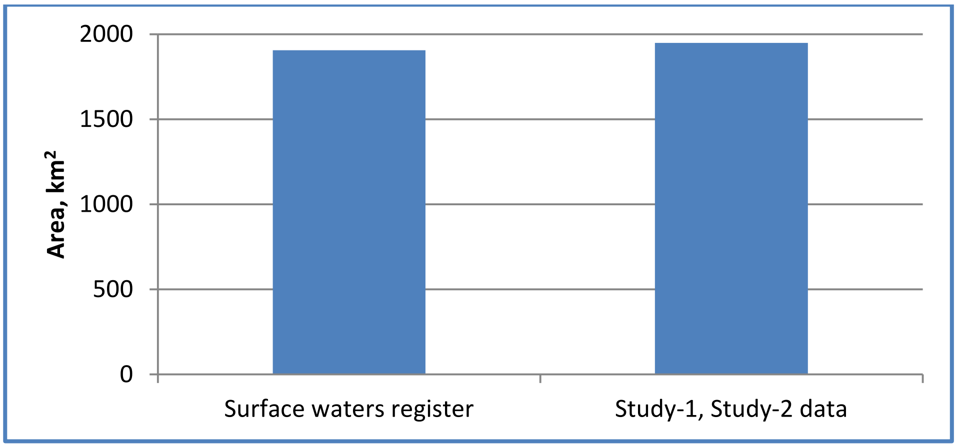

Figure 7-30. Comparison of data used for greenhous gas estimations (*Study-1* and *Study-2*) and data presented by Lithuanian Surface Waters Register

7.5.1 Source category description

Inland waters are distributed into two separate groups of managed and unmanned wetlands. Unmanaged wetlands are all surface waters (Lakes, riverbeds, lakelets, ponds etc.) and unmanaged peatlands. Managed wetlands are considered as peat extraction areas, which are monitored by Lithuanian Geological Service.

Table 7-35. Distribution of wetlands, thous. ha

Year	Unmanaged wetlands		Managed wetlands
	Surface waters	Peatlands, mires, bogs	Peat lands for extraction
1990	240,4	104,6	18,0
1991	240,4	99,4	18,0
1992	240,4	97,8	18,0
1993	240,8	98,1	15,7
1994	240,8	95,2	18,7
1995	240,8	95,3	18,6
1996	240,8	93,3	18,5
1997	240,8	95,2	16,6
1998	240,8	94,6	16,8
1999	240,8	93,9	16,8
2000	240,4	90,6	17,6
2001	240,4	90,1	17,7
2002	240,4	94,2	14,4
2003	240,4	95,3	12,6
2004	240,0	94,6	13,3
2005	240,0	93,2	13,8
2006	239,6	91,6	14,3
2007	239,6	90,2	14,0
2008	239,2	90,7	14,0
2009	239,2	91,4	14,0
2010	239,2	90,2	14,0

2011	240,0	89,3	13,8
2012	242,44	86,1	13,8

Surface waters are distributed by several groups, which are presented in the Figure below.

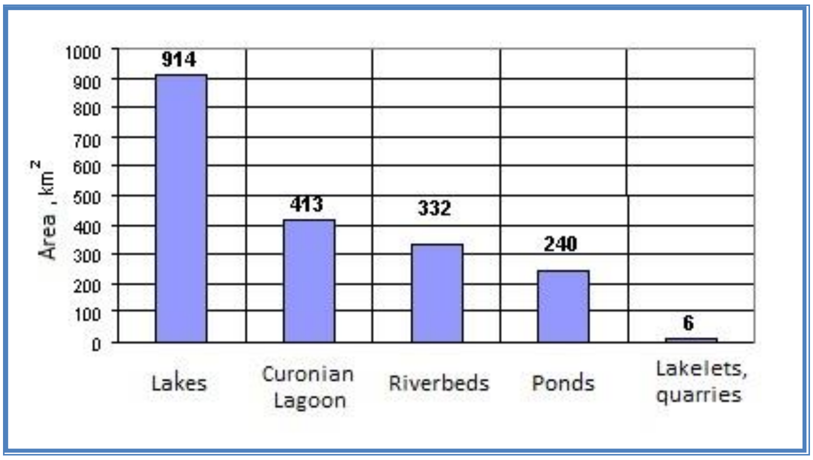

Figure 7-31. Surface waters area

Peat extraction areas are recorded by the Lithuanian Geological Service since 1992. Extraction area was fairly stable from 1992 to 2001 fluctuating in approximately 12% range (Table 7-35). Since 2002 extraction area has been decreasing by approximately 20%. It was assumed that peat extraction area in 1990 and 1991 was the same as in 1992. In 2012 peat extraction area comprised to 13778 ha.

7.5.2 Methodological Issues

The method provided in *IPCC 2003* addresses emissions from vegetation removal from land prepared for peat extraction and changes in soil organic matter due to oxidation of peat in the aerobic layer on the land during the extraction. As the total peat extraction area is slightly decreasing, it was assumed that emissions from removal of vegetation for peat extraction are negligible and was not taken into account. CO_2 emissions due to oxidation of peat were calculated using modified Equation 3a.3.6 of the Appendix 3a.3 of the *IPCC 2003*.

$$\Delta C_{drainage} = A_{Nrich} \times EF_{Nrich}$$

where:
$\Delta C_{drainage}$ – annual change in carbon stocks in soils due to drainage of organic soils converted to peat extraction, tonnes C yr^{-1}
A_{Nrich} – area of nutrient rich organic soils converted to peat extraction, ha
EF_{Nrich} – emission factor for changes in carbon stocks in nutrient rich organic soils converted to peatextraction, tonnes C ha^{-1} yr^{-1}.

As data on areas of nutrient rich and nutrient poor organic soils were not available, emission factor for carbon stocks change for soils that were converted to peat extraction was applied the one that is designed for nutrient rich peat land (*IPCC 2003* Table 3.5.2, p. 3.138).

7.5.3 Uncertainty assessment

CO_2 emissions from wetlands were evaluated as a result of forest land conversion to wetlands. Converted areas are relatively very 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%.

7.5.4 Source-specific QA/QC and verification

Quality control procedures named in *IPCC 2003* were established.

7.5.5 Source-specific recalculation

No recalculations were made.

7.5.6 Source specific planned improvements

Additional studies and information research are planned in order to improve reporting of areas and greenhouse gas emissions/removals under this land use category.

7.6 Settlements (CRF 5.E)

7.6.1 Source category description

NLS indicates two subcategories under settlements category – build 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.

7.6.2 Methodological issues

7.6.2.1 Settlements remaining Settlements

Areas continiously managed as a Settlements and areas coverted to Settlements after 20 consecutive years followed conversion reported in the category Settlements remaining Settlements (SS). General method was used to estimate changes in biomass carbon stocks as a result of tree growth, subtracting losses in biomass carbon stocks due to pruning and mortality. While growing conditions in parks and gardens usually are good, the growth and health condition of older trees are assumed to progressively deteriorate with time because of the harshness of urban conditions (e.g. relatively low radiation levels, air pollution). Therefore, estimation method assumes, that the accumulation of carbon in biomass slows down with the age and thus for trees older than 20 years increase in biomass carbon is assumed to offset losses from pruning and mortality. This is conservatively accounted for by setting $\Delta B_{SSG} = \Delta B_{SSL}$ (*IPCC 2003*, p. 3.298). Carbon stock changes in Settlements remaining Settlements assumed to be close to zero in Lithuania and reported as NO.

7.6.2.2 Land converted to Settlements

The cumulative areas over the 20-year transition period reported in Figure 7-32. For each year, the cumulative total area reported under Land converted to Settlements category accounted as equal 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.

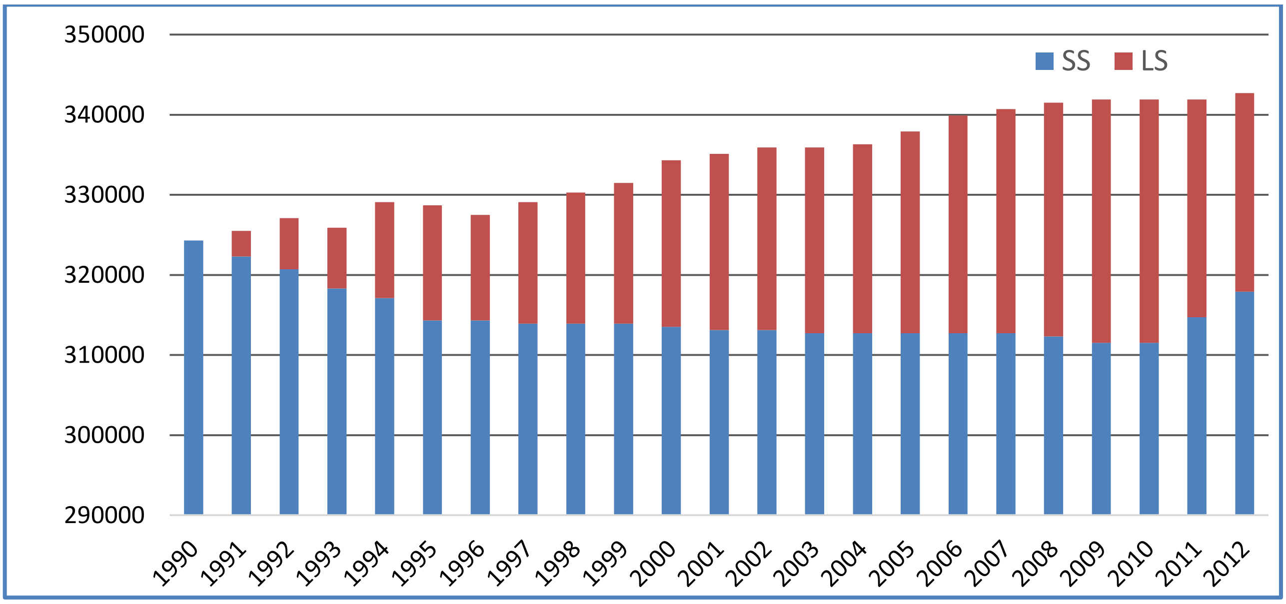

Figure 7-32. Settlements area changes during the period 1990-2012, ha

All land conversions to Settlements (LS) except conversion of Forest land accounted as Settlements remaining Settlements. 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.

7.6.3 Uncertainty assessment

CO_2 emissions from settlements were evaluated as a result of Forest land conversion to Settlements. Converted areas are relatively very 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%.

7.6.4 Source-specific QA/QC and verification

Quality control procedures named in *IPCC 2003* were established when calculating emissions from Settlements category.

7.6.5 Source-specific recalculations

Carbon stock changes due to loss of living biomass from conversions of Grasslands to Settlements were re-estimated: C_{before} values corrected – from 5 t C ha^{-1} to 1,2 t C ha^{-1}.The total difference between emission/removals from Settlements of this submission and submission of 2013 is presented in Table 7-36.

Table 7-36. Reported in previous submission and recalculated emission/removals from Settlements during the period 1990-2011

Year	Previous submission, $GgCO_2$ eqv.	This submission, $GgCO_2$ eqv.	Absolut difference, $GgCO_2$ eqv.	Relative difference, %
1990	NE,NO	NE,NO	-	-
1991	749,1	732,4	-16,7	-2,2
1992	774,1	768,6	-5,5	-0,7
1993	354,6	349,0	-5,6	-1,6

1994	1313,9	1291,7	-22,2	-1,7
1995	524,6	524,6	0,0	0,0
1996	NE,NO	NE,NO	-	-
1997	249,5	243,9	-5,6	-2,2
1998	249,5	243,9	-5,6	-2,2
1999	394,5	383,4	-11,1	-2,8
2000	959	942,3	-16,7	-1,7
2001	249,5	243,9	-5,6	-2,2
2002	209,9	209,9	0,0	0,0
2003	144,7	139,1	-5,6	-3,9
2004	104,8	104,8	0,0	0,0
2005	458,8	458,8	0,0	0,0
2006	723,9	701,6	-22,3	-3,1
2007	289,7	278,6	-11,1	-3,8
2008	394,5	383,4	-11,1	-2,8
2009	394,5	383,4	-11,1	-2,8
2010	NE,NO	NE,NO	-	-
2011	NE,NO	NE,NO	-	-

7.6.6 Source-specific planned improvements

Colection of additional information is planned in order to harmonize NLS and NFI data and improve reporting of areas that currently are under NA, NE notation keys. Improvement of reporting is planned to include subcategories with vegetation and without vegetation.

7.7 Other land (CRF 5.F)

7.7.1 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. For reporting activities, subcategories of national statistics were reduced significantly – swamps reported under Wetland category. Trees and bushes plantations in urban areas reported under Settlements category. Disturbed land and unmanaged land accounted under Other land category.

7.7.2 Methodological issues

7.7.2.1 Other Land Remaining Other Land

Carbon stocks changes and non-CO_2 emissions and removals are not considered for this category as it is not required according to *IPCC 2003* guidelines.

7.7.2.2 Land converted to Other Land

Emissions and removals from Land converted to Other Land (OL) reported using *Tier 1* method and include two subcategories of CO_2 emissions/removals:

- changes in carbon stocks in living biomass;
- changes in carbon stocks in soils.

For calculation of total change in carbon stocks in Land converted to Other Land the following equation was used (*IPCC 2003* eqv. 3.7.1, p. 3.145):

$$\Delta C_{LO} = \Delta C_{LOLB} + \Delta C_{LOSoils}$$

where:
ΔC_{LO} – annual change in carbon stocks in land converted to Other Land, tonnes C yr^{-1};
ΔC_{LOLB} – annual change in carbon stocks in living biomass in land converted to Other land, tonnes C yr^{-1};
$\Delta C_{LOSoils}$ – annual change in carbon stocks in soils in land converted to Other Land, tonnes C yr^{-1}.

To convert tonnes of C to Gg CO_2, value was multiplied by 44/12 and by 10^{-3}.

Change in carbon stocks in living biomass

Tier 1 method was used to estimate annual change in carbon stocks in living biomass on Lands converted to Other Land. The default assumption for *Tier 1* is that all carbon in biomass is lost to the atmosphere through decay processes either on- or off-site. The following equation was used for calculation (*IPCC 2003* eqv. 3.7.2, p. 3.146):

$$\Delta C_{LOLB} = A_{Conversion} \times (B_{After} - B_{Before}) \times CF$$

where:
ΔC_{LOLB} – annual change in carbon stocks in living biomass in land converted to Other Land, tonnes C yr^{-1};
$A_{Conversion}$ – area of land converted annually to Other Land from some initial land uses, ha yr^{-1};
B_{After} – amount of living biomass immediately after conversion to Other Land, tonnes d.m. ha^{-1};
B_{Before} – amount of living biomass immediately before conversion to Other Land, tonnes d.m. ha^{-1};
CF – carbon fraction of dry matter (default = 0,5), tonnes C (tonnes d.m.)$^{-1}$.

It is assumed that the entire biomass is removed in the year of conversion, thus, the default values for B_{After} is 0 tonnes C ha^{-1}. Default estimate of 10,0 tonnes d.m. ha^{-1} for B_{Before} has been used (*IPCC 2003* Table 3.4.8, 3.124) for conversions from Cropland, default 2,4 tonnes d.m. ha^{-1} estimate for B_{Before} has been used (*IPCC 2003* Table 3.4.2, 3.109) for conversions from Grassland.

The default assumption is that carbon stock after conversion is zero and reported as NO.

Change in carbons stock in soils

Soil carbon stocks after conversion are assumed to be zero for Other Land such as bare or degraded soils or deserts. It is also assumed that the changes in carbon stocks in organic soils are not relevant in this section.

7.7.3 Uncertainty assessment

Default uncertainty level of 75% of the estimated CO_2 emissions/removals has been assumed based on expert judgment.

7.7.4 Source-specific QA/QC and verification

Quality control procedures named in *IPCC 2003* were established when calculating emissions from Other Land category.

7.7.5 Source-specific recalculation

No recalculations were made.

7.7.6 Source-specific planned improvements

With implementation of new regulation of NLS, coming into force on 28th January 2014 and based on satelite image information accurasy of activity data will be improved.

8 WASTE (CRF 6)

8.1 Overview of Waste Sector

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

In Lithuania greenhouse gases emissions (GHG) from Waste Sector originate from the following sources:

- solid waste disposal on land including sewage sludge (CRF 6.A);
- wastewater handling (industrial and domestic/commercial wastewater)(CRF 6.B);
- human sewage(CRF 6.B.2.2);
- waste incineration (CRF 6.C).

Few emission sources from Waste Sector were identified as key source category, by level and trend, without LULUCF. Waste-water handling (CH_4, N_2O) was identified by Tier 2 and Solid Waste Disposal on Land (CH_4) by both approaches.

Table 8-1. Key category from Waste in 2012 by Level and Trend excluding LULUCF

IPCC source categoty	Gas	Identification criteria	Approach used
6.A Solid Waste Disposal on Land	CH_4	Level	Tier 1 / Tier 2
		Trend	Tier 1 / Tier 2
6.B Wastewater handling	CH_4	Level	Tier 2
		Trend	Tier 2
6.B Wastewater handling	N_2O	-	-
		Trend	Tier 2

GHG emissions from Waste Sector are summarised in Table 8-2.

Table 8-2. Summary of GHG emissions from Waste Sector, Gg CO_2 eqv.

Year	Solid waste disposal	Sewage sludge	Waste-water handling	Humane sewage	Waste incineration	Total
1990	827	37,5	173,9	79,9	4,5	1123
1991	847	38,3	174,1	80,2	4,5	1144
1992	865	38,9	172,8	80,3	1,3	1158
1993	878	41,7	171,9	80,1	3,8	1176
1994	885	40,0	170,4	79,8	1,2	1176
1995	885	40,8	169,0	79,4	4,3	1179
1996	888	45,1	167,8	78,9	1,4	1181
1997	891	48,5	166,8	78,5	1,4	1187
1998	891	52,1	165,8	78,2	1,5	1189
1999	890	56,1	162,3	77,8	0,7	1187
2000	896	58,3	157,0	77,4	1,9	1191
2001	926	59,7	151,6	77,0	2,5	1216
2002	937	58,0	147,2	76,5	2,3	1221
2003	948	56,4	138,0	76,6	6,3	1225
2004	934	52,0	131,7	76,5	3,2	1198
2005	918	49,6	124,8	76,0	5,9	1175

2006	906	46,1	112,9	75,5	5,5	1146
2007	895	42,4	110,7	75,3	0,8	1124
2008	881	39,6	118,9	75,2	0,7	1116
2009	870	35,1	111,8	75,1	0,7	1092
2010	854	31,0	102,9	74,2	2,0	1064
2011	782	26,9	101,8	73,2	7,3	991
2012	766	23,6	102,2	72,8	1,7	966

During the period 1990-2003 total GHG emission from Waste Sector increased by 9,1 % but during 2003-2012 it decreased by 21,1 %. The average GHG emission for period 1990-2012 was 1149 Gg 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 81,7% of the total GHG emission from Waste Sector in 2012 (79,3% excluding disposal of sewage sludge). Fluctuations of GHG emissions caused by solid waste disposal on land were not significant. 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. Positive effect on GHG emissions from solid waste disposal had extraction of landfill gas from several closed landfills started in 2008.

Variations of GHG emissions from solid waste disposal on land during the period 1990 to 2012 are shown in Figure 8-1.

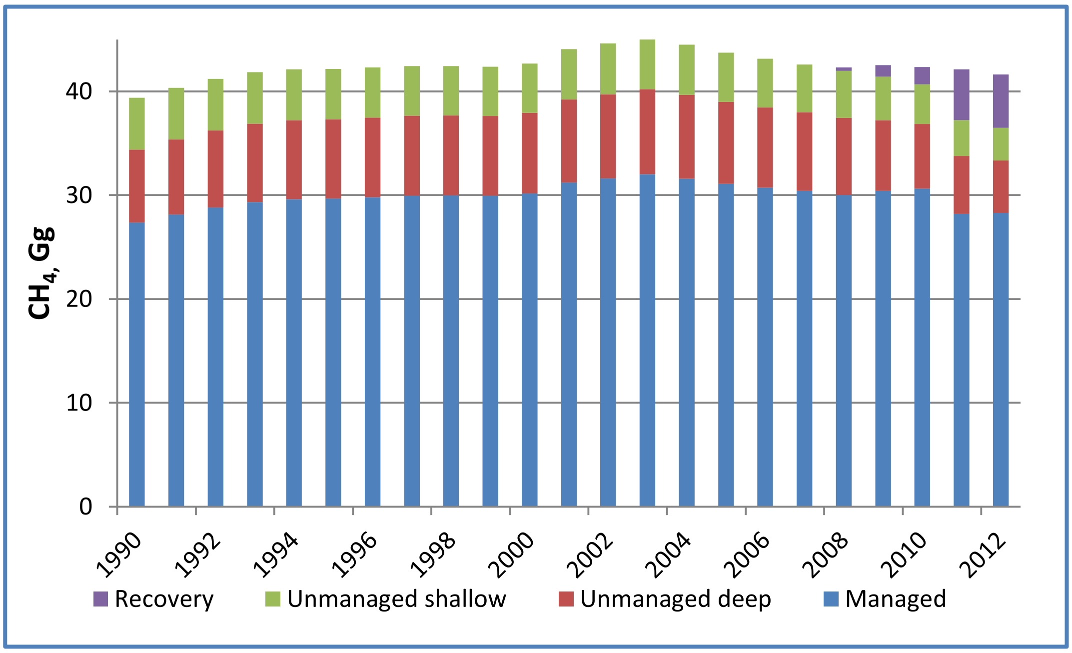

Figure 8-1. Variations of GHG emissions in Waste Sector (1990-2012)

Wastewater handling contributed around 13,0 % of GHG emissions from Waste Sector in 2012 including 2,4% contribution of sewage sludge management. Wastewater in Lithuania is treated with aerobic treatment system with minimum CH_4 generation. However, significant part of population still does not have connection to public sewerage systems and emissions from sewage collected in septic caused significant emissions.

Humane sewage is responsible on average for 6,7 % of the total GHG emission from Waste Sector, fluctuating from 6,3 % in 2001 to 7,5 % in 2012.

Waste incineration is used in Lithuania on a very small scale contributing during the period 1990-2012 on average only 0,25 % of the total waste GHG emission.

8.2 Solid waste disposal on land (CRF 6.A)

8.2.1 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 8-3). Major part of waste is generated in industrial sector of which about 100 thous tonnes - hazardous waste. Annual municipal waste generation is a bit more than 1 million tonnes.

Table 8-3. Waste collection and treatment in 2011, thou. tonne

Statistical waste category		Collected	Treatment methods*							
			D1, D5	D2, D4, D6	Export	R1	D10	R2-R9	R10, R11	D8, D9, D14, R12,S5
2011										
01	Chemical compound wastes	9,3	0,1	0,0	1,8	0,0	0,7	1,9	0,0	5,0
02	Chemical preparation wastes	1,2	0,1	0,0	0,2	0,0	1,5	0,0	0,0	0,4
03	Other chemical wastes	55,3	0,5	3,0	4,5	0,0	0,9	53,5	0,0	16,8
05	Health care and biological wastes	1,2	0,2	0,0	0,4	0,0	0,4	0,0	0,0	0,1
06	Metallic wastes	686,6	0,0	0,0	661,6	0,0	0,0	11,8	0,0	0,1
07	Non-metallic wastes	449,6	9,7	0,0	60,9	101,1	0,3	273,2	4,6	0,3
08	Discarded equipment	66,3	0,0	0,0	8,7	0,0	0,2	14,2	0,0	42,8
09	Animal and vegetal wastes	267,8	11,0	0,5	2,1	1,7	0,0	201,2	53,9	0,3
10	Mixed ordinary wastes	3238,2	3162,0	6,6	23,5	0,2	0,0	40,6	0,8	3,7
11	Common sludge	54,5	1,3	0,5	0,5	0,0	0,0	10,6	15,9	0,0
12	Mineral wastes	619,6	106,0	28,8	1,1	0,0	0,4	333,2	67,4	8,3
	Total	5449,6	3290,8	39,4	765,4	103,0	4,4	940,2	142,6	77,8

*List of treatment operations is provided in Table 8-4. below
Source: Lithuanian EPA

Amount of waste generated by industry and other economic activities has increased from 2 to 4 million tonnes from 2000 to 2011. Waste generation during this period grew more slowly than production. About half of generated waste is still disposed of in landfills.

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 666 landfills and dumps not in line with the environmental protection and public health safety requirements were closed by 2012 and 142 landfills are foreseen to close by the end of 2013. 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.

Landfill gas collection with energy recovery is planned at major old landfills. Recovery of landfill gas started at 2 landfills in 2008. Currently landfill gas is recovered in 3 operating and 6 closed landfills (Draft National Waste management Plan[165]).

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 the Draft National Waste Management Plan, waste collection services were provided to 94,8% of population. Differences between provision of services in cities, towns and rural areas are decreasing. In 2011-2012, waste collection services were provided to 97% of population in towns and cities with population exceeding 1000 inhabitants and to 79% of population in small towns and villages with population less than 200 inhabitants.

Table 8-4. 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)

[165] Lietuvos Respublikos Vyriausybės nutarimo „Dėl Lietuvos Respublikos Vyriausybės 2002 m. balandžio 12 d. nutarimo Nr. 519 „Dėl valstybinio strateginio atliekų tvarkymo plano patvirtinimo" pakeitimo" projektas

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

Packaging waste makes a relatively large part (9% in 2011) of generated municipal waste and its steadily increasing due to grow of packaging placed on market. In 2011 more than 290 thous tonnes (7% more than in 2010) of packaging were placed on the market. Paper and cardboard packaging makes about 30%, glass and plastic packaging – about 20% each of packaging placed on the market (Table 8-5).

On average, about 60% of packaging waste is recovered and recycled. More than 70% of paper and cardboard and glass packaging and about two thirds of metal packaging are recycled.

Table 8-5. Generation and recovery of packaging waste

Packaging material	**Placed on the market**	**Recovered**	
	tonne	**tonne**	**%**
2010			
Glass	61,238	40,989	66,9
Plastic	56,522	21,689	38,4
Paper, cardboard	82,360	68,763	83,5
Metal	11,632	8,039	69,1
Composite	825	181	21,9
Wood	53,780	24,955	46,4
Other	6,121	0	0,0
Total	272,478	164,616	60,4
2011			
Glass	63,233	46,850	74,1
Plastic	60,356	23,477	38,9

Paper, cardboard	88,589	74,178	83,7
Metal	13,093	8,958	68,4
Composite	936	233	24,9
Wood	66,141	30,208	45,7
Total	292,348	183,904	62,9

Source: Lithuanian EPA

From about 15 to 22 thous tonne of oils placed on the Lithuanian market about one forth is recovered (Table 8-6). Oil producers and importers are obliged to ensure that oil waste equivalent to 30% of oils placed on the market is recycled from 2008 and at least 50% from 2012.

Table 8-6. Collection and recovery of spent oils (tonne)

Year	Placed on the market	Collected	Recovered/recycled
2008	22,020	5,742	5,620
2009	16,854	4,607	3,988
2010	15,266	3,971	3,822
2011	19,549	4,162	4,169

Source: Lithuanian EPA

Amendments to the Waste Management Law passed by the Seimas in 2012 place stricter requirements on producers and importers of batteries and accumulators as well as other equipment (electric and electronic equipment, oils, etc.) in order to improve collection, reuse, recovery and recycling of waste for which producer responsibility is established. Car batteries comprise more than 98% of the total amount of collected batteries and accumulators (Table 8-7).

Table 8-7. Collection and treatment of batteries and accumulators (tonne)

Waste category		Collection	Export	Recycling	Other treatment
2010					
16 06 01	Lead batteries	15498,9	3023,2	11615,4	
16 06 02	Ni-Cd batteries	3,9		1,4	
17 06 03	Mercury-containing batteries	0,0			
18 06 04	Alkaline batteries (except 16 06 03)	7,6		7,1	
19 06 05	Other batteries and accumulators	188,5		191,4	
20 01 33	Batteries and accumulators included in 16 06 01, 16 06 02 or 16 06 03 and unsorted batteries and accumulators containing these batteries	12,3		3,5	
20 01 34	Batteries and accumulators other than those mentioned in 20 01	13,6	1,0	0,13	0,23

	33				
	Total	15724,7	3024,2	11818,9	0,23
	2011				
16 06 01	Lead batteries	14843,9	3534,0	11279,9	748,9
16 06 02	Ni-Cd batteries	4,0		4,1	
17 06 03	Mercury-containing batteries	0,0			
18 06 04	Alkaline batteries (except 16 06 03)	2,7			
19 06 05	Other batteries and accumulators	312,0		317,9	
20 01 33	Batteries and accumulators included in 16 06 01, 16 06 02 or 16 06 03 and unsorted batteries and accumulators containing these batteries	28,3			13,9
20 01 34	Batteries and accumulators other than those mentioned in 20 01 33	16,4	10,3		
	Total	15207,3	3544,3	11601,9	762,8

Source: Lithuanian EPA

Available data on generation and treatment of waste electrical and electronic equipment (WEEE) are provided in Table 8-8.

Approximately 17% of WEEE placed on the market is collected as waste. Most of collected waste is treated in Lithuania, however certain part of wastes, such as waste containing ozone depleting substances, is exported for treatment in other, mainly EU, countries.

Table 8-8. Generation and treatment of WEEE (tonne)

	EEE category	EEE placed on the market		Collection		Treatment		Recovery
		total	for households	from households	other than households	in Lithuania	abroad	
2010								
1	Large household appliances	14102,3	14026,8	5045,4	9,5	3524,9	724,4	748,9
2	Small household appliances	2135,6	2134,1	579,1	0,2	413,6		174,3
3	IT and telecommunications equipment	2842,9	2490,8	1111,2	35,7	1027,6		205,1
4	Consumer equipment	1714,9	1709,7	776,4	14,9	668,9		292,5
5	Lighting equipment, except fluorescent lamps	484,6	251,8	121,7	1,0	116,7		7,7
5a	Fluorescent lamps	460,0	388,6	151,4	6,7	73,1	96,4	
6	Electrical and electronic tools	1463,6	1452,0	571,9	1,5	304,9		242,3
7	Toys, leisure and sports equipment	307,5	304,6	113,6		77,1		45,6
8	Medical devices	156,5	115,4	72,8	3,0	37,5		44,3
9	Monitoring and control instruments	285,1	230,5	284,7	12,2	101,5	138,7	76,9
10	Automatic dispensers	44,6	37,6		14,7	12,7		5,3
	Total	23997,6	23141,9	8828,2	99,5	6358,3	959,5	1843,0
2011								
1	Large household appliances	14203,7	14137,4	6513,2	17,6	3533,1	387,7	2622,6
2	Small household appliances	2191,0	2189,5	624,6	0,0	322,6	0,0	299,8
3	IT and telecommunications equipment	3011,4	2677,5	1521,2	16,1	577,2	20,7	870,3
4	Consumer equipment	2267,0	2262,0	1188,3	12,5	402,4	128,4	635,7
5	Lighting equipment, except fluorescent lamps	529,8	311,1	172,4	19,3	148,2	0,0	31,9

5a	Fluorescent lamps	426,1	410,2	206,1	5,9	92,6	146,5	0,0
6	Electrical and electronic tools	1879,0	1857,4	852,1	6,7	506,1	0,0	333,5
7	Toys, leisure and sports equipment	327,7	325,9	134,4	11,8	45,3	0,0	58,5
8	Medical devices	213,1	167,1	84,8	4,3	27,7	9,2	53,6
9	Monitoring and control instruments	434,3	279,0	148,0	265,0	70,4	175,1	84,0
10	Automatic dispensers	39,5	36,4	0,0	32,4	21,1	0,0	1,8
	Total	25437,2	24576,2	11445,1	391,7	5746,7	867,6	4991,8

Source: Lithuanian EPA

Waste reporting

There was no recording or reporting of waste generation or disposal in Lithuania during the Soviet time.

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 8-9 and waste disposal and recovery operations listed in Table 8-10.

Table 8-9. 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 8-10. 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 8-11).

Table 8-11. 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 authorised 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 summarised 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[166] 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 should have been started in 2013 covering waste generation and management in 2012. In response to the newly approved Rules, the existing waste database should have been upgraded, however the modernization works were late thus the data for the year 2012 were not submitted on time. The data processing takes several months therefore the preliminary data on waste for year 2012 are used for this submission.

8.2.2 Source 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.

[166] Lietuvos Respublikos Aplinkos ministro 2011 m. gegužės3 d. įsakymas Nr. D1-367 „Dėl Atliekų susidarymo ir tvarkymo apskaitos ir ataskaitų teikimo taisyklių patvirtinimo“

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[167] it was assumed that generation of municipal waste should be about 750 thous tonnes annually.

Starting from 1999 amount of waste disposed of in landfills has stabilised at approximately 1 million tonnes. It was agreed in the discussion at the Ministry of Environment[168] 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[169]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 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 8-2) 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.

[167] State of the Environment 2001, p. 85th Ministry of Environment of the Republic of Lithuania, Vilnius, 2002
[168] Meeting at the Ministry of Environment with the Head of Waste Division Ingrida Kavaliauskienė and senior specialist Ingrida Rimaitytė, September 25, 2009
[169] 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

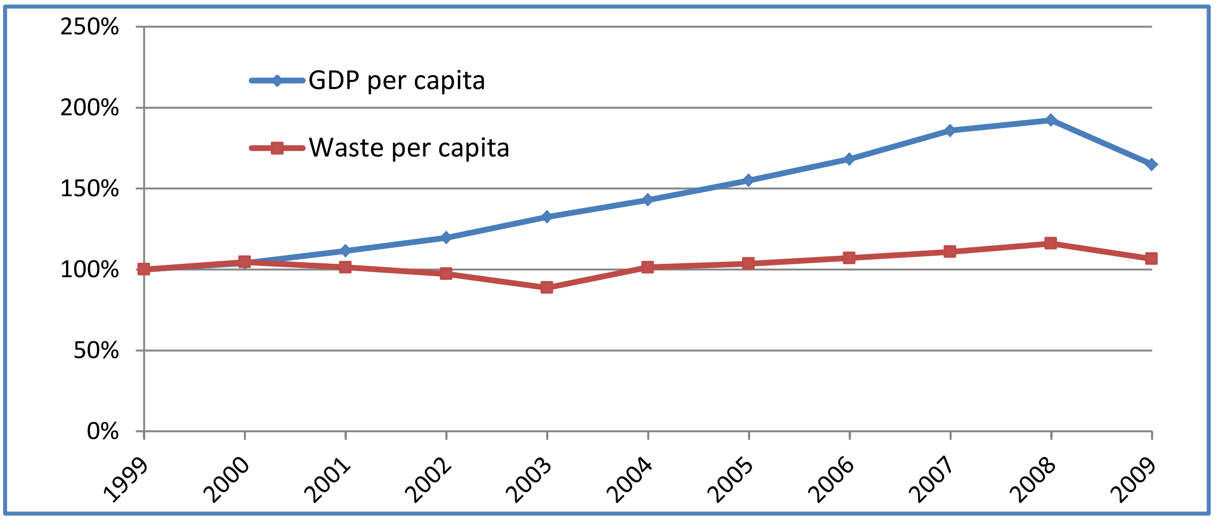

Figure 8-2. Variations of GDP and waste disposal per capita during 1999-2009

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 8-12.

Table 8-12. 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 1999-2012. For the period 1990-1998 waste disposal was evaluated (Figure 8-3) using estimated annual changes shown in Table 8-12 and population number provided by the Statistics Lithuania.

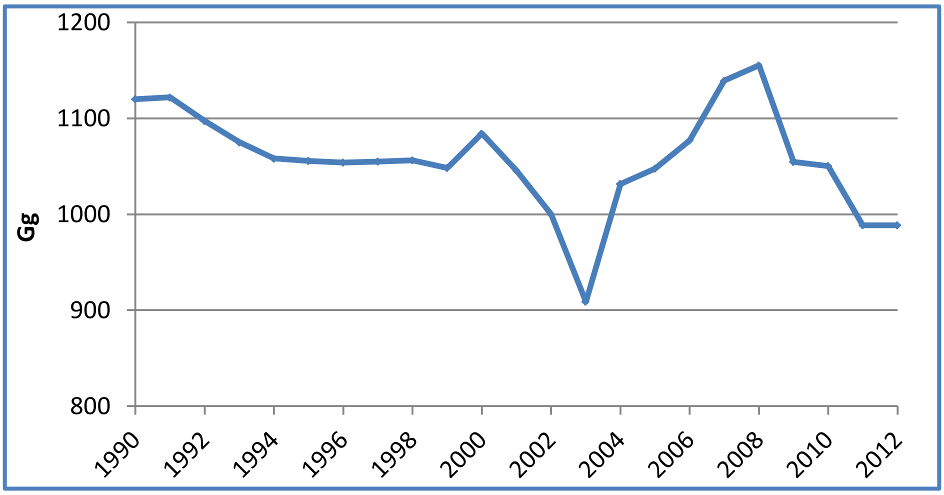

Figure 8-3. Municipal solid waste disposed of on land in 1990-2012

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[170] 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[171]. 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 8-13.

Table 8-13. Reported data on disposal of biodegradable waste of industrial and commercial origin in landfills in 1991-2012, thous tonne

[170] 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)

[171] *Official Journal L 332 , 09/12/2002 P. 0001 - 0036*

Year	Paper and cardboard wastes	Wood wastes	Textile wastes	Food waste	Green wastes	Sewage sludge	Total
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	082	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	7,59	135,0	171,6
2006	0,19	4,88	1,83	1,91	13,78	113,6	136,2
2007	0,67	0,81	1,96	3,30	9,32	121,5	137,6
2008	013	4,61	1,37	3,18	6,54	61,7	77,5
2009	0,05	5,12	2,02	2,57	8,02	49,0	66,8
2010	0,04	0,98	3,18	2,39	5,64	32,96	45,2
2011	0,00	0,94	3,77	0,86	10,10	32,71	48,4
2012	0,10	0,46	4,13	0,90	8,85	51,42	41,0

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 8-14). 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[172] (Table 8-15).

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 biowaste was found in waste collected from rural areas in Panevėžys region. It is understandable that biowaste 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.

[172] Ibid.

Table 8-14. 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 8-15. 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 is 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 thous, and 0,3 tonne from municipalities with population less than 100 thous.

Waste fractions to be identified during analysis are listed in Table 8-16.

Table 8-16. 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 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 part of biodegradable waste was accounted as other waste (Figure 8-4, a).

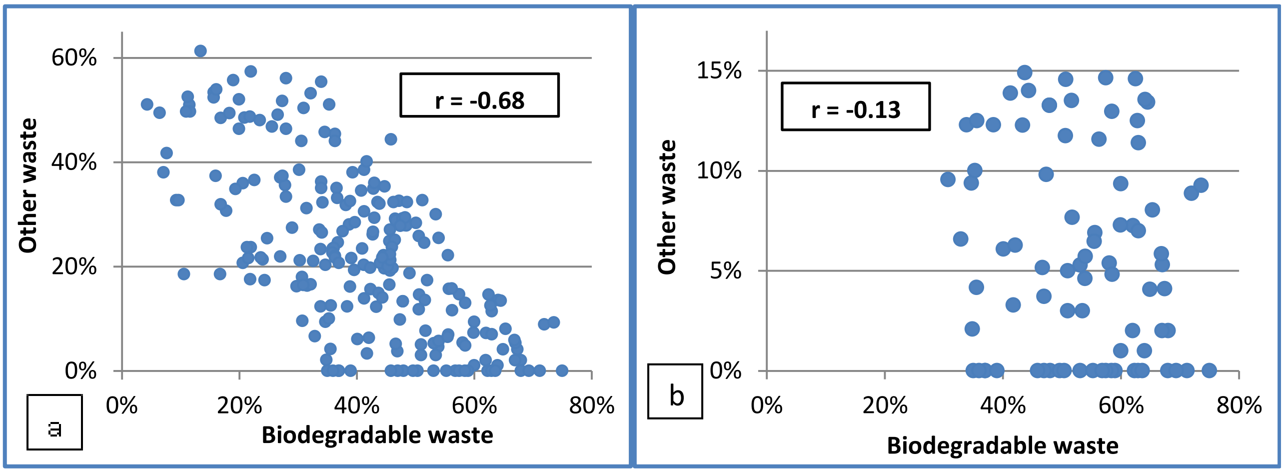

Figure 8-4. Correlation between the total fraction of biodegradable waste and unidentified fraction of "other waste" in reported data on waste composition; a - all available data, b - data from regions in which "other waste" is less than 20%

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, Fig. 8-4, 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 8-17.

Table 8-17. 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 8-17) 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 8-18).

Table 8-18. Summary data on municipal waste composition, 2012

No	Ingredient	Minimum	Maximum	Average	Standard deviation
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%

Composition of biodegradable waste in municipal waste stream was determined in the following way (Table 8-19):

- 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: assumed corresponding to average composition determined in 2012 (see Table 8-18).

Table 8-19. 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%

Table 8-20 provides data on the total amount of biodegradable waste disposed of in landfills obtained by adding biodegradable waste of industrial and commercial origin (Table 8-13) to municipal biodegradable waste estimated using percentages provided in Table 8-19.

It was assumed that amount and composition of waste of industrial and commercial origin in 1990 was the same as in 1991.

Table 8-20. Biodegradable components in landfilled waste evaluated for calculation of CH_4 generation (Gg)

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	12,5%	4,4%	4,4%	36,5%	3,6%	61,4%
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%	24,0%	12,7%	54,9%
2012	9,0%	3,1%	6,0%	21,8%	14,1%	54,0%

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 8-5).

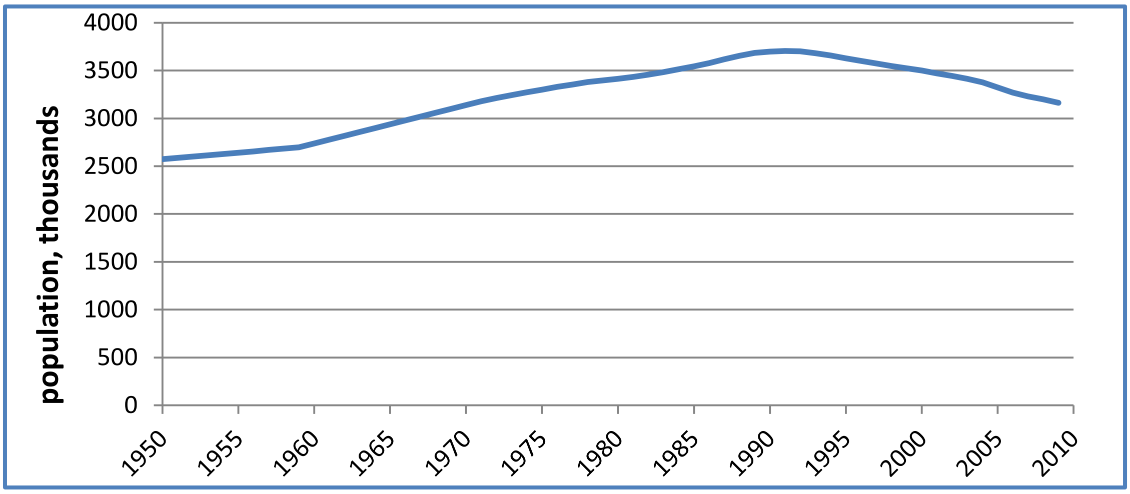

Figure 8-5. Variation of population in Lithuania in 1950-2012[173]

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[174] evaluated by the Statistics Lithuania are shown in Figure 8-6. It should be noted, however, that it was measured in current prices and did not reflect correctly the change in living standard.

[173] Statistics Lithuania
[174] GDP: Conversion from material product balances to the system of national accounts in 1980-1990 at current prices. Lithuanian Department of Statistics, Vilnius, 1994

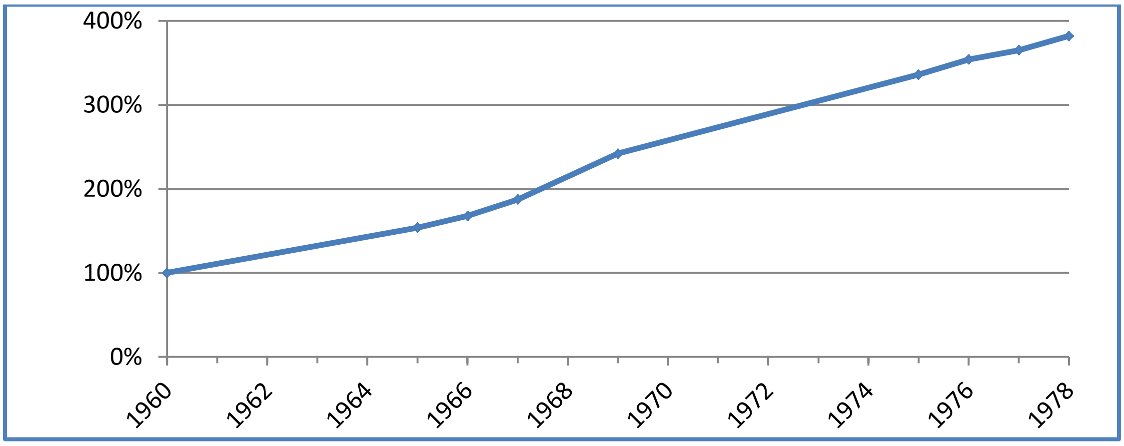

Figure 8-6. Variation of the total public product from 1960 to 1978

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[175]. Relative variations of population and GDP per capita from 1980 (1990 = 100%) are shown in Figure 8-7.

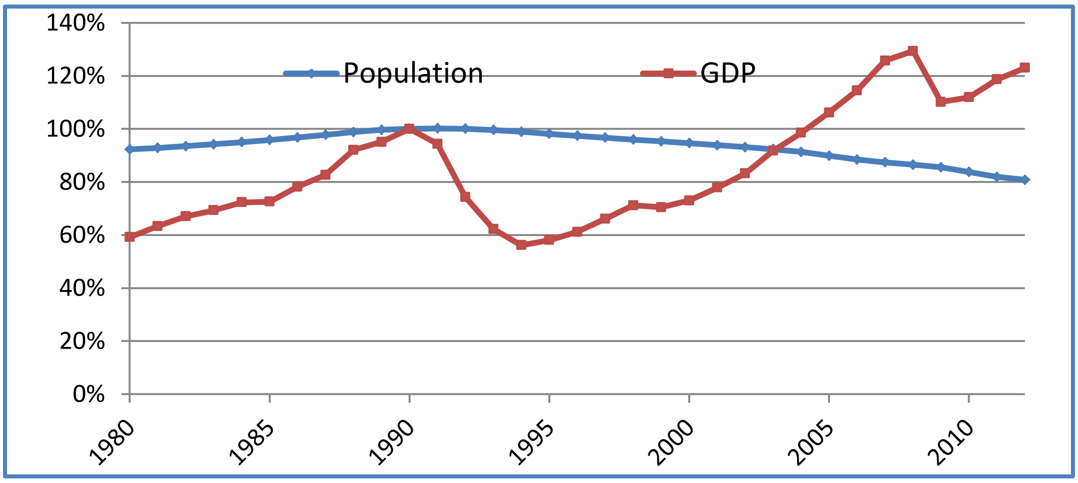

Figure 8-7. Relative variation of population and GDP per capita from 1980 (1990 = 100%)

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 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

[175] Ibid.

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 8-8.

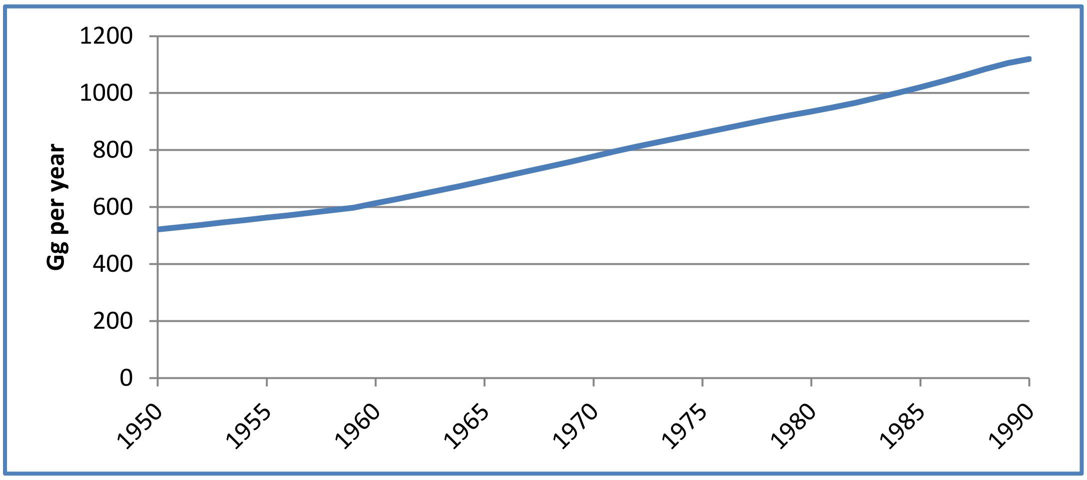

Figure 8-8. Assumed variation of municipal waste disposal from 1950 to 1990

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 8-21.

Table 8-21. 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, Gg 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 1990-2012 is shown in Table 8-22.

Table 8-22. Impact of assumed different growth rates of waste disposal in 1959-1989 on methane emissions in 1990-2012 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%	-1,7%
2012	0,9%	-1,6%

As could be seen from the Table 8-22, 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 1990-2012 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 managed landfills.

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. Small landfills and dumps in rural areas were assigned to unmanaged shallow landfills (<5 m waste).

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 2001-2008 are shown in Table 8-8. 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 8-9.

Table 8-23. 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

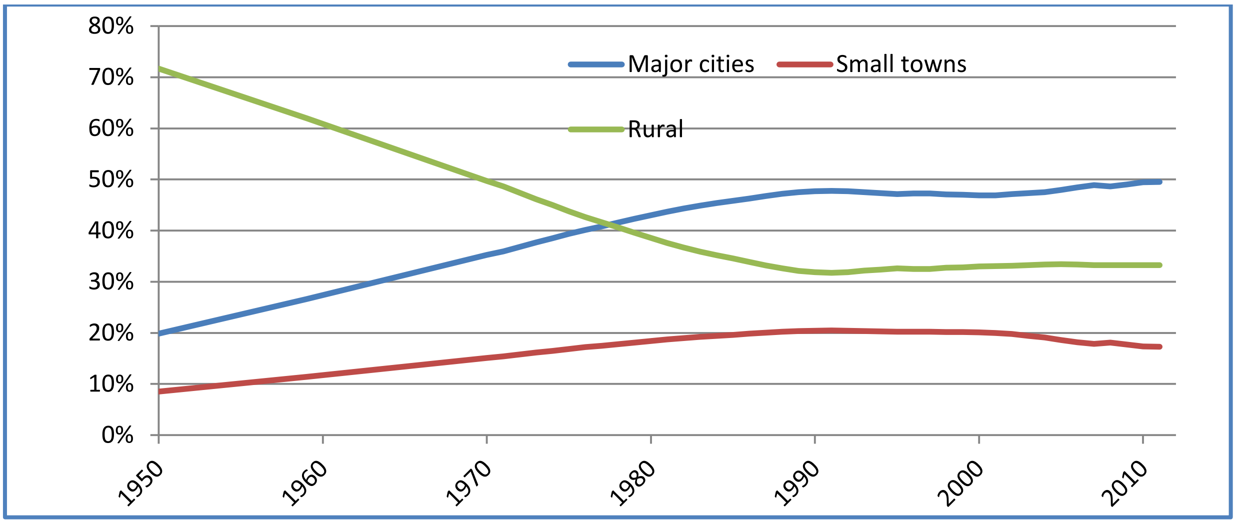

Figure 8-9. Estimated variations of population in major cities, towns and rural areas from 1950[176]

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 8-24.

Table 8-24. 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
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

[176] Statistics Lithuania

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 8-25.

Table 8-25. 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[177] 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:

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).

[177] Meeting at the Ministry of Environment with the Head of Waste Division Ingrida Kavaliauskienė and senior specialist Ingrida Rimaitytė, September 25, 2009

The amounts of waste disposed of in managed, deep unmanaged and shallow 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.

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 sludge dry matter. All data were carefully checked and converted to wet sludge using dry matter/wet sludge conversion factor 0.2[178]

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[179] performed in 2012 concluded that about 73% of sewage sludge are disposed on shallow (depth <5 m) sites for which use of MCF value 0.4 is recommended. Remaining 27% are disposed on deep (depth >5 m) sites for which MCF value 0.8 should be used.

Part of sludge is treated in anaerobic digesters, composted or used as fertilizer in the agriculture sector. There is no methodology provided in the 1996 IPCC guidelines for estimation of CH4 or N2O from composting facilities or compost spreading on agricultural soil. Some countries (e.g. Belgium, Netherlands) have provided estimates from composting sites based on country-specific investigations. Such investigations were not performed in Lithuania.

Methane recovery

Landfill gas collection started in 2008 in closed Kaunas and Utena landfills. From 2010 landfill gas recovery started also in closed Vilnius, Klaipėda and Marijampolė 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 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.

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[178] Wet - dry conversion of sludges. ARGUS for Eurostat - Environment Statistics. Meeting of the Working Group "Statistics of the Environment", Sub-Group "Waste". Eurostat, 2008.

[179] 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

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 Gg was calculated assuming that methane lower heating value is 50 TJ/Gg[180]. 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 8-26.

Table 8-26. Methane recovery from landfills, Gg

Year	Recovery
2008	0,34
2009	1,12
2010	1,66
2011	4,90
2012	5,14

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.

8.2.3 Methodology

First Order Decay Model

The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (1996 Guidelines, IPCC, 1997) and the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (GPG 2000, IPCC, 2000) describe two methods for estimating CH4 emissions from solid waste disposal sites (SWDS): the mass balance method (Tier 1) and the First Order Decay (FOD) method (Tier 2). Use of the mass balance method is strongly discouraged in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories as it produces results that are not comparable with the FOD method which produces more accurate estimates of annual emissions. Therefore, CH4 emissions from solid waste disposal sites were estimated using FOD model provided in the 2006 IPCC Guidelines.

[180] http://www.engineeringtoolbox.com/gross-net-heating-values-d_420.html

The FOD method was selected using Decision Tree (figure 5.1) provided in the GHG 2000, p. 5.6. Parameters required for calculation are provided in the GHG 2000, however certain reservations concerning their use are provided in the guidelines. Therefore, the parameters provided in the GHG 2000 were compared to parameters provided in the 2006 IPCC guidelines.

GHG 2000 provides only general discussion on possible value of methane rate generation constant *k* and do not associate definite values with specific components. On the other hand, 2006 IPCC guidelines provide k values for each specific component based on the results of latest investigations.

Only roughly estimated data are provided in the GHG 2000 on fractions of degradable organic carbon DOC), while 2006 IPCC guidelines more detailed evaluations and, what is especially important, provide references to the results of latest investigations on which evaluation of DOC values is based.

GHG 2000 provide default value of 0,77 for fraction of degradable organic carbon (DOC_f) but warn that this default value is probably overestimated. 2006 IPCC guidelines give DOC_f value 0.5 which corresponds to the suggestion in the GHG 2000.

Finally, GHG 2000 do not provide the values of parameters for sludge which was included in calculations.

The FOD method was selected to estimate the CH4 emissions from solid waste disposal, in line with the IPCC good practice guidance taking into consideration that the 2006 IPCC Guidelines take into account the latest research (e.g. the degradable organic carbon (DOC) values provided therein allow to disaggregate the emissions more finely by waste type). In addition, the Revised 1996 IPCC Guidelines and the IPCC good practice guidance do not provide differentiated parameter values for the methane generation rate constant, but that the 2006 IPCC Guidelines do provide differentiated methane generation rate constants per type of waste. The IPCC good practice guidance does not provide any parameter values for sludge, but the 2006 IPCC Guidelines do.

Therefore it was concluded that parameter values provided in the 2006 IPCC guidelines are more reliable and precise and were used for calculation of methane emissions by FOD model.

CH_4 generation was evaluated using FOD model according to an IPCC Tier 2 approach (IPCC 1997, 2000 and 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[181]:

$$DDOC_m = DDOC_m(0) \cdot e^{-kt}$$

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;
k is the reaction constant.

[181] *2006 IPCC GPG vol 5*

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 (IPCC GPG 2000, p. 5.7):

$$CH_4 \text{ emitted in year } t \text{ (Gg/yr)} = [CH_4 \text{ generated in year } t - R(t)] \bullet (1 - OX)$$

where:
R(t) is recovered CH_4 in inventory year t (Gg/yr);
OX is oxidation factor (assumed *OX* = 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.

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 (IPCC GPG 2000, p. 5.9).

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 (IPCC GPG 2000, p. 5.9).

Small landfills and dumps in rural areas were assigned to unmanaged shallow landfills (<5 m waste) with CH_4 correction factor = 0,4 (IPCC GPG 2000, p. 5.9).

Other parameters

Other parameters were taken as IPCC 2006 default values.
DOC (weight fraction, wet basis) (IPCC 2006, v. 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[182] 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 (v. 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})

Food waste	0,185
Paper	0,06
Wood	0,03
Textile	0,06
Green waste	0,1
Sewage sludge	0,185

DOC_f (fraction of DOC dissimilated)	0,5 (IPCC 2006, v. 5, p. 3.13)
Delay time (months)	6 (IPCC 2006,v. 5, p. 3.19)
Fraction of CH_4 in developed gas	0,5 (IPCC 2006, v. 5, p. 3.26)
Conversion factor, C to CH_4	16/12 = 1,33 (IPCC 2006, v. 5, p. 3.37)
Methane oxidation	0 (IPCC 2006, v. 5, p. 3,15)

Separate methane generation rate constant (k) values specific for each component were used in calculations. k value entered in the CRF database represents weighed average for all components and slightly changes from year to year depending on waste composition. Only single line is provided in the CRF database for entering additional information on k value therefore we decided to enter weighed average rather than separate k for a separate component. Calculated average values were not included in calculations and have no impact on calculation results.

Methane is recovered only from major old closed landfills, methane from newly constructed landfills is not yet recovered.

Same as in case of methane generation rate constant, weighed average DOC values were calculated for entering in the CRF database using values for separate components provided in NIR p. 340 and waste composition for each year.

8.2.4 Uncertainties and Time-Series Consistency

Uncertainties

Uncertainty of activity data was assumed to be 30% (IPCC 2006, v. 3, Table 3.5).

[182] 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

Uncertainties of separate input parameters for Tier 1 uncertainty analysis were taken as average values of uncertainties provided in IPCC 2006, v. 3, Table 3.5.

Table 8-27. 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%

* GPG 2000, p. 5.12, Table 5.2)

Uncertainty of implied emission factor for three separate MCF values was established using IPCC 2000, equation 6.4 (p. 6.12):

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \ldots + U_n^2},$$

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 8-27 are provided in Table 8-28.

Table 8-28. 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 IPCC 2000, equation 6.3 (p. 6.12):

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

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 126,5%.

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.

8.2.5 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 2012. 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.

8.2.6 Source-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[183].

Tier 1 General Inventory Level QC was performed based on recommendations provided in IPCC 2000, page 8.8-8.9, Table 8.1 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.

In addition, verification of methane emissions from solid waste disposal on land was performed by comparing per capita emission data with neighbouring countries: Latvia, Estonia, Poland, and Denmark. The results are shown in Table 8-29.

Table 8-29. Comparison of GHG emissions from solid waste disposal on land (kg per capita)

Year	Lithuania 2012	Denmark 2011	Latvia 2011	Estonia 2011	Poland 2011
1990	11,1	13,7	5,9	5,5	9,3

[183] National Greenhouse Gas Emission Inventory of the Republic of Lithuania. Quality Assurance and Quality control Plan 2011-2012. Vilnius, 2011.

1991	11,4	13,7	6,1	5,8	9,4
1992	11,6	13,5	6,4	6,3	9,4
1993	11,9	13,2	6,7	7,0	9,5
1994	12,0	12,5	6,9	7,5	9,5
1995	12,2	11,6	7,1	6,6	9,6
1996	12,3	11,1	7,2	7,2	9,7
1997	12,5	10,3	7,4	9,3	9,9
1998	12,7	9,6	7,6	10,9	10,1
1999	12,8	9,6	7,8	11,2	10,3
2000	13,0	9,5	8,1	12,5	10,5
2001	13,5	9,4	8,3	12,9	10,3
2002	13,8	8,8	8,4	12,4	10,2
2003	14,0	8,8	7,8	12,3	10,0
2004	13,9	7,8	7,5	12,5	10,0
2005	13,9	7,6	7,8	11,5	10,1
2006	13,9	7,8	8,3	11,3	10,1
2007	13,8	7,4	8,8	10,9	10,1
2008	13,7	7,1	9,2	10,9	9,8
2009	13,6	6,7	9,4	9,7	9,8
2010	13,6	6,2	9,8	9,6	9,5
2011	12,7	6,0	10,1	9,0	9,0

Established methane emissions per capita from solid waste disposal on land in 1990 in Lithuania are 23% lower than in Denmark but in 2010 substantially higher apparently because of significantly increased methane recovery in Denmark. Lithuania's emissions per capita are higher than in Estonia, Latvia and Poland.

In general, it may be concluded that evaluated methane generation in Lithuania is in the middle between Danish data and emissions reported by other compared countries.

8.2.7 Source specific recalculations

Recalculated methane emissions from waste (including both solid waste and sewage sludge) disposal on land from 2003 to 2011 are slightly higher than in previous submission as a result of corrected values of biodegradable components based on additional waste composition data collected in 2012. Nevertheless, the difference is insignificant, not exceeding 0,16%.

Impact of recalculations of CH_4 emission (Gg) from solid waste disposal on land is shown in Table 8-30.

Table 8-30. Impact of recalculations of CH_4 emissions (Gg CO_2 eqv.) from solid waste disposal on land

Year	Previous submission	This submission	Difference	
			Gg	%
2003	1004,1	1004,3	0,1	0,01%
2004	986,1	986,4	0,3	0,03%
2005	967,5	968,0	0,4	0,05%
2006	951,0	951,8	0,7	0,08%
2007	935,9	936,9	1,1	0,12%

2008	919,4	920,9	1,4	0,16%
2009	903,6	905,0	1,4	0,15%
2010	883,9	885,1	1,2	0,13%
2011	807,8	808,6	0,8	0,10%

8.2.8 Planned improvements

No improvements are planned in this sector.

8.3 Wastewater Handling (CRF 6.B)

8.3.1 Source category description

Wastewater treatment

There are close to 1700 wastewater treatment facilities in Lithuania but about 86% of wastewater is treated in municipal biological treatment plants with N and P removal (Table 8-31).

Table 8-31. Wastewater treatment facilities in Lithuania in 2012

Code	Treatment method	No facilities	Treated BOD		
			tonne O_2	Fraction of total	Cumulative total
313	Biological treatment with N and P removal	58	64626,8	85,8%	85,8%
311	Pneumatic aeration tanks	376	7097,6	9,4%	95,2%
300	Biological treatment	13	1973,1	2,6%	97,8%
304	Pneumatic aeration channels	40	317,7	0,4%	98,2%
0	Discharge without treatment	589	308,52	0,4%	98,7%
900	Other facilities	1	274,00	0,4%	99,0%
305	Mechanical aeration channels	51	197,6	0,3%	99,3%
312	Mechanical aeration tanks	22	177,1	0,2%	99,5%
700	Storm water treatment	347	99,4	0,1%	99,6%
302	Biofilters	15	78,5	0,1%	99,8%
307	Other biological treatment facilities	37	63,0	0,1%	99,8%
100	Mechanical treatment	41	50,1	0,1%	99,9%
500	Infiltration fields without discharge	21	28,2	0,0%	99,9%
303	Natural treatment methods	23	20,0	0,0%	100,0%
400	Infiltration fields	7	11,0	0,0%	100,0%
306	Biological ponds	12	8,5	0,0%	100,0%
201	Primary physico-chemical treatment	1	5,0	0,0%	100,0%
600	Agricultural irrigation fields	6	0,2	0,0%	100,0%
200	Physical-chemical treatment	2	0,0	0,0%	100,0%
	Total	**1662**	**75336**		

Wastewater discharge

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.

Wastewater treatment facilities in Lithuania are aerobic and CH_4 emissions can occur only in pipelines or treatment facilities if anaerobic conditions develop.

Substantial part of Lithuanian population is still not connected to centralised sewer networks as shown in Table 8-32.

Table 8-32. 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%

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 8-10). 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.

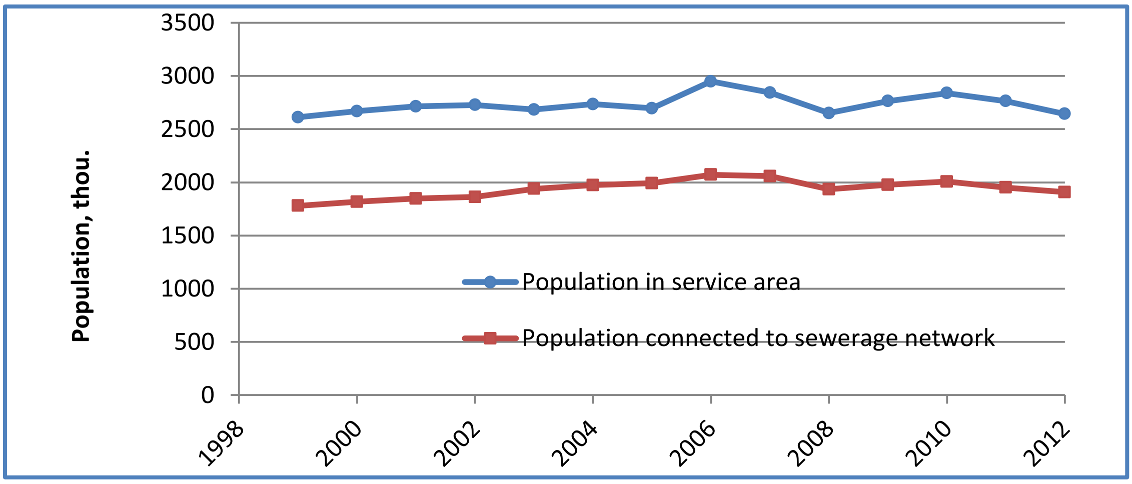

Figure 8-10. Variations of population residing in area covered by wastewater collection services and connected to sewerage network

Revised 1996 IPCC Guidelines recommend calculation of CH_4 emissions separately from domestic and from industrial wastewater assuming that organic matter is measured as biochemical oxygen demand (BOD) in municipal wastewater and as chemical oxygen demand (COD) in industrial wastewater. However 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[184] 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 as recommended by the IPCC Guidelines 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 CH4 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 last amended on 20th September 2001. 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 8-33 both parameters are provided for the same samples without specification of municipal or industrial wastewater

[184] *Lithuanian Water Suppliers Association. Certificate on municipal wastewater treatment plant capacity assessment, 2011.03.04.*

sources. Therefore, there is no possibility to separate industrial and municipal wastewater streams.

Table 8-33. 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
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

CH_4 recovery from wastewater sludge has been started in 1999 by Utena waste supply company. Currently CH_4 production facilities are in operation in four water supply companies.

Evaluated CH_4 emissions from wastewater are shown in Table 8-34.

Table 8-34. Evaluated CH_4 emissions from wastewater, Gg

Year	Wastewater treatment	Septic tanks	Total
1990	0,18	8,10	8,28
1991	0,18	8,11	8,29
1992	0,13	8,10	8,23
1993	0,12	8,06	8,18
1994	0,10	8,01	8,11
1995	0,10	7,95	8,05
1996	0,10	7,89	7,99
1997	0,11	7,83	7,94
1998	0,12	7,77	7,90
1999	0,09	7,64	7,73
2000	0,11	7,37	7,48
2001	0,11	7,11	7,22
2002	0,09	6,92	7,01
2003	0,11	6,46	6,57
2004	0,12	6,15	6,27
2005	0,11	5,83	5,94
2006	0,13	5,25	5,38

2007	0,13	5,14	5,27
2008	0,13	5,53	5,66
2009	0,12	5,20	5,32
2010	0,13	4,77	4,90
2011	0,13	4,72	4,85
2012	0,14	4,73	4,87

8.3.2 Methodological issues

Wastewater discharge

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

Reported BOD load to the Raseiniai mechanical treatment plant in 1992 was 272 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. It was considered as an obvious outlier and corresponding figure was divided by 100.

In addition, according to the data provided for 1992, 286 tonnes of BOD (or about 10% of the total amount) were generated by small construction company which wasn't included in the records neither before nor after 1992. Once again it was considered to be an obvious outlay and corresponding data were deleted from the database.

BOD data reported by the Šiauliai wastewater treatment facility in 1992 and 1994 were roughly 10 times higher than during the remaining period. These deviations were considered as outlays and were reduced 10 times.

BOD discharge in 1990 was assumed to be the same as in 1991.

Discharges of degradable organic matter in Lithuania in 1990-2012 are shown in Table 8-35.

Table 8-35. Discharge of degradable organic matter, Gg BOD

Year	Discharge of degradable organic matter, Gg BOD
1990	100,4
1991	100,4
1992	70,3
1993	66,2
1994	58,1
1995	55,3
1996	56,4
1997	63,0
1998	68,3
1999	48,6
2000	59,2
2001	62,3
2002	49,2

2003	61,1
2004	67,9
2005	63,8
2006	69,9
2007	74,6
2008	70,8
2009	69,0
2010	69,9
2011	72,3
2012	75,3

Methodology

CH_4 emissions from wastewater were estimated following Revised IPCC 1996 Guidelines and IPCC 2000 Good Practice Guidance, Emissions from sewer systems, primary settling tank and biological N and P removal processes were estimated as:

$$CH_4\ emission = TOW_{influent} \cdot B_0 \cdot MCF_{sewer+WWTP}$$

where:
$TOW_{influent}$ is influent organic degradable matter measured as biological oxygen demand (BOD) in the influent waste water flow;
B_0 is default maximum CH_4 producing capacity 0,6 kg CH_4 per kg BOD (1996 IPCC guidelines);
$MCF_{sewer+WWTP}$ is the fraction of DOC that is anaerobically converted in sewers and WWTPs;
$MCF_{sewer+WWTP}$ was taken from the Denmark's national report[185] in which it was evaluated equal to 0,003 based on an expert judgement of a conservative estimate of the fugitive CH_4 emission from the primary settling tanks and biological treatment processes.

Denmark was involved in the development of the Lithuanian wastewater handling system after the declaration of independence and the two systems are very similar. Therefore use of data on anaerobically convertible DOC fraction should be considered justifiable.

It should be emphasised that country specific instrumental measurements were used for establishing methane emissions which provide more reliable and precise results than the IPCC default data (EFs and AD) which are based on conditions in other countries.

BOD load from population not connected to sewerage networks was evaluated according to methodology provided in Revised 1996 IPCC Guidelines (v. 3, p. 6.23, Table 6.5) using default BOD_5 generation value 18,25 kg per person per year. The total BOD load is sum of BOD discharge from sources connected to sewerage networks and calculated BOD load from population having no connection to sewerage networks.

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 Gg using methane Lower Heating Value (LHV) = 50 TJ/Gg.

[185] *Denmar k's National Inventory Report 2011. Emission Inventories 1990-2009 NERI Technical Report no. 827, 2011, p. 490*

It should be noted that statistical data are provided by the Statistics Lithuania from 2002 while methane recovery in UAB Utenos Vandenys was started in 1999 and in UAB Kauno Vandenys in 2000.

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 Gg per million m^3. Data provided by water supply companies for 2002-2003 are a bit higher than provided by the Statistics Lithuania.

Data on methane recovery from sewage sludge were modified in 2012 submission taking into consideration information reported by the Statistics Lithuania. Data provided by the companies in volume were recalculated to weight (Gg) using mass/volume ratio calculated from statistical data. Data provided by the companies (in volume multiplied by 0,4 Gg per million m^3) were used for reporting (Table 8-36).

Table 8-36. CH_4 recovery, Gg

Year	Gg
1999	0,22
2000	0,84
2001	0,85
2002	0,85
2003	0,91
2004	0,94
2005	1,14
2006	1,24
2007	1,38
2008	1,40
2009	1,78
2010	2,50
2011	2,58
2012	2,60

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.

8.3.3 Uncertainties and time-series consistency

Uncertainty

Bearing in mind that certain problems related to reliability of data discussed above, it was assumed that uncertainty of $TOW_{influent}$ is ±30%. Uncertainty of CH_4 emission factor evaluated in the Danish NIR is 32%.

Uncertainties of parameters used for evaluating CH_4 emissions from septic tanks were taken from IPCC 2000 (p. 5.19, Table 5.3) Table 8-37.

Table 8-37. Uncertainties of parameters used for evaluating CH_4 emissions from septic tanks

Parameter	Uncertainty Range
Human Population	±5%
BOD/person	±30%
Maximum CH_4 Producing Capacity (B_0)	±30%

Fraction treated anaerobically	50% (average between 0 and 1)

Evaluated emission factor (EF) uncertainties of CH_4 emission from wastewater pipelines and treatment facilities calculated using equation 6.4 from GPG 2000, p. 6.12 is 44%. Calculated EF uncertainty of CH_4 emissions from septic tanks is 66%.

Evaluated overall EF uncertainty (IPCC 2000, equation 6.3 (p. 6.12) for CH_4 emissions from wastewater treatment is 65%.

Time-Series Consistency

Emissions from wastewater handling were calculated for the whole time series using the same method and data sets.

8.3.4 Source-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[186].

Tier 1 General Inventory Level QC was performed based on recommendations provided in IPCC 2000. Table 8.1 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.

8.3.5 Source specific recalculations

Statistics Lithuania recalculated population data which starting from 2001 appeared to be lower than earlier established. Recalculated methane emissions using new population data resulted in up to 0,9% higher emissions than reported in previous submission.

Impact of recalculations on CH_4 emissions (Gg) from wastewater handling is shown in Table 8-38.

Table 8-38. Impact of recalculations on CH_4 emissions (Gg CO_2 eqv.) from wastewater handling

Year	Previous submission	This submission	Difference	
			Gg	%
2001	151,5	151,6	0,1	0,1%
2002	147,0	147,2	0,2	0,1%
2003	137,7	138,0	0,3	0,2%

[186] National Greenhouse Gas Emission Inventory of the Republic of Lithuania. Quality Assurance and Quality control Plan 2011-2012. Vilnius, 2011.

2004	131,2	131,7	0,4	03%
2005	124,1	124,8	0,7	0,6%
2006	112,0	112,9	0,9	0,8%
2007	109,8	110,7	0,9	0,9%
2008	118,1	118,9	0,8	0,7%
2009	111,2	111,8	0,6	0,5%
2010	102,7	102,9	0,6	0,6%
2011	102,0	101,8	0,6	0,6%

8.3.6 Planned Improvements

No improvements are planned in this section.

8.3.7 Emissions from human sewage (CRF 6B 2.2)

8.3.7.1 Source category description

Nitrous oxide emissions were calculated using protein intake per capita evaluated at the Nutrition Centre under the Ministry of Health[187] (77,4 g/capita/day in 1998, 78,1 g/capita/day in 2002, and 81,91 g/capita/day in 2007). Linear interpolation of this data was used for calculation of N_2O emissions (Table 8-39).

Table 8-39. Evaluated N_2O emissions from human sewage

Year	Protein consumption/ kg/person/year	N_2O emissions, Gg
1990	27,7	0,26
1991	27,8	0,26
1992	27,9	0,26
1993	27,9	0,26
1994	28,0	0,26
1995	28,1	0,26
1996	28,1	0,25
1997	28,2	0,25
1998	28,3	0,25
1999	28,3	0,25
2000	28,4	0,25
2001	28,4	0,25
2002	28,5	0,25
2003	28,8	0,25
2004	29,1	0,25
2005	29,3	0,25
2006	29,6	0,24
2007	29,9	0,24
2008	30,2	0,24
2009	30,5	0,24
2010	30,7	0,24

[187] 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.

2011	31,0	0,24
2012	31,3	0,23

8.3.7.2 Methodological issues

The emissions of N_2O from human sewage were calculated according to Revised 1996 IPCC Guidelines (p. 6.28) methodology (equation 15):

$$N_2O \text{ emission} = Protein \times Frac_{NPR} \times NR_{PEOPLE} \times EF_6,$$

where:
N_2O emission is emissions from human sewage (kg N_2O-N/yr);
Protein is annual per capita protein intake (kg/person/yr);
NR_{PEOPLE} is number of people in country;
EF_6 is emission factor (0,01 kg N_2O-N/kg sewage-N produced with default fraction of nitrogen in protein 0,16 kg N/kg protein) (See Table 4-18 in Agriculture Chapter);
$Frac_{NPR}$ is fraction of nitrogen in protein (default = 0,16 kg N/kg protein) (see Table 4-19 in Agriculture Chapter).

8.3.7.3 Uncertainties

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 6.4 (GPG 2000, p. 6.12) is 58%.

8.3.7.4 Source specific recalculations

N_2O emissions from human sewage were recalculated for period 2001-2011 due to updated population data by Statistics Lithuania. This caused changes in calculated N_2O emissions up to 0,32%.

Impact of recalculations on N_2O emissions (Gg) from human sewage is shown in Table 8-40.

Table 8-40. Impact of recalculations on N_2O emissions from human sewage, Gg

Year	Previous submission	This submission	Difference	
			Gg	%
2001	0,248	0,248	0,000	0,03%
2002	0,247	0,247	0,000	0,07%
2003	0,247	0,247	0,000	0,10%
2004	0,246	0,247	0,000	0,14%
2005	0,245	0,245	0,001	0,24%
2006	0,243	0,244	0,001	0,31%
2007	0,242	0,243	0,001	0,32%
2008	0,242	0,243	0,001	0,28%
2009	0,242	0,242	0,000	0,20%
2010	0,239	0,239	0,000	0,08%
2011	0,236	0,236	0,000	-0,07%

8.3.7.5 Planned improvements

No improvements are planned.

8.4 Waste incineration (CRF 6.C)

8.4.1 Source category description

Emissions from hazardous and clinical/hospital waste incineration without energy recovery are included in this category.

Emissions from waste incineration fluctuate quite strongly. There were no dedicated waste incineration 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 (it is worth noting that the total amount of incinerated waste is very small, even at its maximum).

In 2010 new hazardous waste incineration facility with capacity 8000 tonnes waste per year have started pilot burnings. The amount of incinerated waste in 2011 increased several times to approximately 4 thous tonnes. However, because of disagreements between the operating company and equipment supplier the plant had not started full scale operation and the amount of incinerated waste in 2012 shrank again to approximately one thou. tonne.

Evaluated CO_2 emissions from waste incineration are provided in Table 8-41.

Table 8-41. CO_2 emissions from waste incineration, Gg

Year	Hazardous	Clinical Health care	Sewage sludge	Municipal	Total
1990	4,32	0,01	0,00	0,00	4,33
1991	4,32	0,01	0,00	0,00	4,33
1992	1,20	0,00	0,00	0,00	1,21
1993	3,48	0,00	0,00	0,10	3,59
1994	1,05	0,01	0,00	0,05	1,11
1995	4,07	0,01	0,00	0,00	4,08
1996	1,36	0,01	0,00	0,00	1,38
1997	1,33	0,03	0,00	0,00	1,37
1998	1,28	0,15	0,00	0,02	1,44
1999	0,56	0,06	0,00	0,01	0,62
2000	1,84	0,00	0,00	0,00	1,84
2001	2,34	0,09	0,00	0,00	2,44
2002	2,22	0,02	0,00	0,00	2,24
2003	6,01	0,00	0,00	0,00	6,02
2004	3,05	0,03	0,00	0,00	3,09
2005	5,47	0,22	0,00	0,00	5,69
2006	5,07	0,16	0,00	0,00	5,23
2007	0,30	0,43	0,00	0,00	0,73
2008	0,03	0,57	0,00	0,00	0,61
2009	0,02	0,62	0,00	0,00	0,64
2010	1,35	0,58	0,00	0,00	1,93
2011	6,66	0,33	0,00	0,00	6,99
2012	1,61	0,03	0,00	0,00	1,64

Evaluated N_2O emissions from waste incineration are provided in Table 8-42.

Table 8-42. N_2O emissions from waste incineration, Gg

Year	N_2O emissions from waste incineration
1990	0,0006
1991	0,0006
1992	0,0002
1993	0,0006
1994	0,0002
1995	0,0006
1996	0,0002
1997	0,0002
1998	0,0002
1999	0,0001
2000	0,0003
2001	0,0003
2002	0,0003
2003	0,0008
2004	0,0004
2005	0,0008
2006	0,0007
2007	0,0002
2008	0,0002
2009	0,0002
2010	0,0003
2011	0,0010
2012	0,0002

8.4.2 Methodological issues

In 1990-2005 small amounts of waste were incinerated in various combustion installations not meant specifically for waste incineration.

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 ^{o}C. 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.

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 thous tonnes in 2011. Due to contractual disputes plant operations were significantly reduced to approximately one thous tonnes in 2012.

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 ^{o}C with at least 2 seconds residence time. If halogenated compounds are present, temperature is raised to 1100 ^{o}C. 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 2010-2012 during limited test runs supervised by equipment supplier and energy production was not recorded. There was no energy recovery in hospital waste incineration plant.

In previous years when there was no dedicated incinerator in Lithuania, waste was incinerated in various existing combustion facilities. Incinerated waste included calorific waste such as spent oils used, for example, for heating garages, etc.

The data on waste incineration are reported in the framework of overall waste reporting obligations.

The data were reported 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 incinerators 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 8-43). Data collection and validation procedures are described in chapter 1.2.1.1.

Table 8-43. Amounts of incinerated waste 1990-2012, Gg

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

Carbon dioxide emissions from waste incineration were calculated according to GPG 2000, equation 5.11 (p. 5.25):

$$CO_{emissions} = \sum_i (IW_i \cdot CCW_i \cdot FCF_i \cdot EF_i \cdot 44/12) \text{ (Gg/yr)}$$

where:
i = MSW: municipal solid waste:
HW: hazardous waste
CW: clinical waste
SS: sewage sludge
IW_i is amount of incinerated waste of type i (Gg/yr);
CCW_i is fraction of carbon content in waste of type i;
FCF_i is fraction of fossil carbon in waste of type i;
EF_i is burn out efficiency of combustion of incinerators for waste of type i (fraction);
44 / 12 is conversion from C to CO_2.

Default values, provided in IPCC Good Practice Guidance 2000 were used (Table 8-44):

Table 8-44. Default data for estimation of CO_2 emissions from waste incineration (GPG 2000, p. 5.29)

Parameter	**MSW**	**Sewage sludge**	**Clinical waste**	**Hazardous waste**
C content of waste	40%	30%	60%	50%
Fossil carbon as % of total carbon	40%	0%	40%	90%
Efficiency of combustion	95%	95%	95%	99,5%

The same activity data (waste inputs into incinerator) were used for calculation of emissions from waste of both fossil and biogenic origin. Emissions resulting from incineration of wastes of biogenic origin were calculated by the same formula provided above using the value of biogenic carbon fraction (1 - FCF_i) instead of fossil carbon fraction (FCF_i).

N_2O emissions from waste incineration were estimated using methodology provided in IPCC GPG 2000. Average mean of default values range (225 kg/N_2O/Gg waste) for rotating plants was used. N_2O emissions from waste of biogenic origin were not separated from the total emissions.

8.4.3 Uncertainties and time-series consistency

Activity data uncertainty for waste incineration was assumed to be the same as for solid waste disposal on land, i.e. 30%, as data source is the same.

Uncertainty of emission factors was assumed to be 30% for CO_2 and 100% for N_2O.

Combined uncertainties for GHG emissions from waste incineration calculated using equation 6.4 (GPG 2000, p. 6.12) are the following:

CO_2 - 42%
N_2O - 104%

8.4.4 Source-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[188].

Tier 1 General Inventory Level QC was performed based on recommendations provided in IPCC GPG 2000. Table 8.1 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.

8.4.5 Source specific recalculations

No recalculations were made.

8.4.6 Planned improvements

No improvements are planned for the next submission.

[188] National Greenhouse Gas Emission Inventory of the Republic of Lithuania. Quality Assurance and Quality control Plan 2011-2012. Vilnius, 2011.

9 OTHER (CRF 7)

Not applicable.

10 RECALCULATIONS AND IMPROVEMENTS

List of improvements made in response to provisional main findings and recommendations provided during the review of Lithuania's 2013 annual submission given in the Annex VII.

Major changes in methodological descriptions compared to the previous submission are summarizied in the Table 10-1.

Table 10-1. Major changes in methodological descriptions compared to the previous year

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	DESCRIPTION OF METHODS Please tick where the latest NIR includes major changes in methododological descriptions compared to the previous year NIR	RECALCULATIONS Please tick where this is also reflected in recalculations compared to the previous year CRF	REFERENCE If ticked please provide some more detailed information for example related to sub-category, gas, reference to pages in the NIR, etc
Total (Net Emissions)			
1. Energy			
A. Fuel Combustion (Sectoral Approach)			
1. Energy Industries		√	Dissagregation of activity data for anthracite, coking coal and sub-bituminous since 2000 based on the newest information provided by Lithuanian Statistics in November 2013. Correction of CO_2 plant specific emission factor for not liquefied petroleum gas based on EU ETS data (Chapter 3.2.6).
2. Manufacturing Industries and Construction		√	Corrections of activity data of residual fuel oil, LPG, gasoil, natural gas, peat, coke and wood/wood waste consumption based on the newest statistical information provided by Lithuanian Statistics in November 2013. Dissagregation of activity data for anthracite, coking coal and sub-bituminous since 2000 based on the newest information provided by Lithuanian Statistics in November 2013 (Chapter 3.3).
3. Transport		√	CO_2, CH_4 and N_2O emissions from Road Transportation have been recalculated in this submission with respect to the new fuel consumption activity data (Chapter 3.4.2). Country specific CO_2 emission factor for natural gas based on study on "Determination of national GHG emission factors for energy sector" was applied (Chapter 3.4.5).
4. Other Sectors		√	Dissagregation of activity data for anthracite, coking coal and sub-bituminous since 2000 based on the newest information provided by Lithuanian Statistics in November 2013 (Chapter 3.5).
5. Other			
B. Fugitive Emissions from Fuels			
1. Solid Fuels			
2. Oil and Natural Gas			
2. Industrial Processes			
A. Mineral Products	√	√	CO_2 from Soda ash use CRF 2.A.4.2 (Chapter 4.2.4) CO_2 from Road paving with asphalt CRF 2.A.6 (Chapter 4.2.6)
B. Chemical Industry	√	√	CO_2 from Methanol production CRF 2.B.5 (Chapter 4.3.3)
C. Metal Production			
D. Other Production			
E. Production of Halocarbons and SF_6			
F. Consumption of Halocarbons and SF_6		√	HFCs from CRF 2.IIA.F.1.1 (Chapter 4.7.1.1) HFCs from CRF 2.IIA.F.1.2 (Chapter 4.7.1.2) HFCs from CRF 2.IIA.F.1.3 (Chapter 4.7.1.3)
G. Other			
3. Solvent and Other Product Use		√	NMVOC, CO_2 from CRF 3 (Chapter 5.1)

4. Agriculture			
A. Enteric Fermentation	√	√	CH_4 from CRF 4.A (Chapter 6.2). GE intake of dairy cattle recalculated due to updated values of average animal weight. Also correction of EF for baa-lambs.
B. Manure Management	√	√	CH_4, N_2O from CRF 4.B (Chapter 6.3). GE intake of dairy cattle recalculated due to updated values of average animal weight. Also update of manure management systems for swine. Update of protein consumption for the period 1990-2011 and N retention for dairy cattle according.
C. Rice Cultivation			
D. Agricultural Soils	√	√	N_2O from CRF 4.D (Chapter 6.5). Recalculations made in manure management (N_2O) had impact on emission estimates in following subsectors: animal manure applied to soils (4.D.1.2), pasture, range and paddock (4.D.2) and indirect soil emissions (4.D.3). Also recalculations made due to update of activity data in sewage sludge (4.D.1.6).
E. Prescribed Burning of Savannas			
F. Field Burning of Agricultural Residues			
G. Other			
5. Land Use, Land-Use Change and Forestry			
A. Forest Land	√	√	CO_2 from Forest Land CRF 5.A (Chapter 7.2). Emission reestimation from wildfires. Also re-estimations made in carbon stock changes in organic soils associated with conversions from Settlements and Other lands to Forest land.
B. Cropland	√	√	CO_2 from Land converted to Cropland CRF 5.B.2 (Chapter 7.3.2.2). Recalculations were made in subsector Other land converted to Cropland, calculations included evaluation of carbon stock gain of mineral soils. Inacuracies in activity data where corrected (organic soils accounts for 0,7% of Cropland area).
C. Grassland	√	√	CO_2 from Land converted to Grassland CRF 5.C.2 (Chapter 7.4.2.2). Recalculations were made in subsector Other land converted to Grassland, gain of mineral soil carbon stocks included in to the calculations.
D. Wetlands			
E. Settlements	√	√	CO_2 from Land converted to Settlement CRF 5.E.2 (Chapter 7.6.2.2). Re-estimating of Carbon stock changes due to loss of living biomass from conversions of Grasslands to Settlements: Cbefore values corrected – from 5 t C ha-1 to 1.2 t C ha-1.
F. Other Land			
G. Other			
6. Waste			
A. Solid Waste Disposal on Land		√	CH_4 from CRF 6.A (Chapter 8.2)
B. Waste-water Handling		√	CH_4 from CRF 6.B.2.1 (Chapter 8.3) N_2O from CRF 6.B.2.2 (Chapter 8.3.7)
C. Waste Incineration			
D. Other			
7. Other (as specified in Summary 1.A)			
Memo Items:			
International Bunkers			
Aviation		√	Correction of activity data (jet kerosene) based on the newest information provided by the Lithuanian Statistics in November 2013. (Chapter 3.2.2)
Marine			
Multilateral Operations			
CO_2 **Emissions from Biomass**			

NIR Chapter	DESCRIPTION Please tick where the latest NIR includes major changes in descriptions compared to the previous year NIR		REFERENCE If ticked please provide some more detailed information for example reference to pages in the NIR
Chapter 1.2 Institutional arrangements			
Chapter 1.6 QA/QC plan			

10.1 Source specific recalculations

Energy sector

Energy subsectors (except transport)

Following recalculations has been done taking into account the ERT recommendations for all subsectors of Energy sector (except transport):

- dissagregation of activity data for anthracite, coking coal and sub-bituminous since 2000 based on the newest information provided by Lithuanian Statistics in November 2013;
- correction of CO_2 plant specific emission factor for residual fuel oil, not liquefied petroleum gas based on EU ETS data;
- corrections of activity data of motor gasoline, peat, coke, residual fuel oil, LPG, gasoil, sub-bituminous coal, lignite, charcoal, natural gas, biogas, wood/wood waste and other solid biomass consumption based on the newest statistical information provided by Lithuanian Statistics in November 2013.

Transport

Correction of activity data of jet kerosene and diesel oil based on the newest information provided by the Lithuanian Statistics in November 2013.

CO_2, CH_4 and N_2O emissions from Road Transportation have been recalculated in this submission with respect to the new fuel consumption activity data.

Country specific CO_2 emission factor for natural gas based on study on "Determination of national GHG emission factors for energy sector" was applied.

Industrial processes sector

Cement production

In this submission more precise 2005-2011 CO_2 values were entered as in the last submission these values were rounded.

Lime production

Typing error was corrected for CO_2 emission (2002).

Limestone and dolomite use

In this submission more precise 1990-2011 CO_2 values were entered as in the last submission these values were rounded.

Soda ash use

Soda ash use emission was recalculated for the years 2010 and 2011 due to change of activity data. Data on overall soda ash use for period 1990-2009 was taken from Statistic Lithuania. The collection of this data was stopped in 2010, therefore the data for 2010 and 2011 was extrapolated in the previous submission. In this submission for the years 2010 – 2012 overall soda ash use is determined via balancing (import minus export).

Road paving with asphalt

Data on NMVOC and CO_2 emissions from road paving with asphalt are reported for the first time in Lithuanian inventory.

Bricks and Tiles production

Typing error was corrected for CO_2 emission (2008).

Nitric Acid production
In this submission more precise 1990 - 2011 N_2O values were entered as in the last submission these values were rounded.

Methanol production

Data on CO_2 emissions from methanol production are reported for the first time in Lithuanian inventory.

Pig Iron production
Typing error was corrected for CO_2 emission (1990-1992).

Domestic refrigeration
HFC emissions from domestic refrigeration were recalculated for the period 1997-2011 based on the updated population, the average size of households and the percentage of households using domestic refrigerators data provided by Statistics Lithuania.

Commercial refrigeration
Emissions were recalculated for the period 2001-2011, based on updated data from TUB "Rinkuskiai" and newly obtained data from AB "Kauno alus".

Potential emissions from refrigeration and air conditioning equipment
Potential emissions from refrigeration and air conditioning equipment were recalculated due to updated information provided by Statistics Lithuania and stock company in domestic and commercial refrigeration subsectors.

Transport refrigeration
Emissions of HFC-134a from disposal of refrigerated freight wagons for the period 2009-2012 are reported for the first time, based on newly obtained data from AB Lietuvos geležinkeliai.

Stationary air-conditioning
Emissions of HFC-32, HFC-125, HFC-134a and HFC-125 were recalculated for the 2011, based on the more accurate data acquired of installed heat pumps according to Study carried out by EurObser'ER in 2013.

Fire extinguishers
Typing errors were corrected for HFC-134a emission (2002-2008).

Solvent and other product use

NMVOC and CO_2 emissions from Paint application, Industrial degreasing, Dry cleaning, Graphic arts, Glues and adhesives and Domestic solvent use were recalculated for the period 2001-2011 due to updated population data by Statistics Lithuania.

Agriculture sector

Enteric fermentation
In order to increase consistency of used methodologies for calculation of emission from enteric fermentation, the following recalculations have been made during this submission:

- Gross energy intake for dairy cattle for the period 1991-2012 was recalculated due to recalculation of weight of dairy cattle;
- Emissions from sheep for 2011 were recalculated due to correction of CH_4 emission factors for baa-lambs.

Manure management CH_4

In order to ensure consistency of methodologies used to estimate CH_4 emission from manure management, the following recalculations have been made:

- Due to update of manure management systems for swine recalculations were made in this submission in 2011;
- Due to updated average weight for the period 1991-2011 and gross energy data for dairy cattle for the period 2008-2011 emissions of CH_4 were recalculated.

Manure management N_2O

N_2O emission was recalculated due to updated gross energy intake and protein consumption for the period 1990-2011 and N retention for dairy cattle according to *IPCC GPG 2000*[189] metodology for entire time series. Similarly N_2O emission was recalculated due to updated data for manure management system for swine in 2011.

Agricultural soils

Recalculations of direct N_2O emissions from agricultural soils were performed in this submission due to:

- Recalculations in manure management – N_2O subsector what caused recalculations in subsector animal manure applied to soils (4.D.1.2);
- Following the recommendations of ERT during centralized review 2013 recalculations were performed in subsector sewage sludge using $Frac_{GAZF}$ value 0,2 instead of 0,1 (4.D.16). Also recalculations were performed for the quantity of sewage sludge that was used as amendment to agricultural soils – inaccuracies in data gaps during the period 2000-2003 were corrected.

N_2O emissions from pasture, range and paddock manure (4.D.2) were recalculated due to recalculations made in subsector manure management – N_2O (4.B.(b)).

Recalculations performed in subsector of Indirect N_2O emissions from agricultural soils are related to N_2O emission recalculations made in manure management subsector.

Land use, Land-Use Change and Forestry sector

Forest Land

Following ERT 2012 recommendations emissions from wildfires in Forest land were included into total emissions/removals from Forest land, as they were reported separately in the previous submissions and caused double-counting in this category. Since now these emissions are accounted correctly, and reported using IE notation key in the relevant CRF tables.

There were also minor re-estimations made in carbon stock changes in organic soils associated with conversions from Settlements and Other lands to Forest land.

Cropland

Recalculations were made in subsector Other land converted to Cropland, also there were calculations including evaluation of carbon stock gain of mineral soils. Some inaccuracies in activity data where corrected, organic soils now accounts for 0,7% of Cropland area (instead of 0,8 % used in previous submission).

[189] *IPCC GPG 2000*. Agriculture. Eq. 4,19, p. 4.45.

Grassland

Recalculations were made in subsector Other land converted to Grassland, there were gain of mineral soil carbon stocks included in to the calculations.

Settlements

Recalculations were made re-estimating Carbon stock changes due to loss of living biomass from conversions of Grasslands to Settlements: C_{before} values corrected – from 5 t C ha^{-1} to 1.2 t C ha^{-1}.

Waste sector

Solid waste disposal on land

CH_4 emissions were recalculated from waste disposal on land (including both solid waste and sewage sludge) due to corrected values of biodegradable components based on additional waste composition data collected in 2012.

Wastewater Handling

CH4 emissions starting from 2001 were recalculated from wastewater handling and human sewage due to updated population data by Statistics Lithuania.

Waste incineration

Typing error was corrected for amount of incinerated waste (2010).

KP-LULUCF

There were some minor changes made in KP-LULUCF emisions/removals calculations comparing with those provided in the previos submission (NIR 2013). Lithuania is constantly updating afforested, reforested and deforested areas that were established during the required accounting period. This is the result of continuous data, related to ARD areas, input to State Forest Cadaster, which is the main data provider for ARD areas. Updated information had impact on overall areas and emission/removals calculations not only for ARD but also for the whole Forest management subsector.

10.2 Planned improvements

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 planned work for 2015 submission is related to proper application and implementation of reporting requirements of IPCC 2006 Guidelines, IPCC 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement) and 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (KP Supplement). Lithuanian GHG inventory experts participate in the EU support project on the implementation of the 2006 IPCC Guidelines in national GHG inventories – online communication platform and workshop which will take place on 18-19 June 2014, Brussels (Belgium). Lithuanian experts also participated in the Workshop on the implementation of the 2006 IPCC Guidelines in Dessau (Germany), 24-25 March 2014.

Energy sector

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

Industrial processes sector

F-gases

The new EU Regulation on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006 is expected to come 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.

In early 2014 Ministry of Environment initiated a study on F-gases regulation review where necessary legislative, administrative, reporting system improvement measures to be proposed in order to effectively implement the requirements of the abovementioned Regulation. In the scope of this study also analysis of new F-gases (such as NF_3 etc.) use in Lithuania will be performed and methodological changes of Lithuania's F-gases emissions estimates applying IPCC 2006 Guidelines will be discussed.

Agriculture sector

Enteric fermentation

Lithuania is planning to proceed with collection of more precise data on cattle weight.

Manure management

Collection of more accurate data on manure storage systems used in Lithuanian agriculture will be proceeded. Collection of more accurate data on manure utilization and appliance to biogas plants in Lithuania is planned. Additional data should enable better and more reliable judgments on N_2O emissions from manure management.

Land use, land use change and forestry sector

Forest land

Following the recommendations of ERT 2012, Lithuania is planning to revise methodology used for estimation of country-specific mass values of available fuel for wildfires, including dead wood and litter.

Cropland

Estimations of CO_2 emissions from liming of cropland will be improved, more liming agents will be included with specific emission factors. Living biomass activity data for Croplands is planned to be upgraded with short rotation woody crops (Salix plantations).

Following the recommendations of ERT 2012, Lithuania plans to revise reference carbon stocks with country-specific values and implement more detailed stratification of management systems.

Grassland

Uncertainty assessment of emissions from grassland will be improved.

Wetland

Additional studies and information research are planned in order to improve reporting of areas and greenhouse gas emissions/removals under this land use category.

Settlement

Colection of additional information is planned in order to harmonize NLS and NFI data and improve reporting of areas that currently are under NA, NE notation keys. Improvement of reporting is planned to include subcategories with vegetation and without vegetation.

Other land

With implementation of new regulation of NLS, coming into force on 28th January 2014 and based on satelite image information accuracy of activity data will be improved.

PART II: SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1

11 KP-LULUCF

11.1 General information

Lithuania has been successfully implementing the commitments under the Kyoto protocol – to reduce greenhouse gas emissions by 8% below 1990 level during the first commitment period of 2008 – 2012. By 2012, the greenhouse gas emissions in Lithuania have been reduced by 55,7% compared with 1990. Nevertheless, Lithuania is neither protected from changes in global climate nor from their consequences, therefore additional effort should be added in reduction of emissions and increase of removals.

Lithuania provides supplementary information under Article 7 of the Kyoto Protocol for the Land Use, Land-Use Change and Forestry sector. This information is further specified in Decision 15/CMP.1, 16/CMP.1 and *IPCC Good Practice Guidance* (*IPCC 2003*) for LULUCF.

Estimations of anthropogenic emissions by sources and removals by sinks since 1990 are associated with Afforestation (A), Reforestation (R) and Deforestation (D) activities under Article 3.3 and Forest Management (FM) the only elected activity under Article 3.4 of the Kyoto Protocol.

Lithuania reports activities under Article 3.3 and 3.4 including geographical boundaries of areas encompassing units of land or land only subject to a single activity by reporting *Method 2* and *Approach 3* (Table 4.2.2 of the *IPCC 2003*). Allocation of ARD areas is more precise and is made using slightly different methodology than monitoring land use changes under Convention reporting. More information on restoration of historical data for 1990-2011, methods used for estimation of ARD areas and etc. could be also find in Chapter 7.1 as well as in the text below.

Net removals from Article 3.3 activities were -129,9 GgCO_2 eqv. in 2012. Afforestation and reforestation resulted in a net removals of -195,9 GgCO_2 eqv. and deforestation a net emissions of 66,0 GgCO_2 eqv. (Table 11-1).

Table 11-1. Net GgCO_2 eqv. emissions/removals from ARD areas, 2008-2012

Year	Afforestation/ Reforestation	Deforestation	Total
2008	-115,6	29,4	**-86,2**
2009	-135,7	17,9	**-117,8**
2010	-146,4	46,0	**-100,4**
2011	-166,8	18,4	**-148,4**
2012	-195,9	66,0	**-129,9**

The area subjected to AR was 34,63 thous. ha in 2012. There could be two moment distinguished in the time series of 1990-2012 describing the AR trendline. The first time period of artificial afforestation/reforestation has started in 1990-2000 and is related with Lithuanian history. After the restoration of Independence in 1990's forest expansion was the key priority among politicians therefore afforested and reforested areas constituted to more than 500 ha annually. But this number was steadily decreasing in 1994. After the spruce dieback which hardly hit the Lithuanian forest in 1994, afforestation and reforestation rates again returned to the 1990's level. Another two hughe increases in AR area were recorded in 2001-2007 (result of the storm damages in 2001) and 2009-2011 (introduction of the EU support schemes for AR).

In the beginning of 2013, deforested area since 1st of January 1990 was 1247,8 ha (Table 11-4). Deforstation was mainly caused by the forest area convertions to Settlements (road building, cities expansion etc.), Other lands (quarrys etc.) and Wetlands (flooding etc.) land use categories.

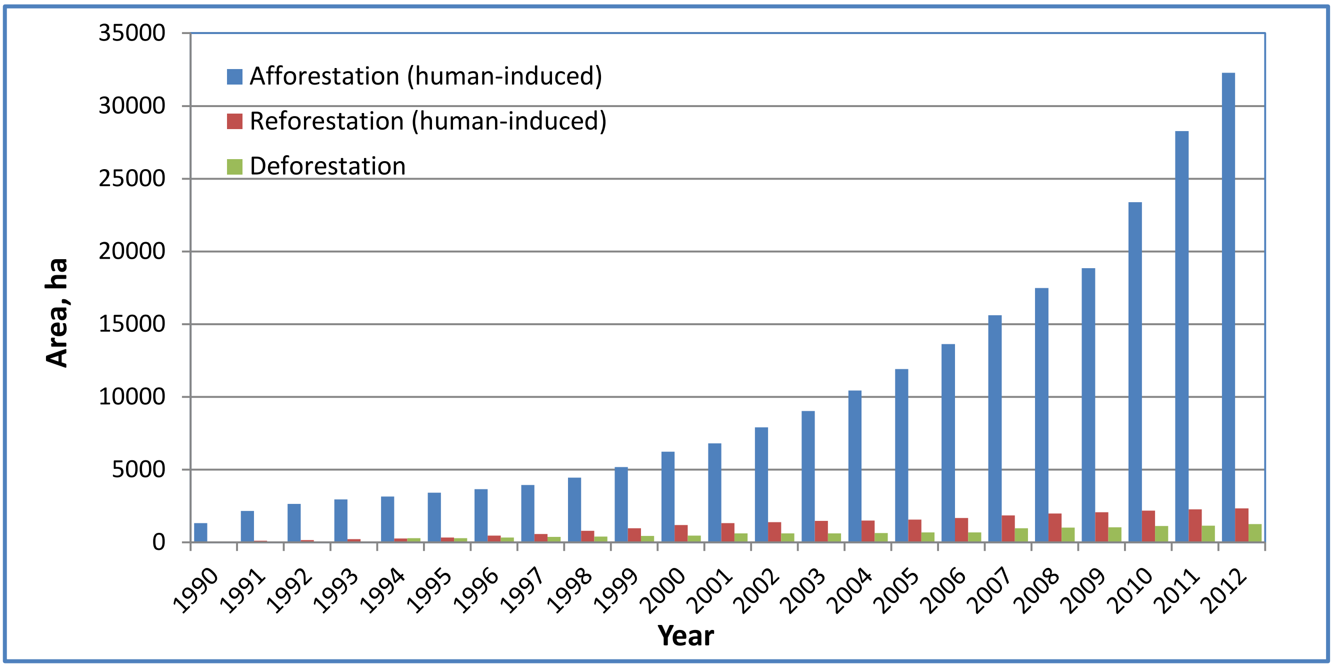

Figure 11-1. Cumulative area of afforestation, reforestation and deforestation, 1990-2012

Additionaly Lithuania has distinguished naturally afforested and reforested areas by using wall-to-wall method (Figure 11-2). Neither emissions nor removals of CO_2 under the requirements of Article 3.3 of the Kyoto Protocol are calculated for these land areas, they are only constantly supplementing areas under Forest management (FM) and are used for overall data consistency purposes.

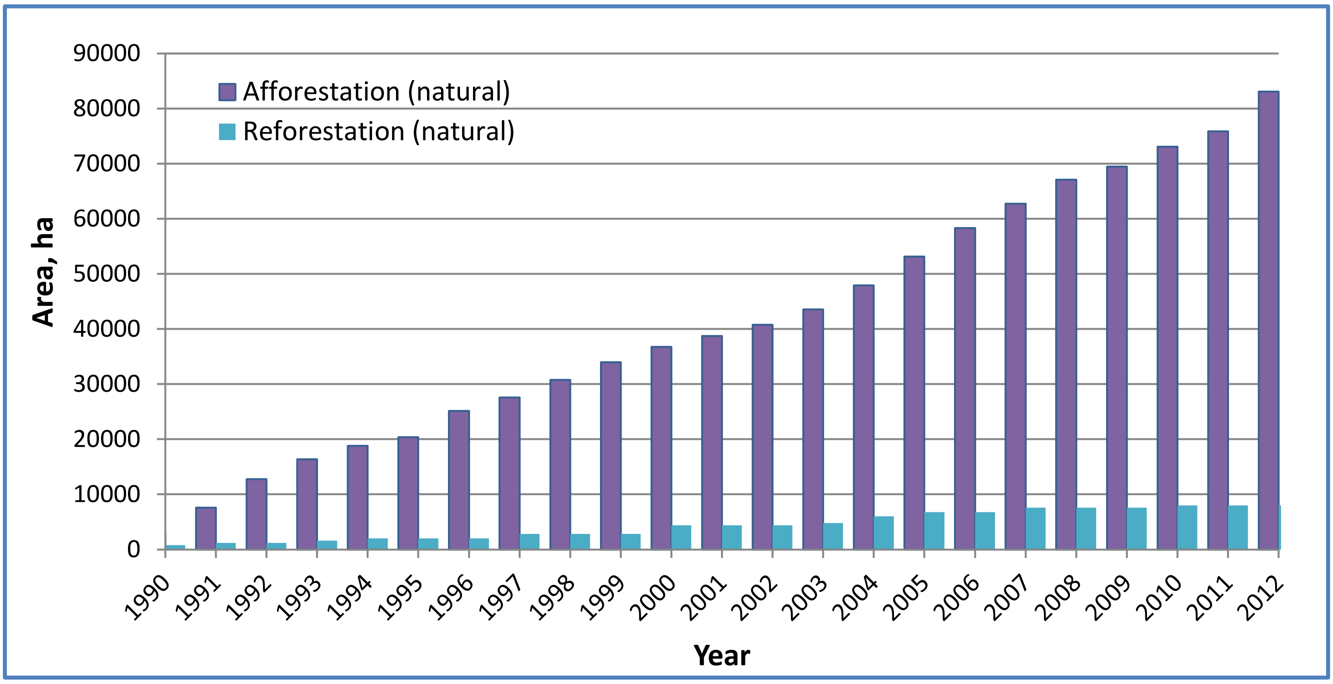

Figure 11-2. Cumulative area of naturally afforested and reforested areas, 1990-2012

Net removals from Article 3.4 activity Forest Management (FM) were -9235,0 $GgCO_2$ (Table 11-17). The area subjected to FM was 2150,2 thous. ha in the end of the commitment period (Table 11-5).

Lithuania has elected commitment period accounting for KP-LULUCF.

11.1.1 Definition of forest and any other criteria

Forest land is defined according to Forests Law of the Republic of Lithuania: "Forest – a land area not less than 0,1 hectare in size covered with trees, the height of which in a natural site in the maturity 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 0,3 (or crown cover less than 30%) are not acceptable for high productivity forestry". This threshold is used when including land into forest land areas (Table 11-2). The same forest parameters were used in Lithuania's Initial report under the Kyoto protocol. The definition of Forest land is consistent with LULUCF reporting under the UNFCCC.

Table 11-2. Selected parameters defining forest in Lithuania for the reporting

Parameter	Range (FAO)	Values (Lithuania)
Minimum land area	0,05 – 1 ha	0,1 ha
Minimum crown cover	10 – 30 %	30 %
Minimum height at mature age	2 – 5 m	5 m

Table 11-3. Forest land area 1990-2012, thous. ha

Years	Forest land
1990	2061,4
1991	2068,6
1992	2074,6
1993	2079,7
1994	2082,5
1995	2084,9
1996	2090,1
1997	2093,7
1998	2097,3
1999	2100,1
2000	2105,7
2001	2108,9
2002	2113,3
2003	2118,9
2004	2126,9
2005	2134,9
2006	2142,1
2007	2150,4
2008	2157,2
2009	2160,0
2010	2166,4
2011	2173,2
2012	2184,8

Forest land area was estimated using National definition of forest land, described in Forest Law of the Republic of Lithuania. Land areas which transition to forest land are not over yet, and which are still used as grasslands or croplands are not included in the forest land area.

Area change of afforestation, reforestation and deforestation activities is presented in Table 11-4.

Table 11-4. Area changes of afforestation, reforestation and deforestation, thous. ha

	Afforestation	Reforestation	Total AR	Deforestation
1990	1,33	0,04	1,37	0,00
1991	0,83	0,07	0,90	0,00
1992	0,48	0,04	0,52	0,00
1993	0,31	0,06	0,37	0,19
1994	0,21	0,04	0,26	0,10
1995	0,25	0,08	0,33	0,01
1996	0,25	0,12	0,37	0,05
1997	0,29	0,13	0,41	0,04
1998	0,50	0,20	0,70	0,02
1999	0,73	0,19	0,92	0,05
2000	1,07	0,21	1,28	0,02
2001	0,55	0,13	0,68	0,14
2002	1,10	0,07	1,18	0,00
2003	1,14	0,09	1,23	0,00
2004	1,40	0,03	1,44	0,01
2005	1,48	0,06	1,54	0,05
2006	1,70	0,11	1,80	0,00
2007	2,00	0,18	2,18	0,29
2008	1,87	0,13	2,00	0,05
2009	1,37	0,09	1,45	0,03
2010	4,54	0,12	4,66	0,07
2011	4,88	0,08	4,95	0,03
2012	4,02	0,08	4,09	0,10
Total 1990 - 2012	32,29	2,34	34,63	1,25

11.1.2 Elected activities under Article 3, paragraph 4, of the Kyoto Protocol

For this first commitment period taking place in 2008-2012 Lithuania has chosen to account emissions and removals from Forest Management under Article 3.4 of the Kyoto Protocol, but did not elect Cropland Management, Grazing Land Management and Revegetation. The decision is supported by the importance of forests in Lithuania and available accounting data of forest resources allowing present transparent and comprehensive results for greenhouse gas inventories. Regular information on Lithuanian forest resources is provided by Standwise Forest Inventory already since 1922. Lithuania has made essential improvements in data quality on forest resources since 2002, when NFI permanent sample plots net has completely covered all Lithuania's territory.

To estimate areas required by the Article 3.3 and 3.4 of the Kyoto Protocol, additional studies were executed in order to recover ARD activities for the period of 1990 – 2011. Some data sources took back to 1946. Completed studies recovered required data on ARD areas for the 1990 – 2011 and has made the background for the amendment, supplementation and adoption of new relevant legislation (Chapter 7.1), in order to set the rules and also to oblige forest owners and managers to register newly afforested, reforested and deforested areas to State Forest Cadaster, which is serving as the main data provider for ARD areas identification reported under Kyoto Protocol since 2012. Thus, starting already since 2009 every deforestation case, which is under very strict regulation and control by the Forest Law, is recorded in the special database as well as afforestation and reforestation activities.

Lithuania elected *Method 2* for the reporting of lands that are subject to Article 3.3 and Article 3.4 activities, which is based on spatially explicit and complete geographical identification of all units of land subjected to Article 3.3 activities and all lands subjected to Article 3.4 activities.

ARD areas were assessed using wall-to-wall mapping and FM areas were assessed using sample based (NFI sample plots grid) techniques.

11.1.3 Description on how the definitions of each activity under Article 3.3 and each elected activity under Article 3.4 have been implemented and applied consistently over time

The definitions of Afforestation (A), Reforestation (R) and Deforestation (D) activities are in accordance with the *IPCC 2003*.

ARD definitions presented in *IPCC 2003* under the Kyoto Protocol are applied for KP-LULUCF assessment in Lithuania. It is considered that afforestation and reforestation is human-induced artificial planting of croplands, grasslands and wetlands. Separation of afforested and reforested areas requires more effort in studying archive data of SFI and aerial photographs up to 1940's (*Study-1*). Areas of deforestation are under very strict regulation and control legitimated by the Forest Law (original text adopted in 1994) and Lithuanian Republic Governmental Resolution No 1131 dated on Sept 28, 2011. In general forest conversion to other land is very rare i.e. only for road building or settlements establishement and also requires special procedure of compensation. Statutory way of compensation is re-establishment of forest on non-forest land on area up to 3 times larger than used for deforestation.

Forest Law regulates afforestation process on agricultural and other lands (swamps, peatlands, other land) as well. Afforestation of these lands could be done by artificial planting as well as by natural regeneration. The legitimated substitution of naturally afforested agricultural and other land to forest is only possible when tree crowns cover attains 30% of the area not less than 0.1 ha and the age of trees exceed 20 years. Natural afforestation is included in area of forest management (FM). All afforested land (human induced and natural) is recorded during SFI and legitimated registration at State Forest Cadastre.

The main data source to identify areas for calculating emissions and removals under Article 3.3 and Article 3.4 of the Kyoto Protocol is study "Forest land changes in Lithuania during 1990-2011" (*Study-1*) (detailed description is provided in Chapter 7.1.1) implemented in 2012.

The main objective of the study was to identify forest land areas and their changes in Lithuania during 1990-2011 following the requirements of *IPCC 2003*. Study revealed the following Forest land areas and their changes annually in 1990-2011:

– afforested areas with human inducement (AR) – wall-to-wall method used;
– naturally afforested areas which are included in FM – sampling method used;
– deforested areas (D) – wall-to-wall method used;
– forest management areas (FM) – sampling method used.

The *Study-1* covers all Lithuania's forest land territory (or areas, where forest land has been registered at least once) during 1990-2011 years.

The main data sources used:

– Data from National forest inventory (NFI), which is executed on 16 325 (all Lithuania's territory with non-forest land) systematically distributed permanent sample plots, was used to estimate total land area assigned to Forest Management activity as well as to calculate living biomass and deadwood;
– Lithuanian State Forest Cadastre (LSFC);
– Standwise forest inventory databases and maps (S 1:10 000);
– Orthophoto maps (S 1:10 000);
– National Paying Agency's data of declarations for afforested areas (2010-2011);
– Topographical maps 1973-1990 (S 1:50 000);
– Archive cartographical material backwards to 1946-1949 (S 1:10 000);
– Maps of Lithuanian forest resources (1998-1999) (S 1:50 000).

The *Study-1* resulted in the following outcomes:

– units of land subject to activities under Article 3, paragraph 3, which would otherwise be included in land subject to elected activities under Article 3, paragraph 4, under the provisions of paragraph 8 of the annex to decision 16/CMP.1 were identified and distinguished;
– GIS layers for Afforested, Reforested and Deforested (ARD) areas and areas remaining under Forest Management were prepared;
– report, showing relevant land units changes was prepared;
– proposals on land use definitions harmonization and development of the harmonized methodology for the data evaluation and estimations of emissions and removals for LULUCF sector according to the UNFCCC and the Kyoto Protocol requirements were elaborated.

The definition of Forest Management is in accordance with the *IPCC 2003*. Forest land area under Forest management reported for *KP-LULUCF* calculations is provided in Table 11-5. Data source for determining area under Forest Management activity is *Study-1*, where Forest Management area is assessed using NFI permanent sample plots data. Area of organic soils and drained organic soils is determined using data of NFI. NFI provides data on forest land distribution by forest soils, which are classified using forest site types classification prepared by M. Vaičys (Chapter 7.2.1). Area of mineral soils amounts to 84,3% and area of organic soils – 15,7% of the total forest land area. Drained organic forest soils constitute to 7,9% of the total forest land. The same proportions of organic and mineral soils were also accepted for determination of organic and drained organic soils on Forest management area.

Table 11-5. Area of Forest management*, thous. ha

	Total area	Organic soils		
		Not drained	Drained	Total
1990	2060,0	160,7	162,7	323,4
1991	2066,3	161,2	163,2	324,4
1992	2071,8	161,6	163,7	325,3
1993	2076,6	162,0	164,0	326,0
1994	2079,1	162,2	164,3	326,4
1995	2081,2	162,3	164,4	326,7
1996	2086,0	162,7	164,8	327,5
1997	2089,2	163,0	165,0	328,0
1998	2092,1	163,2	165,3	328,5
1999	2094,0	163,3	165,4	328,8
2000	2098,3	163,7	165,8	329,4
2001	2100,8	163,9	166,0	329,8
2002	2104,0	164,1	166,2	330,3
2003	2108,4	164,5	166,6	331,0
2004	2114,9	165,0	167,1	332,0
2005	2121,4	165,5	167,6	333,1
2006	2126,8	165,9	168,0	333,9
2007	2133,0	166,4	168,5	334,9
2008	2137,8	166,7	168,9	335,6
2009	2139,1	166,8	169,0	335,8
2010	2140,8	167,0	169,1	336,1
2011	2142,7	167,1	169,3	336,4
2012	2150,2	167,7	169,9	337,6

**Natural afforestation and reforestation area is included in Forest management area*

11.1.4 Description of precedence conditions and/or hierarchy among Article 3.4 activities, and how they have been consistently applied in determining how land was classified

Lithuania has elected to report only Forest management under Article 3.4 activities, therefore there is no hierarchy among Article 3.4 activities. For the consistency reasons and to be sure that reported forest management activities have occurred on forest land, total land area was splitted into six land use categories as it is required by UNFCCC reporting, and each land area was classified under one land use category only.

11.2 Land-related information

Lithuania applies reporting *Method 2* in combination with *Approach 3* to represent areas under Article 3 of the Kyoto protocol. *Study-1* also elaborated in defining geographical borders of afforested, reforested and deforested areas required by KP-LULUCF reporting (Figure 11-3).

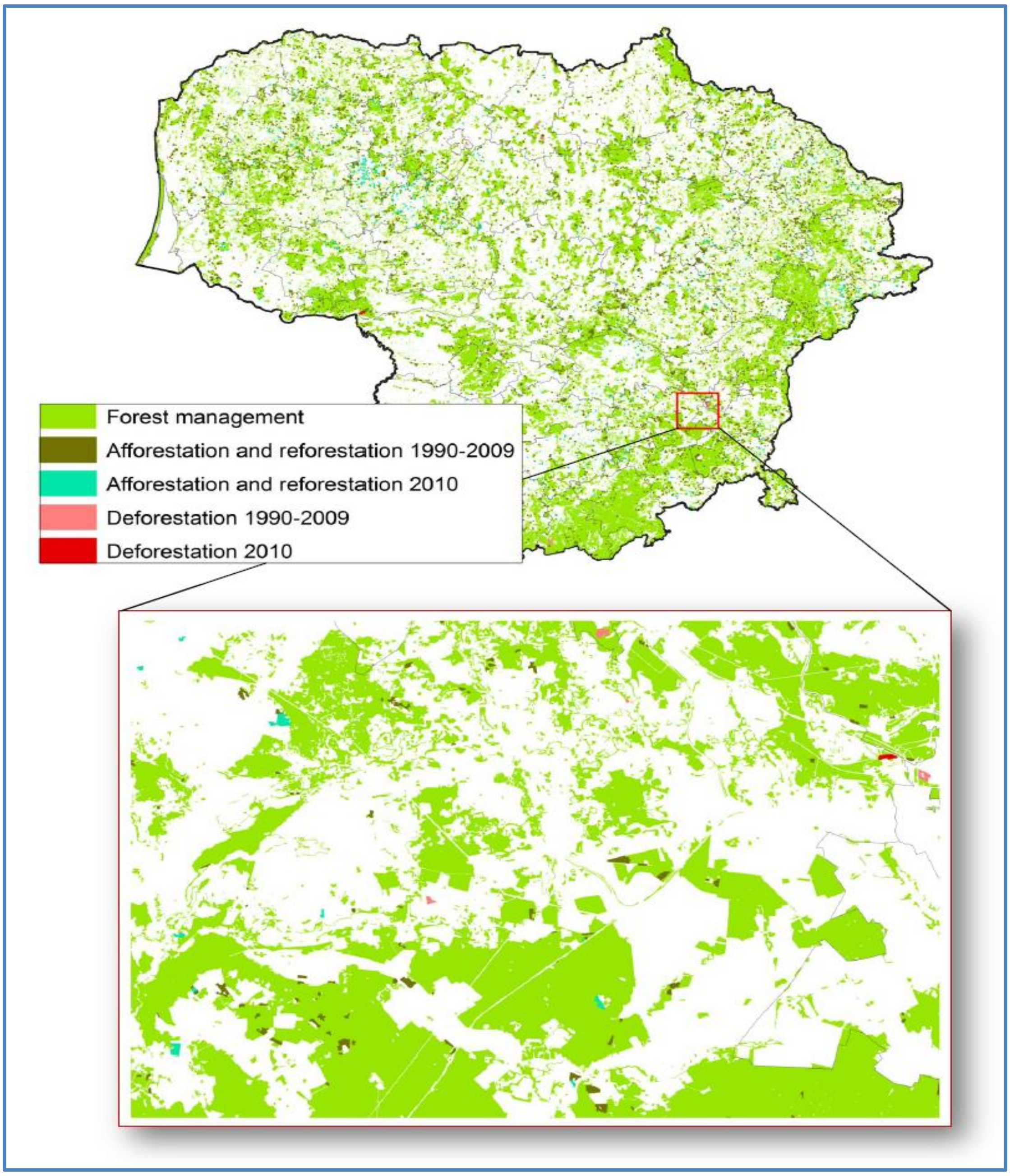

Figure 11-3. Afforestation, reforestation and deforestation activities 1990-2010

To achieve annual wall-to-wall mapping of forest land areas and to detect changes several types of source material were used. These were: State Forest Cadastre, National paying agency's information on agricultural land, afforestation of non-agricultural and abandoned land, Lithuanian forest resource database at a scale of 1:50 000, all available orthophotos of the country, developed during the analysed period, satellite maps from CORINE, USGS[190] and other projects done by the contractors.

The decision, for allocation of certain land areas to relevant land use categories, has been made using decision tree with named relevant sources of information, and involved organizations, who were providing necessary data. Such decision tree was prepared and used throughout the land areas allocation process by study executing team experts (Figure 11-4).

[190] *Available from: http://earthexplorer.usgs.gov/*

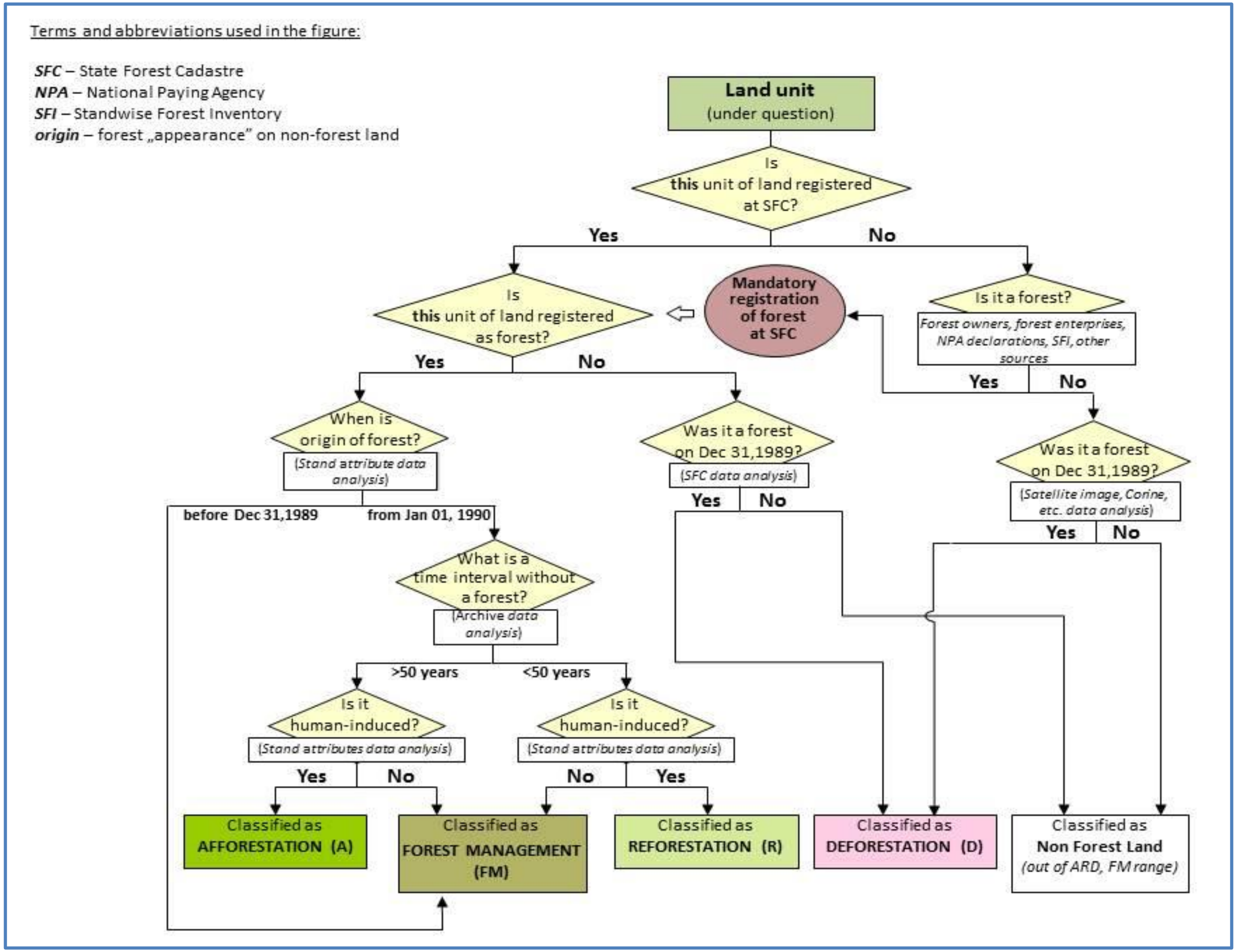

Figure 11-4. Decision tree for land units allocation to relevant land use categories

Codes that were used by *Study-1* experts for identification of activities on forest land are presented in Table 11-6.

Table 11-6. Codes to identify Article 3.3 and 3.4 activities

Codes used	Descriptions
FM	*Forest management*
A1	*Afforestation (**human – induced**)*
A2	*Afforestation (**natural**; included in Forest management area)*
R1	*Reforestation (**human – induced**)*
R2	*Reforestation (**natural**; included in Forest management area)*
D	*Deforestation*

As could be seen from the table above, two additional groups were distinguished. A2 and R2 are naturally afforested and reforested land areas that are included into SFC according to Forest Law of the Republic of Lithuania. Such segregation is not required neither by *IPCC 2003* nor are in compliance for requirements for human induced AR areas under Article 3.3 of the Kyoto Protocol. Therefore, these areas are consistently supplementing FM area and are used for consistency purposes only.

Areas of human–induced afforestation and reforestation were assessed mainly relying on areas of forest plantations registered either by State Forest Cadastre or received as declarations from State Forest Enterprises and private owners. All registered areas have authorizations and certified forest planting projects (Figure 11-5). Projects must be prepared according to Regulations for afforestation and reforestation[191]. Since 2008 most of reforestation cases in Lithuania receive financial support from National Paying Agency and therefore are registered in relevant database.

[191] *Lietuvos Respublikos Seimas. 2012. [Seimas of the Republic of Lithuania]. Miško atkūrimo ir įveisimo nuostatai. [Regulations for afforestation and reforestation]. Nr. D1-1052. Available from: http://www3.lrs.lt/pls/inter3/dokpaieska.showdoc_l?p_id=416395&p_query=&p_tr2=2 (In Lithuanian)*

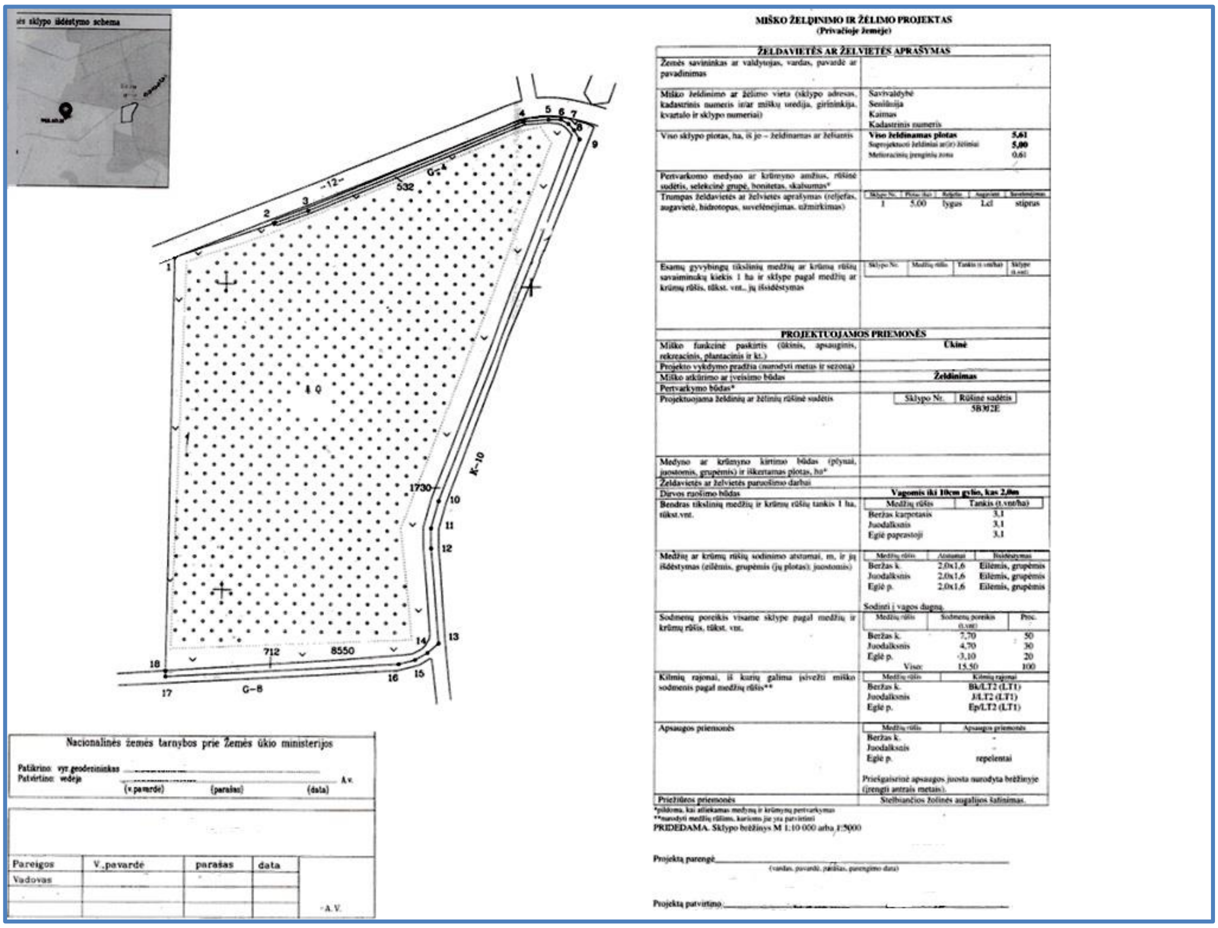

Figure 11-5. Forest planting (afforestation/reforestation) project provided to SFC

The main data source used for identification of AR and D areas was the geographic data from the State Forest Cadastre. These data sets include borders of all forest compartments in Lithuania (around 1.3 mill polygons), and is associated with the data describing stand characteristics of the compartment. Age of all stands was updated to fit defined datum-line – the year 2011. Then, the year of forest stand registration to forest cadastre was estimated, subtracting the age of stand from 2011 (and adding 10 for naturally regenerated forests, as according to national regulations naturally regenerated forest is accounted under forest land at 10 years age). Then, the origin of each compartment was checked to identify whether the forest appeared on forest or other (i.e. non-forest) land.

Two basic and one additional criteria were used to identify the exact appearance of forest: 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 previously executed standwise forest inventories and there were numerous forest compartments, actually grown on non-forest land, omitted. Therefore, special spatial overlay and selection techniques were developed and applied to identify forests, which were appearantly existing, but were missing 50 years ago (according to the database developed and 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 standwise forest inventory. However, such approach faced some limitations how to reflect the newly established forests, as the State forest cadastre data was based on the information originating from standwise forest inventory. Standwise forest inventories in Lithuania are carried-out on a 10-years cycle basis, thus, there were some regions with quite outdated information on the compartments and missing the boundaries of stands, established already after the stand-wise inventory. Several solutions were used to fill such information gaps.

First of all, information from the recent Standwise Forest Inventories was acquired from forest inventory contractors, which had not been officially delivered to the State Forest Service yet. Next, all non-forest compartments stored in the State forest cadastre database were checked for the records on potentially established forests there. Simultaneously, State forest enterprises were asked to confirm facts on newly established forests. Data from National paying agency was acquired, to represent borders of afforested areas, which were applied for EU subsidies. Special geo-processing technique was developed to eliminate overlapping in space and time of afforested and reforested areas, resulted by repeated identification of considered areas in independent input data sets.

The decision whether the forest stand, detected to be grown on non-forest land was afforestation or reforestation, was taken based on simple spatial queries testing – verifying presence or absence of the forest land at a certain area in 1950s.

Several techniques were used to detect deforested areas during the last two decades. First of all, deforestation cases that were accounted under the State Forest Cadastre were taken into consideration. There were also records of the officially registred deforestations in State Forest Cadastre, that were also used for this analysis. Recently non-forest land types, identified as forest stands during the previous forest inventories were candidates to be assigned to the deforestation category.

Deforestation was manually mapped using available GIS, orthophoto and satellite image 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 done before 1991. The accuracy of forest cover identification in that database was confirmed by the NFI to be around 95%. Thus, differences between forest covers in the GIS database of Lithuanian forest resources at a scale 1:50 000 and State Forest Cadastre were reasoned by the imperfections of the first data set or the deforestation. All such areas were visually inspected and all deforestations were identified using orthophotos available for Lithuania (referring to 4 dates in the period from 1990). Exact date of deforestation was adjusted using archive satellite data (mainly Landsat, but also coming from SPOT and DMC).

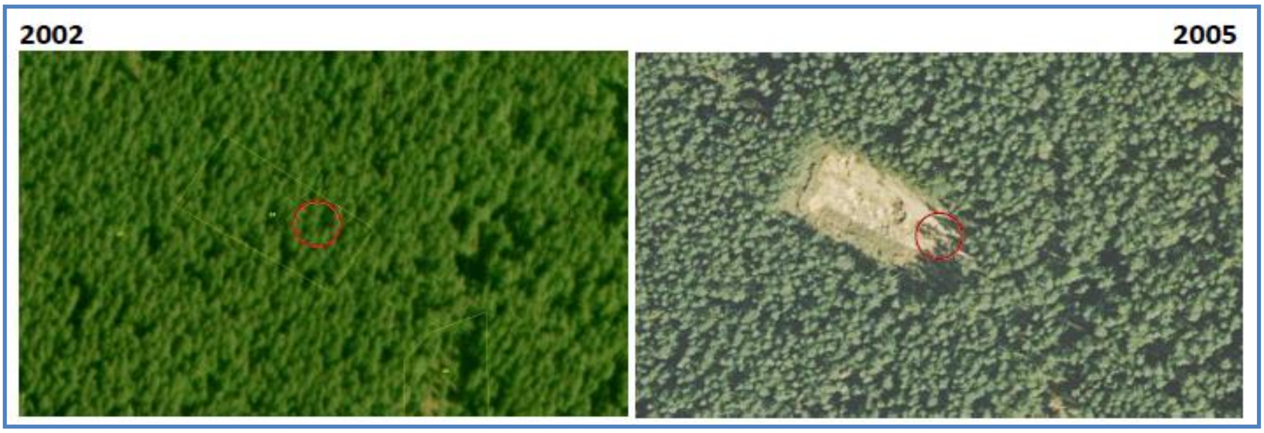

Figure 11-6. Identification of deforestation (D) case using two consecutive orthophotos

Figure 11-7. Identification of human induced afforestation (A1) based on two consecutive orthophotos

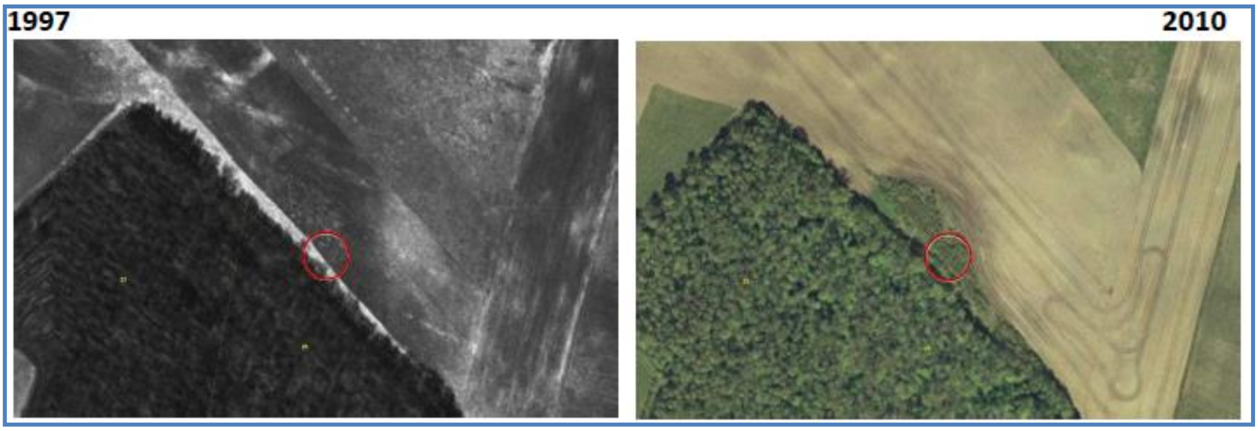

Figure 11-8. Identification of natural afforestation (A2) case using two consecutive orthophotos

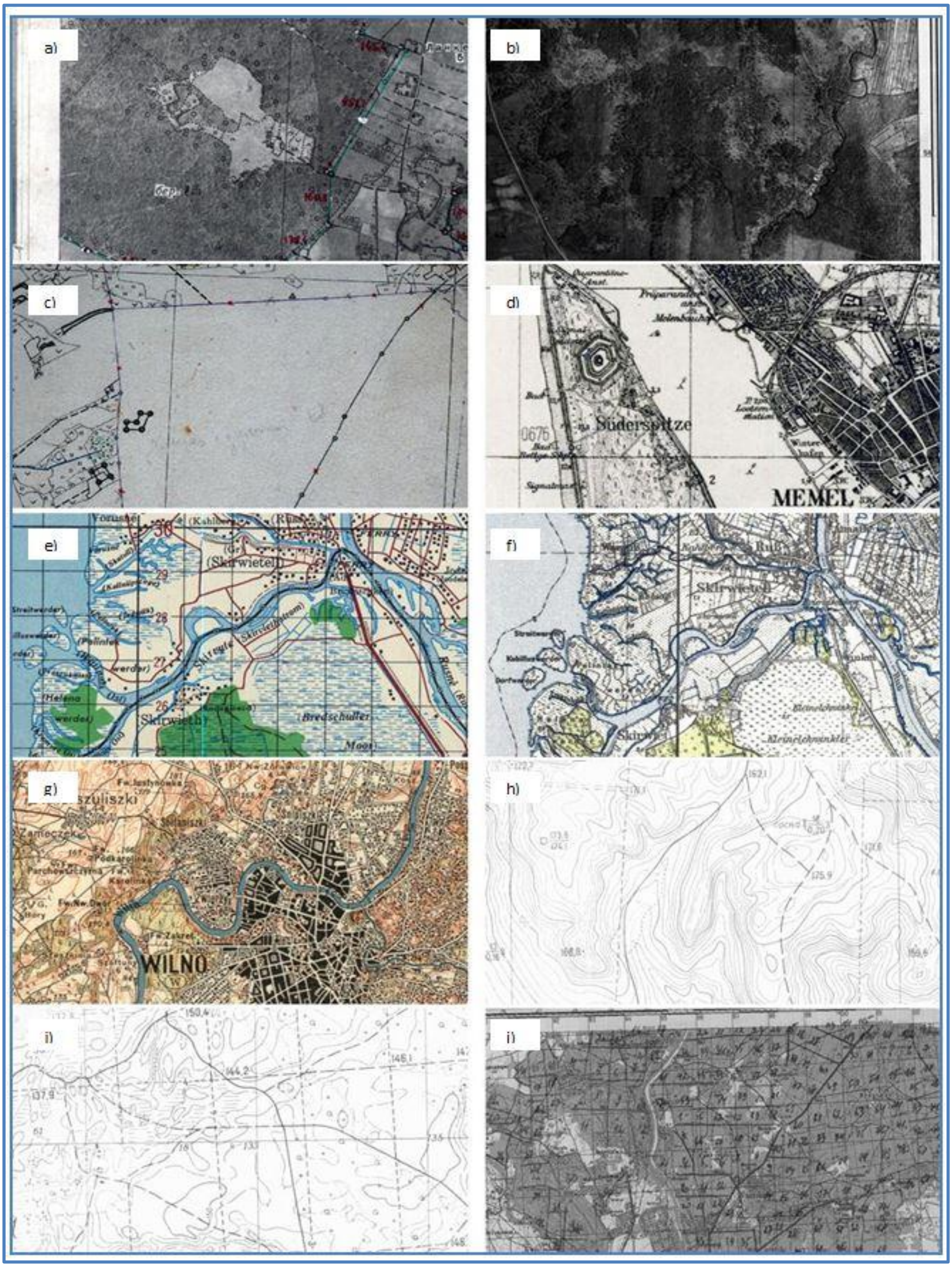

Figure 11-9. Examples of archive cartographical data used for *Study-1*:

a – scanned orthophotographic map 1949-1952; b – scanned photography negative of orthophotographic map 1949-1952; c – ground survey based map; d – German topographic maps compiled in 4-5th decade of the XX century (d - S 1:25000; f – S1:100000); e – US army cartography department maps compiled in 1944 (S 1:100000); g – Polish army cartography department maps of Vilnius compiled in 1934 (S 1:25000); h – topographical maps of different origin developed in former USSR (h – S 1:10000; i – S 1:25000); j – topographical maps in 1942 coordinate system (S 1:50000).

11.2.1 Spatial assessment unit used for determining the area of the units of land under Article 3.3

The spatial assessment unit for determining the area of land units under Article 3.3 is 0.1 ha, which is the same as the minimum area of forest.

11.2.2 Methodology used to develop the land transition matrix

Figure 11-10 represents total afforestation and reforestation area alterations and differences between LSFC (wall-to-wall method) data, which was used for *Study-1*, and NFI (sampling method) data. As it can be seen fluctuations between these two data sources are minor, and confirms consistency among them. Therefore, NFI data serves for quality assurance as it rather well reitereits AR areas represented by LSFC. NFI data was used to determine total forest land area. Afforestation, reforestation and deforestation area was determined using wall-to-wall method described in chapter 11.2. Forest management area was calculated subtracting afforested, reforested, deforested areas from the total forest land.

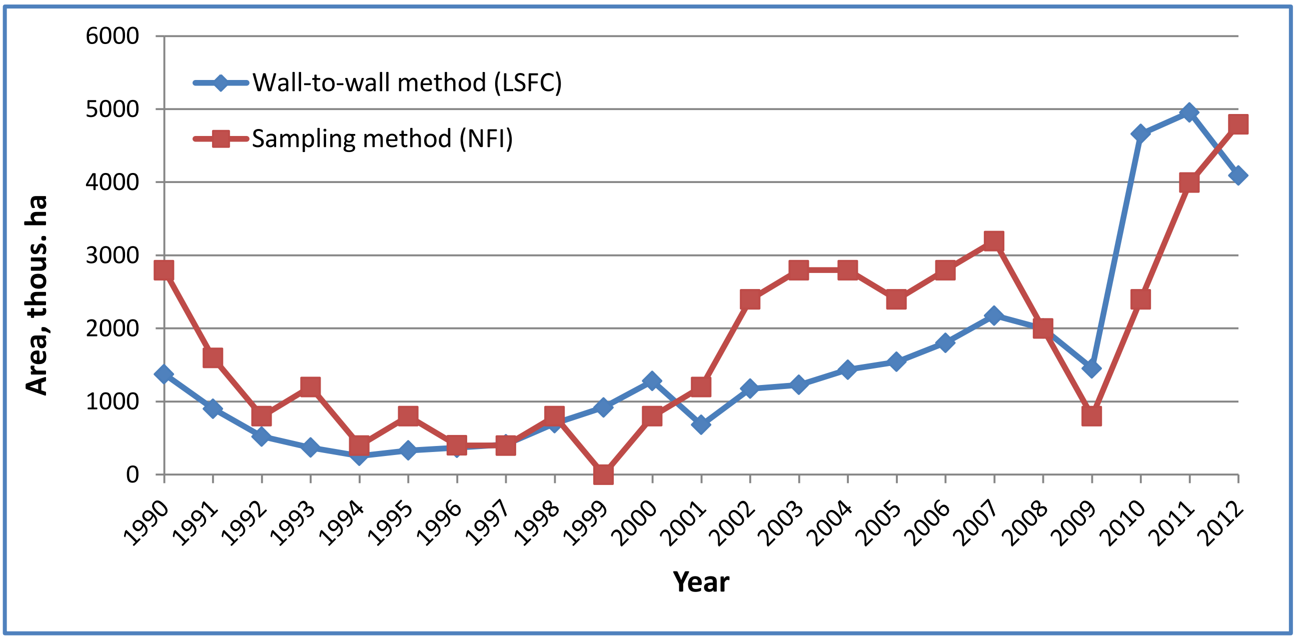

Figure 11-10. Wall-to-wall method quality assurance using NFI data

Decrease in afforestation and reforestation area in 2008-2009 was caused by accounting shortcomings. Data base which contains accurate data on afforested and reforested areas was created only in 2009, and some of the areas afforested in 2007-2009 were included in 2010 accounting due to unknown exact establishment date, therefore such a high increase in area in 2010 and decrease in 2008-2009 occurs.

Table 11-7 presents areas and changes in areas between previous and current inventory years.

Table 11-7. Land transition matrix for 2012, thous. ha

To current inventory year / From previous inventory year		Article 3.3 activities		Article 3.4 activities				Other	Total area at the beginning of the current inventory year
		A/R	D	FM	CM	GLM	REV		
		thous. ha							
Article 3.3 activities	A/R	30,54	0,00						30,54
	D		1,15						1,15
Article 3.4 activities	FM		0,10	2142,57					2142,67
	CM	NA	NA		NA	NA	NA		NA
	GLM	NA	NA		NA	NA	NA		NA
	REV	NA			NA	NA	NA		NA
Other[192]		4,09	0,00	7,59	NA	NA	NA	4343,96	4355,65
Total area at the end of the current inventory year		34,63	1,25	2150,16	NA	NA	NA	4343,96	6530,00

Abbreviations used: A – afforestation, R – reforestation, D – deforestation, FM – forest management, CM – cropland management, GLM – grazing land management, REV – revegetation, NA – not applicable.

11.2.3 Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations

Lithuanian State Forest Cadastre

The total forest land area was estimated using NFI data, but for consistency LSFC maps (S 1:10 000) and database were used.

NFI data was used to determine total forest area and area under Forest management category as well as for estimations of living biomass, deadwood, area of organic soils etc. for forest management and afforestation, reforestation, deforestation activities.

After the *Study-1*, which was used to recover unknown information on ARD areas for the period 1990-2011, State Forest Cadastre was named as the main data provider for newly afforested, reforested and deforested areas by the Amendment of the Governmental Resolution No 1255 that was adopted in 2012. Several legal acts were also introduced in 2012 setting rules and routines and also obliging forest owners and enterprises to provide information on human induced afforestation, reforestation and deforestation as well as natural AR to State Forest Cadastre:

- **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 (deforestation) and compensation for lost forest land.

[192] "Other" includes the total area of the country that has not been reported under an Article 3.3 or an elected Article 3.4 activity.

- **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.

Lithuanian State Forest Cadastre (LSFC) database is presented in Figure 11-11. The database:

- covers 100% country's forest land territory, GIS based;
- easy accessible on web for registered users;
- open for forest managers, controllers and other specialists;
- user friendly;
- up to date;
- real time.

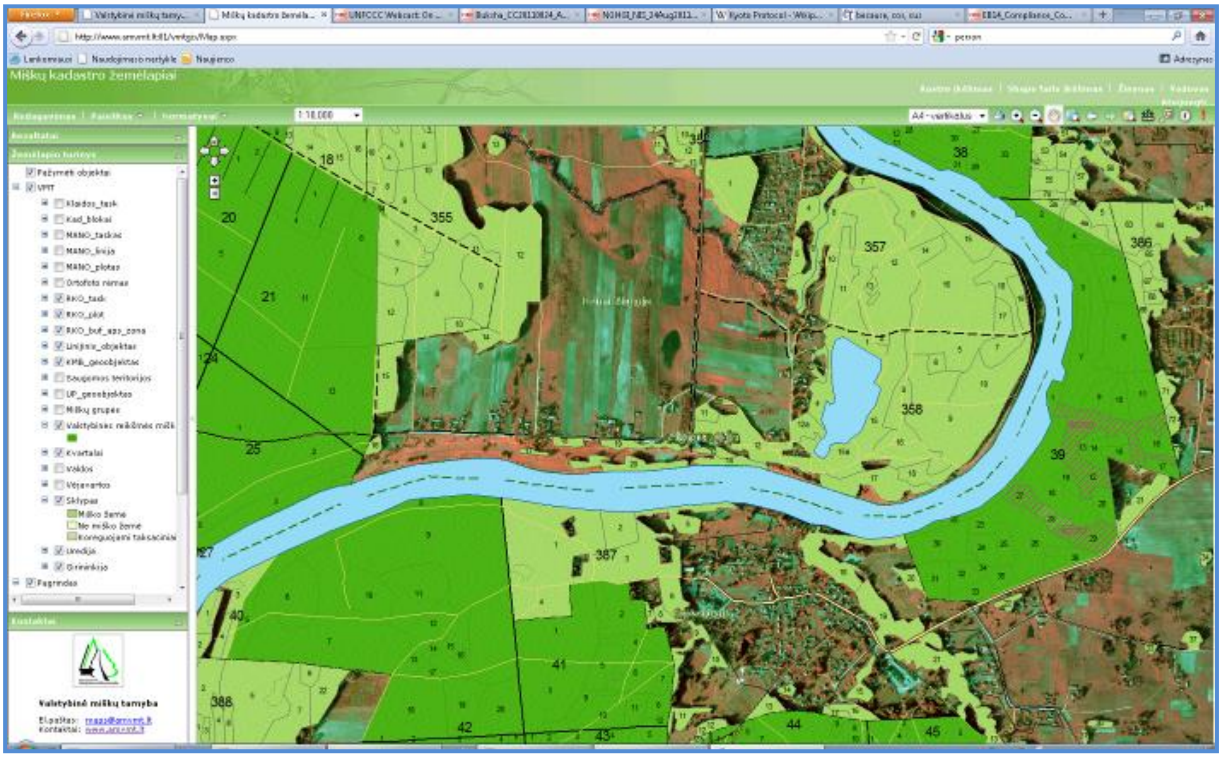

Figure 11-11. Preview of LSFC database

The main object of Lithuanian NFI is forest land area including all forestry related activities. The purpose of the NFI is strategic planning of the forest sector, control of its efficiency at the National level. Execution of NFI is entrusted to State Forest Service under Ministry of Environment.

National Forest Inventory

NFI is based on continuous, multistage sampling and GIS integrated technology and is organized in the same manner for all forests of Lithuania. Lithuanian NFI was started in 1998. The systematic grid of the NFI of Lithuania covers all land classes (Figure 11-12) including inland waters.

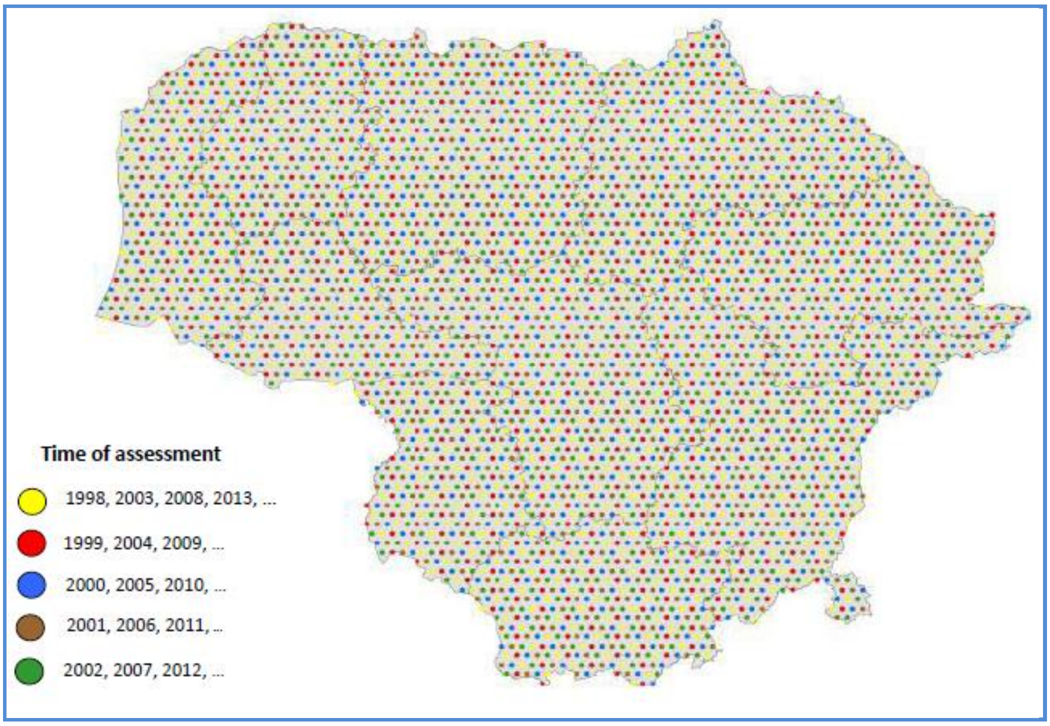

Figure 11-12. Distribution of NFI plots on Lithuania's territory

Sampling is conducted using a 4×4 km systematic grid with a random starting point.

The systematic grid assures a uniform distribution of group of plots over the entire country and regular monitoring of conversions amongst land use categories. The sample units are arranged to square shape clusters and include four permanent, regularly measured plots.

Taking into account 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 covers 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.

In 2012, in total around 16 000 permanent sample plotas were established on Lithuanian territory using uniqe NFI sample plots net. 6 000 sample plotas are allocated on forest land and nearly 10 000 sample plots are established on non-forest land. Allocation of each permanent sample plot to relevant land use category is presented in the Figure 11-13. Each sample plot could be allocated to only one land use category according to UNFCCC requirements. NFI net with all permanenet sample plots covers entire Lithuanian territory. Attribution of each permanent sample plot to relevant land use category related to *IPCC 2003* is performed during the inventory, by direct measurements of NFI field measurements team.

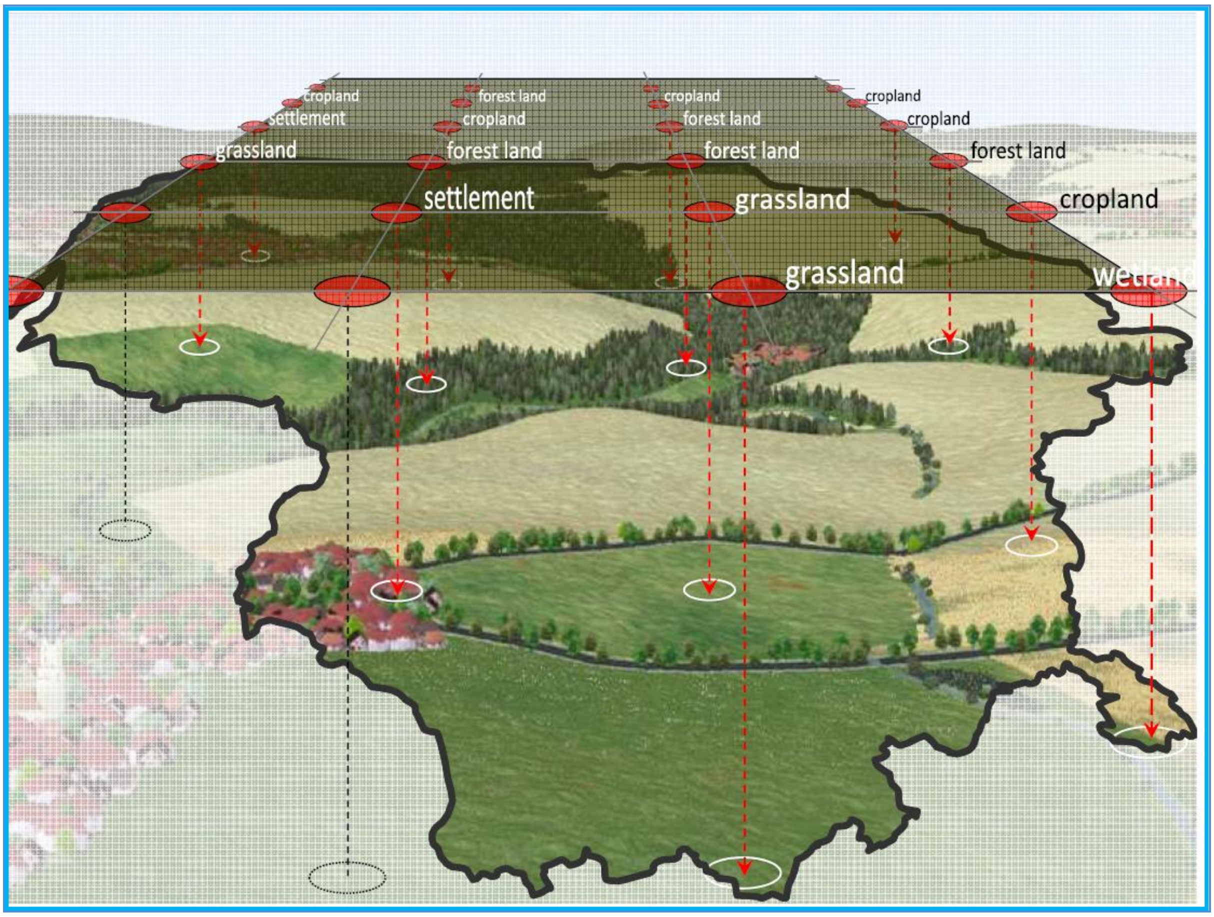

Figure 11-13. Allocation of sample plots to relevant land use category

The aim of establishment of permanent plots is reliably, by direct measurements estimate: growing stock volume, gross volume increment, mortality and felled trees, to control the dynamics of forest areas in the country.

11.3 Activity-specific information

11.3.1 Methods for carbon stock change and GHG emission and removal estimates

11.3.1.1 Description of the methodologies and the underlying assumptions used

Living biomass pool in this greenhouse gas inventory refers to aboveground biomass and belowground biomass. For the estimation of carbon stock changes in living biomass in afforested and reforested areas, growing stock volume of afforested and reforested areas estimated using data of NFI permanent sample plots and mean growing stock volume of afforested/reforested areas according to the year of afforestation and reforestation (Table 11-9). 3rd order polynomial trend was used to come up with the mean growing stock volume and mean growing stock volume change (Table 11-8) of afforested and reforested areas per hectare.

Above and below ground biomass for deforestation was calculated separately from emissions and removals under Forest Management.

Growing stock volume for deforested areas was calculated using deforested area which is detected using wall-to-wall method and mean growing stock volume which is estimated using NFI data (sampling method). It is assumed that any deforested area previously had mean GSV per hectare equal to mean GSV per hectare of forest land estimated by NFI, before it was removed. NFI and wall-to-wall methods has not detected any deforestation cases on afforested or reforested areas, therefore mean GSV detected by NFI is the same as mean GSV of FM. At this stage Lithuania has no possibilities to use exact growing stock volume which was before deforestation using wall-to-wall method.

Growing stock volume as well as emissions or removals of above and below ground biomass of deforested areas is calculated as losses (emissions) only as it is assumed that all above and below ground biomass is removed entirely during conversion process of forest land to Wetlands, Settlements, Other land. One should be considered that if forest land is converted, for instance, to Settlements, deforestation should be applied only during conversion process and this area cannot be kept as deforested forever, because new green areas (parks, individual trees etc. of residential areas) usually emerge after buildings construction and starts to accumulate greenhouse gases, but Lithuania has no technical possibilities to track and to estimate such small green areas or individual trees.

Growing stock volume change for afforested and reforested areas was estimated by using equation presented below:

$$\Delta V = \sum [A_i (V_{t_2} - V_{t_1}))$$

where:
ΔV – GSV change on afforested/reforested land, m^3;
A_i – area according to land use category, ha;
V_{t_1} – GSV at time t_1, m^3;
V_{t_2} - GSV at time t_2, m^3.

Annual change in carbon stocks in living biomass in afforested and reforested areas was calculated using equation 3.2.25 (p. 3.53) of the *IPCC 2003*:

$$\Delta C_{LFLB} = \Delta C_{LFGROWTH} + \Delta C_{LFCONVERSION} - \Delta C_{LFLOSS}$$

where:
$\Delta C_{LF_{LB}}$ – annual change in carbon stocks in living biomass in afforested/reforested land, tonnes C yr^{-1};
$\Delta C_{LF_{GROWTH}}$ – annual increase in carbon stocks in living biomass due to growth in afforested/reforested land, tonnes C yr^{-1};
$\Delta C_{LF_{CONVERSION}}$ – annual change in carbon stocks in living biomass due to afforestation/reforestation, tonnes C yr^{-1};
$\Delta C_{LF_{LOSS}}$ – annual decrease in carbon stocks in living biomass due to losses from harvesting, fuel wood gathering and disturbances in afforested/reforested land, tonnes C yr^{-1}.

Annual change in carbon stocks in living biomass due to afforestation/reforestation was calculated employing equation 3.2.26 (p. 3.53) of the *IPCC 2003*:

$$\Delta C_{LF_{CONVERSION}} = \sum_i [B_{AFTER_i} - B_{BEFORE_i}] \times \Delta A_{TO\_FOREST_i} \times CF$$

where:
$\Delta C_{LF_{CONVERSION}}$ – change in carbon stocks in living biomass in land annually afforested/reforested, 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 afforested/reforested, ha yr^{-1};
CF – carbon fraction of dry matter (default = 0.5), tonnes C (tonnes d.m.)$^{-1}$;
I – represent different types of land converted to forest.

B_{BEFORE} value was borrowed from the modelled curve presented in Figure 11-14 and is equal to zero.

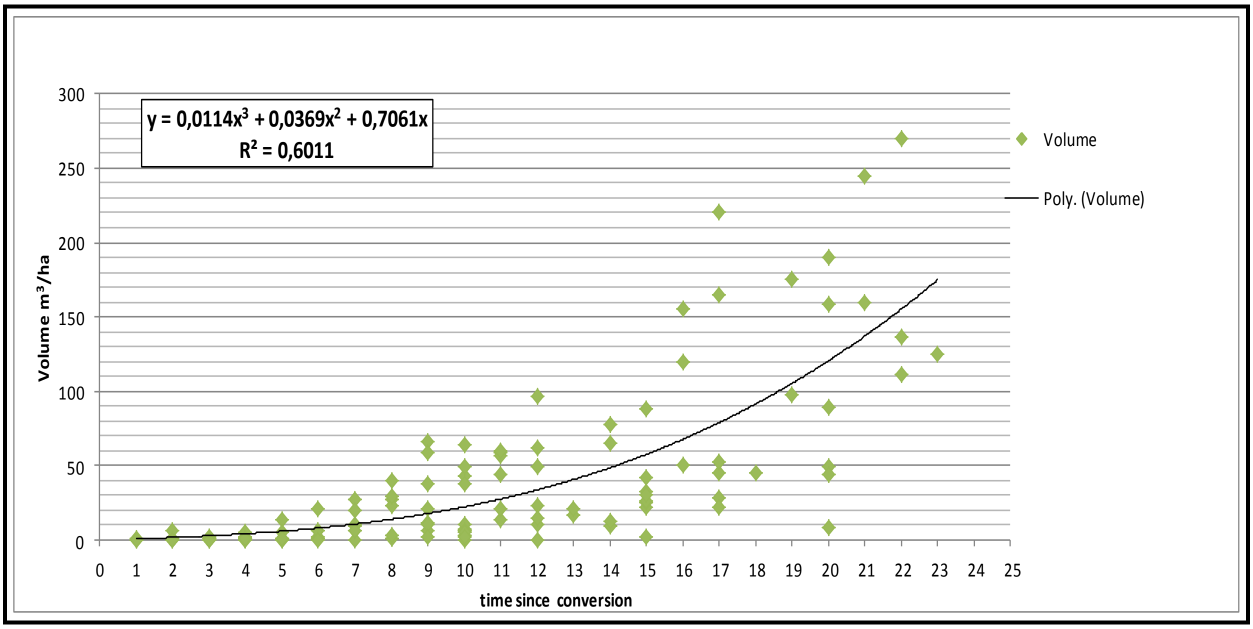

Figure 11-14. NFI data on growing stock volume of afforested and reforested (A1R1) areas

Table 11-8. Mean growings stock volume and mean growing stock volume change in ha for afforested and reforested (A1R1) areas at the time of afforestation/reforestation

Time since conversion	Mean growing stock volume, m^3/ha	Mean growing stock volume change, m^3/ha
1	0,8	0,8
2	1,7	0,9
3	2,8	1,1
4	4,1	1,4
5	5,9	1,7
6	8,0	2,1
7	10,7	2,6
8	13,8	3,2
9	17,7	3,8
10	22,2	4,5
11	27,4	5,3
12	33,5	6,1
13	40,5	7,0
14	48,4	7,9
15	57,4	9,0
16	67,4	10,1
17	78,7	11,2
18	91,2	12,5

19	104,9	13,8
20	120,1	15,2
21	136,7	16,6
22	154,8	18,1
23	174,5	19,7

Table 11-9. Aggregated data for AR areas and growing stock volume at the year of afforestation and reforestation

Time since afforestation/reforestatio	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Mean volume, m^3/ha	0,8	1,7	2,8	4,1	5,9	8,0	10,7	13,8	17,7	22,2	27,4	33,5	40,5	48,4	57,4	67,4	78,7	91,2	104,9	120,1	136,7	154,8	174,5
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
A1R1 area, ha	1373,5	901,0	520,3	369,3	256,2	331,1	367,2	412,5	701,4	920,0	1280,1	680,6	1175,6	1227,7	1435,6	1542,1	1803,2	2176,0	1997,0	1454,0	4659,0	4954,0	4093,0
A1R1 cumulative area, ha	1373,5	2274,5	2794,8	3164,1	3420,3	3751,4	4118,6	4531,2	5232,5	6152,5	7432,6	8113,2	9288,8	10516,5	11952,1	13494,2	15297,4	17473,4	19470,4	20924,4	25583,4	30537,4	34630,4
ha	1373,5	1373,5	1373,5	1373,5	1373,5	1373,5	1373,5	1373,5	1373,5	1373,5	1373,5	1373,5	1373,5	1373,5	1373,5	1373,5	1373,5	1373,5	1373,5	1373,5	1373,5	1373,5	1373,5
m3	1036,1	2267,6	3788,3	5692,2	8073,3	11025,4	14642,6	19018,7	24247,8	30423,7	37640,5	45992,0	55572,2	66475,1	78794,6	92624,6	108059,1	125192,0	144117,3	164928,9	187720,8	212587,0	239670,4
ha		901,0	901,0	901,0	901,0	901,0	901,0	901,0	901,0	901,0	901,0	901,0	901,0	901,0	901,0	901,0	901,0	901,0	901,0	901,0	901,0	901,0	901,0
m3		679,7	1487,6	2485,2	3734,3	5296,3	7233,0	9606,0	12476,9	15907,3	19958,9	24693,3	30172,2	36457,1	43609,7	51691,7	60764,6	70890,1	82129,9	94545,5	108198,6	123150,8	139463,7
ha			520,3	520,3	520,3	520,3	520,3	520,3	520,3	520,3	520,3	520,3	520,3	520,3	520,3	520,3	520,3	520,3	520,3	520,3	520,3	520,3	520,3
m3			392,5	859,1	1435,2	2156,5	3058,5	4177,0	5547,3	7205,2	9186,2	11526,0	14260,1	17424,0	21053,5	25184,0	29851,2	35090,7	40938,1	47428,9	54598,7	62483,2	71117,9
ha				369,3	369,3	369,3	369,3	369,3	369,3	369,3	369,3	369,3	369,3	369,3	369,3	369,3	369,3	369,3	369,3	369,3	369,3	369,3	369,3
m3				278,6	609,7	1018,5	1530,4	2170,6	2964,3	3936,8	5113,3	6519,2	8179,7	10119,9	12365,3	14941,0	17872,3	21184,5	24902,8	29052,5	33658,8	38747,1	44342,4
ha					256,2	256,2	256,2	256,2	256,2	256,2	256,2	256,2	256,2	256,2	256,2	256,2	256,2	256,2	256,2	256,2	256,2	256,2	256,2
m3					193,3	423,0	706,6	1061,7	1505,8	2056,5	2731,2	3547,4	4522,7	5674,7	7020,8	8578,5	10365,4	12399,1	14696,9	17276,5	20155,4	23351,0	26881,0
ha						331,1	331,1	331,1	331,1	331,1	331,1	331,1	331,1	331,1	331,1	331,1	331,1	331,1	331,1	331,1	331,1	331,1	331,1
m3						249,8	546,7	913,3	1372,3	1946,3	2658,0	3530,0	4585,0	5845,6	7334,4	9074,2	11087,6	13397,1	16025,5	18995,5	22329,6	26050,4	30180,8
ha							367,2	367,2	367,2	367,2	367,2	367,2	367,2	367,2	367,2	367,2	367,2	367,2	367,2	367,2	367,2	367,2	367,2
m3							277,0	606,3	1012,8	1521,9	2158,5	2947,7	3914,8	5084,8	6482,9	8134,0	10063,5	12296,4	14857,7	17772,7	21066,4	24764,0	28890,5
ha								412,5	412,5	412,5	412,5	412,5	412,5	412,5	412,5	412,5	412,5	412,5	412,5	412,5	412,5	412,5	412,5
m3								311,2	681,1	1137,9	1709,7	2424,9	3311,6	4398,1	5712,5	7283,1	9138,1	11305,8	13814,3	16691,8	19966,6	23666,9	27821,0
ha									701,4	701,4	701,4	701,4	701,4	701,4	701,4	701,4	701,4	701,4	701,4	701,4	701,4	701,4	701,4
m3									529,1	1157,9	1934,5	2906,7	4122,5	5630,0	7477,1	9711,8	12381,9	15535,6	19220,8	23485,5	28377,5	33945,0	40235,8
ha										920,0	920,0	920,0	920,0	920,0	920,0	920,0	920,0	920,0	920,0	920,0	920,0	920,0	920,0
m3										694,0	1518,9	2537,5	3812,8	5407,7	7385,1	9808,0	12739,3	16241,9	20378,7	25212,7	30806,8	37223,9	44526,9
ha											1280,1	1280,1	1280,1	1280,1	1280,1	1280,1	1280,1	1280,1	1280,1	1280,1	1280,1	1280,1	1280,1
m3											965,7	2113,5	3530,9	5305,4	7524,6	10276,2	13647,5	17726,3	22600,0	28356,3	35082,6	42866,6	51795,8
ha												680,6	680,6	680,6	680,6	680,6	680,6	680,6	680,6	680,6	680,6	680,6	680,6
m3												513,4	1123,6	1877,1	2820,5	4000,3	5463,1	7255,4	9423,8	12014,8	15075,0	18650,9	22789,1
ha													1175,6	1175,6	1175,6	1175,6	1175,6	1175,6	1175,6	1175,6	1175,6	1175,6	1175,6
m3													886,9	1941,0	3242,6	4872,3	6910,4	9437,3	12533,5	16279,3	20755,2	26041,6	32218,8
ha														1227,7	1227,7	1227,7	1227,7	1227,7	1227,7	1227,7	1227,7	1227,7	1227,7
m3														926,2	2026,9	3386,2	5088,1	7216,4	9855,2	13088,4	17000,1	21674,2	27194,7
ha															1435,6	1435,6	1435,6	1435,6	1435,6	1435,6	1435,6	1435,6	1435,6
m3															1083,0	2370,1	3959,6	5949,6	8438,3	11523,9	15304,6	19878,6	25344,1
ha																1542,1	1542,1	1542,1	1542,1	1542,1	1542,1	1542,1	1542,1
m3																1163,3	2546,0	4253,3	6390,9	9064,3	12378,8	16440,0	21353,3
ha																	1803,2	1803,2	1803,2	1803,2	1803,2	1803,2	1803,2
m3																	1360,3	2977,1	4973,6	7473,3	10599,3	14475,2	19224,1
ha																		2176,0	2176,0	2176,0	2176,0	2176,0	2176,0
m3																		1641,6	3592,6	6001,8	9018,2	12790,5	17467,6
ha																			1997,0	1997,0	1997,0	1997,0	1997,0
m3																			1506,5	3297,0	5508,1	8276,4	11738,4
ha																				1454,0	1454,0	1454,0	1454,0
m3																				1096,9	2400,6	4010,4	6026,0
ha																					4659,0	4659,0	4659,0
m3																					3514,7	7692,0	12850,5
ha																						4954,0	4954,0
m3																						3737,3	8179,1
ha																							4093,0
m3																							3087,8
Total volume, m3	1036,1	2947,3	5668,5	9315,1	14045,6	20169,4	27994,8	37864,7	50337,4	65987,4	85575,4	109251,6	137995,0	172566,7	213933,6	263099,4	321298,1	389990,2	470396,5	563586,5	673516,5	802502,9	952399,6

The estimation of carbon stock changes in living biomass in areas refering to Forest Management is consistent with the *Method 2* further described in the *IPCC 2003*, 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 (*IPCC 2003* eq. 3.2.3, p. 3.24):

$$\Delta C_{LB} = (C_{t2} - C_{t1})/(t_2 - t_1) \quad \text{and} \quad C = (\Delta AGB + \Delta BGB) \times CF \text{ (modified eq. 3.2.3)}$$

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;
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 (default = 0,5), t C (tonne d. m.)$^{-1}$.

Annual growing stock volume (GSV) change for Forest Management from 2007 was estimated based on NFI data using the following steps:

1. Annual GSV change in all forest area (total forest management and afforested/reforested area) is estimated by sampling method. This estimation is based on the change of GSV on the same area (re-measured permanent sample plots data $V_{rem_{t2}} - V_{rem_{t1}}$) and adding GSV increment (ΔV_{new}) of first time measured permanent sample plots i.e. new afforested areas or other plots which have no re-measurement data;
2. Annual GSV change of afforested/reforested area is 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 of all forest annual GSV change (*step 1*) and annual GSV change of afforested/reforested area (*step 2*).

The equations presenting calculations on growing stock volume change in Forest Management area are shown below:

$$\Delta FF_t = ((V_{rem_{t2}} - V_{rem_{t1}}) + \Delta V_{new}) - \Delta A1R1$$

where:
ΔFF_t – growing stock volume change for Forest Management for the defined year, m^3;
$V_{rem_{t1}}$ – growing stock volume calculated at time t_1, m^3;
$V_{rem_{t2}}$ – growing stock volume calculated at time t_2, m^3;
ΔV_{new} – growing stock volume change of the new measured sample plots, m^3;
ΔA1R1 – growing stock volume change of afforested/reforested areas, m^3.

Carbon stock changes in dead wood, litter and soil

Carbon stock changes in dead wood of afforested and reforested areas is assumed to be equal to zero, therefore reported as 'NO'. The accumulation of dead wood was assumed to be marginal on afforested and reforested sites, during 1990-2012, and also presumed that dead wood pool can not decrease, because there is actually no dead wood before the conversion. The dead wood starts to accumulate when natural mortality or thinnings occur that is at the age of over 20 years.

Annual change in carbon stocks in dead organic matter in Forest Management is calculated following the summarising 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 i.e. roots. It is assumed that BGB decays in equal parts in 5 years. Modified equation 3.2.10 (p. 3.32) of *IPCC 2003* has been used to calculate carbon stock change in dead organic matter:

$$\Delta C_{DOM} = C_{DW} + C_{DW_H}$$

where:
ΔC_{DOM} – annual change in carbon stocks in dead organic matter, t C yr^{-1};
C_{DW} – change in carbon stocks in dead wood (*measured available dead stems*), t C yr^{-1};
C_{DW_H} – 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 using stock change method and employing equation 3.2.12, p. 3.34 of *IPCC 2003*.

It was assumed that carbon stock in litter in afforested and reforested areas 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 3.2.1 of *IPCC 2003* (p. 3.36). Average value accumulated in litter in AR areas equal to 1,2 t/ha/year (24 t/ha/20 years). Change in carbon stock in litter in AR areas was calculated using area from annual AR conversion matrix (Table 11-10).

Table 11-10. Aggregated data of carbon stock changes in litter of afforested and reforested areas at the year of afforestation or reforestation

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Time since afforestation/ reforestation		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Annual carbon stock in litter, t/ha/year		1,2	2,4	3,6	4,8	6	7,2	8,4	9,6	10,8	12	13,2	14,4	15,6	16,8	18	19,2	20,4	21,6	22,8	24	24	24	24
Year		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
A1R1 area, ha		**1373,5**	**901,0**	**520,3**	**369,3**	**256,2**	**331,1**	**367,2**	**412,5**	**701,4**	**920,0**	**1280,1**	**680,6**	**1175,6**	**1227,7**	**1435,6**	**1542,1**	**1803,2**	**2176,0**	**1997,0**	**1454,0**	**4659,0**	**4954,0**	**4093,0**
Cumulative A1R1 area, ha		**1373,5**	**2274,5**	**2794,8**	**3164,1**	**3420,3**	**3751,4**	**4118,6**	**4531,2**	**5232,5**	**6152,5**	**7432,6**	**8113,2**	**9288,8**	**10516,5**	**11952,1**	**13494,2**	**15297,3**	**17473,3**	**19470,3**	**20924,3**	**25583,3**	**30537,3**	**34630,33**
Annual change in carbon stocks in litter, t		1648,2	1648,2	1648,2	1648,2	1648,2	1648,2	1648,2	1648,2	1648,2	1648,2	1648,2	1648,2	1648,2	1648,2	1648,2	1648,2	1648,2	1648,2	1648,2	1648,2	0,0	0,0	0,0
			1081,2	1081,2	1081,2	1081,2	1081,2	1081,2	1081,2	1081,2	1081,2	1081,2	1081,2	1081,2	1081,2	1081,2	1081,2	1081,2	1081,2	1081,2	1081,2	1081,2	0,0	0,0
				624,4	624,4	624,4	624,4	624,4	624,4	624,4	624,4	624,4	624,4	624,4	624,4	624,4	624,4	624,4	624,4	624,4	624,4	624,4	624,4	0,0
					443,1	443,1	443,1	443,1	443,1	443,1	443,1	443,1	443,1	443,1	443,1	443,1	443,1	443,1	443,1	443,1	443,1	443,1	443,1	443,1
						307,4	307,4	307,4	307,4	307,4	307,4	307,4	307,4	307,4	307,4	307,4	307,4	307,4	307,4	307,4	307,4	307,4	307,4	307,4
							397,3	397,3	397,3	397,3	397,3	397,3	397,3	397,3	397,3	397,3	397,3	397,3	397,3	397,3	397,3	397,3	397,3	397,3
								440,7	440,7	440,7	440,7	440,7	440,7	440,7	440,7	440,7	440,7	440,7	440,7	440,7	440,7	440,7	440,7	440,7
									495,0	495,0	495,0	495,0	495,0	495,0	495,0	495,0	495,0	495,0	495,0	495,0	495,0	495,0	495,0	495,0
										841,6	841,6	841,6	841,6	841,6	841,6	841,6	841,6	841,6	841,6	841,6	841,6	841,6	841,6	841,6
											1104,0	1104,0	1104,0	1104,0	1104,0	1104,0	1104,0	1104,0	1104,0	1104,0	1104,0	1104,0	1104,0	1104,0
												1536,2	1536,2	1536,2	1536,2	1536,2	1536,2	1536,2	1536,2	1536,2	1536,2	1536,2	1536,2	1536,2
													816,7	816,7	816,7	816,7	816,7	816,7	816,7	816,7	816,7	816,7	816,7	816,7
														1410,8	1410,8	1410,8	1410,8	1410,8	1410,8	1410,8	1410,8	1410,8	1410,8	1410,8
															1473,2	1473,2	1473,2	1473,2	1473,2	1473,2	1473,2	1473,2	1473,2	1473,2
																1722,7	1722,7	1722,7	1722,7	1722,7	1722,7	1722,7	1722,7	1722,7
																	1850,5	1850,5	1850,5	1850,5	1850,5	1850,5	1850,5	1850,5
																		2163,8	2163,8	2163,8	2163,8	2163,8	2163,8	2163,8
																			2611,2	2611,2	2611,2	2611,2	2611,2	2611,2
																				2396,4	2396,4	2396,4	2396,4	2396,4
																					1744,8	1744,8	1744,8	1744,8
																						5590,8	5590,8	5590,8
																							5944,8	5944,8
																								4911,6
Total carbon stock change in litter, t		**1648,2**	**2729,4**	**3353,8**	**3796,9**	**4104,4**	**4501,7**	**4942,3**	**5437,4**	**6279,0**	**7383,0**	**8919,2**	**9735,8**	**11146,6**	**12619,8**	**14342,5**	**16193,0**	**18356,8**	**20968,0**	**23364,4**	**25109,2**	**29051,8**	**33915,4**	**38202,58**
Gg		**1,64816**	**2,72941**	**3,35381**	**3,79694**	**4,10435**	**4,50169**	**4,94234**	**5,43738**	**6,27901**	**7,38299**	**8,91916**	**9,73582**	**11,1466**	**12,6198**	**14,3425**	**16,193**	**18,3568**	**20,968**	**23,3644**	**25,1092**	**29,0518**	**33,9154**	**38,20258**

NFI provides data on forest land distribution by forest soils (Table 7-9, Chapter 7.2.1). According to NFI[193] 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 afforested and reforested areas, 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 afforested and reforested areas. The proportion was distributed to afforestated/reforestated Croplands, Grasslands and Wetlands. It was also assumed that all area of Wetlands is under organic soils.

Carbon stock change in mineral and organic forest soils in afforested/reforested areas was calculated using area of afforested and reforested land and emission factors estimated by Finland (*Finish NIR 2013, appendix_7g*). Emission factors for mineral soils were applied for Southern Finland considering similar climatic conditions as in Lithuania. Carbon stock changes in organic soils were estimated separetely for forested Croplands, Graslands and Wetlands. Due to the lack of information in forest planting projects at the State Forest Cadastre on the exact land use before afforestation or reforestation, area of afforested/reforested Croplands, Grasslands and Wetlands was estimated using NFI sample plots data on land use areas distribution and assuming the same proportion of Croplands, Grasslands, Wetlands were afforested and reforested. For afforested/reforested Settlements and Other lands it was assumed that carbon stock changes in organic soil are equal to zero, because there is no organic soil layer on such lands before the afforestation/reforestation.

Table 11-11. The aggregated annual emission factors for soil organic matter (SOM) and dead organic matter (DOM) stock change on lands converted to forest land on mineral and on organic soils applied by Lithuania, tonnes C per ha (negative values represents loss of carbon)

Year after conversion	Cropland mineral	Grassland mineral	Cropland organic	Grassland organic	Wetlands organic
1	-1,09	-0,97	-3,77	-1,90	-1,47
2	-0,89	-0,80	-3,74	-1,90	-1,45
3	-0,76	-0,71	-3,71	-1,90	-1,44
4	-0,65	-0,62	-3,68	-1,90	-1,43
5	-0,55	-0,54	-3,65	-1,90	-1,41
6	-0,46	-0,47	-3,62	-1,90	-1,40
7	-0,38	-0,41	-3,60	-1,90	-1,39
8	-0,32	-0,35	-3,57	-1,90	-1,37
9	-0,26	-0,29	-3,54	-1,90	-1,36
10	-0,21	-0,25	-3,51	-1,90	-1,35
11	-0,17	-0,21	-3,48	-1,90	-1,33
12	-0,14	-0,17	-3,45	-1,90	-1,32
13	-0,10	-0,14	-3,43	-1,90	-1,31
14	-0,08	-0,11	-3,40	-1,90	-1,30
15	-0,05	-0,08	-3,37	-1,90	-1,28
16	-0,03	-0,06	-3,34	-1,90	-1,27
17	-0,01	-0,04	-3,31	-1,90	-1,26
18	0,00	-0,02	-3,28	-1,90	-1,24
19	0,02	0,00	-3,26	-1,90	-1,23
20	0,03	0,01	-3,23	-1,90	-1,22

[193] *Lithuanian National Forest Inventory 2003 – 2007. Forest resources and their dynamics*

Carbon stock change in drained organic forest soils for Forest Management was calculated using equation 3.2.15 of the *IPCC 2003* (p. 3.42):

$$\Delta C_{FOS} = A_{Drainage} \times EF_{Drainage}$$

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 3.2.3 of the *IPCC 2003* (p. 3.42) was used in calculations. Default $EF_{Drainage}$ for temperate forests is 0,68 tonnes C ha^{-1} yr^{-1}.

For calculations on carbon stock changes caused by conversion (deforestation) of forest land to settlements and other lands it was assumed that all above and below ground forest biomass as well as dead wood and litter – organic matter was removed entirely as a result of conversion. For deforestation which occurred on Forest management area, mean biomass stock that is lost for the year of deforestation was used.

Lithuanian forests since 1990 showed a continuous increase in per hectare density of carbon stocks in the biomass and dead mass carbon pools; same trend is observed over the whole Baltic region[165]. The increased amounts of living biomass and dead mass causes increasingly quantity of organic material being transferred to the litter and soil organic carbon (SOC) pools, so potentially determining an accumulation of organic carbon. Therefore, Poland, Sweden and Finland are accounting for net carbon-stock increases in both pools; while Germany having not found significant changes is not accounting for both.

A study performed by the European Union all over its territory, the Biosoil project[194], shows for Lithuanian forests a slightly, not significant, increase in soil carbon stocks from 1992 to 2006[195] (Table 11-12).

Table 11-12. Mean carbon stock in forest land according to the soil monitoring in *ICP-Forest* sample plots Level I 1992 and 2006

Year	Mean carbon stock in litter, g/kg	Mean carbon stock in mineral soil (0-10 cm depth), g/kg	Mean carbon stock in mineral soil (10-20 cm depth), g/kg	Research activity
1992*	370,69 ± 12,8	29,1 ± 4,4	15,6 ± 2,8	Soil monitoring in *ICP-Forests* 74 sample plots Level I
2006	399,0 ± 96,6	29,9 ± 18,2	15,8 ± 11,6	"Biosoil" project in *IPC-Forests* 62 sample plots Level I

**- Due to some differences in sampling and analyses methods data adopted with some assumptions*.

Not having proof of significant increase in mineral soils in forest land and having information that this pool is not a source, Lithuania has decided to be conservative and consequently not to account for this pool under Forest management (including areas of natural afforestation/reforestation, which are included into Forest management, see chapter 11.2)

[194] *http://ec.europa.eu/dgs/jrc/index.cfm?id=1410&obj_id=10400&dt_code=NWS&lang=en*
[195] *EU-JRC: Evaluation of BioSoil Demonstration Project - Preliminary Data Analysis (http://eusoils.jrc.ec.europa.eu/ESDB_Archive/eusoils_docs/other/EUR24258.pdf) and EU-JRC: Evaluation of BioSoil Demonstration Project - Soil Data Analysis (http://eusoils.jrc.ec.europa.eu/ESDB_Archive/eusoils_docs/other/EUR24729.pdf)*

therefore reported as 'NO'. However Lithuania is calculating carbon stock changes in litter in naturally afforested/reforested areas and in drained organic forest soils which are under Forest management category (including natural AR areas).

Biomass burning

Data on areas affected by forest fires is provided by the Directorate General of State Forests (Table 11-13). The Directorate General of State Forests under the Ministry of Environment performs the functions of founder of forest enterprises and coordinator of their activities as well as legislator of mandatory norms for forest enterprises regarding reforestation, protection and management of State forests.

Lithuania is one of the few Europe countries 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 forest ownership type. Every forest enterprise provides data on forest fires to the Directorate General of State Forests every year.

Since 2013 Directorate General of State Forests is using special methodology for assessment of forest fires prepared by State Forest Service. More accurate data on burnt areas and burnt living biomass percent is being provided in reports.

Prescribed or controlled burning of forest biomass is not used in Lithuania.

GHG emissions (CO_2, CH_4, N_2O) resulting from wildfires for afforestation and reforestation activities and Forest management were calculated separately in this submission. Data on wildfires occurring on afforested and reforested areas was received from Directorate General of State Forests (DGSF). GIS layer of burnt AR areas, based on DGSF data, was prepared and intersected with *Study-1* GIS layer of afforested and reforested areas (A1R1), to receive complete information on areas for GHG emissions calculations. Burned area of Forest management was calculated by subtracting burnt area of afforested and reforested areas form the total burn forest land area.

Table 11-13. CO_2 emissions from biomass burning[196] (Gg) and area of ARD and FM that was burned (ha)

Year	Afforestation & Reforestation		Deforestation		Forest Management	
	Area burned, ha	CO_2, Gg	Area burned, ha	CO_2, Gg	Area burned, ha	CO_2, Gg
2008	1,93	0,06	NO	NO	110,47	3,40
2009	3,06	0,09	NO	NO	312,24	9,62
2010	2,17	0,07	NO	NO	19,33	0,60
2011	2,78	0,09	NO	NO	290,22	8,93
2012	1,20	0,04	NO	NO	19,09	0,60

N_2O emissions from disturbances associated with land-use conversion to cropland

Not relevant for Lithuania as there are no conversion of forest land to cropland (*Study-1* and *Study-2* results). Deforestation mainly refers to conversion of forest land to Settlements, Wetlands and Other land use categories.

[196] Note that emisions from biomass burning of ARD and FM activities are presented here as information only, thus these are reported as IE in the relevant CRF tables

N_2O emissions from drainage of soils

N_2O emissions were calculated using methodology used by NFI for distinguishing organic and drained organic soils, which refers to 15,7% of organic soils 7,9% of drained organic soils from the total forest land area. 2,6% infertile and 5,3% of fertile soils contribute to the total area of drained organic forest soils. N_2O emisions were calculated for the total forest land area, thus emisions from AR were also included.

N_2O emissions from drained organic soils were calculated employing equation 3A.2.1 (Appendix 3A.2, *IPCC 2003*). In Tier 1 Equation 3a.2.1 simple disaggregation of drained organic soils into "nutrient rich" and "nutrient poor" areas is applied and default emission factors are used. For „nutrient rich" areas default emission factor of 0,6 and for „nutrient poor" areas default emission factor of 0,1 according to table 3A.2.1 (Appendix 3A.2, *IPCC 2003*) were used.

Considering assumption that carbon inputs and losses in mineral soil balance is equal one to another and the net changes are close to zero, there is no N_2O emissions from mineral soils (reported as 'NO').

Fertilization and liming

Information presented by Directorate General of State Forests indicates that there were no fertilization or liming of forest land in Lithuania since 1990 to 2012.

Fertilization and liming of forests could be useful applying biofuel ashes, but there are only few studies done in Lithuania, evaluating impact of application of ashes on forest land, but unfortunatelly there is no clear evidence on efficiency of such application[197].

Fertilization of forest land with other mineral fertilizers is still not worth economically due to high prices of fertilizers and unclear benefit for forest growth in our climatic conditions.

Windbrakes and windfalls

Accounting and data collection principles used by State Forest Service, includes all timber from windbreaks and windfalls into round wood or fuel wood removals as this timber is still consumable. Therefore, to avoid double counting, windbreaks and windfalls were not included in calculations of carbon losses due to disturbances.

Information that emissions/removals from Article 3.3 are not accounted under Article 3.4

According to decision 15/CMP.1 paragraph 9(c) – emissions/removals from living biomass, biomass burning, deadwood etc. under Article 3.4 activities (FM) are not accounted under Article 3.3. (ARD) and are accounted separately.

11.3.1.2 Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected activities under Article 3.4

Based on NFI 1998-2011 data changes of dead wood are not significant in the afforested and reforested lands. For estimation of carbon stock change of dead wood it was assumed to be zero and reported as 'NO'.

[197] *Ozolinčius R., Armolaitis K., Mikšys V., Varnagirytė-Kabašinskienė I. 2010. Recommendations for compensating wood ash fertilization (2nd revised edition).*

11.3.1.3 Information on whether or not indirect and natural GHG emissions and removals have been factored out

No factoring out has been performed in the estimatesd emissions and removals.

11.3.1.4 Uncertainty estimates

Uncertainty values for Article 3.3 and Article 3.4 assessment are represented in Table 11-14.

Table 11-14. Uncertainty assessment values

Indicator	Category	Unit	Uncertainty
Growing stock volume	AR	m^3	15,6%
	D	m^3	2,6%
	FM	m^3	2,6%
Dead trees volume	AR	m^3	15,6%
	FM	m^3	2,6%
Area	FL	ha	2,3%
	AR	ha	3,8%
	D	ha	3,8%
	FM	ha	2,2%
Emission factor	AR	$GgCO_2$	39,1%
	D	$GgCO_2$	62%
	FM	$GgCO_2$	34%

11.3.1.5 Information on other methodological issues

In its initial report under the Kyoto protocol Lithuania has chosen to account for the emissions and removals under Articles 3.3 and 3.4 at the end of the commitment period. Lithuania has made major improvements in its data collection, required for greenhouse gas assessment under Kyoto Protocol, referring to reconstruction of historical data and improved way forward for further accounting under the second commitment period.. Having this in mind, the estimates presented in this submission for the period of 2008-2012 should be considered as final. There are no methods presented in this final Inventory Report that could require further clarification than those already explained.

11.3.1.6 The year of the onset of an activity, if after 2008

After finalizing *Study-1* Lithuania became able to identify areas of Article 3.3 and Article 3.4 under Kyoto Protocol activities since 1990, using wall-to-wall (Article 3.3 activities) and sampling (Article 3.4 activities) methods. The relevant area sizes of Article 3.3 activities that began after 2008 are represented in Table 11-4. The relevant area sizes of Article 3.4 activities that began after 2008 are represented in Table 11-5.

11.4 Article 3.3

11.4.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are direct human-induced

Reported deforestation activities are directly human-induced. Areas of deforestation are under very strict regulation and control of forest lands legitimated by the Forest Law and Lithuanian Republic Government Resolution No 1131 dated on Sept 28, 2011. According to these acts forest land can be converted to non-forest land only using special procedure of compensation. Main way of compensation is re-establishment of forest land on non-forest land on area up to 3 times larger as compared with area of land converted to non-forest land.

Reported Afforestation and Reforestation activities are defined only as human-induced activities without natural forest expansion. Forest Law regulates afforestation process in agricultural lands and other lands (swamps, peatlands, other land) as well. Afforestation of these lands could be done by artificial way as well as by natural way. The legitimation of changes of agricultural and other land to forest land by natural afforestation are obligatory if trees crown cover attains 30% of an area not less than 0,1 ha and age of trees exceed 20 years. Natural afforestation is included in area of forest management (FM).

Data of Afforestation, Reforestation and Deforestation for the period 1990-2011 estimated as the result of the *Study-1*. Special methodology and descriptive codes (Table 11-6) were used to identify natural and human induced activities under Article 3.3.

Using wall-to-wall method (LSFC) together with SFI data, areas of Afforestation, Reforestation and Deforestation were determined. As quality assurance data from NFI was used to compare with results received from *Study-1*. Comparison revealed that differences are minor and the common trend retained over the study period (1990-2011).

11.4.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

According to Lithuanian Forest Law the clear cut areas should be reforested during 3 years and are under strict control of forest management and State inspection.

Temporarily unstocked areas after harvesting remain forests and are not accounted as deforestation. Every deforestation case must be reported to Lithuanian State Forest Cadastre and is very rare. Any deforested area must follow the afforestation of three times larger area than the one was deforested.

All forest land, where forest was growing in 1990 according to Lithuanian State Forest Resources Database (LTDBK50000-V) scale 1:50 000, but was not fixed in Lithuanian State Forest Cadastre (LSFC) were visually checked, simultaneously inspecting LSFC data (MKAD, MKAD_ARCH and MKAD_2012 databases) as well as all orthophotomaps compiled in the last two decades on Lithuania's territory together with satellite images from CORINE land cover database (Figure 11-15).

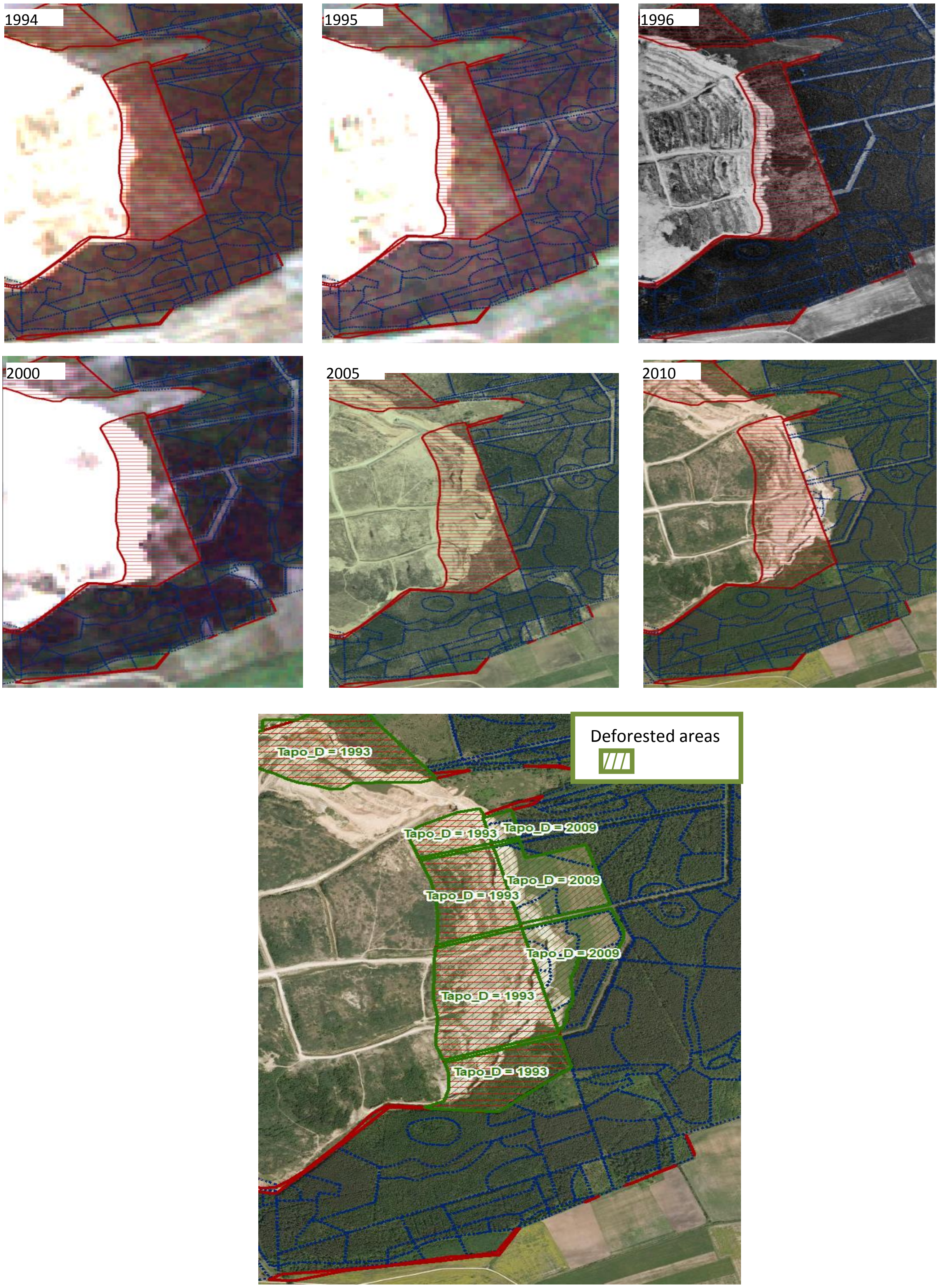

Figure 11-15. Technical procedure of identification of deforested areas 1994 – 2010

11.4.3 Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested

Clear-cut area in forests land (temporarily unstocked areas) is not considered as deforestation in Lithuania. In 2011 area of clear fellings was 16535 ha, in 2012 – 17154 ha. Every clear felling is planned according to forest management plan prepared by forestry expert, and is applied to the area which meets the requirements approved in the Rules for forest fellings[198]. Permission for clear felling is mandatory despite clear felling being prepared according to forest management plan and could be issued at Regional Environmental Protection Agency after provision of responsible officer in situ.

11.4.4 Emissions and removals under Article 3.3

Afforestation and reforestation activities were a net sink of -146,4 GgCO_2 in 2010 -166,8 GgCO_2 in 2011 and -195,9 GgCO_2 in 2012 (Table 11-15). For afforestation and reforestation it was assumed that carbon inputs and losses in dead wood balance are equal and net change is close to zero (NO). Deforestation activities were a continuous net source of 46,0 GgCO_2 in 2010, emitting 18,4 GgCO_2 in 2011 and 66,0 GgCO_2 in 2012 (Table 11-16).

Table 11-15. Carbon stock change and emission/removals of CO_2 in Afforestation and Reforestation, Gg

Year	**Carbon stock change in living biomass**		**Carbon stock change in dead organic matter**		**Carbon stock change in soil**		**Total carbon stock change**	**Emissions/ removals of** CO_2
	Above-ground	Below-ground	Dead wood	Forest litter	Mineral soil	Organic soil		
2008	21,03	4,81	NO	23,36	-10,84	-6,84	31,52	-115,6
2009	24,38	5,57	NO	25,11	-10,70	-7,34	37,02	-135,7
2010	28,75	6,58	NO	29,05	-15,46	-8,99	39,93	-146,4
2011	33,73	7,71	NO	33,92	-19,13	-10,74	45,49	-166,8
2012	39,20	8,96	NO	38,20	-20,77	-12,17	53,42	-195,9

Table 11-16. Carbon stock change and emission/removals of CO_2 in Deforestation, Gg

Year	**Carbon stock change in living biomass**		**Carbon stock change in dead organic matter**		**Carbon stock change in soil**		**Total carbon stock change**	**Emission/ removals of** CO_2
	Above-ground	**Below-ground**	**Dead wood**	**Forest litter**	**Mineral soil**	**Organic soil**		
2008	-2,74	-0,62	-0,14	-1,13	-2,85	-0,53	-8,01	29,4
2009	-1,68	-0,38	-0,09	-0,68	-1,72	-0,32	-4,88	17,9
2010	-4,37	-1,00	-0,23	-1,74	-4,39	-0,82	-12,54	46,0
2011	-1,77	-0,40	-0,09	-0,69	-1,75	-0,33	-5,03	18,4
2012	-6,37	-1,46	-0,34	-2,46	-6,22	-1,16	-17,99	66,0

11.5 Article 3.4

11.5.1 Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

Forest area at the end of 2011 was estimated by using *Study – 1* data (see chapter 7.1.1.). Forest land area for the end of 1989 was followed by adding deforested areas and subtracting afforested and reforested areas. Forest land areas that were forests on the 1st of January 1990 were included under Forest management category, since Lithuania considers that all forest land is managed.

[198] *Seimas of the Republic of Lithuania. Regulations for forest fellings. Lietuvos Respublikos Seimas: 2010-01-27, Nr. D1-79. Valstybės žinios: 2010-02-03, Nr.14-676. (In Lithuanian).*

11.5.2 Information relating to Cropland Management, Grazing Land Management and Revegetation, if elected, for the base year

Lithuania has not chosen to account emissions and removals from Cropland Management, Grazing Land Management and Revegetation under Article 3.4 of the Kyoto Protocol.

11.5.3 Information relating to Forest Management

Objective information related to Forest management is received from NFI. Permanent sample plots are hidden, what means that they can only be identified during NFI measurements and are not visible and known for forest owners or managers, who could subjectively influence forest management results.

Net removals and emissions resulting from Forest management are provided in Table 11-17.

Table 11-17. Net emissions/removals from Forest management during the period 2008-2012, Gg

	2008	**2009**	**2010**	**2011**	**2012**
Net CO_2 removals	-9056,21	-11681,62	-10634,33	-10888,97	-9234,98
CH_4 emissions	0,02	0,05	0,00	0,05	0,00
N_2O emissions	0,07	0,07	0,07	0,08	0,08
Total (CO_2 eqv.)	**-9032,76**	**-11657,33**	**-10611,15**	**-10864,63**	**-9211,61**

11.5.3.1 Information that the definition of forest for this category conforms with the definition in item 11.1 above

In accordance with definitions in item 11.1 above, all forest land is managed and there is no unmanaged forest land in Lithuania. Only for accounting under Kyoto Protocol purposes all forest land is splitted into ARD and FM according to *IPCC 2003*.

11.5.3.2 Information that 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 (paragraph 1 (f) of the annex to decision 16/CMP.1 (Land use, land –use change and forestry)

Forest represents one of the major Lithuanian natural resources serving for the welfare of the state and its citizens, preserving stability of the landscape and environmental quality. Despite the forest ownership form, forest, primarily, is the national property that shall be preserved for the future generations at the same time meeting ecological, economic and social needs of the society. Being a source of supply of timber and other forest products, forest is the essential factor of the ecological balance providing living places for numerous animals and plant species, stopping the soil erosion, absorbing the carbon dioxide and purifying the air, protecting the ground and the surface waters, providing opportunities for recreation of the urban and rural people.

With the purpose of ensuring a sustainable forestry development, satisfying forest-related needs of various groups of the society, and ensuring preservation of forests for further generations, acknowledging a long forest growth duration, and with respect to the differences of the ownership forms and their relationships, by promoting conditions for proper management of forests with the purpose of economic benefits for the country, a long-term forestry policy has been formed in Lithuania in compliance with policies of other branches of the economy of the country, based on the traditions of the country and requirements of the

European Union legal norms, international conventions, resolutions, agreements, programmes, and national legal acts.

The following instruments are used for the purpose of implementation of the forestry policy: well-organised, qualified forestry administration independent from any temporal political changes; the Forest Law and other legal acts; taxes revenues and financial support; education and training; management of the forestry information; public relations.

The Lithuanian forestry policy is being formed upon the following principles:

- *responsibility* for the continuous and sustainable use of the forest resources. Considering forests as the major renewable natural resource for the society, forestry policy ensures the responsibility of forest owners, forest governors and users as well as sustainable use of these resources and their restoration. The state, execute state regulation functions on all forests of the country, develop forest infrastructure, forest protection against natural calamities, widespread diseases and pests, provide legal, financial and other preconditions for the preservation of forests, ensure rational use of forest resources, meeting social needs of the society and environmental protection;
- *compliance* to the national legal system and international agreements. Lithuanian forestry policy is formed following the Constitution of the Republic of Lithuania and other legal acts, as well as the Convention on the Conservation of European Wildlife and Natural Habitat, signed in 1979 in Bern, the Biodiversity Convention signed in Rio de Janeiro in 1992, and Forest Protection Principles adopted at the United Nations conference "Environment and Development", the Strasbourg 1990, Helsinki 1993, and Lisbon 1998 resolutions of the Ministerial Conferences on Protection of Forests in Europe , the principles of the European Union forestry strategies, European Union directives on forestry and environmental protection issues;
- *participation* and co-operation of all interested groups of the society. The policy takes into regard the opinion of all interested groups of the society, complies and balances interests of forest owners, forest governors and users, wood processors, environmental protection organisations, and other social groups related to forest and forestry-related economy. All major forestry policy statements shall be in compliance with separate stakeholders and submitted for public consideration of the society;
- *variety* of forest ownership forms and their equality of rights. The equality of rights for economic activities in forests of all ownership forms is implemented. Equal legal and other conditions both for the management and economic activities in private as well as state-owned forests are created. During the development of the Lithuania forestry, the market economy relationship and free competition principles are strengthened at the private as well as in the state-owned forestry sector;
- *complexity* of forestry. Forestry is being developed in a complex manner upon the basis of multiple use taking into regard its significance and relations to the consumers of forest products and services, wood processing industry structures as well as other groups of society having their interests in forests and forestry;
- *continuation* of the forestry traditions. Lithuanian forestry has traditions tested through the course of time, which are taken into consideration while transferring experience of foreign countries. Forestry reforms and reorganisations, implementation of novelties on forestry management and other issues shall be performed consistently, taking into consideration the practical know-how of the specialists, public opinion, and interests of the state.

Mission of the State in forestry development is:

- To form and implement a rational forestry development policy, which would ensure ecologically, economically and socially balanced development of forestry sector;
- To ensure the stability of forest ecosystems, preservation of biodiversity, increase in forest productivity, improve forest quality and healthiness;
- To preserve valuable forest genetic fund by using the national forest genetic resources for the establishment and creation of new objects of forest seed basis;
- To increase forest coverage of Lithuania by planting forests on uncultivated and poor-quality soils as well as other non-used land areas where forest planting would contribute to the formation of Lithuanian natural carcass;
- To ensure the variety of forest ownership forms and the efficiency of state forestry regulation;
- To ensure meeting general forest-related social needs of the society;
- To create a favourable legal, economic and institutional environment for the effective and competitive functioning of the forest economy, wood industry and a variety of forest business enterprises in a free market;
- To encourage innovations, competitiveness, development of markets and establishment of working places;
- To ensure the maintenance of the scientific potential and its rational application as well as preparation of high-qualification forestry specialists.

The main legal acts forming forest policy in Lithuania since 1990:

- Forest Law of the Republic of Lithuania. *Adopted on: 2001.04.10. No IX-240;*
- Land Law of the Republic of Lithuania. *Adopted on: 2004.01.27. No IX-1983;*
- Land reform Law of the Republic of Lithuania. *Adopted on: 1997.07.02. No VIII-370;*
- Law on territory planning of the Republic of Lithuania. *Adopted on: 2004.01.15. No X-1962.*

Recently adopted legal acts to improve KP-LULUCF accounting:

- Order of the Minister of Environment and Minister of Agriculture on Approval of Action plan to improve LULUCF reporting of Lithuania. *Adopted on: 2011.12.16. No D1-987/3D-927;*
- Order of the Minister of Environment on Approval of Harmonised Principles for data collection and reporting on LULUCF. *Adopted on: 2012.01.12. No D1/27;*
- Amendment of the Order of the Minister of Environment No D1-570 on National forest inventory by sampling method. *Adopted on: 2012.01.24. No D1-59;*
- Amendment of the Government Resolution No 1255 on State Forest Cadastre. *Adopted on: 2012.05.23. No 570;*
- Amendment of the Minister of Environment and Minister of Agriculture Order No 3D-130/D1-144 on Rules for afforestation of non-forest land. *Adopted on: 2012.04.03. No 3D-239/D1-285;*
- Order of the Minister of Environment and Minister of Agriculture on Inventory and Registration of natural afforestation of non-forest land. *Adopted on: 2012.05.08. No D1-409/3D-331.*

11.6 Other information

11.6.1 Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

Key category analysis for KP-LULUCF was developed according to section 5.4 of the *IPCC 2003*.

Categories under Articles 3.3 and 3.4 were considered as key if their contribution was greater than the smallest category considered key in the UNFCCC inventory (including LULUCF). The results are presented in Table 11-18.

Table 11-18. Key categories for Article 3.3 and 3.4. activities

Key categories of emissions and removals	Gas	Criteria used for key category identification	
		Associated category in UNFCCC inventory is key	Category contribution is greater than the smallest category considered key in the UNFCCC inventory (including LULUCF)
Forest Management	CO_2	Forest land remaining forest land	Yes
Forest Management	CH_4	Forest land remaining forest land	No
Forest Management	N_2O	Forest land remaining forest land	No
Afforestation and Reforestation	CH_4	Conversion to forest land	No
Afforestation and Reforestation	CO_2	Conversion to forest land	No
Afforestation and Reforestation	N_2O	Conversion to forest land	No
Deforestation	CH_4	Convertion to cropland, settlements and other land	No
Deforestation	CO_2	Convertion to cropland, settlements and other land	No
Deforestation	N_2O	Convertion to cropland, settlements and other land	No

11.7 Information relating to Article 6

No projects in this sector under Article 6 (Joint implementation projects) are implemented in Lithuania.

12 INFORMATION ON ACCOUNTING OF KYOTO UNITS

12.1. Background information

The standard electronic format (SEF) report for 2013 is included in the submission (see "SEF_LT_2014_1_12-6-35 12-3-2014.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 2013 to and from other Parties of the Kyoto Protocol.

12.2. Summary of information reported in the SEF tables

At the beginning of 2013 there were 160 861 894 AAUs and 213 586 ERUs in Lithuania's national holding accounts. 2 950 596 ERUs and 392 438 CERs were in entity holding accounts. In the retirement account were 19 519 889 AAUs, 1 810 374 ERUs and 2 562 399 CERs.

3 263 364 AAUs, 1 667 611 ERUs and 785 732 CERs were surrendered by Lithuania's operators and retired to Lithuania's national retirement account.

At the end of 2013 147 145 268 AAUs were left in National holding account, 4 930 174 ERUs and 237 289 CERs were held in the entity holding accounts.

During the reported year the registry did not contain any RMUs, t-CERs or l-CERs and no units were in the Article 3.3/3.4 net source cancellation accounts and the t-CER and l-CER replacement accounts.

Full details are available in the SEF tables.

12.3. Discrepancies and notifications

No discrepancies and notifications occurred in 2013.

12.4. Publicly accessible information

All non-confidential information required to be publicly accessible by the 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. Updating Commitment period reserve (CPR)

Each Party included in Annex I shall maintain, in its national registry, a commitment period reserve which should not drop below 90 per cent of the Party's assigned amount calculated pursuant to Article 3, paragraphs 7 and 8, of the Kyoto Protocol, or 100 per cent of five times the most recently reviewed inventory, whichever is lowest.

In the case of the Lithuania, the relevant size of the Commitment Period Reserve is five times the most recent inventory (2012), which is calculated below:

5 x 21,622,285,41 = 108,111,427 tonnes CO_2 eqv.

13 INFORMATION ON CHANGES IN NATIONAL SYSTEM

No changes in national system had occured during 2013.

14 INFORMATION ON CHANGES IN THE NATIONAL GREENHOUSE GAS REGISTRY

The following changes to the national registry of Lithuania have therefore occurred in 2013.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	The change of Registry administrators occured in 2013: Registry administrator Justė Akmenskytė (contact information: juste@laaif.lt, 0037052169799) was replaced by Registry administrator Monika Ozarinskienė (contact information: m.ozarinskiene@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	An updated diagram of the database structure is attached as Annex A. Iteration 5 of the national registry released in January 2013 and Iteration 6 of the national registry released in June 2013 introduces changes in the structure of the database. Changes introduced in release 5 and 6 of the national registry 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 in release 5 and 6 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 (see Annex B). Annex H testing was carried out in February 2014 and the successful test report has been attached. No other change in the registry's conformance to the technical standards occurred for the reported period.

Reporting Item	Description
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 of security measures occurred during the reporting period
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 in release 5 and 6 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; the report is attached as Annex B. Annex H testing was carried out in February 2014 and the successful test report has been attached.

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 provided full and final information on it's funding for the Fast Start Finance period, which contributed to the EU's overall objective.

In 2012 Lithuania has adopted the Strategy for National Climate Change Management Policy by 2050, following which the Inter-institutional Action Plan on the Implementation of the Goals and Objectives for 2013-2020 of the Strategy for the National Climate Change Management Policy was adopted by the Government on 23rd of April, 2013. The Action Plan contains an objective to identify possible public and private financing sources, including alternative sources (such as flexible mechanisms), which would contribute to financing and implementation of climate change mitigation and adaptation projects in the developing and third countries.

Furthermore, on 21st of October, 2013, Lithuania has pledged to contribute a total of 100 000 EUR to the Eastern European Energy Efficiency and Environment Fund, which is administered by European Bank for Reconstruction and Development (EBRD). The aim is to finance climate change mitigation and adaptation projects in such countries as Moldova, Georgia and other strategic Eastern European partners. A total amount of 32 000 LTL was allocated to bilateral project in Ukraine, through Official Development Assistance (ODA) Programme in 2013. Furthermore, some 4 000 EUR were made as a voluntary contribution (offset) to the fund, which in total adds up to 114 000 EUR of climate finance committed to the developing countries in 2013, which has increased compared to the 2012 levels. The Contribution Agreement with EBRD is planned to be signed in the first half of 2014, after which funds shall be disbursed to different climate change mitigation and adaptation projects. More detailed information on project types financed would be available next year.

Disbursements of the funds committed in 2012 (a total of 100 000 LTL to Energy Sector Management Assistance Programme, operated by the World Bank) were made in 3rd quarter of 2013. Those proceeds were disbursed to both mitigation and adaption projects (cross-cutting), more detailed information on the project type is reported in Lithuania's 6th National Communication and 1st Biennial report under the UNFCCC.

Lithuania plans to increase its bilateral project assistance through the ODA and additional contributions from its Special Programme for Climate Change. Climate change is set as one of the priorities areas for areas in the Development cooperation and democracy promotion guidelines for 2014, approved by the Order of the Minister of Foreign Affairs. The guidelines set the priorities for projects financed in developing and third countries.

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