LITHUANIA'S NATIONAL INVENTORY REPORT 2017

GREENHOUSE GAS EMISSIONS 1990-2015

VILNIUS, 2017

PREFACE

Lithuania's GHG inventory submission under the 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 1990-2015;
- SEF (Standard Electronic Format) tables for reporting of Kyoto units (AAUs, ERUs, CERs, tCERs, lCERs, RMUs) in the National registry during the year 2016 (CP1, CP2).

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Abbreviations

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

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

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EXECUTIVE SUMMARY

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

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

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

At the Paris climate conference (COP21) in December 2015, 195 countries adopted the first-ever universal, legally binding global climate deal. The agreement sets out a global action plan to put the world on track to avoid climate change by limiting global warming to well below 2°C. Lithuania signed the Paris Agreement on 22 April 2016 and ratified on 30 December 2016. Under the Paris Agreement Lithuania jointly with the EU and its Member States took a binding target of at least a 40% domestic reduction in economy wide GHG emissions by 2030 compared to 1990, which was endorsed in the conclusions of the European Council of 23 and 24 October 2014 on the EU 2030 climate and energy policy framework. On 6 March 2015, the Council adopted this contribution of the Union and its Member States as their intended nationally determined contribution, which was submitted to the Secretariat of the UNFCCC. The target will be delivered implementing the EU legal acts on 2030 climate and energy targets by all economy sectors, with the reductions in the Emission trading system (ETS) and non-ETS sectors amounting to 43% and 30% respectively by 2030 compared to 2005.

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 decision 24/CP.19 "Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to Convention" (FCCC/CP/2013/10/Add.3). GHG inventory is compiled in accordance with the methodology recommended by the Intergovernmental Panel on Climate Change (IPCC) in its

2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006), 2013 Supplement to the 2*006 IPCC* Guidelines for National Greenhouse Gas Inventories: Wetlands (IPCC, 2014), 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (IPCC, 2014) and taking into account recommendations by the UNFCCC expert review teams, provided in the Reports of the individual review of the annual submissions of Lithuania and remarks received during EU annual GHG inventory quality checks and GHG inventory technical reviews under EU Decision 406/2009/EC (Effort sharing decision).

The first national GHG inventory data was submitted in 1996 for the first National Communication under the UNFCCC. In 2004 first National Inventory Report (NIR) and Common reporting format (CRF) tables have been developed. In 2006 for the first time complete time series for the period 1990-2004 of the GHG inventory has been developed and submitted to European Commission and the UNFCCC Secretariat together with Lithuania's Initial Report under the Kyoto Protocol. In 2016 Lithuania submitted its Second Initial Report under the Kyoto protocol (Report to facilitate the calculation of the assigned amount for the second commitment period pursuant to Article 3, paragraphs 7bis, 8 and 8bis of the Kyoto Protocol).

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

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

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

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

The national GHG inventory report contains detailed information about Lithuania's emissions by sources and removals by sinks for the period 1990-2015.

For the preparation of the inventory upgraded CRF Reporter inventory software (v6.0.1) has been used. The NIR includes trends of GHG emissions, description of each emission category relevant to CRF, key sources, uncertainty estimates, planned improvements and description of performed procedures of quality assurance and quality control (QA/QC).

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

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

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

The summary of Lithuania's GHG emissions and removals for the period 1990-2015 is presented in Table 1.

Table 1. Greenhouse gas emissions/removals by sectors during the period 1990-2015, kt CO_2 eqv.

GHG source and sink categories	Energy	IPPU	Agriculture	LULUCUF	Waste	Total (including LULUCF)	Total (excluding LULUCF)
1990	33,107.7	4,502.7	8,853.5	-3,511.9	1,576.7	44,528.7	48,040.6
1991	35,175.0	4,535.1	8,673.7	-3,840.0	1,602.4	46,146.2	49,986.2
1992	19,881.6	2,689.8	6,607.2	-4,009.2	1,571.6	26,740.9	30,750.1
1993	16,003.5	1,759.3	5,362.2	-5,143.0	1,593.4	19,575.4	24,718.4
1994	15,044.2	1,955.9	4,750.6	-4,921.3	1,549.4	18,378.8	23,300.1
1995	14,062.4	2,243.1	4,442.4	-3,795.3	1,578.3	18,530.8	22,326.1
1996	14,519.4	2,633.1	4,613.6	1,516.0	1,577.3	24,859.4	23,343.4
1997	14,052.4	2,596.4	4,648.5	142.8	1,579.5	23,019.6	22,876.8
1998	14,734.4	3,003.7	4,536.2	-7,613.5	1,565.4	16,226.2	23,839.7
1999	12,361.0	2,939.2	4,272.8	-7,232.3	1,539.9	13,880.5	21,112.8
2000	10,808.2	3,094.4	4,157.0	-9,820.5	1,540.8	9,779.8	19,600.3
2001	11,434.5	3,342.6	4,054.6	-7,981.6	1,583.7	12,433.8	20,415.4
2002	11,525.7	3,515.2	4,226.8	-7,262.4	1,573.7	13,579.0	20,841.4
2003	11,529.9	3,597.8	4,339.9	-7,164.1	1,561.4	13,864.8	21,029.0
2004	12,162.9	3,787.2	4,387.7	-6,991.2	1,532.8	14,879.4	21,870.5
2005	13,042.0	4,108.6	4,420.5	-6,328.3	1,496.7	16,739.6	23,067.8
2006	13,116.6	4,367.4	4,396.1	-5,372.9	1,460.6	17,967.8	23,340.7
2007	13,367.7	6,144.9	4,488.5	-6,974.7	1,435.8	18,462.2	25,437.0
2008	13,186.3	5,475.5	4,340.2	-7,045.5	1,421.8	17,378.3	24,423.8

2009	11,922.8	2,294.4	4,381.1	-7,472.1	1,376.2	12,502.5	19,974.6
2010	12,874.7	2,239.2	4,329.2	-9,901.1	1,339.4	10,881.3	20,782.5
2011	12,029.0	3,719.5	4,345.4	-10,228.0	1,250.6	11,116.6	21,344.6
2012	12,071.3	3,565.4	4,379.5	-9,217.1	1,211.7	12,010.8	21,228.0
2013	11,419.7	3,000.4	4,357.3	-8,504.5	1,170.6	11,443.6	19,948.1
2014	11,049.6	3,176.9	4,529.7	-7,332.0	1,113.0	12,537.1	19,869.1
2015	11,057.1	3,396.6	4,600.3	-6,705.0	1,042.2	13,391.2	20,096.2
2015/1990, %	-66.6	-24.6	-48.0	90.9	-33.9	-69.9	-58.2

The most significant source of GHG emissions in Lithuania is energy sector with 55% share of the total emissions in 2015. Agriculture is the second most significant source and accounted for 22.9% of the total emissions. Emissions from industrial processes contributed 16.9% of the total GHG emissions, waste sector – 5.2%.

Main contributors in energy sector are Energy industries and Transport sectors. In 2015 these sectors composed 15.7% and 25.4% of the total national GHG emissions respectively.

The composition of GHG emissions by sectors in 2015 is presented in Figure 1.

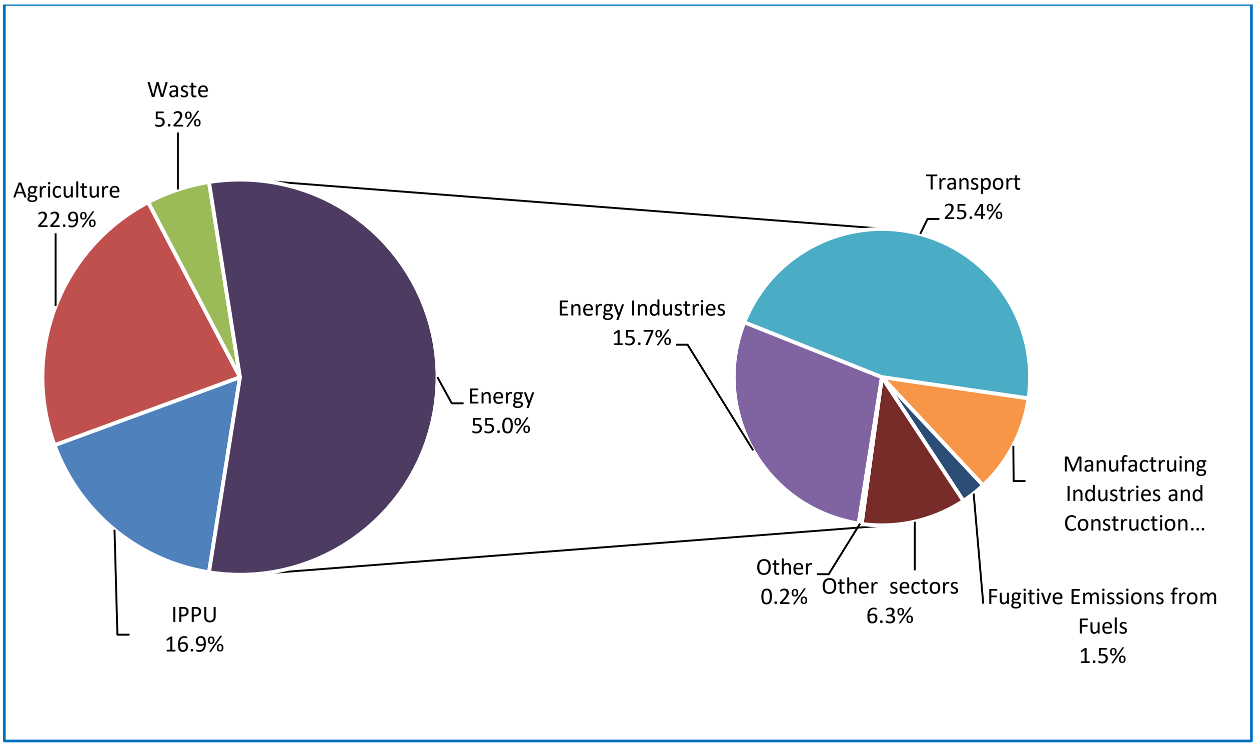


Figure 1. The composition of Lithuanian GHG emissions (CO_2 eqv.) by sectors (excl. LULUCF) in 2015[1]

The total GHG emission (excl. LULUCF) amounted to 20,096.2 kt CO_2 eqv. in 2015. The emissions have decreased by 58.2% comparing with the base year. The base year is 1990 for the greenhouse gases CO_2, CH_4, N_2O and 1995 for the F-gases HFC, PFC, SF_6 and NF_3.

The largest source of CO_2 emission is the energy sector that accounted 79.3% of the total national CO_2 emission (excl. LULUCF) in 2015. The energy industries contribute 29.7% and the transport sector accounts for 48.4% of the CO_2 emission in energy section.

[1] Transport, Energy Industries, Manufacturing industries and construction, Fugitive emissions from fuels, Other, Other sectors values represent emissions in percentages compared to total National GHG emissions.

Comparing with 2014 CO_2 emission from energy sector in 2015 have slightly changed with an increase of 0.004% wherein CO_2 emission from the energy industries decreased by 0.8% and emissions from transport increased 5.5%.

The most important GHG in 2015 was CO_2, it contributed 65.4% of the total national GHG emissions expressed in CO_2 eqv. followed by N_2O (15.4%) and CH_4 (16.8%). HFCs, SF_6 and NF_3 together amounted 2.4% of the total GHG emissions (excl. LULUCF) in Lithuania.

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

Comparing with 2014 the total GHG emissions have increased by 1.1% (excl. LULUCF) in 2015.

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 1990-2015.

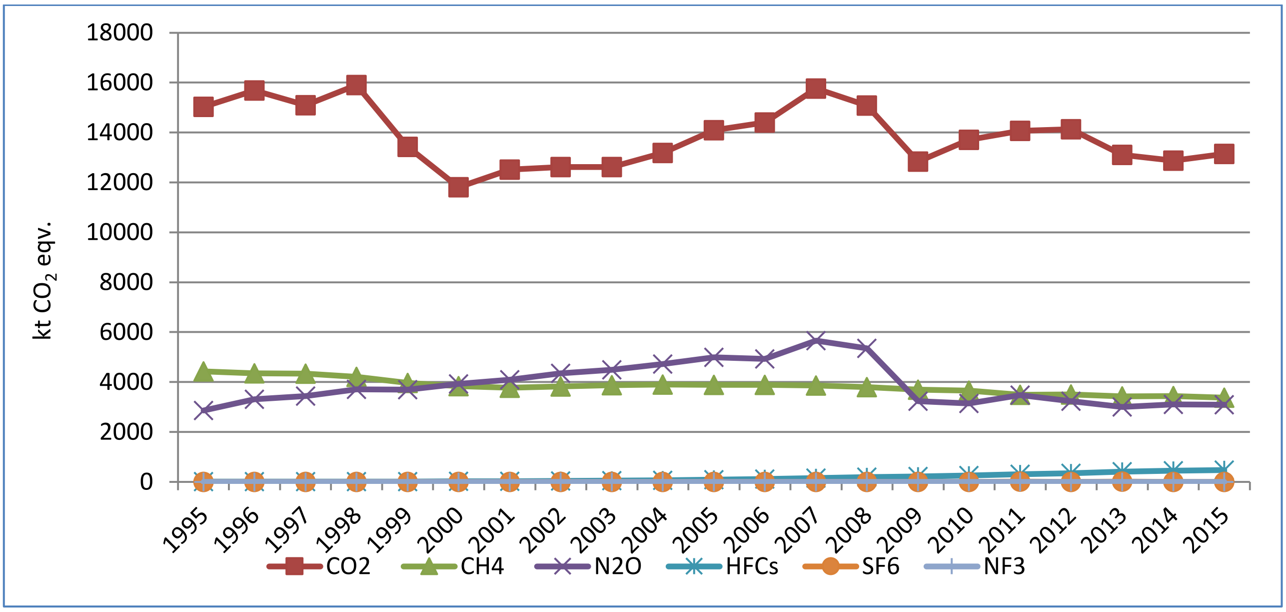


Figure 2. Trends of GHG emissions by gas (excl. LULUCF)

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% share of the total emissions (excl. LULUCF) in 2015. Emissions from energy include CO_2, CH_4 and N_2O GHG.

CO_2 emission from energy sector contained 79.3% of the total national CO_2 emissions (excl. LULUCF) in 2015. The main categories are energy industries and transport which contribute 29.7% and 48.4% to the total national CO_2 emission (excl. LULUCF) respectively. Comparing with 2014 CO_2 emissions from energy sector have increased by 0.004% in 2015. The emissions of CH_4 have increased by 1.5% and N_2O emissions decreased by 0.1%.

The second most important source of GHG emissions is agriculture sector accounting for 22.9% of the total national GHG emissions (excl. LULUCF). This sector is the most significant source of CH_4 and N_2O emissions accounting for 56.4% and 85.1% of the total CH_4 and N_2O emissions, respectively. The main source of CH_4 emissions is enteric fermentation contributing 86% to the total agricultural CH_4 emissions. Agricultural soils are the most significant source of N_2O emissions accounting for 92.4% of the total agricultural N_2O emissions. Comparing with 2014 GHG emissions in agriculture sector have increased by 1.6% in 2015.

Emissions from industrial processes and product use amounted to 16.9% of the total GHG emissions (excl. LULUCF) in 2015. The main categories are: ammonia production, nitric acid production and cement production. Ammonia production is the largest source of CO_2 emissions in industrial processes and product use sector contributing 15.4% to the total national CO_2 emissions (excl. LULUCF) in 2015. Nitric acid production is the single source of N_2O emissions in industrial processes sector and accounts for 8.3% in the total national N_2O emissions (excl. LULUCF) in 2015. GHG emissions in 2015 from industrial processes and product use sector have increased by 6.9% comparing with 2014.

Waste sector accounted for 5.2% of the total GHG emissions in 2015 (excl. LULUCF). The solid waste disposal on land is the second important source of CH_4 emissions. It contributes 23.8% to the total CH_4 emissions (excl. LULUCF). There was 7.1% reduction in CH_4 emission from waste sector in 2015 comparing with 2014.

PART 1:

ANNUAL INVENTORY SUBMISSION

1 INTRODUCTION

1.1 Background information on GHG inventories and climate change

1.1.1 Background information on climate change in Lithuania

Lithuanian climate is formed affected by global factors and local geographical circumstances. Key features of the climate depend on the country's geographical location. The territory of Lithuania lies in the northern part of the temperate climate zone. The distance from the equator (6,100 km) and from the North Pole (3,900 km) determines general solar radiation flux and atmospheric circulation patterns over the country. According to the general classification of climate, almost the entire territory of Lithuania is assigned to the south-western sub-region of the continental forest region of the middle latitudes of the Atlantic Ocean, because its climate is close to that of Western Europe; while the Baltic coast is assigned to the South Baltic sub-region.

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

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

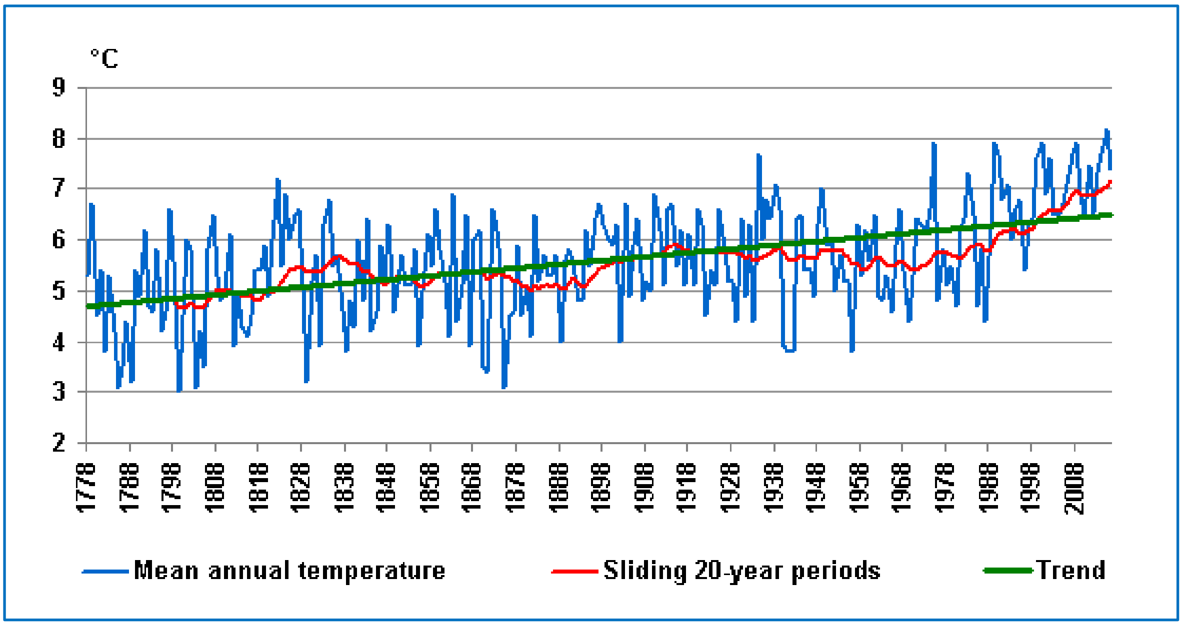


Figure 1-1. Average annual temperature in Vilnius, 1778-2016[2]

Average annual temperature, compared with the beginning of 20th century, has increased 0.7-0.9°C which leads to more frequent droughts (for example 1992, 1994, 2002, 2006 summer

[2] Lithuanian Hydrometeorological Service under the Ministry of Environment. Available from: http://www.meteo.lt/en/web/guest/weather-temperature

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 21st century in Lithuania should increase. Highest changes are predicted during cold season. In Vilnius, average maximum and minimum temperature could increase by 4°C in year 2100. During different months, however, this increase could be up to 7°C.

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

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

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

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

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

1.1.2 Background information on greenhouse gas inventories

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

Since 2004, inventory is prepared using common reporting format (CRF). From 2006 inventory was being prepared using CRF Reporter software, developed by UNFCCC secretariat. In 2006 for the first time complete time series 1990-2004 has been developed and submitted to the European Commission and the UNFCCC secretariat together with Lithuania's Initial Report under the Kyoto protocol. In 2016 Lithuania submitted its Second Initial Report under the Kyoto protocol (Report to facilitate the calculation of the assigned amount for the second commitment period pursuant to Article 3, paragraphs 7bis, 8 and 8bis of the Kyoto Protocol).

The GHG inventory presented here contains information on anthropogenic emissions by sources and removals by sinks for the direct (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3) and indirect (CO, NOx, SO_2, NMVOCs,) greenhouse gases. This report contains detailed information about Lithuania's GHG inventory for the period 1990-2015. NIR includes description of the methodologies and data sources used for emissions estimation by sources and removals by sinks, also description of the trends, key categories analysis, uncertainty estimates, planned improvements and description of performed procedures of QA/QC. The purpose of the report is to ensure the transparency, consistency, comparability, completeness and accuracy of GHG inventory. For the preparation of inventory upgraded CRF Reporter v.6.0.1.1 available as online application has been used.

The GHG inventory is prepared in accordance with the decision 24/CP.19 "Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to Convention" (FCCC/CP/2013/10/Add.3). Greenhouse gas inventory is compiled in accordance with IPCC methodology: Guidelines for National Greenhouse Gas Inventories (IPCC, 2006); 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (IPCC, 2014), 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (IPCC, 2014), and also in accordance with decision No 529/2013/EU of the European Parliament and of the Council of 21 May 2013 when NIR is being submitted to EC.

1.2 A description of the national inventory arrangements

1.2.1 Institutional, legal and procedural arrangements

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

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

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

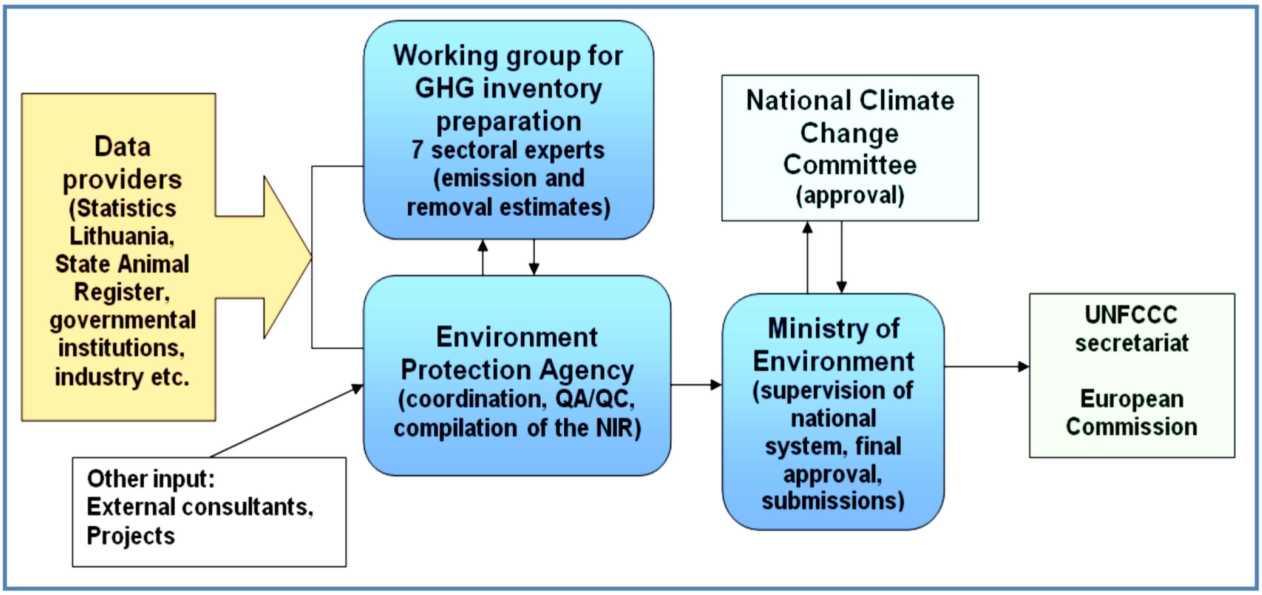


Figure 1-2. Institutional arrangement for GHG inventory

Ministry of Environment

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

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

Environmental Protection Agency

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

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

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

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

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

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

EPA establishes and operates GHG inventory archive, where GHG inventory submissions and all supporting reference material is stored and maintained. Backups are prepared on regular basis following the EPA's information management procedures. The archive is managed according to the EPA Director's Order No AV-152 concerning the approval of the National GHG inventory data archiving procedures (26th June 2012). The main QA/QC procedures under responsibility of EPA are performed according to the EPA Director's Order No AV-191 concerning the approval of the National GHG inventory data quality assurance and quality control procedures (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 SFS in the GHG inventory preparation process is responsible for calculations of emissions and removals of LULUCF (forestry part) sector and Kyoto Protocol activities under Art. 3 para. 3 and 4 following the Order of the Minister of Environment 29 of July, 2010 No D1-666 (repealed by the Order of the Minister of Environment No D1-61, 23-01-2014). SFS representative is also a member of permanent working group for GHG inventory preparation under the Government Resolution No 683. In this framework, the SFS has the following responsibilities:

- Collection of activity data and emission factors used to calculate emissions and removals for LULUCF and KP-LULUCF sectors;
- Selection of methods (complying with IPCC Good Practice Guidance for LULUCF) for calculation of emissions and removals giving the priority to key categories and categories with a high uncertainty;

- Emission and removals estimates for LULUCF and KP-LULUCF sectors, preparation of CRF tables and NIR parts for LULUCF and KP-LULUCF and providing the final estimates for the EPA;
- Uncertainty assessment for LULUCF and KP-LULUCF sector;
- Checking and archiving of input data, prepared estimates and used materials;
- Implementation of QA/QC plan and specific QA/QC procedures related to LULUCF and KP-LULUCF;
- Evaluation of requirements for new data, based on recommendations received during internal and external reviews.

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

Permanent GHG Inventory working group

Permanent GHG Inventory preparation working group is established by the Governmental Resolution No 683 (as amended on 10-02-2016 by Governmental Resolution No 101) and MoE Order No D1-538 (as amended on 14-03-2016 by the Minister of Environment Order No D1-185). 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);
- Aleksandras Stulginskis University (LULUCF, except forestry);
- State Forest Service (LULUCF, forestry; KP-LULUCF);
- Public body Centre for Environmental Policy (waste).

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

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

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

The composition of the Working group for GHG inventory preparation (as approved by MoE Order No D1-538 and amended on 14-03-2016 by the MoE Order No D1-185) is as follows:

- Mr. Vitalijus Auglys (Ministry of Environment) – Chairman of the working group;
- Mr. Vytautas Krušinskas (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;
- Mr. Gintaras Kulbokas (State Forest Service) – LULUCF (forestry), KP-LULUCF;
- Dr. Romualdas Lenkaitis (Centre for Environmental Policy) – waste sector.

National Climate Change Committee

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

Data providers

Data providers are responsible for:

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

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

- Statistics Lithuania publishes Lithuanian annual statistical publications (annual statistical data on energy balance, agriculture, production and commodities);
- State Forest Service under the Ministry of Environment executes National Forest Inventory (NFI), publishes annual statistical data on forestry (Lithuanian Statistical Yearbook of Forestry (2001-2015); Lithuanian Country Report on Global Forest Resources Assessment (2005, 2010));
- Annual EU Emissions Trading System (ETS) data reports by the operators;
- Environmental Protection Agency collects data and maintains database on wastewater and waste, F-gases;
- Industrial companies (nitrogen fertilizers and chemical products production company (ammonia, nitric acid production data and natural gas consumption data), oil refinery

(CO_2 EFs for fuel combustion), cement production company (activity data and CaO/MgO content), lime production company (limestone composition data), glass production companies (data on dolomite, soda ash, potash and chalk use), mineral wool producer (rock wool production data, etc.));
- Institute of Physics annually calculates precursors (NOx, SO_2, CO, NMVOC) emissions under the UNECE Convention on Long-range Transboundary Air Pollution;
- Agricultural Information and Rural Business Centre of Ministry of Agriculture (data on livestock population);
- State Medicines Control Agency (data on metered dose inhalers, N_2O use in medicine);
- The Geological Survey of Lithuania provides data on peat extraction areas.

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

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

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

External consultants

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

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

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

- A training program for Lithuanian inventory experts to raise the technical competence in the GHG inventory and GHG emissions projections development process (*completed*).
- The improvement of Quality assurance/Quality control (QA/QC) procedures and QA (Agricultural soils category and LULUCF sector) performed by Norwegian experts (*completed*).
- 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 (*completed*).
    - 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 (*completed*).
    - 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 (*completed)*.
    - 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 (*completed)*.
- National emission factors for energy sector development and revision study (*completed*).
- 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 (*completed*).

Project activities were implemented during the period 2015-2016 and were finalized by 31st of March 2017. Under the planned Project activities in October 2015 two training seminars took place in Oslo, Norway: the first one was the experience sharing event on GHG inventory, and the second was dedicated to uncertainty evaluation, in which besides Norwegian and Lithuanian GHG inventory experts Latvian experts were involved. During the experience sharing seminar in break-out groups sectoral experts (energy, agriculture, industrial processes, waste and LULUCF) have discussed the most important issues and shared the experience on *2006 IPCC* Guidelines application. Additionally, during the workshop the national systems, QA/QC procedures and other cross-cutting issues were discussed. As a result of these discussions, aiming to increase the quality of Lithuania's GHG inventory, GHG inventory improvement plan will be developed. Uncertainty evaluation seminar gave an opportunity to discuss methodological and practical aspects of the uncertainty evaluation in GHG inventory, such as the collection and documentation of the expert judgement information, use of uncertainty analysis and key category analyses to prioritize inventory improvements, delimitation of uncertainty analyses, Tier 2 uncertainty evaluation (Monte Carlo method). More information about the Project ant its activities can be found at the Ministry of Environment website http://www.am.lt/VI/index.php#r/1704 (in lithuanian).

In 2016 the Partnership agreement between the Ministry of Environmental Protection and Regional Development of the Republic of Latvia, the Ministry of Environment of the Republic of Lithuania and the Ministry of the Environment of Estonia for the implementation of the **SEED Project S91 "Baltic Expert Network for Greenhouse Gas Inventory, Projections and PaMs Reporting (BENGGI)**" was signed.

This network will be established in order to improve the quality of inventory and projections preparation under EU and UNFCCC. Networking would allow acquiring necessary knowledge and sharing experience between experts. Baltic countries share similar natural, economical, social and political conditions that influence GHG inventory reporting procedures, as well as reported content. Under the BENGGI project following activities are planned:

– State of the art report and assessment of GHG inventory and projections reporting to the UNFCCC and European Commission in the Baltic Sea region (BSR).

– Identifying partners for the main project - network (organizations, experts, institutes etc.)

– Organizing seminars on networking in cooperation with Scandinavian experts and holding a showcase seminar/workshop in which experts could review real issues related to reporting process and inventory preparation.

– Designing a work plan for the main project and planning indicative budget plan.

The first project seminar took place on October 24-25, 2016 in Riga (Latvia) bringing together 42 participants from 3 Baltic states and 1 participant from Sweden. The aim of the seminar was to identify strengths and weaknesses of participating countries reports and discuss how to improve the quality of reported GHG related data to the UNFCCC and European Commission. Seminar helped identify main problems within GHG inventory reporting, projections and PaMs among Baltic States. Input from Swedish expert helped frame the future network based on the Nordic experience. Experience sharing between experts added input to the research conducted by "Green Liberty" consultants.

The second project seminar took place on 22 February, 2017 in Riga (Latvia). During the workshop several issues that has potential to be solved within the cooperation network were detected. A special session was dedicated to LULUCF action issues, where experts from all Baltic states discussed the problems of LULUCF sector accounting and reporting. Next steps include sector based consultations between experts and it is planned a workshop to be held in autumn 2017 to discuss the relevant issues and ways to resolve it.

1.2.2 Overview of inventory planning, preparation and management

Lithuania prepares National Inventory Report and fills in CRF tables according to requirements of the UNFCCC, the Kyoto Protocol and the EU greenhouse gas monitoring mechanism Regulation No 525/2013. The organization of the preparation and reporting of Lithuania's GHG inventory and the responsibilities of its different institutions are described in previous section.

The annual GHG inventory preparation follows the Work schedule for reporting. Work schedule for preparation and submission of National GHG inventory 2017 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 secretariat shall be submitted by 15th April annually.

Table 1-2. Work plan for preparation and submission of National GHG inventory in 2017

Activity	**Responsible institutions**	**Deadlines**
Updated QA/QC plan 2016-2017	EPA, MoE	November 2016
Data collection - sending of official letters to data providers; Methods development; QC procedures, data archiving	EPA, WG sectoral experts	September-October 2016
Meetings of all involved institutions for defining specific areas for improvements and recalculations	MoE, EPA, SFS, WG sectoral experts	September 2016
Sectoral experts input results to EPA	WG sectoral experts	October-November 2016
Filling in CRF Reporter, QC procedures, data archiving	EPA	November 2016
Filling in CRF and prepare NIR part on LULUCF and KP-LULUCF and sending to EPA, data archiving	SFS	November 2016
Prepare draft NIR and send to MoE and other institutions for comments	EPA	By December 2016
Comments from MoE and others to EPA	MoE	By 15 December 2016
Submission of CRF tables, xml file and draft NIR to European Commission	MoE	By 15 January 2017
Possible CRF and NIR updates and final approval by MoE	EPA, WG sectoral experts, MoE	By March 2017
Sending NIR to NCCC for comments and final approval, QA procedures	MoE	By 15 March 2017
Submission of GHG inventory to European Commission	MoE	By 15 March 2017
Submission of GHG inventory to UNFCCC secretariat	MoE	By 15 April 2017

This schedule does not include timeframe for the EU inventory consistency checks, UNFCCC reviews and Lithuania's responses though the Work Plan may be updated during the year.

Possible legislation improvements for a proper National System functioning are also not included in this scheme, but will be considered during the year and will be drafted by the Ministry of Environment, if necessary.

1.2.3 Quality assurance, quality control and verification plan

1.2.3.1 Quality assurance and quality control procedures

General Quality Control procedures applied

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

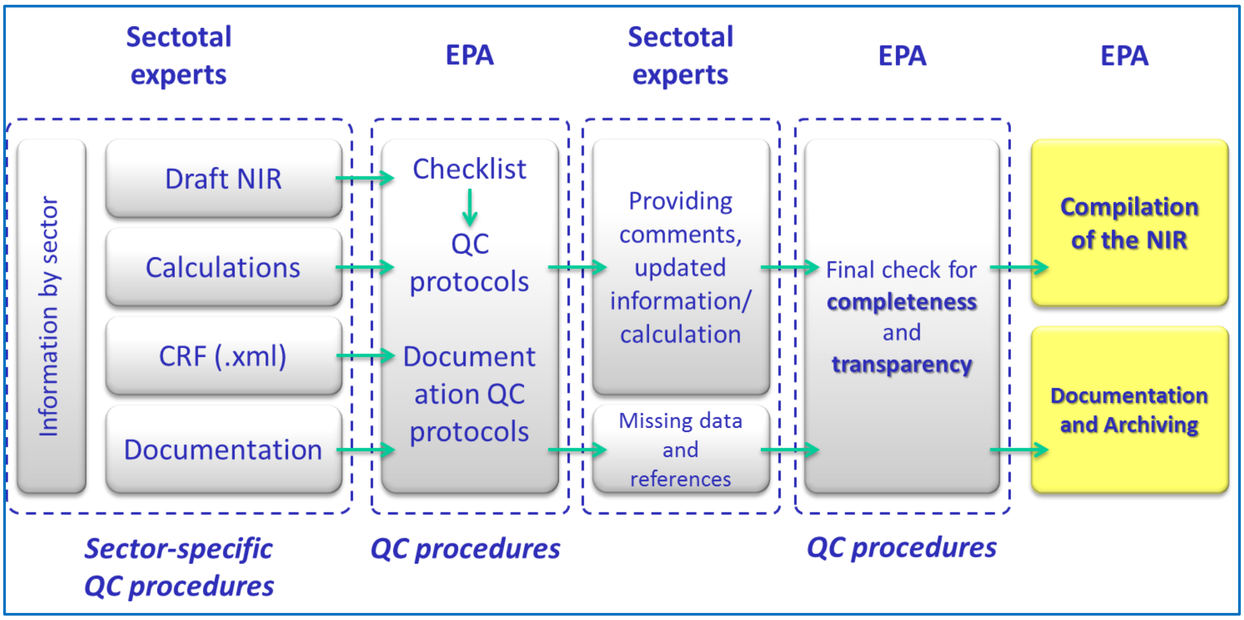


Figure 1-3. General QC procedures performed by EPA

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

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

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

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

Quality Assurance

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

National QA procedures

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

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

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

International reviews

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

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

Other reviews

In 2016 review (QA) of agricultural soils category and LULUCF sector was performed by GHG inventory experts from Norwegian Environment Agency in the scope of Lithuania's and

Norway's partnership project on GHG inventory. The aim of the project was capacity building and improvement of Lithuania's GHG inventory. During this QA few inconsistencies/errors in estimation of agricultural soils GHG emissions have been identified (emissions from organic soils and crop residues) and recommendations how to improve transparency of NIR were provided. All review findings and recommendations were taken into consideration and where possible implemented in this submission.

Since 2016 Lithuania participates in the "Baltic Expert Network for Greenhouse Gas Inventory, Projections and PaMs Reporting" (BENGGI) project. The purpose of the project is to develop a GHG inventory and projections expert network between the three Baltic States: Estonia, Latvia and Lithuania. The network's main objective is to increase the quality of GHG inventory reports and projections through knowledge and experience sharing. In the light of this project peer reviews in the Baltic states are foreseen.

1.2.3.2 QA/QC plan

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

QA/QC plan was updated in 2016. EPA was responsible for the update of QA/QC plan which was approved by the MoE. EPA is responsible for the coordination and implementation of the Plan with a supervision performed by the MoE.

The QA/QC Plan describes the quality objectives of the GHG inventory, the national system for inventory preparation, tasks and responsibilities. A description is provided of various formal procedures already implemented in the development of the GHG inventory and planned improvements for the period 2016-2017.

1.2.3.3 Verification activities

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

- a brief assessment whether the emissions estimates of carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen oxides (NOx) and volatile organic compounds, in inventories submitted by the Member State under Directive 2001/81/EC of the European Parliament and of the Council and under the UNECE Convention on Long-range Transboundary Air Pollution are consistent with the corresponding emission estimates in greenhouse gas inventories under Regulation (EU) No 525/2013;
- comparison between the reference approach calculated on the basis of the data included in the greenhouse gas inventory and the reference approach calculated on the basis of the data reported pursuant to Article 4 of Regulation (EC) No 1099/2008 of the European Parliament and of the Council and Annex B to that Regulation (EU) No 525/2013;

- consistency check of the data reported on fluorinated greenhouse gases in the greenhouse gas inventory with the data reported pursuant to Article 6(1) of Regulation (EC) No 842/2006 (referred to in Article 7(1)(m)(ii) of Regulation (EU) No 525/2013);
- consistency check of reported emissions in the greenhouse gas inventory with data of the actual or estimated allocation of the verified emissions reported by installations and operators under Directive 2003/87/EC (referred to in Article 7(1)(k) of Regulation (EU) No 525/2013);
- Lithuania also conducts annual consistency checks of activity data (mainly livestock population) provided in the greenhouse gas inventory with those reported by FAO statistics.

1.2.3.4 Treatment of confidential information

There is no information in GHG inventory that would be identified as confidential.

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

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

1.3 Inventory preparation, and data collection, processing and storage

1.3.1 Inventory preparation process

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

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

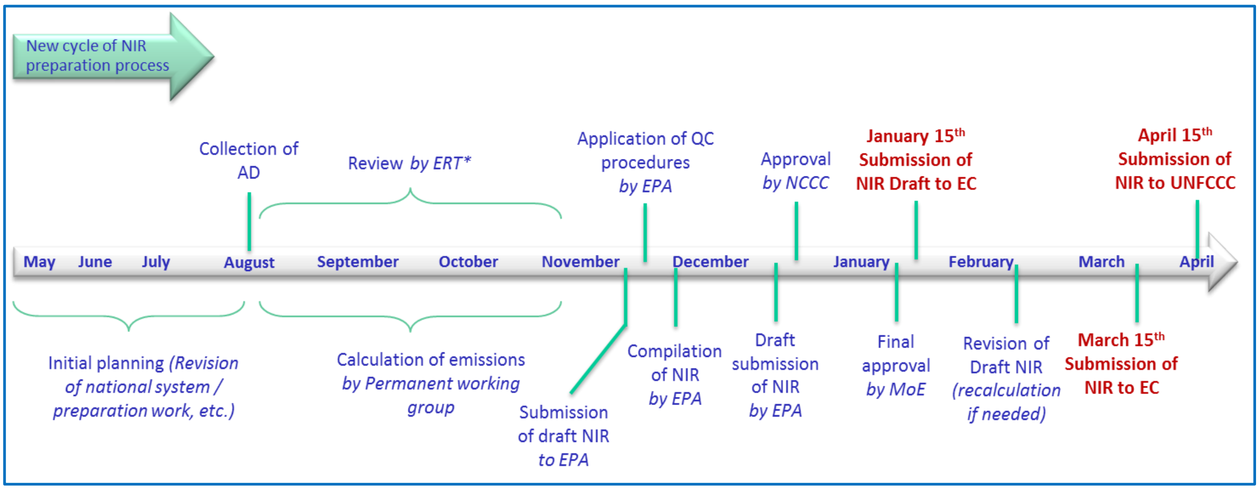


Figure 1-4. General Timeline of NIR preparation and submission process

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

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

1.3.2 Data collection, processing and storage

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

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

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

- to develop documentation checklists for each CRF category;
- to complete GHG inventory archive with the documentation provided by the sectoral experts;
- to develop a manual describing common archiving procedures (archive data structure, timing, data security etc.).

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

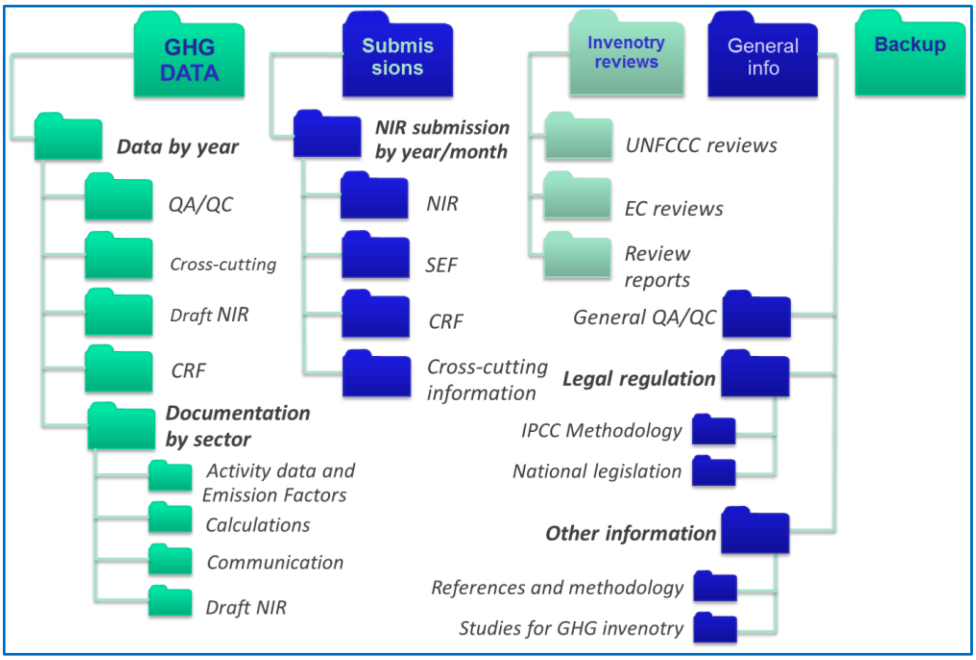


Figure 1-5. Lithuania's GHG inventory archive structure

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

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

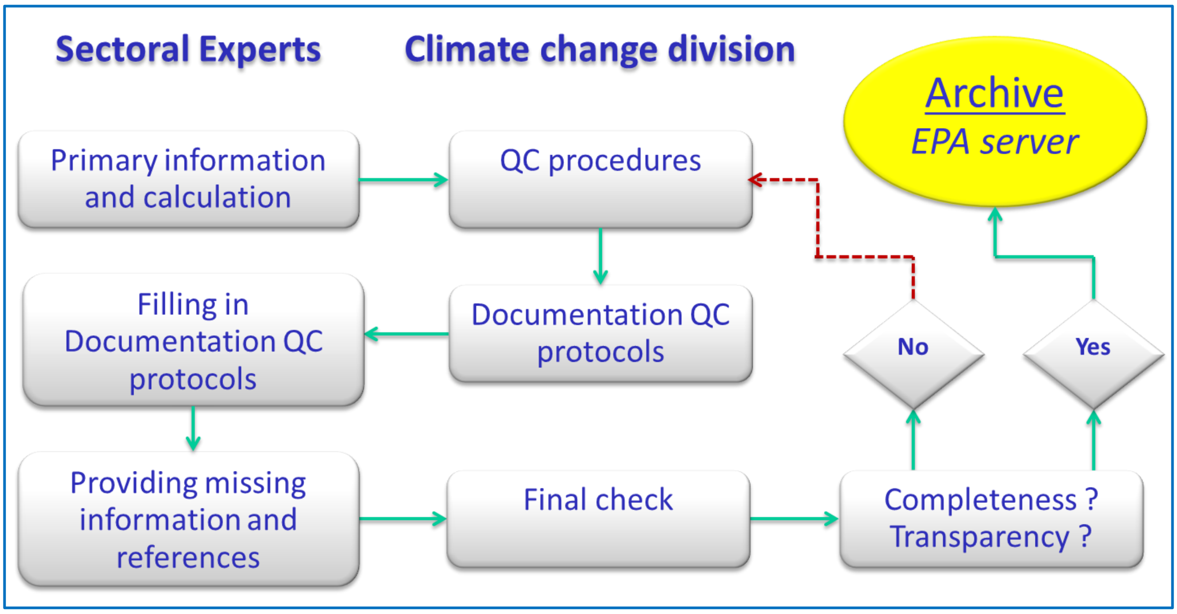


Figure 1-6. Quality control procedures applied for data archiving system

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

1.4 Brief general description of methodologies and data sources used

1.4.1 Methodologies used for preparation of GHG inventory

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

The GHG inventory is prepared in accordance with IPCC methodology:

- 2006 IPCC Guidelines for National Greenhouse Gas Inventories (*IPPC, 2006*);
- 2013 Supplement to the 2*006 IPCC* Guidelines for National Greenhouse Gas Inventories: Wetlands (*IPCC, 2014*);
- 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (*IPCC, 2014*).

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

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

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

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

	Water and wastewater database (EPA) Regional Waste Management Centres

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

1.5 Brief description of key categories

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

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

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

Approach 1 key category (level assessment) with a highest contribution to national total emission in 2015 and 1990 is 4.A.1 Forest land remaining forest land - carbon stock change in biomass (CO_2). Its contribution to national total is 20% in 2015 and 10% in the base year. The second most important source of greenhouse gas emissions in 2015 is 1.A.3.b Road transportation accounting for 12% of the total emissions whereas in the base year was 1.AA.1.a Public electricity and heat production – Liquid fuel (CO_2) accounting for 9% of the total emissions.

Approach 1 key category (trend assessment) with a highest contribution to national total emission in 2015 is 1.AA.1.A Public electricity and heat production - Liquid fuel (CO_2) accounting for 14% of the total emissions.

Key category analysis using a subset of inventory estimates was conducted. The LULUCF sector has been excluded from the analyses. Level and trend assessment of the subset identified additional categories when compared to Approach 1 analysis of total inventory. Additional category identified by level and trend assessment are 1.A.1.c Manufacture of solid fuels and other energy industries - Gaseous fuels (CO_2), 1.A.4 Other sectors-Peat (CO_2), 3.B.1.1 Manure Management – Cattle (CH_4).

Approach 2 key category (level assessment) with a highest contribution to national total emission in 2015 is 4.A.1 Forest land remaining forest land - carbon stock change in biomass (CO_2) and in 1990 is 4.B.2 Land converted to cropland - net carbon stock change in mineral soils (CO_2). Its contribution to national total is 16% in 2015 and 17% in the base year.

The following categories were identified by Approach 2 using subset (Level and Trend assessment) that was different from categories identified by Approach 1 and Approach 2:

- 1.A.1. Energy industries-Biomass (N_2O);
- 1.A.1. Energy industries-Biomass (CH_4);
- 1.A.4 Other sectors-Biomass (N_2O);

– 5.B Biological treatment of waste (CH_4).

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

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

IPCC Category	*Greenhouse gas*	*Identification criteria*	*Comments **
1.A.1 Energy industries-Other fossil fuels	CO_2	T1	
1.A.1 Energy industries-Solid fuels	CO_2	T1	
1.A.1 Energy industries-Biomass	N_2O	T2	
1.A.1 Energy industries-Biomass	CH_4		T2sub
1.A.1.a Public electricity and heat production - Gaseous Fuels	CO_2	L1,T1,T2	
1.A.1.a Public electricity and heat production - Liquid Fuels	CO_2	L1,T1, T2	
1.A.1.b Petroleum refining - Liquid Fuels	CO_2	L1,T1	
1.A.1.c Manufacture of solid fuels and other energy industries - Gaseous fuels	CO_2		T1sub
1.A.2 Manufacturing industries and construction-Gaseous fuels	CO_2	L1,T1	
1.A.2 Manufacturing industries and construction-Liquid fuels	CO_2	T1,T2	
1.A.2 Manufacturing industries and construction-Solid fuels	CO_2	L1,T1	
1.A.3.b Road transportation	CO_2	L1,T1,T2	
1.A.3.c Railways	CO_2	L1, T1	
1.A.4 Other sectors-Biomass	CH_4	L1,L2,T1,T2	
1.A.4 Other sectors-Biomass	N_2O		L2sub, T2sub
1.A.4 Other sectors-Gaseous fuels	CO_2	L1,T1	
1.A.4 Other sectors-Liquid fuels	CO_2	L1,T1, T2	
1.A.4 Other sectors-Liquid fuels	N_2O	T1	
1.A.4 Other sectors-Peat	CO_2		T1sub
1.A.4 Other sectors-Solid fuels	CO_2	L1,T1,T2	
1.A.4 Other sectors-Solid fuels	CH_4		T2sub
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	L1,T1	
2.A.1 Cement Production	CO_2	L1,T1	
2.A.2 Lime Production	CO_2	T1	
2.A.4 Other process use of carbonates	CO_2	T1	
2.B.1 Ammonia Production	CO_2	L1,T1	
2.B.2 Nitric Acid Production	N_2O	L1,T1	
2.F.1 Refrigeration and Air Conditioning Equipment	HFCs	L1,T1, T2	
3.A.1 Enteric Fermentation - Cattle	CH_4	L1,L2,T1,T2	
3.B.1.1 Manure Management - Cattle	CH_4	L1	
3.B.1.3 Manure Management - Swine	CH_4	T1	
3.B.2 Manure Management - Cattle	N_2O		L1sub
3.B.2 Manure Management - Indirect N_2O Emissions	N_2O	L2, T1,T2	
3.D.1.1 Direct N_2O Emissions From Managed Soils - Inorganic N Fertilizers	N_2O	L1,L2,T2	
3.D.1.2 Direct N_2O Emissions From Managed Soils - Organic N Fertilizers	N_2O	L1, T2	

3.D.1.3 Direct N_2O Emissions From Managed Soils - Urine and dung deposited by grazing animals	N_2O	L1,L2,T1,T2	
3.D.1.4 Direct N_2O Emissions From Managed Soils - Crop Residues	N_2O	L1,L2	
3.D.1.6 Direct N_2O Emissions From Managed Soils -Cultivation of organic soils	N_2O	L1,L2,T1,T2	
3.D.2.1 Indirect N_2O Emissions From Managed Soils - Atmospheric deposition	N_2O	L2	
3.D.2.2 Indirect N_2O Emissions From Managed Soils - Nitrogen leaching and run-off	N_2O	L1, L2	
4.A Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	L1,L2,T1,T2	
4.A.1 Forest land remaining forest land - carbon stock change in biomass	CO_2	L1,L2,T1,T2	
4.A.1 Forest land remaining forest land - net carbon stock change in dead wood	CO_2	L1	
4.A.2 Land converted to forest land - carbon stock change in biomass	CO_2	L1,L2,T1,T2	
4.A.2 Land converted to forest land - net carbon stock change in litter	CO_2	L1,L2,T1,T2	
4.B Cropland, Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	L1	
4.B Cropland	N_2O	L1, L2, T2	
4.B.2 Land converted to cropland - net carbon stock change in mineral soils	CO_2	L1,L2,T1,T2	
4.B.2 Land converted to cropland- carbon stock change in biomass	CO_2	L1,L2,T1,T2	
4.C.2 Land converted to grassland - net carbon stock change in mineral soils	CO_2	L1,L2,T1,T2	
4.D.1 Wetlands remaining wetlands -net carbon stock change in organic soils	CO_2	L1,L2,T1,T2	
4.E.2 Land converted to settlements	CO_2	L1,L2,T1,T2	
4.G Harvested wood products	CO_2	L1,L2,T1,T2	
5.A Solid Waste Disposal	CH_4	L1,L2,T2	
5.B Biological treatment of waste	CH_4		T2sub
5.D Wastewater Treatment and Discharge	CH_4	L1,T1,T2	

**Lsub, Tsub denote the categories that were identified by level and trend assessment for a subset without LULUCF when compared to Approach 1*

In this submission qualitative assessment of the key categories was performed (high uncertainty, mitigation technologies, significant anticipated changes in future emission levels criteria). Application of qualitative criteria identified the same source categories already defined as key through the quantitative analysis. For example, high uncertainty criteria is considered already by using Approach 2 key categories assessment, where results of the uncertainty analysis to identify key categories are used; mitigation technologies criteria could be applied to N_2O emissions from nitric acid production, but this is already key category according to KCA Approach 1 and Approach 2; there are also no expectations to grow emissions significantly in Lithuania in the future according to national GHG emission projections developed by Lithuania and overall Lithuania's commitments and policy to reduce GHG emissions in the future.

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

Uncertainty estimation was performed using Approach 1 of *2006 IPCC Guidelines*. Quantitative uncertainties assessment was carried out for the emission level 2015 and for 1990-2015 (1995-

2015 for F-gases) trend in emissions for all source categories comprising emissions of CO_2, CH_4, N_2O, HFCs 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 *2006 IPCC Guidelines* with uncertainties based on expert judgment, consultation with statistical office. Approach 1 uncertainty evaluation analysis (including and excluding LULUCF) is presented in Annex II Tables 2-1, 2-2.

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

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

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

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

Overall uncertainty

The total national GHG emission including LULUCF in the year 2015 is estimated with an uncertainty of ±39.8% and the trend of GHG emission 1990-2015 has been estimated to be ±8.7%.

The total national GHG emission excluding LULUCF in the year 2015 is estimated with an uncertainty of ±11% and the trend of GHG emission 1990-2015 has been estimated to be ±2.3%.

1.7 General assessment of the completeness

Lithuania's GHG emission inventory includes all the major emission/removal sources identified by the *2006 IPCC Guidelines* with some exceptions reported as "not estimated" (NE) (see Table 1-5. Emissions/removals are not estimated mainly due to lack of available IPCC methodologies and/or lack of activity data.

Table 1-5. Source/sinks categories reported as "NE" in the GHG inventory

GHG	Source/Sink category	Explanation
CH_4	4.F Other Land 4.F Other Land/4(V) Biomass Burning	No default methodology is provided for estimation of emissions from biomass burning in other land category therefore it is reported as NE.
CH_4	4.A Forest Land/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Total Organic Soils/Drained Organic Soils/Sub_01	Under Tier 1 (*2006 IPCC Guidelines*, Chapter 7, p. 7.14) methane emissions are assumed to be insignificant in the drained peatlands.
CO_2	4.F Other Land	No default methodology is provided for

	4.F Other Land/4(V) Biomass Burning"	estimation of emissions from biomass burning in other land category therefore it is reported as NE.
CO_2	4.B Cropland/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Total Organic Soils/Drained Organic Soils	Data is not available, inventory of drained soils is ongoing in Lithuania.
CO_2	4.C Grassland/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Total Organic Soils/Drained Organic Soils	Data is not available, inventory of drained soils is ongoing in Lithuania.
N_2O	4.F Other Land 4.F Other Land/4(V) Biomass Burning"	No default methodology is provided for estimation of emissions from biomass burning in other land category therefore it is reported as NE.

Summary of Lithuania's GHG inventory completeness is provided below.

Table 1-6. Summary of GHG inventory completeness

IPCC source and sink categories	CO_2	CH_4	N_2O	HFCs	PFC	SF_6	NF_3
1 Energy							
A Fuel combustion	√	√	√				
1 Energy industries	√	√	√				
2 Manufacturing industries and construction	√	√	√				
3 Transport	√	√	√				
4 Other sectors	√	√	√				
5 Other	√	√	√				
B Fugitive emissions from fuels	√	√	√				
1 Solid fuels	NO	NO	NO				
2 Oil and natural gas	√	√	√				
C CO_2 Transport and storage	NO						
D Memo items							
1 International Bunkers	√	√	√				
2 Multilateral Operations	NO	NO	NO				
3 CO_2 emissions from biomass	√						
4 CO_2 Captured	NO						
2 Industrial processes and product use							
A Mineral products	√						
B Chemical industry	√	NO	√	NO	NO	NO	NO
C Metal production	√	NO	NO	NO	NO	NO	NO
D Non-energy products from fuels and solvent	√	NO	NO				

	use							
E	Electronics industry				NO	NO	√	√
F	Product uses as substitutes for ODS				√	NO	NO	NO
G	Other product manufacture and use	NO	NO	√	NO	NO	√	NO
H	Other	√	NO	NO	NO	NO	NO	NO
3	**Agriculture**							
A	Enteric fermentation		√					
B	Manure management		√	√				
C	Rice cultivation		NO					
D	Agricultural soils		NA	√				
E	Prescribed burning of savannahs		NO	NO				
F	Field burning of agricultural residues		NO	NO				
G	Liming	√						
H	Urea application	√						
I	Other carbon-containing fertilizers	NO						
J	Other	NO	NO	NO				
4	**Land use, land use change and forestry**							
A	Forest land	√	√	√				
B	Cropland	√	√	√				
C	Grassland	√	√	√				
D	Wetlands	√	NO/NE	√				
E	Settlements	√	NO	√				
F	Other land	√	NO/NE	√				
G	Harvested Wood Products	√						
H	Other land	NO	NO	NO				
5	**Waste**							
A	Solid waste disposal on land	NO/NA	√					
B	Biological treatment of solid waste		√	√				
C	Incineration and open burning of waste	√	√	√				
D	Wastewater treatment and discharge		√	√				
E	Other	NO	NO	NO				
6	**Other**	NO	NO	NO	NO	NO	NO	NO

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

2 TRENDS IN GREENHOUSE GAS EMISSIONS

2.1 Description and interpretation of emission trends for aggregated GHG emissions

Total GHG emissions amounted to 20,096.2 kt CO_2 eqv. excluding LULUCF and 13,391.2 kt CO_2 eqv. including LULUCF in 2015. GHG include CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3. The emissions of GHG expressed in kt CO_2 eqv. in 2015 have decreased by 58.2% comparing to the base year excluding LULUCF and by 69.9% including LULUCF. Figure 2-1 shows the estimated total GHG emissions in CO_2 eqv. from 1990 to 2015.

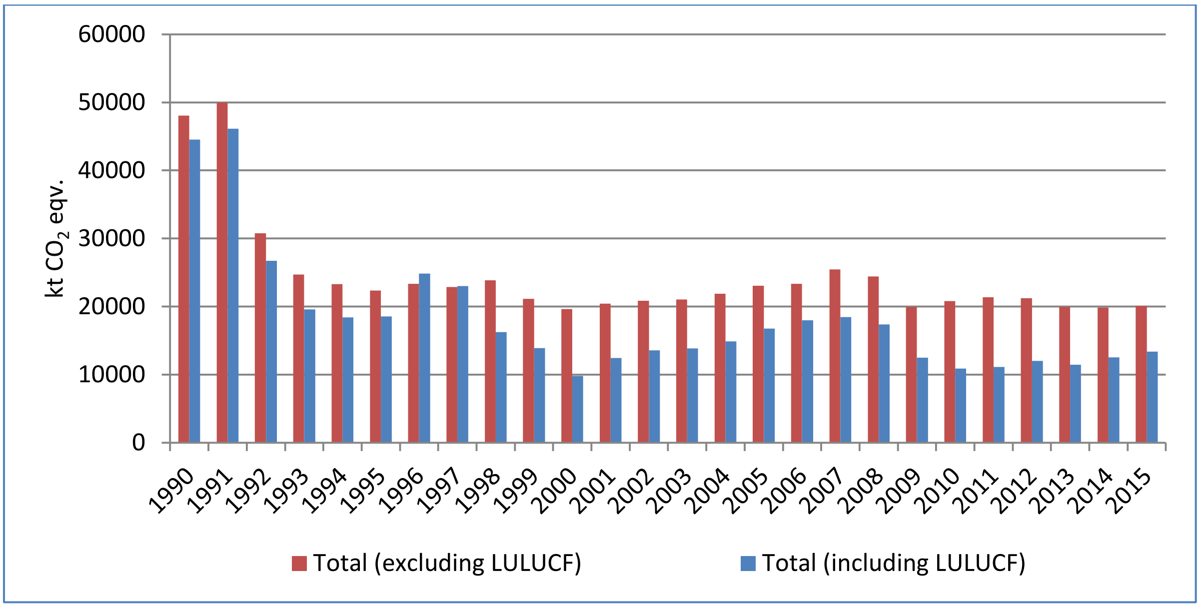


Figure 2-1. Emission trends for aggregated GHG in 1990-2015

The most important greenhouse gas is CO_2 as it contributed 65.4% to the total national GHG emissions expressed in CO_2 eqv. in 2015, followed by N_2O (15.4%) and CH_4 (16.8%). PFCs, HFCs, SF_6 and NF_3 amounted together to 2.4% of the total GHG emissions (excl. LULUCF) in Lithuania.

Upon its independence from the Soviet Union in 1990, after 50 years of annexation, Lithuania inherited an economy with high energy intensity. A blockade of resources, imposed by USSR during 1991-1993 led to a sharp fall in economic activity, as reflected by the decrease of the Gross Domestic Product (GDP) in the beginning of nineties. The economic situation improved in the middle of the last decade and GDP has been increasing until 1999 (during 1999-2000, GDP decreased due to the economic crisis in Russia) and GDP continued increasing from 2001 to 2008. In 2009 GDP decreased due to the world economic crisis and the slight growth of GDP in 2011 was observed 6.1%, in 2012 – 6.6%, in 2013 – 4.9%, in 2014 – 4.5% and in 2015 – 2%. These fluctuations were reflected in the country's emissions of greenhouse gases.

2.2 Description and interpretation of emission trends by sector

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

Energy

Energy sector is the most significant source of GHG emissions in Lithuania with 55% share of the total emissions (excl. LULUCF) in 2015. Emissions from energy include CO_2, CH_4 and N_2O GHG.

Emissions of total GHG from energy sector have decreased almost 3 times from 33,107.7 kt CO_2 eqv. in 1990 to 11,057.1 kt CO_2 eqv. in 2015 (Figure 2-2). Significant decrease of emissions was mainly due to economic slump in the period 1991-1995. During the fast economic growth over the period 2000-2008 GHG emission in energy sector was increasing about 2.5% per annum. The global economic recession had impact on GHG reduction in energy sector by 9.6% in 2009. The closure of Ignalina NPP and GDP increase had impact on greenhouse gas increase by 8% in 2010.

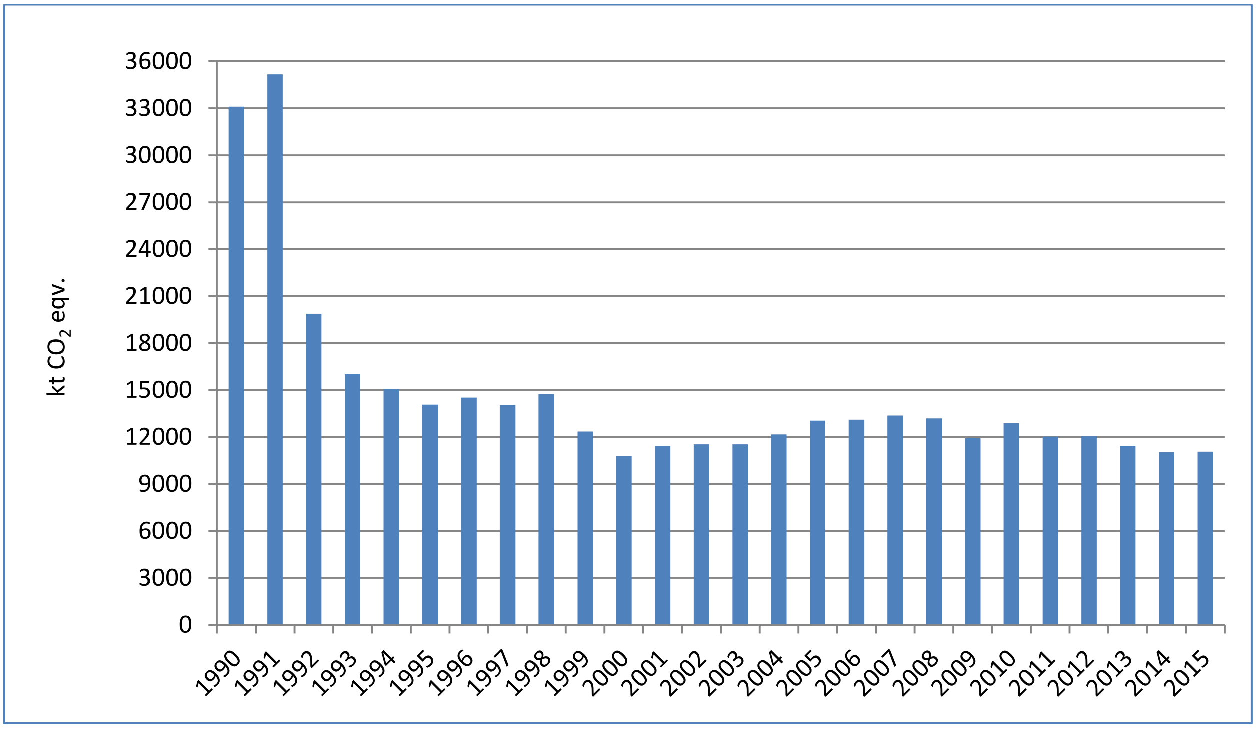


Figure 2-2. Trend of GHG emissions in energy sector during the period 1990-2015

During the period 1990-2015 the share of transport sector significantly increased. In 1990 transport sector accounted for 17.6% of total GHG emission in energy sector whereas in 2015 – 46.2%. This growth is influenced by the rapid increase of the density of transport routes and the number of road vehicles.

The increase of GHG emissions from fugitive is mainly caused by the increase of CH_4 emissions from natural gas distribution, reflecting the increase of the length of natural gas pipelines. Since 2000 GHG emissions from this subsector was increasing by average 3.2% per annum.

Industrial Processes and Product Use

Emissions from industrial processes and product use (referred to as non-energy related ones) amount to 16.9% of the total emissions (excl. LULUCF) in 2015. Emissions from industrial processes and product use include CO_2, N_2O and F-gases emissions. Emissions of total GHG from the industrial processes and product use sector have decreased by 1.3 times from 4,502.7 kt CO_2 eqv. in 1990 to 3,396.6 kt CO_2 eqv. in 2015 (Figure 2-3).

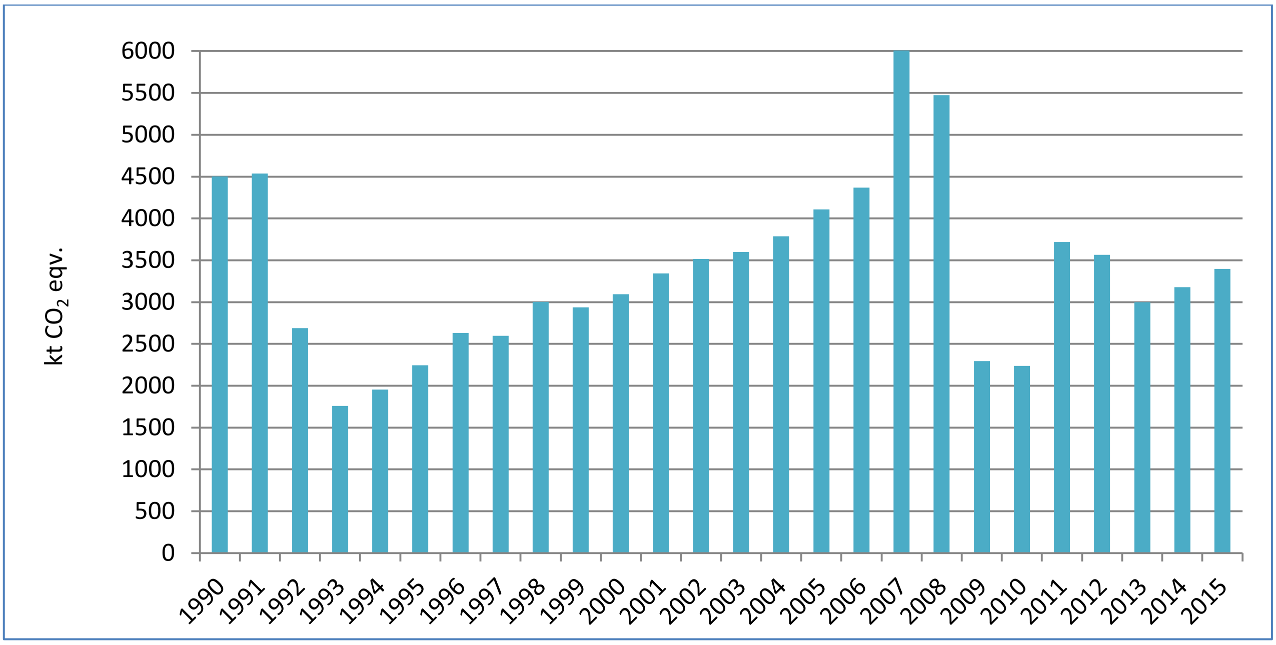


Figure 2-3. Trend of GHG emissions in industrial processes and product use sector during the period 1990-2015

CO_2 emissions from ammonia production contributed 15.3% to the total national CO_2 emissions (excl. LULUCF) in 2015. The lowest emission of CO_2 was in 1993 due to decrease of the ammonia production and the peak of CO_2 emissions were in 2007 when the ammonia production increased. Comparing with 2014 CO_2 emissions increased by 8%.

Nitric acid production is the single source of N_2O emissions in industrial processes sector and accounts for 8.3% in the total national N_2O emissions (excl. LULUCF) in 2015. N_2O emissions had been increasing since 1995 and reached its peak in 2007. After the installation of the secondary catalyst in nitric acid production enterprise in 2008 the emissions of N_2O dropped drastically till 2010 and started to increase because of the increase of production capacity. After 2011 emissions began to decrease because the project ("Nitrous Oxide Emission Reduction Project at GP Nitric Acid Plant in AB Achema Fertiliser Factory) of catalyst installation has been finished. Comparing with 2014 nitric acid production increased by 4.7% however N_2O emissions decreased by 28.6%.

Agriculture

Agriculture sector is the second most important source of greenhouse gas emissions in Lithuania contributing 22.9% to the total GHG emission (excl. LULUCF). The emissions from agriculture sector in 2015 include CH_4, N_2O and CO_2 emissions. Emissions of total greenhouse gases from agriculture sector have decreased 1.9 times from 8,853.5 kt CO_2 eqv. in 1990 to 4,600.3 kt CO_2 eqv. in 2015 (Figure 2-4).

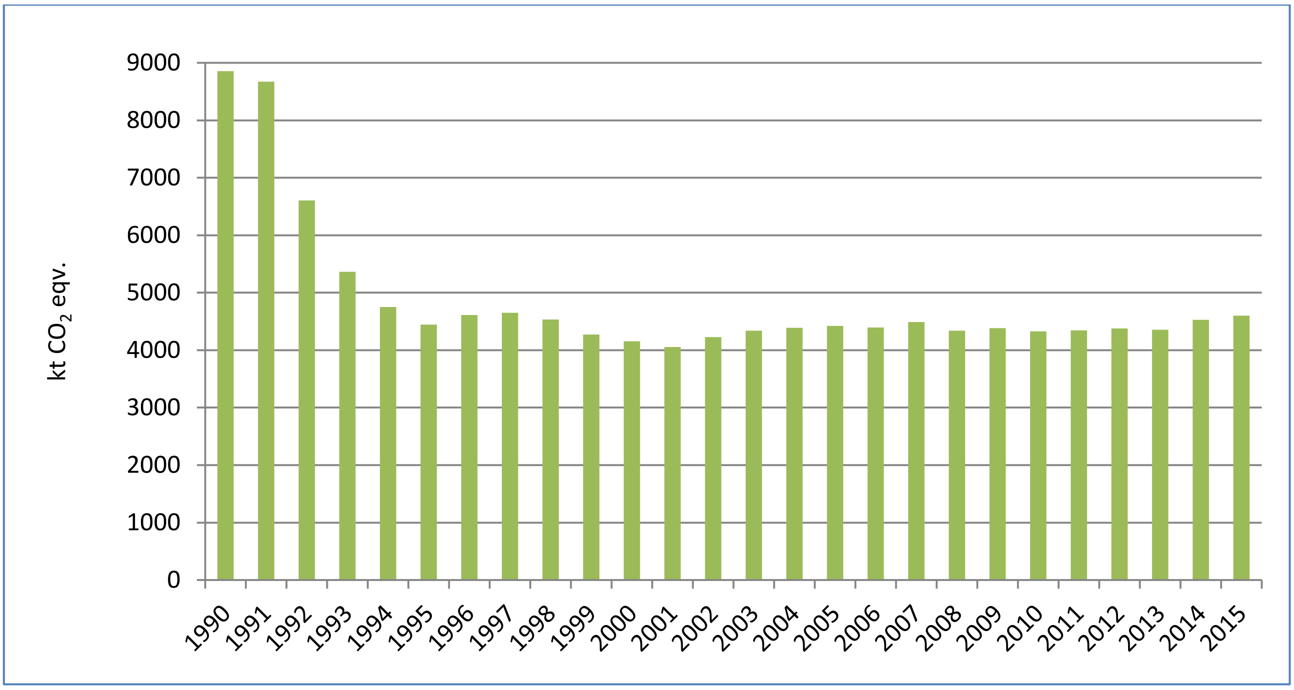


Figure 2-4. Trend of GHG emissions in agriculture sector during the period 1990-2015

Agriculture sector is the most significant source of the CH_4 and N_2O emissions accounting for 56.4% and 85.1% in the total CH_4 and N_2O emissions, respectively. The emissions of CH_4 and N_2O from agriculture sector decreased by 61.2% and 32.4% compare to the base year, respectively. The reduction of CH_4 emissions is caused by the decrease in total number of livestock population.

The major part of the agricultural CH_4 emission originates from digestive processes. Enteric fermentation contributes 48.5%, manure management – 7.9% to the total national CH_4 emissions.

Agricultural soils are the most significant source of N_2O emissions accounting for 78.6% in the total national N_2O emissions.

LULUCF

The Land Use, Land-Use Change and Forestry (LULUCF) sector for 1990-2015 as a whole acted as a CO_2 sink except in 1996 and 1997 when emission constituted to 1,516 kt CO_2 eqv. and 142.8 kt CO_2 eqv. (Figure 2-5). That is explained by sudden spruce dieback that caused huge losses in trees volume, in Lithuania`s spruce stands, which has direct impact on biomass calculations and on CO_2 balance from this sector.

Lower removals from LULUCF sector in 2015 comparing with 2014 has been mainly caused by decreased mean annual volume change from forest land (from 4.7 mill. m^3 in 2014 up to 3.6 mill. m^3 in 2015). For instance, total removals in forest land decreased to 8,898 kt CO_2 in 2015 comparing with 9,262 kt CO_2 removed in the previous year.

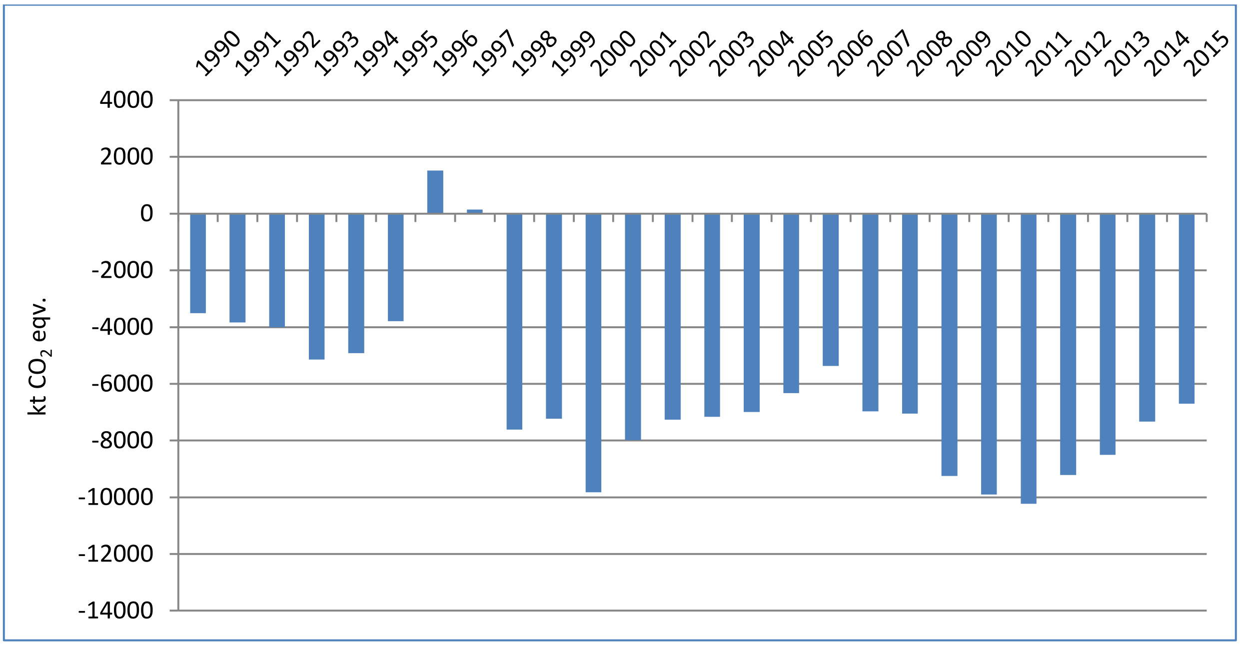


Figure 2-5. Total GHG emissions/removals from LULUCF sector for the period 1990-2015

Waste

The waste sector accounted for 5.2% of the total greenhouse gas emissions in 2015 (excl. LULUCF). The emissions from waste sector in 2015 included CO_2, CH_4 and N_2O emissions. Emissions of the total GHG from waste sector have decreased from 1,576.7 kt CO_2 eqv. in 1990 to 1,042.2 kt CO_2 eqv. in 2015 (Figure 2-6).

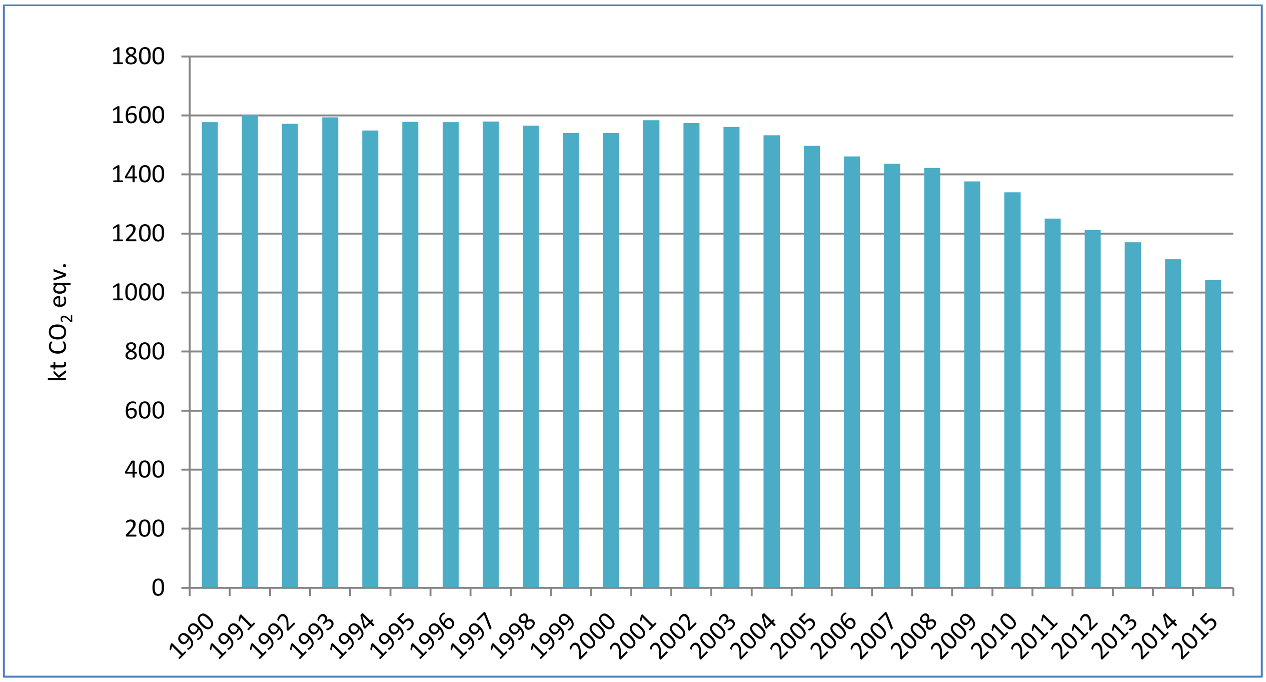


Figure 2-6. Trend of GHG emissions in waste sector during the period 1990-2015

Solid waste disposal on land including disposal of sewage sludge is the largest GHG emission source from waste sector. It contributed around 77% of the total GHG emission from waste sector in 2015 (73.9% excluding disposal of sewage sludge). GHG emissions occurring due to solid waste and sewage sludge disposal on land were increasing slightly from 1990 to 2003 and then started to decrease due to reduction of disposed waste, extraction of landfill gas, anaerobic digestion of sewage sludge.

Certain increase of emissions was observed from 2001 to 2003 and was caused mainly by disposal of large amounts of organic sugar production waste. In later years the producers managed to hand this waste over to farmers for use in agriculture and GHG emissions declined.

Wastewater treatment and discharge contributed around 18.4% of GHG emissions from waste sector in 2015. Wastewater in Lithuania is treated in aerobic treatment systems with minimum CH_4 generation. However, significant part of population still does not have connection to public sewerage systems and emissions from sewage collected from septic tanks are significant.

3 ENERGY (CRF 1)

3.1 Overview of the sector

Sudden political upheaval, after the collapse of the Former Soviet Union, was followed by deep and complicated changes in all sectors of the Lithuanian economy, including Energy sector. Economic slump in Lithuania was comparatively large: at the end of 1994 Lithuanian Gross Domestic Product (GDP) dropped to 56.1% of the 1990 level. Since 1995 country's economy has been gradually recovering (Figure 3-1). Lithuanian GDP decreased by 1.1% 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 8.1% per annum (Statistics Lithuania, Statistical Yearbook of Lithuania, 2008). The impact of global economic recession was dramatic in Lithuania. The global economic crisis had an effect on Lithuanian GDP already in 2008, but GDP growth rate in 2008 was still positive (2.6%). In 2009, GDP decreased by 14.8%. Since 2010 Lithuania's GDP has grown slightly by 1.6% in 2010, 6.0% in 2011 and 3.8% in 2012. During 2013–2014, GDP growth rates slightly slowdown and accounted 3.5% per annum. In 2015, GDP growth rate reduced by two times (to 1.8%). Increased by 6.2% import volume of goods and services and by 0.4% reduced export volume were the key drivers of slacken rate of GDP growth. However, increased governmental (by 0.9%) and households' consumption (by 4.1%) expenditure, as well increased gross capital formation (by 22.7%) contributed to GDP growth in 2015 (Statistics Lithuania, Database of gross domestic product, 2016).

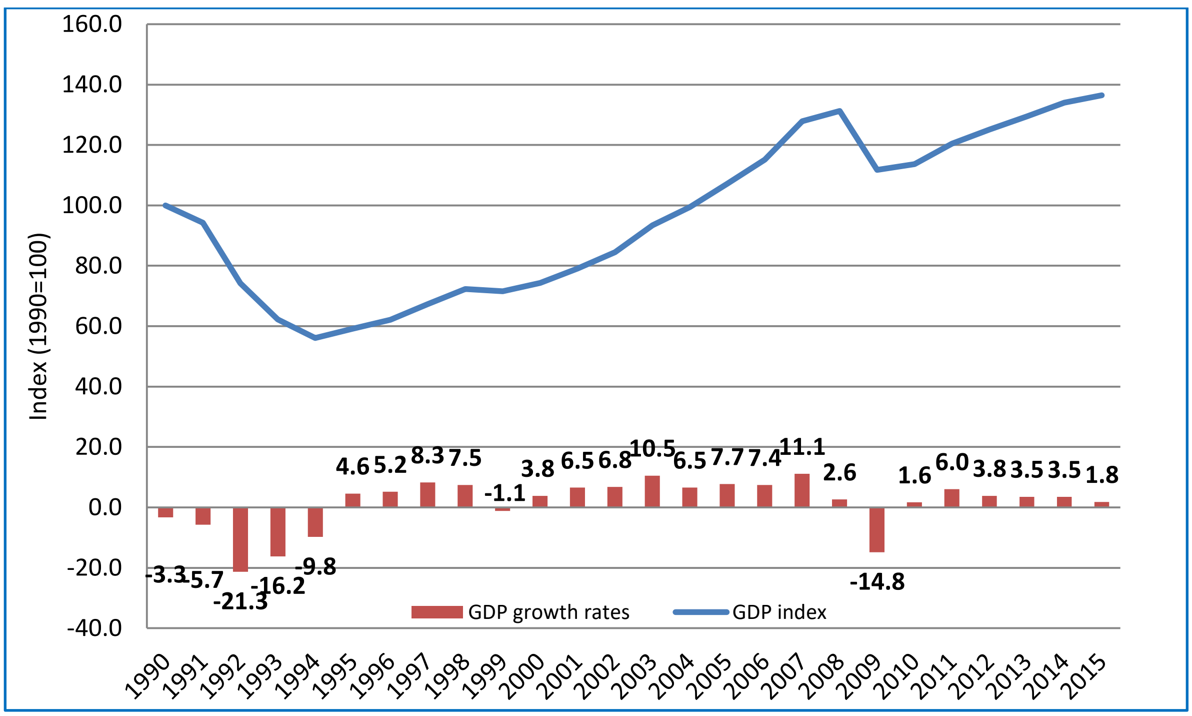


Figure 3-1. Changes of GDP annual growth rates and index in Lithuania

Dynamics of primary energy consumption in Lithuania during 1990-2015 is presented in Figure 3-2. Total primary energy consumption in 1990 amounted to 675.61 PJ (16.14 Mtoe) and in 2015 – 298.78 PJ (7.14 Mtoe). Oil and oil products were the most important fuel in Lithuania over the previous decade. Since 2000 their share in the primary energy balance has been fluctuating about

31.5% with the smallest portion of 25.3% in 2003 and the largest share of 36.4% in 2015. The major factors influencing changes in the role of oil products were decreasing consumption of heavy oil products for production of electricity and district heat and growing consumption of motor fuels in the transport sector. In 2009, due to significant reduction of motor fuel consumption, share of oil products decreased to 28.7%, but in 2010 due to the closure of Ignalina Nuclear Power Plant (NPP) the share of oil products increased to 36.2%. With reference to data of 2015, the share of oil and oil products was 36.4%.

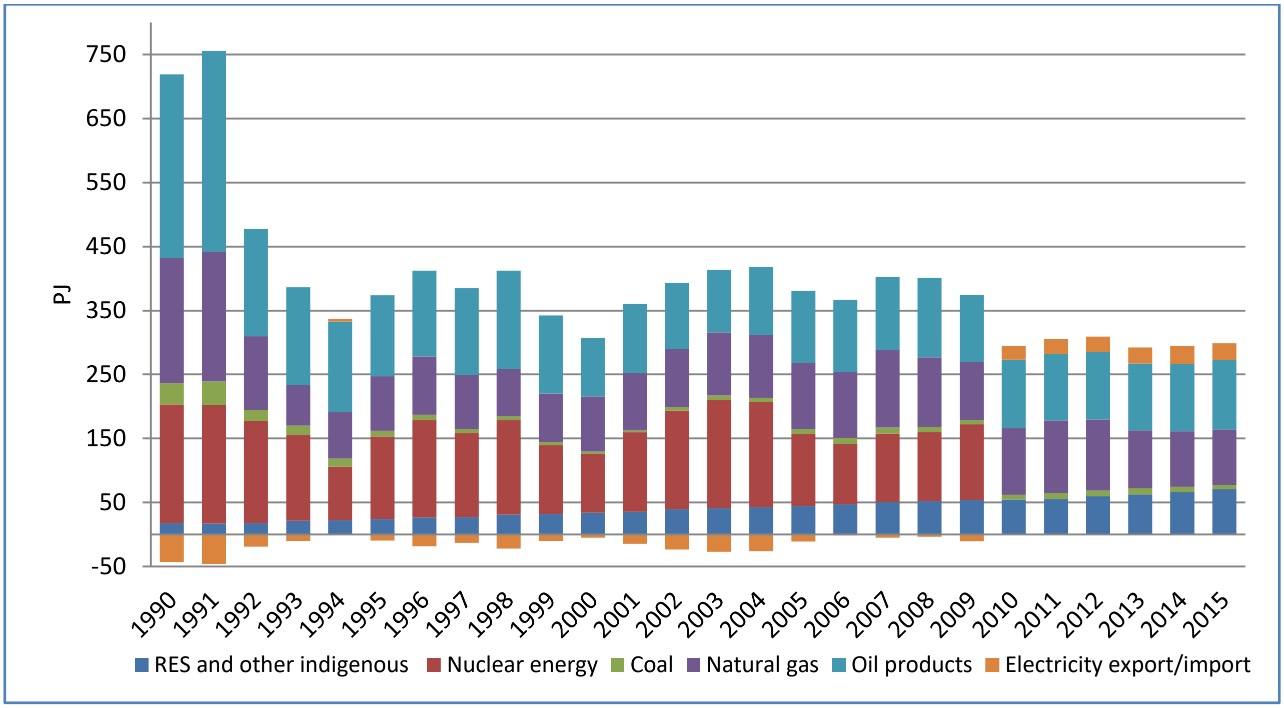


Figure 3-2. Primary energy consumption in Lithuania

At present natural gas is the most important fuel in the Lithuanian primary energy balance. The share of natural gas was fluctuating about 26.9% over the period 2000-2009 with the lowest contribution of 24.6% in 2002 and the largest share of 30.5% in 2007. Total consumption of natural gas decreased owing to reduction of its use for non-energy needs in 2008 and 2009. Consumption of gas for production of mineral fertilizers in 2009 was by 1.9 times less than in 2007. Since the beginning of Lithuanian economy recovery after the global crisis, the share of natural gas increased by 12.8 percentage points, i.e. from 25.1% in 2009 till 37.2% in 2011. The consumption of natural gas started reducing by 6.6% a year since 2011 and, in 2015, its share was 29.0% in the balance of primary energy consumption.

During the period 1990-2009 the share of nuclear energy was very high and fluctuated about 33.3% with the lowest value of 25.0% in 1994 and the highest value of 43.7% 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 32.6%. 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 2014, the share of electricity generated by all Lithuanian power plants was about 37% in the balance of gross electricity consumption and 63% of electricity necessary to meet internal requirements was covered by electricity import. Electricity import in the primary energy balance accounted 8.7% in 2015.

Over the period 2000-2015 the share of coal in the primary energy balance was fluctuating about 2.1%, and in 2015 contribution of this fuel was 2.3%.

Comparison of the primary energy consumption structure in 1990 and in 2015 is presented in Figure 3-3.

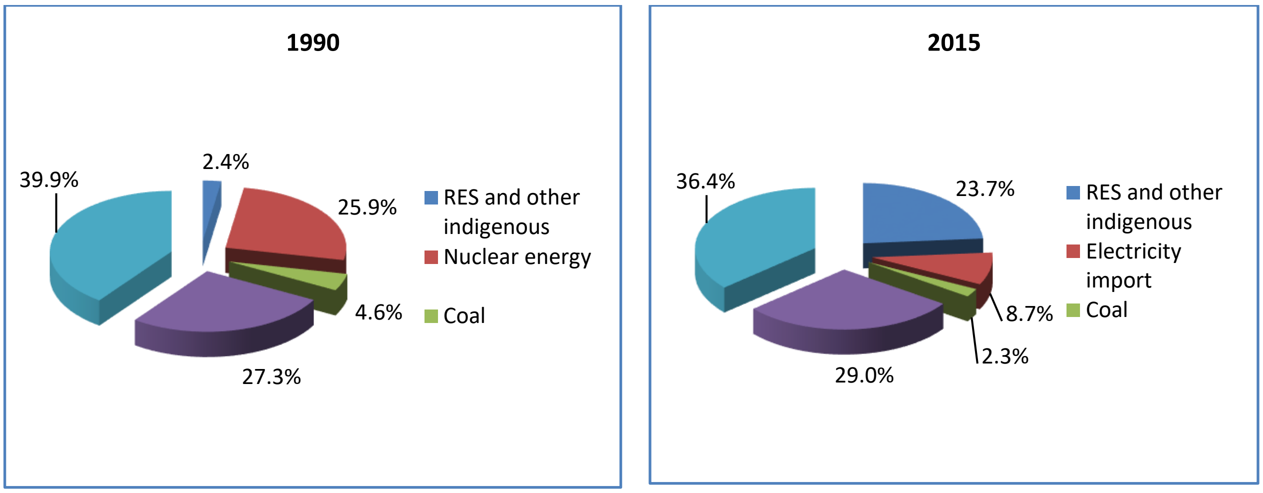


Figure 3-3. Structure of primary energy consumption in Lithuania

Indigenous energy resources in Lithuania are rather scarce. Certain contribution into balance of indigenous resources is originated from local oil, peat and energy of chemical processes. Contribution of renewable energy sources into the country's primary energy balance during the period 1990-2015 was increasing (Statistics Lithuania, Energy balances). During the period 1990-2015 primary energy supply from renewable sources increased by 4.4 times with an average annual growth of 6.1%.

The consumption of renewable energy sources by energy forms are presented in Figure 3-4. Currently the main domestic energy resource is solid biomass. Solid biomass accounted for 84.8% in the balance of renewable energy sources in 2015. The second largest renewable energy source is liquid biomass. In 2015, a share of bioethanol and biodiesel was 4.8%. Wind energy accounted 4.9% of total renewable energy. Hydro power is fluctuating and currently provides 2.1% in the balance of renewable energy sources. The shares of biogas, municipality waste (renewable), solar energy and geothermal energy were 1.7%, 1.1%, 0.4% and 0.1% in 2015, respectively.

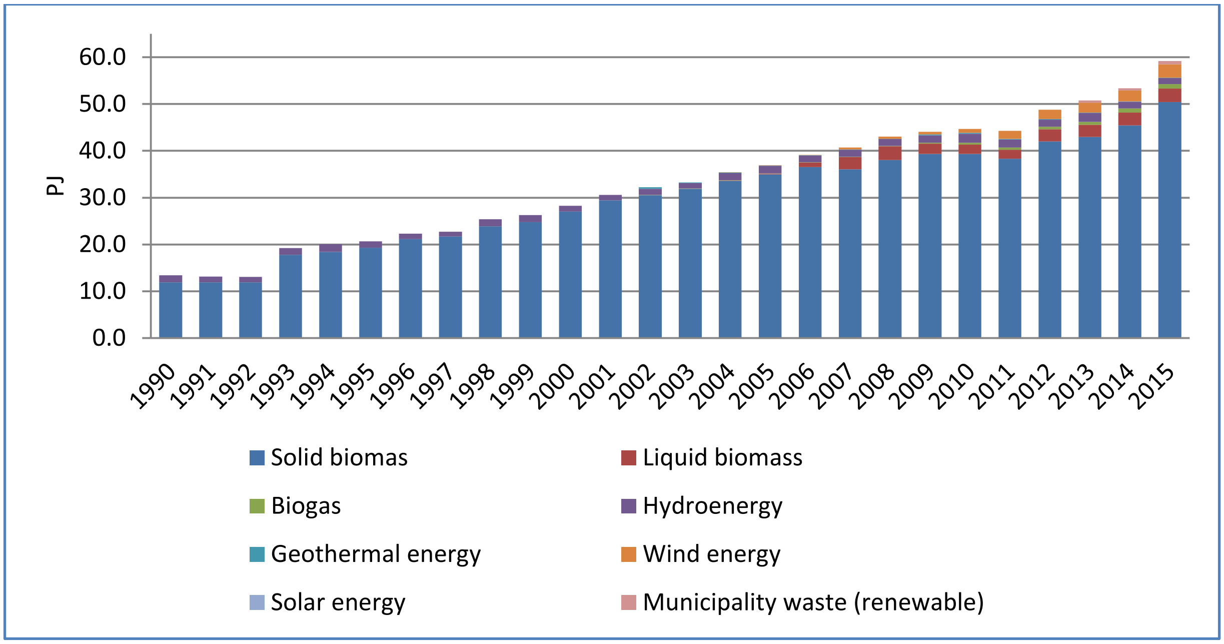


Figure 3-4. Consumption of renewable energy sources in Lithuania

Ignalina NPP played a key role in the Lithuanian energy sector producing up to 70-80% of the electricity. Even after the closure of Unit 1 at the end of 2004 this power plant was dominating in the electricity market – its share in the balance of gross electricity generation in 2009 has been almost 70.7%. Therefore the most important internal changes in the Lithuanian energy sector in 2010 are related with the final closure of Ignalina NPP (Figure 3-5). After the closure of Ignalina NPP Lithuanian Thermal Power Plant (Lithuanian TPP) is the major electricity generation source. Lithuanian TPP can cover up to 50-60% of the gross internal consumption. But the cost of electricity production at this power plant is high due to high price of natural gas. Thus, currently more than half of required electricity is imported from neighbouring countries.

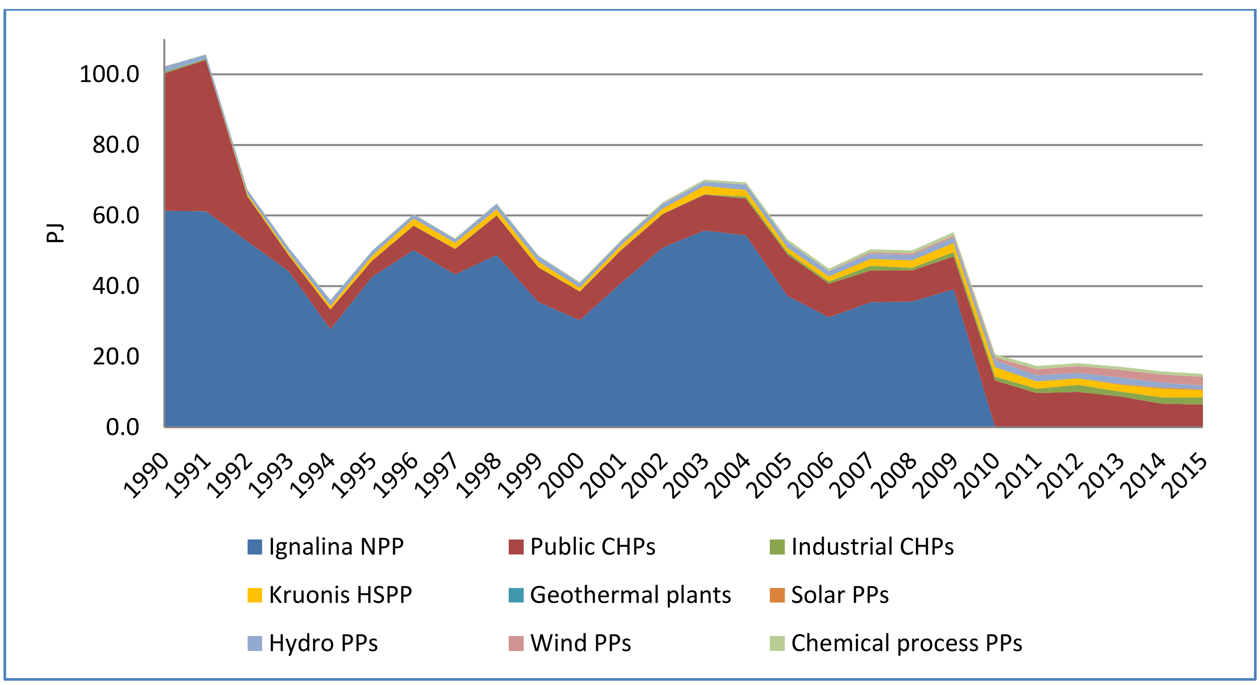


Figure 3-5. Structure of electricity generation in Lithuania

Baltic Energy Market Interconnection Plan (BEMIP) was signed in 2009 seeking to diverse and ensure the electricity supply to the Baltic States. Connecting the Lithuania, Latvia and Estonia to neighbouring EU countries and the internal market is the main priority of the BEMIP Action Plan. This priority requires the full implementation of the internal market rules in order to enable the three Baltic States to participate into the EU electricity market. Interconnection between Lithuania and Poland (project LitPol Link) is fully in line with the EU energy policies and National energy strategies in the region. The 500 MW power link connecting Lithuania and Poland was put into operation in December 2015. By 2020, the LitPol Link will start operating at a 1,000 MW capacity.

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

Taking into consideration general EU energy policy, 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 portfolio became more diversified and renewable electricity generation volume was increasing on average by 11.3% per year. In 2015, electricity generation from renewable energy sources was dominated by wind power, generating about 48.2%, hydro power, producing 20.8%, and biomass, biogas and municipality waste, about 26.6%, of green electricity. Solar electricity contribution to the structure of green electricity production was 4.4% in2015. Totally 6.05 PJ (1679.8 GWh) of green electricity was produced in2015.

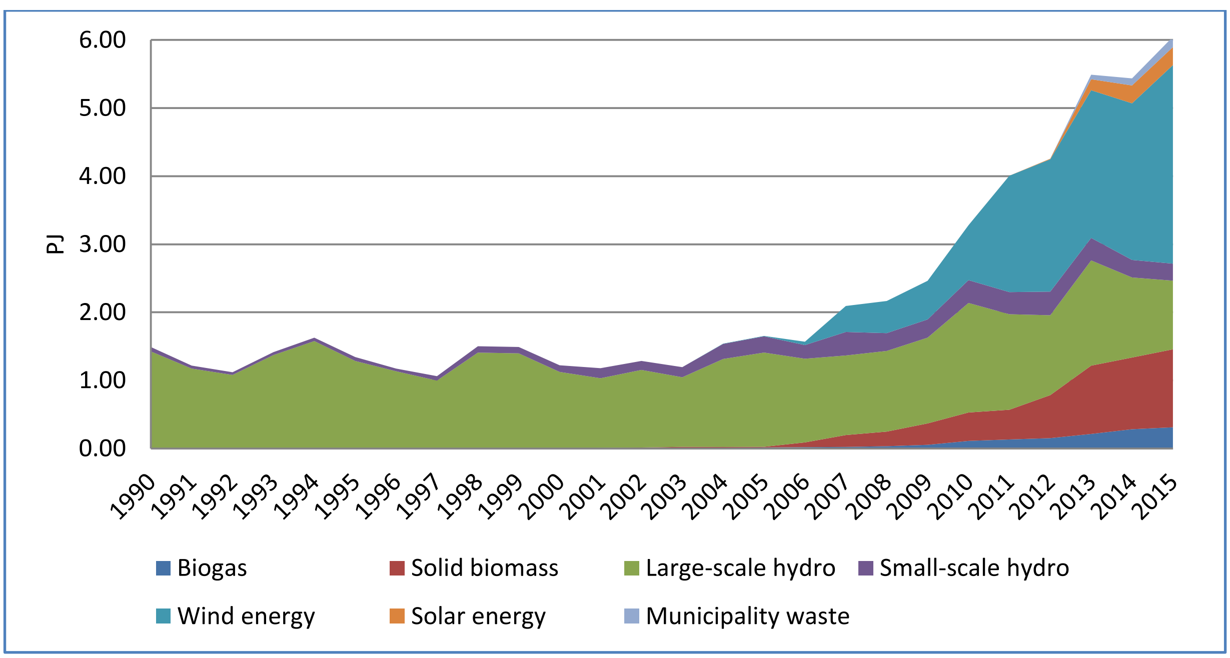


Figure 3-6. Green electricity production in Lithuania

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 405,26 PJ (9.68 Mtoe). In 1991-1994 final energy consumption decreased approximately by 2 times (Figure 3-7). During the period 2000-2008 the final energy consumption was increasing by 3.8% per annum, and in 2008 it was 212.1 PJ (5.1 Mtoe) (Statistics Lithuania, Energy balances). During this period the final energy consumption was increasing in all sectors of the national economy.

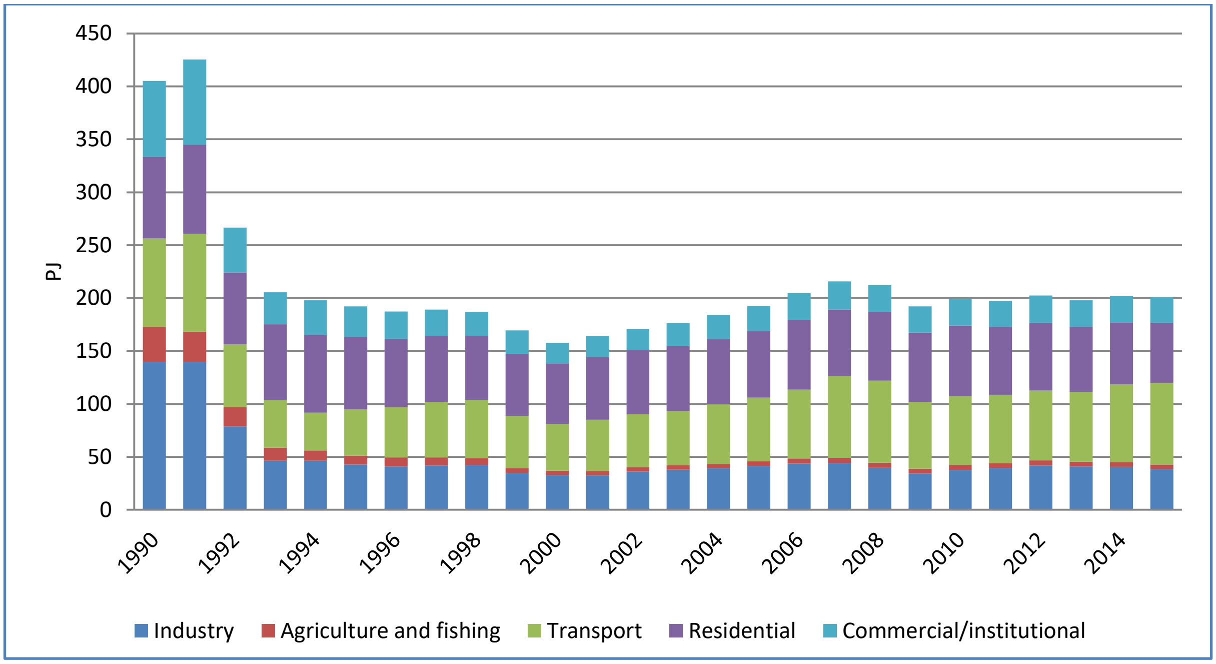


Figure 3-7. Final energy consumption in Lithuania

In 2009, total final energy consumption was by 9.4% less than in the previous year, and the most severe impact of the economic recession was in the construction sector where energy consumption decreased by 34.9%. Energy consumption decreased in the transport sector by 18.5%. As a result of recovering Lithuanian economy, final energy consumption increased by 3.6% in 2010. However, in 2011 the final energy consumption reduced by 0.9% and amounted to 199.12 PJ (4.76 Mtoe). This decrease was mainly caused by reduced energy consumption in transport, residential and commercial/institutional sectors. During 2012-2015 the final energy consumption remains rather stable. In 2015, it amounted to 200.9 PJ (4.80 Mtoe). This is by 0.5% less than in 2014.

During the transition to market economy period significant improvements in the energy efficiency has been achieved due to replacement of the old energy intensive technologies by the new innovative technologies in the industry and implementation of various energy efficiency improvement measures in other sectors of the economy. During 2000-2015 period the final energy consumption and the final electricity consumption was growing slower than the GDP was increasing (Figure 3-8).

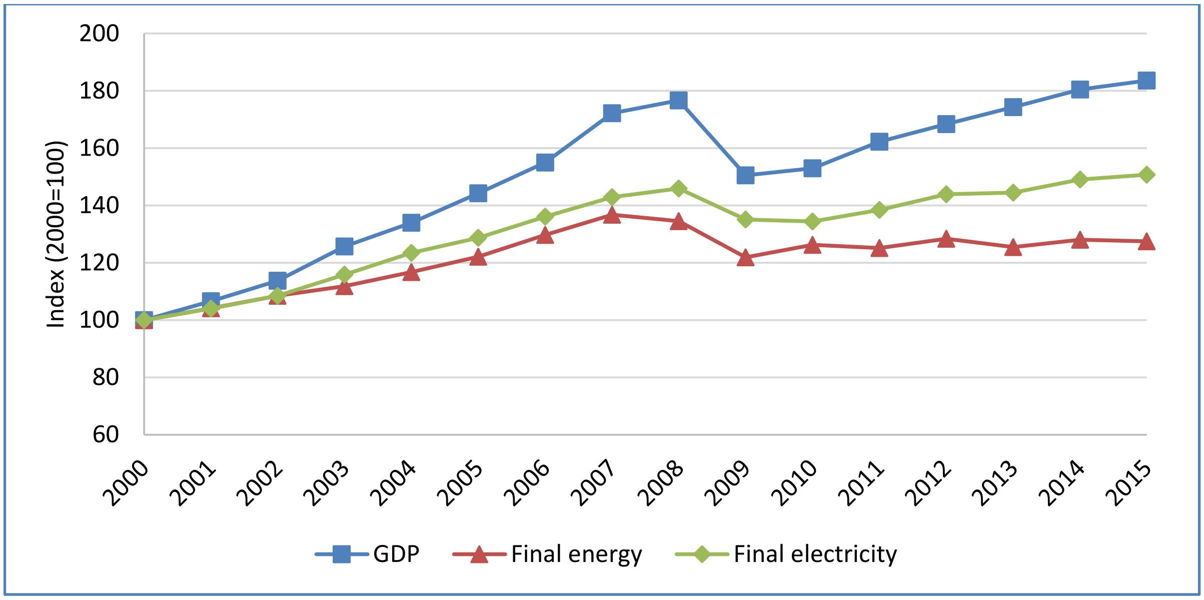


Figure 3-8. GDP, final energy and final electricity growth index

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

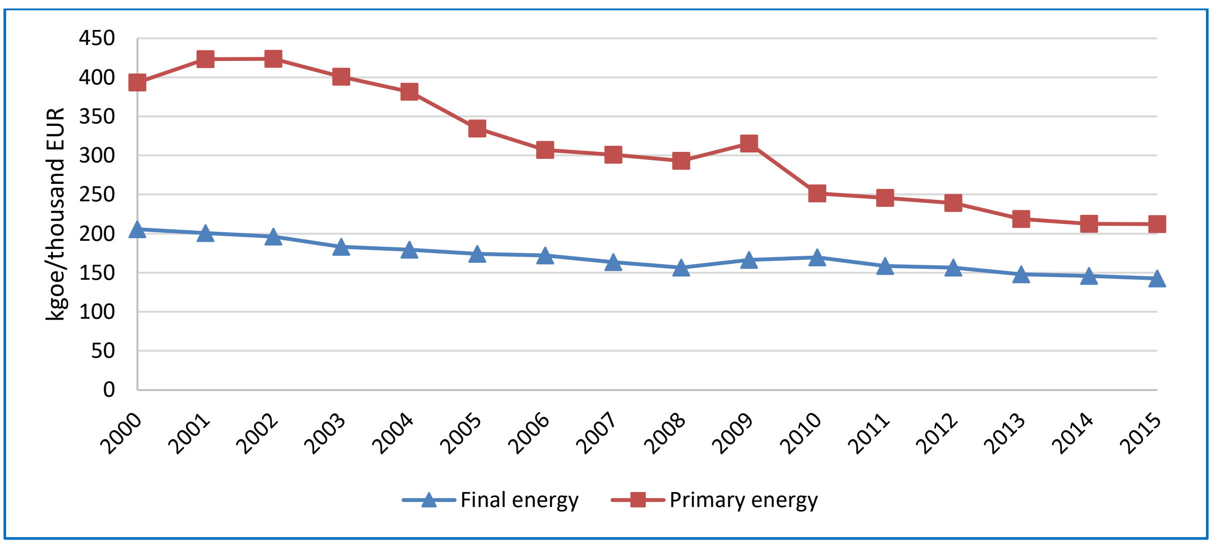


Figure 3-9. Changes in primary and final energy intensity

Substantial changes in the power sector and the above mentioned changes in the primary energy balance has led to a very significant reduction in the primary energy intensity. In 2015 the primary energy intensity made 69.4% of the 2000 level. The final energy intensity decreased by 30.6% - from 205.58 kgoe/thous. EUR in 2000 to 142.64 kgoe/thous. EUR in 2015. A further reduction in primary energy intensity depends very much on the efforts to reduce the final energy intensity, i.e.

on the successful implementation of the energy efficiency measures in the respective branches of the economy.

Several emission sources in the Energy Sector are key categories. Key categories in 2015 by level (L) and trend (T) are listed in Table 3-1.

Table 3-1. Key category from Energy Sector in 2015

IPCC Category	***Greenhouse gas***	***Identification criteria***	***Comments****
1.A.1 Energy industries-Other fossil fuels	CO_2	T1	
1.A.1 Energy industries-Solid fuels	CO_2	T1	
1.A.1 Energy industries-Biomass	N_2O	T2	
1.A.1 Energy industries-Biomass	CH_4		T2sub
1.A.1.a Public electricity and heat production - Gaseous Fuels	CO_2	L1,T1,T2	
1.A.1.a Public electricity and heat production - Liquid Fuels	CO_2	L1,T1, T2	
1.A.1.b Petroleum refining - Liquid Fuels	CO_2	L1,T1	
1.A.1.c Manufacture of solid fuels and other energy industries - Gaseous fuels	CO_2		T1sub
1.A.2 Manufacturing industries and construction-Gaseous fuels	CO_2	L1,T1	
1.A.2 Manufacturing industries and construction-Liquid fuels	CO_2	T1,T2	
1.A.2 Manufacturing industries and construction-Solid fuels	CO_2	L1,T1	
1.A.3.b Road transportation	CO_2	L1,T1,T2	
1.A.3.c Railways	CO_2	L1, T1	
1.A.4 Other sectors-Biomass	CH_4	L1,L2,T1,T2	
1.A.4 Other sectors-Biomass	N_2O		L2sub, T2sub
1.A.4 Other sectors-Gaseous fuels	CO_2	L1,T1	
1.A.4 Other sectors-Liquid fuels	CO_2	L1,T1, T2	
1.A.4 Other sectors-Liquid fuels	N_2O	T1	
1.A.4 Other sectors-Peat	CO_2		T1sub
1.A.4 Other sectors-Solid fuels	CO_2	L1,T1,T2	
1.A.4 Other sectors-Solid fuels	CH_4		T2sub
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	L1,T1	

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

In the Energy sector emissions of CO_2 contribute about 94% of total greenhouse gas emissions CO_2 eqv. in 2015. Trends of total GHG emissions calculated as CO_2 equivalents from the energy sector are presented in Figure 3-10. Total greenhouse gases (GHG) from the energy sector have decreased by almost 3.0 times from 33,107.7 kt CO_2 eqv. in 1990 to 11,073.9 kt CO_2 eqv. in 2015. 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 emissions 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 8.0% in 2010. In 2011, total GHG emissions in Energy sector decreased by 7.0%. This trend was stipulated by almost 16.3% decrease of GHG emissions in public electricity and heat production sector due to increased share of electricity import from neighbouring countries, increased use of renewable energy sources and natural gas. The level of total GHG emissions in Energy sectors in 2012 remain almost the same as in 2011. In 2013, total GHG emissions in Energy sector decreased by 5.3% and in 2014 by 3.2% due to high share of electricity import and increased use of renewable energy sources. In 2015, total GHG emissions in Energy sector increased by 0.03% due to increasing trend of GHG in transport sector.

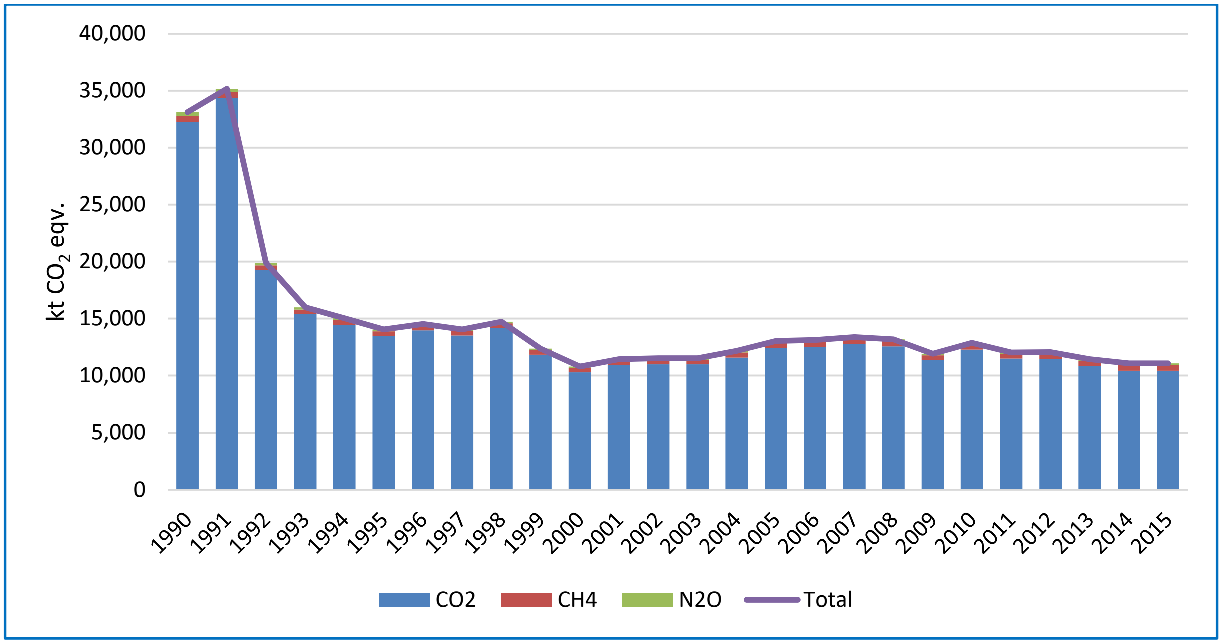
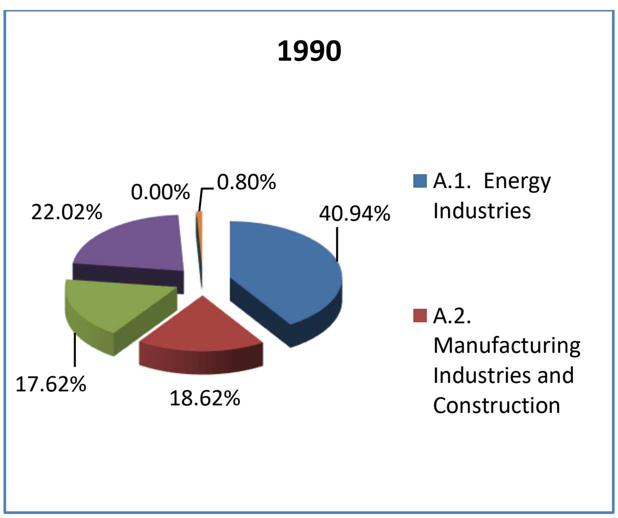


Figure 3-10. Trends of total GHG emissions from the Energy Sector (CRF 1), kt CO_2 eqv.

Changes in structure of GHG emissions in energy sector showed in Figure 3-11. Historically the 1.A.1 Energy industries accounted for the largest share of GHG emissions from Energy Sector (40.94% in 1990). In 2015, this source category decreased till 28.49% of total GHG emissions from energy sector. During the period 1990-2015 the share of transport sector increased significantly. In 1990 transport sector accounted for 17.62% of total GHG emissions from Energy Sector and in 2015 – 46.34%. In 2015 transport accounted the largest share of GHG emissions from Energy sector.



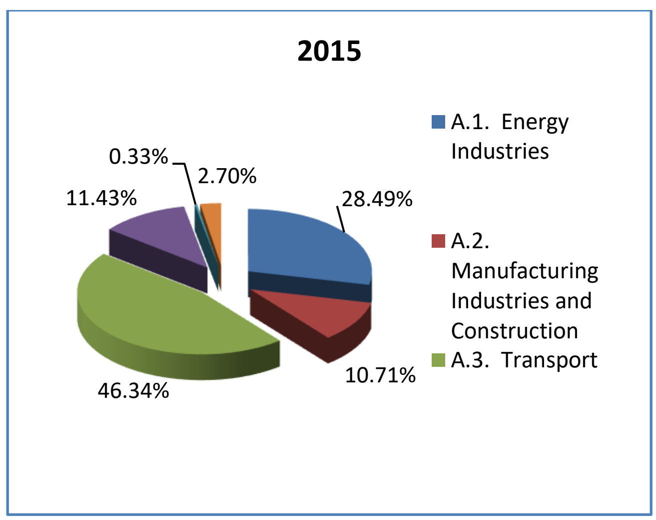


Figure 3-11. Structure of GHG emissions from Energy Sector in 1990 and 2015

The trends of GHG emissions calculated as CO_2 equivalent from different subsectors within the Energy Sector are presented in Figure 3-12. The most important subsector regarding total emissions 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 emissions increase in this subsector. In 2010 GHG emissions increased by approximately 11.5% in energy industries. In 2011 GHG emissions in energy industries reduced by almost 16.3%, in 2012 - by 1.1%, in 2013 – 12.7%, in 2014 – 17.8% and 2015 – 0.4%. Since 2013 transport sector become one of the most important source of GHG emissions in energy sector. After the global economic crisis GHG emissions in transport sector are increasing quite significantly, about 2.3% per annum. Growing activities in the Manufacturing industries and construction sector stipulated increase in GHG emissions during 2009-2012, but GHG emissions in this sector decreased by 8.6% in 2014 and by 9.4% in 2015. An increase took place in Other sectors (1.A.4). Since 2000 GHG emissions in this subsector was growing about 2.1% per annum. Such increase was mainly stipulated by significant growth of natural gas and coal consumption in residential and commercial/institutional subsectors. However, since 2011 GHG emissions in Other sectors started to decrease by almost 4.5% per year mainly due to implemented energy efficiency measures and increased share of biomass consumption.

Trends of GHG emissions from 1.B Fugitive emissions from fuels are mainly caused by the CH_4 emissions from natural gas transmission and distribution. Since 1990 GHG emissions from this subsector increased by 12.3%. In 2015 fugitive emissions accounted 298.5 kt CO_2 eqv.

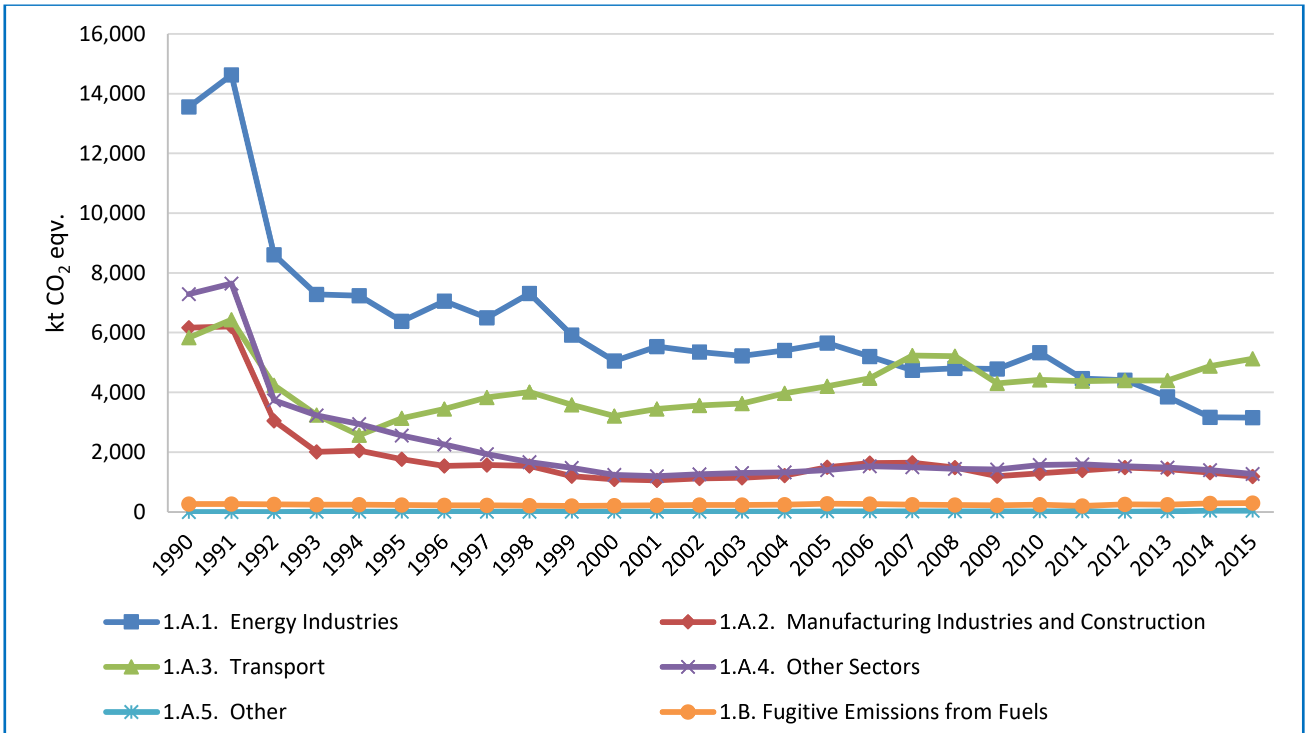


Figure 3-12. Total GHG emissions from the different subsectors within the Energy Sector, (CRF 1), kt CO_2 eqv

3.2 Fuel combustion (CRF 1.A)

Fuel Combustion category (CRF 1.A) comprises following sources:

- Fuel Combustion – Sectoral Approach (CRF 1.A.A)
  - o Energy Industries (CRF 1.A.A.1)
  - o Manufacturing Industries and Construction (CRF 1.A.A.2)
  - o Transport (CRF 1.A.A.3)
  - o Other Sectors (CRF 1.A.A.4)
  - o Non-Specified (CRF 1.A.A.5)
- Fuel Combustion – Reference Approach (CRF 1.A.B.)
- Difference - Reference and Sectoral Approach (CRF 1.A.C)
- Feedstocks and non-energy use of fuels (CRF 1.A.D)

This chapter gives an overview of emissions and key sources of fuel combustion activities, includes information on completeness, QA/QC, planned improvements as well as on emissions, emissions trends and methodologies applied (including emission factors). Furthermore, information on sectoral/reference approach and feedstocks/non-energy use of fuels is given in this sector. Additionally to information provided in this Chapter, Annex III includes information on the activity data used for emissions estimation, i.e. national energy balance data are presented and Annex IV includes summary of study on "Update of country specific GHG emission factors for Energy sector" (fuel combustion) performed by Lithuanian Energy Institute in April 2016. This study includes updated values of country specific CO_2 emission factors and default emission factors (CH_4 and N_2O) based on *2006 IPCC* methodology.

3.2.1 Comparison of sectoral approach with the reference approach

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

Differences between sectoral and reference approach were estimated for fuel consumption and CO_2 emissions. Figure 3-13 shows comparison of CO_2 emissions estimates for the two approaches for the period 1990–2015.

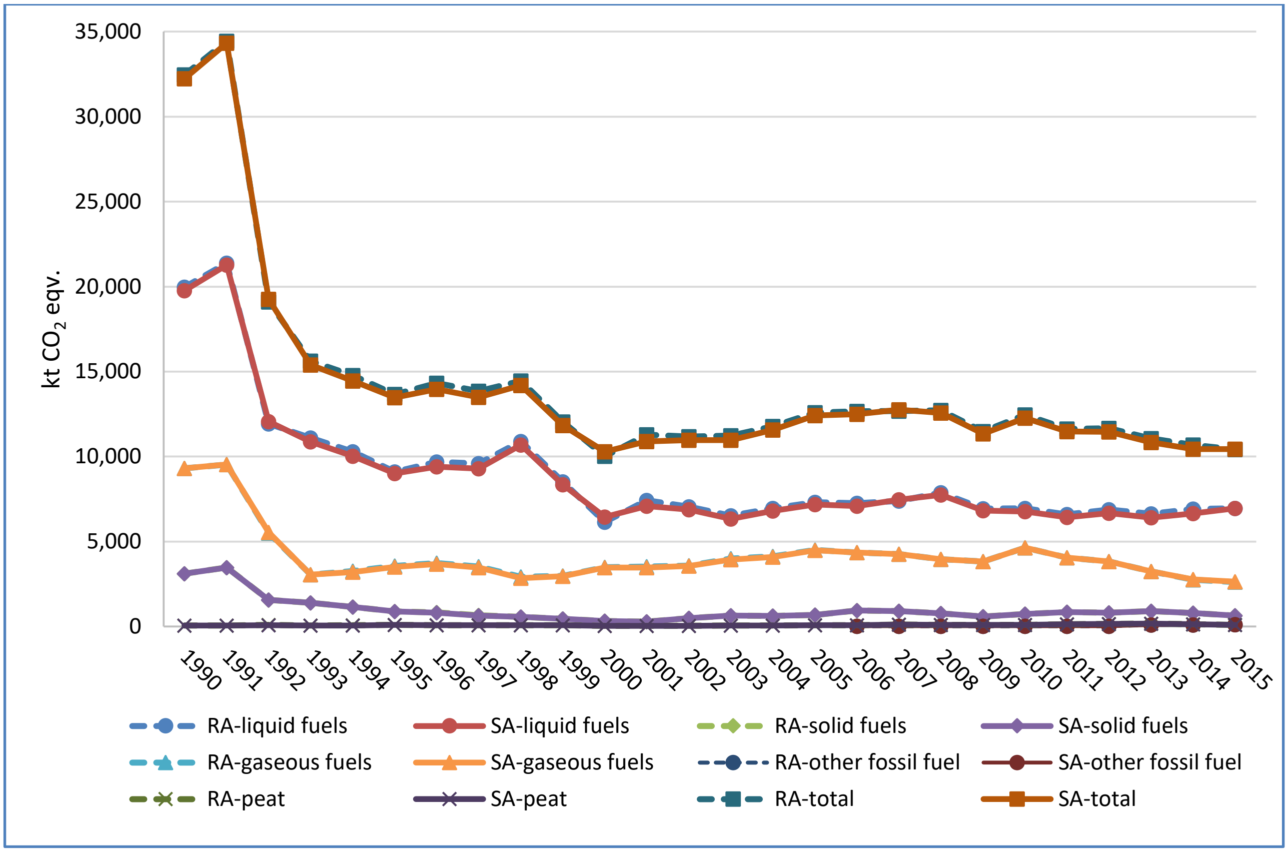


Figure 3-13. Comparison of CO_2 emissions between sectoral and reference approach

Figure 3-13 shows that the differences for CO_2 emissions are very closely correlated. Table 3-2 presents CO_2 emissions of sectoral and reference approach.

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

	Reference approach						**Sectoral approach**					
Year	**Liquid**	**Solid**	**Ga-seous**	**Other fossil fuel**	**Peat**	**Total**	**Liquid**	**Solid**	**Ga-seous**	**Other fossil fuel**	**Peat**	**Total**
1990	19,983	3,106	9,314	-	57	32,460	19,770	3,106	9,307	-	56	32,239
1995	9,110	884	3,571	-	90	13,655	9,012	882	3,498	-	89	13,481
2000	6,151	326	3,495	-	46	10,019	6,441	325	3,472	-	46	10,284
2001	7,429	287	3,528	-	46	11,290	7,095	286	3,471	-	46	10,898
2002	7,042	496	3,590	-	46	11,173	6,879	492	3,554	-	46	10,970
2003	6,522	649	3,991	-	61	11,223	6,326	645	3,936	-	58	10,964
2004	6,957	622	4,137	-	58	11,773	6,812	621	4,088	-	56	11,576
2005	7,320	683	4,507	-	70	12,581	7,173	682	4,484	-	70	12,409
2010	6,953	736	4,640	18	103	12,450	6,768	735	4,645	18	103	12,270
2011	6,590	845	4,051	21	125	11,632	6,436	844	4,058	21	125	11,484
2012	6,878	804	3,822	23	144	11,670	6,668	803	3,829	23	144	11,467
2013	6,639	913	3,239	97	177	11,065	6,403	912	3,248	97	177	10,837
2014	6,909	787	2,755	92	133	10,677	6,660	785	2,766	92	133	10,437
2015	6,962	647	2,617	114	88	10,429	6,950	646	2,635	114	88	10,434

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

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

Year	Liquid fuels, %	Solid fuels, %	Gaseous fuels, %	Other fossil fuel, %	Peat, %	Total, %
1990	1.07	0.00	0.08		1.69	0.69
1995	1.08	0.27	2.09		1.17	1.29
2000	-4.51	0.35	0.67		1.51	-2.58
2005	2.05	0.10	0.52		0.99	1.38
2010	2.72	0.12	-0.11	0.00	0.00	1.47
2011	2.39	0.10	-0.16	0.00	0.00	1.29
2012	3.14	0.11	-0.17	0.00	0.00	1.78
2013	3.68	0.11	-0.28	0.00	0.00	2.10
2014	3.75	0.23	-0.39	0.00	0.00	2.31
2015	0.17	0.16	-0.68	0.00	0.00	-0.05

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

During previous reviews 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 emissions estimates in the sectoral approach and in the reference approach are based on activity data which is provided by the Lithuanian Statistics using the same NCV. According to the *2006 IPCC Guidelines* "fuel statistics collected by an officially recognised national body are usually the most appropriate and accessible activity data".

3.2.2 International bunker fuels

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

Table 3-4. Emission factors used for International bunkers

	CO2, t/TJ	EF	CH4, t/TJ	EF	N2O, t/TJ	EF
International navigation						
Gas/diesel oil	72.89 72.73*	CS	0.007	D	0.002	D
Residual fuel oil	77.60 78.40*	CS	0.007	D	0.002	D
International aviation						
Jet kerosene	72.24 71.74*	CS	0.0005	D	0.002	D

CS - country specific emission factors;
D - default emission factors (*2006 IPCC Guidelines*);
* - CS emission factors applied from 2015 based on the results of 2016 study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute (values of country specific CO_2 EFs for gas/diesel oil, jet kerosene, residual fuel oil were determined in the basis of measurements performed by the accredited Laboratory of Quality Research Centre of JSC ORLEN Lietuva). Summary of the study is presented in Annex IV.

Summary of study on "Update of country specific GHG emission factors for Energy sector" is presented in Annex IV. Seeking to ensure higher accuracy of GHG inventory it is valuable to apply the updated CO_2 emission factors for a period after 2015 and for a period 1990-2014 to use the emission factors determined in the study of 2012 (as presented in Annex IV).

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

Table 3-5. GHG emissions and activity from 1.D International bunkers-navigation 1990-2015

Year	Activity data, TJ	CO_2, kt	CH_4, kt	N_2O, kt
1990	3,894	302.2	0.027	0.008
1995	5,780	448.5	0.040	0.012
2000	3,828	292.6	0.027	0.008
2005	5,933	456.8	0.042	0.012
2010	5,781	445.0	0.040	0.012
2011	5,883	452.4	0.041	0.012
2012	5,006	384.5	0.035	0.010
2013	3,626	278.7	0.025	0.007
2014	477	35.4	0.003	0.001
2015	3,196	240.7	0.022	0.006

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

Table 3-6. GHG emissions and activity from 1.D International bunkers-aviation 1990–2015

Year	Activity data, TJ	CO_2, kt	CH_4, kt	N_2O, kt
1990	5,522	398.9	0.003	0.011
1995	1,622	117.2	0.001	0.003
2000	972	70.2	0.000	0.002
2005	1,923	138.9	0.001	0.004
2010	2,012	145.3	0.001	0.004
2011	2,311	166.9	0.001	0.005
2012	2,634	190.3	0.001	0.005
2013	2,922	211.1	0.001	0.006
2014	3,241	234.1	0.002	0.006
2015	3,416	245.1	0.002	0.007

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

3.2.3 Feedstocks and non-energy use of fuels

Feedstocks and non-energy use of fuel are included in national Energy balances (see Annex III). Use of fuels for feedstocks and non-energy use is dominated by natural gas (Figure 3-14). In 2015, natural gas amounted about 84.3% in the structure of feedstocks and non-energy use of fuels.

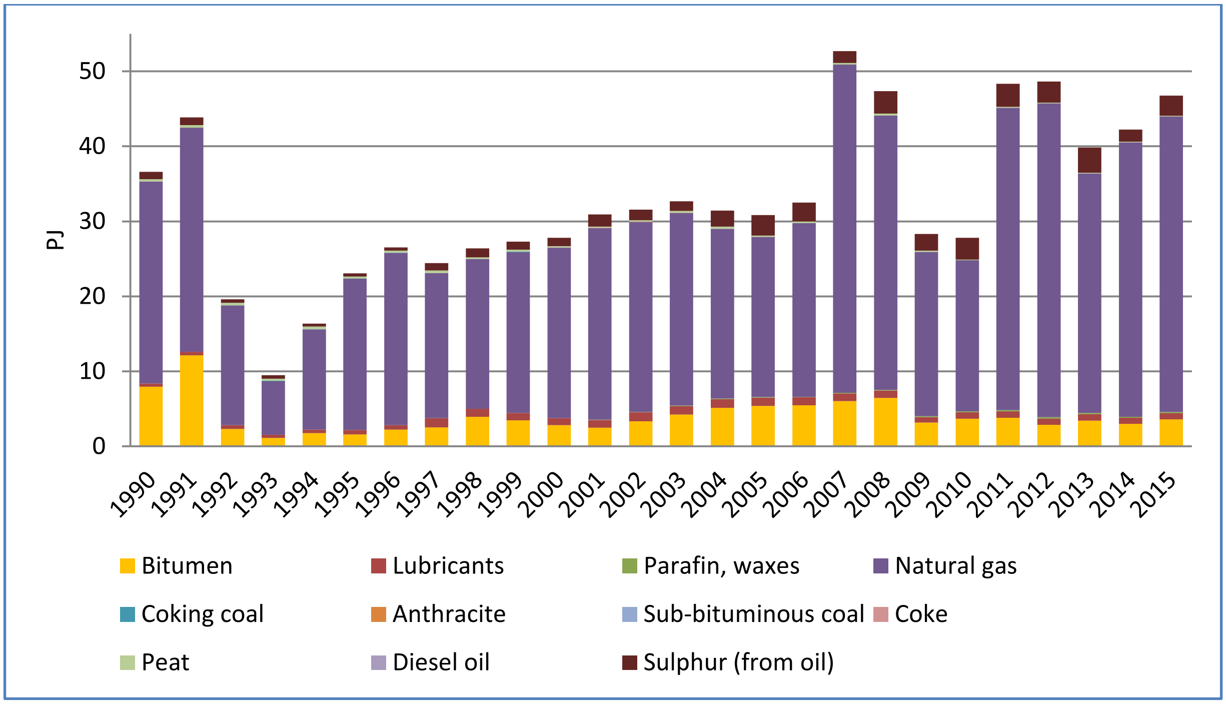


Figure 3-14. Feedstocks and non-energy use of fuels in Lithuania

The natural gas is used for ammonia, calcium ammonium nitrate, organic products and nitric acid production in the JSC Achema. JSC Achema is a leading manufacturer of nitrogen fertilizers and chemical products in Lithuania and the Baltic states. The previous ERT recommended to cross-check the data reported as non-energy use in the energy sector and the data reported under the industrial processes as the calculated CO_2 non-emitted from the use of natural gas for non-energy purpose differs from CO_2 emissions from ammonia production. A cross-check between the natural gas data used in industrial processes and the data reported as non-energy use in the energy sector showed that difference occur due to the use of different calorific values for the natural gas. In the industrial processes sector a specific calorific value is based on average annual lower calorific value of natural gas which is calculated on the basis of reports from the natural gas supplier AB Lietuvos dujos, which measure the calorific value twice a month. In the energy sector calculations are based on the data provided by the Lithuanian Statistics where fuel consumption is calculated in terms of tonnes of oil equivalent and terajoules using the net calorific value. The data reported as non-energy use in the energy sector and the data reported under the industrial processes also differs because the data reported as non-energy use in the energy sector accounts not only feedstocks for ammonia production, but also feedstocks for calcium ammonium nitrate, organic products and nitric acid production. It is necessary to mentioned that JSC Achema revised data for non-energy use for 2005-2014 in 2016, therefore in this submission revised data are reported in CRF 1.AD Feedstocks, reductants and other non-energy use of fuels.

The amounts of excluded carbon were calculated in accordance with the methodology provided in *2006 IPCC Guidelines* Volume 2 (page 6.7). The amounts of excluded carbon are reported in CRF 1.AD Feedstocks, reductants and other non-energy use of fuels and linked to the CRF 1.AB Fuel Combustion - Reference Approach as excluded carbon.

3.2.4 CO_2 capture from flue gases and subsequent CO_2 storage

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

3.2.5 Country-specific issues

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

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

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

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

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

1.A.2.i Peat	+	+	+
1.A.2.i Biomass	+	+	+
1.A.2.j Wood and wood products			
1.A.2.j Liquid fuels	+	+	+
1.A.2.j Solid fuels	+	+	+
1.A.2.j Gaseous fuels	+	+	+
1.A.2.j Other fossil fuels	NO	NO	NO
1.A.2.j Peat	+	+	+
1.A.2.j Biomass	+	+	+
1.A.2.k Construction			
1.A.2.k Liquid fuels	+	+	+
1.A.2.k Solid fuels	+	+	+
1.A.2.k Gaseous fuels	+	+	+
1.A.2.k Other fossil fuels	NO	NO	NO
1.A.2.k Peat	+	+	+
1.A.2.k Biomass	+	+	+
1.A.2.l Textile and leather			
1.A.2.l Liquid fuels	+	+	+
1.A.2.l Solid fuels	+	+	+
1.A.2.l Gaseous fuels	+	+	+
1.A.2.l Other fossil fuels	NO	NO	NO
1.A.2.l Peat	+	+	+
1.A.2.l Biomass	+	+	+
1.A.2.m Non-specified industry			
1.A.2.m Liquid fuels	+	+	+
1.A.2.m Solid fuels	+	+	+
1.A.2.m Gaseous fuels	+	+	+
1.A.2.m Other fossil fuels	+	+	+
1.A.2.m Peat	+	+	+
1.A.2.m Biomass	+	+	+
1.A.3. TRANSPORT			
1.A.3.a Domestic aviation			
1.A.3.a Liquid fuels	+	+	+
1.A.3.a Biomass	NO	NO	NO
1.A.3.b Road Transportation			
1.A.3.b Liquid fuels	+	+	+
1.A.3.b Solid	NO	NO	NO
1.A.3.b Gaseous fuels	+	+	+
1.A.3.b Other fossil fuels	NO	NO	NO
1.A.3.b Biomass	+	+	+
1.A.3.c Railways			
1.A.3.c Liquid fuels	+	+	+
1.A.3.c Solid	NO	NO	NO
1.A.3.c Gaseous fuels	NO	NO	NO
1.A.3.c Other fossil fuels	NO	NO	NO
1.A.3.c Biomass	NO	NO	NO
1.A.3.d Domestic Navigation			
1.A.3.d Liquid fuels	+	+	+

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

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

3.2.6.1 Category description

During 1990-2010 Ignalina NPP was dominating in the internal electricity market - its share in the structure of electricity generation was fluctuating at around 80%. At the beginning of 2009 the total installed capacity of the Lithuanian power plants was 5029 MW, including Ignalina NPP with 1300 MW and Lithuanian TPP with 1800 MW of electrical capacity. After the decommissioning of Ignalina NPP (Unit 1 was closed in 2004 and Unit 2 in 2009) total available capacity of Lithuanian power plants was 3605 MW in 2010. Currently Lithuanian TPP is dominating in the structure of capacities. Almost 29.3% of the overall installed electrical capacity is covered by this power plant. Currently more than half of required electricity (61.1% in 2015) is imported as the cost of electricity production at Lithuanian TPP is high due to high price of natural gas.

During 2010-2012, almost a third of the electricity was produced by the Lithuanian TPP, about 20% was produced by the Vilnius CHP and Kaunas CHP. Later, the role of Lithuanian TPP, Vilnius CHP and Kaunas CHP started reducing. The Lithuanian TPP produced 25.0% (2013), 20.7% (2014) and 22.8% (2015) of electricity in the country. The structural share of Vilnius CHP and Kaunas CHP was 7.7% in 2015. The share of green electricity is increasing.

The key trend in public electricity and heat production sector - power generation becoming more geographically distributed due to the installation being relatively small power plants based on biomass.

Characteristics of the Lithuanian power plants in 1 January 2016 are presented in Table 3-8.

Table 3-8. Characteristics of the Lithuanian power plants in 1 January 2016 (Litgrid, 2016)

Power plant	Fuel	Installed capacity, MW
Lithuanian TPP*	Residual fuel oil, natural gas, orimulsion	1045
Vilnius CHP	Residual fuel oil, natural gas	360
Kaunas CHP	Residual fuel oil, natural gas	170
Petrasiunai CHP	Natural gas	8
Panevezys CHP	Natural gas	35
Kaunas hydro PP	-	101
Kruonis hydro pumped storage PP	-	900
Small hydro PP	-	27
Wind PP	-	438
Biofuel PP	Biomass, biogas	108
Solar PP	-	73
Industrial PP	Residual fuel oil, natural gas, energy from chemical processes	292
Total	**-**	**3558**

* – 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 the heat production sector. About 75% of the residential buildings in Lithuania's towns are supplied with heat from the district heating systems.

In 2015, 31.5% (3,628 GWh) of heat supplied to district heating systems was produced at Combined Heat and Power plants (CHP), 45.0% (5,187 GWh) - at heat only boilers, 23.2% (2,667 GWh) – at plants using energy from chemical processes and 0.3% (34 GWh)- at geothermal plants.

Natural gas is the main fuel used in the district heating sector. Since 2000 the share of renewable energy (biomass, wood, straw, chips, sawdust, wood pellets) increased significantly from 2% (2000) to 40.0% (2015) in Lithuanian district heating sector. Relevant share of residual fuel oil used for heat production in district heating systems was replaced by renewable energy sources mainly by biomass.

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

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

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

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

3.2.6.3.1 Methodological issues

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

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

where:

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

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

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

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

Emission factors and methods

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

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

Fuel	**CO_2**			**CH_4**			**N_2O**		
	CO_2, kg/GJ	**EF**	**Method**	**CH_4, kg/TJ**	**EF**	**Method**	**N_2O, kg/TJ**	**EF**	**Method**
Residual fuel oil	77.60 78.40*	CS	T2	3.0	D	T1	0.6	D	T1
LPG	65,42 66.34*	CS	T2	1.0	D	T1	0.1	D	T1
Not liquefied petroleum gas	Table 3-10	PS	T3	1.0	D	T1	0.1	D	T1
Orimulsion	Table 3-10	PS	T3	3.0	D	T1	0.6	D	T1

Emulsified vacuum residue	Table 3-10	PS	T3	3.0	D	T1	0.6	D	T1
Natural gas	Table 3-11	CS	T2	1.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	1.0	D	T1	1.5	D	T1
Wood/ wood waste	101.34	CS	T2	30.0	D	T1	4.0	D	T1
Other solid biomass	103.69	CS	T2	30.0	D	T1	4.0	D	T1
Biogas	58.45	CS	T2	1.0	D	T1	0.1	D	T1
Municipal waste (non biomass fraction)	111.65	CS	T2	30.0	D	T1	4.0	D	T1
Municipal waste (biomass fraction)	109.03	CS	T2	30.0	D	T1	4.0	D	T1
Industrial waste	143.00	D	T1	30.0	D	T1	4.0	D	T1

Abbreviations:
CS - country specific emission factors;
PS - plant specific emission factors are based on EU ETS data and considering to the *Tier 3* reliability that ensures the lowest uncertainty of emission factor.
D - default emission factors (*2006 IPCC Guidelines*);
* - CS emission factors applied from 2015 based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute. Summary of the study is presented in Annex IV;
T1 – *Tier 1*; T2 – *Tier 2*; T3 – *Tier 3*.

Plant specific emission factors based on EU ETS data (*Tier 3*) for Combined Heat and Power Generation (1.A.1.a.ii) are presented in Table 3-10. Emulsified vacuum residue and not liquefied petroleum gas are combusted at the ORLEN Lietuva CHP: emulsified vacuum residue was combusted in 2008; not liquefied petroleum gas was combusted in 2012-2014. Orimulsion was combusted at the Lithuanian TPP during 1995-2008 period. The fuel composition for most fuels might change over time and plant specific EFs show this variance. Following recommendations given from the experts during the implementation of European Commission project "Assistance to EU Member states with KP reporting requirements" the average value of CO_2 emission factor was used for the period 1990-2004 and variable yearly values for the period 2005-2008.

Table 3-10. Plant specific CO_2 emission factors for category Combined Heat and Power Generation (1.A.1.a.ii)

Fuel	Average CO_2 EF 1990-2004, kg/GJ	Ranges of CO_2 EF 2005-2015, kg/GJ
Not liquefied petroleum gas	-	56.92 – 59.03
Orimulsion	81.74	80.33 – 82.95

Emulsified vacuum residue	-	79.41

Summary of study on "Update of country specific GHG emission factors for Energy sector" is presented in Annex IV. Seeking to ensure higher accuracy of GHG inventory it is valuable to apply the updated CO_2 emission factors for a period after 2015 and for a period 1990-2014 to use the emission factors determined in the study of 2012 (as presented in Annex IV).

Updated country specific CO_2 emission factor for natural gas is determined considering to the chemical composition of natural gas during 2004-2014 that was provided by Central Calibration and Test Laboratory of JSC "Lietuvos dujos". Seeking to ensure higher accuracy of GHG inventory variable yearly values of CO_2 emission factor for a period 2004-2014 was applied and an average value (55,14 t/TJ) for a period 1990-2003 in this submission.

Since January 2015 the liquefied natural gas (LNG) terminal started operation in Lithuania which opened the natural gas market in Lithuania. Till 2015 natural gas in Lithuania was imported from Russia via pipelines and the country depended on Russia for 100% of its natural gas. LNG terminal allows the natural gas supply from different suppliers. Currently Statoil is contracted to supply LNG for five years to cover the minimum operational need of the terminal. Gas is originating from the Snohvit field in the Norwegian Sea. The chemical composition of natural gas imported through the pipeline from Russia and the LNG terminal is quite different. CO_2 emission factor for natural gas (55.53 kg/GJ) in 2015 was determined considering chemical composition of natural gas that was provided by ESO (Energijos Skirstymo Operatorius AB) taking into consideration gas imported via LNG terminal and via pipeline. ESO was established January 1 of 2016 merging a JSC "Lietuvos dujos" and LESTO AB. The main activities of ESO is natural gas and electricity distribution in Lithuania.

The natural gas CO_2 emission factors are presented in Table 3-11.

Table 3-11. Natural gas CO_2 emission factors

Year	CO_2, kg/GJ
1990-2003	55.14
2004	55.09
2005	55.09
2006	55.12
2007	55.11
2008	55.11
2009	55.16
2010	55.12
2011	55.12
2012	55.16
2013	55.21
2014	55.24
2015	55.53

2006 IPCC Guidelines default emission factors were used for CH_4 and N_2O emissions estimation.

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.

Net calorific values (NCVs) used to convert fuel consumption in natural units into energy units are provided in the tables below.

Table 3-12. Specific net calorific values

Type of fuel	Tonne	TJ/tonne	Source
Hard coal	1.0	0.02512	Statistics Lithuania
Coke	1.0	0.02930	Statistics Lithuania
Peat	1.0	0.01172	Statistics Lithuania
Peat briquettes	1.0	0.01500	Statistics Lithuania
Firewood (m^3)	1.0	0.00820[3]	Statistics Lithuania
Biogas (1000 m^3)	1.0	0.02000[4]	Statistics Lithuania
Natural gas (1000 m^3)	1.0	0.03349[5]	Statistics Lithuania
Liquefied petroleum gases	1.0	0.04642	Statistics Lithuania
Motor gasoline	1.0	0.04479	Statistics Lithuania
Gasoline type jet fuel	1.0	0.04479	Statistics Lithuania
Kerosene type jet fuel	1.0	0.04316	Statistics Lithuania
Transport diesel	1.0	0.04307	Statistics Lithuania
Heating and other gasoil	1.0	0.04307	Statistics Lithuania
Residual fuel oil	1.0	0.04006	Statistics Lithuania
Crude oil	1.0	0.04278	Statistics Lithuania
Bioethanol	1.0	0.02700	Statistics Lithuania
Biodiesel (methyl ester)	1.0	0.03700	Statistics Lithuania
Shale oil	1.0	0.03810	Statistics Lithuania
Wood waste	1.0	0.01560	*2006 IPCC Guidelines*, Volume 2 p. 1.19 table 1.2
Industrial waste	1.0	0,0100	Statistics Lithuania

[3] Firewood NCV value is given as 0.0082 TJ per solid cubic meter.
[4] This NCV value is expressed as TJ per 1000 m^3.
[5] This NCV value is expressed as TJ per 1000 m^3.

Municipal waste (non biomass fraction)	1.0	0,0070	Statistics Lithuania
Municipal waste (biomass fraction)	1.0	0,0100	Statistics Lithuania

Table 3-13. 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, 2005 and 2010-2015 are provided in the Annex III. The entire time series (1990-2015) are publically available at the databases of the Statistics of Lithuania[6]. In the Annex III the energy balance data are provided in Tera joule (TJ).

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

As it is seen from Figure 3-15, during the latter ten years the consumption of fuels in Combined Heat and Power Generation was rather stable – about 45 PJ a year. However, in 2013 fuel consumption reduced by 13.3% in comparison to 2012, in 2014 – by 18.2% in comparison to 2013 and in 2015 – by 3.4% in comparison to 2014. This is mainly due to reduction of electricity and heat generation based on natural gas and liquid fuels and increased share of electricity import from neighboring countries. CHPs based on municipal (non-biomass fraction and biomass fraction) and industrial waste started operation in 2013.

Consumption of fuels in Combined Heat and Power Generation (including Electricity Generation) totaled 30.1 PJ in 2015.

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

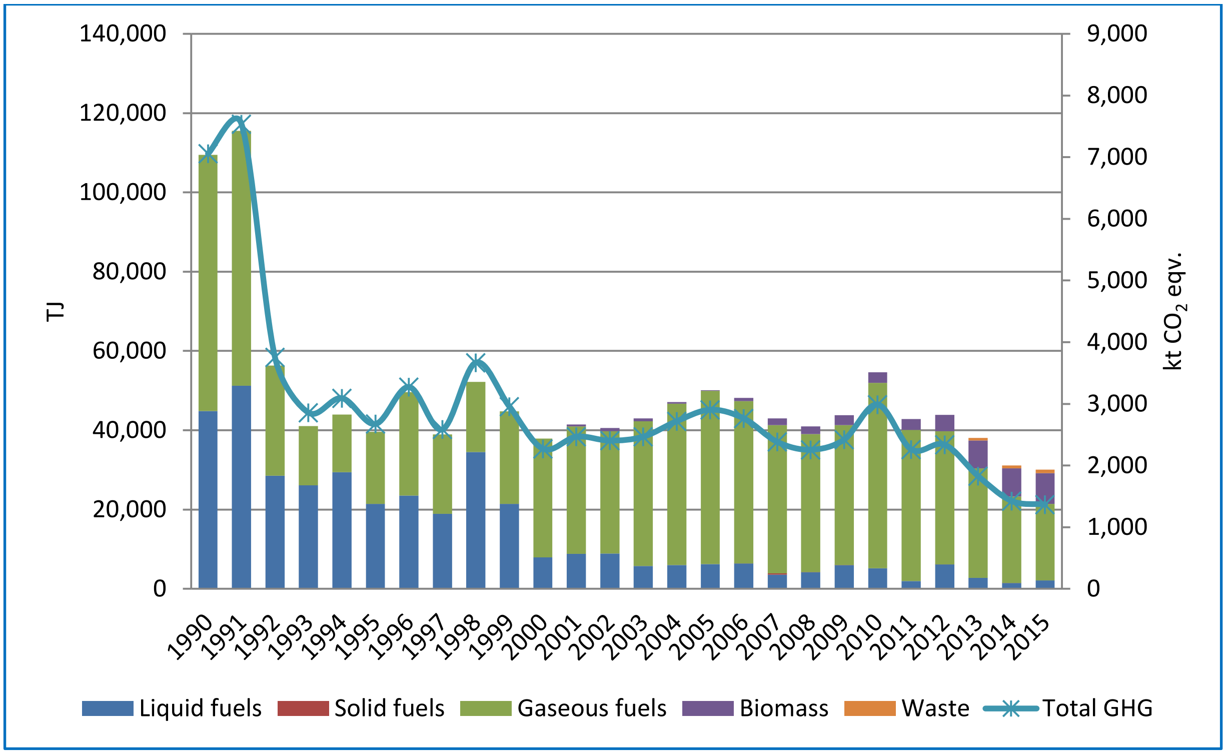


Figure 3-15. Tendencies of fuel consumed and GHG emissions in Combined Heat and Power Generation (1.A.1.a.ii)

Natural gas dominates in the structure of total fuel combusted for Combined Heat and Power Generation. In 2015 natural gas accounted 64.2%. The share and volume of liquid fuels drastically reduced since 1990s and in 2015 accounted only 7.1% in structure of fuel combusted. Since 2001 wood/wood waste started to be used for Combined Heat and Power Generation. During a last decade, the share of biomass (including biogas) increased from 1.1% (2001) till 25.6% (2015). Municipal and industrial waste in the structure of total fuel combusted accounted 3.1% in 2015.

Biogas from manure management is combusted in co-generators for energy purposes which is included in subcategory 1.A.1.Aii Combined heat and power generation. Further explanation is provided in chapter 5.3.2.2. Characterization of manure management systems.

Total GHG emissions from Combined Heat and Power Generation reduced by 5.1 times since 1990 and amounted 1,368.1 kt CO_2 eqv. In 2015.

3.2.6.3.2 Uncertainties and time-series consistency

Uncertainty in activity data in Combined Heat and Power Generation is ±2.0% taking into consideration recommendations provided by *2006 IPCC Guidelines* for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by *2006 IPCC Guidelines*.

Uncertainties of CO_2 emission factors for liquid fuels (residual fuel oil, LPG, non-liquefied petroleum gas, orimulsion and emulsified vacuum residue) and gaseous fuels (natural gas) are ±2.0% in Combined Heat and Power Generation. Uncertainties of CO_2 emission factors for solid fuels (peat) and waste are ±5.0%. Estimated uncertainties of CO_2 emission factors for biomass are ±15%.

Uncertainties of all country specific CO_2 emission factors were revised in the study "Update of country specific GHG emission factors for Energy sector" (see Annex IV).

Uncertainties of CH_4 and N_2O emission factors for liquid, solid, gaseous fuels and waste were assigned as very high about ±50%. Uncertainties of emission factors for biomass were assumed ±150%. Uncertainties were derived considering *2006 IPCC Guidelines*.

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

3.2.6.3.3 Category-specific QA/QC and verifications

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

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

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

3.2.6.3.4 Category-specific recalculations

Following recalculations in this category has been done:

- revision of CO_2 emission factor for natural gas (see Table 3-11), wood/wood waste, other solid biomass and municipal waste (biomass fraction and non-biomass fraction) based on study on "Update of country specific GHG emission factors for Energy sector" (performed in April 2016 by Lithuanian Energy Institute).

Impact of these recalculations on GHG emissions from 1.A.1.a.ii Combined Heat and Power Generation sector is presented in Table 3-14.

Table 3-14. Impact of recalculation on GHG emissions from 1.A.1.a.ii Combined Heat and Power Generation

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO2 eqv.	Relative difference, %
1990	7,062.8	7,057.0	-5.82	-0.08
1991	7,543.4	7,537.6	-5.79	-0.08
1992	3,756.9	3,754.4	-2.50	-0.07
1993	2,858.6	2,857.3	-1.34	-0.05
1994	3,093.7	3,092.4	-1.31	-0.04
1995	2,675.0	2,673.3	-1.63	-0.06
1996	3,277.1	3,274.8	-2.35	-0.07
1997	2,587.4	2,585.6	-1.80	-0.07
1998	3,671.1	3,669.6	-1.59	-0.04
1999	2,959.2	2,957.1	-2.10	-0.07

2000	2,275.5	2,272.8	-2.70	-0.12
2001	2,470.4	2,467.5	-2.90	-0.12
2002	2,406.9	2,404.2	-2.77	-0.12
2003	2,470.6	2,467.3	-3.29	-0.13
2004	2,725.4	2,719.7	-5.70	-0.21
2005	2,910.5	2,904.4	-6.12	-0.21
2006	2,769.0	2,764.5	-4.50	-0.16
2007	2,387.2	2,382.7	-4.49	-0.19
2008	2,260.6	2,256.5	-4.18	-0.19
2009	2,424.2	2,421.7	-2.48	-0.10
2010	2,994.2	2,989.1	-5.14	-0.17
2011	2,266.7	2,262.5	-4.20	-0.19
2012	2,340.8	2,338.5	-2.35	-0.10
2013	1,819.9	1,828.7	8.78	0.48
2014	1,415.1	1,425.3	10.15	0.71

3.2.6.3.5 Category-specific planned improvements

The following improvements are foreseen:

- Further investigate possibilities of using the new available data provided in the EU ETS, reported by the operators for the energy sector emission estimates.

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

3.2.6.4.1 Methodological issues

CO_2 emissions were calculated applying *Tier 2* or *Tier 3*, CH_4 and N_2O were calculated applying *Tier 1* (as presented in Table 3-15).

Emission factors and methods

Emission factors and methods used in the calculations of emissions from Heat Plants (1.A.1.a.iii) are presented in Table 3-15.

Table 3-15. Emission factors and methods for category Heat Plants (1.A.1.a.iii)

Fuel	**CO_2**			**CH_4**			**N_2O**		
	CO_2, kg/GJ	**EF**	**Method**	**CH_4, kg/TJ**	**EF**	**Method**	**N_2O, kg/TJ**	**EF**	**Method**
Crude oil	77.74	CS	T2	3.0	D	T1	0.6	D	T1
Shale oil	77.40 76.60*	CS	T2	3.0	D	T1	0.6	D	T1
Residual fuel oil	77.60 78.40*	CS	T2	3.0	D	T1	0.6	D	T1
LPG	65.42 66.34*	CS	T2	1.0	D	T1	0.1	D	T1

Not liquefied petroleum gas	Table 3-16	PS	T3	1.0	D	T1	0.1	D	T1
Gasoil	72.89 72.73*	CS	T2	3.0	D	T1	0.6	D	T1
Diesel oil	72.89 72.73*	CS	T2	3.0	D	T1	0.6	D	T1
Coking coal	94.90 95.10*	CS	T2	1.0	D	T1	1.5	D	T1
Sub-bituminous coal	Table 3-16	PS	T3	1.0	D	T1	1.5	D	T1
Anthracite	Table 3-16	PS	T3	1.0	D	T1	1.5	D	T1
Natural gas	Table 3-11	CS	T2	1.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	1.0	D	T1	1.5	D	T1
Wood/ wood waste	101.34	CS	T2	30.0	D	T1	4.0	D	T1
Other solid biomass	103.69	CS	T2	30.0	D	T1	4.0	D	T1
Biogas	58.45	CS	T2	1.0	D	T1	0.1	D	T1

Abbreviations:
CS - country specific emission factors;
PS - plant specific emission factors are based on EU ETS data and considering to the *Tier 3* reliability that ensures the lowest uncertainty of emission factor;
D - default emission factors (*2006 IPCC Guidelines*);
* - CS emission factors applied from 2015 based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute. Summary of the study is presented in Annex IV;
T1 - *Tier 1*; T2 - *Tier 2*; T3 - *Tier 3*.

Plant specific CO_2 EFs based on EU ETS data applied for not liquefied petroleum gas, sub-bituminous coal and anthracite for category Heat Plants (1.A.1.a.iii) are presented in Table 3-16. Not liquefied petroleum gas was combusted at heat plant located at the ORLEN Lietuva during 2007-2011. Sub-bituminous coal and anthracite was combusted at heat plant located and JSC "Akmenes cementas": the average value of CO_2 emission factor was used for the period 2000-2004 and variable yearly values for the period 2005-2015 following recommendations given from the experts during the implementation of European Commission project "Assistance to EU Member states with KP reporting requirements".

Table 3-16. Plant specific CO_2 emission factors for category Heat Plants (1.A.1.a.iii)

Fuel	**Average CO_2 EF 1990-2004, kg/GJ**	**Ranges of CO_2 EF 2005-2015, kg/GJ**
Not liquefied petroleum gas	-	54.86 – 57.53
Sub-bituminous coal	95.63	94.90 – 96.00

Anthracite	106.55	106.00 – 107.10

Activity data

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

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

Total fuel consumption in Heat Plants reduced by 3.3 times since 1990 (Figure 3-16). During the 2004-2012 the consumption of fuels in Heat Plants was rather stable – about 20 PJ a year. In 2013 fuel consumption reduced by 11.0% in comparison to 2012, 2014 increased by 10.0% in comparison to 2013 and in 2015 increased by 19.5% in comparison to 2014. Consumption of fuels in Heat plants amounted 23.2 PJ in 2015.

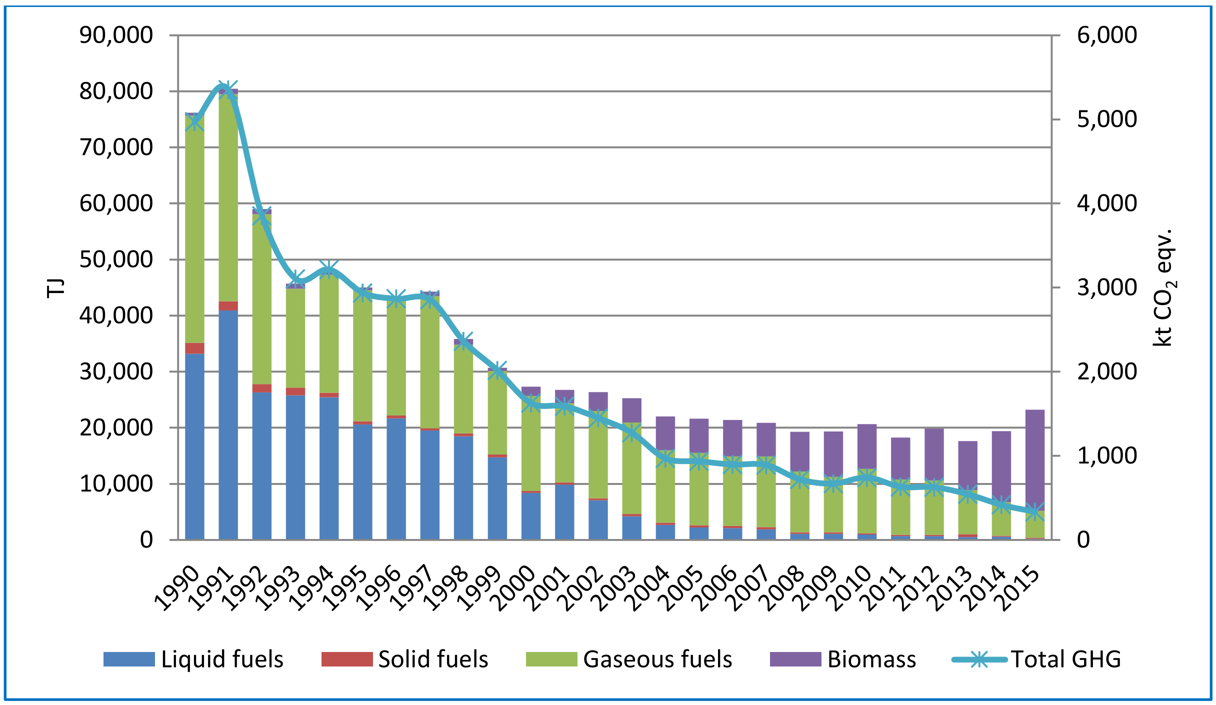


Figure 3-16. Tendencies of fuel consumed and GHG emissions in Heat Plants (1.A.1.a.iii)

Currently biomass and natural gas dominates in the structure of total fuel combusted in Heat Plants. In 2015 biomass accounted 77.7% and natural gas – 20.6%. Since 2000 wood/wood waste started to be widely used for heat generation in Heat Plants. During a last decade, the share of biomass increased from 6.0% (2000) till 77.7% (2015). The share and volume of liquid fuels drastically reduced since 1990s and in 2015 accounted only 1.0% in structure of fuel combusted. Solid fuels accounted 0.4 % in 2015.

Total GHG emissions from Heat Plants reduced by almost 15 times since 1990 and amounted 333.4 kt CO_2 eqv.

3.2.6.4.2 Uncertainties and time-series consistency

Uncertainty in activity data in category Heat Plants is ±2.0% taking into consideration recommendations provided by *2006 IPCC Guidelines*. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by *2006 IPCC Guidelines*.

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 ±2.0% in category Heat Plants. Uncertainties of CO_2 emission factors for solid fuels (peat and coking coal) are ±5.0%. Estimated uncertainties of CO_2 emission factors for biomass are ±15%. Uncertainties of all country specific CO_2 emission factors were revised in the study "Update of country specific GHG emission factors for 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 *2006 IPCC Guidelines*.

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

3.2.6.4.3 Category-specific QA/QC and verifications

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

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

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

3.2.6.4.4 Category-specific recalculations

Following recalculations in this category has been done:

- revision of CO_2 emission factor for natural gas (see Table 3-11), wood/wood waste and other solid biomass based on study on "Update of country specific GHG emission factors for Energy sector" (performed in April 2016 by Lithuanian Energy Institute).

Impact of these recalculations on GHG emissions from 1.A.1.a.iii Heat Plants is presented in Table 3-17.

Table 3-17. Impact of recalculation on GHG emissions from 1.A.1.a.iii Heat Plants

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	4,977.1	4,973.5	-3.65	-0.07

1991	5,353.9	5,350.6	-3.32	-0.06
1992	3,855.9	3,853.1	-2.73	-0.07
1993	3,106.0	3,104.4	-1.59	-0.05
1994	3,216.6	3,214.7	-1.89	-0.06
1995	2,939.4	2,937.3	-2.10	-0.07
1996	2,868.9	2,867.0	-1.86	-0.06
1997	2,859.9	2,857.7	-2.12	-0.07
1998	2,363.1	2,361.6	-1.42	-0.06
1999	2,018.5	2,017.2	-1.34	-0.07
2000	1,628.0	1,626.5	-1.55	-0.10
2001	1,590.4	1,589.1	-1.31	-0.08
2002	1,451.3	1,449.8	-1.44	-0.10
2003	1,276.1	1,274.6	-1.50	-0.12
2004	971.3	969.5	-1.83	-0.19
2005	936.2	934.3	-1.84	-0.20
2006	897.4	896.0	-1.40	-0.16
2007	892.5	890.9	-1.55	-0.17
2008	720.8	719.5	-1.32	-0.18
2009	669.8	669.1	-0.70	-0.10
2010	743.5	742.3	-1.28	-0.17
2011	632.9	631.8	-1.10	-0.17
2012	626.9	626.3	-0.68	-0.11
2013	543.5	543.3	-0.16	-0.03
2014	416.5	416.6	0.06	0.01

3.2.6.4.5 Category-specific planned improvements

The following improvements are foreseen:

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

3.2.6.5 CO_2 emission from carbonates use in flue gas desulphurisation (2.H.3)

There is one power plant in Lithuania which has flue gas desulphurisation facility since 2008. CO_2 emissions were calculated using *Tier 1* method based on mass of carbonates used (equation 2.14, page 2.34) described in IPCC 2006 Guidelines:

$$CO_2Emissions = M_c \times (0.85EF_{is} + 0.155EF_d)$$

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

Activity data (limestone use) was supplied by power plant, default emission factor (0.43971 tonnes CO_2/tonne carbonate) suggested in *2006 IPCC Guidelines* Volume 3 Table 2.1 (page 2.7) was used. Results are provided in Table 3-18.

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

Table 3-18. CO_2 emission from limestone use in flue gas desulphurisation

	2008	2009	2010	2011	2012	2013	2014	2015
Limestone use, tonnes	4,14	2,24	3,65	49.00	10,03	2,70	155.00	450.00
CO_2 emission, kt	1.55	0.84	1.37	0.02	3.75	1.01	0.06	0.17

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

3.2.7.1 Category description

Refineries process crude oil into a variety of hydrocarbon products such as gasoline, kerosene and etc. UAB ORLEN Lietuva[7] is the only petroleum refining company operating in the Baltic States. Oil refinery processes approximately 10 million tons of crude oil a year. The company is the most important supplier of petrol and diesel fuel in Lithuania, Latvia and Estonia. Motor gasoline, jet kerosene, gas/diesel oil, residual fuel oil, LPG and non-liquefied petroleum gas used in Lithuania are produced by the oil refinery UAB ORLEN Lietuva. Imports of the fuels specified above comprise only a minor fraction of the fuels used in Lithuania.

3.2.7.2 Methodological issues

Emission factors and methods used in the calculation of emissions from Petroleum Refinery (1.A.1.b) are presented in the Table 3-19.

Table 3-19. 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	Table 3-20	PS	T3	3.0	D	T1	0.6	D	T1
LPG	65.42 66.34*	CS	T2	1.0	D	T1	0.1	D	T1
Petroleum coke	94.06	CS	T2	3.0	D	T1	0.6	D	T1

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

Diesel oil	7289 72.73*	CS	T2	3.0	D	T1	0.6	D	T1
Not liquefied petroleum gas	Table 3-20	PS	T3	1.0	D	T1	0.1	D	T1
Natural gas	Table 3-11	CS	T2	1.0	D	T1	0.1	D	T1
Wood / wood waste	101.34	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations:
CS - country specific emission factors;
PS - plant specific emission factors are based on EU ETS data and considering to the *Tier 3* reliability that ensures the lowest uncertainty of emission factor;
D - default emission factors (*2006 IPCC Guidelines*);
* - CS emission factors applied from 2015 based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute. Summary of the study is presented in Annex IV;
T1 - *Tier 1*; T2 - *Tier 2*; T3 - *Tier 3*.

Plant specific CO_2 EFs based on EU ETS data applied for residual fuel oil and not liquefied petroleum gas for category Petroleum Refinery (1.A.1.b) are presented in Table 3-20. Residual fuel oil ("non-tradable" residual fuel oil) and not liquefied petroleum gas was combusted at the petroleum refinery company ORLEN Lietuva during 1990-2014: the average value of CO_2 emission factor was used for the period 1990-2004 and variable yearly values for the period 2005-2014.

Table 3-20. Plant specific CO_2 emission factors for category Petroleum Refinery (1.A.1.b)

Fuel	**Average CO_2 EF 1990-2007, kg/GJ**	**Ranges of CO_2 EF 2008-2015, kg/GJ**
Residual fuel oil	81.65	80.21 – 83.04
Not liquefied petroleum gas	57.13	54.86 – 59.03

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 are presented in Figure 3-17.

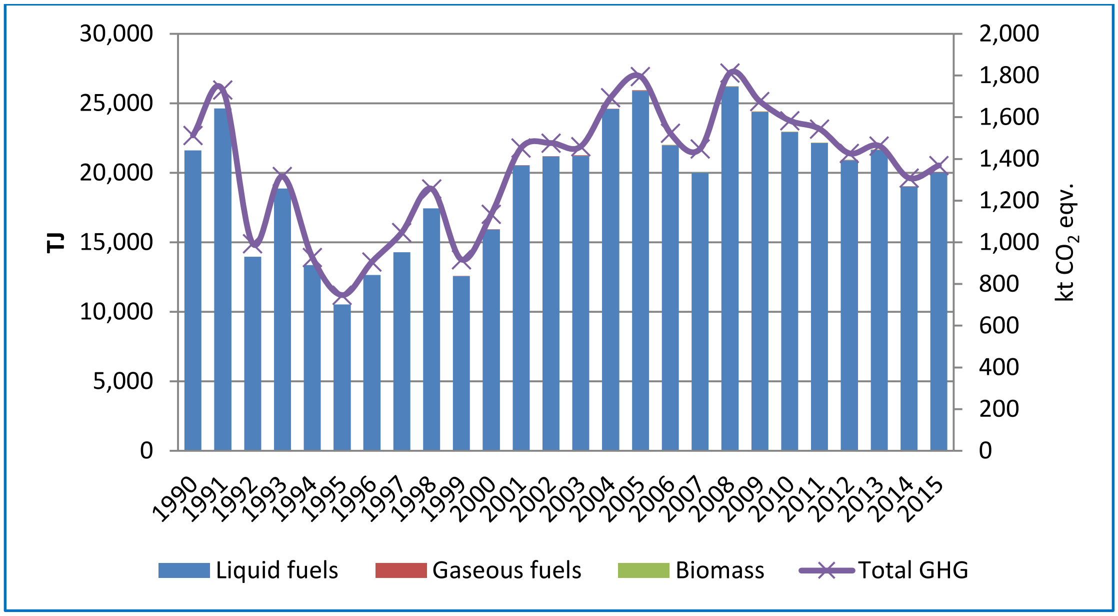


Figure 3-17. Tendencies of fuel consumed and total GHG emissions in Petroleum Refinery (1.A.1.b)

As it is seen from Figure 3-17, liquid fuels are mainly used in Lithuanian Petroleum Refinery industry. Liquid fuels accounted 99.9% of fuel structure in 2015. Historically, non-liquefied petroleum gas made more than 50% of total fuel consumed in petroleum refinery. With reference to data of 2015, there was consumed 20.0 PJ, from which non-liquefied petroleum gas accounted 69.1%, petroleum coke – 18.6%, residual fuel oil – 12.2%.

Total GHG emissions from Petroleum Refinery in 2015 were below 1990 level by 9.5% and amounted 1,369.0 kt CO_2 eqv.

3.2.7.3 Uncertainties and time-series consistency

Uncertainty in activity data in Petroleum Refinery is ±2.0% taking into consideration recommendations provided by *2006 IPCC Guidelines* for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by *2006 IPCC Guidelines*.

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 ±2.0% in Petroleum refinery. Estimated uncertainties of CO_2 emission factors for biomass are ±15%. Uncertainties of all country specific CO_2 emission factors were revised in the study "Update of country specific GHG emission factors for 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 *2006 IPCC Guidelines*.

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 Category-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 Category-specific recalculations

Following recalculations in this category has been done:

- revision of CO_2 emission factor for natural gas (see Table 3-11) and wood/wood waste based on study on "Update of country specific GHG emission factors for Energy sector" (performed in April 2016 by Lithuanian Energy Institute).
- correction of CO_2 plant specific emission factor for residual fuel oil and not liquefied petroleum gas based on EU ETS data due to typing mistake in 2012 data in previous submission.

Impact of these recalculations on GHG emissions from 1.A.1.b is Petroleum Refinery presented in Table 3-21.

Table 3-21. Impact of recalculation on GHG emissions from 1.A.1.b Petroleum Refinery

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	1,506.9	1,512.8	5.92	0.39
1991	1,723.9	1,731.0	7.13	0.41
1992	990.4	994.5	4.07	0.41
1993	1,311.0	1,316.2	5.22	0.40
1994	924.7	928.3	3.63	0.39
1995	744.2	747.0	2.77	0.37
1996	903.5	906.8	3.26	0.36
1997	1,043.9	1,047.6	3.69	0.35
1998	1,252.5	1,256.8	4.35	0.35
1999	914.3	917.6	3.33	0.36
2000	1,131.0	1,134.9	3.95	0.35
2001	1,448.3	1,453.4	5.08	0.35
2002	1,470.8	1,476.1	5.31	0.36
2003	1,455.0	1,460.1	5.12	0.35
2004	1,688.1	1,693.9	5.85	0.35
2005	1,789.2	1,795.5	6.31	0.35
2006	1,518.1	1,523.5	5.36	0.35
2007	1,443.3	1,448.6	5.28	0.36
2012	1,417.1	1,427.0	9.94	0.70
2014	1,308.3	1,308.6	0.33	0.03

3.2.7.6 Category-specific planned improvements

Category-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 Category description

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

3.2.8.2 Manufacture of solid fuels (CRF 1.A.1.c.i)

3.2.8.2.1 Methodological issues

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

Emission factors and methods

Emission factors and methods used in the calculations of emissions from Manufacture of Solid Fuels (1.A.1.c.i) are presented in Table 3-22.

Table 3-22. Emission factors and methods for category Manufacture of Solid Fuels (1.A.1.c.i)

Fuel	**CO_2**			**CH_4**			**N_2O**		
	CO_2, kg/GJ	**EF**	**Method**	**CH_4, kg/TJ**	**EF**	**Method**	**N_2O, kg/TJ**	**EF**	**Method**
Motor gasoline	72.97 72.77*	CS	T2	3.0	D	T1	0.6	D	T1
Gasoil	72.89 72.73*	CS	T2	3.0	D	T1	0.6	D	T1
Diesel oil	72.89 72.73*	CS	T2	3.0	D	T1	0.6	D	T1
Peat	104.34	CS	T2	1.0	D	T1	1.5	D	T1
Wood/wood waste	101.34	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations:
CS - country specific emission factors;
D - default emission factors (*2006 IPCC Guidelines*);
* - CS emission factors applied from 2015 based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute. Summary of the study is presented in Annex IV;
T1 - *Tier 1*; T2 - *Tier 2*.

Activity data

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

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

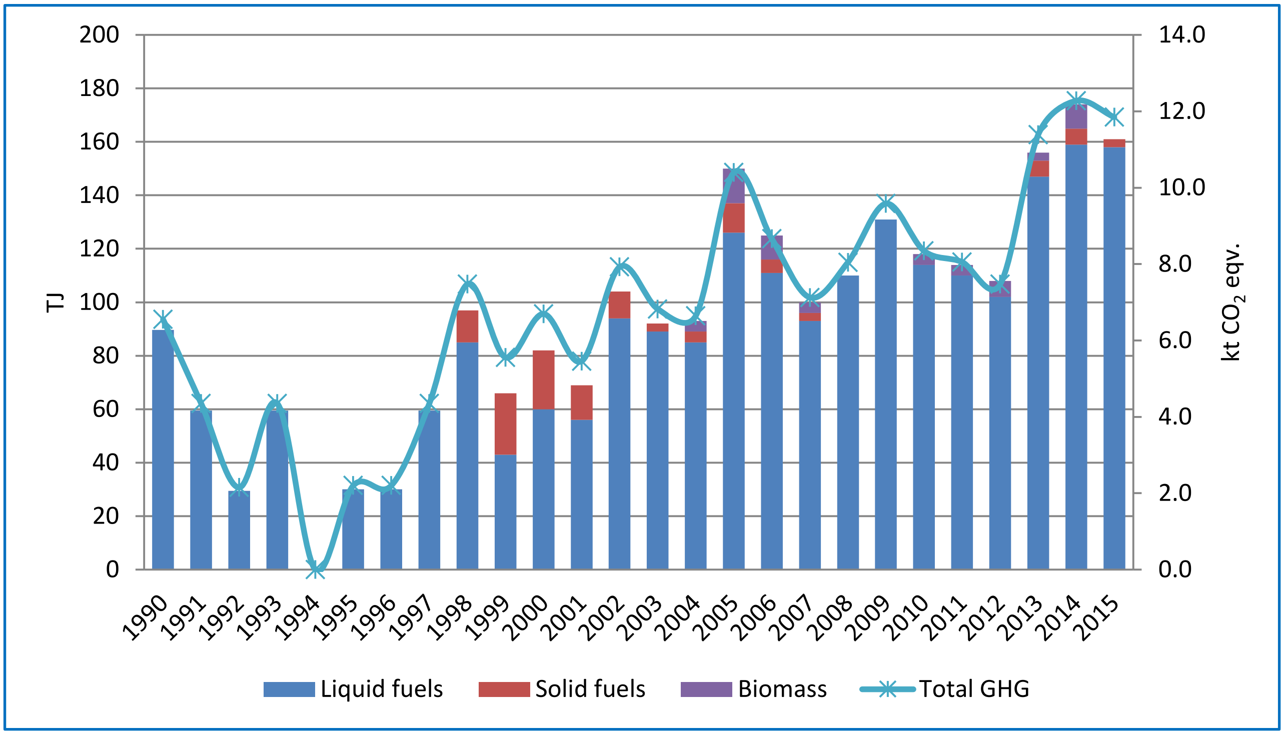


Figure 3-18. Tendencies of fuel consumption and total GHG emissions in Manufacture of Solid Fuels (1.A.1.c.i)

As it is seen from Figure 3-18, fuel consumption in Manufacture of Solid Fuels decreased by 7.4% in comparison to 2014 and accounted 161 TJ in 2015. With reference to data of 2015, liquid fuels accounted 98.1% and solid fuels 1.9% of structure.

In 2015, total GHG emissions from Manufacture of Solid Fuels were about 2 times higher than in 1990 and amounted 11.8 kt CO_2 eqv.

3.2.8.2.2 Uncertainties and time-series consistency

Uncertainty in activity data in Manufacture of Solid Fuels is ±2.0% taking into consideration recommendations provided by *2006 IPCC Guidelines* for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by *2006 IPCC Guidelines*.

Uncertainties of CO_2 emission factors for liquid fuels (motor gasoline, gasoil, LPG, diesel oil) and gaseous fuels (natural gas) are ±2.0% in Manufacture of solid fuels. Estimated uncertainties of CO_2 emission factors for biomass are ±15%. Uncertainties of all country specific CO_2 emission factors were revised in the study "Update of country specific GHG emission factors for 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 *2006 IPCC Guidelines.*

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.

3.2.8.2.3 Category-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.

3.2.8.2.4 Category-specific recalculations

No recalculations have been done.

3.2.8.2.5 Category-specific planned improvements

Category-specific improvements are not planned.

3.2.8.3 Other Energy Industries (CRF 1.A.1.c.ii)

3.2.8.3.1 Methodological issues

CO_2 emissions were calculated applying *Tier 2*, CH_4 and N_2O were calculated applying *Tier 1* (as presented in Table 3-23) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculations of emissions from Other Energy Industries (1.A.1.c.ii) are presented in Table 3-23.

Table 3-23. Emission factors and methods for category Other Energy Industries (1.A.1.c.ii)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	**EF**	**Method**	**CH_4, kg/TJ**	**EF**	**Method**	**N_2O, kg/TJ**	**EF**	**Method**
Motor gasoline	72.97 72.77*	CS	T2	3.0	D	T1	0.6	D	T1
LPG	65.42 66.34*	CS	T2	1.0	D	T1	0.1	D	T1
Diesel oil	72.89 72.73*	CS	T2	3.0	D	T1	0.6	D	T1
Natural gas	Table 3-11	CS	T2	1.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	1.0	D	T1	1.5	D	T1
Wood/wood waste	101.34	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations:

CS - country specific emission;
D - default emission factors (*2006 IPCC*);
* - CS emission factors applied from 2015 based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute. Summary of the study is presented in Annex IV;
T1 - *Tier 1*; T2 - *Tier 2*.

Activity data

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

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

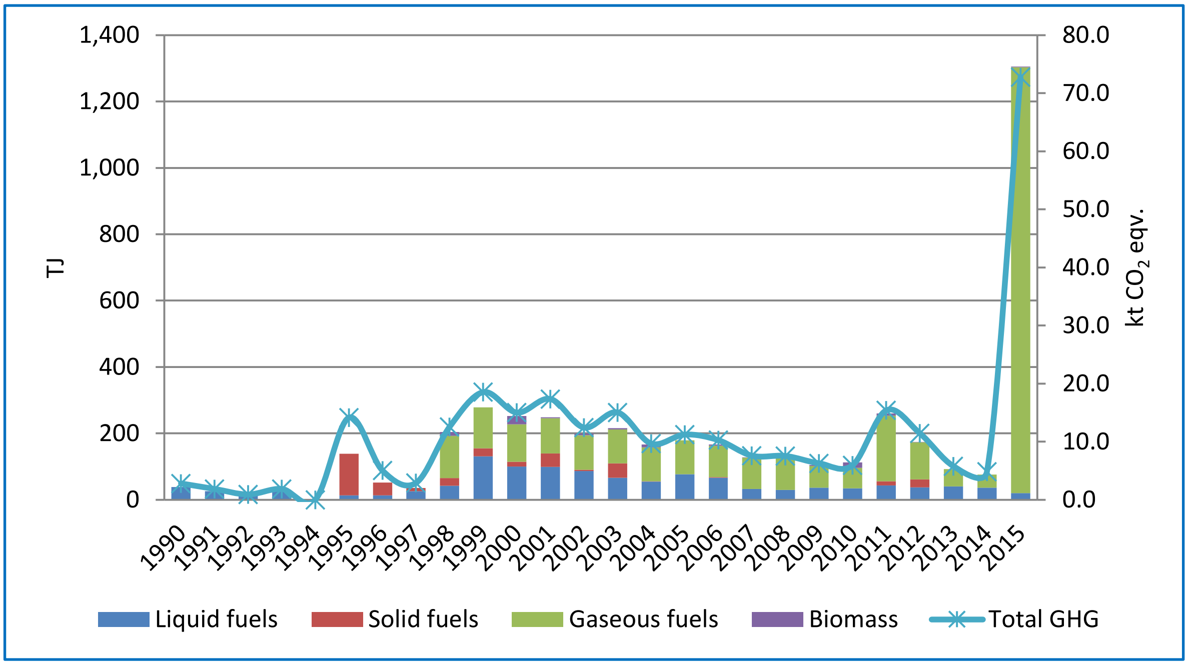


Figure 3-19. Tendencies of fuel consumption and total GHG emissions in Other Energy Industries (1.A.1.c.ii)

As it is seen from Figure 3-19, fuel consumption in Other Energy Industries increased significantly due to start of LNG terminal operation since January 2015. In 2015, 1.220 TJ of natural gas was combusted at LNG terminal for operational needs. The total fuel consumption in Other Energy Industries amounted 1,305 TJ in 2015. With reference to data of 2015, natural gas accounted 98.3%, liquid fuels – 1.5% and biomass – 0.2% of structure.

In 2015, total GHG emissions from Manufacture of Solid Fuels were about 20 times higher than in 1990 and amounted 72.8 kt CO_2 eqv.

3.2.8.3.2 Uncertainties and time-series consistency

Uncertainty in activity data in Other Energy Industries is ±2.0% taking into consideration recommendations provided by *2006 IPCC Guidelines* for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by *2006 IPCC Guidelines*.

Uncertainties of CO_2 emission factors for liquid fuels (motor gasoline, gasoil, LPG, diesel oil) and gaseous fuels (natural gas) are ±2.0% in Other Energy Industries. Estimated uncertainties of CO_2 emission factors for biomass are ±15%. Uncertainties of all country specific CO_2 emission factors were revised in the study "Update of country specific GHG emission factors for 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 *2006 IPCC Guidelines.*

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.

3.2.8.3.3 Category-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.

3.2.8.3.4 Category-specific recalculations

Following recalculations in this category has been done:

- revision of CO_2 emission factor for natural gas (see Table 3-11), wood/wood waste and other solid biomass based on study on "Update of country specific GHG emission factors for Energy sector" (performed in April 2016 by Lithuanian Energy Institute).

Impact of these recalculations on GHG emissions from 1.A.1.c.ii Other Energy Industries presented in Table 3-24.

Table 3-24. Impact of recalculation on GHG emissions from 1.A.1.c.ii Other Energy Industries

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eqv.	Relative difference, %
1998	12.6	12.6	-0.01	-0.09
1999	18.5	18.5	-0.01	-0.06
2000	15.0	15.0	-0.01	-0.07
2001	17.4	17.4	-0.01	-0.05
2002	12.4	12.4	-0.01	-0.08
2003	15.0	15.0	-0.01	-0.06
2004	9.7	9.7	-0.01	-0.15
2005	11.2	11.2	-0.01	-0.13
2006	10.3	10.3	-0.01	-0.10
2007	7.6	7.6	-0.01	-0.15
2008	7.6	7.5	-0.01	-0.15

2009	6.3	6.3	0.00	-0.07
2010	6.0	6.0	-0.01	-0.11
2011	15.4	15.4	-0.02	-0.14
2012	11.5	11.5	-0.01	-0.07
2013	5.8	5.8	0.00	-0.02
2014	4.8	4.8	0.00	0.01

3.2.8.3.5 Category-specific planned improvements

Category-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 are no Iron and Steel industries in Lithuania. All emissions are reported as not occurring/not applicable therefore there are no "not estimated" sectors.

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

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

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

3.3.3.1 Category description

The Chemicals industry is one of the largest manufacturing industries in Lithuania. It produces a number of different products among which the most important are the following: sulphur acid (SO_2), ethyl alcohol, fermented preparations, ammonium nitrate, urea, diammonium phosphate, amino resins, phenolic resins and polyurethanes in primary form, toilet and washing soap, preparations for use on hair and yarn of cellulose acetate. During the latter decade it has been noticed an intensive development of this industry. According to the data of 2015, chemicals industry produced 5,882 thousand dal of ethyl alcohol, 1,544 tons of preparations for use on hair, 799,2 thousand tons of diammonium phosphate, 789,5 thousand tons of sulphur acid and other chemicals in smaller numbers[8]. As a result, this allowed to achieve 11.3% of the total value added created in a manufacturing industry. During the latter economic crisis, when the price of fertilizer has been decreasing and natural gas price has been increasing, the value added of the industry has decreased by 8.7% in 2008 (compared to value in 2007). It is worth noting that labour productivity and new technology implementation in Lithuanian chemical industry is rather above the country's average (Kaunas Technology University, 2009).

3.3.3.2 Methodological issues

CO_2 emissions were calculated applying *Tier 2*, CH_4 and N_2O were calculated applying *Tier 1* (as presented in Table 3-25) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

[8] Lithuanian Statistics (2015). Manufacturing of products in Lithuania during 2000-2015 // http://osp.stat.gov.lt/temines-lenteles49.

Emission factors and methods used in the calculation of emissions from Chemical industries (1.A.2.c) are presented in Table 3-25.

Table 3-25. 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 78.40*	CS	T2	3.0	D	T1	0.6	D	T1
LPG	65.42 66.34*	CS	T2	1.0	D	T1	0.1	D	T1
Gasoil	72.89 72.73*	CS	T2	3.0	D	T1	0.6	D	T1
Sub-bituminous coal	96.00 96.10*	CS	T2	10.0	D	T1	1.5	D	T1
Natural gas	Table 3-11	CS	T2	1.0	D	T1	0.1	D	T1
Wood/ wood waste	101.34	CS	T2	30.0	D	T1	4.0	D	T1
Biogas	58.45	CS	T2	1.0	D	T1	0.1	D	T1

Abbreviations:
CS - country specific emission factors;
D - default emission factors (*2006 IPCC Guidelines*);
* - CS emission factors applied from 2015 based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute. Summary of the study is presented in Annex IV;
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 for the 1990-2007 period. Since 2008 activity data are available at the Lithuanian Statistics database (http://www.stat.gov.lt/lt/). Activity data are provided below in the Table 3-26.

Table 3-26. Energy consumption by fuel type in Chemicals industries, TJ

Year	**RFO**	**LPG**	**Gasoil**	**Sub-bitu-minous coal**	**Natural gas**	**Wood/ wood waste**	**Biogas**	**Total**
1990	883.1	0.0	0.0	0.0	6,001.0	0.0	0.0	6,884.1
1995	281.0	0.0	0.0	0.0	1,563.0	0.0	0.0	1,844.0
2000	20.0	0.0	0.0	0.0	190.9	3.0	0.0	213.9
2005	0.0	6.9	0.0	0.4	4,972.4	0.4	0.0	4,980.1
2010	47.0	17.0	0.0	0.0	5,476.0	0.0	94.0	5,634.0
2011	0.0	4.0	0.0	0.0	5,825.0	0.0	31.0	5,860.0

2012	0.0	27.4	0.0	0.0	6,652.0	0.0	52.0	6,731.4
2013	0.0	26.0	0.0	0.0	5,130.0	0.0	66.0	5,222.0
2014	0.0	26.0	0.0	0.0	5,666.0	0.0	55.0	5,747.0
2015	0.0	31.0	0.0	0.0	5,489.0	66.0	84.0	5,670.0

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

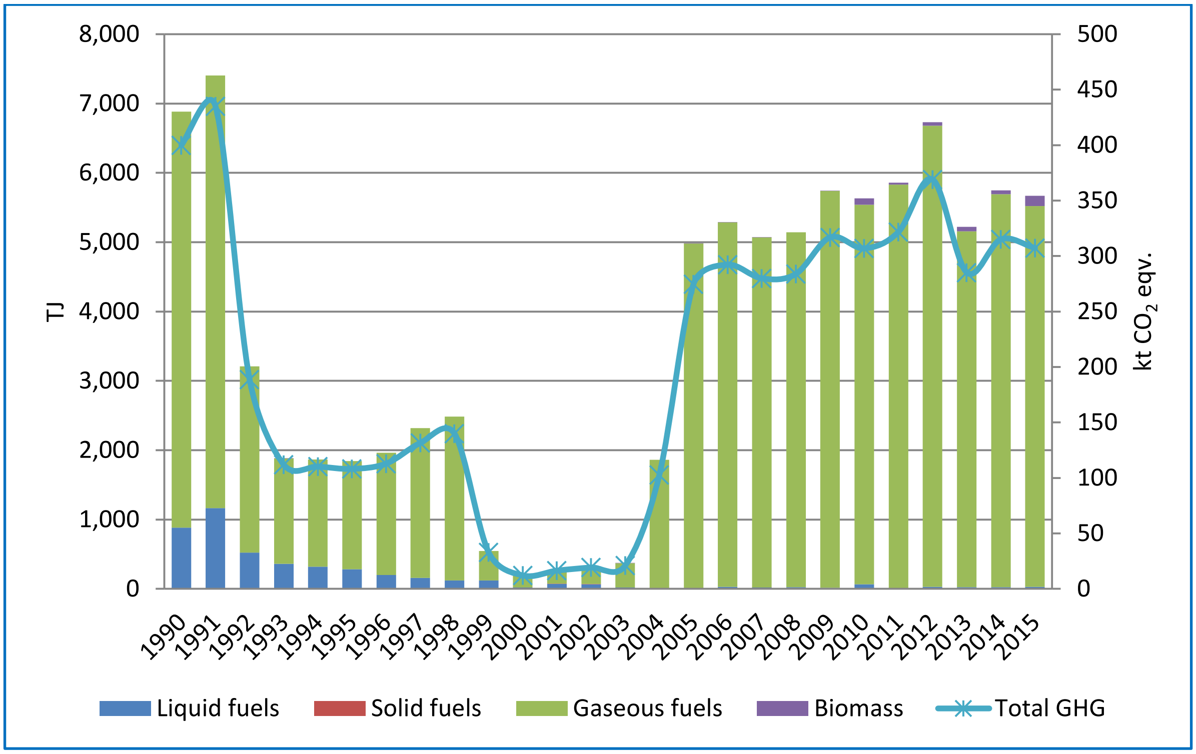


Figure 3-20. Tendencies of fuel consumption and total GHG emissions in Chemical industries (1.A.2.c)

Natural gas is the main fuel used in chemical industry in Lithuania. During 1990-2015 period, it has contained 71-99% of total fuel used in industry. During economic recession and "recovery" period (1990-2002) fuel consumption in Lithuania's chemical industry has had a tendency to decrease by 22.5% a year with a large decrease of natural gas consumption (Figure 3-20). Since 2003, when economy has started to grow at very fast rates, energy consumption in Chemical industries began to increase. In 2015, energy consumption in Chemical industries decreased by 1.3% (in comparison to 2014) and amounted 5.7 PJ. With reference to data of 2015, natural gas accounted 96,8% in the structure of total fuel consumption in Chemical industry, biomass - 2.6% and liquid fuels – 0.5%.

In 2015, total GHG emissions from Chemical industries were about 1.3 times lower than in 1990 and amounted 307.3 kt CO_2 eqv.

3.3.3.3 Uncertainties and time-series consistency

Uncertainty of activity data in Chemical industries is ±2.0% taking into consideration recommendations provided by *2006 IPCC Guidelines*. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by *2006 IPCC Guidelines*.

Uncertainties of CO_2 emission factors for liquid fuels (residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.0% in Chemical industries. Uncertainties of CO_2 emission factors for solid fuels (coking coal) are ±5.0%. Estimated uncertainties of CO_2 emission factors for biomass are ±15%. Uncertainties of all country specific CO_2 emission factors were revised in the study "Update of country specific GHG emission factors for 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 *2006 IPCC Guidelines.*

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 Category-specific QA/QC and verifications

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

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

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

3.3.3.5 Category-specific recalculations

Following recalculations in this category has been done:

- revision of CO_2 emission factor for natural gas (see Table 3-11) and wood/wood waste based on study on "Update of country specific GHG emission factors for Energy sector" (performed in April 2016 by Lithuanian Energy Institute);
- correction of activity data on natural gas (for period 2005-2014) based on the newest information provided by the Lithuanian Statistics in November 2016. The Lithuanian Statistics provided the revised data on natural gas consumption in chemical industries due to revision of activity data performed by JSC Achema. JSC Achema is a leading manufacturer of nitrogen fertilizers and chemical products in Lithuania. JSC Achema revised activity data and reallocated from non-energy to energy use. Revised activity data on natural gas consumption in Chemical industries presented in Table 3-27. This reallocation of data had significant impact on recalculated GHG emissions in Chemical industries (1.A.2.c) for 2005-2014 period.

Table 3-27. Revised activity data on natural gas consumption in 1.A.2.c Chemical industries

	Natural gas consumption in Chemical industries, TJ									
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Submission 2017	4972.4	5254.4	5048.0	5120.0	5720.0	5476.0	5825.0	6652.0	5130.0	5666.0

Submission 2016	2019.6	3419.3	2399.4	2468.0	3493.0	3306.0	2781.0	3721.0	2713.0	3019.0

Impact of these recalculations on GHG emissions from 1.A.2.c Chemical industries presented in Table 3-28.

Table 3-28. Impact of recalculation on GHG emissions from 1.A.2.c Chemical industries

Year	Submission 2016, kt CO2 eqv.	Submission 2017, kt CO2 eqv.	Absolute difference, kt CO2 eqv.	Relative difference, %
1990	400.5	400.0	-0.54	-0.14
1991	435.7	435.2	-0.56	-0.13
1992	189.1	188.8	-0.24	-0.13
1993	112.1	112.0	-0.14	-0.12
1994	110.4	110.2	-0.14	-0.13
1995	108.3	108.1	-0.14	-0.13
1996	113.0	112.9	-0.16	-0.14
1997	131.7	131.5	-0.19	-0.15
1998	140.2	139.9	-0.21	-0.15
1999	32.9	32.9	-0.04	-0.12
2000	12.1	12.1	-0.02	-0.14
2001	16.4	16.4	-0.02	-0.10
2002	19.3	19.3	-0.02	-0.12
2003	21.0	21.0	-0.03	-0.15
2004	103.1	102.8	-0.26	-0.25
2005	112.1	274.7	162.55	59.17
2006	191.4	292.2	100.87	34.52
2007	134.1	279.9	145.82	52.10
2008	137.9	283.9	146.00	51.43
2009	194.2	316.9	122.72	38.73
2010	187.5	306.9	119.37	38.89
2011	154.0	321.7	167.65	52.12
2012	207.5	369.1	161.57	43.78
2013	151.7	285.2	133.52	46.81
2014	168.6	315.0	146.40	46.47

3.3.3.6 Category-specific planned improvements

Category-specific improvements are not planned.

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

3.3.4.1 Category description

The Pulp, Paper and Print industries is a small branch of manufacturing industry in Lithuania. With reference to data of 2014, value added created by Pulp, Paper and Print industries made 4.9% in the structure of manufacturing industry. The Pulp, Paper and Print industries has been growing by 10.1% during 2005-2008, and the growth rates have been by 4.6 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 1.0%, the Pulp, Paper and Print industries has remained the sector with the lowest decline rate, which was 1.5% in 2009. In 2015, Pulp, Paper and Print industry produced 128.2 thousand tons of paper and paperboard (i.e. this is by 2.4% more than in 2014), as well 110.4 thousand tons of corrugated paper and paperboard, cartons, boxes and cases of corrugated paper or paperboard (i.e. this is by 3.7% more than in 2014).

3.3.4.2 Methodological issues

CO_2 emissions were calculated applying *Tier 2*, CH_4 and N_2O were calculated applying *Tier 1* (as presented in Table 3-29) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Pulp, Paper and Print industries (1.A.2.d) is presented in Table 3-29.

Table 3-29. 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 72.73*	CS	T2	3.0	D	T1	0.6	D	T1
Residual fuel oil	77.60 78.40*	CS	T2	3.0	D	T1	0.6	D	T1
LPG	65.42 66.34*	CS	T2	1.0	D	T1	0.1	D	T1
Coke	109.11	CS	T2	10.0	D	T1	1.5	D	T1
Coking coal	94.90 95.10*	CS	T2	10.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00 96.10*	CS	T2	10.0	D	T1	1.5	D	T1
Natural gas	Table 3-11	CS	T2	1.0	D	T1	0.1	D	T1
Wood/ wood waste	101.34	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations:
CS - country specific emission factors;
D - default emission factors (*2006 IPCC Guidelines*);
* - CS emission factors applied from 2015 based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute. Summary of the study is presented in Annex IV;
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 for the 1990-2007 period. Since 2008 activity data are available at the Lithuanian Statistics database (http://www.stat.gov.lt/lt/). Activity data are provided in the Table 3-30.

Table 3-30. Energy consumption by fuel type in Pulp, paper and print industries, TJ

Year	Gasoil	RFO	LPG	Coke	Coking coal	Sub-bitumi-nous coal	Na-tural gas	Wood/ wood waste	Total
1990	0.0	883.1	0.0	0.0	0.0	0.0	3,388.0	3.0	**4,274.1**
1995	0.0	401.4	0.0	0.0	75.4	0.0	749.0	5.0	**1,230.8**
2005	0.0	0.0	3.9	0.0	0.0	0.1	448.3	0.4	**452.8**
2010	0.0	0.0	3.0	0.0	0.0	0.0	1,172.0	128.0	**1,303.0**
2011	20.0	0.0	4.0	0.0	0.0	0.0	921.0	140.0	**1,085.0**
2012	15.0	0.0	4.4	0.0	00	0.0	778.0	86.0	**883.4**
2013	0.0	0.0	5.0	0.0	0.0	0.0	780.0	217.0	**1,002.0**
2014	0.0	0.0	6.0	0.0	0.0	0.0	475.0	219.0	**700.0**
2015	0.0	0.0	6.0	0.0	0.0	0.0	384.0	161.0	**551.0**

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

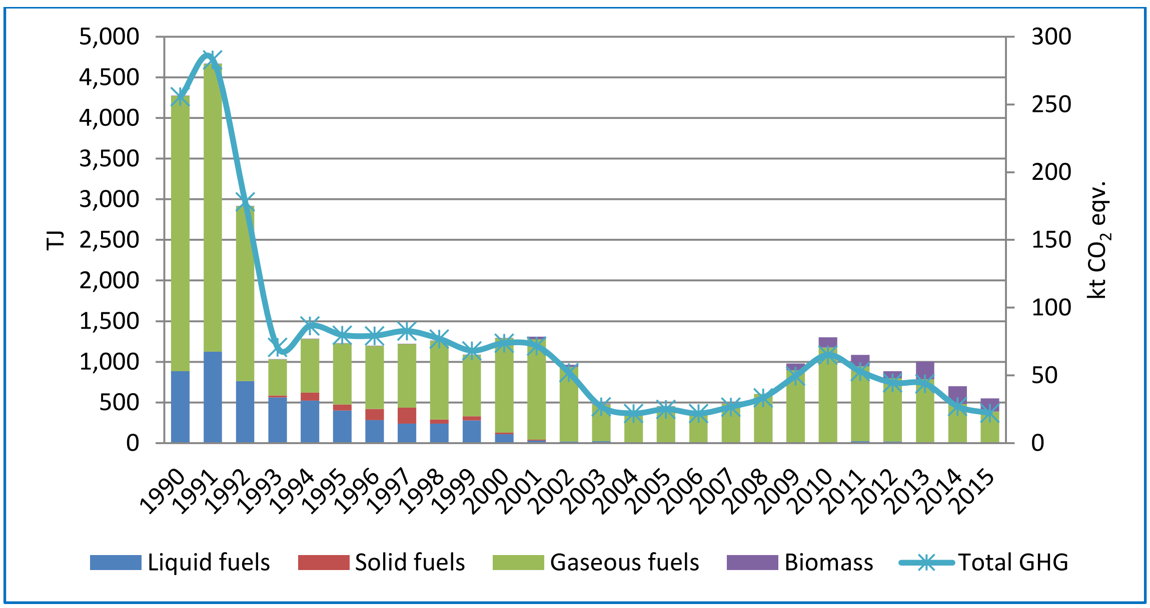


Figure 3-21. Tendencies of fuel consumption and total GHG emissions in Pulp, Paper and Print industries (1.A.2.d)

In 2015, fuel consumption in Pulp, Paper and Print industries decreased by 21.3% and total fuel consumption amounted to 551.0 TJ.

Historically natural gas was the main fuel used in Pulp, Paper and Print industries. In 2015, the share of natural gas was 69.7%. During 2000-2013 biomass consumption increased by almost 7 times. Thus, in 2015, the share of biomass accounted 29.2%, natural gas – 69.7%, liquid fuels - only 1.1% in the structure of fuel used in Pulp, Paper and Print industries.

In 2015, total GHG emissions from Pulp, Paper and Print industries were even 11.6 times lower than in 1990 and amounted 22.1 kt CO_2 eqv.

3.3.4.3 Uncertainties and time-series consistency

Uncertainty in activity data in Pulp, Paper and Print industries is ±2.0% taking into consideration recommendations provided by *2006 IPCC Guidelines* for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by *2006 IPCC Guidelines*.

Uncertainties of CO_2 emission factors for liquid fuels (residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.0% in Pulp, Paper and Print industries. Uncertainties of CO_2 emission factors for solid fuels (coke, coking coal) are ±5.0%. Estimated uncertainties of CO_2 emission factors for biomass are ±15%. Uncertainties of all country specific CO_2 emission factors were revised in the study "Update of country specific GHG emission factors for 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 *2006 IPCC Guidelines.*

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 Category-specific QA/QC and verifications

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

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

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

3.3.4.5 Category-specific recalculations

Following recalculations in this category has been done:

- revision of CO_2 emission factor for natural gas (see Table 3-11) and wood/wood waste based on study on "Update of country specific GHG emission factors for Energy sector" (performed in April 2016 by Lithuanian Energy Institute).

Impact of these recalculations on GHG emissions from 1.A.2.d Pulp, Paper and Print industries presented in Table 3-31.

Table 3-31. Impact of recalculation on GHG emissions from 1.A.2.d Pulp, Paper and Print industries

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	256.1	255.8	-0.30	-0.12
1991	283.4	283.1	-0.32	-0.11
1992	178.4	178.2	-0.19	-0.11
1993	70.7	70.7	-0.04	-0.06
1994	86.7	86.7	-0.06	-0.07
1995	79.9	79.8	-0.07	-0.08
1996	79.3	79.3	-0.07	-0.09
1997	82.8	82.7	-0.07	-0.09
1998	77.1	77.0	-0.09	-0.11
1999	68.3	68.3	-0.07	-0.10
2000	73.9	73.8	-0.10	-0.14
2001	71.8	71.7	-0.11	-0.16
2002	52.1	52.0	-0.08	-0.16
2003	26.9	26.8	-0.04	-0.15
2004	22.0	21.9	-0.05	-0.25
2005	25.1	25.0	-0.06	-0.25
2006	21.9	21.8	-0.04	-0.19
2007	26.8	26.7	-0.06	-0.22
2008	33.5	33.5	-0.07	-0.22
2009	49.7	49.6	-0.06	-0.13
2010	65.2	65.1	-0.13	-0.20
2011	52.9	52.8	-0.10	-0.19
2012	44.6	44.5	-0.05	-0.12
2013	43.9	43.9	-0.02	-0.04
2014	27.1	27.1	0.00	0.02

3.3.4.6 Category-specific planned improvements

Category-specific improvements are not planned.

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

3.3.5.1 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 43.2% (1995) till 26.2% (2008), but remained the largest manufacturing industry in Lithuania. During the last decade food processing industry, has passed a rapid restructuring process, when number of active economic entities in the main branches of food industry (except in fruit and berries industry) has noticeably decreased. However, the share of large companies has increased. Food processing industry has kept a stable share in terms of value added in the structure of national economy and rapid growth rates in the export structure (Kaunas Technology University, 2009). Currently, the share of value added in Food Processing, Beverages and Tobacco industry accounts 23.4% of total value added in manufacturing industry. In 2015, industry produced 223.0 thousand tons of meat and meat sub-products, 100.0 thousand tons of food fish, 33.5 thousand tons of prepared preserved vegetables, fruits and nuts, 11.2 thousand tons of fruits and vegetables, 112.7 thousand tons of milk, 482.5 thousand tons of flour, 148.1 thousand tons of bread and pastry products, 31,082 thousand dal of beer, 15,241 thousand dal of natural mineral and aerated waters without sugar and non-flavoured, 21,662 thousand dal of non-alcoholic beverages and other.

3.3.5.2 Methodological issues

CO_2 emissions were calculated applying *Tier 2*, CH_4 and N_2O were calculated applying *Tier 1* (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 3-32.

Table 3-32. 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 76.60*	CS	T2	3.0	D	T1	0.6	D	T1
Residual fuel oil	77.60 78.40*	CS	T2	3.0	D	T1	0.6	D	T1
LPG	65.42 66.34*	CS	T2	1.0	D	T1	0.1	D	T1
Gasoil	72.89 72.73*	CS	T2	3.0	D	T1	0.6	D	T1
Coking coal	94.90 95.10*	CS	T2	10.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00 96.10*	CS	T2	10.0	D	T1	1.5	D	T1
Anthracite	106.55	CS	T2	10.0	D	T1	1.5	D	T1
Coke	109.11	CS	T2	10.0	D	T1	1.5	D	T1

Peat	104.34	CS	T2	2.0	D	T1	1.5	D	T1
Natural gas	Table 3-11	CS	T2	1.0	D	T1	0.1	D	T1
Wood/ wood waste	101.34	CS	T2	30.0	D	T1	4.0	D	T1
Other solid biomass	103.69	CS	T2	30.0	D	T1	4.0	D	T1
Biogas	58.45	CS	T2	1.0	D	T1	0.1	D	T1

Abbreviations:
CS - country specific emission factors;
D - default emission factors *(2006 IPCC Guidelines*);
* - CS emission factors applied from 2015 based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute. Summary of the study is presented in Annex IV;
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 for the 1990-2007 period. Since 2008 activity data are available at the Lithuanian Statistics database (http://www.stat.gov.lt/lt/). Activity data are provided in the Table 3-33.

Table 3-33. Energy consumption by fuel type in Food Processing, Beverages and Tobacco industries, TJ

Year	Shale oil	RFO	LPG	Gasoil	Peat	Coking coal	An-thra-cite	Sub-bitu-minous coal	Coke	Natural gas	Wood and wood waste	Biogas	Other solid biomass	Total
1990	0.0	2,247.8	0.0	0.0	0.0	351.7	0.0	0.0	0.0	8,498.0	36.0	0.0	0.0	**11,133.5**
1995	0.0	1,605.6	0.0	0.0	0.0	150.7	0.0	0.0	0.0	2,077.0	57.0	0.0	0.0	**3,890.3**
2000	0.0	1,567.2	121.0	3.0	0.0	67.5	0.0	0.0	105.0	2,890.2	77.1	0.0	0.0	**4,831.0**
2001	0.0	1,120.0	60.0	0.0	0.0	0.0	0.0	37.7	99.5	2,987.3	42.6	0.0	0.0	**4,347.1**
2002	0.0	875.6	64.0	4.3	0.8	0.0	0.0	61.3	98.0	3,792.1	49.4	0.0	0.0	**4,945.4**
2003	0.0	677.0	74.3	29.5	1.5	0.0	0.0	40.9	105.5	4,025.5	71.3	0.0	0.0	**5,025.6**
2004	5.0	588.0	102.0	47.0	1.5	0.0	0.0	34.1	76.0	3,710.7	112.0	0.0	0.0	**4,676.2**
2005	13.0	334.2	157.5	148.4	5.5	0.0	0.0	49.6	63.5	3,695.4	297.3	0.0	0.0	**4,764.5**
2006	40.0	292.0	210.0	89.8	1.5	0.0	0.0	41.0	62.0	3,868.1	140.0	5.0	0.0	**4,749.4**
2007	22.0	379.2	237.3	51.7	2.0	0.0	0.0	36.0	60.0	4,213.3	82.2	13.0	0.0	**5,096.7**
2008	27.0	274.0	205.0	92.0	2.0	0.0	0.0	32.0	29.0	3,933.0	102.0	10.0	0.0	**4,706.0**
2009	0.0	233.0	186.0	73.0	1.0	36.0	0.0	7.0	45.0	3,645.0	78.0	18.0	0.0	**4,322.0**
2010	0.0	212.0	192.0	94.0	15.0	3.0	0.0	38.0	54.0	4,005.0	93.0	10.0	0.0	**4,716.0**
2011	0.0	268.0	194.0	86.0	9.0	29.0	18.0	9.0	49.0	4,295.0	87.5	10.0	0.0	**5,054.5**
2012	0.0	243.0	221.0	121.0	11.0	29.0	24.0	2.0	44.0	4,422.0	63.0	0.0	0.0	**5,180.0**
2013	0.0	213.0	215.0	93.0	9.0	28.5	38.0	0.0	41.0	4,178.0	190.0	20.0	3.0	**5,028.5**
2014	0.0	243.0	157.0	120.0	10.0	36.0	21.0	0.0	60.0	3,566.0	556.0	30.0	5.0	**4,804.0**
2015	0.0	271.0	209.0	99.0	7.0	36.0	0.0	0.0	45.0	3,379.0	668.0	35.0	16.0	**4,765.0**

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

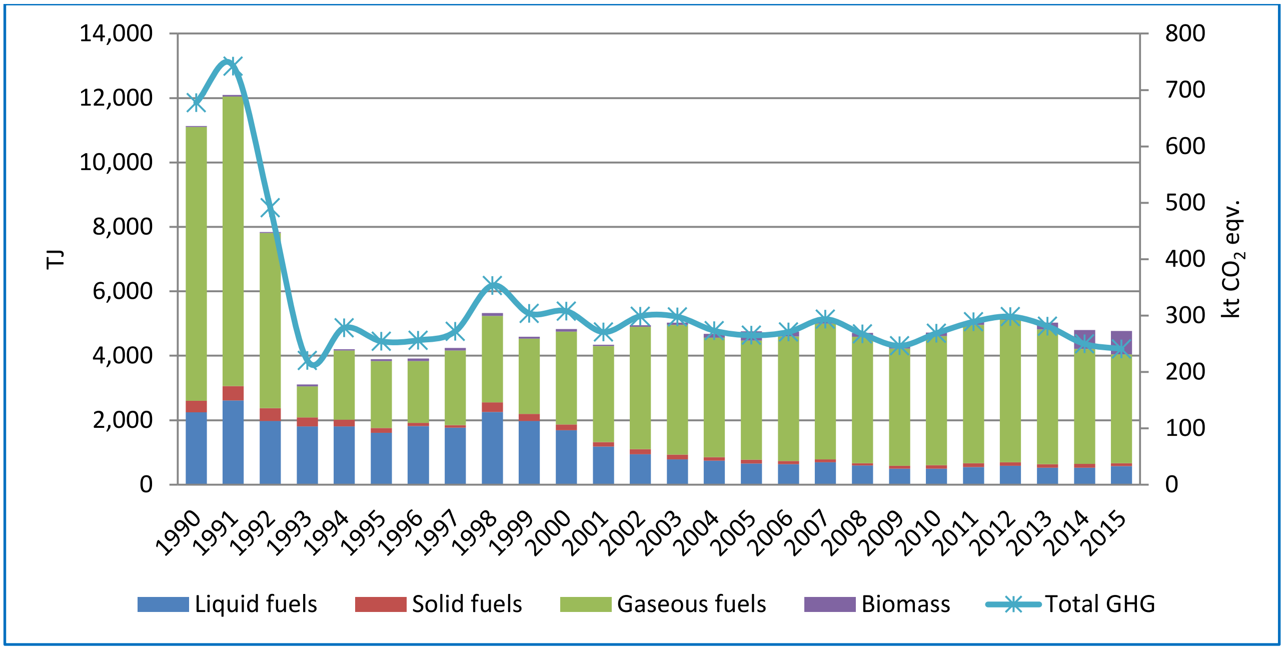


Figure 3-22. Tendencies of fuel consumption and total GHG emissions in Food Processing, Beverages and Tobacco industries (1.A.2.e)

Fuel consumed in Food Processing, Beverages and Tobacco industries has become more diversified compared to the structure that have existed in 1990. Instead of three fuels (residual fuel oil, coking coal and natural gas) that have been widely used in industry in early 1990s, currently LPG, gasoil, peat, wood/wood waste and biogas penetrate the market (Figure 3-22). In 2015, natural gas accounted 70.9%, liquid fuels – 12.2%, biomass – 15.1% and solid fuels – 1.8% in the total structure of fuel combusted Food Processing, Beverages and Tobacco industries.

In 2015, total GHG emissions from Food Processing, Beverages and Tobacco industries were 2.8 times lower than in 1990 and amounted 240.7 kt CO_2 eqv.

3.3.5.3 Uncertainties and time-series consistency

Uncertainty in activity data in Food Processing, Beverages and Tobacco industries is ±2.0% taking into consideration recommendations provided by *2006 IPCC Guidelines* for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by *2006 IPCC Guidelines*.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.0% in Food Processing, Beverages and Tobacco industries. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and coke) are ±5.0%. Estimated uncertainties of CO_2 emission factors for biomass are ±15%. Uncertainties of all country specific CO_2 emission factors were revised in the study “Update of country specific GHG emission factors for 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 *2006 IPCC Guidelines.*

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 Category-specific QA/QC and verifications

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

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

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

3.3.5.5 Category-specific recalculations

Following recalculations in this category has been done:

- revision of CO_2 emission factor for natural gas (see Table 3-11), wood/wood waste and other solid biomass based on study on "Update of country specific GHG emission factors for Energy sector" (performed in April 2016 by Lithuanian Energy Institute).

Impact of these recalculations on GHG emissions from 1.A.2.e Food Processing, Beverages and Tobacco industries presented in Table 3-34.

Table 3-34. Impact of recalculation on GHG emissions from 1.A.2.e Food Processing, Beverages and Tobacco industries

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	678.5	677.7	-0.76	-0.11
1991	743.3	742.5	-0.81	-0.11
1992	491.9	491.4	-0.49	-0.10
1993	220.5	220.4	-0.09	-0.04
1994	278.5	278.3	-0.19	-0.07
1995	254.3	254.2	-0.19	-0.07
1996	256.3	256.1	-0.17	-0.07
1997	272.1	271.9	-0.21	-0.08
1998	353.5	353.3	-0.24	-0.07
1999	303.8	303.6	-0.21	-0.07
2000	308.1	307.8	-0.26	-0.08
2001	270.9	270.7	-0.27	-0.10
2002	299.2	298.8	-0.34	-0.11

2003	298.1	297.8	-0.36	-0.12
2004	273.4	272.9	-0.52	-0.19
2005	265.4	264.9	-0.52	-0.20
2006	271.2	270.8	-0.43	-0.16
2007	293.9	293.4	-0.51	-0.17
2008	267.7	267.2	-0.47	-0.18
2009	246.5	246.2	-0.26	-0.10
2010	269.0	268.6	-0.44	-0.16
2011	289.4	288.9	-0.47	-0.16
2012	298.4	298.0	-0.31	-0.10
2013	281.1	281.0	-0.08	-0.03
2014	249.5	249.6	0.04	0.01

3.3.5.6 Category-specific planned improvements

Category-specific improvements are not planned.

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

3.3.6.1 Category description

The category of Non-Metallic Minerals takes into account production and processing of glass, building material from clay (mole), pottery, cement and their products. In 2014, value added created in the Non-Metallic Minerals industry accounted 214.8 million EUR, i.e. 3.9% of total value added of the manufacturing industry. There were produced 1,327.0 thous. m^2 of multiple-walled insulating units of glass, 157.6 millions of bottles of colourless and coloured glass, 41.1 thous. m^3 of clay building bricks, 257.3 thous. t of silicate bricks and blocks, 979.6 thous. t of cement, 6.4 mill. m^2 of sheets from non-asbestos cement and 660.1 thous. t of prefabricated structural components for building or civil engineering in 2015. The economic crisis hitted the Non-Metallic Minerals industry the most within all other manufacturing industries. In 2009, value added created in the industry reduced by 46% and the structural share from 5.3% (2008) till 3.4% (2009). Production of all types products significantly reduced. During 2009-2014 annual growth rate of value added was 10.0% a year, however, thus far the pre-crisis level is not reached, i.e. in 2014, value added made only 77.2% of 2007 level.

3.3.6.2 Methodological issues

CO_2 emissions were calculated applying *Tier 2*, CH_4 and N_2O were calculated applying *Tier 1* (as presented in Table 3-33) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Non-Metallic Minerals industries (1.A.2.f) are presented in Table 3-35.

Table 3-35. Emission factors and methods for category Non-Metallic Minerals industries (1.A.2.f)

Fuel	CO_2	CH_4	N_2O

	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Residual fuel oil	77.60 78.40*	CS	T2	3.0	D	T1	0.6	D	T1
LPG	65.42 66.34*	CS	T2	1.0	D	T1	0.1	D	T1
Gasoil	72.89 72.73*	CS	T2	3.0	D	T1	0.6	D	T1
Petroleum coke	94.06	CS	T2	3.0	D	T1	0.6	D	T1
Coking coal	94.90 95.10*	CS	T2	10.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00 96.10*	CS	T2	10.0	D	T1	1.5	D	T1
Anthracite	106.55	CS	T2	10.0	D	T1	1.5	D	T1
Coke	109.11	CS	T2	10.0	D	T1	1.5	D	T1
Natural gas	Table 3-11	CS	T2	1.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	2.0	D	T1	1.5	D	T1
Wood/ wood waste	101.34	CS	T2	30.0	D	T1	4.0	D	T1
Other solid biomass	103.69	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations:
CS - country specific emission factors;
D - default emission factors (*2006 IPCC Guidelines*);
* - CS emission factors applied from 2015 based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute. Summary of the study is presented in Annex IV;
T1 – *Tier 1*; T2 – *Tier 2*.

Activity data

For calculation of GHG emissions in category Non-Metallic Minerals (1.A.2.f) activity data had been obtained from the Lithuanian Statistics. The Lithuanian Statistics provided data on energy consumption in manufacturing industries and construction according to the type of economic activity based on special request for the 1990-2007 period. Since 2008 activity data are available at the Lithuanian Statistics database (http://www.stat.gov.lt/lt/). Activity data are provided in the Table 3-36.

Table 3-36. Energy consumption by fuel type in Non-Metallic Minerals industries, TJ

Year	RFO	LPG	Gasoil	Petroleum coke	Peat	Coking coal	Anthracite	Subbituminous coal	Coke	Natural gas	Wood /wood waste	Other solid biomass	Total
1990	3,5443.6	0.0	0.0	0.0	168.0	628.0	0.0	0.0	0.0	6,934.0	19.0	0.0	**43,192.6**
1995	7,787.2	0.0	0.0	0.0	227.0	326.6	0.0	0.0	0.0	1,833.0	63.0	0.0	**10,236.7**
2000	3,522.2	5.0	0.0	0.0	43.4	7.5	0.0	0.0	190.0	1,775.0	151.7	0.0	**5,694.8**
2001	3,534.0	4.6	0.0	0.0	35.2	0.0	0.0	0.0	190.0	1,845.3	159.1	0.0	**5,768.2**
2002	1,872.3	5.9	0.4	0.0	11.0	102.0	0.0	1,580.0	187.0	1,280.5	367.4	0.0	**5,406.4**
2003	543.0	4.6	38.0	0.0	12.9	414.5	690.0	1,816.0	231.5	1,282.7	606.8	0.0	**5,640.0**
2004	996.0	4.6	30.0	17.0	1.2	580.3	95.0	2,233.7	255.0	1,185.5	581.0	0.0	**5,979.3**
2005	1180.3	5.2	148.2	46.2	7.0	0.0	0.0	2,924.1	401.5	1,615.3	565.8	0.0	**6,893.6**
2006	815.0	4.6	98.4	325.0	3.0	125.6	0.0	4,202.0	586.0	1,691.2	469.0	0.0	**8,319.9**
2007	4.0	6.1	104.3	793.3	4.0	0.0	0.0	4,526.4	585.0	1,785.0	528.2	0.0	**8,336.4**
2008	82.0	7.0	83.0	218.0	6.0	301.0	75.0	3,665.0	411.0	1,538.0	501.0	0.0	**6,887.0**
2009	20.0	3.0	69.0	685.0	6.0	1,184.0	370.0	679.0	240.0	813.0	360.0	0.0	**4,429.0**
2010	1.0	2.0	65.0	111.0	11.0	2,847.0	0.0	153.0	387.0	909.0	345.0	0.0	**4,831.0**
2011	14.0	5.0	69.0	0.0	36.0	3,701.0	73.0	5.0	440.0	1,005.0	501.5	0.0	**5,849.5**
2012	145.0	3.0	56.0	13.0	38.0	4,307.0	0.0	9.0	481.0	1,007.0	460.0	3.0	**6,522.0**
2013	112.0	3.0	66.0	1.0	40.0	5,033.5	0.0	0.0	498.0	947.0	451.0	4.0	**7,155.5**
2014	89.0	2.0	112.0	0.0	38.0	4,337.0	0.0	0.0	395.0	959.0	429.0	0.0	**6,361.0**
2015	57.0	3.0	75.0	0.0	33.0	3,545.0	0.0	0.0	336.0	945.0	266.0	0.0	**5,260.0**

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

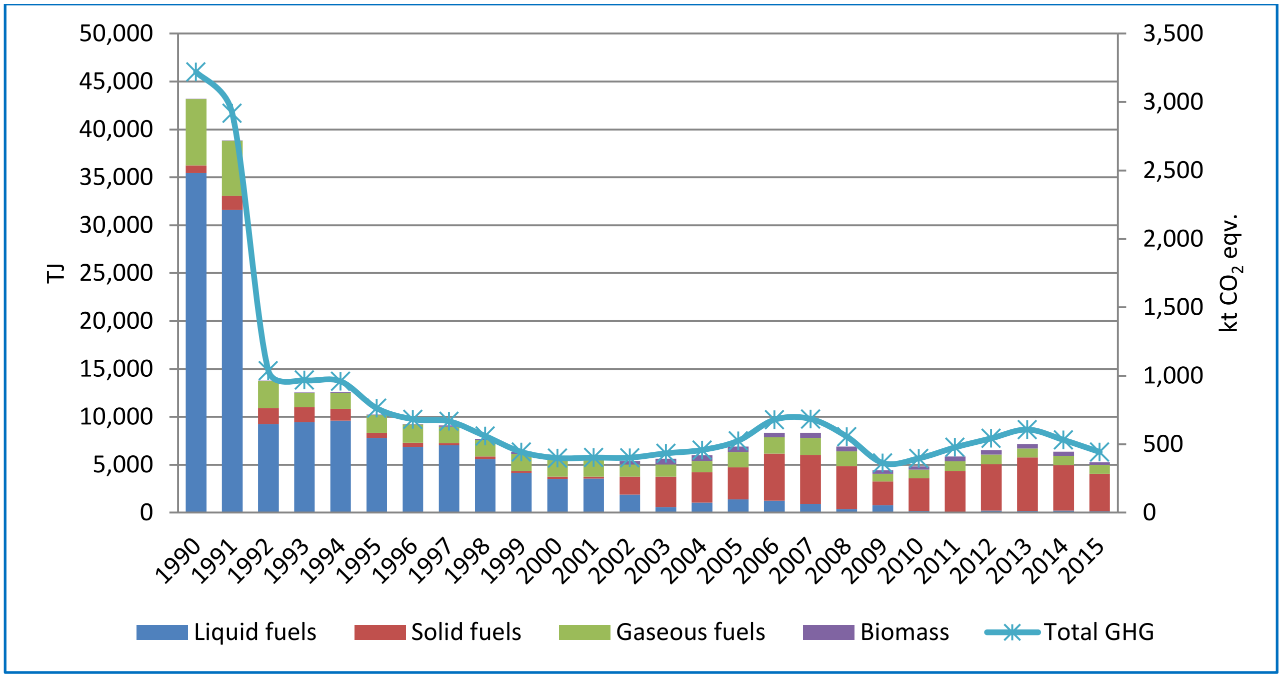


Figure 3-23. Tendencies of fuel consumption and total GHG emissions in Non-Metallic Minerals (1.A.2.f)

Due to significant economic slump after restoration of independence fuel consumption in Non-Metallic Minerals industries reduced by almost 7.6 times during 1990-2000. In 1990 liquid fuels dominated in the structure of total fuel consumed in Non-Metallic Minerals industries and since 2003 solid fuels started to dominate. In 2015, the share of solid fuels was 73.8%, natural gas – 18.0%, biomass – 5.0%, liquid fuels – 2.6% and peat – 0.6%.

In 2015, total GHG emissions from Non-Metallic Minerals industries were 7.3 times lower than in 1990 and amounted 443.2 kt CO_2 eqv.

3.3.6.3 Uncertainties and time-series consistency

Uncertainty in activity data in Non-Metallic Minerals industries is ±2.0% taking into consideration recommendations provided by *2006 IPCC Guidelines* for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by *2006 IPCC Guidelines*.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.0% in Non-Metallic Minerals industries. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and coke) are ±5.0%. Estimated uncertainties of CO_2 emission factors for biomass are ±15%. Uncertainties of all country specific CO_2 emission factors were revised in the study "Update of country specific GHG emission factors for 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 *2006 IPCC Guidelines.*

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 Category-specific QA/QC and verifications

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

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

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

3.3.6.5 Category-specific recalculations

Following recalculations in this category has been done:

- revision of CO_2 emission factor for natural gas (see Table 3-11), wood/wood waste and other solid biomass based on study on "Update of country specific GHG emission factors for Energy sector" (performed in April 2016 by Lithuanian Energy Institute).

Impact of these recalculations on GHG emissions from 1.A.2.f Non-Metallic Minerals industries presented in Table 3-37.

Table 3-37. Impact of recalculation on GHG emissions from 1.A.2.f Non-Metallic Minerals industries

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	3,220.4	3,219.8	-0.62	-0.02
1991	2,919.4	2,918.8	-0.52	-0.02
1992	1,038.2	1,037.9	-0.25	-0.02
1993	968.4	968.3	-0.14	-0.01
1994	959.7	959.6	-0.15	-0.02
1995	762.7	762.6	-0.16	-0.02
1996	682.8	682.6	-0.17	-0.02
1997	667.3	667.1	-0.15	-0.02
1998	559.7	559.6	-0.16	-0.03
1999	443.6	443.5	-0.16	-0.04
2000	399.1	398.9	-0.16	-0.04
2001	402.3	402.1	-0.17	-0.04
2002	401.9	401.8	-0.12	-0.03
2003	433.4	433.3	-0.12	-0.03
2004	458.1	457.9	-0.17	-0.04
2005	525.4	525.2	-0.23	-0.04
2006	679.0	678.8	-0.19	-0.03
2007	685.2	685.0	-0.21	-0.03
2008	556.4	556.3	-0.18	-0.03

2009	362.6	362.5	-0.06	-0.02
2010	397.0	396.9	-0.10	-0.03
2011	477.2	477.1	-0.11	-0.02
2012	542.8	542.7	-0.07	-0.01
2013	607.1	607.1	-0.02	0.00
2014	531.1	531.1	0.01	0.00

3.3.6.6 Category-specific planned improvements

Category-specific improvements are not planned.

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

3.3.7.1 Category description

The category of Transport Equipment takes into account manufacture of motor-vehicles, trailers and semi-trailers, as well manufacture of other transport equipment. In 2015, there were manufactured 2.1 thousand of trailers and semi-trailers, 7.2 thousand tons of insulated ignition wiring sets and 255.6 thousand of bicycles. This influenced on the creation of 171.4 million EUR of value added. Since 2007 manufacturing volume of aforementioned goods was reducing. Especially manufacturing of bicycles decreased. In 2015, volume of manufactured bicycles made 63.1% of 2007 level. Today Transport Equipment industry is one of the smallest in the country. In 2015, value added created made 3.0% of total value added of the manufacturing industry.

3.3.7.2 Methodological issues

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

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Transport Equipment industries (1.A.2.g) are presented in Table 3-38.

Table 3-38. Emission factors and methods for category Transport Equipment industries (1.A.2.g)

Fuel	**CO_2**			**CH_4**			**N_2O**		
	CO_2, kg/GJ	**EF**	**Method**	**CH_4, kg/TJ**	**EF**	**Method**	**N_2O, kg/TJ**	**EF**	**Method**
Residual fuel oil	77.60 78.40*	CS	T2	3.0	D	T1	0.6	D	T1
LPG	65.42 66.34*	CS	T2	1.0	D	T1	0.1	D	T1
Gasoil	72.89 72.73*	CS	T2	3.0	D	T1	0.6	D	T1
Coking coal	94.90 95.10*	CS	T2	10.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00 96.10*	CS	T2	10.0	D	T1	1.5	D	T1

Natural gas	Table 3-11	CS	T2	1.0	D	T1	0.1	D	T1
Wood/ wood waste	101.34	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations:
CS - country specific emission factors;
D - default emission factors (*2006 IPCC Guidelines*);
* - CS emission factors applied from 2015 based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute. Summary of the study is presented in Annex IV;
T1 - *Tier 1*; T2 - *Tier 2*.

Activity data

For calculation of GHG emissions in category Transport Equipment (1.A.2.g) activity data had been obtained from the Lithuanian Statistics. The Lithuanian Statistics provided data on energy consumption in manufacturing industries and construction according to the type of economic activity based on special request for the 1990-2007 period. Since 2008 activity data are available at the Lithuanian Statistics database (http://www.stat.gov.lt/lt/). Activity data are provided in the Table 3-39.

Table 3-39. Energy consumption by fuel type in Transport Equipment industries, TJ

Year	Gasoil	Residual fuel oil	LPG	Coking coal	Sub-bituminous coal	Natural gas	Wood/ wood waste	Total
1990	0.0	0.0	0.0	0.0	0.0	189.0	0.0	**189.0**
1995	0.0	0.0	0.0	0.0	0.0	102.0	0.0	**102.0**
2000	0.0	0.0	9.3	0.0	0.0	170.8	0.0	**180.1**
2005	0.7	0.0	8.1	0.0	4.1	238.4	0.6	**251.9**
2010	1.0	0.0	1.0	1.0	1.0	105.0	1.0	**110.0**
2011	0.0	0.0	2.0	1.0	0.0	48.0	0.0	**51.0**
2012	1.0	0.0	3.0	1.0	1.0	59.0	0.0	**65.0**
2013	1.0	0.0	1.0	2.0	0.0	54.0	0.0	**58.0**
2014	1.0	0.0	1.0	4.0	0.0	50.0	0.0	**56.0**
2015	1.0	0.0	2.0	4.0	0.0	47.0	0.0	**54.0**

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

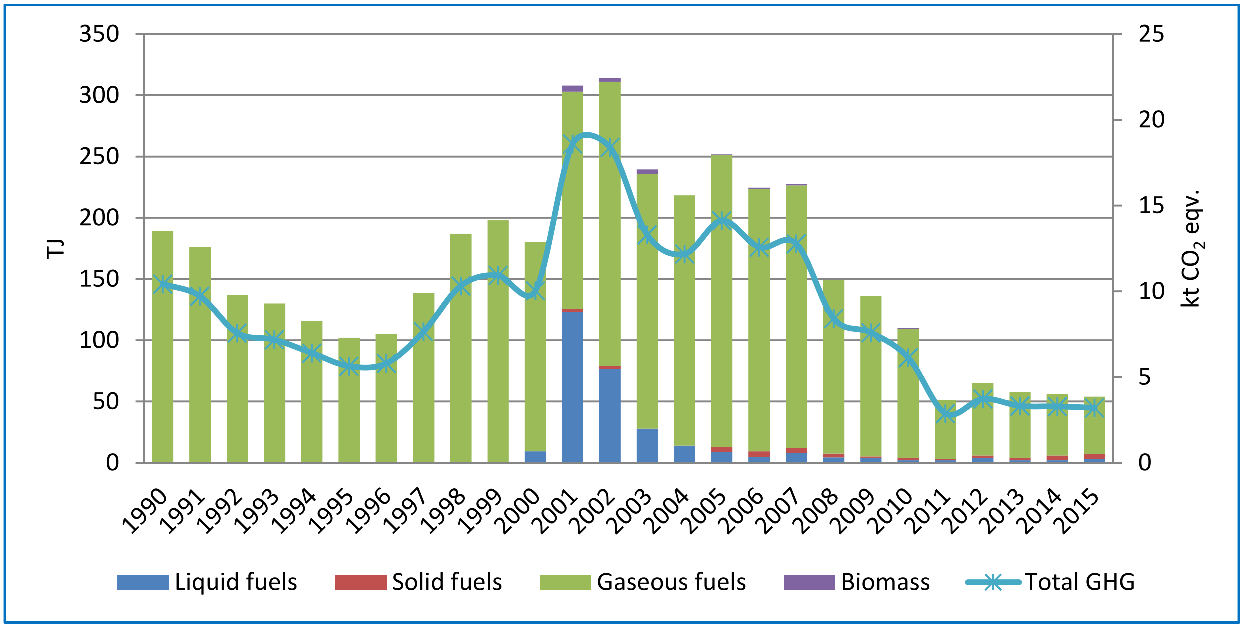


Figure 3-24. Tendencies of fuel consumption and total GHG emissions in Transport Equipment industries (1.A.2.g)

Historically natural gas was the main fuel used in Transport Equipment industries. In 2015, the share of natural gas was 87.0%, liquid fuels – 5.6% and solid fuels accounted 7.4% in the structure of fuel used in Transport Equipment industries.

In 2015, total GHG emissions from Transport Equipment industries were 3.3 times lower than in 1990 and amounted 3.2 kt CO_2 eqv.

3.3.7.3 Uncertainties and time-series consistency

Uncertainty in activity data in Transport Equipment industries is ±2.0% taking into consideration recommendations provided by *2006 IPCC Guidelines* for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by *2006 IPCC Guidelines*.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.0% in Transport Equipment industries. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and coke) are ±5.0%. Estimated uncertainties of CO_2 emission factors for biomass are ±15%. Uncertainties of all country specific CO_2 emission factors were revised in the study "Update of country specific GHG emission factors for 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 *2006 IPCC Guidelines*.

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

3.3.7.4 Category-specific QA/QC and verifications

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

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

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

3.3.7.5 Category-specific recalculations

Following recalculations in this category has been done:

- revision of CO_2 emission factor for natural gas (see Table 3-11) and wood/wood waste based on study on "Update of country specific GHG emission factors for Energy sector" (performed in April 2016 by Lithuanian Energy Institute).

Impact of these recalculations on GHG emissions from 1.A.2.g Transport Equipment industries presented in Table 3-40.

Table 3-40. Impact of recalculation on GHG emissions from 1.A.2.g Transport Equipment industries

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	10.4	10.4	-0.02	-0.16
1991	9.7	9.7	-0.02	-0.16
1992	7.6	7.6	-0.01	-0.16
1993	7.2	7.2	-0.01	-0.16
1994	6.4	6.4	-0.01	-0.16
1995	5.6	5.6	-0.01	-0.16
1996	5.8	5.8	-0.01	-0.16
1997	7.7	7.6	-0.01	-0.16
1998	10.3	10.3	-0.02	-0.16
1999	10.9	10.9	-0.02	-0.16
2000	10.1	10.0	-0.02	-0.15
2001	18.6	18.6	-0.02	-0.09
2002	18.4	18.4	-0.02	-0.11
2003	13.3	13.3	-0.02	-0.14
2004	12.2	12.2	-0.03	-0.23
2005	14.2	14.1	-0.03	-0.24
2006	12.6	12.6	-0.02	-0.19
2007	12.8	12.8	-0.03	-0.20
2008	8.4	8.4	-0.02	-0.20
2009	7.6	7.6	-0.01	-0.12
2010	6.1	6.1	-0.01	-0.19
2011	2.9	2.9	-0.01	-0.18

2012	3.7	3.7	0.00	-0.11
2013	3.3	3.3	0.00	-0.03
2014	3.3	3.3	0.00	0.02

3.3.7.6 Category-specific planned improvements

Category-specific improvements are not planned.

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

3.3.8.1 Category description

The category of Machinery takes into account manufacture of fabricated metal products, except machinery and equipment, manufacture of computer, electronic and optical products, manufacture of electrical equipment and manufacture of machinery and equipment. The most important goods produced within the Machinery industry in Lithuania are as follows: windows, doors, their frames and thresholds from iron, metallic containers (less than 50 l), liquid supply meters, electricity supply meters, TV sets, electric wires and cables, chandeliers and other electric ceiling or wall lighting fittings, refrigerators and freezers. In 2015, value added created in Machinery industry made 13.9% of total value added of manufacturing industry. In 2009 value added decreased by 24.7% (compared to 2008). However, it recovered faster compared to other industries.

3.3.8.2 Methodological issues

CO_2 emissions were calculated applying *Tier 2*, CH_4 and N_2O were calculated applying *Tier 1* (as presented in Table 3-39) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Machinery industries (1.A.2.h) are presented in Table 3-41.

Table 3-41. Emission factors and methods for category Machinery industries (1.A.2.h)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Residual fuel oil	77.60 78.40*	CS	T2	3.0	D	T1	0.6	D	T1
LPG	65.42 66.34*	CS	T2	1.0	D	T1	0.1	D	T1
Gasoil	72.89 72.73*	CS	T2	3.0	D	T1	0.6	D	T1
Coking coal	94.90 95.10*	CS	T2	10.0	D	T1	1.5	D	T1
Anthracite	106.55	CS	T2	10.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00 96.10*	CS	T2	10.0	D	T1	1.5	D	T1

Coke	109.11	CS	T2	10.0	D	T1	1.5	D	T1
Natural gas	Table 3-11	CS	T2	1.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	2.0	D	T1	1.5	D	T1
Wood/ wood waste	101.34	CS	T2	30.0	D	T1	4.0	D	T1
Other solid biomass	103.69	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations:

CS - country specific emission factors;

D - default emission factors (*2006 IPCC Guidelines*);

* - CS emission factors applied from 2015 based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute. Summary of the study is presented in Annex IV;

T1 - *Tier 1*; T2 - *Tier 2*.

Activity data

For calculation of GHG emissions in category Machinery (1.A.2.h) activity data had been obtained from the Lithuanian Statistics. The Lithuanian Statistics provided data on energy consumption in manufacturing industries and construction according to the type of economic activity based on special request for the 1990-2007 period. Since 2008 activity data are available at the Lithuanian Statistics database (http://www.stat.gov.lt/lt/). Activity data are provided in the Table 3-42.

Table 3-42. Energy consumption by fuel type in Machinery industries, TJ

Year	RFO	LPG	Gasoil	Peat	Coking coal	Anthracite	Subbituminous coal	Coke	Natural gas	Wood/wood waste	Other solid biomass	Total
1990	1565.5	0.0	0.0	0.0	50.2	0.0	0.0	0.0	2,923.0	14.0	0.0	**4,552.7**
1995	481.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,036.0	68.0	0.0	**1,585.7**
2000	48.0	4.6	0.0	0.0	7.5	0.0	0.0	23.0	924.3	108.2	0.0	**1,115.7**
2005	0.1	15.4	3.6	0.5	0.0	0.0	13.2	17.0	1,098.8	373.1	0.0	**1,521.6**
2006	0.0	18.6	0.0	0.0	0.0	0.0	18.2	18.0	532.5	279.0	0.0	**866.2**
2010	0.0	9.0	8.0	3.0	0.0	3.0	2.0	3.0	262.0	36.0	9.0	**335.0**
2011	0.0	5.0	7.0	3.0	5.0	0.0	1.0	5.0	284.0	35.0	6.0	**351.0**
2012	0.0	4.0	11.0	5.0	6.0	0.0	0.0	0.0	267.0	99.0	3.0	**395.0**
2013	0.0	5.0	9.0	3.0	6.0	2.0	0.0	0.0	214.0	48.0	0.0	**287.0**
2014	0.0	8.0	4.0	3.0	9.0	0.0	0.0	0.0	229.0	13.0	0.0	**266.0**
2015	3.0	7.0	2.0	1.0	5.0	0.0	0.0	0.0	238.0	14.0	0.0	**270.0**

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

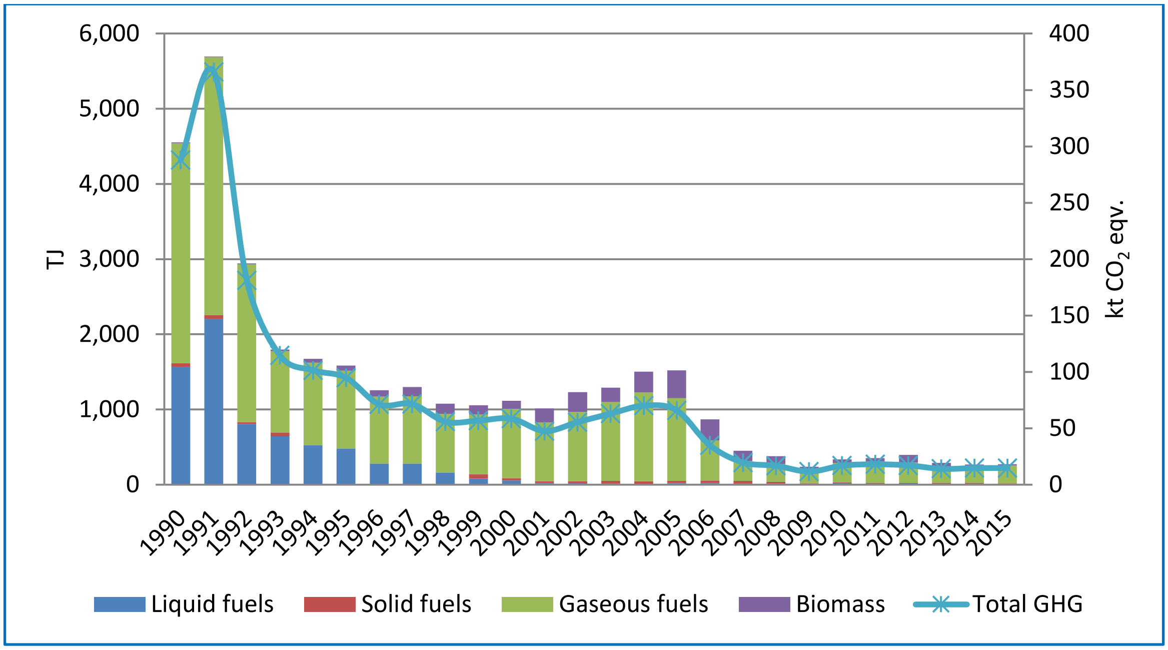


Figure 3-25. Tendencies of fuel consumption and total GHG emissions in Machinery industries (1.A.2.h)

Since 1990 fuel consumption in Machinery industries reduced by 17 times from 4,553 TJ in 1990 till 270 TJ in 2015. The share and volume of liquid fuels drastically reduced and in 2015 accounted only 4.4% in structure of fuel combusted. In 2015, the share of natural gas was 88.1%, solid fuels accounted 2.2% and biomass – 5.2% in the structure of fuel used in Machinery industries.

In 2015, total GHG emissions from Machinery industries were almost 20 times lower than in 1990 and amounted 14.7 kt CO_2 eqv.

3.3.8.3 Uncertainties and time-series consistency

Uncertainty in activity data in Machinery industries is ±2.0% taking into consideration recommendations provided by *2006 IPCC Guidelines* for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by *2006 IPCC Guidelines*.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.0% in Machinery industries. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and coke) are ±5.0%. Estimated uncertainties of CO_2 emission factors for biomass are ±15%. Uncertainties of all country specific CO_2 emission factors were revised in the study “Update of country specific GHG emission factors for 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 *2006 IPCC Guidelines.*

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

3.3.8.4 Category-specific QA/QC and verifications

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

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

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

3.3.8.5 Category-specific recalculations

Following recalculations in this category has been done:

- revision of CO_2 emission factor for natural gas (see Table 3-11), wood/wood waste and other solid biomass based on study on "Update of country specific GHG emission factors for Energy sector" (performed in April 2016 by Lithuanian Energy Institute).

Impact of these recalculations on GHG emissions from 1.A.2.h Machinery industries presented in Table 3-43.

Table 3-43. Impact of recalculation on GHG emissions from 1.A.2.h Machinery industries

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	288.3	288.0	-0.26	-0.09
1991	366.4	366.1	-0.31	-0.08
1992	181.2	181.1	-0.19	-0.10
1993	114.7	114.6	-0.10	-0.09
1994	101.5	101.4	-0.10	-0.10
1995	94.9	94.8	-0.09	-0.10
1996	71.3	71.2	-0.08	-0.11
1997	71.6	71.5	-0.08	-0.11
1998	55.9	55.8	-0.07	-0.13
1999	56.8	56.8	-0.07	-0.13
2000	58.6	58.5	-0.08	-0.14
2001	47.6	47.5	-0.07	-0.15
2002	55.5	55.4	-0.08	-0.15
2003	63.1	63.0	-0.09	-0.15
2004	70.2	70.1	-0.17	-0.24
2005	65.9	65.8	-0.15	-0.23
2006	34.9	34.9	-0.06	-0.17
2007	19.7	19.7	-0.03	-0.16

2008	16.8	16.8	-0.03	-0.17
2009	11.6	11.6	-0.01	-0.11
2010	16.9	16.9	-0.03	-0.17
2011	18.1	18.0	-0.03	-0.17
2012	17.1	17.1	-0.02	-0.11
2013	14.0	14.0	0.00	-0.03
2014	14.7	14.7	0.00	0.02

3.3.8.6 Category-specific planned improvements

Category-specific improvements are not planned.

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

3.3.9.1 Category description

The category of Mining and Quarrying takes into account mining and quarrying of silica sand, construction sand, gravel, pebbles, shingle and silica, crushed dolomite, crushed granite and extraction of peat in Lithuania. In 2015, there were mined 11,570 thousand tons of aforementioned resources (36.6% of construction sand, 25.6% of crushed dolomite, 30.4% of gravel, pebbles, shingle and silica). This is by 6.4% more than in 2014. Value added created in the industry was 90.2 million EUR and this made 0.3% of total value added created in the economy.

3.3.9.2 Methodological issues

CO_2 emissions were calculated applying *Tier 2*, CH_4 and N_2O were calculated applying *Tier 1* (as presented in Table 3-42) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Mining and Quarrying industries (1.A.2.i) are presented in Table 3-44.

Table 3-44. Emission factors and methods for category Mining and Quarrying industries (1.A.2.i)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Residual fuel oil	77.60 78.40*	CS	T2	3.0	D	T1	0.6	D	T1
Gasoil	72.89 72.73*	CS	T2	3.0	D	T1	0.6	D	T1
Coking coal	94.90 95.10*	CS	T2	10.0	D	T1	1.5	D	T1
Anthracite	106.55	CS	T2	10,0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00 96.10*	CS	T2	10.0	D	T1	1.5	D	T1

Natural gas	Table 3-11	CS	T2	1.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	2.0	D	T1	1.5	D	T1
Wood/ wood waste	101.34	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations:
CS - country specific emission factors;
D - default emission factors (*2006 IPCC Guidelines*);
* - CS emission factors applied from 2015 based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute. Summary of the study is presented in Annex IV;
T1 - *Tier 1*; T2 - *Tier 2*.

Activity data

For calculation of GHG emissions in category Mining and Quarrying (1.A.2.i) activity data had been obtained from the Lithuanian Statistics. The Lithuanian Statistics provided data on energy consumption in manufacturing industries and construction according to the type of economic activity based on special request for the 1990-2007 period. Since 2008 activity data are available at the Lithuanian Statistics database (http://www.stat.gov.lt/lt/). Activity data are provided in the Table 3-45.

Table 3-45. Energy consumption by fuel type in Mining and Quarrying industries, TJ

Year	RFO	Gasoil	Peat	Coking coal	Anthra-cite	Sub-bituminous coal	Natural gas	Wood/ wood waste	Total
1990	80.3	0.0	0.0	0.0	0.0	0.0	270.0	0.0	**350.3**
1995	40.1	0.0	0.0	0.0	0.0	0.0	264.0	0.0	**304.1**
2000	56.0	0.0	0.0	2.5	0.0	0.0	20.1	1.6	**80.2**
2005	0.0	4.9	0.0	0.0	0.0	2.0	41.1	4.9	**52.9**
2010	0.0	0.0	1.0	0.0	0.0	0.0	17.0	4.0	**22.0**
2011	0.0	1.0	0.0	0.0	0.0	0.0	2.0	4.0	**7.0**
2012	0.0	1.0	0.0	1.0	0.0	0.0	11.0	1.0	**14.0**
2013	0.0	1.0	0.0	0.0	1.0	0.0	11.0	11.0	**24.0**
2014	0.0	1.0	0.0	0.0	1.0	0.0	11.0	18.0	**31.0**
2015	0.0	1.0	0.0	1.0	0.0	0.0	11.0	18.0	**31.0**

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

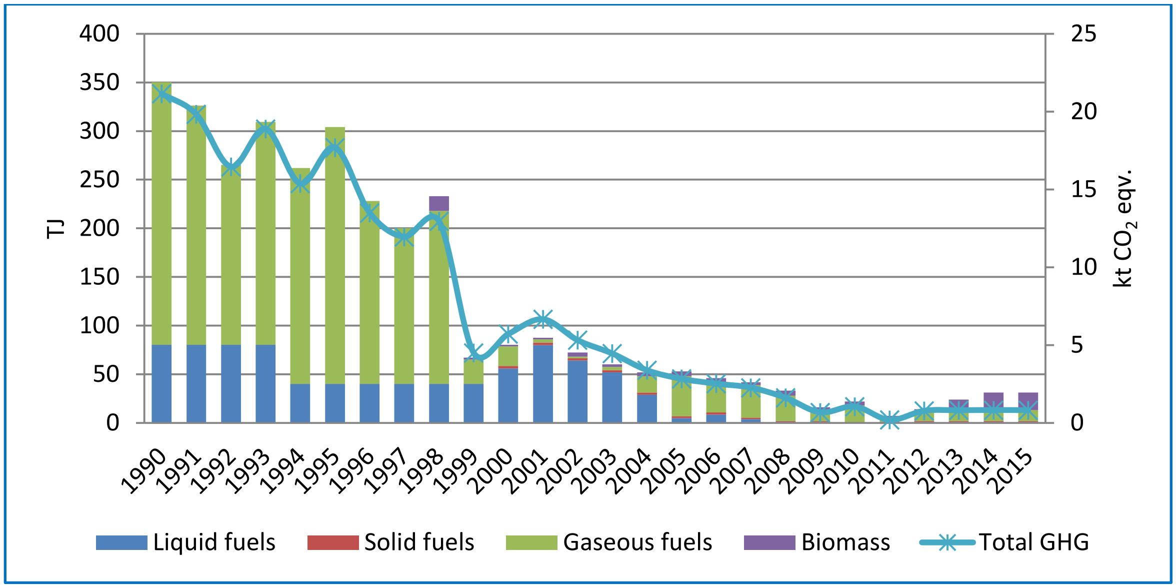


Figure 3-26. Tendencies of fuel consumption and total GHG emissions in Mining and Quarrying industries (1.A.2.i)

Since 1990 fuel consumption in Mining and Quarrying industries reduced significantly from 350.3 TJ in 1990 till 31,0 TJ in 2015. In 2015, the share of biomass accounted about 58.1%, natural gas – 35.5%, liquid and solid fuels - about 6.4% in the structure of fuel used in Mining and Quarrying industries.

In 2015, total GHG emissions from Mining and Quarrying industries were 26 times lower than in 1990 and amounted 0.8 kt CO_2 eqv.

3.3.9.3 Uncertainties and time-series consistency

Uncertainty in activity data in Mining and Quarrying industries is ±2.0% taking into consideration recommendations provided by *2006 IPCC Guidelines* for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by *2006 IPCC Guidelines*.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.0% in Mining and Quarrying industries. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and coke) are ±5.0%. Estimated uncertainties of CO_2 emission factors for biomass are ±15%. Uncertainties of all country specific CO_2 emission factors were revised in the study "Update of country specific GHG emission factors for 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 *2006 IPCC Guidelines.*

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

3.3.9.4 Category-specific QA/QC and verifications

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

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

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

3.3.9.5 Category-specific recalculations

Following recalculations in this category has been done:

- revision of CO_2 emission factor for natural gas (see Table 3-11) and wood/wood waste based on study on "Update of country specific GHG emission factors for Energy sector" (performed in April 2016 by Lithuanian Energy Institute).

Impact of these recalculations on GHG emissions from 1.A.2.i Mining and Quarrying industries presented in Table 3-46.

Table 3-46. Impact of recalculation on GHG emissions from 1.A.2.i Mining and Quarrying industries

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	21.2	21.2	-0.02	-0.11
1991	19.9	19.8	-0.02	-0.11
1992	16.5	16.5	-0.02	-0.10
1993	18.9	18.9	-0.02	-0.11
1994	15.4	15.4	-0.02	-0.13
1995	17.7	17.7	-0.02	-0.13
1996	13.5	13.5	-0.02	-0.13
1997	12.0	12.0	-0.01	-0.12
1998	13.0	13.0	-0.02	-0.12
1999	4.5	4.5	0.00	-0.05
2000	5.7	5.7	0.00	-0.03
2001	6.7	6.7	0.00	0.00
2002	5.3	5.3	0.00	0.00
2003	4.5	4.5	0.00	-0.01
2004	3.4	3.4	0.00	-0.07
2005	2.8	2.8	-0.01	-0.20
2006	2.5	2.5	0.00	-0.13
2007	2.3	2.3	0.00	-0.18
2008	1.6	1.6	0.00	-0.19
2009	0.7	0.7	0.00	-0.09
2010	1.1	1.1	0.00	-0.18
2011	0.2	0.2	0.00	-0.12

2012	0.8	0.8	0.00	-0.10
2013	0.8	0.8	0.00	-0.03
2014	0.8	0.8	0.00	0.01

3.3.9.6 Category-specific planned improvements

Category-specific improvements are not planned.

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

3.3.10.1 Category description

The category of Wood and Wood Products takes into account manufacture of plywood and similar laminated wood, particle board of wood, fibre board, windows and their frames and doors and their frames of wood in Lithuania. In 2014, Wood and Wood Products industry created value added of 406.8 million EUR. This made 7.3% of total value added created in the manufacturing industry. The structural share of value added was rather stable during 2008-2013. In 2015, Wood and Wood Products industry manufactured 47.6 thousand m^3 of plywood and similar laminated wood, 711.9 thousand m^3 of particle board of wood, 21.7 million m^2 of fibre board, 150.1 thousand of windows and their frames and 675.7 thousand of doors and their frames of wood.

3.3.10.2 Methodological issues

CO_2 emissions were calculated applying *Tier 2*, CH_4 and N_2O were calculated applying *Tier 1* (as presented in Table 3-45) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Wood and Wood Products industries (1.A.2.j) are presented in Table 3-47.

Table 3-47. Emission factors and methods for category Wood and Wood Products industries (1.A.2.j)

Fuel	**CO_2**			**CH_4**			**N_2O**		
	CO_2, kg/GJ	**EF**	**Method**	**CH_4, kg/TJ**	**EF**	**Method**	**N_2O, kg/TJ**	**EF**	**Method**
LPG	65.42 66.34*	CS	T2	1.0	D	T1	0.1	D	T1
Residual fuel oil	77.60 78.40*	CS	T2	3.0	D	T1	0.6	D	T1
Gasoil	72.89 72.73*	CS	T2	3.0	D	T1	0.6	D	T1
Peat	104.34	CS	T2	2.0	D	T1	1.5	D	T1
Anthracite	106.55	CS	T2	10.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00 96.10*	CS	T2	10.0	D	T1	1.5	D	T1

Natural gas	Table 3-11	CS	T2	1.0	D	T1	0.1	D	T1
Wood/ wood waste	101.34	CS	T2	30.0	D	T1	4.0	D	T1
Other solid biomass	103.69	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations:
CS - country specific emission factors;
D - default emission factors (*2006 IPCC Guidelines*);
* - CS emission factors applied from 2015 based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute. Summary of the study is presented in Annex IV;
T1 - *Tier 1*; T2 - *Tier 2*.

Activity data

For calculation of GHG emissions in category Wood and Wood Products (1.A.2.j) activity data had been obtained from the Lithuanian Statistics. The Lithuanian Statistics provided data on energy consumption in manufacturing industries and construction according to the type of economic activity based on special request for the 1990-2007 period. Since 2008 activity data are available at the Lithuanian Statistics database (http://www.stat.gov.lt/lt/). Activity data are provided in the Table 3-48.

Table 3-48. Energy consumption by fuel type in Wood and Wood Products industries, TJ

Year	Gasoil	RFO	LPG	Anthra-cite	Sub-bituminous coal	Peat	Natural gas	Other solid biomass	Wood / wood waste	Total
1990	0.0	1,204.2	0.0	0.0	0.0	0.0	1,167.0	0.0	240.0	**2,611.2**
1995	0.0	321.1	0.0	0.0	0.0	0.0	451.0	0.0	284.0	**1,056.1**
2000	0.0	147.9	4.6	0.0	0.0	0.0	288.0	0.0	465.8	**906.3**
2005	2.6	147.5	3.5	0.0	11.8	1.2	1,046.1	0.0	2,081.1	**3,293.9**
2010	0.0	31.0	19.0	0.0	0.0	1.0	944.0	0.0	1,905.0	**2,900.0**
2011	0.0	0.0	5.0	0.0	0.0	0.0	650.0	1.0	1,804.0	**2,460.0**
2012	2.0	0.0	3.0	0.0	0.0	0.0	396.0	0.0	2,252.0	**2,653.0**
2013	0.0	0.0	5.0	0.0	0.0	0.0	399.0	0.0	2,052.0	**2,456.0**
2014	0.0	0.0	6.0	0.0	0.0	0.0	270.0	0.0	1,646.0	**1,922.0**
2015	0.0	0.0	7.0	0.0	0.0	1.0	131.0	0.0	1,670.0	**1,809.0**

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

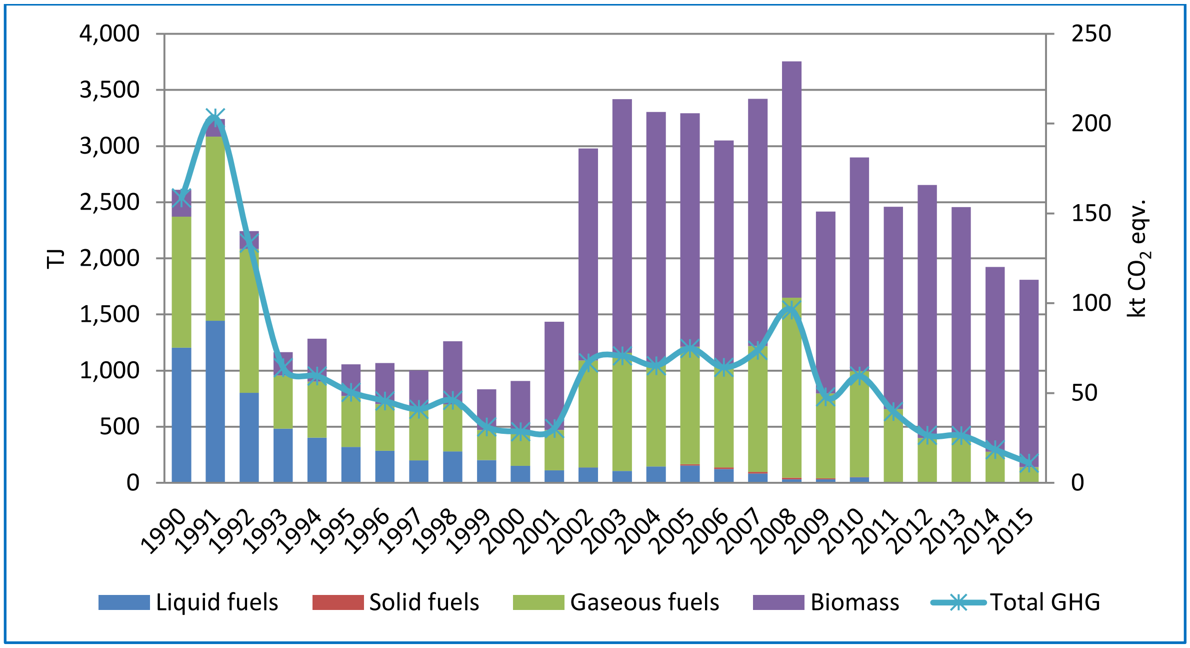


Figure 3-27. Tendencies of fuel consumption and total GHG emissions in Wood and Wood Products industries (1.A.2.j)

The share of liquid fuels has reduced from 46.1% (1990) till 0.4% (2015) in the structure of fuel consumed in Wood and Wood Products industries. In general liquid and gaseous fuels were replaced by biomass. Since 2000 the share of biomass increased from 51.4% till 92.3% in 2015. In 2015, the share of natural gas accounted 7.2%.

In 2015, total GHG emissions from Wood and Wood Products industries were 14 times lower than in 1990 and amounted 11.1 kt CO_2 eqv.

3.3.10.3 Uncertainties and time-series consistency

Uncertainty in activity data in Wood and Wood Products industries is ±2.0% taking into consideration recommendations provided by *2006 IPCC Guidelines* for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by *2006 IPCC Guidelines*.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.0% in Wood and Wood Products industries. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and coke) are ±5.0%. Estimated uncertainties of CO_2 emission factors for biomass are ±15%. Uncertainties of all country specific CO_2 emission factors were revised in the study “Update of country specific GHG emission factors for 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 *2006 IPCC Guidelines.*

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

3.3.10.4 Category-specific QA/QC and verifications

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

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

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

3.3.10.5 Category-specific recalculations

Following recalculations in this category has been done:

- revision of CO_2 emission factor for natural gas (see Table 3-11), wood/wood waste and other solid biomass based on study on "Update of country specific GHG emission factors for Energy sector" (performed in April 2016 by Lithuanian Energy Institute).

Impact of these recalculations on GHG emissions from 1.A.2.j Wood and Wood Products industries presented in Table 3-49.

Table 3-49. Impact of recalculation on GHG emissions from 1.A.2.j Wood and Wood Products industries

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	158.7	158.6	-0.11	-0.07
1991	203.4	203.2	-0.15	-0.07
1992	133.6	133.5	-0.12	-0.09
1993	64.2	64.1	-0.04	-0.07
1994	59.6	59.6	-0.05	-0.08
1995	50.5	50.4	-0.04	-0.08
1996	45.6	45.6	-0.04	-0.08
1997	41.0	41.0	-0.04	-0.10
1998	46.0	46.0	-0.04	-0.08
1999	31.2	31.1	-0.02	-0.08
2000	28.6	28.6	-0.03	-0.09
2001	30.4	30.4	-0.03	-0.11
2002	67.0	67.0	-0.09	-0.13
2003	70.8	70.7	-0.09	-0.13
2004	65.5	65.4	-0.13	-0.19
2005	75.1	74.9	-0.15	-0.20
2006	64.4	64.3	-0.10	-0.15
2007	74.0	73.8	-0.13	-0.18
2008	96.5	96.3	-0.19	-0.20
2009	48.1	48.1	-0.05	-0.11

2010	59.7	59.5	-0.10	-0.17
2011	39.8	39.7	-0.07	-0.18
2012	26.6	26.6	-0.03	-0.10
2013	26.4	26.4	-0.01	-0.03
2014	18.5	18.5	0.00	0.01

3.3.10.6 Category-specific planned improvements

Category-specific improvements are not planned.

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

3.3.11.1 Category description

Construction sector of Lithuania has approximately 5 thousand of enterprises of which 39% are specialized in constructing buildings and their parts. Small enterprises (the personnel is less than 49) are prevailing in this sector. The largest concentration of construction enterprises is in Vilnius and Kaunas counties. This situation was mainly caused by unequal distribution of investments within the territory of Lithuania. Till the last crisis, construction sector was one of the most developing industry branches in Lithuania. It created 7.3% (2005) – 9.9% (2008) of total value added in the country. This was mainly caused by the growth of national industry, good credit terms, possibilities given by EU Structural Funds, a larger demand for residential, commercial and industrial buildings, increasing selection of new building materials and technologies (Analysis of Lithuanian Construction Market, 2011). However, already in 2009 value added significantly reduced and in 2010 it made only 51.0% of 2008 level. In 2015, Construction sector created 6.8% of total value added.

3.3.11.2 Methodological issues

CO_2 emissions were calculated applying *Tier 2*, CH_4 and N_2O were calculated applying *Tier 1* (as presented in Table 3-48) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Construction (1.A.2.k) are presented in Table 3-50.

Table 3-50. Emission factors and methods for category Construction (1.A.2.k)

Fuel	**CO_2**			**CH_4**			**N_2O**		
	CO_2, kg/GJ	**EF**	**Method**	**CH_4, kg/TJ**	**EF**	**Method**	**N_2O, kg/TJ**	**EF**	**Method**
LPG	65.42 66.34*	CS	T2	1.0	D	T1	0.1	D	T1
Residual fuel oil	77.60 78.40*	CS	T2	3.0	D	T1	0.6	D	T1
Gasoil	72.89 72.73*	CS	T2	3.0	D	T1	0.6	D	T1

Coking coal	94.90 95.10*	CS	T2	10.0	D	T1	1.5	D	T1
Anthracite	106.55	CS	T2	10.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00 96.10*	CS	T2	10.0	D	T1	1.5	D	T1
Natural gas	Table 3-11	CS	T2	1.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	2.0	D	T1	1.5	D	T1
Wood/ wood waste	101.34	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations:
CS - country specific emission factors;
D - default emission factors (*2006 IPCC*);
* - CS emission factors applied from 2015 based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute. Summary of the study is presented in Annex IV;
T1 - *Tier 1*; T2 - *Tier 2*.

Activity data

For calculation of GHG emissions in category Construction (1.A.2.k) activity data had been obtained from the Lithuanian Statistics. The Lithuanian Statistics provided data on energy consumption in manufacturing industries and construction according to the type of economic activity based on special request for the 1990-2007 period. Since 2008 activity data are available at the Lithuanian Statistics database (http://www.stat.gov.lt/lt/). Activity data are provided in the Table 3-51.

Table 3-51. Energy consumption by fuel type in Construction industries, TJ

Year	Gasoil	RFO	LPG	Coking coal	Anthracite	Subbituminous coal	Peat	Natural gas	Wood/wood waste	Total
1990	0.0	1,044.0	92.0	226.0	0.0	0.0	0.0	1,030.0	51.0	**2,443.0**
1995	0.0	201.0	46.0	25.0	0.0	0.0	0.0	219.0	105.0	**596.0**
2000	7.0	58.0	74.0	14.0	0.0	0.0	0.0	266.0	100.0	**519.0**
2005	25.0	110.0	77.0	0.0	0.0	18.0	0.0	513.0	185.0	**928.0**
2010	47.0	75.0	122.0	0.0	2.0	2.0	0.0	501.0	143.0	**892.0**
2011	49.0	72.0	48.0	11.0	0.0	1.0	0.0	459.0	145.0	**785.0**
2012	63.0	35.0	32.0	7.0	0.0	1.0	0.0	490.0	157.0	**785.0**
2013	60.0	37.0	35.0	7.0	0.0	0.0	0.0	509.0	125.0	**773.0**
2014	80.0	31.0	43.0	4.0	0.0	0.0	0.0	457.0	99.0	**714.0**
2015	67.0	35.0	38.0	6.0	0.0	0.0	0.0	477.0	62.0	**685.0**

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

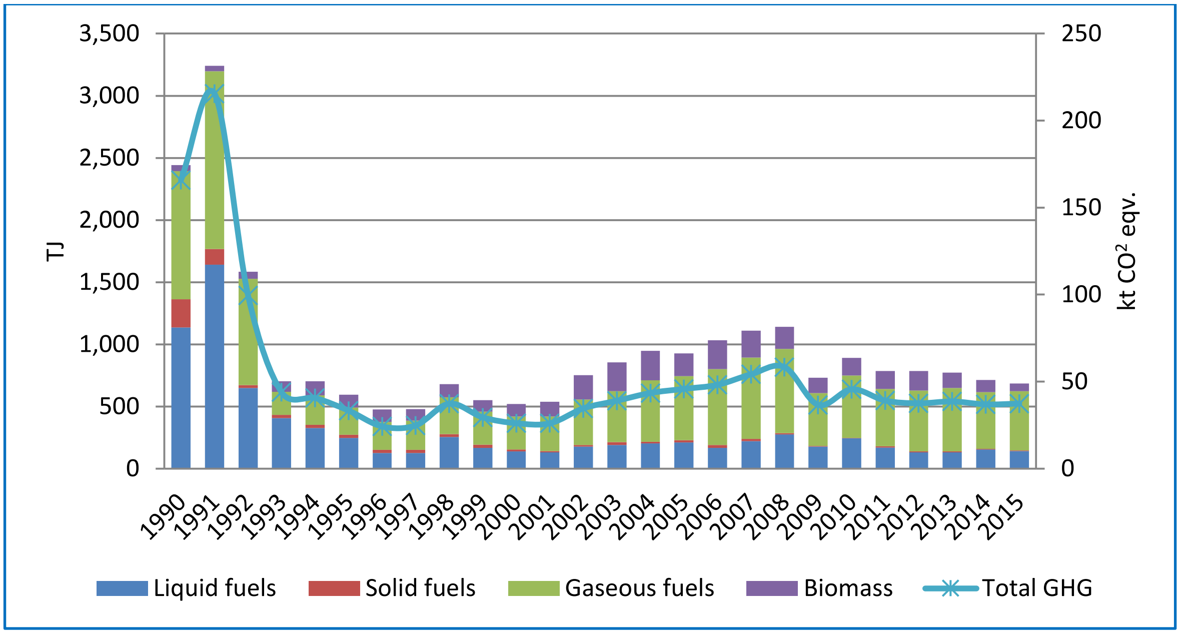


Figure 3-28. Tendencies of fuel consumption and total GHG emissions in Construction (1.A.2.k)

The final energy consumption was increasing during the period 2000-2008 by 10.0% per annum in Construction, but the most severe impact of the economic recession was in this sector where energy consumption decreased by 35% in 2009. In 2015, the share of natural gas accounted 69.6%, liquid fuels – 20.4%, biomass – 9.1% and solid fuels – 0.9% in the total fuel structure used for the Construction.

In 2015, total GHG emissions from Construction industries were 4.4 times lower than in 1990 and amounted 37.4 kt CO_2 eqv.

3.3.11.3 Uncertainties and time-series consistency

Uncertainty in activity data in Construction industries is ±2.0% taking into consideration recommendations provided by *2006 IPCC Guidelines* for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by *2006 IPCC Guidelines*.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.0% in Construction industries. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and coke) are ±5.0%. Estimated uncertainties of CO_2 emission factors for biomass are ±15%. Uncertainties of all country specific CO_2 emission factors were revised in the study "Update of country specific GHG emission factors for 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 *2006 IPCC Guidelines.*

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

3.3.11.4 Category-specific QA/QC and verifications

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

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

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

3.3.11.5 Category-specific recalculations

Following recalculations in this category has been done:

- revision of CO_2 emission factor for natural gas (see Table 3-11) and wood/wood waste based on study on "Update of country specific GHG emission factors for Energy sector" (performed in April 2016 by Lithuanian Energy Institute).

Impact of these recalculations on GHG emissions from 1.A.2.k Construction presented in Table 3-52.

Table 3-52. Impact of recalculation on GHG emissions from 1.A.2.k Construction

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	166.0	165.9	-0.09	-0.06
1991	215.6	215.5	-0.13	-0.06
1992	99.6	99.6	-0.08	-0.08
1993	43.9	43.9	-0.02	-0.04
1994	40.6	40.6	-0.02	-0.05
1995	33.4	33.3	-0.02	-0.06
1996	24.3	24.2	-0.02	-0.08
1997	24.9	24.8	-0.02	-0.09
1998	37.3	37.3	-0.03	-0.07
1999	29.5	29.5	-0.02	-0.08
2000	26.1	26.1	-0.02	-0.09
2001	26.0	26.0	-0.03	-0.10
2002	34.7	34.6	-0.03	-0.10
2003	39.0	39.0	-0.04	-0.09
2004	43.5	43.5	-0.07	-0.16
2005	45.9	45.8	-0.07	-0.16
2006	48.2	48.1	-0.07	-0.14
2007	54.3	54.2	-0.08	-0.15

2008	58.4	58.4	-0.08	-0.14
2009	36.7	36.7	-0.03	-0.08
2010	45.6	45.6	-0.06	-0.12
2011	39.1	39.1	-0.05	-0.13
2012	37.6	37.6	-0.03	-0.09
2013	38.6	38.6	-0.01	-0.03
2014	36.9	36.9	0.00	0.01

3.3.11.6 Category-specific planned improvements

Category-specific improvements are not planned.

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

3.3.12.1 Category description

Textile and Leather industry in Lithuania integrates 3 branches of the industry, i.e. production of textile products, sewing of clothes and manufacture of leather and leather articles. The industry is considered as one of the most important industries in the country. In 2015, the Textile and Leather industry created 8.5% of total value added created in the manufacturing industry, which remained stable during the latter three years. The following below is presented the most important products and their production volumes in 2015: 2,417.2 thous. of trousers, overalls, breeches and shorts, 1,403.7 thous. of women and girls' blouses, 1,558.0 thous. of dresses, 963.7 thous of jackets and blousers and other.

3.3.12.2 Methodological issues

CO_2 emissions were calculated applying *Tier 2*, CH_4 and N_2O were calculated applying *Tier 1* (as presented in Table 3-51) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Textile and Leather industries (1.A.2.l) are presented in Table 3-53.

Table 3-53. Emission factors and methods for category Textile and Leather industries (1.A.2.l)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	**EF**	**Method**	**CH_4, kg/TJ**	**EF**	**Method**	**N_2O, kg/TJ**	**EF**	**Method**
LPG	65.42 66.34*	CS	T2	1.0	D	T1	0.1	D	T1
Residual fuel oil	77.60 78.40*	CS	T2	3.0	D	T1	0.6	D	T1
Gasoil	72.89 72.73*	CS	T2	3.0	D	T1	0.6	D	T1
Coking coal	94.90 95.10*	CS	T2	10.0	D	T1	1.5	D	T1

Anthracite	106.55	CS	T2	10.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00 96.10*	CS	T2	10.0	D	T1	1.5	D	T1
Natural gas	Table 3-11	CS	T2	1.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	2.0	D	T1	1.5	D	T1
Wood/ wood waste	101.34	CS	T2	30.0	D	T1	4.0	D	T1
Other solid biomass	103.69	CS	T2	30.0	D	T1	4.0	D	T1

Abbreviations:
CS - country specific emission factors;
D - default emission factors (*2006 IPCC Guidelines*);
* - CS emission factors applied from 2015 based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute. Summary of the study is presented in Annex IV;
T1 – *Tier 1*; T2 – *Tier 2*.

Activity data

For calculation of GHG emissions in category Textile and Leather (1.A.2.l) activity data had been obtained from the Lithuanian Statistics. The Lithuanian Statistics provided data on energy consumption in manufacturing industries and construction according to the type of economic activity based on special request for the 1990-2007 period. Since 2008 activity data are available at the Lithuanian Statistics database (http://www.stat.gov.lt/lt/). Activity data are provided in the Table 3-54.

Table 3-54. Energy consumption by fuel type in Textile and Leather industries, TJ

Year	Gasoil	RFO	LPG	Coking coal	Anthra-cite	Sub-bituminous coal	Peat	Natural gas	Other solid biomass	Wood / wood waste	Total
1990	0.0	1,364.8	0.0	527.5	0.0	0.0	0.0	2,467.0	0.0	20.0	**4,379.3**
1995	0.0	441.5	0.0	100.5	0.0	0.0	0.0	646.0	0.0	50.0	**1,238.0**
2000	0.0	139.9	4.6	34.5	0.0	0.0	0.0	810.5	0.0	109.1	**1,098.6**
2005	76.2	40.5	2.1	0.0	0.0	48.6	0.6	1,228.0	41.0	37.0	**1,474.0**
2010	41.0	4.0	12.0	7.0	2.0	8.0	1.0	591.0	2.0	18.0	**686.0**
2011	19.0	6.0	10.0	11.0	0.0	1.0	3.0	608.0	0.0	15.0	**673.0**
2012	20.0	4.0	13.0	7.0	0.0	7.0	4.0	551.0	0.0	19.0	**625.0**
2013	19.0	3.0	13.0	9.0	0.0	4.0	4.0	553.0	0.0	6.0	**611.0**
2014	26.0	3.0	12.0	11.0	0.0	3.0	3.0	548.0	0.0	9.0	**615.0**
2015	26.0	11.0	14.0	10.0	0.0	0.0	0.0	568.0	0.0	35.0	**664.0**

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

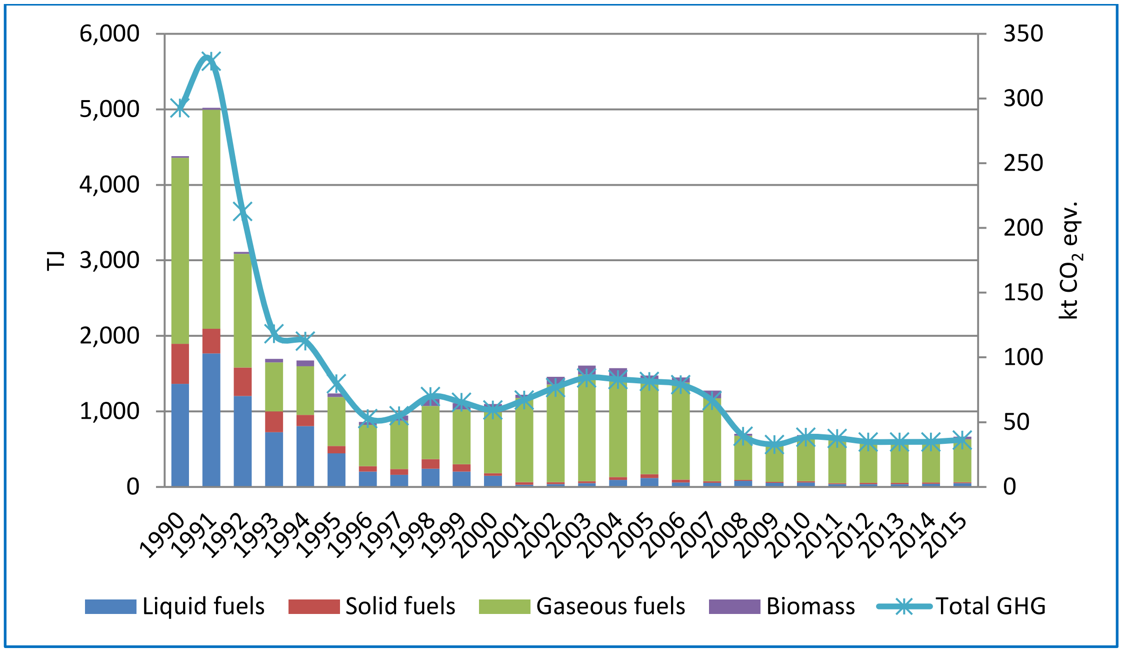


Figure 3-29. Tendencies of fuel consumption and total GHG emissions in Textile and Leather industries (1.A.2.l)

The fuel consumption in Textile and Leather industries reduced almost 7 times since 1990. In 2015, the natural gas accounted 85.5%, liquid fuels – 7.7%, solid fuels – 1.5% and biomass about 5.3% in the structure of fuel used in Textile and Leather industries.

In 2015, total GHG emissions from Textile and Leather industries were 8 times lower than in 1990 and amounted 36.3 kt CO_2 eqv.

3.3.12.3 Uncertainties and time-series consistency

Uncertainty in activity data in Textile and Leather industries is ±2.0% taking into consideration recommendations provided by *2006 IPCC Guidelines* for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by *2006 IPCC Guidelines*.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.0% in Textile and Leather industries. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and coke) are ±5.0%. Estimated uncertainties of CO_2 emission factors for biomass are ±15%. Uncertainties of all country specific CO_2 emission factors were revised in the study "Update of country specific GHG emission factors for 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 *2006 IPCC Guidelines.*

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

3.3.12.4 Category-specific QA/QC and verifications

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

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

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

3.3.12.5 Category-specific recalculations

Following recalculations in this category has been done:

- revision of CO_2 emission factor for natural gas (see Table 3-11), wood/wood waste and other solid biomass based on study on "Update of country specific GHG emission factors for Energy sector" (performed in April 2016 by Lithuanian Energy Institute).

Impact of these recalculations on GHG emissions from 1.A.2.l Textile and Leather industries presented in Table 3-55.

Table 3-55. Impact of recalculation on GHG emissions from 1.A.2.l Textile and Leather industries

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	293.1	292.9	-0.22	-0.08
1991	329.2	328.9	-0.26	-0.08
1992	213.1	213.0	-0.14	-0.06
1993	118.6	118.5	-0.06	-0.05
1994	112.7	112.7	-0.06	-0.05
1995	79.8	79.7	-0.06	-0.07
1996	53.0	52.9	-0.05	-0.09
1997	55.2	55.1	-0.06	-0.10
1998	69.9	69.8	-0.06	-0.09
1999	65.4	65.4	-0.07	-0.10
2000	59.5	59.4	-0.07	-0.12
2001	67.3	67.2	-0.10	-0.15
2002	77.0	76.9	-0.12	-0.15
2003	84.5	84.3	-0.13	-0.15
2004	83.2	83.1	-0.18	-0.22
2005	81.7	81.5	-0.17	-0.21
2006	79.2	79.1	-0.14	-0.18
2007	66.9	66.8	-0.13	-0.20
2008	39.4	39.4	-0.07	-0.18
2009	32.8	32.8	-0.03	-0.11

2010	38.6	38.5	-0.07	-0.17
2011	37.6	37.5	-0.07	-0.18
2012	34.9	34.9	-0.04	-0.11
2013	34.7	34.7	-0.01	-0.03
2014	34.9	34.9	0.01	0.02

3.3.12.6 Category-specific planned improvements

Category-specific improvements are not planned.

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

3.3.13.1 Category description

Non-Specified Industries in Lithuania include the following activities:

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

In 2015, there were produced 1,370.8 thous. m^3 of polystyrene, 3,528.5 million of plastic bottles, 8,213.5 thous. units of various type of furniture.

3.3.13.2 Methodological issues

CO_2 emissions were calculated applying *Tier 2*, CH_4 and N_2O were calculated applying *Tier 1* (as presented in Table 3-54) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Non-Specified Industry (1.A.2.m) are presented in Table 3-56.

Table 3-56. Emission factors and methods for category Non-Specified Industry (1.A.2.m)

Fuel	**CO_2**			**CH_4**			**N_2O**		
	CO_2, kg/GJ	**EF**	**Method**	**CH_4, kg/TJ**	**EF**	**Method**	**N_2O, kg/TJ**	**EF**	**Method**
LPG	65.42 66.34*	CS	T2	1.0	D	T1	0.1	D	T1
Residual fuel oil	77.60 78.40*	CS	T2	3.0	D	T1	0.6	D	T1
Gasoil	72.89 72.73*	CS	T2	3.0	D	T1	0.6	D	T1
Coking coal	94.90 95.10*	CS	T2	10.0	D	T1	1.5	D	T1
Anthracite	106.55	CS	T2	10.0	D	T1	1.5	D	T1

Sub-bituminous coal	96.00 96.10*	CS	T2	10.0	D	T1	1.5	D	T1
Coke	109.11	CS	T2	10.0	D	T1	1.5	D	T1
Natural gas	Table 3-11	CS	T2	1.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	2.0	D	T1	1.5	D	T1
Wood/ wood waste	101,34	CS	T2	30.0	D	T1	4.0	D	T1
Other solid biomass	103,69	CS	T2	30.0	D	T1	4.0	D	T1
Biogas	58,45	CS	T2	1.0	D	T1	0.1	D	T1
Industrial waste (used tires)	Table 3-55	PS	T3	30.0	D	T1	4.0	D	T1
Industrial waste	143.00	D	T1	30.0	D	T1	4.0	D	T1

Abbreviations:
CS - country specific emission factors;
PS - plant specific emission factors are based on EU ETS data and considering to the *Tier 3* reliability that ensures the lowest uncertainty of emission factor.
D - default emission factors (*2006 IPCC Guidelines*);
* - CS emission factors applied from 2015 based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute. Summary of the study is presented in Annex IV;
T1 - *Tier 1*; T2 - *Tier 2*.

Plant specific CO_2 EF based on EU ETS data applied for industrial waste (used tires) for category Non-Specified Industry (1.A.2.m) are presented in Table 3-57. This type of industrial waste was combusted at JSC "Akmenes cementas" during 2006-2013 therefore the variable yearly CO_2 EF values was used for CO_2 estimation.

Table 3-57. Plant specific CO_2 emission factor for category Non-Specified Industry (1.A.2.m)

Fuel	**Ranges of CO_2 EF 2006-2013, kg/GJ**
Industrial waste (used tires)	84.20 – 86.50

Activity data

For calculation of GHG emissions in category Non-Specified Industry (1.A.2.m) activity data had been obtained from the Lithuanian Statistics. The Lithuanian Statistics provided data on energy consumption in manufacturing industries and construction according to the type of economic activity based on special request for the 1990-2007 period. Since 2008 activity data are available at the Lithuanian Statistics database (http://www.stat.gov.lt/lt/). Activity data are provided in the Table 3-58.

Table 3-58. Energy consumption by fuel type in Non-Specified Industry, TJ

Year	RFO	LPG	Gasoil	Peat	Coking coal	Anthracite	Subbituminous coal	Coke	Natural gas	Wood/wood waste	Other solid biomass	Biogas	Industrial waste (used tires)	Industrial waste	Total
1990	321.1	0.0	0.0	0.0	25.1	0.0	0.0	0.0	4,228.0	121.0	0.0	0.0	0.0	0.0	**4,695.2**
1995	160.6	0.0	0.0	0.0	50.2	0.0	0.0	0.0	195.0	229.0	0.0	0.0	0.0	0.0	**634.8**
2000	0.0	9.3	0.0	0,0	0.0	0.0	5.0	28.0	53.6	300.1	0.0	0.0	0.0	0.0	**396.0**
2005	3.4	26.4	19.9	0.5	0.0	0.0	5.0	52.0	189.1	646.5	0.0	0.0	0.0	0.0	**942.9**
2010	0.0	18.0	11.0	4.0	2.0	0.0	5.0	29.0	189.0	390.0	0.0	0.0	209.4	0.0	**857.4**
2011	1.0	30.0	12.0	1.,0	3.0	0.0	0.0	28.0	461.0	440.0	0.0	0.0	248.8	0.0	**1,236.8**
2012	0.0	41.0	13.0	16.0	2.0	0.0	0.0	29.0	436.0	420.0	0.0	0.0	264.8	0.0	**1,221.8**
2013	0.0	52.0	11.0	12.0	4.0	1.0	0.0	22.0	204.0	405.0	6.0	2.0	263.8	0.0	**982.8**
2014	0.0	51.0	22.0	11.0	7.0	0.0	0.0	23.0	250.0	423.0	0.0	1.0	0.0	0.0	**788.0**
2015	0.0	47.0	24.0	7.0	1.0	0.0	0.0	18.0	225.0	622.0	0.0	2.0	0.0	8.6	**954.6**

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

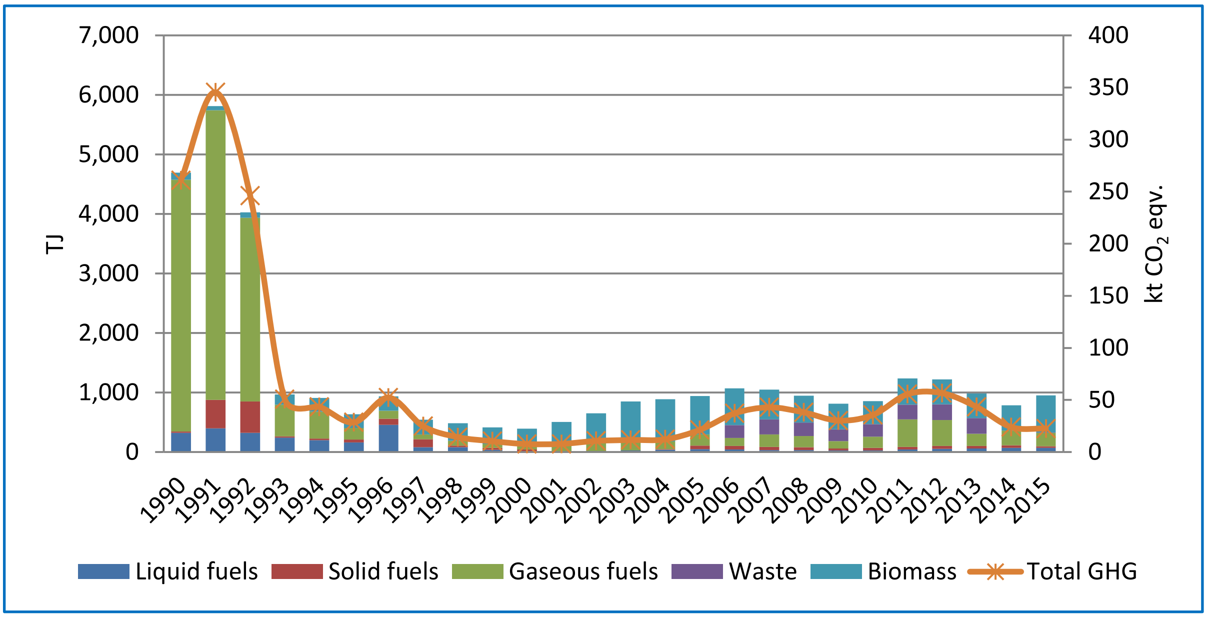


Figure 3-30. Tendencies of fuel consumption and total GHG emissions in Non-Specified Industry (1.A.2.m)

Fuel consumed in the Non-Specified industry has become more diversified in 2015 compared to the structure that has existed in 1990. In 2015, biomass accounted 65.4%, natural gas – 23.6%, liquid fuels – 7.4%, solid fuels – 2.7% and industrial waste – 0.9% in the total structure of fuel combusted in the Non-Specified industry.

In 2015, total GHG emissions from Non-Specified industry were 12 times lower than in 1990 and amounted 22.6 kt CO_2 eqv.

3.3.13.3 Uncertainties and time-series consistency

Uncertainty in activity data in Non-Specified industry is ±2.0% taking into consideration recommendations provided by *2006 IPCC Guidelines* for National GHG Inventories. Since data on biomass as fuel are not well developed as for fossil fuel, the uncertainty rage for biomass is ±30% as recommended by *2006 IPCC Guidelines*.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.0% in Non-Specified industry. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and coke) are ±5.0%. Estimated uncertainties of CO_2 emission factors for biomass are ±15%. Uncertainties of all country specific CO_2 emission factors were revised in the study "Update of country specific GHG emission factors for 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 *2006 IPCC Guidelines.*

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

3.3.13.4 Category-specific QA/QC and verifications

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

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

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

3.3.13.5 Category-specific recalculations

Following recalculations in this category has been done:

- revision of CO_2 emission factor for natural gas (see Table 3-11), wood/wood waste and other solid biomass based on study on "Update of country specific GHG emission factors for Energy sector" (performed in April 2016 by Lithuanian Energy Institute).

Impact of these recalculations on GHG emissions from 1.A.2.m Non-Specified Industry presented in Table 3-59.

Table 3-59. Impact of recalculation on GHG emissions from 1.A.2.m Non-Specified Industry

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	261.4	261.0	-0.38	-0.15
1991	345.8	345.4	-0.44	-0.13
1992	246.3	246.0	-0.28	-0.11
1993	50.8	50.8	-0.05	-0.09
1994	43.5	43.5	-0.04	-0.09
1995	28.5	28.5	-0.02	-0.06
1996	52.3	52.3	-0.01	-0.02
1997	24.9	24.9	-0.01	-0.03
1998	14.3	14.3	-0.01	-0.05
1999	10.4	10.4	-0.01	-0.06
2000	7.7	7.7	0.00	-0.06
2001	7.9	7.9	-0.01	-0.13
2002	10.7	10.7	-0.01	-0.13
2003	11.6	11.6	-0.01	-0.12
2004	12.2	12.2	-0.02	-0.15
2005	21.4	21.4	-0.03	-0.12
2006	37.2	37.2	-0.01	-0.04
2007	43.0	42.9	-0.03	-0.06
2008	38.2	38.1	-0.02	-0.06
2009	30.3	30.3	-0.01	-0.03
2010	35.7	35.7	-0.02	-0.06
2011	55.6	55.6	-0.05	-0.09
2012	56.6	56.6	-0.03	-0.05
2013	43.3	43.3	0.00	-0.01
2014	23.9	23.9	0.00	0.01

3.3.13.6 Category-specific planned improvements

Category-specific improvements are not planned.

3.4 Transport (CRF 1.A.3)

The source category 1.A.3 comprises the sources presented in Table 3-60. 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 3-60. Description of categories in the 1.A.3 Transport sector

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

1.A.3.b.iv	Motorcycles (M)	Emissions from any motor vehicle designed to travel with not more than three wheels in contact with the ground and weighing less than 680 kg.
2.D.3	Urea-based catalysts	CO_2 emissions from use of urea-based additives in catalytic converters (non-combustive emissions)
1.A.3.c *Railways*	Railway transport operated by diesel locomotives	Emissions from railway transport for both freight and passenger traffic routes.
1.A.3.d *Water-borne Navigation*	Merchant ships, passenger ships, container ships, cargo ships, technical ships, tourism ships and other inland vessels.	Fishing emissions are included in the CRF 1.A(a).4.c
1.A.2.g; 1.A.3.e; 1.A.4*;* 1.A.5.b	Transport of gases via pipelines, military activity and off-road transport.	1.A.2.g Transport Equipment 1.A.4 Other Sectors (Off-road): 1.A.4.a.ii Commercial/Institutional 1.A.4.b.ii Residential 1.A.4.c Agriculture/Forestry 1.A.4.c.ii Off-road Vehicles and Other Machinery 1.A.4.c.iii Fishing

Emissions from motorized mobile road traffic in Lithuania includes traffic on public roads within country, except for agricultural and forestry transports. 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 3-47).Fuel consumption in 1.A.3 Transport sector accounted for 57,721 TJ and 73,117 TJ in 2005 and 2015, respectively. The sector emissions increased from 4,208.32 in 2005 to 5,114.24 kt CO_2 equivalent in 2015. In 2015 the most important source of transportation GHGs was road transport, with a share of 92% (Figure 3-31). Lithuania's railway system is mainly driven by diesel oil (~3% 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 2015 about 0.03% 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.

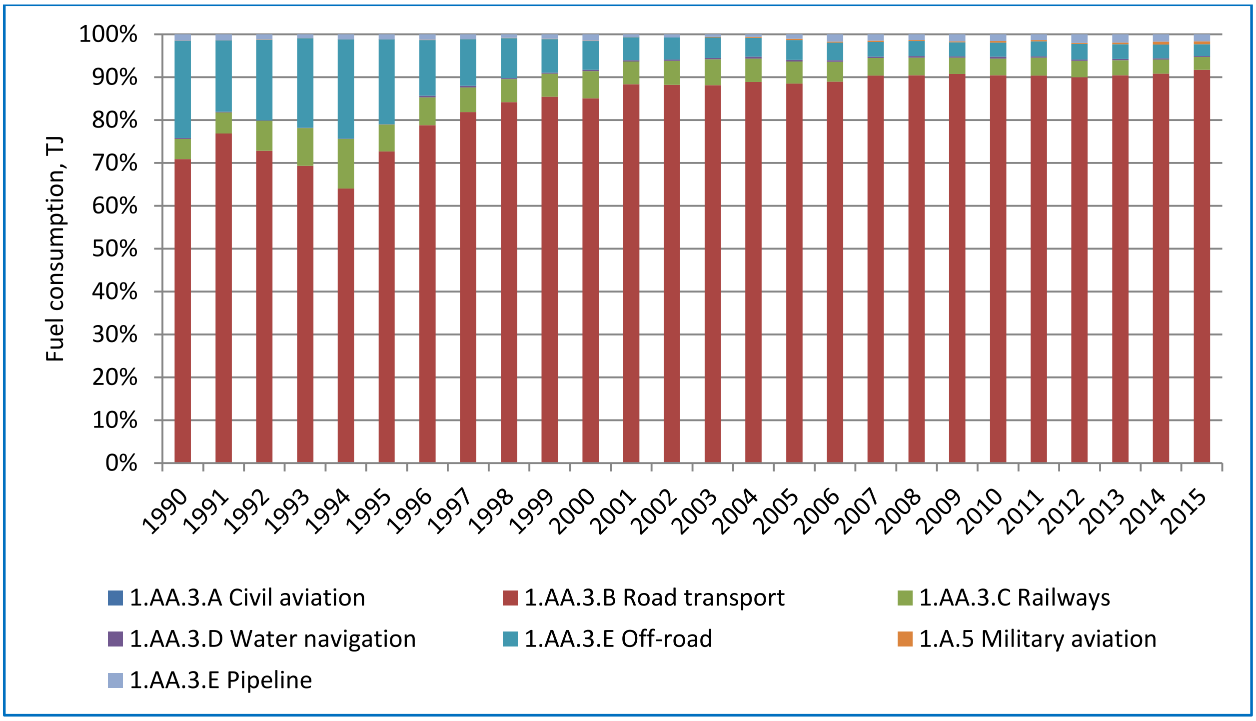


Figure 3-31. Fuel consumption distribution in Transport sector in 1990-2015

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, 2016). 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 2015 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 economic 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 *2006 IPCC Guidelines.*

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

3.4.1.1 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 3-32).

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

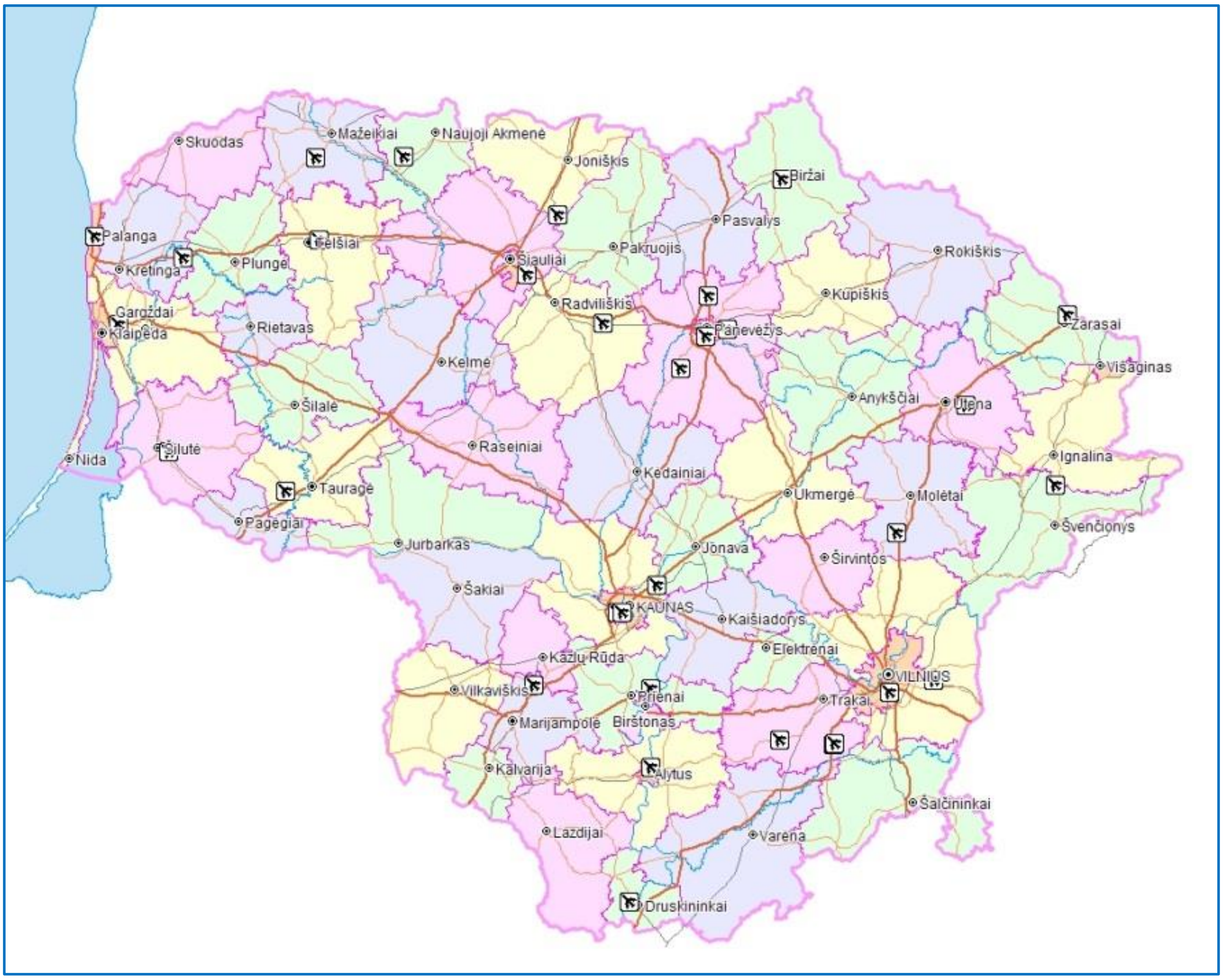


Figure 3-32. Map of aerodromes in Lithuania

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 3-61[9].

Table 3-61. 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

In 2015, the number of take-offs and landings at Lithuanian airports by aircraft of both Lithuanian and foreign airlines amounted to 49.5 thousand, which is by 5.2 per cent more than in 2014. The number of take-offs and landings by air craft on commercial flights totalled 47.4 thousand, or 95.6 per cent of all flights.

In 2015, the number of passengers who arrived at and departed from Lithuanian airports amounted to 4.2 million, which is by 11.3% more than in 2014. The majority of passengers

[9] *2006 IPCC Guidelines*, Volome 2, Chapter 3, p.3.16

arrived from and departed to the United Kingdom (19.6%), Germany (9.7%), Norway (8.1%), Italy (6.8%) and Denmark (6%). The number of passengers on scheduled flights totalled 3.9 million, or 91.4% of all passengers, which is by 13.3% more than in 2014. 9.2% of all passengers arrived and departed by the aircraft of Lithuanian airlines.

In 2015, freight and mail loaded and unloaded at Lithuanian airports amounted to 14.9 thousand tonnes, which is by 12.8% more than in 2014. In 2015, the total number of passengers carried by the aircraft of Lithuanian airlines amounted to 657.1 thousand, which is by 27% more than in 2014. The number of passengers carried on scheduled flights amounted to 58.7 thousand, or 8.9% of all passengers carried by the aircraft of Lithuanian airlines, which is by 55.8% less than in 2014. The number of passengers carried on non-scheduled flights amounted 598.4 thousand, or 91.1% of all passengers carried by the aircraft of Lithuanian airlines, which is by 55.6% more than in 2014. Passenger-kilometres amounted to 1.47 milliard, which is by 43.8% more than in 2014. In 2015, the amount of freight and mail carried by the air craft of Lithuanian airlines totalled 817 tonnes, which is by 9.6% more than in 2014. Freight and mail tonne-kilometres amounted to 459 thousand, which is by 8.1% more than in 2014.

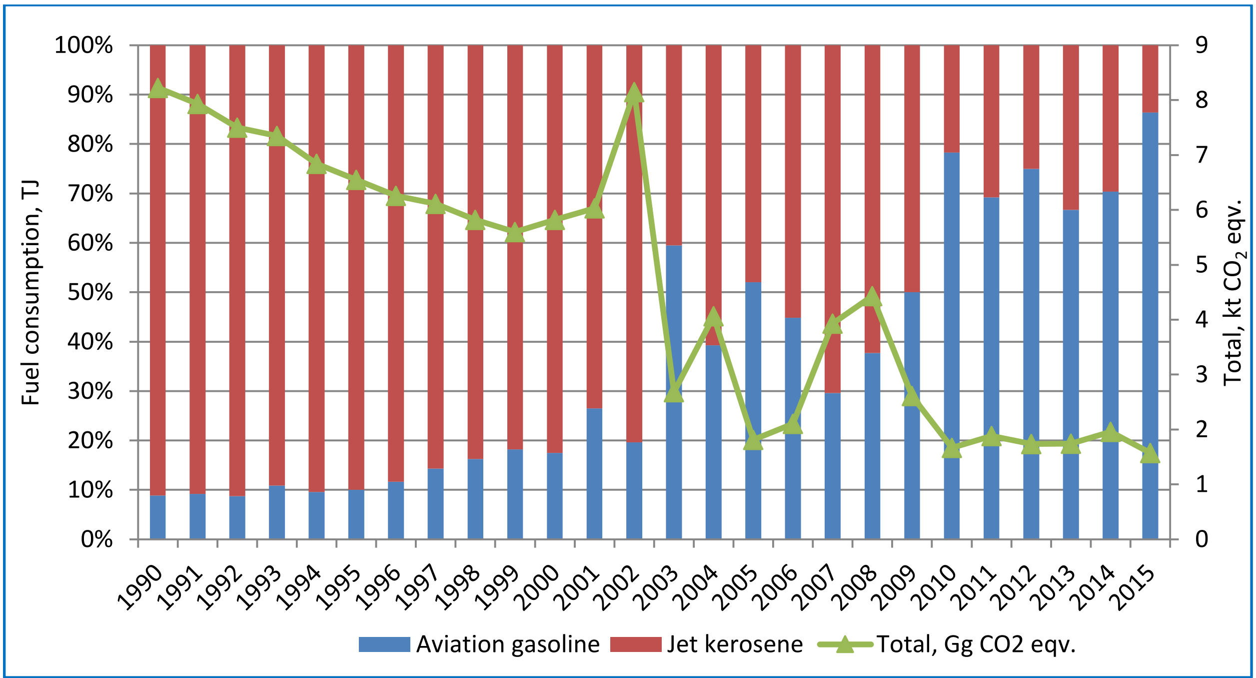


Figure 3-33. Trend of GHG emissions in Civil Aviation sector

3.4.1.2 Methodological issues

The aviation gasoline consumption and GHG emissions were based on *Tier 1* approach as this method should be used to estimate emissions from aircraft that use aviation gasoline which is only used in small aircraft and generally represents less than 1% of fuel consumption from aviation. The jet kerosene fuel consumption and emissions within Lithuania associated with sub-category 1.A.3(a) Civil Aviation was estimated using a *Tier 2* approach (*2006 IPCC Guidelines*) 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 2015 where data is available.

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

In *Tier 2* the emissions for the LTO and cruise phases are estimated separately (Fig. 3-34), in order to harmonize 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.

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

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

where:

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

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

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

Activity data

Following advice from experts[11] it was decided to distinguish GHG emissions from aviation bunkers in such a way that all aviation gasoline and part of kerosene type jet fuel is used for domestic purposes and the rest kerosene type jet fuel is used for international flights – the latter could therefore be considered as aviation bunkers. Activity data on aviation gasoline split between domestic and international aviation is available only from 2000. Following the recommendation of ERT in 2011 the estimates of aviation gasoline consumption were linearly interpolated for the period 1996-1999 since effect of annual fluctuations was considered negligible. Emissions were estimated by assuming a constant annual rate of growth in fuel consumption from 1995 to 2000 (*2006 IPCC Guidelines, Vol. 1. General Guidance and Reporting*). Trend extrapolation of GHG from jet kerosene for 1990-2002 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 (2006 *IPCC Guidelines, Vol. 1. General Guidance and Reporting*).

[10] 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.

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

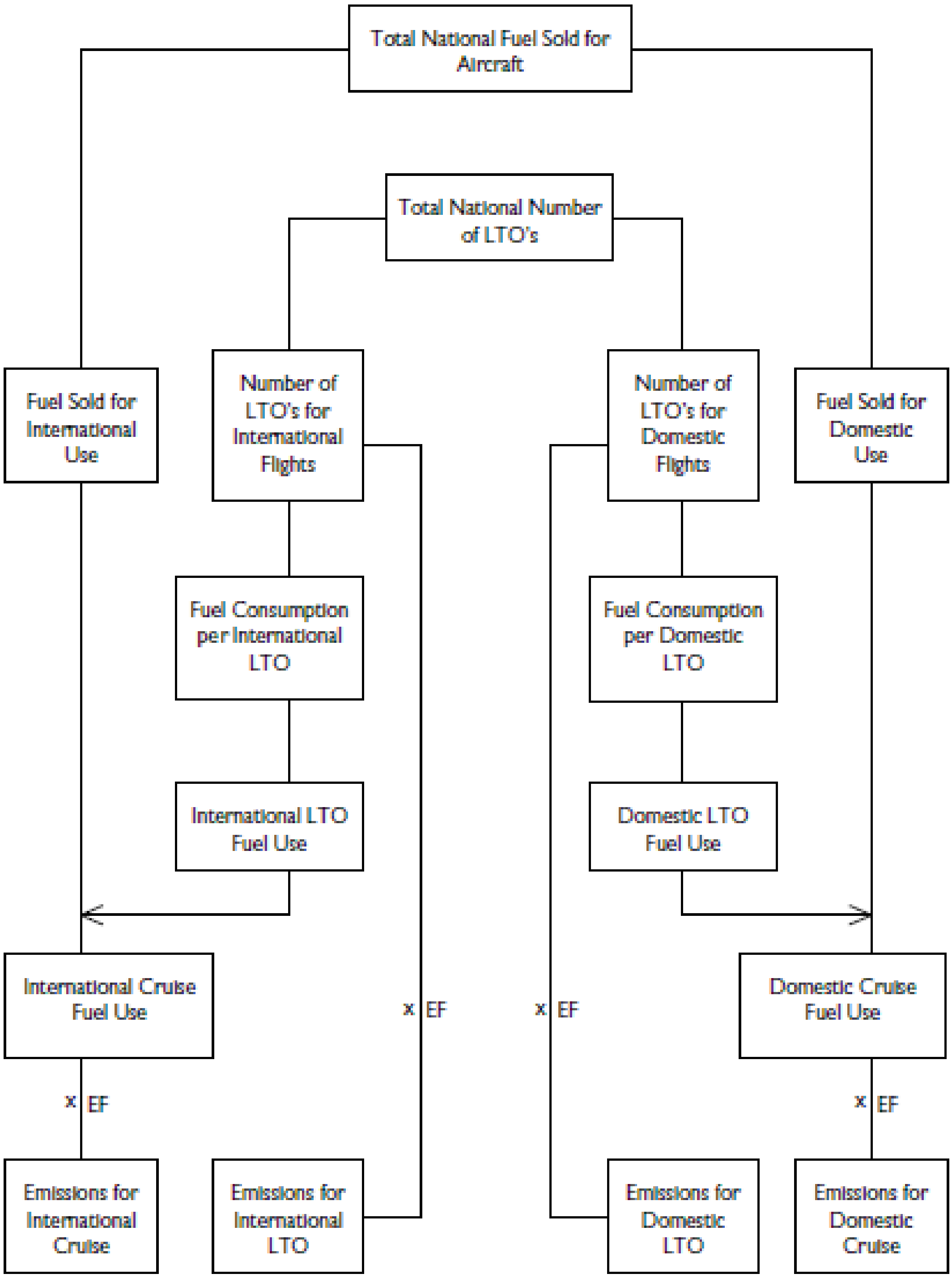


Figure 3-34. Estimation of Aircraft Emissions with the *Tier 2* Method

Following the recommendation of ERT in 2012[12] 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 its own extrapolation algorithm and surrogate data was used as parameters for comparison (for example Average length of carriage per tonne, km) (Fig. 3-35).

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

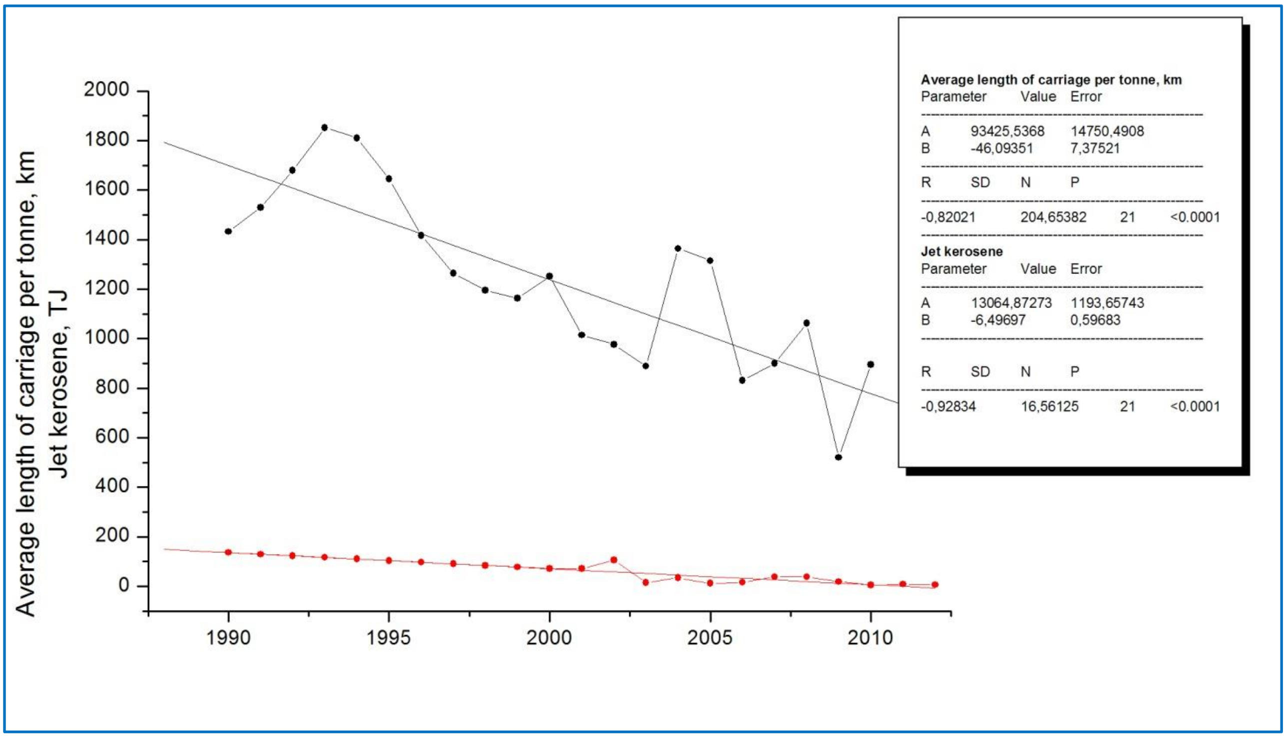


Figure 3-35. The intercomparison between surrogate data and trend of civil aviation emissions

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

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

Additionally expert asks the data by special inquiry data on consumption of aviation fuels for international bunkering and inland consumption every year because this data is not published in the National Energy Balances and Annual Yearbooks, i.e. data of aviation fuels is given in total and is not splitted into national and international use. For 2006-2015 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 3-62. Country-specific CO_2 EFs were applied based on the results of the study "Determination of national GHG emission factors for energy sector", which was prepared by Lithuanian Energy Institute in 2012 and 2016. Values of country - specific CO_2 EFs for gasoline, diesel, gasoil, jet kerosene and liquefied petroleum gas were determined on the basis of measurements performed by the accredited Laboratory of Quality Research Centre of JSC "ORLEN Lietuva"

Table 3-62. Emission factors for Civil aviation sector used in the Lithuanian GHG inventory

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

Aviation gasoline	71.62 70.81*	CS	T2	0.5	D	T1, T2	2	D	T1, T2
Jet kerosene	72.24 71.74*	CS	T2	0.5	D	T1, T2	2	D	T1, T2

*applied from 2015 based on the results of 2016 study "Update of country specific GHG emission factors for energy sector" (Summary of the study is presented in Annex IV).

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 results of 2016 study "Update of country specific GHG emission factors for energy sector". Uncertainty in activity data of fuel consumption for 1990-2000 in civil aviation is influenced by data based on extrapolation (jet kerosene).

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

3.4.1.4 Category-specific QA/QC and verification

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

3.4.1.5 Category-specific recalculations

No recalculations have been done.

3.4.1.6 Category-specific planned improvements

Category-specific improvements are not planned.

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

3.4.2.1 Category description

Lithuania has a fairly well-developed road network provided with a dense road (1,294 km/km²) network (2015). At the end of 2015, the length of roads amounted to 84.9 thousand kilometres; the length of E-roads amounted to 1,639 kilometres, that of motorways – 309 km (Statistics Lithuania, 2015).

Road transportation is the most important emission source in the Transport sector. This sector includes all types of vehicles on roads (passenger cars (PC), light duty vehicles (LD), heavy duty trucks and buses (HD), motorcycles and mopeds (2-wheels)) (Table 3-50). 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.

Implementing the amendment to Order No 260 of 25 May 2001 of the Minister of the Interior of the Republic of Lithuania on the approval of the Rules for the Registration of Motor Vehicles and Their Trailers, made by Order No IV-445 of 30 June 2014, the state enterprise Regitra deregistered vehicles whose compulsory technical inspection or vehicle owner's compulsory civil liability insurance expired by 1 July 2014. For this reason, in 2014, against 2013, the number of all vehicles registered in the country markedly decreased. In 2014, 1,206 thousand passenger cars, 6.9 thousand buses, 23.4 thousand motorcycles, 9.8 thousand mopeds, 113.7 thousand heavy duty vehicles were registered in the country. In 2014, compared to 2013, the number of passenger cars decreased by – 33.4, lorries – 34, buses – 45, motorcycles – 49.2, mopeds – 53.%. In 2015, compared to 2014, the number of motorcycles increased by 14, mopeds – 13.4, road tractors – 5.5, passenger cars – 3.2, lorries – 2.6%, while the number of buses decreased by 1.2%. 69.3% mopeds, 29.2% of motorcycles, 21.0% of passenger cars, 30.2% of buses, 39.2% of lorries and 73.3% of road tractors were produced up to 10 year ago.

Table 3-63. 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
1995	19.2*	718.5	125.9	844.4
2000	19.8	1,172.4	113.7	1,305.9
2005	24.0	1,455.3	137.3	1,616.6
2010	36.3	1,541.9	147.2	1,725.4
2011	33.8	1,577.6	193.6	1,805.0
2012	26.8	1,617.7	196.2	1,840.7
2013	25.1	1,630.0	194.2	1,849.3
2014	27.7	1,171.8**	113.7**	1,311.3
2015	32.8	1,208.7	117.3	1,358.8

*Number of re-registered motorcycles

**Number of re-registered passenger cars and heavy duty vehicles

In 2015, greenhouse gas emissions from road transport increased by 2% from 4753 to 4840 kt CO_2 eqv. in 2014 and amounted to ~92% of the sector's emissions, respectively. This increase is primarily caused by a 9% increase in diesel oil fuel consumption by road transportation (Table 3-50). The lowest emission level in the road transportation was achieved in 1994 (2108.19 kt CO_2 eqv) because of the economic depression in Lithuania. The greenhouse gas emissions from the road transport sector are summarized in Fig. 3-36.

Table 3-64. Fuel consumption, [TJ]

Year	Motor gasoline	Transport diesel	LPG	Bioethanol*	Biodiesel*	CNG
1990	41,840	29,275.61	920	-	-	-
1995	25,887	11,133	1,058	-	-	-
2000	16,337	18,366	5,032	-	-	-
2005	14,685	29,262	9,593	26	119	-
2010	12,405	36,892	7,275	436	1,454	97
2011	10,804	38,491	6,790	397	1,481	123
2012	9,656	40,053	6,400	365	2,168	121
2013	8,749	41,322	6,147	284	2,173	161
2014	8,577	48,031	5,966	232	2,409	194
2015	8,356	52,599	5,573	405	2,422	321

*carbon from biofuel is reported as a memo item but not included in national CO_2 totals, as required by the *2006 IPCC Guidelines, Volume 2, Chapter 3: Mobile Combustion, 3.13 p*.

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 3-65[13].

Table 3-65. 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[14]. From 2000-2007, these emissions increased, since growth in mileage travelled outweighed improvements in vehicle fuel consumption. Road traffic is an important source of N_2O from fuel combustion and from 1994-2007 emissions has increased in line with the increasing share of catalyst-controlled vehicles in the national fleet (exception 2000 when the consumption of motor gasoline was noticeably decreased). The use of liquefied petroleum gas is strongly influenced by the fluctuation of fuel prices.

Since 1990 the density of transport routes as well as the number of road vehicles has increased rapidly. Since 1995, the number of personal cars almost increased by a factor of 2 over the last years (Table 3-49). 90% of the fuel in transportation sector is consumed by road transport.

[13] *2006 IPCC Guidelines*, Volume2, Chapter 3, p.3.16.

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

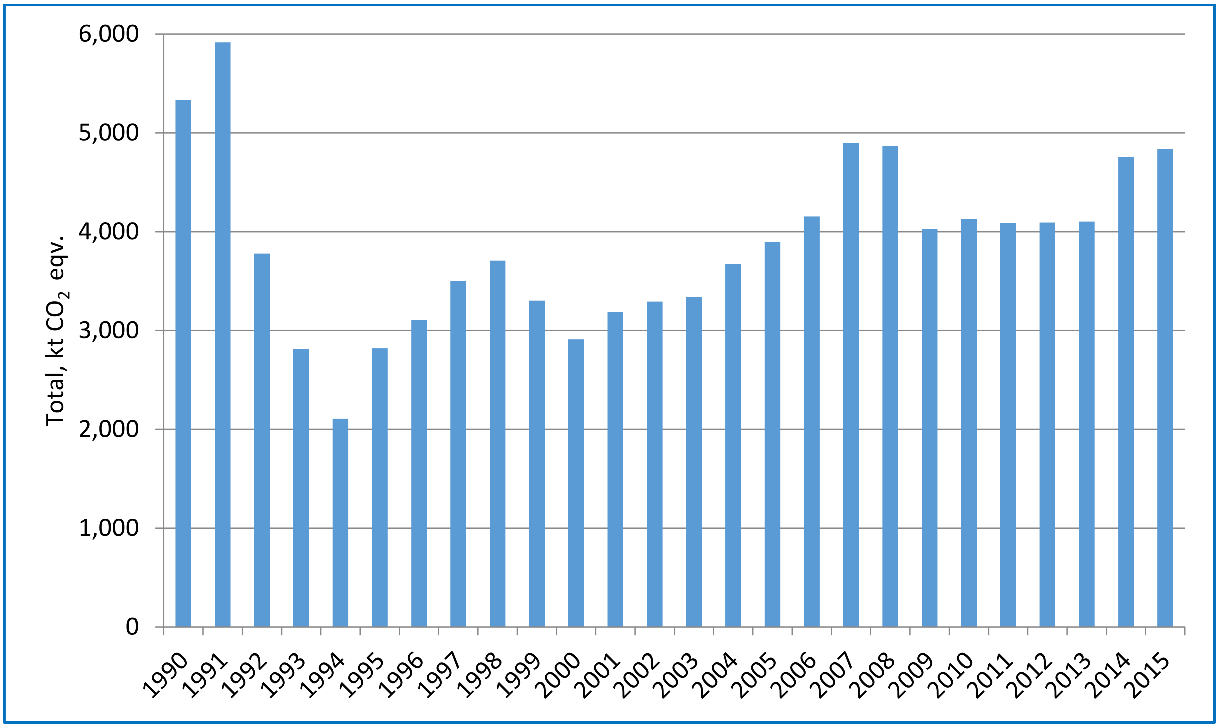


Figure 3-36. Development of GHG emissions from road transport, kt CO_2 eqv in 1990-2015

CH_4 emissions in Road transport are presented in Figure 3-37. The majority of CH_4 emissions from road transport came from gasoline passenger cars. 2015 emission shares for CH_4 were 75, 22 and 3 % for passenger cars, heavy duty vehicles and light-duty vehicles, respectively.

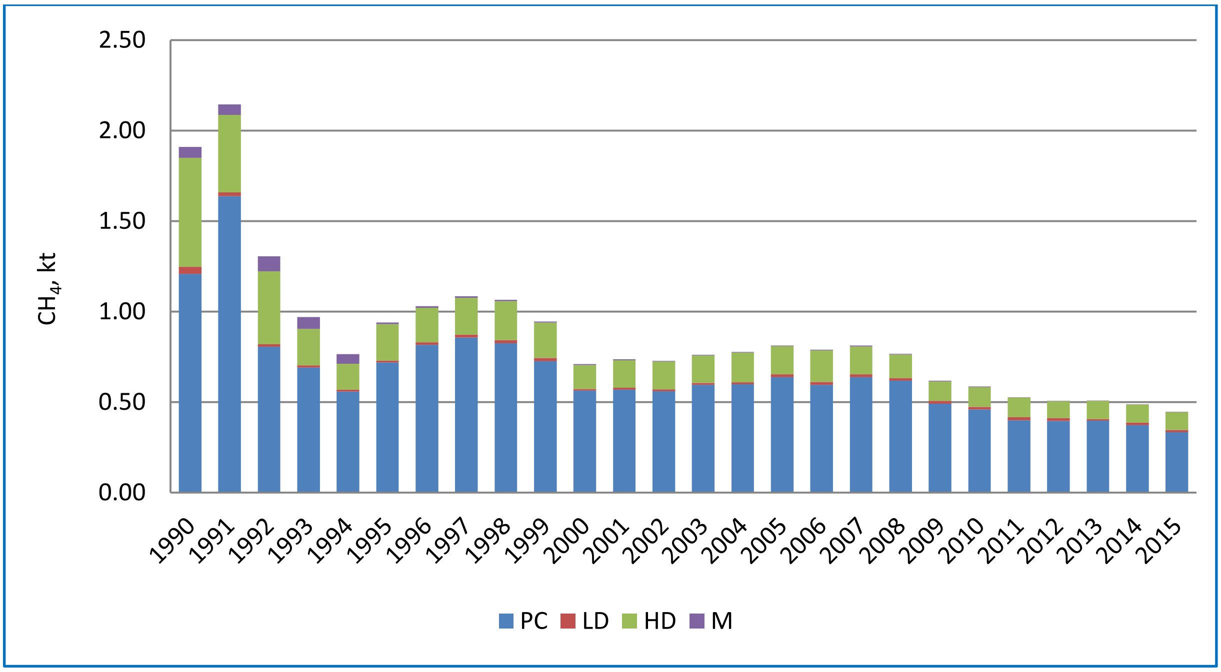


Figure 3-37. CH_4 emissions in Road transport during 1990-2015

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 depends on driving cycle variables, catalyst composition, catalyst age, catalyst exposure to variable levels of sulphur compounds. N_2O emissions are not limited by law. Initially, growth in numbers of cars with the first generation catalyst converters (Euro 1) 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 (Figure 3-38)

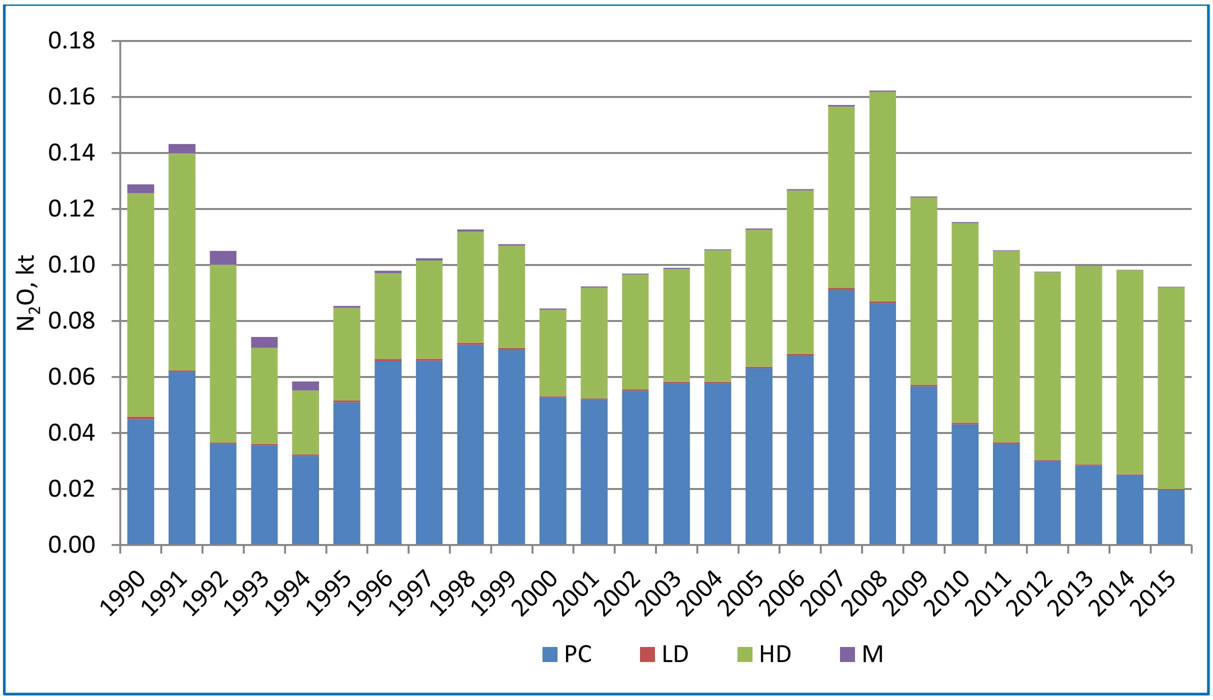


Figure 3-38. N_2O emissions in Road transport during 1990-2015

During the last years emissions of N_2O have decreased. The effect of fuel sulphur 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.

Emissions from two-stroke engines are considered as insignificant, as these emissions do not exceed the threshold of significance. According to Copert data, 36-37 TJ of petrol were used for two-stroke engines in 2014-2015. In accordance with 2006 IPCC Guidelines (vol. 2, Chapter 3, box 3.2.4), a two-stroke petrol engine should be lubricated by a mixture of lubricating oil and petrol in suitable proportion according to the manufacturer's recommendations. Depending on the engine type, mixtures of 1:25, 1:33 and 1:50 are common. Based on these proportions, lubricants use in two-stroke engines in 2015 amounts only to 0,74-1,48 TJ, consequently emissions do not exceed threshold of significance.

There is a marked switch from petrol engines to diesel (Table 3-51). The number of petrol engines (all vehicles) and as a result petrol fuel consumption has dropped between 1990 and 2015, while the number of diesel engines increased significantly from ~116 to 790 thousand for the same period.

Passenger cars represent the most fuel-consuming vehicle category, followed by heavy-duty vehicles, light duty vehicles and 2-wheelers, in decreasing order (Figs 3-39 – 3-40).

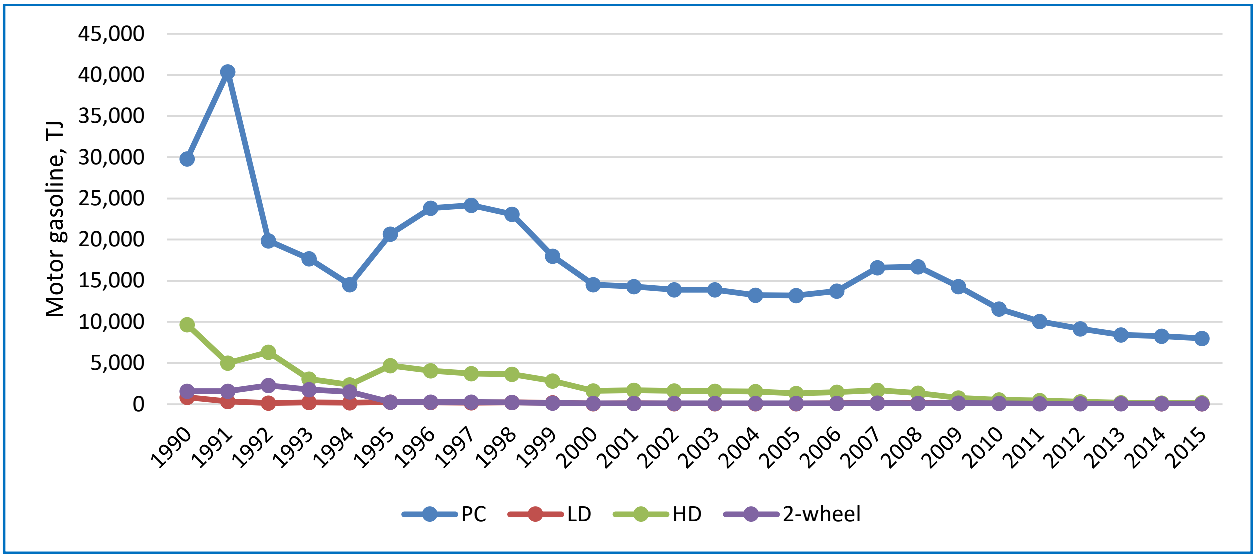


Figure 3-39. Gasoline fuel consumption per vehicle type for road transport 1990-2015

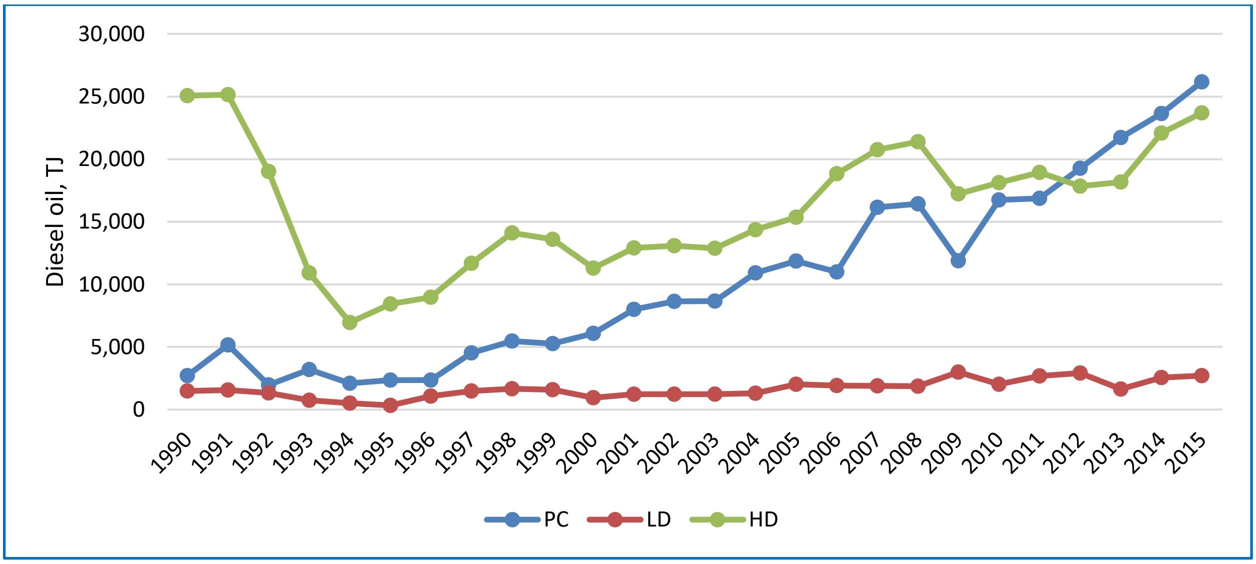


Figure 3-40. Diesel oil consumption per vehicle type for road transport 1990-2015

In 2015, fuel consumption shares for diesel passenger cars, diesel heavy-duty vehicles, gasoline passenger cars, diesel light duty vehicles were 39 %, 36%, 12%, 4%, respectively (Figure 3-41).

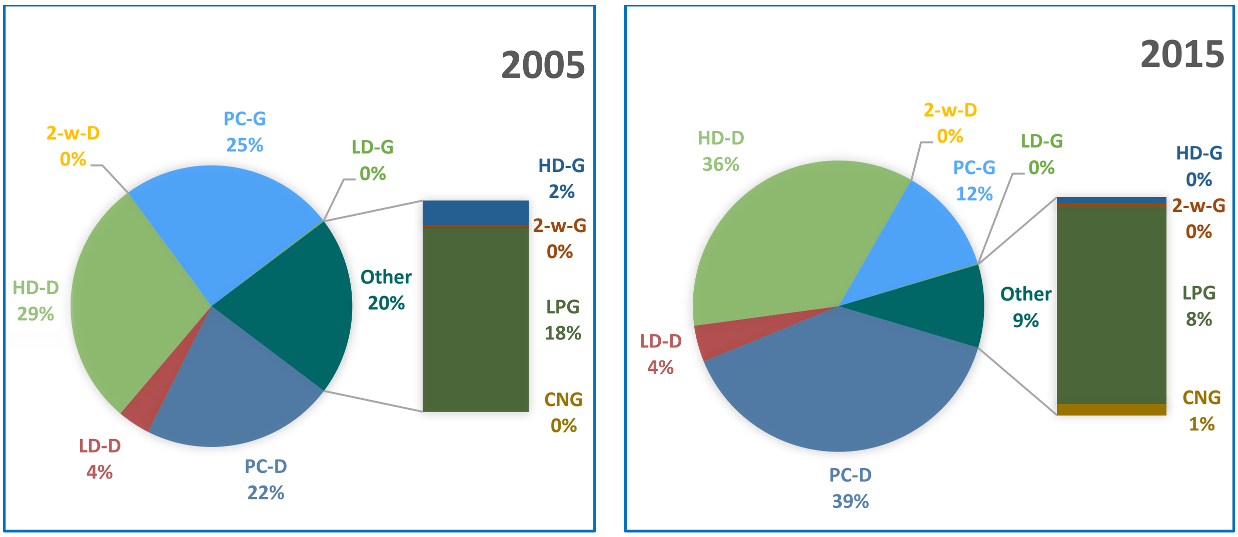


Figure 3-41. Fuel consumption share (TJ) per vehicle type and fuel type for road transport in 2005 and 2015

As seen from Figure 3-42, most of GHG emissions from road transport sector are emitted from passenger cars and heavy duty vehicles.

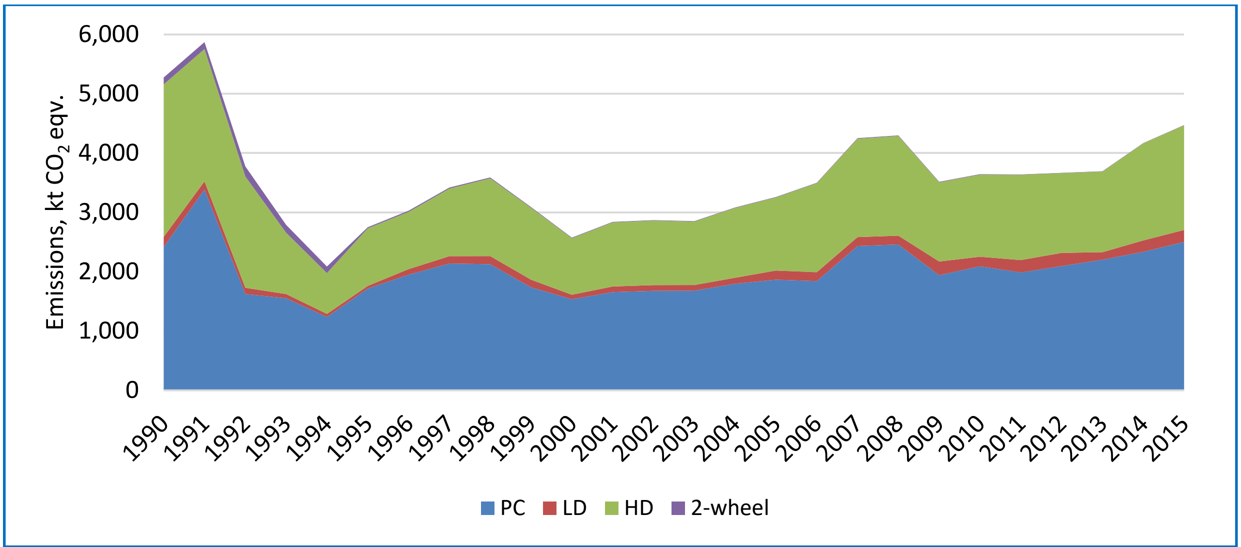


Figure 3-42. Emissions from road transportation by types of vehicle (kt CO_2 eqv.)

Methodological issues

Emission estimations from road transportation are made using the *2006 IPCC* Guidelines *Tier 2* method (for CO_2 emissions) and for CH_4 and N_2O emissions based on the COPERT IV (v11.0) model (best practice) which corresponds to the 2006 *IPCC Guidelines 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:

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

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.*

$$E_{TOTAL} = E_{HOT} + E_{COLD}. \tag{2}$$

where,

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

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

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

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

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

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

where:

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

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

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

Emissions of CO_2 were calculated on the basis of the amount and type of fuel combusted (equal to the fuel sold) and its carbon content (*2006 IPCC Guidelines*. Vol. 2, p. 3-10):

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

where:

Emission - emissions of CO_2, kg;

$Fuel_a$ - fuel sold, TJ;

EF_a - emission factor, kg/TJ. This is equal to the carbon content of the fuel multiplied by 44/12;

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

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

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

where:

Emission - emission of CH_4 or N_2O;

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

$Distance_{a,b,c,d}$ - distance travelled during thermally 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 Lithuanian Road Administration and study funded by the European Commission – DG Environment and executed in collaboration with, KTI, Renault, E3M-Lab/NTUA, Oekopol, and EnviCon. The source for these data is various European measurement programmes. Fuel consumption was calculated on the basis of appropriate assumptions for annual mileage of the different vehicle categories can be balanced with available fuel statistics (Ntziachristos et al., 2008). In general the COPERT IV v.11 data are transformed into trip-speed dependent fuel consumption and emission factors for all vehicle categories and layers. The calculated fuel consumption in COPERT IV must equal the statistical fuel sale totals according to the UNFCCC and UNECE emissions reporting format. The statistical fuel sales for road transport are derived from the Statistics Lithuania.

For example, if a country has bulk fuel sold but does not have fuel use by vehicle type, they may allocate total fuel consumption across vehicle types based on the consumption patterns of their fleet (TRB's National Cooperative Highway Research Program (NCHRP) project report, Greenhouse Gas Emission Inventory Methodologies for State Transportation Departments). By applying a trial-and-error approach, it was possible to reach acceptable estimates of mileage. For each group, the emissions were 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 based on the results of 2016 study "Update of country specific GHG emission factors for energy sector". 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, 2016. Correction factors were applied to the baseline emission factors for gasoline cars and light-duty vehicles to account for different vehicle age (COPERT IV v11.0). It is assumed that emissions do not further degrade above 120,000 km for Euro 1 and Euro 2 vehicles and above 160,000 km for Euro 3 and Euro 4 vehicles.

Emission factors for Road transportation used in the Lithuanian national GHG inventory are provided in Tables 3-66.

Table 3-66. Emission factors for Road transportation sector used in the Lithuanian GHG inventory

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Motor gasoline	72.97 72.77**	CS	T2	-	CR*	T3	-	CR	T3
Gas/Diesel oil	72.89 72.73**	CS	T2	-	CR*	T3	-	CR	T3
LPG	65.42 66.01**	CS	T2	-	CR*	T3	-	CR	T3
Biodiesel	70.8	D	T1	3.0	D	T1	0.6	D	T1
Bioethanol	70.8	D	T1	3.0	D	T1	0.6	D	T1

*CR – values modelled using COPERT4

** applied from 2015 based on the results of 2016 study "Update of country specific GHG emission factors for energy sector" (Summary of the study is presented in Annex IV).

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".

3.4.2.2 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 *2006 IPCC Guidelines*, 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.

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

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

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

Emissions of N_2O are a function of many complex aspects of combustion and mileage dynamics as well as the type of emission control systems used. During the last decades the stock of Lithuanian diesel passenger cars and heavy-duty vehicles has intensively grown. In the period from 1990 to 2000 the number of diesel-powered vehicles was increased by about 13% per year. As was expected, the linear regression analysis did not provide statistically significant linear relationship between total diesel fuel consumption and N_2O IEF values for the reason that the variation from year to year between sub-sectors and technology differ due to changes in abatement technologies and mileage. For the period between 1990 and 2000, it was necessary to estimate the figures with the aid of numerous scientific assumptions regarding mileage distribution between subsectors. In conjunction with decreasing fuel consumption 1990-1994 the number of diesel powered vehicles was increased (for example, in 1992 the fuel consumption was sharply decreased by 26% while the number of diesel powered vehicles was increased by 13%). We had to make fuel correction by reduce/increase mileage from our initial calculations to match the statistical fuel consumption. The correction for fuel consumption within ± one standard deviation of the official value is very critical as it reduces the uncertainty of the calculation N_2O, conversely good knowledge of the statistical fuel consumption and comparison with the calculated fuel consumption was necessary to improve the quality of the inventory. The uncertainty in annual N_2O emissions from road transport is estimated to be ±50%.

Developing emission factors for CH_4 and N_2O is more difficult because these pollutants require technology-based emission factors rather than aggregate default emission factors. Following in-country review ERT 2012 recommended providing justification of gasoline N_2O IEF fluctuation 2006-2008. Over 1990-2013 period the number of passenger cars (dominant gasoline consumers) increased despite the fact of economic crisis. Therefore, decreasing fuel consumption was balanced by mileage, although N_2O emission exceptionally differ according to the fuel sulphur level (Fig. 3-40) since a regression line of nitrous oxide emission factors against mileage for passenger vehicles yielded a slight not significant slope (Barton and Simpson, 1994):

$$EF_{N2O} = (a \times Mj,k + b) \times EF_{BASE}, \quad (6)$$

where,

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

a, b depend on fuel sulphur content

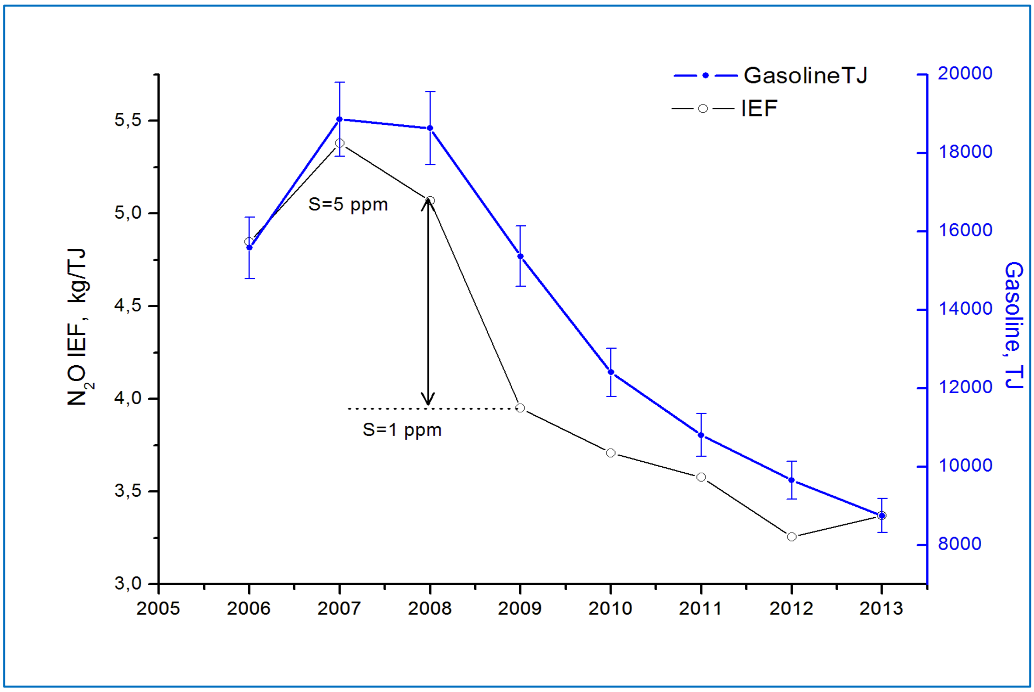


Figure 3-43. Dynamic of implied emission factors of N_2O for gasoline

The fuel consumption slightly decreased in 2007-2014, 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 sulphur 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 sulphur content less than 10 ppm. The implementation of regulations reducing fuel sulphur levels across the EU in 2008 also reduced N_2O emissions for vehicles of all technology categories[15] .

3.4.2.3 Category-specific QA/QC and verification

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

3.4.2.4 Category-specific recalculations

Following recalculations in this category has been done:

- Emissions correction for diesel oil from road transportation according updated activity data in 2013-2014.

Impact of these recalculations on GHG emissions from 1.A.3.b is presented in Table 3-67.

Table 3-67. Impact of recalculation on GHG emissions from Road transport

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eq.	Relative difference, %
2013	4,127.66	4,111.34	-16.33	-0.40
2014	4,588.57	4,569.47	-19.10	-0.42

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

3.4.2.5 Category-specific planned improvements

Road transport GHG emissions will be updated using newer COPERT 5.0 version (available since October 2016).

3.4.3 CO_2 emissions from urea-based catalysts (CRF 2.D.3)

3.4.3.1 Category description

"AdBlue" urea solution reduces nitrogen oxide emission from auto exhaust system (fitted with SCR technology). The solution is injected to diesel engine exhaust systems before selective reduction catalyst, consequently due to the solution reaction with nitrogen oxide gasses emissions are converted to water vapour and nitrogen. This technology optimizes engine performance by reducing particle emission and maximizing fuel energy generation. Another significant effect of the process is reduced fuel consumption (on average 5%).

AdBlue is produced according to the German standard DIN 70070 and European standard ISO/PAS 22,241-1. Only the product meeting the aforementioned standards may be marked with the AdBlue trademark. AdBlue produced by AB "Achema" and distributed by "Gaschema", the branch of "Achema", is the only certified product of such type in Baltic region.

The Euro V step was introduced in October of 2008 and the Euro VI step in September of 2013. Euro V introduced SCR to the majority of heavy duty engines.

3.4.3.2 Methodological issues

Tier 3 category specific method assuming 1-3% of diesel consumption for vehicles using urea as a selective catalytic reduction agent (SCR) supplemented by guidance for ammonia emissions from the EMEP-EEA Guidebook 2013. This requires detailed knowledge of the diesel fleet to estimate the number of SCR vehicles and their fuel use. COPERT and TREMOVE provided defaults for the necessary detail of fleet make-up for European fleets. The *2006 IPCC Guidelines* suggest urea consumption can be estimated as 1-3% of diesel consumed by vehicles using urea (as an SCR agent).

$$E_{CO2} = Activity \cdot \frac{12}{60} \cdot Purity \cdot \frac{44}{12}. \qquad (7)$$

Where:

ECO_2 = CO_2 emissions from urea-based additive in catalytic converters (kt CO_2),

Activity = amount of urea-based additive consumed for use in catalytic converters (kt),

Purity = the mass fraction (= percentage divided by 100) of urea in the urea-based additive.

The factor (12/60) captures the stoichiometric conversion from urea ($CO(NH_2)_2$) to carbon, while factor (44/12) converts carbon to CO_2. On the average, the activity level is 1 to 3 percent of diesel consumption by the vehicle. Thirty two and half percent can be taken as default purity in case country-specific values are not available (Peckham, 2003). As this is based on the properties of the materials used, there are no tiers for this source.

Tier 3 category specific method as applied assuming 3% of diesel consumption for vehicles using urea as a SCR (EMEP-EEA Guidebook). This share was obtained by COPERT model in the diesel consumption for Euro V and VI catalysts equipped cars (cars, trucks, buses, mobile machinery).

3.4.3.3 Uncertainties and time-series consistency

Expert judgement suggests that the uncertainty of the CO_2 estimate is approximately ±10%, based on studies with reliable fuel statistics. The primary source of uncertainty is the activity data rather than emission factors.

3.4.3.4 Category-specific QA/QC and verification

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

3.4.3.5 Category-specific recalculations

No recalculations have been done.

3.4.3.6 Category-specific planned improvements

Category-specific improvements are not palnned.

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

3.4.4.1 Category description

In 2015, the operational length of railways amounted to 1,877.2 km. The length of electrified lines remained unchanged (122 km).

In 2015, compared to 2014, the number of railway vehicles decreased: that of locomotives – by 4.2, wagons – 2.4, coaches (including diesel and electric railcars) – 7.3%. 52% of locomotives, 71% of coaches (including diesel and electric railcars) and 86% of wagons were produced 15 and more years ago. Emissions from producing electricity used in electric trains are not included in this category, but in category 1.A 1.

Lithuanian Railways (*Lithuanian*: "Lietuvos Geležinkeliai") is the national, state-owned railway company of Lithuania. Lithuanian's trains operate frequent services across the whole of Lithuania (Fig. 3-44).

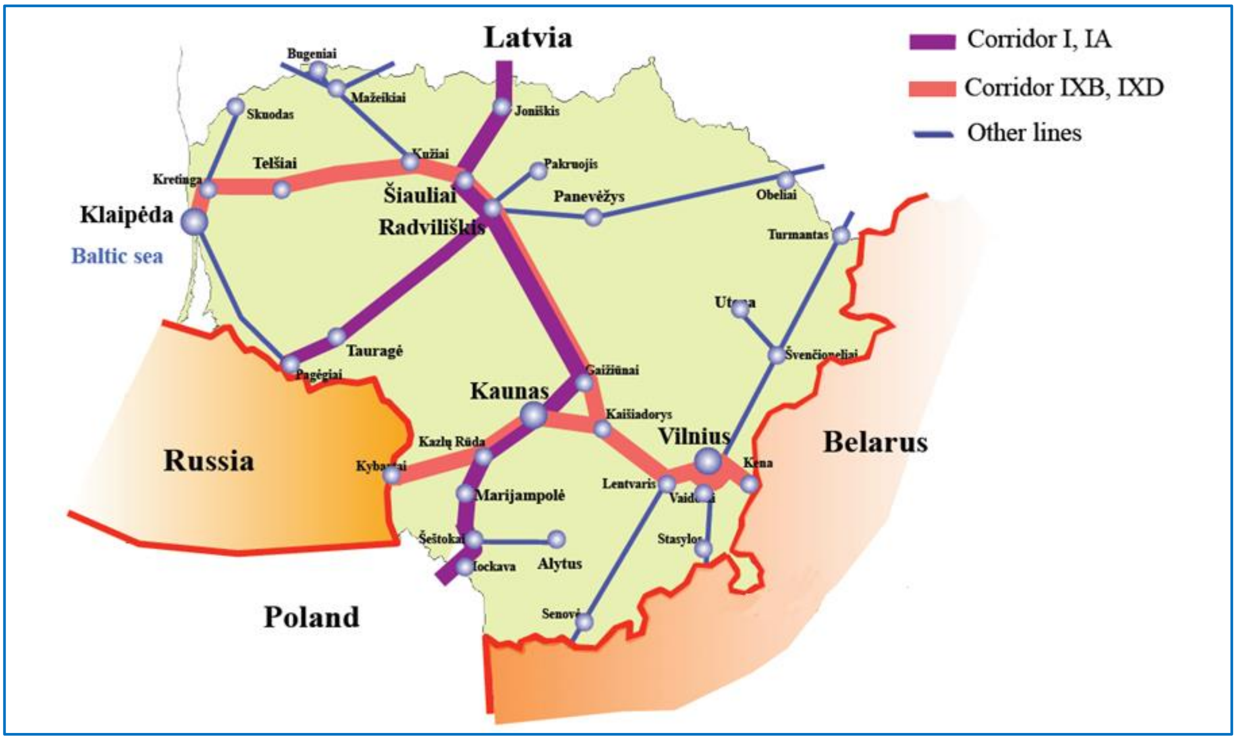


Figure 3-44. Lithuanian railways network

In 2015, goods transport by rail amounted to 48.1 million tonnes, which is by 1.9% less than in 2014. National goods transport by rail amounted to 14.4 million tonnes, which is by 0.4% less than in 2014; international goods transport by rail amounted to 33.6 million tonnes, which is by 2.6% less than in 2014. In 2015, 31.4% of all the goods carried by rail (15.1 million tonnes) were chemicals, chemical products and man - made fibres, rubber and plastic products, nuclear fuel; compared to 2014, their carriage increased by 2.2%. Coke and refined petroleum products carried by rail amounted to 13.9 million tonnes, or 29% of all the goods carried; compared to 2014, their carriage increased by 6.7%. Metal ores and other mining and quarrying products, peat, uranium and thorium amounted to 4.4 million tonnes, or 9.2% of all the goods carried by rail; compared to 2014, their carriage decreased by 23.9%.

The major proportion of goods was carried from Belarus (73.9%) and Russia (19.5%). Most goods from Lithuania were carried to Latvia (24.9), Ukraine (21.5%), Estonia (15.7%), and Belarus (13.0%). In 2015, passenger-kilometers amounted to 14036 million, which is decreased by 1.9% compared to 2014. In 2015, compared to 2014, national passenger transport decreased by 6.6, international transport – by 12.0%. In 2015, compared to 2014, the number of arriving passengers decreased by 22.1%, that of departing passengers by 19.3%. The majority of passengers departed to (86.7%) and arrived from (87.4%) Belarus. Fuel consumption 1990-2015 for railways, based on energy statistics from Statistics Lithuania is shown in Figure 3-45.

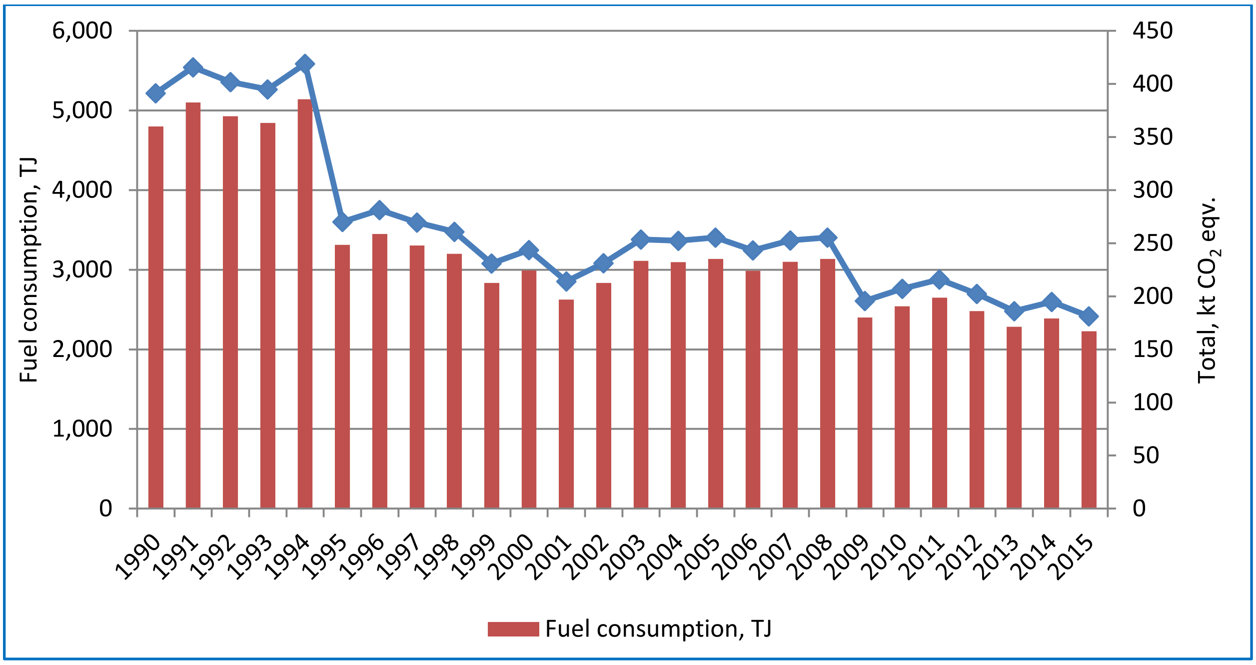


Figure 3-45. Trend of GHG emissions in Railways sector

The trend of GHG emissions follows in general the fuel consumption trend in the railway transportation sector. The Lithuanian railway transport has suffered two obvious downturns within the last two decades, the first relating to Lithuania's separation from the Soviet Union and the second one – to the global financial and economic crisis.

3.4.4.2 Methodological issues

CO_2 emission calculations are based on the *Tier 2* methodology with country specific emission factors and CH_4 and N_2O on default *Tier 1* methodology (*2006 IPCC Guidelines*). Currently, the *Tier 2* methodology for CH4 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 (8) with country-specific data on the carbon content of the fuel (2006 *IPCC Guidelines, vol*. 2, p. 3.41):

$$Emission = \sum_j (Fuel_j \cdot EF_j)\,. \qquad (8)$$

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 on 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 3-68.

Table 3-68. Emission factors for Railways sector used in the Lithuanian GHG inventory

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Diesel oil	72.89 72.73*	CS	T2	4.15	D	T1	28.6	D	T1

*applied from 2015 based on the results of 2016 study "Update of country specific GHG emission factors for energy sector" (Summary of the study is presented in Annex IV).

Emissions from electricity used in electric trains are not included in this category, but in category 1.A 1. In 2015 emissions of railway transportation were 181.1 kt (CO_2 eqv.), it was only ~3% of the *Transport* sector emissions. Substantial decrease from the year 2008 was caused by the ongoing economic depression (Figure 3-45).

3.4.4.3 Uncertainties and time-series consistency

The uncertainty in activity data (fuel use) is 5%. Uncertainties in CH_4 and N_2O emission factors are larger than those in CO_2 (±2%) obtained by study "Update of country specific GHG emission factors for energy sector", 2016. 2006 *IPCC Guidelines* refers that the uncertainty range for the default factors for *Tier 1* method is estimated to be +50%/-100%. The time series for all data have been studied carefully in search for outliers.

3.4.4.4 Category-specific QA/QC and verification

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

3.4.4.5 Category-specific recalculations

No recalculations have been dane.

3.4.4.6 Category-specific planned improvements

Category-specific improvements are not planned.

3.4.5 Water borne navigation (CRF 1.A.3.d)

Lithuania has ~900 km of inland waterways. Inland waterways are navigable rivers, canals, lakes, man-made water bodies, and part of the Curonian Lagoon belonging to the Republic of Lithuania. Length of inland waterways regularly used for transport in Lithuania equalled 452 km in 2015. In 2015, transport of goods by inland waterways amounted to 1.1 million thousand tonnes, the number of passengers carries – 2.0 million. In 2015 compared to 2014, transport of goods increased by 1.7%, passenger transport decreased by 1.8 %.

As seen in Figure 3-46 fuel consumption decreased by 17.2% between 2005 and 2015. This decrease is obviously due to the impact of the decreased fuel consumption in inland waterways.

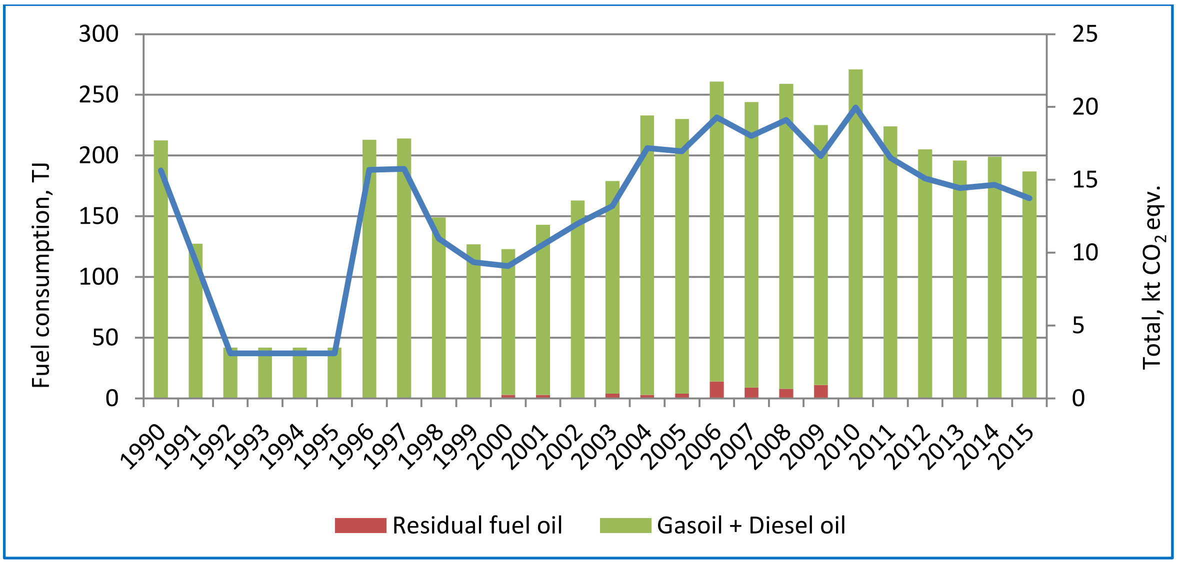


Figure 3-46. Trend of GHG emissions in Water navigation sector

3.4.5.1 Category description

Inland waterways are navigable rivers, canals, lakes, man-made water bodies, and part of the Curonian Lagoon belonging to the Republic of Lithuania. Emissions of domestic navigation were 13.75 kt (CO_2 eqv.) in 2015 it was ~0.3% of the sector's emissions.

3.4.5.2 Methodological issues

Tier 1 method was applied with default for N2O and CH_4 and country specific for CO_2 values (Tables 3-55). The existing default *Tier 2* approach provided in the *2006 IPCC Guidelines* provides only limited benefits over the *Tier 1* approach:

$$Emission = \sum (FuelConsumed_{ab} \cdot EF_{ab}) . \qquad (9)$$

where:

Emission - *emissions, kg;*

EF_j - *emission factor, kg TJ^{-1};*

a - *fuel type;*

b - *water-borne navigation type. At Tier 1 fuel used differentiation by type of vessel can be ignored) (2006 IPCC Guidelines, vol. 2, p. 3.47).*

Activity data

Data on fuel consumption for *Water navigation* and *Fishing sectors* are obtained from official statistics (Statistics Lithuania, 2016). Diesel oil consumed in Fisheries sector was assumed as consumed by fishing ships and presented in 1.A.4.c.iii sector.

Emission factors

Emission factors used in the calculation of emissions from *Water-borne navigation* are presented in Table 3-69.

Table 3-69. Emission factors for Water-borne navigation and Fishing sectors used in the Lithuanian GHG inventory

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	EF	Method	CH_4, kg/TJ	EF	Method	N_2O, kg/TJ	EF	Method
Residual Fuel Oil	77.60 78.40*	CS	T2	7.0	D	T1	2.0	D	T1
Gasoil and Diesel oil	72.89 72.73*	CS	T2	7.0	D	T1	2.0	D	T1

* applied from 2015 based on the results of 2016 study "Update of country specific GHG emission factors for energy sector" (Summary of the study is presented in Annex IV).

3.4.5.3 Uncertainties and time-series consistency

The uncertainty in activity data (fuel use) is 5%. The uncertainty value of CO_2 emission factor is ± 3%. The uncertainty of the N_2O emission factor -40 – +140% and CH_4± 50% (2006 *IPCC Guidelines*).

3.4.5.4 Category-specific QA/QC and verification

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

3.4.5.5 Category-specific recalculations

No recalculations have been done.

3.4.5.6 Category-specific planned improvements

Category-specific improvements are not planned.

3.4.6 Other (CRF 1.A.3.e)

3.4.6.1 Natural gas transportation in pipelines (CRF 1.A.3.e.i)

In Lithuania, natural gas is transported via gas transmission and distribution systems (Fig. 3-47). Statistics Lithuania started collecting data on consumption of natural gas used for gas transportation in pipeline compressor stations from 2001.

JSC "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 3-70).

Table 3-70. 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 3-47. Gas distribution network in Lithuania

3.4.6.1.1 Category description

Transport via pipelines includes transport of gases via pipelines.

3.4.6.1.2 Methodological issues

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 3-71 and Table 3-72.

Table 3-71. CO_2 emission factors for Natural gas transportation in pipelines sector used in the Lithuanian national GHG inventory

Year	**CO_2, kg/GJ***
1990-2003	55.14
2004	55.09
2005	55.09
2006	55.12
2007	55.11
2008	55.11
2009	55.16
2010	55.12
2011	55.12
2012	55.16
2013	55.21
2014	55.24
2015	55.53

*based on the results of 2016 study "Update of country specific GHG emission factors for energy sector" (Summary of the study is presented in Annex IV).

Table 3-72. CH_4 and N_2O emission factors for Natural gas transportation in pipelines sector used in the Lithuanian national GHG inventory

Fuel	**CH_4**			**N_2O**		
	CH_4, kg/TJ	**EF**	**Method**	**N_2O, kg/TJ**	**EF**	**Method**
Natural gas	1.0	D	T1	0.1	D	T1

3.4.6.1.3 Uncertainties and time-series consistency

The uncertainty in activity data (fuel use) is 5%. CO_2 emission factor uncertainty is ±2% based on results of 2016 study "Update of country specific GHG emission factors for energy sector". The uncertainty of the N_2O and CH_4 emission factor is ± 50% (*2006 IPCC Guidelines*).

3.4.6.1.4 Category-specific QA/QC and verification

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

3.4.6.1.5 Category-specific recalculations

Following recalculations in this category has been done:

-Application of CO_2 EF for natural gas from pipelines transportation according new study.

Impact of these recalculations on GHG emissions from 1.A.3.e is presented in Table 3-73.

Table 3-73. Impact of recalculation on GHG emissions from 1.A.3.e

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eq.	Relative difference, %
1990	85.50	85.36	-0.14	-0.16
1991	82.29	82.16	-0.13	-0.16
1992	47.22	47.14	-0.08	-0.16
1993	26.46	26.41	-0.04	-0.16
1994	28.89	28.84	-0.05	-0.16
1995	33.75	33.69	-0.05	-0.16
1996	37.83	37.77	-0.06	-0.16
1997	35.51	35.46	-0.06	-0.16
1998	27.50	27.46	-0.04	-0.16
1999	31.26	31.21	-0.05	-0.16
2000	38.33	38.27	-0.06	-0.16
2001	18.67	18.64	-0.03	-0.16
2002	20.71	20.68	-0.03	-0.16
2003	17.78	17.76	-0.03	-0.16
2004	17.84	17.79	-0.05	-0.25
2005	35.73	35.64	-0.09	-0.25
2006	60.31	60.19	-0.12	-0.20
2007	63.24	63.10	-0.14	-0.22
2008	55.45	55.33	-0.12	-0.22
2009	56.06	55.99	-0.07	-0.13
2010	56.78	56.66	-0.11	-0.20
2011	47.61	47.51	-0.09	-0.20
2012	73.46	73.36	-0.09	-0.13
2013	69.04	69.01	-0.02	-0.04
2014	68.04	68.06	0.01	0.02

3.4.6.1.6 Category-specific planned improvements

Category-specific improvements are not planned.

3.5 Other sectors (CRF 1.A.4)

3.5.1 Commercial/institutional (CRF 1.A.4.a.i)

3.5.1.1 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 equipment, 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 67.9% (1995) till 67.8% (2009). In 2015 the share of value added in commercial / institutional sector reduced till 66.3%. Retail, wholesale trade, transport, accommodation and catering services' sector is the largest sector prescribed to this category. With reference to data of 2015, it created 32.5% 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* and *Tier 2* (as presented in Table 3-60) 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 3-74.

Table 3-74. 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 76.60*	CS	T2	10.0	D	T1	0.6	D	T1
Residual fuel oil	77.60 78.40*	CS	T2	10.0	D	T1	0.6	D	T1
LPG	65.42 66.34*	CS	T2	5.0	D	T1	0.1	D	T1
Gasoil	72.89 72.73*	CS	T2	10.0	D	T1	0.6	D	T1
Charcoal	109.90	CS	T2	200.0	D	T1	1.0	D	T1
Coking coal	94.90 95.10*	CS	T2	10.0	D	T1	1.5	D	T1
Anthracite	106.55	CS	T2	10.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00 96.10*	CS	T2	10.0	D	T1	1.5	D	T1
Lignite	101.20 101.0*	CS	T2	10.0	D	T1	1.5	D	T1
Natural gas	Table 3-11	CS	T2	5.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	10.0	D	T1	1.4	D	T1
Wood/ wood waste	101.34	CS	T2	250.0	CS*	T2	4.0	D	T1

Other solid biomass	103.69	CS	T2	250.0	CS*	T2	4.0	D	T1
Biogas	58.45	CS	T2	5.0	D	T1	0.1	D	T1

Abbreviations:
CS - country specific emission factors;
CS* - country specific emission factors are based on internationally referenced sources and EFs from neighboring countries appropriate to Lithuania's national circumstances. These EFs were estimated following recommendation provided by ERT in 2013 (Report of the individual review of the annual submission of Lithuania submitted in 2013, paragraph 31);
* - CS emission factors applied from 2015 based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute. Summary of the study is presented in Annex IV;
D - default emission factors (*2006 IPCC Guidelines*); 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 3-48.

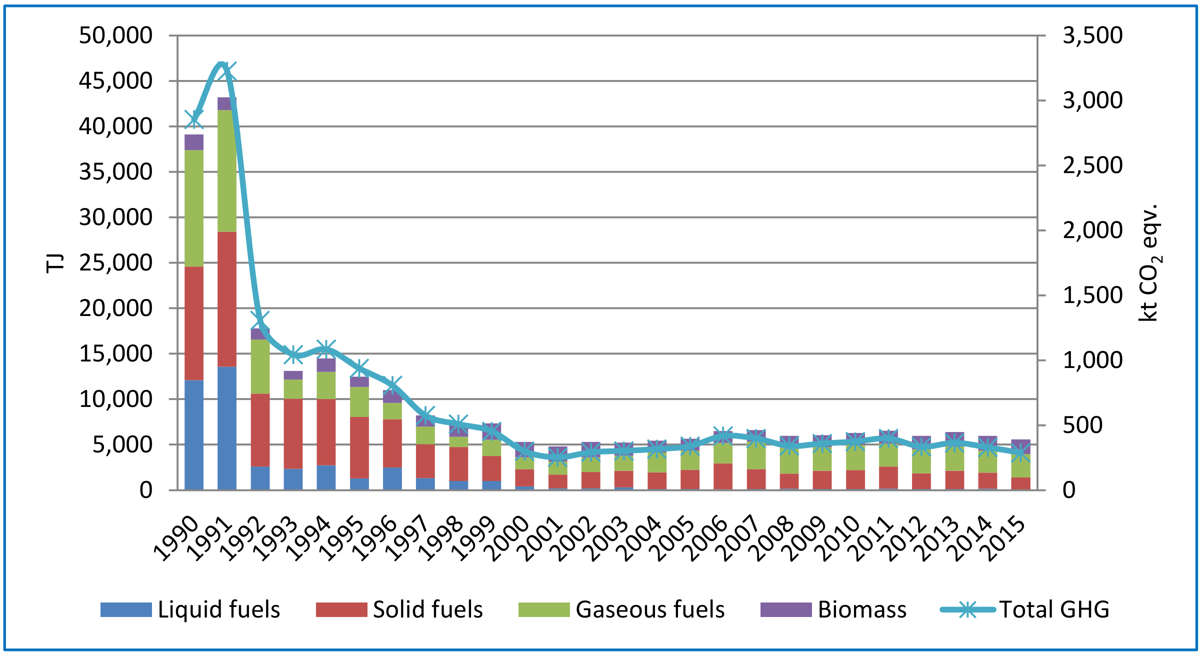


Figure 3-48. Tendencies of fuel consumption and total GHG emissions in Commercial / institutional sector (1.A.4.a)

After the drastically reduced fuel consumption volume in Commercial/institutional sector during 1990-2000, later (2001-2007) fuel consumption volumes was increasing by 5.5% a year. However, during the time of global economic crisis fuel consumption volumes was further reduced by 4.8%. In 2015 there was consumed 5.57 PJ of fuel in Commercial/institutional sector. This was by 6.9% less than in 2014. In 2015, natural gas accounted 46.2% in the fuel structure, solid fuels – 23.6%, biomass – 28.9% and liquid fuels – 1.3%.

In 2015, total GHG emissions from Commercial/institutional sector were almost 10 times lower than in 1990 and amounted to 286.8 kt CO_2 eqv.

3.5.1.3 Uncertainties and time-series consistency

Uncertainty in activity data in Commercial/ institutional sector is ±3.0% taking into consideration recommendations provided by *2006 IPCC* 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 Guidelines*.

Uncertainties of CO_2 emission factors for liquid fuels (shale oil, residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.0% in Commercial/institutional sector. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and lignite) are ±5.0%. Estimated uncertainties of CO_2 emission factors for biomass are ±15%. Uncertainties of all country specific CO_2 emission factors were revised in the study "Update of country specific GHG emission factors for 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 *2006 IPCC Guidelines.*

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 Category-specific QA/QC and verifications

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

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

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

3.5.1.5 Category-specific recalculations

Following recalculations in this category has been done:

- revision of CO_2 emission factor for natural gas (see Table 3-11), wood/wood waste and other solid biomass based on study on "Update of country specific GHG emission factors for Energy sector" (performed in April 2016 by Lithuanian Energy Institute).

Impact of these recalculations on GHG emissions from 1.A.4.a Commercial / institutional sector presented in Table 3-75.

Table 3-75. Impact of recalculation on GHG emissions from 1.A.4.a Commercial / institutional sector

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	2,855.2	2,854.1	-1.15	-0.04
1991	3,227.0	3,225.8	-1.20	-0.04
1992	1,308.1	1,307.6	-0.54	-0.04
1993	1,043.6	1,043.4	-0.19	-0.02

1994	1,084.8	1,084.6	-0.27	-0.02
1995	937.7	937.4	-0.30	-0.03
1996	806.0	805.8	-0.16	-0.02
1997	574.3	574.1	-0.18	-0.03
1998	508.4	508.3	-0.10	-0.02
1999	453.5	453.3	-0.16	-0.04
2000	298.5	298.4	-0.12	-0.04
2001	253.4	253.3	-0.13	-0.05
2002	291.9	291.7	-0.15	-0.05
2003	303.0	302.8	-0.15	-0.05
2004	316.7	316.4	-0.30	-0.10
2005	339.8	339.5	-0.30	-0.09
2006	417.5	417.3	-0.25	-0.06
2007	398.3	398.0	-0.36	-0.09
2008	340.9	340.5	-0.34	-0.10
2009	359.3	359.1	-0.18	-0.05
2010	374.7	374.4	-0.31	-0.08
2011	397.9	397.6	-0.28	-0.07
2012	334.5	334.3	-0.19	-0.06
2013	364.1	364.1	-0.05	-0.01
2014	329.6	329.6	0.02	0.01

3.5.1.6 Category-specific planned improvements

Category-specific improvements are not planned.

3.5.2 Residential sector (CRF 1.A.4.b.i)

3.5.2.1 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 2015 – 67.5 m^2. With reference to data of 2015, 63% 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 - 9 kWh/m^2/month. Dwelling of this type of multifamily house consumes 540 kWh/60 m^2 of energy per month. This corresponds to 54 kgoe of fuel combusted for energy production per month. There are 113 thousand dwellings and 0.323 million people live in the dwellings.
- Multifamily houses of old construction after full renovation - 15 kWh/m^2/month. Dwelling of this type of multifamily house consumes 900 kWh/60 m^2 of energy per month. This corresponds to 90 kgoe of fuel combusted for energy production per month. There are 46 thousand dwellings and 0.13 million people live in the dwellings.

- Multifamily houses of old construction and still not renovated - 21 kWh/m^2/month. Dwelling of this type of multifamily house consumes 1260 kWh/60 m^2 of energy per month. This corresponds to 126 kgoe of fuel combusted for energy production per month. There are 420 thousand dwellings and 1.2 million people live in the dwellings.
- Multifamily houses of old construction and with poor thermal isolation - 35 kWh/m^2/month. Dwelling of this type of multifamily house consumes 2,100 kWh/60 m^2 of energy per month. This corresponds to 210 kgoe of fuel combusted for energy production per month. There are 121 thousand dwellings and 0.34 million people live in the dwellings.

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 3-62) 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 3-76.

Table 3-76. 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 78.40*	CS	T2	10.0	D	T1	0.6	D	T1
LPG	65.42 66.34*	CS	T2	5.0	D	T1	0.1	D	T1
Gasoil	72.89 72.73*	CS	T2	10.0	D	T1	0.6	D	T1
Coking coal	94.90 95.10*	CS	T2	300.0	D	T1	1.5	D	T1
Anthracite	106.55	CS	T2	300.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00 96.10*	CS	T2	300.0	D	T1	1.5	D	T1
Lignite	101.20 101.0*	CS	T2	300.0	D	T1	1.5	D	T1
Natural gas	Table 3-11	CS	T2	5.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	300.0	D	T1	1.4	D	T1
Wood/ wood waste	101.34	CS	T2	260.0	CS*	T2	4.0	D	T1

Other solid biomass	103.69	CS	T2	260.0	CS*	T2	4.0	D	T1

Abbreviations:
CS - country specific emission factors;
CS* - country specific emission factors are based on internationally referenced sources and EFs from neighboring countries appropriate to Lithuania's national circumstances. These EFs were estimated following recommendation provided by ERT in 2013 (Report of the individual review of the annual submission of Lithuania submitted in 2013, paragraph 31);
* - CS emission factors applied from 2015 based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute. Summary of the study is presented in Annex IV;
D – default emission factors (*2006 IPCC Guidelines*); 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 consumed and total GHG emissions in Residential sector are presented in Figure 3-49.

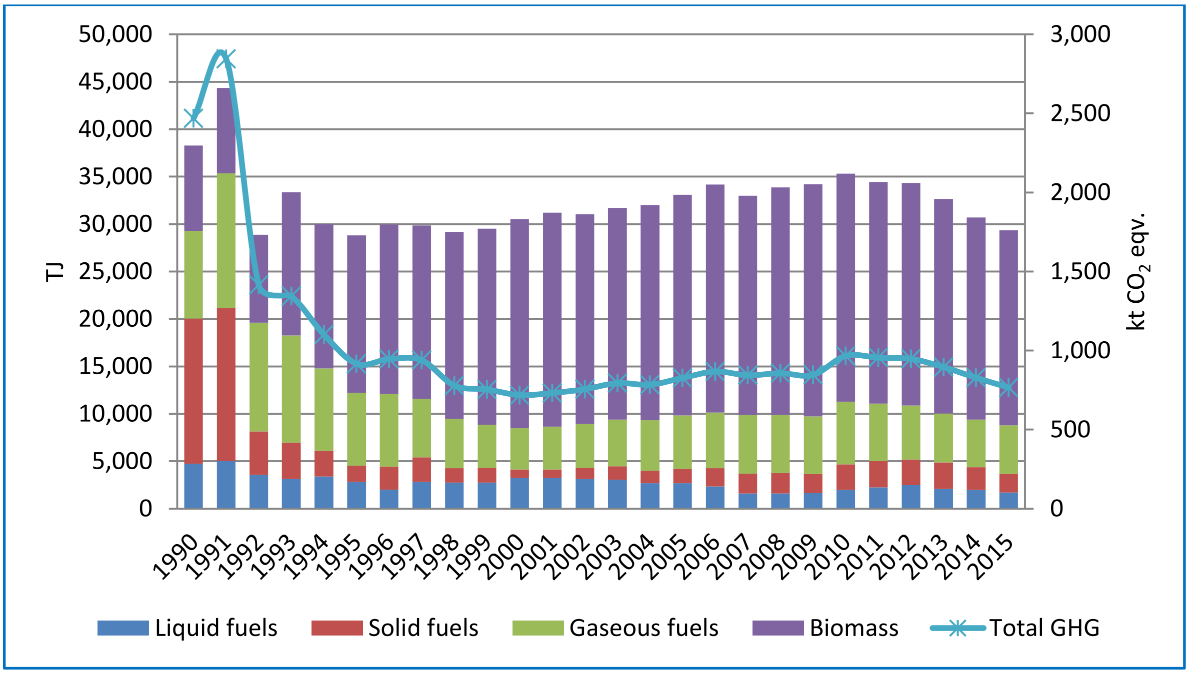


Figure 3-49. Tendencies of fuel consumption and total GHG emissions in Residential sector (1.A.4.b)

As it is seen from Figure 3-49, biomass dominates in the structure of fuel consumed in Residential sector. In 2015 there was consumed 29.34 PJ of fuel in Residential sector. This was by 4.4% less than in 2014. Biomass accounted 70.0%, natural gas – 17.5%, solid fuels – 6.7%, liquid fuels – 5.8% of fuel structure in 2015.

In 2015, total GHG emissions from Residential sector were 3.2 times lower than in 1990 and amounted 765.7 kt CO_2 eqv.

3.5.2.3 Uncertainties and time-series consistency

Uncertainty in activity data in Residential sector is ±3.0% taking into consideration recommendations provided by *2006 IPCC Guidelines*. 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 Guidelines*.

Uncertainties of CO_2 emission factors for liquid fuels (residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.0% in Residential sector. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and lignite) are ±5.0%. Estimated uncertainties of CO_2 emission factors for biomass are ±15%. Uncertainties of all country specific CO_2 emission factors were revised in the study "Update of country specific GHG emission factors for 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 *2006 IPCC Guidelines.*

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 Category-specific QA/QC and verifications

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

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

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

3.5.2.5 Category-specific recalculations

Following recalculations in this category has been done:

- revision of CO_2 emission factor for natural gas (see Table 3-11), wood/wood waste and other solid biomass based on study on "Update of country specific GHG emission factors for Energy sector" (performed in April 2016 by Lithuanian Energy Institute).

Impact of these recalculations on GHG emissions from 1.A.4.b Residential sector presented in Table 3-77.

Table 3-77. Impact of recalculation on GHG emissions from 1.A.4.b Residential sector

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	2,469.2	2,468.4	-0.83	-0.03
1991	2,846.4	2,845.1	-1.28	-0.04
1992	1,415.3	1,414.3	-1.03	-0.07
1993	1,344.2	1,343.2	-1.02	-0.08
1994	1,101.2	1,100.4	-0.78	-0.07
1995	916.9	916.2	-0.69	-0.08
1996	947.0	946.3	-0.69	-0.07
1997	939.1	938.5	-0.56	-0.06

1998	778.9	778.4	-0.47	-0.06
1999	754.4	754.0	-0.41	-0.05
2000	718.3	718.0	-0.39	-0.05
2001	731.8	731.4	-0.41	-0.06
2002	756.0	755.6	-0.41	-0.05
2003	794.3	793.8	-0.44	-0.06
2004	784.7	784.0	-0.74	-0.09
2005	827.7	826.9	-0.79	-0.10
2006	868.0	867.3	-0.65	-0.07
2007	844.4	843.7	-0.74	-0.09
2008	857.3	856.6	-0.73	-0.09
2009	846.5	846.1	-0.43	-0.05
2010	966.9	966.2	-0.73	-0.08
2011	955.6	955.0	-0.67	-0.07
2012	947.5	947.1	-0.40	-0.04
2013	895.4	895.3	-0.10	-0.01
2014	827.5	827.5	0.05	0.01

3.5.2.6 Category-specific planned improvements

Category-specific improvements are not planned.

3.5.3 Agriculture/forestry/fisheries sector (CRF 1.A.4.c.i)

3.5.3.1 Category description

Agricultural, forestry and fisheries sector has developed at very moderate rates in Lithuania during 1995-2009. Value added created has been increasing by 0.2% 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 6.8% in 2011. With reference to data of 2013-2015, this sector created 3.4% of total GDP.

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 3-64) based on equation 1 (see chapter 3.2.6).

Emission factors and methods

Emission factors and methods used in the calculation of emissions from Agriculture/forestry/fishing sector – Stationary (1.A.4.c.i) are presented in Table 3-78.

Table 3-78. Emission factors and methods for category Agriculture/forestry/fishing sector – Stationary (1.A.4.c.i)

Fuel	CO_2			CH_4			N_2O		
	CO_2, kg/GJ	**EF**	**Method**	**CH_4, kg/TJ**	**EF**	**Method**	**N_2O, kg/TJ**	**EF**	**Method**
Shale oil	77.40 76.60*	CS	T2	10.0	D	T1	0.6	D	T1
Residual fuel oil	77.60 78.40*	CS	T2	10.0	D	T1	0.6	D	T1
LPG	65.42 66.34*	CS	T2	5.0	D	T1	0.1	D	T1
Gasoil	72.89 72.73*	CS	T2	10.0	D	T1	0.6	D	T1
Coking coal	94.90 95.10*	CS	T2	300.0	D	T1	1.5	D	T1
Anthracite	106.55	CS	T2	300.0	D	T1	1.5	D	T1
Sub-bituminous coal	96.00 96.10*	CS	T2	300.0	D	T1	1.5	D	T1
Natural gas	Table 3-11	CS	T2	5.0	D	T1	0.1	D	T1
Peat	104.34	CS	T2	300.0	D	T1	1.4	D	T1
Wood/ wood waste	101.34	CS	T2	250.0	CS*	T2	4.0	D	T1
Other solid biomass	103.69	CS	T2	250.0	CS*	T2	4.0	D	T1
Biogas	58.45	CS	T2	5.0	D	T1	0.1	D	T1

Abbreviations:
CS - country specific emission factors;
CS* - country specific emission factors are based on internationally referenced sources and Efs from neighboring countries appropriate to Lithuania's national circumstances. These Efs were estimated following recommendation provided by ERT in 2013 (Report of the individual review of the annual submission of Lithuania submitted in 2013, paragraph 31);
* - CS emission factors applied from 2015 based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute. Summary of the study is presented in Annex IV;
D - default emission factors (*2006 IPCC* Guidelines); T1 - *Tier 1*; T2 - *Tier 2*.

Activity data

For calculation of GHG emissions in category Agriculture/forestry/fishing sector - Stationary (1.A.4.c.i) activity data had been obtained from the Lithuanian Statistics database (http://www.stat.gov.lt/lt/). Activity data are provided in the Annex III.

Tendencies of fuel consumed and total GHG emissions in Agriculture/forestry/fishing sector - Stationary are presented in Figure 3-50.

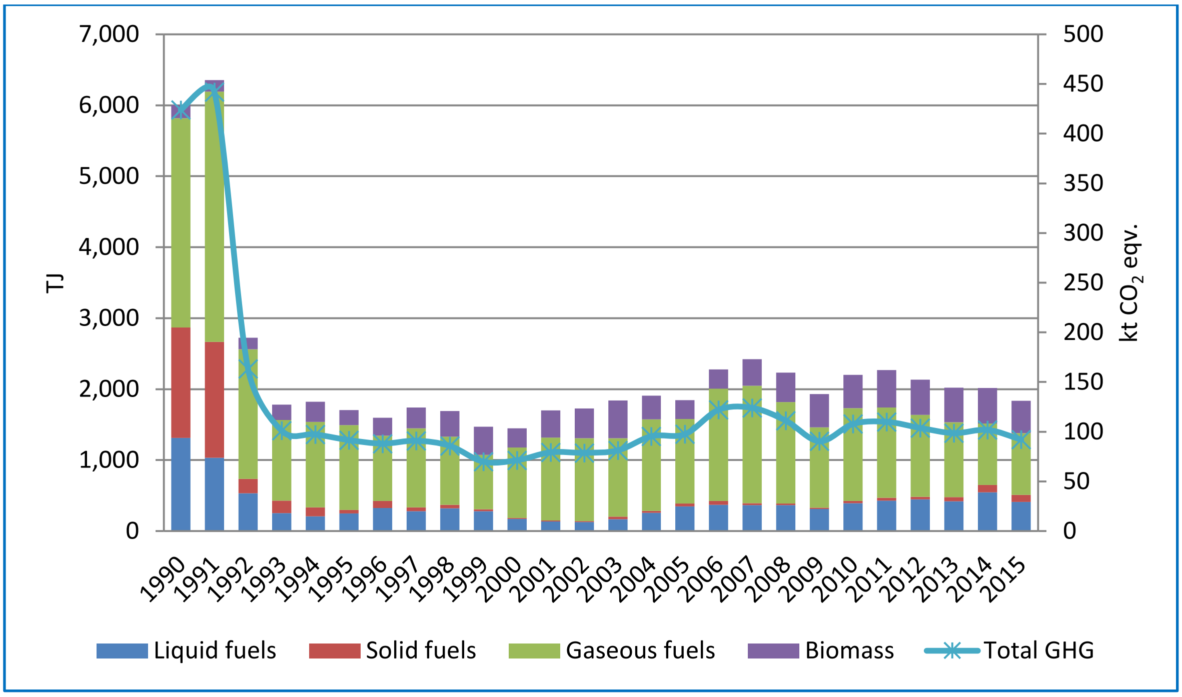


Figure 3-50. Tendencies of fuel consumed and total GHG emissions in Agriculture/forestry/fishing sector - Stationary (1.A.4.c.i)

Figure 3-50 showed that during the rapid economy development period (2000-2007) fuel consumption had a tendency to increase by 4.2% a year. During the time of global economic crisis (2008-2009) fuel consumption in Agriculture/forestry/fishing sector (1.A.4.c.i) reduced by 11.7%. In 2015 fuel consumption decreased by 8.8% in comparison to 2014. In 2015, natural gas made the largest share in the structure of fuel – 47.4%. The share of biomass was 24.8%, liquid fuel – 22.4% and solid fuel – 5.4%.

In 2015, total GHG emissions from Agriculture/forestry/fishing sector (1.A.4.c.i) were almost 5 times lower than in 1990 and amounted 92.1 kt CO_2 eqv.

3.5.3.3 Uncertainties and time-series consistency

Uncertainty in activity data in Agriculture/forestry/fishing sector is ±3.0% taking into consideration recommendations provided by *2006 IPCC 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 Guidelines*.

Uncertainties of CO_2 emission factors for liquid fuels (residual fuel oil, LPG, and gasoil) and gaseous fuels (natural gas) are ±2.0% in Residential sector. Uncertainties of CO_2 emission factors for solid fuels (peat, coking coal and lignite) are ±5.0%. Estimated uncertainties of CO_2 emission factors for biomass are ±15%. Uncertainties of all country specific CO_2 emission factors were revised in the study "Update of country specific GHG emission factors for 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 *2006 IPCC Guidelines.*

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 Category-specific QA/QC and verifications

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

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

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

3.5.3.5 Category-specific recalculations

Following recalculations in this category has been done:

- revision of CO_2 emission factor for natural gas (see Table 3-11), wood/wood waste and other solid biomass based on study on "Update of country specific GHG emission factors for Energy sector" (performed in April 2016 by Lithuanian Energy Institute).

Impact of these recalculations on GHG emissions from 1.A.4.c Agriculture/forestry/fishing sector presented in Table 3-79.

Table 3-79. Impact of recalculation on GHG emissions from 1.A.4.c Agriculture/forestry/fishing sector

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	424.4	424.1	-0.27	-0.06
1991	442.3	442.0	-0.32	-0.07
1992	163.6	163.4	-0.16	-0.10
1993	101.2	101.1	-0.10	-0.10
1994	97.5	97.4	-0.11	-0.11
1995	91.7	91.6	-0.11	-0.12
1996	88.2	88.1	-0.08	-0.09
1997	91.0	90.9	-0.10	-0.11
1998	85.9	85.8	-0.09	-0.10
1999	69.9	69.9	-0.07	-0.10
2000	71.4	71.3	-0.09	-0.13
2001	79.4	79.3	-0.11	-0.13
2002	78.9	78.8	-0.11	-0.14
2003	81.3	81.2	-0.10	-0.12
2004	95.7	95.5	-0.18	-0.19
2005	97.7	97.6	-0.17	-0.17
2006	122.3	122.1	-0.17	-0.14
2007	124.2	124.0	-0.20	-0.16
2008	111.3	111.1	-0.17	-0.15
2009	90.5	90.4	-0.08	-0.09
2010	108.0	107.8	-0.14	-0.13

2011	110.1	109.9	-0.14	-0.13
2012	103.9	103.8	-0.08	-0.08
2013	98.6	98.6	-0.02	-0.02
2014	101.8	101.8	0.01	0.01

3.5.3.6 Category-specific planned improvements

Category-specific improvements are not planned.

3.5.4 Off-road vehicles and other machinery (CRF 1.A.4.a.ii, 1.A.4.b.ii, 1.A.4.c.ii)

3.5.4.1 Category description

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*). New allocation by sectors was applied. Off-road activity data and emissions was allocated by sectors: 1.A.2.g Transport Equipment; 1.A.4 Other Sectors (1.A.4.a.ii Commercial/Institutional, 1.A.4.b.ii Residential, 1.A.4.c Agriculture/Forestry; 1.A.4.cii Off-road Vehicles and Other Machinery, 1.A.4.ciii Fishing).

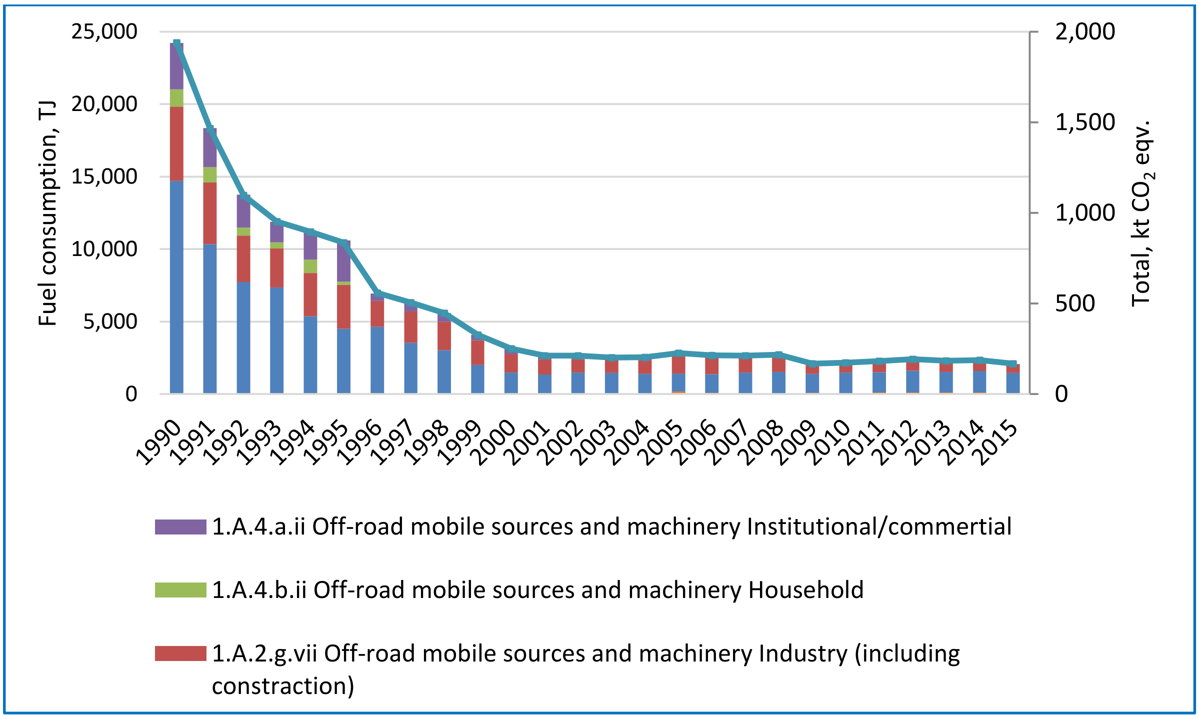


Figure 3-51. Trend of GHG emissions and fuel consumption in Off-road sector

3.5.4.2 Methodological issues

2006 IPCC Guidelines Tier 2 (for CO_2) and *Tier 1* (for CH_4 and N_2O) sectoral approach was used to calculate GHG emissions from the 1.A.4 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 3-80 and 3-81.

Table 3-80. CO_2 emission factors for Off-road vehicles and other machinery sector used in the Lithuanian national GHG inventory

Fuel	**CO_2**		
	CO_2, kg/GJ	**EF**	**Method**
Motor gasoline	72.97 72.77*	CS	T2
Diesel oil	72.89 72.73*	CS	T2

*applied from 2015 based on the results of 2016 study "Update of country specific GHG emission factors for energy sector" (Summary of the study is presented in Annex IV).

Table 3-81. CH_4 and N_2O Emission factors for Off-road vehicles and other machinery sector used in the Lithuanian national GHG inventory

Fuel/Sector	**CH_4, kg/TJ**				**N_2O, kg/TJ**			
	Motor gasoline	Diesel oil	EF	**Method**	Motor gasoline	Diesel oil	EF	**Method**
Agriculture	80	4.15	D	T1	2	28.60	D	T1
Industry (including construction) and commercial maintenance	50	4.15	D	T1	2	28.60	D	T1
Household	120	4.15	D	T1	2	28.60	D	T1
Fishing	-	7	D	T1	-	2	D	T1

3.5.4.3 Uncertainties and time-series consistency

GHG emissions from off-road sources are typically much smaller than those from road transportation, but activities in this category are diverse and are thus typically associated with higher uncertainties because of the additional uncertainty in activity data. Uncertainty in activity data is determined by the accuracy of the surveys 10%. The uncertainty estimate is likely to be dominated by the activity data. The uncertainty on CO_2 emission factor (±2%) based on the results of 2016 study "Update of country specific GHG emission factors for energy sector",N_2O (±150%) and CH_4 (±150%) emission factors from off-road transport is given in *2006 IPCC Guidelines*. The time series for all data have been studied carefully in search for outliers.

3.5.4.4 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.

3.5.4.5 Source-specific recalculation

Emission factors was revised and applied depending on sectors. Impact of these recalculations on GHG emissions from *Off-road transport* is presented in Table 3-82.

Table 3-82. Impact of recalculation on GHG emissions from Off-road transport

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	1,869.38	1,940.76	71,38	3.82
1991	1,401.68	1,466.79	65,11	4.64
1992	1,070.42	1,096.76	26,34	2.46
1993	929.24	952.61	23,37	2.51
1994	835.66	895.52	59,86	7.16
1995	842.90	835.91	-6,99	-0.83
1996	562.20	558.32	-3,88	-0.69
1997	510.59	505.76	-4,83	-0.95
1998	451.54	447.01	-4,53	-1.00
1999	330.44	327.44	-3,00	-0.91
2000	254.07	251.19	-2,87	-1.13
2001	213.79	212.07	-1,72	-0.81
2002	213.31	211.65	-1,66	-0.78
2003	202.23	201.58	-0,65	-0.32
2004	205.44	203.95	-1,50	-0.73
2005	227.81	226.15	-1,66	-0.73
2006	214.94	213.93	-1,01	-0.47
2007	213.99	213.33	-0,66	-0.31
2008	219.40	218.19	-1,21	-0.55
2009	168.40	167.92	-0,48	-0.28
2010	174.59	174.23	-0,36	-0.21
2011	183.71	183.01	-0,71	-0.38
2012	193.25	192.68	-0,56	-0.29
2013	184.10	183.56	-0,54	-0.29
2014	187.77	187.34	-0,44	-0.23

3.5.4.6 Source-specific planned improvements

It is planned to investigate possibility to apply Tier 2 method for this subcategory for the next submission.

3.6 Other sectors (CRF 1.A.5)

3.6.1 Military aviation (CRF 1.A.5.b)

3.6.1.1 Category description

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

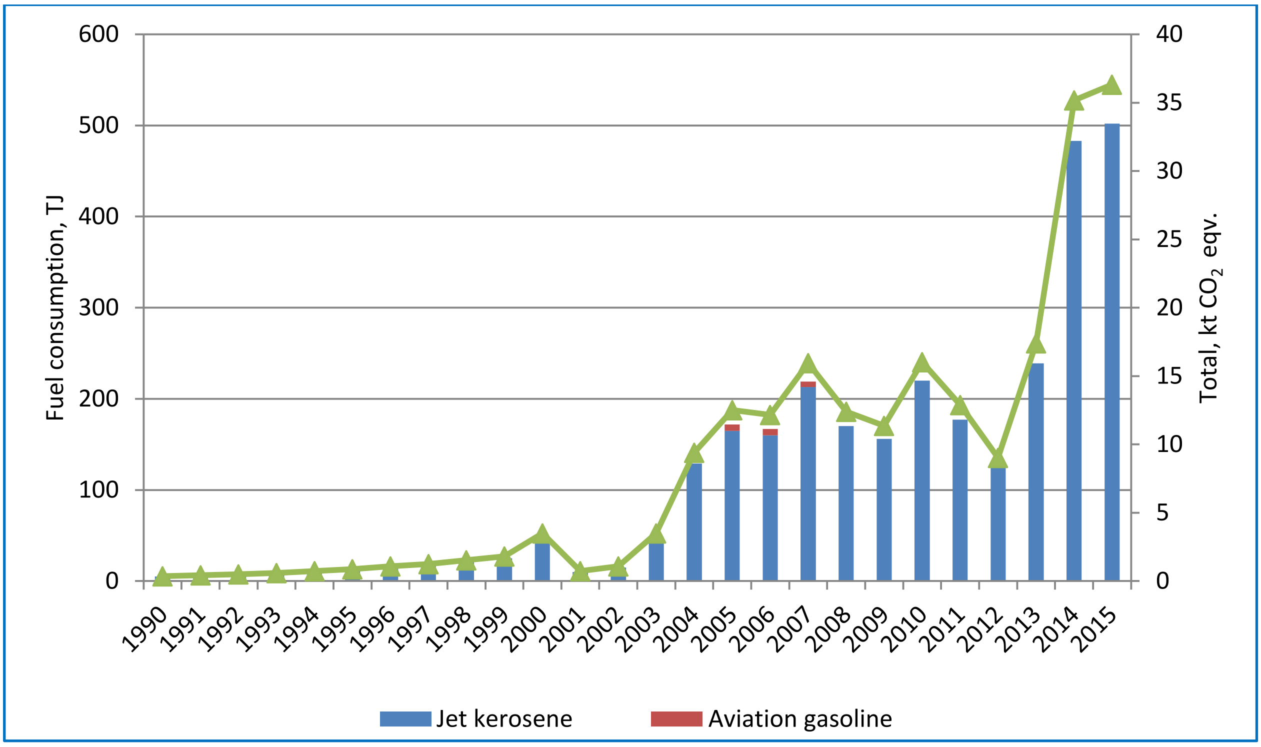


Figure 3-52. Trend of GHG emissions in Military aviation sector

3.6.1.2 Methodological issues

The *2006 IPCC Guidelines Tier 2* (for CO_2) and *Tier 1* (for CH_4 and N_2O) approach has been applied. Emission factors for aviation sources used in the Lithuanian national GHG inventory are provided in Table 3-48. Country specific CO_2 EF was developed based on the results of 2016 study "Determination of national GHG emission factors for energy sector". 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 up to 2001. Data on jet kerosene for 1990-2000 were extrapolated.

Emission factors

Emission factors used in the calculation of emissions from *Military aviation* transportation are presented in Table 3-48 (chapter 3.4.1).

3.6.1.3 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 (*2006 IPCC Guidelines*). 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 *2006 IPCC Guidelines* 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.

3.6.1.4 Category-specific QA/QC and verification

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

3.6.1.5 Category-specific recalculation

Activity data and EF for CO_2 was revised. Impact of these recalculations on GHG emissions from 1.A.5.b is presented in Table 3-83.

Table 3-83. Impact of recalculation on GHG emissions from 1.A.5.b

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eqv.	Relative difference, %
2005	12.02	12.52	0.50	4.00
2006	11.66	12.16	0.50	4.12
2007	15.52	15.95	0.43	2.69

3.6.1.6 Category-specific planned improvements

Category-specific improvements are not planned.

3.7 Fugitive emissions (CRF 1.B)

3.7.1 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.

3.7.2 Fugitive emissions from oil (CRF 1.B.2.a)

3.7.2.1 Category description

Fugitive emissions from oil activities include all emissions from the exploration, production, processing, transport, and use of oil and from non-productive combustion. Fugitive emissions consist of emissions of methane, carbon dioxide and nitrous oxide.

3.7.2.2 Methodological issues

GHG emissions were calculated applying a *Tier 1*. The application of a *Tier 1* is done using equation presented below:

$$E_{oil,\,ga\sin dustry\ segment} = A_{industry\ segment} \cdot EF_{industry\ segmentl}$$

where:

$E_{oil,\,ga\sin dustry\ segment}$ - annual emissions, kt;

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

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

Emission factors

Emissions from oil were calculated by using emission factors provided in the *2006 IPCC Guidelines* Volume 2 (table 4.2.5) and are presented in Table 3-84.

Table 3-84. Emission factors for fugitive emissions from oil (1.B.2.a)

Category	Subcategory	Emission type	Emission factors			Units of measure
			CH_4	CO_2	N_2O	
Wells	Drilling	All	3.3E-05	1.0E-04	0	Gg per 10^3 m^3 total oil production
	Testing	All	5.1E-05	9.0E-03	6,8E-08	Gg per 10^3 m^3 total oil production
	Servicing	All	1.1E-04	1.9E-06	0	Gg per 10^3 m^3 total oil production
Oil production	Conventional oil	Fugitives	1.5E-06	1.1E-07	0	Gg per 10^3 m^3 conventional oil production
		Venting	7.2E-04	9.5E-05	0	Gg per 10^3 m^3 conventional oil production
		Flaring	2.5E-05	4.1E-02	6.4E-07	Gg per 10^3 m^3 conventional oil production
Oil transport	Pipelines	All	5.4E-06	4.9E-07	0	Gg per 10^3 m^3 oil transported by pipeline
Crude oil refining	All	All	2.6E-06	0	0	Gg per 10^3 m^3 oil refined

Activity data

Activity data for fugitive emissions from oil have been obtained from database of the Lithuanian Statistics[16]: oil production and refining data (see Annex III), transportation of crude oil in pipelines (see http://www.stat.gov.lt).

3.7.3 Fugitive emissions from natural gas (CRF 1.B.2.b)

3.7.3.1 Category description

Fugitive emissions from natural gas activities include all emissions from transportation and distribution, and from non-productive combustion. Fugitive emissions consist mainly of emissions of methane and carbon dioxide.

3.7.3.2 Methodological issues

Fugitive emissions from natural gas calculated applying a *Tier 2* considering activity data on natural gas leakages obtained from JSC "Lietuvos dujos" and Amber Grid AB. The company ESO was established in January 2016 by merging JSC "Lietuvos dujos" and LESTO AB. Currently ESO is the operator of Lithuania's natural gas distribution and electricity distribution systems therefore activity data on natural gas leakages in distribution system for 2015 were obtained from ESO. Amber Grid AB is the operator of Lithuania's natural gas transmission system.

The application of a *Tier 2* is done using equation presented below:

$$E_{oil,\,ga\sin dustry\,segment} = A_{industry\,segment} \cdot EF_{industry\,segmentl}$$

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

where:

$E_{oil,ga\sin dustry\ segment}$ - annual emissions, kt;

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

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

Emissions from natural gas transmission and distribution were calculated taking into consideration amount of natural gas leakages in transmission and distribution networks and chemical composition of natural gas provided by ESO and Amber Grid AB.

Tier 2 for fugitive emissions from natural gas started to be applied since Submission 2016 as JSC "Lietuvos Dujos" provided data on natural gas leakages in transmission and distribution networks for the time period 2005-2014. The data on natural gas leakages for the time period 1990-2004 was based on expert judgement. For the time period 1990-2004 data on natural gas leakages were estimated taking into consideration relation between the total natural gas consumption and leakages in transmission and distribution networks for 2005-2014. Performed analysis showed that leakages accounted about 0.4% in transmission system and about 2% in distribution system from total natural gas consumption in 2005-2014 period. Experts from JSC "Lietuvos dujos" approved that this share can be applied for leakages estimates in 1993-2004 period but recommended to adjust activity data for 1990-1992 applying regression analysis. Estimated values on natural gas leakages in transmission and distribution networks for 1990-2004 period were coordinated and agreed with experts from JSC "Lietuvos dujos".

Data are calculated into TJ using country specific natural gas NCV provided in Table 3-12 and into tonnes using natural gas density (Table 3-67). The natural gas leakages are presented in Table 3-85 and chemical parameters of natural gas in Table 3-86.

Table 3-85. Amount of natural gas leakages

Year	Distribution network, thous.t	Transmission network, thous.t
1990	8.649	2.011
1995	7.444	1.619
2000	6.205	1.153
2005	7.551	2.763
2006	8.110	1.682
2007	8.721	0.464
2008	8.237	0.804
2009	7.686	0.806
2010	8.085	1.448
2011	5.232	2.163
2012	8.637	1.063
2013	7.481	2.207
2014	8.284	3.109
2015	8.414	3.712

Table 3-86. Chemical parameters of natural gas

Year	CH_4, %	CO_2, %	Natural gas density, kg/m3

1990-2003	97.769	0.05	0.683
2004	98.079	0.04	0.682
2005	98.050	0.04	0.682
2006	97.906	0.04	0.683
2007	97.963	0.05	0.682
2008	97.933	0.05	0.682
2009	97.639	0.05	0.685
2010	97.895	0.04	0.683
2011	97.873	0.04	0.683
2012	97.689	0.06	0.684
2013	97.349	0.07	0.687
2014	97.090	0.08	0.689
2015	95.448	0.07	0.702

CH_4 and CO_2 emissions are calculated directly from the amounts leaked therefore it was assumed that emissions from natural gas transmission and distribution cover all fugitive emissions from natural gas.

Emissions 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.

3.7.4 Uncertainties and time-series consistency

Uncertainty in activity data for fugitive emissions is ±5.0% taking into consideration recommendations provided by *2006 IPCC Guidelines*.

Uncertainty in CO_2, CH_4 and N_2O emission factors for fugitive emissions from oil and natural gas systems are provided in the Table 3-87.

Table 3-87. Uncertainties of emission factors for fugitive emissions from oil and natural gas systems

Category	**Subcategory**	**Emission type**	**Uncertainty of emission factors, %**		
			CH_4	**CO_2**	**N_2O**
Oil production	Conventional oil	Fugitives	±50	±50	NA
		Venting	±75	±75	NA
		Flaring	±75	±75	±75
Wells	Drilling	All	±50	±50	NA
	Testing	All	±50	±50	±50
	Servicing	All	±50	±50	NA
Oil transport	Pipelines	All	±50	±50	NA
Crude oil refining	All	All	±100	NA	NA
Gas transmission	All	All	±10	±10	NA
Gas distribution	All	All	±10	±10	NA

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

3.7.4.1 Category-specific QA/QC and verifications

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

3.7.4.2 Category-specific recalculations

Following recalculations in this category has been done:

- correction of emission factors for fugitive emissions from oil based on the *2006 IPCC Guidelines* instead of emission factors based on *2000 IPCC Good Practice Guidance* following recommendations provided by the review experts.

Impact of these recalculations on GHG emissions from 1.B.2 Fugitive emissions from oil and natural gas sector presented in Table 3-88.

Table 3-88. Impact of recalculation on GHG emissions from 1.B.2 Fugitive emissions from oil and natural gas sector

Year	Submission 2016, kt CO_2 eqv.	Submission 2017, kt CO_2 eqv.	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	272.4	264.9	-7.44	-2.81
1991	265.9	255.9	-10.04	-3.92
1992	251.2	244.9	-6.29	-2.57
1993	242.4	234.9	-7.54	-3.21
1994	241.5	233.9	-7.61	-3.25
1995	235.9	226.7	-9.12	-4.02
1996	216.1	205.1	-10.98	-5.35
1997	217.8	202.9	-14.99	-7.39
1998	211.5	192.1	-19.43	-10.11
1999	197.2	181.6	-15.59	-8.59
2000	210.3	189.9	-20.50	-10.80
2001	215.6	185.3	-30.25	-16.32
2002	226.5	198.3	-28.16	-14.20
2003	228.7	202.8	-25.83	-12.73
2004	244.9	222.3	-22.60	-10.17
2005	279.7	261.2	-18.42	-7.05
2006	262.2	246.5	-15.72	-6.38
2007	242.2	230.3	-11.85	-5.14
2008	240.1	226.4	-13.68	-6.04
2009	224.1	211.7	-12.40	-5.86
2010	251.0	238.2	-12.78	-5.37
2011	198.6	185.8	-12.79	-6.88
2012	253.4	241.6	-11.80	-4.88
2013	251.3	240.1	-11.16	-4.65
2014	290.6	280.6	-10.01	-3.57

3.7.4.3 Category-specific planned improvements

Category-specific improvements are not planned.

3.8 Comparison of the verified CO_2 emission in GHG Registry and NIR

The Lithuanian GHG emission 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 2014 the Fund provided information on verified CO_2 emissions for 90 fuel combustion installations[17] (see Annex VI). 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 and etc.).

For the purpose of comparison of verified emissions of the GHG 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 3-89.

Table 3-89. Comparison of the verified CO_2 emissions and NIR (sectoral approach), 2015

	Verified CO_2 emissions, Gg	**Calculated CO_2 emissions, Gg**	**Absolute difference, Gg**	**Relative difference, %**
1.A.1.A Electricity and Heat Production	2,075.73	1,649.03	-426.7	-25.9
1.A.1.B Petroleum Refining	1,257.42	1,366.64	109.2	8.0
1.A.1.C Other energy industries	68.71	84.50	15.8	18.7
1.A.2.C Chemicals	158.72	306.86	148.1	48.3
1.A.2.D Pulp, Paper and Print	9.90	21.72	11.8	54.4
1.A.2.E Food Processing, Beverages and Tobacco	36.50	239.01	202.5	84.7
1.A.2.F Non-Metallic Minerals	415.74	439.83	24.1	5.5
1.A.2.J Wood and Wood Products	17.88	7.80	-10.1	-129.3
Total	**4,040.60**	**4,115.39**	**74.8**	**1.8**

Total CO_2 emissions calculated in NIR sectoral approach are by 1.8% higher as compared to verified fuel combustion emissions in the GHG Registry in 2015. The differences mainly occur due to accuracy of emission factors and due to different coverage and thresholds in EU ETS.

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

4 INDUSTRIAL PROCESSES AND PRODUCT USE (CRF 2)

4.1 Overview of 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 90% of the total industrial production (excluding construction) in 2015 (Figure 4-1).

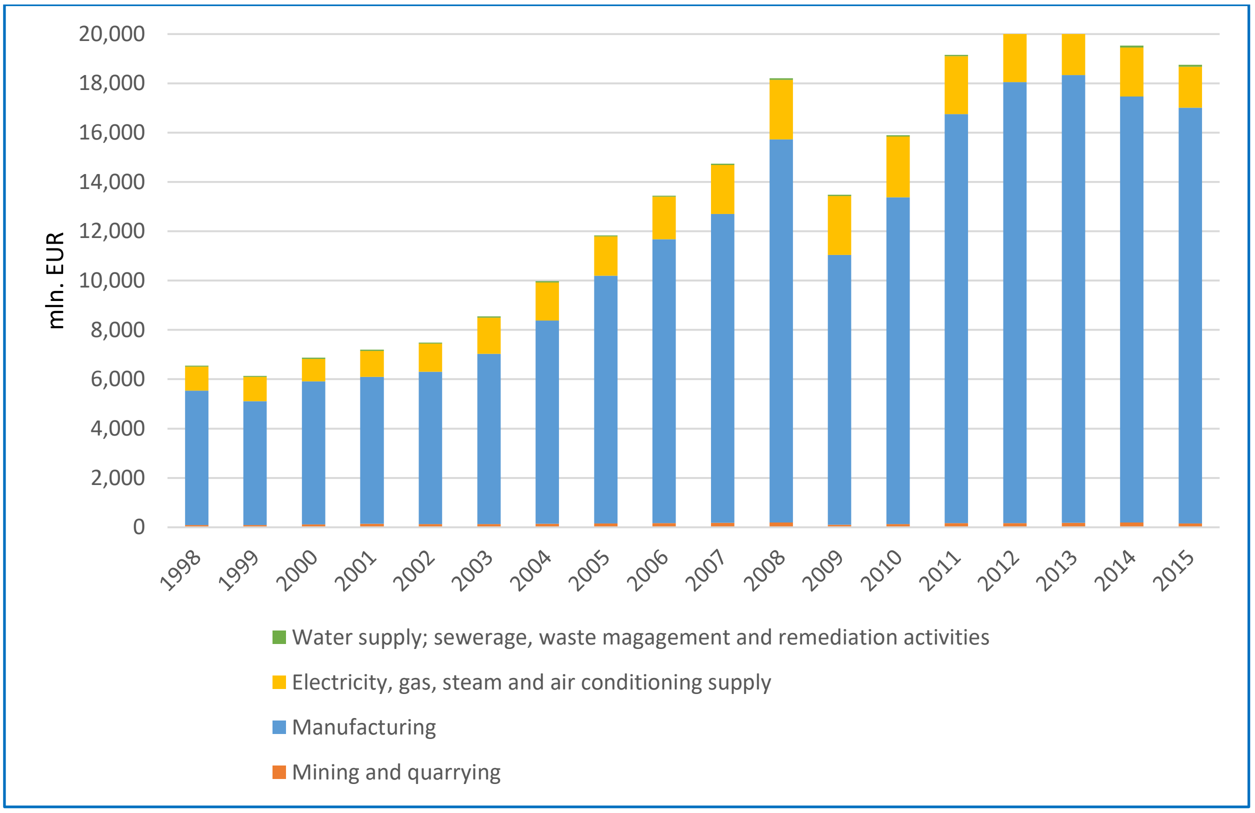


Figure 4-1. Industrial production at constant prices (except construction)

Four most important sectors within manufacturing cumulatively produced 66% of production:

- manufacture of refined petroleum products (21%);
- manufacture of food products and beverages (20%);
- manufacture of wood products and furniture (14%);
- manufacture of chemicals and chemical products (11%).

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

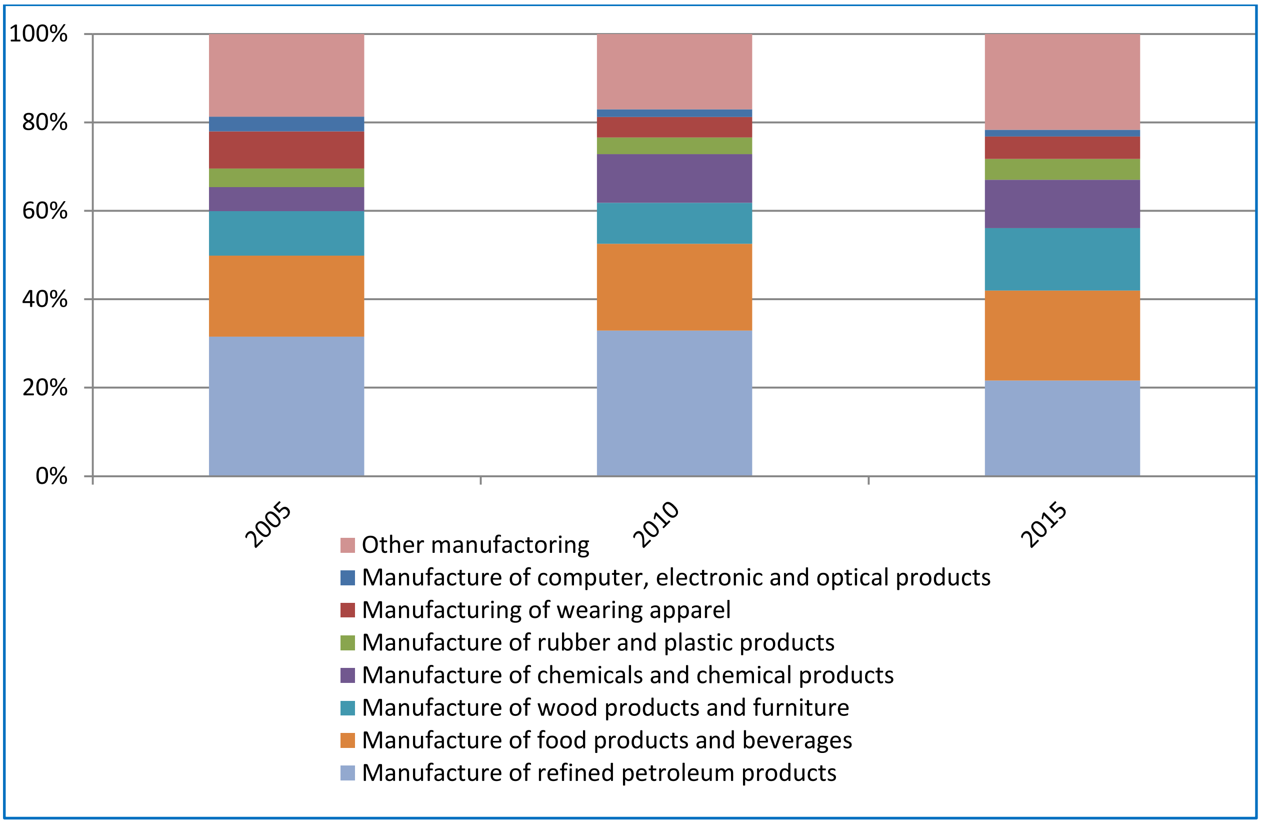


Figure 4-2. Share of the main sectors in production of manufacturing products in Lithuania

Greenhouse gas emissions from industrial processes contributed 16.9% to the total anthropogenic greenhouse gas emissions in Lithuania in 2015, totaling 3,397 kt CO_2 eqv. (Figure 4-3).

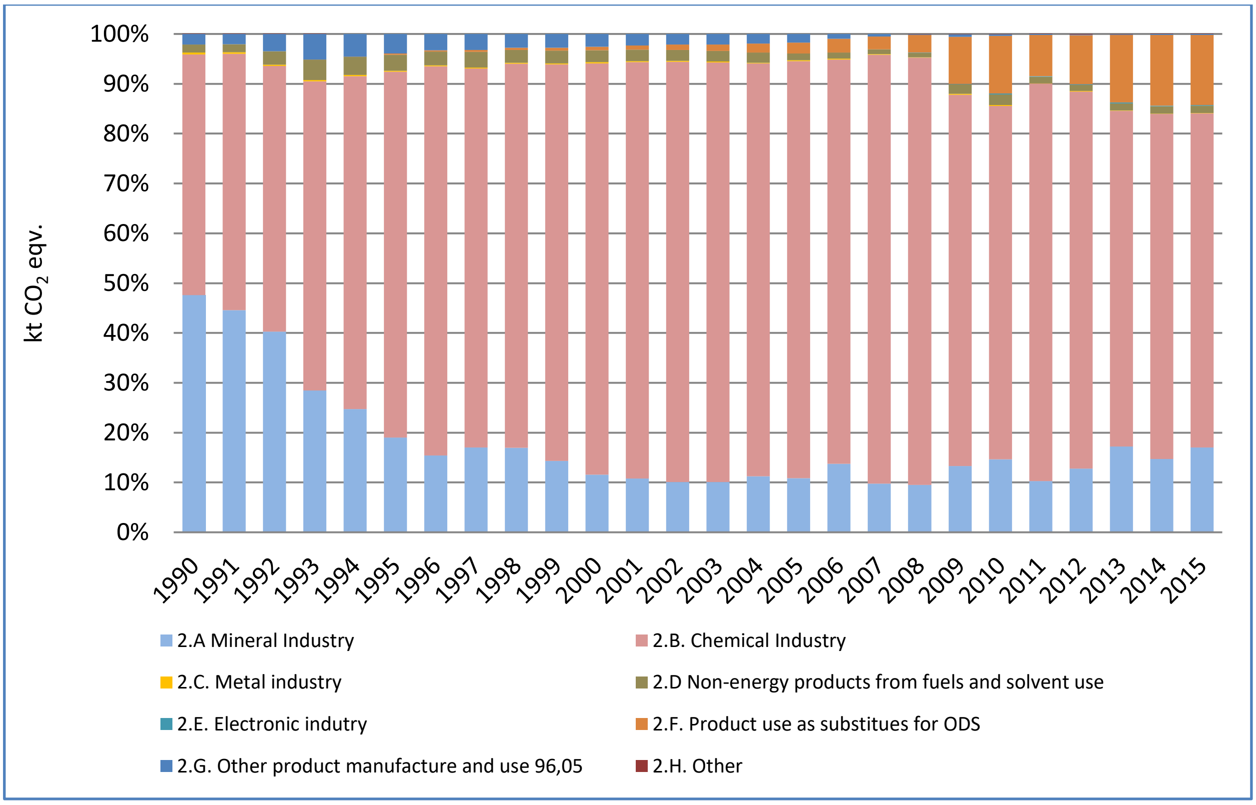


Figure 4-3. GHG emissions from industrial processes in 1990-2015

Lithuanian GHG emissions from industrial processes consist from the following emission categories:

- Mineral Industry (CRF 2.A) include CO_2 emissions from:
  - cement production (CRF 2.A.1);
  - lime production (CRF 2.A.2);
  - glass production (CRF 2.A.3);
  - ceramics (CRF 2.A.4.a);
  - other uses of soda ash (CRF 2.A.4.b);
  - mineral wool production (CRF 2.A.4.d).
- Chemical industry (CRF 2.B) include:
  - CO_2 emissions from ammonia production (CRF 2.B.1) and methanol production (CRF 2.B.8.a);
  - N_2O emissions from nitric acid production (CRF 2.B.2);
  - CH_4 emissions from methanol production (CRF 2.B.8.a).
- Metal industry (CRF 2.C) include CO_2 emissions from the cast iron production (CRF 2.C.1).
- Non-energy products from fuels and solvent use (CRF 2.D) include CO_2 emissions from:
  - lubricant use (CRF 2.D.1);
  - paraffin wax use (CRF 2.D.2);
  - solvent use (CRF 2.D.3);
  - asphalt production and use (CRF 2.D.3);
  - urea-based catalyst (CRF 2.D.3).
- Electronics industry (CRF 2.E) include NH_3 and SF_6 emissions from:
  - semiconductor (2.E.1);
  - photovoltaics (2.E.3).
- Product uses as substitutes for ozone depleting substances (CRF 2.F) include F-gases emissions from:
  - refrigeration and air conditioning (2.F.1);
  - foam blowing agents (2.F.2);
  - fire protection (2.F.3);
  - metered dose inhalers (2.F.4.a).
- Other product manufacture and use (CRF 2.G) include emissions from:
  - SF_6 emissions from electrical equipment (2.G.1);
  - SF_6 emissions from accelerators (2.G.2.b);
  - N_2O emissions from medical applications (CRF 2.G.3.a)
  - N_2O emissions from propellant for pressure and aerosol products (CRF 2.G.3.b).
- Other (CRF 2.H) include:
  - SO_2, NOx, NMVOC and CO_2 emissions from pulp and paper industry (CRF 2.H.1);
  - CO_2 emissions from consumption of carbonates in flue gas desulphurisation (CRF 2.H.3).

Several emission sources in the industrial processes sector are key categories. The key categories in 2015 by level and trend are listed in Table 4-1.

Table 4-1. Key category from industrial processes and product use in 2015

IPCC Category	*Greenhouse gas*	*Identification criteria*
2.A.1 Cement Production	CO_2	L1,T1
2.A.2 Lime Production	CO_2	T1

2.A.4 Other process use of carbonates	CO_2	T1
2.B.1 Ammonia Production	CO_2	L1,T1
2.B.2 Nitric Acid Production	N_2O	L1,T1
2.F.1 Refrigeration and Air Conditioning Equipment	HFCs	L1,T1, T2

4.2 Mineral Industry (CRF 2.A)

This category includes emissions from cement production, lime production, glass production, ceramics (bricks and tiles), other uses of soda ash and mineral wool production (Table 4-2). Cement production is a key source category in Lithuanian GHG inventory.

Table 4-2. Reported emissions under the subcategory mineral products

CRF	Source	Emissions reported
2.A.1	Cement production	CO_2
2.A.2	Lime production	CO_2
2.A.3	Glass production	CO_2
2.A.4.a	Ceramics	CO_2
2.A.4.b	Other uses of soda ash	CO_2
2.A.4.d	Mineral wool production	CO_2

Emissions of the category mineral industry were 47.6% of the emissions of the industrial processes sector in 1990 and 17.0% in 2015. Amount of emissions were 2,142.0 kt CO_2 eqv. in 1990 and 578 kt CO_2 eqv. in 2015 (Figure 4-4, 4-5).

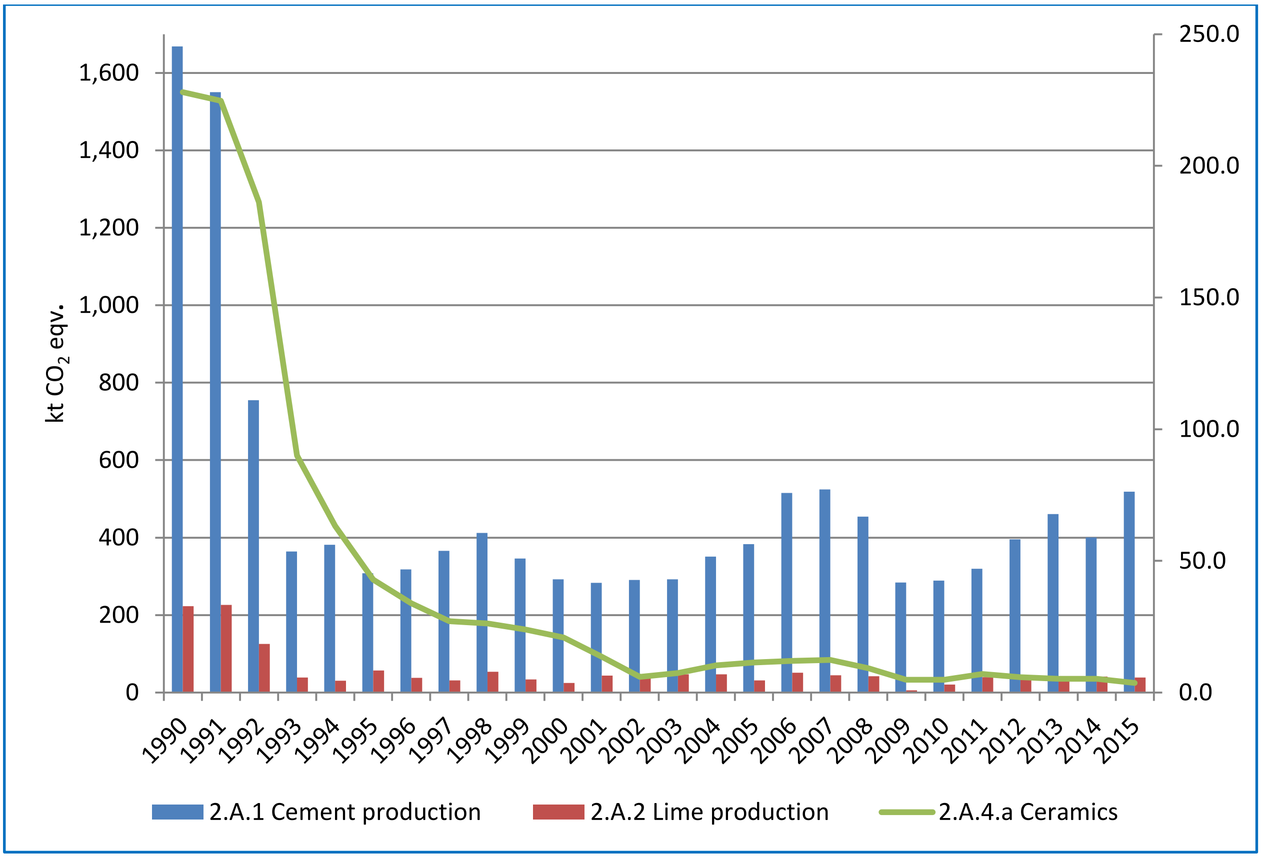


Figure 4-4. Greenhouse gas emission from mineral industry in 1990-2015: cement production, lime production and ceramics

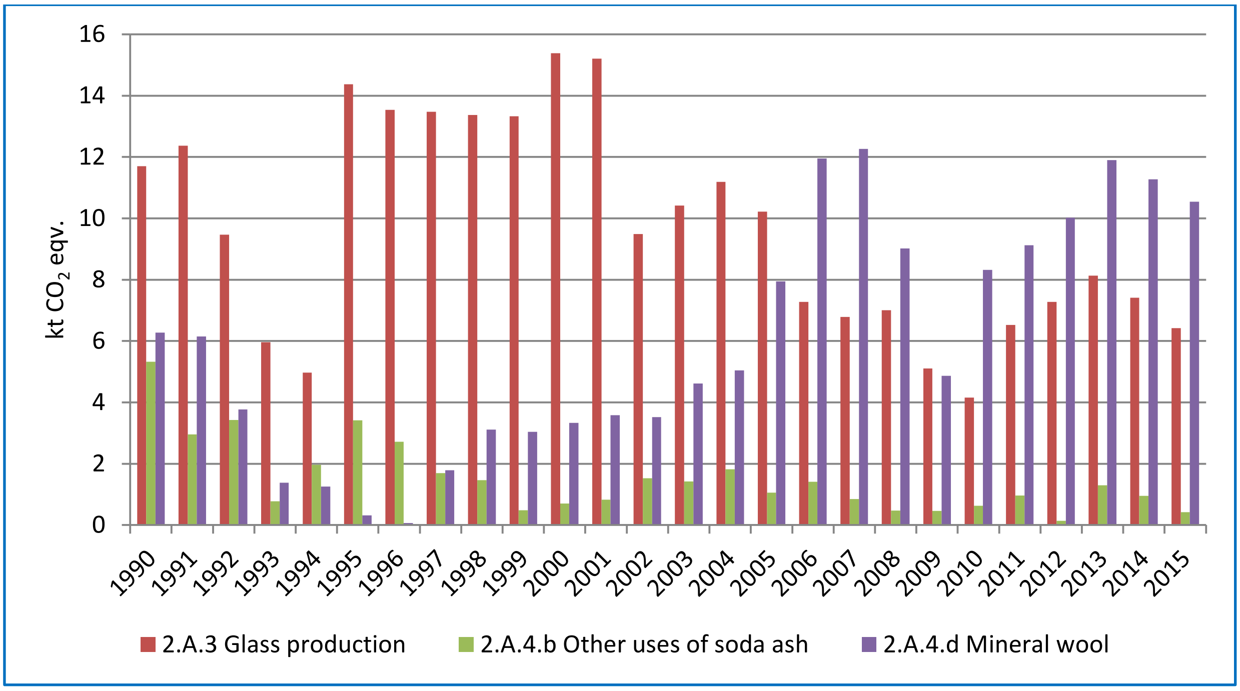


Figure 4-5. Greenhouse gas emission from mineral industry in 1990-2015: glass production, soda ash use and mineral wool production

Cement production is the biggest source of greenhouse gas emissions in the mineral industry category, being 518.3 kt in 2015 (89.6%). Emissions from cement production were 36.8% in 1990 and 15.3 % in 2015 of the emissions in the industrial processes sector. There was a rapid decrease in the production volume in 1990-1993 after gaining independence from Soviet Union. The output has had a slight growing trend in 2003-2007 fuelled by the boost in construction industry. Emissions from other mineral processes are a minor source in the category mineral products.

4.2.1 Cement Production (CRF 2.A.1)

4.2.1.1 Category Description

Category covers CO_2 emissions from cement production. Emissions of CO_2 occur during the production of clinker that is an intermediate component in the cement manufacturing process. High temperatures in cement kilns chemically change calcium carbonate into lime and CO_2. During the production of clinker, limestone, which is mainly calcium carbonate ($CaCO_3$), is heated, or calcinated, to produce lime (CaO) and CO_2 as a by-product. Portland cement is produced in a single company, which is situated in the North Western part of Lithuania. The plant was constructed in Soviet times (1947-1974), cement produced in the factory was exported to other Republics of USSR, Hungary, Cuba and Yugoslavia. The company produces more than 1 million tonnes of portland cement per year. The data on clinker production and composition were provided by the plant. Activity data is collected on company level.

Since the opening of the plant cement has been produced using wet production technology. In 2006 the company has made a strong innovation step and decided to build new 4,500 t/d dry process clinker production line. The construction and installation of new dry clinker production line was completed at the end of 2013 and started operates dry clinker production line since 2014 of August (https://www.youtube.com/watch?v=kb-oKLyN3NY).

Clinker production has fallen sharply after the declaration of independence from more than 3 million tonnes annually in 1990 to about 500 to 600 kt in 2000 (Figure 4-6). Sharp decline in cement production in 1990-1993 is mainly due to loss of market in former USSR. Demand of the cement in the local market has also dropped due to structural changes in industry and economy.

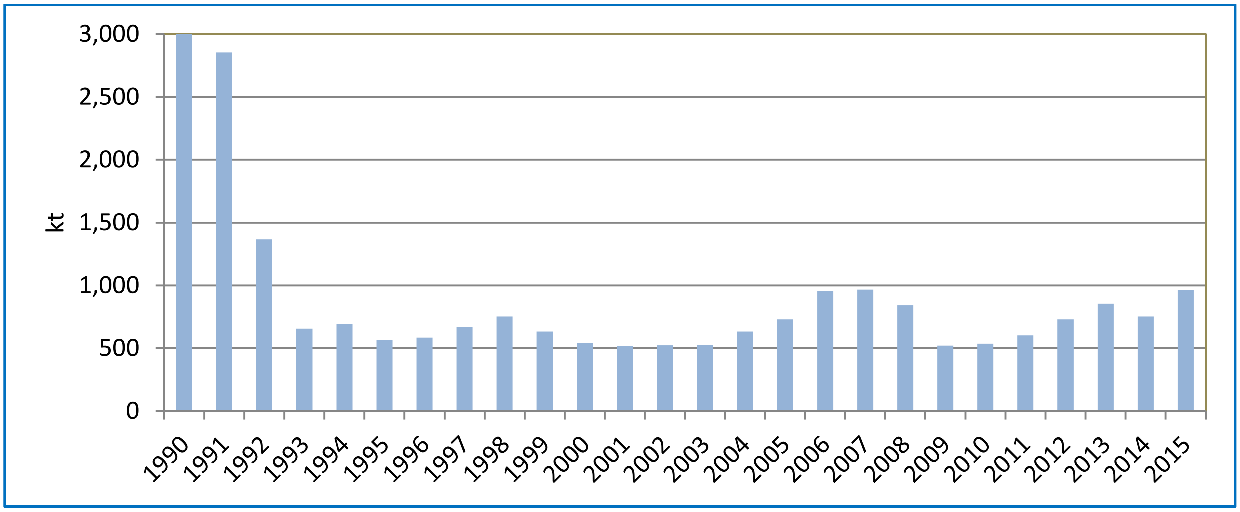


Figure 4-6. Clinker production in 1990-2015

4.2.1.2 Methodological issues

For the period 1990-2004 CO_2 emission was calculated using *Tier 2* method using specific production data provided by the production company. CO_2 emissions were calculated from material mass balance assuming that all carbon contained in raw materials (limestone) was released to the atmosphere as CO_2. Actual CO_2 emission was calculated from the data on clinker production and composition. In addition, it was assumed that CO_2 was released from calcinated fraction of kiln dust. According to the company, only about 5% of the CKD is calcinated.

CO_2 emission was calculated using the following equation:

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

$$+ CKD \times CF \times (C_{CaO} \times (MCO_2/M_{CaO}) + C_{MgO} \times (MCO_2/M_{MgO})),$$

where:
CP – clinker production, kt;
CKD – cement kiln dust generation, kt;
CF – calcinated fraction of the CKD, the time-series of the CKD correction factor is provided in Table 4-3;
C_{CaO} and C_{MgO} – CaO and MgO fractions in clinker;
MCO_2, M_{CaO}, M_{MgO} – molecular weights of CO_2, CaO and MgO.

For the period 2005-2015 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). In 2005 during the manufacture process removed dust was sold and shipped to the quarry, therefore the highest percent of CKD was recorded. The following years CKD value has declined due to increase of production of less alkaline clinker (the content of alkalis less than 0.85 % in the clinker). Since 2014 of August company operates dry clinker production line, where cement kiln dust returned to the kiln therefore, CKD does not occur in dry clinker production.

Estimated CO_2 emissions from cement production are shown in Table 4-3.

Table 4-3. Estimated CO_2 emissions (kt/year) from Cement production

Year	Emission	CKD fraction
1990	1,668.1	1.3 %
1995	308.0	1.3 %
2000	292.5	1.3 %
2005	383.3	2.3 %
2010	289.0	0.2 %
2011	319.8	0.3 %
2012	395.2	0.3 %
2013	460.8	0.4 %
2014	400.8	0.4 %
2015	518.3	NO

4.2.1.3 Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- Activity data uncertainty is assumed to be 2%. Data on clinker production provided by the single production company is considered reliable;
- Emission factor uncertainty is assumed to be 5%;
- Combined uncertainty is 5.4%.

CaO content in clinker fluctuated from 62.3% to 65.3% (from 1990 to 2013), the average value being 64.2%, standard deviation 0.8%.

Data on MgO content in clinker were available for the periods 2000 to 2009 and 2012 to 2013 (provided by the producer). MgO content fluctuated in the range from 3.33% to 4.13%, average value was 3.82%, standard deviation 0.26%. For GHG calculation for the period 1990 to 1999 average MgO content value was used.

Data on generation of cement kiln dust (CKD) (fraction not recycled to the kiln) were available for period 2005-2014. 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%)). It is noted that due to changes in the production method since 2015 CKD does not occur.

4.2.1.4 Category-specific QA/QC and verification

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

As the producer reports CO_2 emissions for EU ETS, it was decided to perform a quality control by comparing the two estimates (*2006 IPCC Tier 2* versus EU ETS). Comparison of CO_2 emissions (*Tier 2* versus EU ETS) for 2005-2009 is provided below:

Table 4-4. Comparison of CO_2 emissions from cement production 2005-2009 (Tier 2 versus EU ETS)

	2005	2006	2007	2008	2009

CO_2 emissions TIER 2, kt	383.4	516.4	523.8	454.1	283.7
CO_2 emissions EU ETS, kt	383.3	515.3	524.1	453.8	284.0
ETS share, %	99.97%	99.78%	100.04%	99.94%	100.11%

The difference between the *Tier 2* estimations based on plant-specific data (annual clinker and CKD data, CaO and MgO content in clinker) and EU ETS data was less than 1%. Therefore, it is concluded that the estimates for the period 1990-2004 and 2005-2015 are consistent.

4.2.1.5 Category-specific recalculations

No recalculations have been done.

4.2.1.6 Category-specific planned improvements

Category-specific improvements are not planned.

4.2.2 Lime Production (CRF 2.A.2)

4.2.2.1 Category Description

After restoration of independence lime production decreased from approximately 300 thous tonnes annually to 50 thous tonnes in 1993 and is fluctuating about this value. Exceptionally low production of lime – only 5.6 kilo tonnes was observed in 2009. (Figure 4-7). Data on lime production were provided by Statistics Lithuania[18] covering the whole reporting period.

Data on hydrated lime production are provided by Statistics Lithuania for the period 1999-2015. The fraction of hydrated lime fluctuated from 0% to 4%.

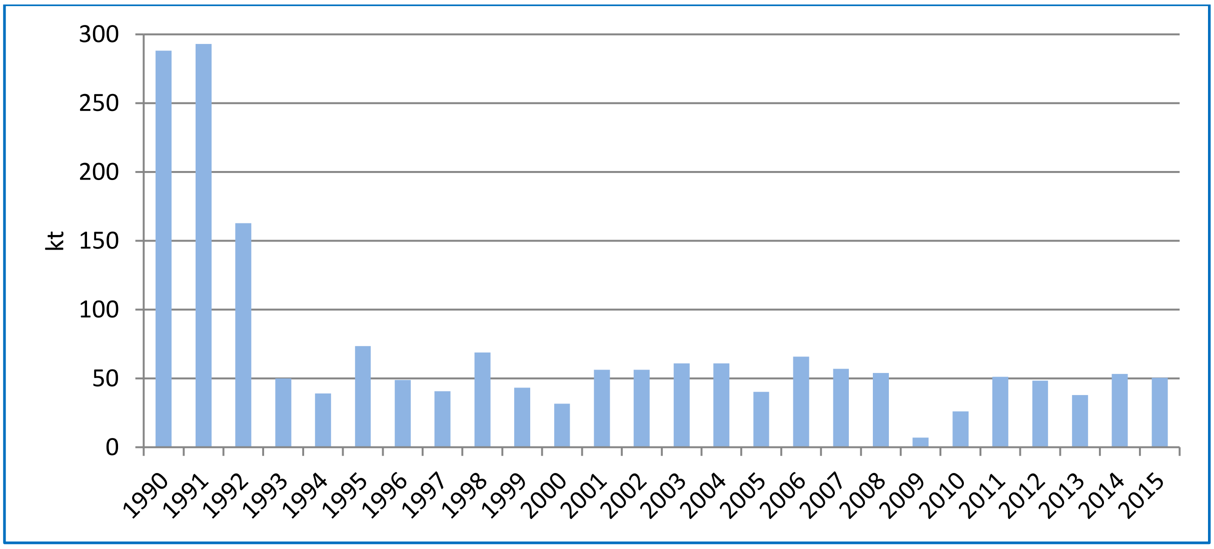


Figure 4-7. Lime production in 1990-2015 in Lithuania

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 1990-2015.

[18] Database of Statistics Lithuania

4.2.2.2 Methodological issues

CO_2 emission from lime production was calculated using production data provided by Statistics Lithuania and limestone composition data provided by the lime production company. According to the data provided by the lime production company, which is the main lime producer in Lithuania, limestone used for lime production contains 90% to 92% of $CaCO_3$ and 4% to 5% of $MgCO_3$. Based on these data it was assumed that products contain 91.1% of CaO, 3.9% of MgO and 5% of impurities. Actual hydrated lime production data were used for emission calculation in 1999-2015 and it was assumed that during 1990-1999 there was no hydrated lime production. In the base year (as no hydrated lime production occured) only the amount of produced quick lime was used for calculation of the emissions. In the recent years the amount of produced hydrated lime is taken into account and the correction factor for hydrated lime is used (the correction factor is taken from *2006 IPCC Guidelines* vol. 3, p. 2.24). The emission from hydrated lime is about 1% of all emission from lime production. CO_2 emissions were calculated by *Tier 2* method using following equation (*2006 IPCC Guidelines*, Volume 3, Part 1, p. 2.21):

$$\textit{Emission}=\sum(EF_{lime} \times M_l \times CF_{lkd} \times C_h)$$

where:
EF_{lime} – emission factors for quick and hydrated lime, tonnes CO_2/tonne lime (EFs calculated using eq. 2.9 from *2006 IPCC Guidelines*, Volume 3, Part 1, p. 2.23);
M_l – quick and hydrated lime production, tonnes;
CF_{lkd} – correction factor for LKD (default 1.02 (*2006 IPCC Guidelines*, Volume 3, Part 1, p. 2.24));
C_h – correction factor for hydrated lime (default 0.97 (*2006 IPCC Guidelines*, Volume 3, Part 1, p. 2.24));

Lime production in sugar industry

For determining activity data and emissions of CO_2 within the sugar industry, the amounts of limestone for the production of quicklime are used. The quantities were obtained directly from the sugar producing companies for the years 1990-2015.

According to the producers the used limestone consists to 97% of $CaCO_3$. In the production of sugar, lime is used for purification of the juice. Lime is added to the raw juice and some impurities are precipitated. In the carbonization step CO_2 is bubbled through the juice and most of the remaining lime is precipitated as $CaCO_3$. The precipitated "limestone" is sold and used within agricultural activities.

Lithuania calculated CO_2 emissions from lime production in sugar refining plants assuming that 86% of CaO is recovered as $CaCO_3$. This assumption is based on the data provided by the sugar producing companies:

$CaCO_3$ content of the limestone used in sugar refineries is on average 97%;

$CaCO_3$ content of the lime after the saturation/carbonation process is on average 83.9%.

Based on this data we assume that 14% of CaO is not recovered as $CaCO_3$. Only the part of CaO which is not recovered as $CaCO_3$ is reported as activity data.

In Table 4-5 the used amounts of limestone, the amounts of produced lime and emitted CO_2, the precipitated $CaCO_3$, and the reported activity data and CO_2 emissions from lime production within the sugar industry is presented.

Table 4-5. Lime production and estimated CO_2 emissions from sugar industry

Year	Used amount of limestone, kt	Amount of lime produced, kt	CO_2 from lime production, kt	Precipitated share of lime, %	Precipitated amount of lime, kt	Reported activity data (lime), kt	Reported CO_2 emissions, kt
1990	34.2	17.6	13.8	86%	15.1	2.5	1.9
1995	24.2	12.4	9.7	86%	10.7	1.7	1.4
2000	17.3	8.9	7.0	86%	7.7	1.2	1.0
2005	14.7	7.6	5.9	86%	6.5	1.1	0.8
2010	19.2	9.9	7.8	86%	8.5	1.4	1.1
2011	22.4	11.5	9.0	86%	9.9	1.6	1.3
2012	29.2	15.0	11.8	86%	12.9	2.1	1.6
2013	31.3	16.4	12.9	86%	14.1	2.3	1.8
2014	29.4	15.4	12.1	86%	13.3	2.2	1.7
2015	18.3	9.6	7.5	86%	8.2	1.3	1.1

Estimated CO_2 emissions from lime production are provided in Table 4-6 (total, including sugar industry).

Table 4-6. Estimated CO_2 emissions from lime production, kt/year

Year	Reported CO_2 emissions from lime production	Reported CO_2 emissions from sugar industry	Total CO_2 emissions
1990	220.7	1.9	222.7
1995	55.4	1.4	56.8
2000	23.5	1.0	24.4
2005	30.3	0.8	31.1
2010	19.0	1.1	20.1
2011	38.4	1.3	39.7
2012	35.7	1.6	37.4
2013	27.5	1.8	29.3
2014	39.5	1.7	41.2
2015	38.0	1.1	39.1

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 30%;
- Combined uncertainty is 30.9%.

CO_2 emission was calculated using production data provided by Statistics Lithuania and limestone composition data provided by lime production company. Quantities of the lime produced in sugar production were obtained from the sugar producing companies. Data is consistent over the time series.

4.2.2.4 Category-specific QA/QC and verification

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

4.2.2.5 Category-specific recalculations

No recalculations have been done.

4.2.2.6 Category-specific planned improvements

Category-specific improvements are not planned.

4.2.3 Glass Production (CRF 2.A.3)

4.2.3.1 Category Description

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

AB Panevėžio stiklas (former AB Klar Glass) produces both sheet glass and container glass. Its production has fallen down substantially in early nineties following the declaration of independence, but increased again later even exceeding pre-independence level. However, sheet glass production was stopped in 2002 causing again substantial reduction in production to approximately 40 thousand tonnes per year.

UAB Kauno stiklas is the oldest glass production plant in Lithuania and produces container glass. In the period 1990 to 2011, its production was comparatively stable averaging about 20 thousand tonnes annually. Due to modernization of container glass production line in 2012 (the company installed a new more powerful and more economical glass melting furnace and purchased equipment to produce thin-walled bottles) the production of glass increased by more than 60% in 2012.

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 1990-2015 is shown in Figure 4-8.

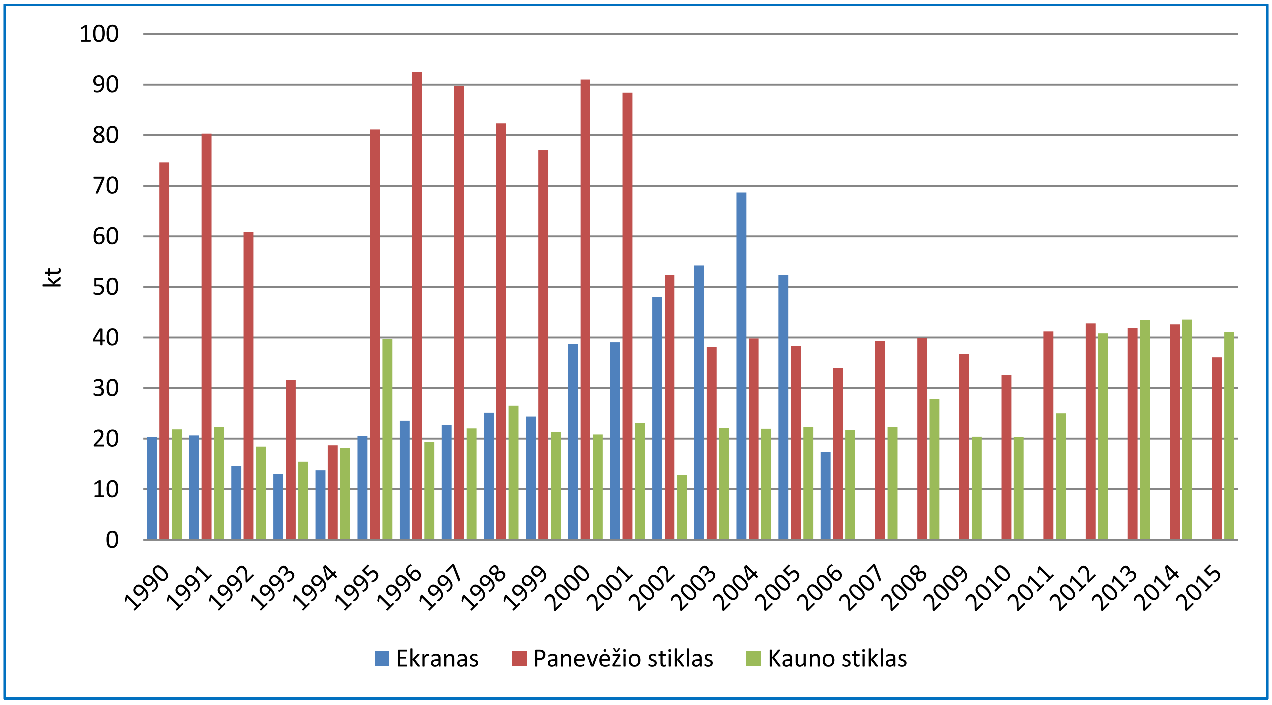


Figure 4-8. Glass production in 1990-2015

4.2.3.2 Methodological issues

CO_2 emissions were calculated using the following equation (*2006 IPCC*, Volume 3, Part 1, p. 2.28):

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

where:
CO_2 Emissions - emissions of CO_2 from glass production, tonnes;
EF_i - emissions factor for the particular carbonate i, tonnes CO_2/tonne carbonate
M_i - mass of the carbonate i consumed, tonnes;
F_i - fraction calcination achieved for the carbonate i, fraction. It was assumed that the fraction calcination is equal to 1.00 for all carbonate types;
EF_c - emissions factor for carbon oxydised in glass furnace, tonnes CO_2/tonne carbon;
M_c - mass of the carbon oxydised in glass furnace, tonnes.

Default emission factors for the particular carbonate (tonnes CO_2/tonne carbonate) were used, as provided in *2006 IPCC* (Volume 3, Part 1, table 2.1, page 2.7). According to EU ETS report of Kauno stiklas, small quantity of carbon is oxidised directly in glass furnace. The factory uses natural gas as a fuel.

CO_2 emissions were calculated for each production plant based on plant specific data on use of particular carbonates. Summary for each production plant is provided below.

AB Ekranas

The production plant produced cathode ray tubes, but got bankrupt in 2006. Production data (number of cathode ray tubes produced) is available for 1990-2006. EU ETS reports provide data on consumption of particular carbonates: Na_2CO_3, K_2CO_3, $BaCO_3$, $CaCO_3$, $SrCO_3$ and dolomite in 2005 and 2006. Average plant specific emission factor (t CO_2/t glass produced, excluding cullet) was calculated based on available 2005-2006 data. The emission factor was used for extrapolation of emissions in 1990-2004.

<u>*AB Panevėžio stiklas*</u>

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

- Glass production data is available for 1990-2015 (tonnes of glass produced).
- Data on cullet use is available for the period 1999-2015.
- Data on consumption of particular carbonates: dolomite ($MgCO_3$, $CaCO_3$), soda ash (Na_2CO_3) and chalk ($MgCO_3$, $CaCO_3$) are available for 1999-2009. In 1999-2002 company has also used small quantities of potash (K_2CO_3) 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 are available for the period 2005-2015.

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.

<u>*UAB Kauno stiklas*</u>

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

- Glass production data is available for 1990-2015 (tonnes of glass produced).
- Data on cullet use is available for the period 2004-2015.
- Data on consumption of particular carbonates: dolomite ($MgCO_3$, $CaCO_3$) and soda ash (Na_2CO_3) 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 are available for the period 2007-2015.

Plant specific emission factor (t CO_2/t glass produced, excluding cullet) was calculated based on available data outlined above. The emission factor was used for extrapolation of emissions in 1990-2003.

Estimated CO_2 emissions (excluding cullet) from glass production are provided in Table 4-7.

Table 4-7. Estimated CO_2 emissions from glass production 1990-2015

Year	CO_2 emission, kt
1990	11.7
1995	14.4
2000	15.4
2005	10.2
2010	4.2
2011	6.5
2012	7.3
2013	8.1
2014	7.4
2015	6.4

4.2.3.3 Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- CO_2 emissions in glass production were calculated from the data on use of raw materials containing carbonates. Data were obtained from the production companies, but only for the second half of the period under consideration (1999-2015). Detailed data on composition of raw materials were available only for the last 6 years. In addition, only very limited data were obtained from cathode ray tubes producer AB Ekranas which got bankrupt in 2006. In view of these considerations, it was assumed that activity data uncertainty for glass production is 7%.
- Emission factor uncertainty is assumed to be 5%;
- Combined uncertainty is 8.6%.

Activity data is not fully consistent over the time-series. Starting from 2005 data is fully consistent and reliable.

4.2.3.4 Category-specific QA/QC and verification

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

Source category-specific quality control procedures have been carried out in this submission. Emission data for years 2010-2015 have been verified with EU ETS data. The difference between the GHG inventory and the EU ETS data is less than 0.5%, as illustrated in the Table 4-8 below.

Table 4-8. Estimated CO_2 emissions (kt/year) from glass production. Comparison of GHG inventory and EU ETS data.

EU ETS, kt CO_2	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Kauno stiklas	1.26	2.45	3.43	3.98	3.09	2.79
Panevėžio stiklas	2.90	4.10	3.84	4.15	4.32	3.63
Glass production, total	4.16	6.55	7.27	8.13	7.41	6.42
CRF, kt CO_2						
Kauno stiklas	1.26	2.45	3.43	3.98	3.09	2.79
Panevėžio stiklas	2.90	4.08	3.84	4.15	4.32	3.63
Glass production, total	4.16	6.53	7.27	8.13	7.41	6.42
EU ETS/ CRF						
Kauno stiklas	100.13%	100.03%	99.99%	99.99%	99.99%	99.99%
Panevėžio stiklas	99.95%	100.48%	100.00%	100.00%	100.00%	100.00%
Glass production, total	100.00%	100.31%	100.00%	99.99%	100.00%	100.00%

4.2.3.5 Category-specific recalculations

No recalculations have been done.

4.2.3.6 Category-specific planned improvements

Category-specific improvements are not planned.

4.2.4 Other process uses of carbonates (CRF 2.A.4)

Category of other process uses of carbonates (CRF 2.A.4) are divided into four sub-categories: ceramics (CRF 2.A.4.a), other uses of soda ash (CRF 2.A.4.b), non-metallurgical magnesia production (CRF 2.A.4.c) and other (please specify) (CRF 2.A.4.d).

4.2.4.1 Category Description

Ceramics (CRF 2.A.4.a)

This category includes CO_2 emissions from bricks and tiles production. Data on ceramic bricks, tiles and vitrified clay pipes production were taken from Statistics Lithuania publications[19]. Production of bricks, tiles and clay pipes has fallen down dramatically from 1990. Tiles are not produced since 2004 and vitrified clay pipes are not produced since 2007.

Ceramic bricks production data from Statistics Lithuania publications for various periods are provided in different units. The data for 1990-2001 are provided in millions of bricks, while the data for the following years are in thousands cubic meters. Recalculation of data to mass units was made by applying average conversion factors based on information provided by the largest ceramic bricks and pipes producer in Lithuania[20]. It was assumed that average brick mass is 2.7 kg and average volume weight of bricks is 1.6 t/m^3.

Vitrified clay pipes production data from Statistics Lithuania publications are provided in thousands of kilometers for the period 1990-2001 and in tonnes for the remaining period. Production of vitrified clay pipes were converted to mass units using conversion factor 3.0 tonnes per km.

Ceramic tiles production data were provided in square meters from 1990 to 2001 and in tile units from 2002. These data were converted to weight units assuming that average tile area is 350×200 mm and average weight is 2.8 kg (information by ceramic bricks producer). Ceramics production in Lithuania in 1990-2015 is provided in Figure 4-9.

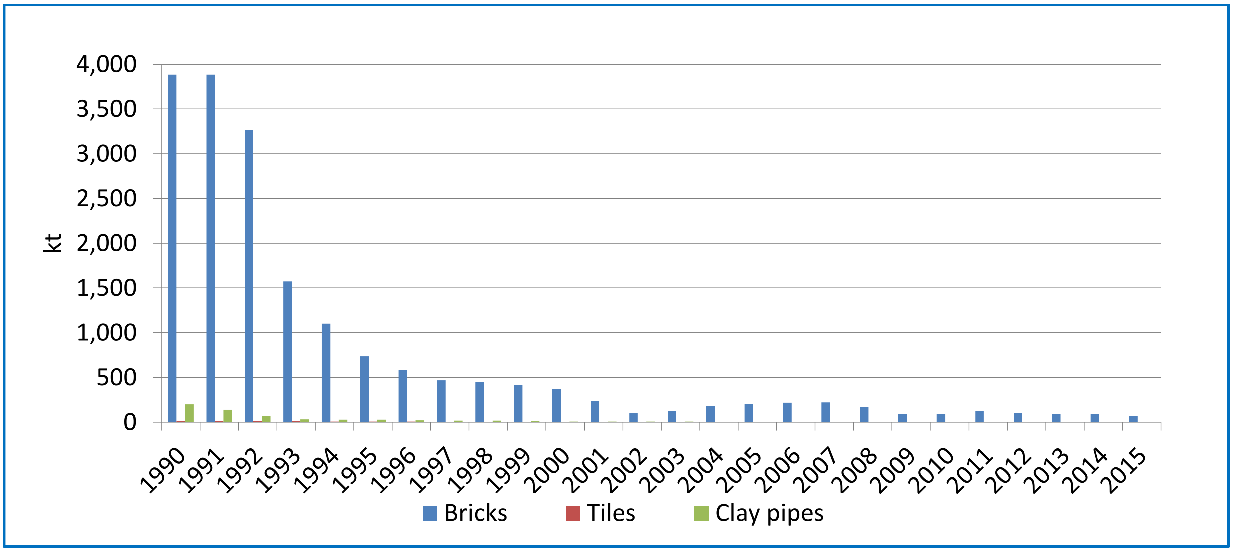


Figure 4-9. Production of ceramic products in 1990-2015

Other Uses of Soda Ash (CRF 2.A.4.b)

[19] Database of Statistics Lithuania
[20] http://www.palemonokeramika.lt/

CO_2 emissions from soda ash consumed in glass production is covered under CRF 2.A.3. This chapter covers other uses of soda ash. The data on overall use of soda ash were obtained from the publications of Statistics Lithuania[21]. In 2010 the Statistics Lithuania has stopped collection of statistical data on the overall use of soda ash. Therefore for the years 2010-2015 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. For the consistency reasons the analysis between data on total soda ash consumption, soda ash use in glass industry and foreign trade data has been conducted (Figure 4-10).

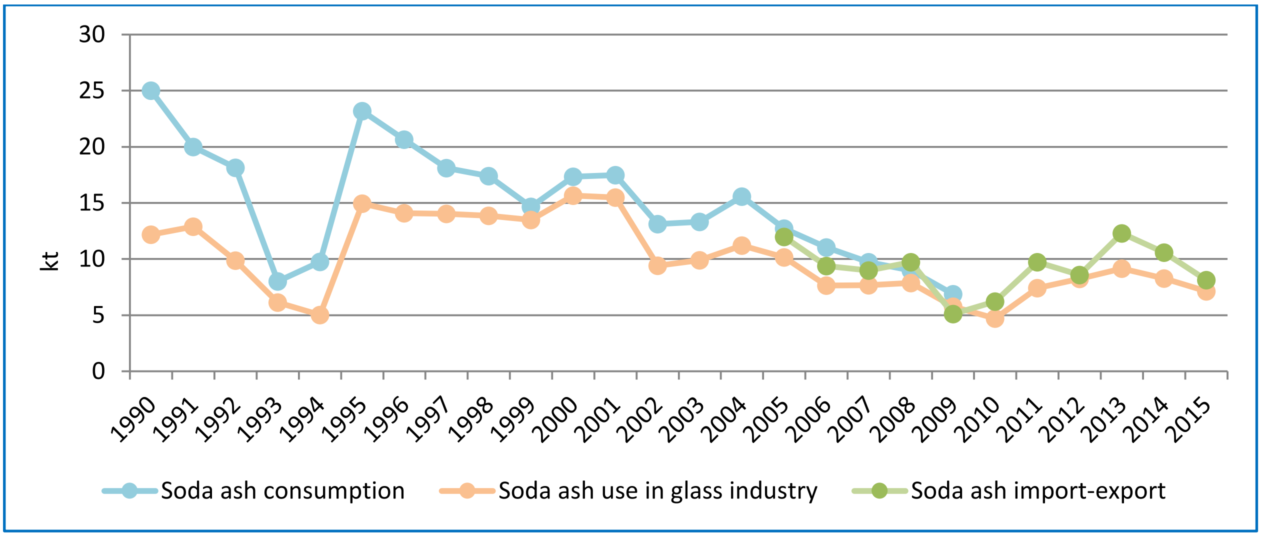


Figure 4-10. Consumption of soda ash 1990-2015

The foreign trade data is available from 2005 onwards. 2005-2009 foreign trade data overlaps with data on soda ash consumption, therefore correlation has been done for this time period. The analysis showed strong correlation (r=0,92) (Figure 4-11 a). The correlation between soda ash use in glass industry and foreign trade data has been done for period 2005-2015 and also showed strong correlation (r=0.91) (Figure 4-11 b), therefore it was concluded that import/export data is consistent for further emission calculation.

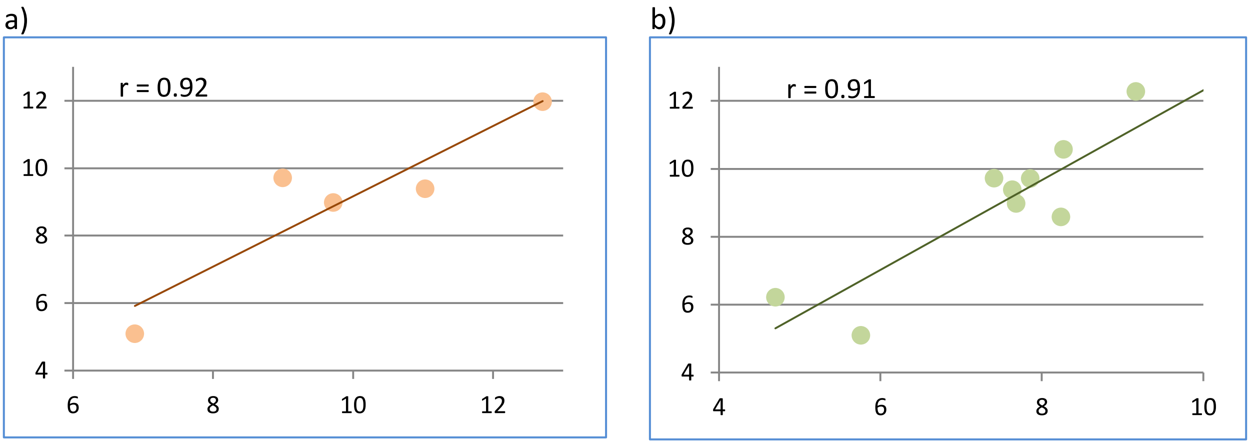


Figure 4-11. Correlation between foreign trade data and total soda ash consumption (a), soda ash us in glass industry (b)

Soda ash consumed in the glass production industry was subtracted from the overall use of soda ash.

[21] Statistic Lithuania publication "Raw Materials"

Soda ash consumption by the glass companies was calculated based on the data on consumption of carbonates by the production companies:

Panevėžio stiklas 1999-2015. 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 2004-2015. 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 4-12.

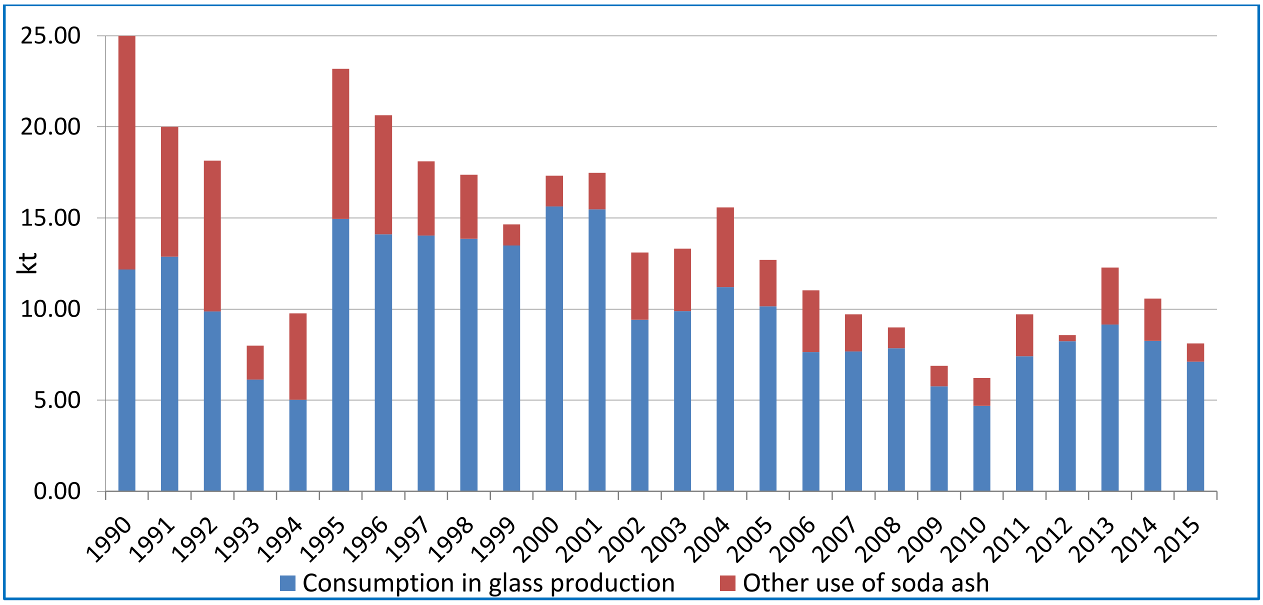


Figure 4-12. Evaluated use of soda ash in 1990-2015

Non Metallurgical Magnesia Production (CRF 2.A.4.c)

Emissions from non-metallurgical magnesia production are not occurring in Lithuania so for the category "CRF 2.A.4.c Non Metallurgical Magnesia Production" notation key "NO" is used.

Mineral wool (CRF 2.A.4.d)

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 1998-2015 were provided by the UAB Paroc company.

Mineral wool production during 1990-2015 is shown in Figure 4-13.

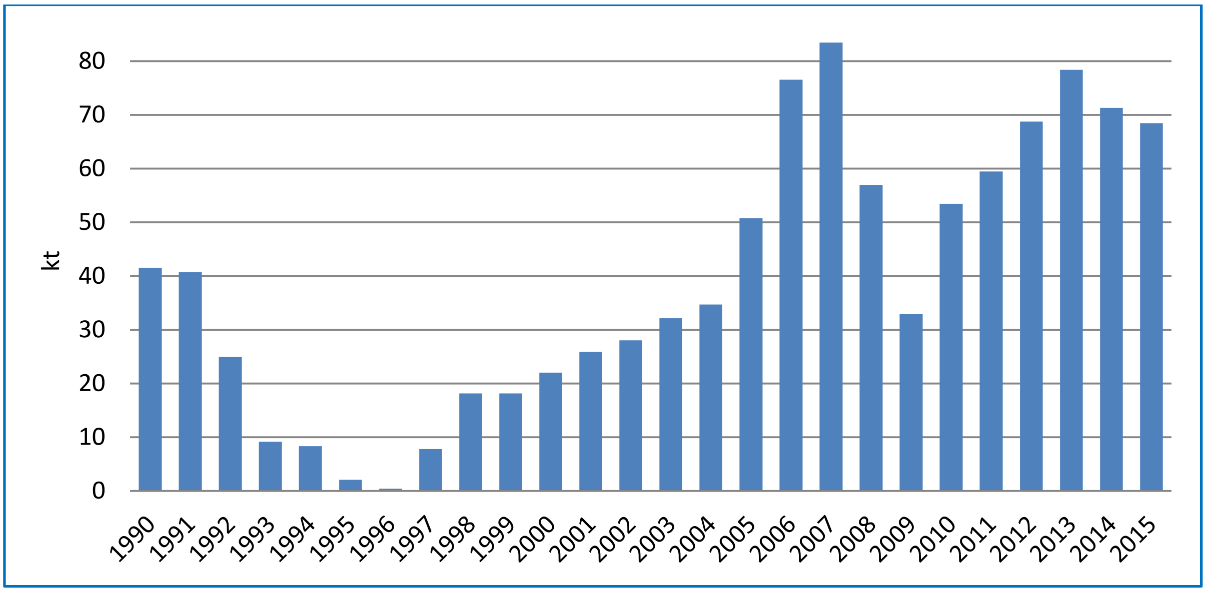


Figure 4-13. Mineral wool production in 1990-2015

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 (1997-2015).

4.2.4.2 Methodological issues

<u>*Ceramics (CRF 2.A.4.a)*</u>

CO_2 emissions from ceramics production were calculated from material balance based on CaO and MgO contents in the product provided by the ceramic bricks producer. According to the company, CaO content in bricks is fluctuating from 3.5% to 4.7% and MgO content is varying from 1.65% to 2.65%. Average values of 4.1% CaO and 2.15% MgO were taken as emission factors for calculation of emissions.

CO_2 emissions were calculated using the following equation:

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

where:
CP - ceramics production, kt;
C_{CaO} and C_{MgO} - CaO and MgO fractions in ceramics products;
MCO_2, M_{CaO}, M_{MgO} - molecular weights of CO_2, CaO and MgO.

Estimated CO_2 emissions from ceramics production are provided in Table 4-9.

Table 4-9. Estimated CO_2 emissions from bricks and tiles production 1990-2015

Year	CO_2 emission, kt
1990	227.9
1995	42.8
2000	20.9
2005	11.4
2010	4.8
2011	7.0
2012	5.8

2013	5.2
2014	5.2
2015	3.7

4.2.4.3 Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- Activity data uncertainty is assumed to be 5%.
- Emission factor uncertainty is assumed to be 5%.
- Combined uncertainty is 7.1%.

Data on ceramic bricks, tiles and vitrified clay pipes production were taken from Statistics Lithuania publications[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 meters. Recalculation of data to mass units was made. Vitrified clay pipes production data in Statistics Lithuania publications are provided in thousands of kilometers for the period 1990-2001 and in tonnes for the remaining period. Production of vitrified clay pipes were converted to mass units. Ceramic tiles production data were provided in square meters from 1990 to 2001 and in tile units from 2002. These data were converted to weight units.

Other uses of soda ash (CRF 2.A.4.b)

CO_2 emissions were calculated from mass balance assuming that all carbon contained in soda ash was released to the atmosphere after use as CO_2. The following equation was used:

$$Emission = M \times EF,$$

where:
M – mass of soda ash, tonnes;
EF – emission factor for soda ash, tonnesCO_2/tonne carbonate.

Estimated CO_2 emissions from other use of soda ash are provided in Table 4-10.

Table 4-10. Estimated CO_2 emissions from soda ash use 1990-2015

Year	CO_2 emission, kt
1990	5.3
1995	3.4
2000	0.7
2005	1.1
2010	0.6
2011	1.0
2012	0.1
2013	1.3
2014	1.0
2015	0.4

Uncertainties and time-series consistency

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

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- Soda ash use was evaluated as difference of data provided by Statistics Lithuania and evaluated other uses (namely glass production). As each of these components contains certain uncertainty, the total uncertainty in soda ash use activity data was assumed to be 15%.
- Emission factor uncertainty is assumed to be 5%.
- Combined uncertainty is 15.8%.

Data on overall use of soda ash were taken from the publications of Statistics Lithuania. Data on overall use of soda ash was not available for 2010-2015 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 Glass Production (CRF 2.A.3).

Mineral wool (CRF 2.A.4.d)

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

The production company has provided data on:

- total production 1998-2015;
- dolomite consumption 1997-2015;
- CO_2 emission factors (t CO_2/t dolomite) 2008-2015.

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

CO_2 emissions in 1997-2015 were calculated using data on consumption of dolomite and emission factor provided by the production company (for the period 1997-2007 average emission factors was used 0.43 t CO_2/t dolomite).

Based on the results, average emission factor for CO_2 emission from mineral wool production was calculated as 0.15 tonnes CO_2 per tonne mineral wool produced. This emission factor was used for calculation on CO_2 emission in 1990-1996.

Estimated CO_2 emissions from mineral wool production are provided in Table 4-11.

Table 4-11. Estimated CO_2 emissions from mineral wool production 1990-2015

Year	CO_2 emission, kt
1990	6.3
1995	0.3
2000	3.3
2005	8.0
2010	8.3
2011	9.1
2012	10.0
2013	11.9
2014	11.3
2015	10.5

4.2.4.4 Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- The data on mineral wool production and raw materials consumption obtained from the production company are reliable and precise, however, they cover only the period after reconstruction of the plant (from 1997). Historic data for 1990-1996 are expert evaluation and is less reliable. It was assumed that overall uncertainty of mineral wool production activity data is 7%.
- Emission factor uncertainty is assumed to be 5%.
- Combined uncertainty is 8.6%.

Production data for the period 1998-2015 were provided by the producer company. Activity data is not available for the period 1990-1997 and was extrapolated.

4.2.4.5 Category-specific QA/QC and verification

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

Mineral wool category-specific quality control procedures have been carried out in this submission. The recalculated emission data based on updated activity data and plant-specific emission factors provided by the producer for years 2008-2015 have been verified with ETS data and the correspondence between these data is 100%.

4.2.4.6 Category-specific recalculations

No recalculations have been done.

4.2.4.7 Category-specific planned improvements

Category-specific improvements are not 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 4-12).

Table 4-12. Reported emissions under the subcategory chemical industry

CRF	Source	Emissions reported
2.B.1	Ammonia production	CO_2
2.B.2	Nitric acid production	N_2O
2.B.8.a	Methanol	CO_2, CH_4

Ammonia and nitric acid production are key sources of this source category in Lithuanian inventory. Adipic acid, caprolactam, glyoxal and glyoxylic acid, carbides, titanium dioxide, pertrochemical and carbon black, fluorochemical production dichloroethylene and styrene are not produced in Lithuania.

Emissions of chemical industry in 2015 were 2,277.6 kt CO_2 eqv., and it was 67% 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 2,019.7 kt in 2015. Emissions of N_2O from nitric acid production were 0.87 kt in 2015. Ammonia and nitric acid production show recovery after the financial crisis and reached the levels of 2007-2008. Significant decline in N_2O emissions in 2009-2012 are due to installing of secondary catalyst in August 2008.

Emissions of CO_2 and CH_4 from methanol production comprise a small fraction in the emissions of greenhouse gases from chemical industry (emissions of CH_4 did not exceed 0.2% and emissions of CO_2 did not exceed 2.7% during the whole time series 1990-2008). No methanol was produced in 1999 and since 2008 due to economic reasons the production of methanol was stopped.

4.3.1 Ammonia Production (CRF 2.B.1)

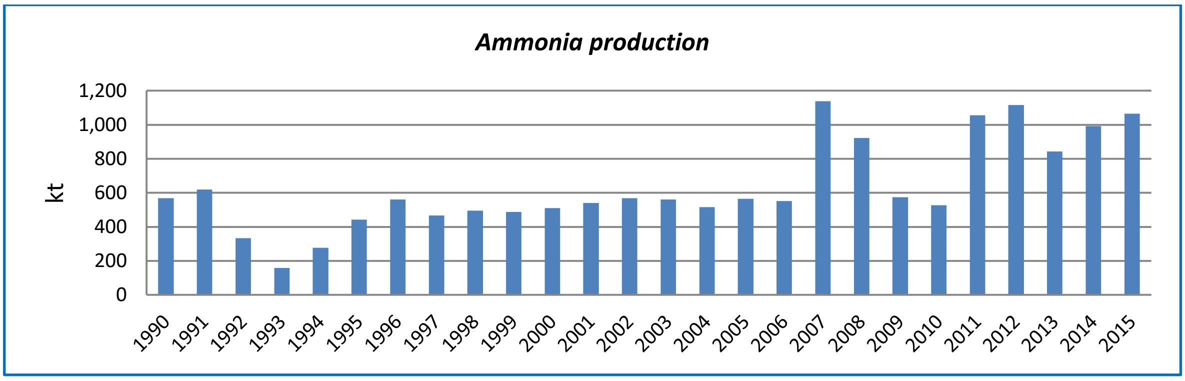
4.3.1.1 Category Description

There is a single ammonia production company in Lithuania. In the production plant ammonia is produced at 22.0-24.0 MPa pressure from hydrogen and nitrogen, which are generated at 800-1100°C temperatures by conversion of natural gas. The converted gas is cleaned from impurities (CO, CO_2, H_2O vapour, etc.).

Capacities of ammonia production:

- AM-70 unit – project (design or primary) capacity was 1,360 t/day; after reconstruction (in 1995) it reached 1,560 t/day or 569,400 t/year.
- AM-80 unit – project capacity is 1,560 t/day or 569,400 t/year.
- Total ammonia capacity is 1,138.800 t/year.

Ammonia production and natural gas consumption data (Figure 4-14) were provided by company. Other fuels are not used in the ammonia production process.



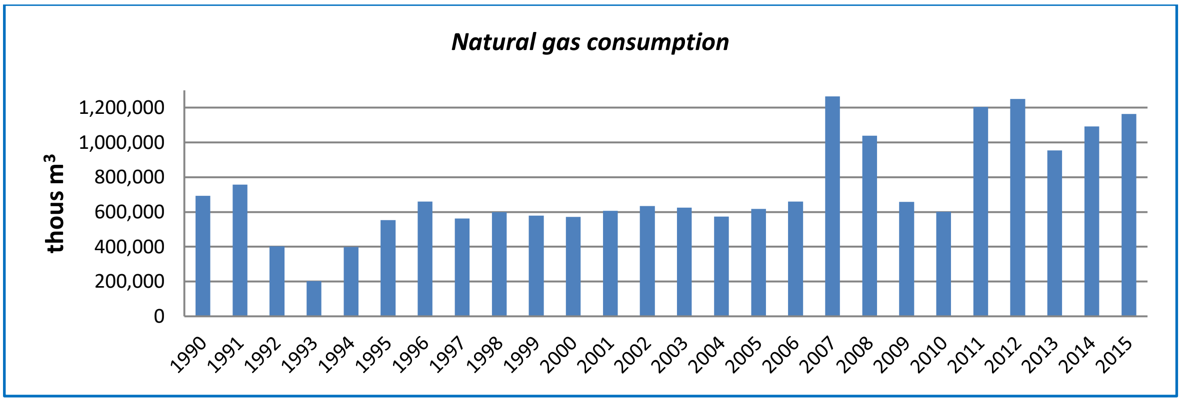


Figure 4-14. Ammonia production and natural gas consumption in 1990-2015

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 2015 ammonia production were 1,064 kt, compared to 2014 ammonia production has increased by 7%.

4.3.1.2 Methodological issues

The CO_2 emissions were calculated using *Tier 3* method (*2006 IPCC Guidelines*, Volume 3, Part 1, p. 3.13) and based on the following data provided by producer:

- annual production of ammonia;
- data on natural gas consumption;
- data on CO_2 recovered for urea production;
- data on amount of exported urea;
- data on CO_2 emitted from urea application on soils;
- data on CO_2 emitted from the use of urea-based catalyst;
- lower calorific values (annual average) of natural gas;
- country specific emission factor.

CO_2 emissions were calculated using the following equation:

$$CO_2\ emitted = (TFR \times Cv \times 4.186 \times 10^{-9} \times EF) - RCO_2$$

Where:

TFR_{NG} – total fuel requirements for ammonia production (= total consumption of natural gas, thousand m^3);

Cv – lower calorific value of the natural gas ($kcal/m^3$);

4.186×10^{-9} – conversion factor TJ/kcal;

EF - updated country specific CO_2 emission factor for natural gas (t CO_2/TJ) is determined considering to the chemical composition of natural gas during 2004-2014 that was provided by Central Calibration and Test Laboratory of JSC "Lietuvos dujos"[23]. Seeking to ensure higher accuracy of GHG inventory variable yearly values of CO_2 emission factor for a period 2004-2012 was applied and an average value (55.14 t/TJ) for a period 1990-2003 in this submission. CO_2 emission factor for natural gas (55.23 t/TJ) for a period 2013-2015 was determined considering chemical composition of natural gas.

R_{CO2} – CO_2 recovered for urea production, kg. According to company data about 25% of urea production is exported in 2015. Emissions from urea fertilizer are reported under agriculture sector. The use of urea-based catalyst in transport sector were simulated considering the number of cars, which use urea based catalyst and by mileage data provided by COPERT model. Emissions from the use of urea-based catalyst are reported under Non-energy products from fuels and solvent use (2.D.3).

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.

[23] Summary of study on "Update of country specific GHG emission factors for Energy sector" is presented in Annex IV

Calorific value of supplied natural gas is measured twice per month at Lithuania's natural gas supplier laboratory.

Total CO_2 emission from ammonia production, amount of CO_2 in exported urea, CO_2 emited from urea used in agriculture and urea-based catalyst are provided in Table 4-13.

Table 4-13. Estimated CO_2 emissions from ammonia production, kt/year

Year	Total CO_2 emission	Exported CO_2	CO_2 emitted from urea application on soils	CO_2 emitted from the use of urea-based catalyst	Reported CO_2 emission
1990	1,289.4	0.0	35.7	0.0	1,253.7
1995	1,015.6	0.0	6.7	0.0	1,008.9
2000	1,053.7	0.0	16.5	0.0	1,037.2
2005	1,138.9	0.0	31.5	0.0	1,107.4
2010	1,111.6	62.3	15.8	0.2	1,033.3
2011	2,226.9	97.5	14.2	0.3	2,114.9
2012	2,316.2	174.8	15.8	0.4	2,125.3
2013	1,777.4	75.4	15.8	1.1	1,685.1
2014	2,038.6	128.6	41.0	1.2	1,867.9
2015	2,182.6	118.7	42.5	1.7	2,019.7

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%.
- Combined uncertainty is 2.8%.

The data is consistent over the time-series. Natural gas consumption data, CO_2 recovered for urea production and annual average lower calorific values of the natural gas were provided by the production company.

4.3.1.4 Category-specific QA/QC and verification

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

4.3.1.5 Category-specific recalculations

Following recalculations in this category has been done:
- revision of CO_2 emission factor for natural gas (see Energy sector table 3-11) based on study on "Update of country specific GHG emission factors for Energy sector" (performed in 2016 by Lithuanian Energy Institute);
- correction of activity data on natural gas (for period 2005-2014) based on the newest information provided by the company in October 2016. The company revised activity data and reallocated part of natural gas consumption from non-energy use to energy use. Revised activity data on natural gas consumption are taken without data of flares;

- recalculation in urea use in agriculture (recalculated CO_2 emissions from urea application in time period 1990-2014 (see Chapter 5.10));
- correction of data on exported urea for the period 2007-2014 based on the data provided by the company.

Table 4-14. Reported in previous submission and recalculated CO_2 emissions from ammonia production 1990-2015, kt

Year	Previous submission	This submission	Absolute difference	Relative difference, %
1990	1,255.82	1,253.68	-2.14	-0.17
1991	1,365.49	1,363.16	-2.33	-0.17
1992	732.41	731.18	-1.23	-0.17
1993	370.66	370.04	-0.62	-0.17
1994	736.26	735.04	-1.22	-0.17
1995	1,010.52	1,008.86	-1.66	-0.16
1996	1,195.09	1,193.11	-1.98	-0.17
1997	1,021.30	1,019.60	-1.70	-0.17
1998	1,088.11	1,086.30	-1.81	-0.17
1999	1,051.30	1,049.55	-1.75	-0.17
2000	1,038.97	1,037.24	-1.73	-0.17
2001	1,114.44	1,112.58	-1.86	-0.17
2002	1,149.51	1,147.58	-1.92	-0.17
2003	1,135.96	1,134.05	-1.90	-0.17
2004	1,043.40	1,040.69	-2.71	-0.26
2005	1,110.39	1,107.40	-2.99	-0.27
2006	1,189.19	1,201.51	12.31	1.04
2007	2,280.28	2,281.77	1.48	0.07
2008	1,886.13	1,881.08	-5.04	-0.27
2009	1,077.50	1,078.51	1.01	0.09
2010	1,033.55	1,033.28	-0.27	-0.03
2011	2,111.43	2,114.94	3.51	0.17
2012	2,117.58	2,125.27	7.69	0.36
2013	1,671.94	1,685.13	13.19	0.79
2014	1,875.12	1,867.87	-7.24	-0.39

4.3.1.6 Category-specific planned improvements

Category-specific improvements are not planned.

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

4.3.2.1 Category Description

Nitric acid is produced by the single nitric acid producer in Lithuania. According to information provided by company, the nitric acid is produced in UKL-7 units and GP, GP-2 units by absorbing NO_2 with water. NO_2 is produced by air oxidation of NO with oxygen. Nitric oxide (NO) produced by air oxidation of ammonia with oxygen on Pt mesh catalyst. UKL-7 units are working by single pressure (high pressure) scheme. Gaseous emissions after absorption are cleaned from NO_x in a reactor. Grande Paroisse (GP) unit uses a dual-pressure scheme (medium/high). Gaseous emissions from GP are cleaned from NO_x in the reactor using a $DeNO_x$ technology. Grande Paroisse 2 (GP-2) nitric acid plant started in late autumn of 2015. This unit will let reduce energy costs and increase productions quantities. It should be noted that data on GP-2 unit was not provided in company`s EU ETS report 2015, due to GP-2 unit normal start-up was at the end of 2015 and GP-2 unit was not in continuous 90-day period operation as required by Commission Decision 2011/278/EU determining transitional Union-wide rules for harmonised free allocation of emission allowances pursuant to Article 10a of Directive 2003/87/EC of the European Parliament and of the Council.

Capacities:

At present company operates 9 UKL-7 units. The biggest capacity of one UKL-7 unit is 120 thous t/year (calculated to 100% HNO_3). Capacity of all UKL-7 units is 1.080 thous t/year. Capacity of GP unit is 360 thous t/year and capacity of GP-2 unit is 239,25 thous t/year. Total nitric acid production capacity is 1.679,25 thous t/year. Information on nitric acid production units operated during 1990-2015 period is provided in Table 4-15.

Table 4-15. Nitric acid production units in 1990 - 2015

Nitric acid production unit	1990-2002	2003	2004	2005-2008	2009-2014	2015
UKL-1	operational	operational	operational	operational	operational	operational
UKL-2	operational	operational	operational	operational	operational	operational
UKL-3	operational	operational	operational	operational	operational	operational
UKL-4	operational	operational	operational	operational	operational	operational
UKL-5	operational	operational	operational	operational	operational	operational
UKL-6	operational	operational	operational	operational	operational	operational
UKL-7		operational	operational	operational	operational	operational
UKL-8				operational	operational	operational
UKL-9					operational	operational
GP unit			operational	operational	operational	operational
GP-2 unit						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 the company.

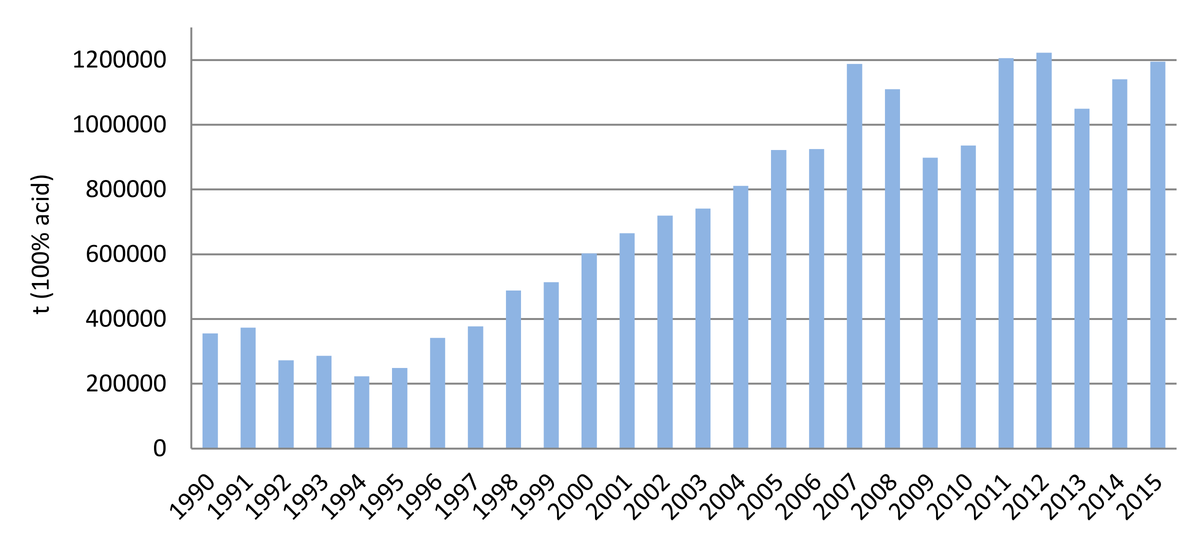


Figure 4-15. Nitric acid production in 1990-2015

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 (2009-2015).
- Production unit specific N_2O emission factors (Table 4-16):
  - Prior to installation of catalyst (2007-2008 monitoring campaign data).
  - After installation of catalyst (2009-2015).

For the years 2009-2015 production unit specific N_2O emission factors were obtained from the producer (Table 4-16). The emission factors are based on the data from the automated monitoring system (AMS) by the plant.

Table 4-16. Production unit specific N_2O emission factors calculated using measured and registered data in automated monitoring system, kg N_2O/t HNO_3 (100%)

Production unit code	2007-2008*	2009	2010	2011	2012	2013	2014	2015
UKL-1	9.63	1.72	1.86	1.87	1.62	1.77	1.79	1.44
UKL-2	9.51	1.43	1.42	1.65	1.71	1.31	1.08	0.84
UKL-3	5.45	2.22	2.92	2.16	1.32	1.18	1.87	1.06
UKL-4	7.73	1.88	2.40	1.68	0.77	0.72	0.97	1.16
UKL-5	6.61	2.07	1.87	1.69	1.43	1.39	1.19	1.01
UKL-6	10.34	3.73	3.51	2.65	2.48	0.88	1.01	0.79
UKL-7	9.09	2.70	1.54	1.16	1.64	0.95	0.66	0.81
UKL-8	6.96	2.35	1.58	1.50	1.18	0.42	0.71	0.55
UKL-9	not operational	4.81	4.84	6.65	1.66	0.54	0.42	0.48
GP	8.83	1.17	0.96	2.32	1.63	1.26	0.76	0.33
GP-2								0.70

* Data source: Report of the plant 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.
- 2009-2015: based on the results of continuous emissions monitoring.

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 4-15).

For 2009-2015 N_2O emissions are based on the measurements carried out in automated monitoring system by the plant. The unit specific emission factors (Table 4-15) 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 4-15).

Estimated emissions of N_2O from nitric acid production are provided in Table 4-17.

Table 4-17. Estimated emissions of N_2O from nitric acid production 1990-2015

Year	CO_2 emission, kt
1990	3.0
1995	2.1
2000	5.1
2005	7.8
2010	1.9
2011	2.9
2012	1.9
2013	1.1
2014	1.1
2015	0.9

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 judgement:

- Activity data is provided by a single producer. Uncertainty is assumed to be 2%.
- Emission factor uncertainty is assumed to be 10%.
- Combined uncertainty is 10.2%.

4.3.2.4 Category-specific QA/QC and verification

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

Plant specific EFs (since 2008 for UKL 1-8, GP, since 2011 for UKL 9 and since 2015 for GP-2) are based on measurements carried out in automated monitoring system by the plant, therefore it is considered that those plant-specific EFs represent the best possible knowledge and are accurate.

4.3.2.5 Category-specific recalculations

No recalculations have been done.

4.3.2.6 Category-specific planned improvements

Category-specific improvements are not planned.

4.3.3 Adipic Acid Production (CRF 2.B.3)

Emissions from adipic acid production are not occurring in Lithuania so for the category "CRF 2.B.3 Adipic Acid Production" notation key "NO" is used.

4.3.4 Caprolactum, Glyoxal and Glyoxylic Acid Production (CRF 2.B.4)

Emissions from caprolactum, glyoxal and glyoxylic acid production are not occurring in Lithuania so for the category "CRF 2.B.4 Caprolactum, Glyoxal and Glyoxylic Acid Production" notation key "NO" is used.

4.3.5 Carbide Production (CRF 2.B.5)

Emissions from carbide production are not occurring in Lithuania so for the category "CRF 2.B.5 Carbide Production" notation key "NO" is used.

4.3.6 Titanium Dioxide Production (CRF 2.B.6)

Emissions from titanium dioxide production are not occurring in Lithuania so for the category "CRF 2.B.6 Titanium Dioxide Production" notation key "NO" is used.

4.3.7 Soda Ash Production (CRF 2.B.7)

Emissions from soda ash production are not occurring in Lithuania so for the category "CRF 2.B.7 Soda Ash Production" notation key "NO" is used.

4.3.8 Petrochemical and Carbon Black Production (CRF 2.B.8)

This category is divided into six sub-categories: methanol production (CRF 2.B.8.a), ethylene production (CRF 2.B.8.b), ethylene dichloride and vinyl chloride monomer (CRF 2.B.8.c), ethylene oxide (CRF 2.B.8.d), acrylonitrile (CRF 2.B.8.e) and carbon black (CRF 2.B.8.f).

Methanol Production (CRF 2.B.8.a)

4.3.8.1 Category Description

AB Achema company is a single methanol production company in Lithuania. According to information provided by the company, methanol is produced from the CO, CO_2 and H_2. The medium temperature technological scheme was used in which methanol synthesis reactions are carried out in 8.0 MPa and 180-280°C. Gases required for methanol synthesis are generated by converting natural gas. Project capacity of methanol unit is 74,000 t/year.

Methanol production data (Figure 4-16) 1990-2008 were obtained from Statistics Lithuania publications[24]. According to AB Achema data methanol was not produced in 1999. The company is not producing methanol since 2008 due to economic reasons (high natural gas prices, competitiveness issues) and there are no plans to renew methanol production in the future.

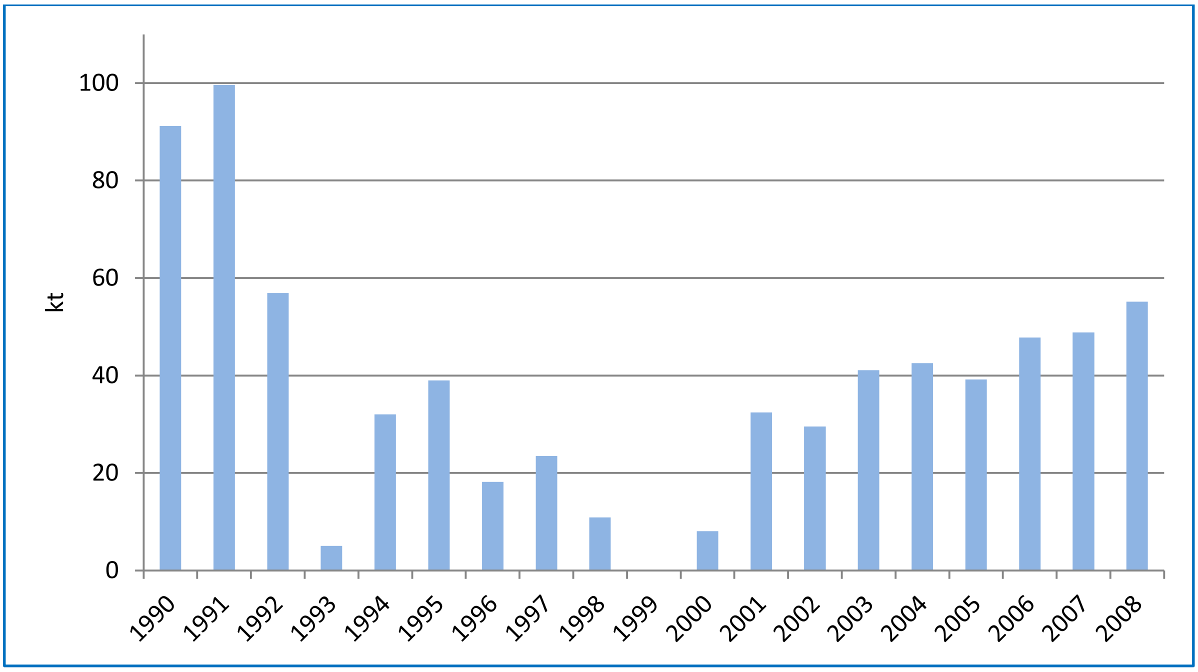


Figure 4-16. Methanol production

Ethylene (CRF 2.B.8.b)

Emissions from ethylene production are not occurring in Lithuania so for the category "CRF 2.B.8.b Ethylene" notation key "NO" is used.

Ethylene Dichloride and Vinyl Chloride Monomer (CRF 2.B.8.c)

Emissions from ethylene dichloride and vinyl chloride monomer production are not occurring in Lithuania so for the category "CRF 2.B.8.b Ethylene Dichloride and Vinyl Chloride Monomer" notation key "NO" is used.

Ethylene Oxide (CRF 2.B.8.d)

Emissions from ethylene oxide production are not occurring in Lithuania so for the category "CRF 2.B.8.d Ethylene Oxide" notation key "NO" is used.

Acrylonitrile (CRF 2.B.8.e)

Emissions from acrylonitrile production is not occurring in Lithuania so for the category "CRF 2.B.8.e Acrylonitrile" notation key "NO" is used.

Carbon Black (CRF 2.B.8.f)

Emissions from carbon black production is not occurring in Lithuania so for the category "CRF 2.B.8.d Carbon Black" notation key "NO" is used.

[24] Database of Statistics Lithuania

4.3.8.2 Methodological issues

Methanol production (CRF 2.B.8.a)

CH_4 emissions were calculated from methanol production data using emission factor 2.3 kg CH_4 per tonne of produced methanol taken from the *2006 IPCC Guidelines* (Volume 3, Part 1, p. 3.74). Estimated emissions of CH_4 (kt/year) from methanol production are provided in Table 4-17.

CO_2 emissions were calculated from methanol production data using default emission factor 0.267 tonne CO_2 per tonne of produced methanol taken from the *2006 IPCC Guidelines* (Volume 3, Part 1, table 3.12, p. 3.73). Estimated emissions of CO_2 (kt/year) from methanol production are provided in Table 4-18.

Table 4-18. Estimated emissions of CH_4 and CO_2 from methanol production

Year	CH_4, kt	CO_2, kt
1990	0.210	24.35
1995	0.090	10.41
2000	0.019	2.15
2005	0.090	10.47
2009-2015	NO	NO

4.3.8.3 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, 2009-2015.

4.3.8.4 Category-specific QA/QC and verification

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

4.3.8.5 Category-specific recalculations

No recalculations have been done.

4.3.8.6 Category-specific planned improvements

Category-specific improvements are not planned.

4.3.9 Fluorochemical Production (CRF 2.B.9)

Fluorochemical production category is divided into two sub-categories: by-product emissions (CRF 2.B.9.a) and fugitive emissions (CRF 2.B.9.b). Emissions from by-product emissions (CRF

2.B.9.a) and fugitive emissions (CRF 2.B.9.b) sub-categories are not occurring in Lithuania so for these sub-categories notation key "NO" is used.

4.3.10 Other (CRF 2.B.10)

Emissions from other production are not occurring in Lithuania so for the category "CRF 2.B.10 Other" notation key "NO" is used.

4.4 Metal industry (CRF 2.C)

In Lithuanian GHG inventory this category includes non-fuel emissions of CO_2 from cast iron production.

There are no key sources in this source category. Steel, sinter, coke, ferroalloys, aluminium, magnesium, lead and zinc are not produced in Lithuania. Emissions from cast iron production in 2015 were 2.02 kt CO_2 eqv., and it was only 0.1% of industry sector's emissions.

4.4.1 Iron and Steel Production (CRF 2.C.1)

4.4.1.1 Category Description

There were three companies producing cast iron until 2009. Only pig iron scrap was used as raw material. The largest company was producing cast iron in induction furnace, but it went bankrupt in 2010. The other two companies are still operating and one is producing cast iron in blast furnace and the other was producing cast iron in blast furnace until 2011, after 2011 it has been using induction furnace. In the blast furnance cast iron is made by remelting scrap pig iron along with coke and limestone. In the induction furnace only limestone is added.

Estimated CO_2 emissions from the cast iron production are shown in Figure 4-17.

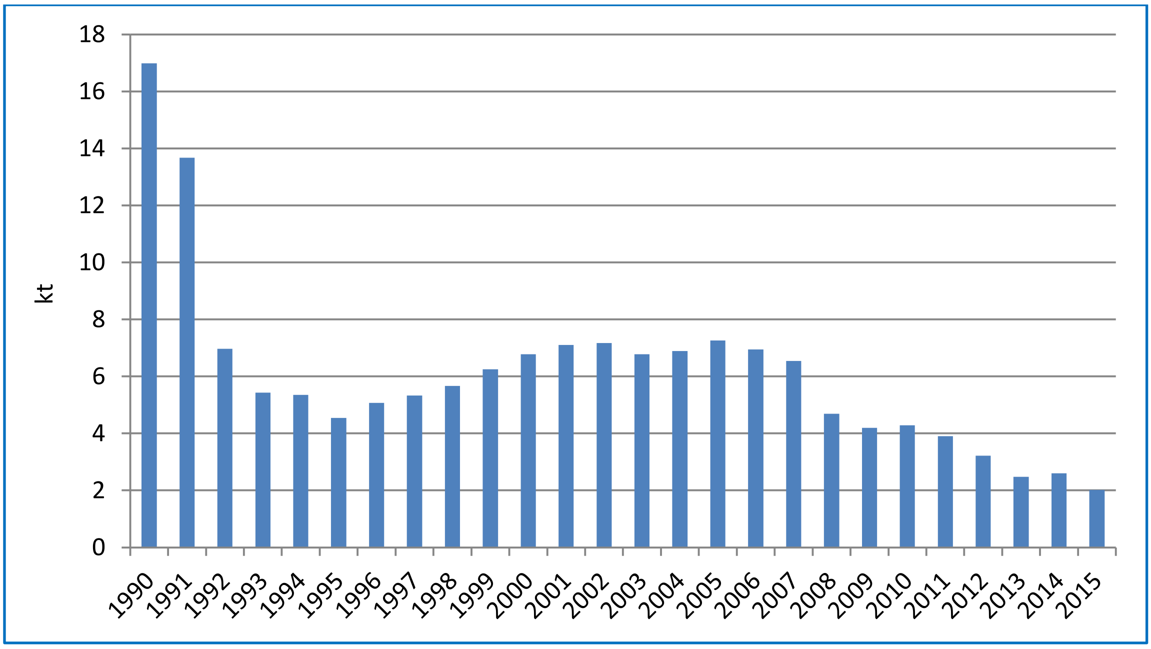


Figure 4-17. CO_2 emissions from the cast iron production

The reason of declining trend after 2011 is that one of the cast iron producing companies have decreased the amount of production due to economic reasons.

4.4.1.2 Methodological issues

The CO_2 emissions from the cast iron production were estimated based on the following data:

- Annual production of cast iron (Statistics Lithuania[25] data (1990-2009) and the producing companies data since 2010).
- Coke consumption (the companie`s data for period 1990-2015).
- Limestone consumption in blast furnace:
  - data on consumed amount of limestone for period 2003-2015 (the company data);
  - amount of limestone consumed for 1 tonne cast iron produced (85 kg/t cast iron, the company data).
- Limestone consumption in induction furnace:
  - data on consumed amount of limestone for 2015 (the company data);
  - amount of limestone consumption for 1 tonne cast iron produced (10 kg/t cast iron, the company data).
  - Carbon content of consumed pig iron scrap and produced cast iron (the company data).

CO_2 emissions from the cast iron production were calculated by *Tier 2* method using following modified *2006 Guidelines IPCC* equation (*2006 IPCC Guidelines*, Volume 3, Part 1, p. 4.22):

$$E_{CO2,non-energy} = [PI \times C_{PI} + PC \times C_{PC} + L \times C_L - CI \times C_{CI}] \times \frac{44}{12}$$

where:

PI – quantity of pig iron consumed in cast iron production, tonnes. (The amount of used pig iron is based on the literature[26]. It was assumed that reduction of the quantity of produced cast iron is 2%);

C_{PI} – carbon content for pig iron scrap consumed (0.04 tonnes C/tonne, the company data);

PC – quantity of coke consumed in cast iron production, tonnes;

C_{PC} – carbon content for coke consumed (default – 0.83 tonnes C/tonne);

L – quantity of limestone consumed in cast iron production, tonnes;

C_L –carbon content for limestone consumed (default – 0.12 tonnes C/tonne);

CI – quantity of produced cast iron, tonnes;

C_{CI} – carbon content for produced cast iron (0.03 tonnes C/tonne, the company data).

4.4.1.3 Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- Data on the total cast iron production for period 1990-2009 were taken from Statistics Lithuania and the data were provided by the production companies since 2010. Uncertainty of the activity data is assumed to be 10%;
- Emission factor uncertainty is assumed to be 10%;

[25] Database of Statistic Lithuania
[26] H S Bawa Manufacturing Processes – I

– Combined uncertainty is 14.1%.

Data is consistent over the time-series.

4.4.1.4 Category-specific QA/QC and verification

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

4.4.1.5 Category-specific recalculations

No recalculations have been done.

4.4.1.6 Category-specific planned improvements

Category-specific improvements are not planned.

4.4.2 Ferroalloys Production (CRF 2.C.2)

Emissions from ferroalloys production are not occurring in Lithuania so for the category "CRF 2.C.2 Ferroalloys Production" notation key "NO" is used.

4.4.3 Aluminium Production (CRF 2.C.3)

Emissions from aluminium production are not occurring in Lithuania so for the category "CRF 2.C.3 Aluminium Production" notation key "NO" is used.

4.4.4 Magnesium Production (CRF 2.C.4)

Emissions from magnesium production are not occurring in Lithuania so for the category "CRF 2.C.4 Magnesium Production" notation key "NO" is used.

4.4.5 Lead Production (CRF 2.C.5)

Emissions from lead production are not occurring in Lithuania so for the category "CRF 2.C.5 Lead Production" notation key "NO" is used.

4.4.6 Zinc Production (CRF 2.C.6)

Emissions from zinc production are not occurring in Lithuania so for the category "CRF 2.C.6 Zinc Production" notation key "NO" is used.

4.4.7 Other (CRF 2.C.7)

Emissions from other production are not occurring in Lithuania so for the category "CRF 2.C.7 Other" notation key "NO" is used.

4.5 Non-energy products from fuels and solvent use (CRF 2.D)

4.5.1 Lubricant use (CRF 2.D.1)

4.5.1.1 Category Description

The Statistics Lithuania provides data on non-energy use of lubricants in Energy Balance (see Annex III). There is no subdivision of lubricants into oils and greases in Energy Balance. Data on consumption of lubricants is available for 1990-2015 and is shown in Figure 4-18.

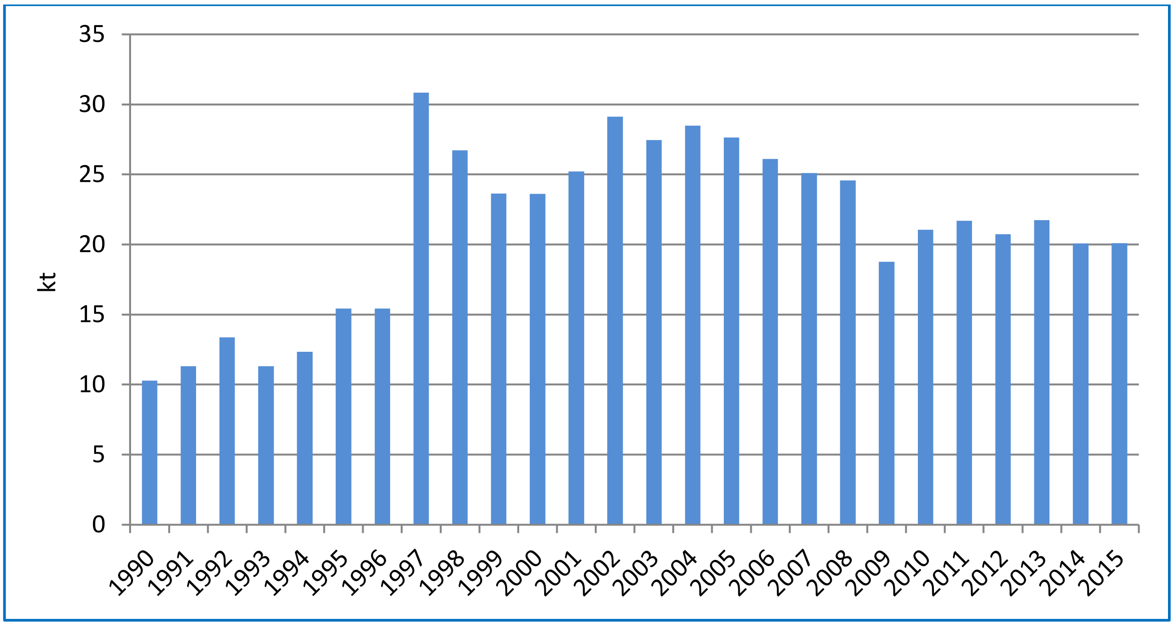


Figure 4-18. Consumption of lubricants for non-energy purposes

4.5.1.2 Methodological issues

CO_2 emission calculations are based on total consumption of lubricants, the default carbon content and ODU factors. Emissions are calculated according to following equation (*2006 IPCC Guidelines*, Volume 3, Part 2, p. 5.7):

$$CO_2Emissions = LC \times CC_{Lubricant} \times ODU_{Lubricant} \times 44/12$$

where

LC – total lubricant consumption, TJ;

$CC_{Lubricant}$ – carbon content of lubricants (default – 20 C/TJ);

$ODU_{Lubricants}$ – amount of lubricants oxidised during use factor (default – 0.2);

44/12 – mass ratio of CO_2/C.

Estimated CO_2 emissions from use of lubricants are provided in Table 4-19.

Table 4-19. Estimated CO_2 emissions from use of lubricants 1990-2015

Year	CO_2 emission, kt
1990	6.1
1995	9.1
2000	13.9
2005	16.3
2010	12.4
2011	12.8
2012	12.2
2013	12.8
2014	11.8
2015	11.9

4.5.1.3 Uncertainties and time-series consistency

Activity data was obtained from Statistics Lithuania publications. Uncertainty is assumed to be 5%. Emission factor uncertainty is assumed to be 50.1% and combined uncertainty is 50.3%.

Data is consistent over the time-series. Data on consumption of lubricants for all period was obtained from Statistics Lithuania.

4.5.1.4 Category-specific QA/QC and verification

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

4.5.1.5 Category-specific recalculations

No recalculations have been done.

4.5.1.6 Category-specific planned improvements

Category-specific improvements are not planned.

4.5.2 Paraffin wax use (CRF 2.D.2)

4.5.2.1 Category Description

The Statistics Lithuania provides data on non-energy use of paraffin wax in Energy Balance (see Annex). Data on consumption of paraffin wax is available for 2001-2015 and is shown in Figure 4-19.

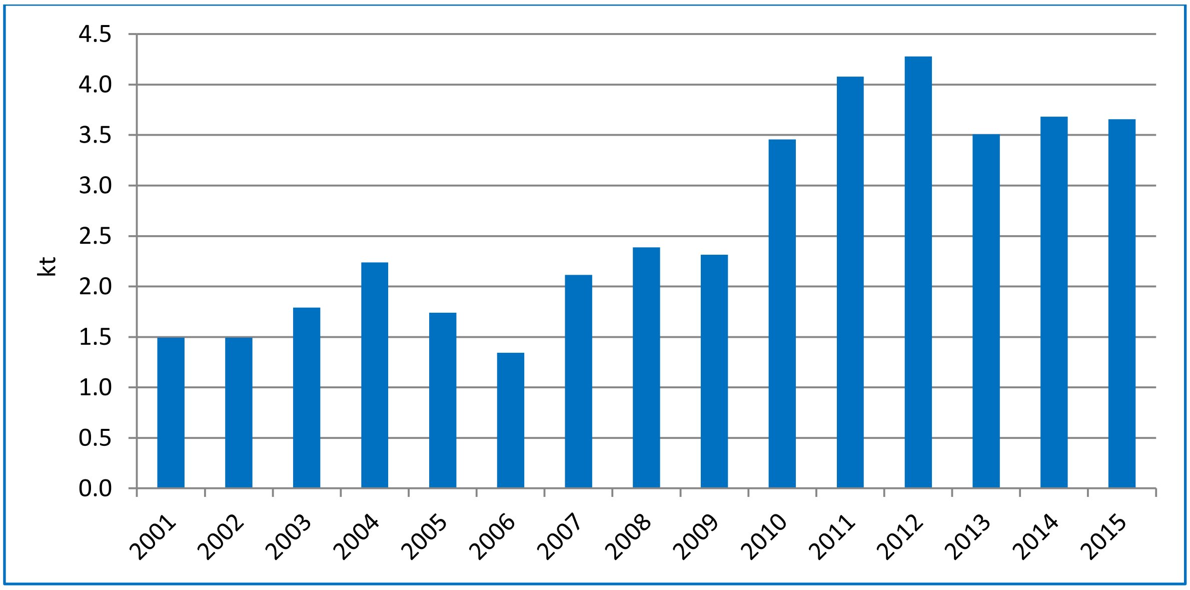


Figure 4-19. Consumption of paraffin wax for non-energy purposes

4.5.2.2 Methodological issues

CO_2 emission calculations are based on total consumption of paraffin wax, the default carbon content and ODU factors. Emissions are calculated according to following equation (*2006 IPCC Guidelines*, Volume 3, Part 2, p. 5.11):

$$CO_2 Emissions = PW \times CC_{Wax} \times ODU_{Wax} \times 44/12$$

where

PW – total wax consumption, TJ;

CC_{Wax} – carbon content of paraffin wax (default – 20 C/TJ);

ODU_{Wax} – amount of paraffin wax oxidised during use factor (default – 0.2);

44/12 – mass ratio of CO_2/C.

Estimated CO_2 emissions from use of paraffin wax are provided in Table 4-20.

Table 4-20. Estimated CO_2 emissions from use of paraffin wax 2001-2015

Year	CO_2 emission,kt
2001	0.9
2005	1.0
2010	2.0
2011	2.4
2012	2.5
2013	2.1
2014	2.2
2015	2.2

4.5.2.3 Uncertainties and time-series consistency

Activity data was obtained from Statistics Lithuania publications. Uncertainty is assumed to be 5%. Emission factor uncertainty is assumed to be 100% and combined uncertainty is 100.2%.

Data is consistent over the time-series. Data on consumption of paraffin wax was obtained from Statistics Lithuania.

4.5.2.4 Category-specific QA/QC and verification

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

4.5.2.5 Category-specific recalculations

No recalculations have been done.

4.5.2.6 Category-specific planned improvements

Category-specific improvements are not planned.

4.5.3 Other (CRF 2.D.3)

4.5.3.1 Category Description

Solvent use

Solvent use contributes a small amount to the total GHG emissions in Lithuania. Share to the total emission was only 0.3% in 2015 (excl. LULUCF). Indirect CO_2 emission from NMVOC for the following subcategories was estimated:

- Domestic solvent use;
- Dry cleaning;
- Degreasing;

- Chemical products;
- Coating applications: paint application;
- Printing;
- Wool.

The inventory of NMVOC emissions from the solvent use sector is performed at Lithuanian Environmental Protection Agency. The NMVOC inventory is carried out to meet the obligations of the UNECE Convention on Long-range Transboundary Air Pollution and EU Directive 2001/81/EC (NEC Directive).

Asphalt roofing

UAB Mida LT is a single company in Lithuania producing asphalt roofing materials. The company started operation in 2001 after reorganization of Soviet construction materials production company. Company produces bitumen tiles as well as roll roofing materials. Data on production of roofing materials was provided by the producer and is available for the period 2001-2013 (Table 4-21). The production of roll roofing materials was almost stopped compared to 2012, this is due to the import of the cheaper production from other countries.

Table 4-21. Production of asphalt roofing materials in Lithuania 2001-2015 (thous m^2)

Year	Bitumen tiles	Roll roofing materials
2001	253	2,087
2005	3,157	4,488
2010	3,681	477
2011	3,265	573
2012	3,737	29
2013	3,743	0.001
2014	3,883	0
2015	3,491	0

According to the producer, asphalt roofing materials were also produced in 1990-2000 prior to reorganization of the company in 2001, but data for this period is not available.

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

Asphalt roofing production is provided in Figure 4-20.

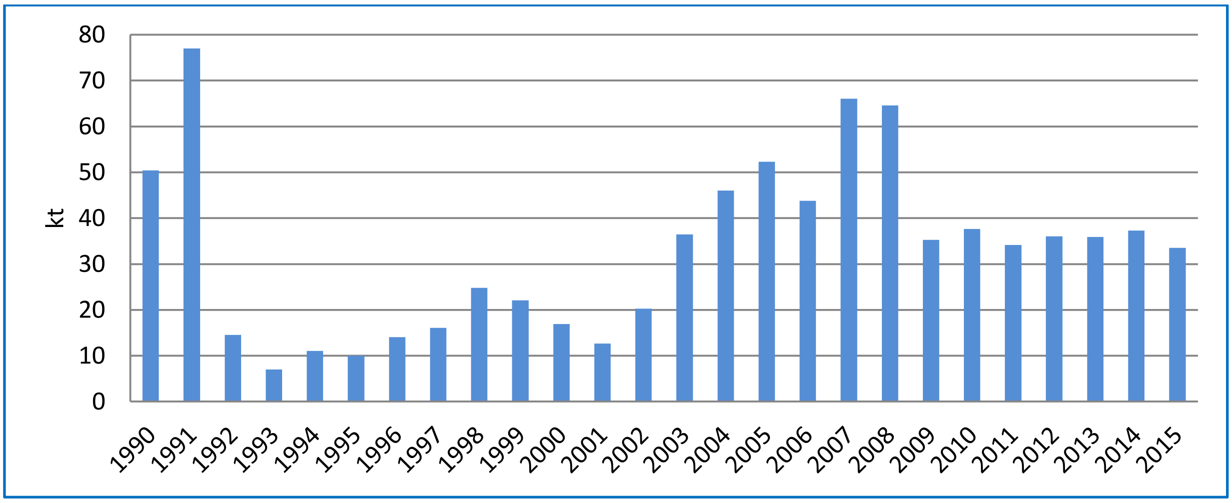


Figure 4-20. Production of asphalt roofing in 1990-2015

Road paving with asphalt

According to the data published in the European Asphalt Pavement Association publication "Asphalt in figures" there were 20 companies in the asphalt industry in 2014 in Lithuania. In the same publication the data on consumption of bitumen in the road industry is also available for the years 2007-2014. Statistics Lithuania collects data on production of bitumen (data available for 2002-2015), 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.

Since data on the consumption of bitumen for 2014-2015 is not published in the European Asphalt Pavement Association publication "Asphalt in figures" and the CO_2 emissions from this category are considered as insignificant (emissions are below 0.05 % of the total inventory (without LULUCF) and they would not exceed 500 kt CO_2 eqv. according to decision 24/CP.19, para. 37(b)), it was assumed that the consumption of bitumen for road paving with asphalt is constant at 100 kt per year.

Consumption of bitumen in road industry is provided in Figure 4-21.

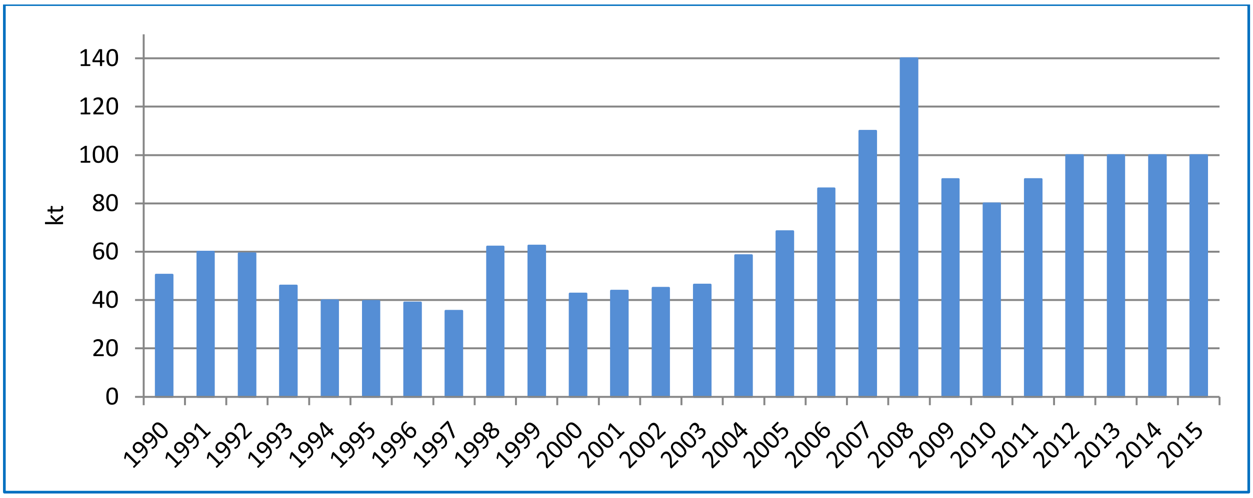


Figure 4-21. Consumption of bitumen in 1990-2015

4.5.3.2 Methodological issues

Solvent use

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

Emissions were calculated using annual average population data provided by the Statistics Lithuania. The default fossil carbon content fraction of NMVOC (*2006 IPCC Guidelines*, Volume 3, part 2, p. 5.17) was used for all categories under sector of solvent use. CO_2 emissions from solvent use were calculated using the equation below.

$$Emission\ CO_2 = Emission\ NMVOC \times 0.6 \times 44/12$$

Emissions from Coating applications sub-category were estimated using a different approaches. For 2005-2015 calculated for Tier 2 method using activity data of production, import and export.

CO_2 and NMVOC emissions from solvent use are presented in Table 4-22.

Table 4-22. CO_2 and NMVOC emissions (kt) from solvent use for the period 1990-2015

Year	CO_2 emission	NMVOC emission
1990	65.31	29.69
1995	63.55	28.88
2000	60.80	27.64
2005	37.61	17.10
2010	31.93	14.51
2011	31.31	14.23
2012	29.28	13.31
2013	26.99	12.27
2014	31.53	14.33
2015	33.65	15.29

Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- Uncertainty of activity data is assumed to be 30%;
- Emission factor uncertainty is assumed to be 20%;
- Combined uncertainty is 36%.

Asphalt roofing

Weight of the asphalt roofing material was calculated using area to weight ratio provided by the production company: 9.6 kg/m^2 for bitumen tiles and 4.9 kg/m^2 for roll roofing material. Amount of bitumen used for production of asphalt roofing is 2 kg/m^2 for bitumen tiles and 2.6 kg/m^2 for roll roofing.

Production of the asphalt roofing materials in 1990-2000 was estimated based on annual average use of bitumen. During the period between 2001 and 2010 production of asphalt roofing materials annually consumed on average 13% of the bitumen used for non-energy uses. Data on bitumen use for non-energy uses was obtained from energy balance by Statistics Lithuania. It was also assumed that only roll roofing was produced in 1990-2000.

Emissions of non-methane volatile organic compounds (NMVOC) from asphalt roofing were calculated from the national data on the total mass of production. Default emission factor of 0.13 kg NMVOC per tonne product was used (*EMEP/EEA*, 2.D.3.c Asphalt roofing, Table 3.1, p.7).

Estimated NMVOC emissions form asphalt roofing production were converted to CO_2 equivalent assuming that NMVOC contain 80% carbon by weight (*2006 IPCC Guidelines*, Volume 3, part 2, page 5.16). Estimated NMVOC and CO_2 eqv. emissions from asphalt roofing production are shown in Table 4-23.

Table 4-23. Estimated NMVOC and CO_2 eqv. emissions from asphalt roofing production

Year	NMVOC, kt	CO_2 eqv., kt
1990	0.0066	0.0192
1995	0.0013	0.0038
2000	0.0022	0.0065
2005	0.0068	0.0199
2010	0.0049	0.0144
2011	0.0044	0.0130
2012	0.0047	0.0137
2013	0.0047	0.0137
2014	0.0048	0.0142
2015	0.0044	0.0128

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 2001-2015. Production of the asphalt roofing materials in 1990-2000 was estimated based on annual average use of bitumen.

Road paving with asphalt

NMVOC emissions from road paving with asphalt are calculated based on annual consumption of bitumen. NMVOC emission was calculated using default emission factor 0.016 kg/tonne of asphalt (*EMEP/EEA*, 2.D.3.b Road paving with asphalt, Table 3.1, p.8).

Estimated NMVOC emissions from road paving with asphalt were converted to CO_2 equivalent assuming that NMVOC contain 45% carbon by mass (*2006 IPCC Guidelines*, Volume 3, part 2, p. 5.16). Estimated NMVOC and CO_2 eqv. emissions from road paving with asphalt are shown in Table 4-24.

Table 4-24. Estimated NMVOC and CO_2 eqv. emissions from road paving with asphalt

Year	NMVOC, kt	CO_2 eqv., kt
1990	0.001	0.001
1995	0.001	0.001
2000	0.001	0.001
2005	0.001	0.002
2010	0.001	0.002
2011	0.001	0.002

2012	0.002	0.003
2013	0.002	0.003
2014	0.002	0.003
2015	0.002	0.003

Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- The data on consumption of bitumen obtained from the European Asphalt Pavement Association are reliable. However, it covers only the period 2007-2013. Historic data for 1990-2006 are expert evaluation and may be less reliable. It was assumed that overall uncertainty of road paving with asphalt activity data is 20%.
- Emission factor uncertainty is assumed to be 50%.

Combined uncertainty is 53.8%.

4.5.3.3 Category-specific QA/QC and verification

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

4.5.3.4 Category-specific recalculations

NMVOC and CO_2 emissions were recalculated due to Printing and Wool sub-categories were included in Solvent use and different methods were used in Coating applications sub-category (Table 4-25).

Table 4-25. Reported in previous submission and recalculated CO_2 emissions from Solvent use 1990-2014, kt

Year	Previous submission	This submission	Absolute difference	Relative difference, %
1990	59.79	65.31	5.52	9.23
1991	59.90	65.28	5.39	9.00
1992	59.83	65.09	5.26	8.79
1993	59.55	64.67	5.13	8.61
1994	59.14	64.13	5.00	8.45
1995	58.68	63.55	4.86	8.29
1996	58.24	62.97	4.73	8.13
1997	57.81	62.42	4.61	7.98
1998	57.39	61.87	4.48	7.81
1999	56.99	61.33	4.35	7.62
2000	56.59	60.80	4.21	7.44
2001	56.12	60.20	4.08	7.27
2002	55.67	59.63	3.95	7.10
2003	55.22	59.05	3.83	6.93
2004	54.61	58.30	3.69	6.77

2005	53.73	37.61	-16.12	-30.00
2006	52.87	38.62	-14.25	-26.96
2007	52.25	44.53	-7.72	-14.78
2008	51.72	34.07	-17.64	-34.12
2009	51.14	31.14	-20.01	-39.12
2010	50.08	31.93	-18.16	-36.25
2011	48.96	31.31	-17.66	-36.06
2012	48.31	29.28	-19.03	-39.39
2013	47.83	26.99	-20.84	-43.57
2014	47.42	31.53	-15.89	-33.51

4.5.3.5 Category-specific planned improvements

Category-specific improvements are not planned.

4.6 Electronics industry (CRF 2.E)

This section covers emissions of sulphur hexafluoride (SF_6) from semiconductor and nitrogen trifluoride (NF_3) from photovoltaics production. There is one company in Lithuania, which produces semiconductors and there is one company, which is manufacturer of high efficiency solar cells. In 2015 the emissions from electronic industry were estimated at 4.99 kt CO_2 eqv.

4.6.1 Integrated Circuit or Semiconductor (CRF 2.E.1)

4.6.1.1 Category Description

There is one company in Lithuania – "Vilniaus Ventos puslaidininkiai", which produces semicondutors. The company's authorities informed that in 2008 company started use SF_6 gas, so the emission data are only available for the period 2008-2015. Only 50% of emissions are released into environment. Emissions from semiconductors fluctuation are highly related to economic situation and production demand.

4.6.1.2 Methodological issues

Emissions of SF_6 from semiconductor manufacturing were calculated using the following modified equation (*2006 IPCC Guidelines* Volume 3, p. 3.104):

$$E_{SF_6,t} = F_{SF_6,t} \times C_i$$

where:

F_{SF6}, t - quantity of HFCs used by the company in year t, t;

C_i - emission factor during production.

Estimates of SF_6 emissions from semiconductor manufacture are demonstrated in Figure 4-22 and Table 4-26 below.

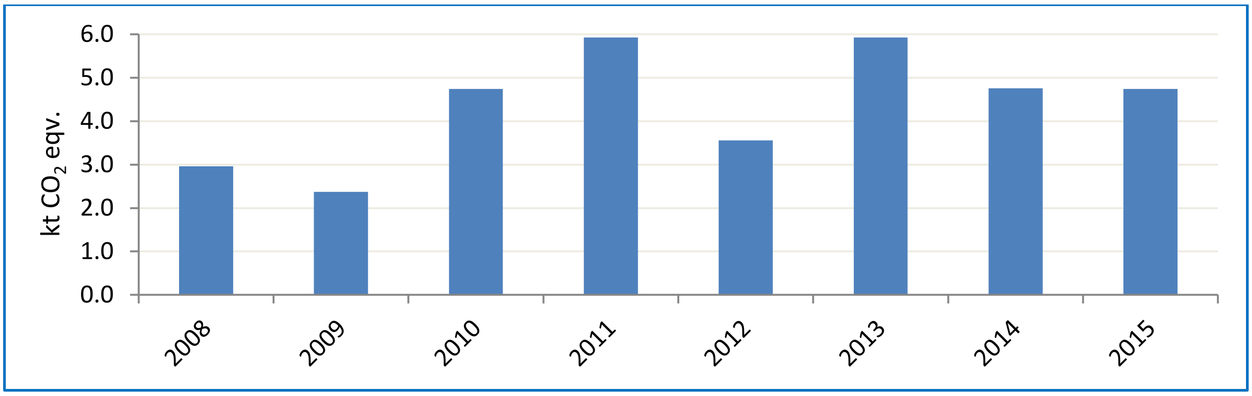


Figure 4-22. SF_6 emissions from semiconductor manufacture for 2008-2015

Table 4-26. SF_6 emissions from semiconductor manufacture for the period 2008-2015

Year	Emissions, kt CO_2 eqv.
2008	2.96
2010	4.74
2011	5.93
2012	3.56
2013	5.93
2014	4.75
2015	4.74

4.6.1.3 Uncertainties and time-series consistency

Emission uncertainty was estimated using Approach 1 of the *2006 IPCC Guidelines* Volume 3 (p. 3.27). Uncertainty estimates of activity data and emission factors are presented in Table 4-27.

Table 4-27. Uncertainty (UN) estimates of SF_6 emissions in the sub-category of semiconductor manufacture

Emission source	Input data UN, %	EF during operation UN, %	Total emission UN, %
CRF 2.E.1Integrated Circuit or Semiconductor	5	5	7

4.6.1.4 Category-specific QA/QC and verification

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

4.6.1.5 Category-specific recalculations

No recalculations have been done.

4.6.1.6 Category-specific planned improvements

Category-specific improvements are not planned.

4.6.2 TFT Flat Panel Display (CRF 2.E.2)

Fluorinated compounds (FC) emissions from TFT flat panel display production are not occurring in Lithuania so for the category "CRF 2.E.2TFT Flat Panel Display" notation key "NO" is used.

4.6.3 Photovoltaics (CRF 2.E.3)

4.6.3.1 Category Description

UAB "SoliTek" is the single company in Lithuania producing high efficiency solar cells. The company owns the latest manufacturing equipment and advanced industrial facilities with an annual capacity of 80 MW from PV cells and 50 MW from Glass/Glass modules. 100% of raw materials used in companies PV cell manufacturing are provided by European suppliers. UAB "SoliTek" holds the complete production chain of PV cells of finished Glass/Glass modules[27].

4.6.3.2 Methodological issues

During year 2015 1496 kg of NF_3 gases has been consumed. One of the solar cell production processes is deposition of antireflective SiNx layer by Plasma Enhanced Chemical Vapour Deposition (PECVD) method. NF_3 is used as cleaning agent for process chambers of PECVD equipment. This equipment is connected to the burner scrubber on the outlet of the vacuum pump. All waste gases generated after chemical vapor deposition process and cleaning step (including NF_3) are diluted in nitrogen and cleaned via burning, wet scrubbing and aerosol retention.

Burning

The gases requiring disposals are called waste gases and they are exposed to a natural gas/compressed air flame. At a temperature of over 1000^0C the reaction products and process gases remaining in the waste gas are either burned or thermally decomposed and converted into products that can be wet scrubbed.

Wet Scrubbing

After leaving the burner unit the waste gases are led to a scrubber column. Components that are soluble or react with the washing liquid are wet scrubbed and neutralized at waste water treatment (WWT) plant. The drain of the scrubber is connected to the waste water treatment plant. Dust particles are retained from the waste gas and are removed with the washing liquid. After burning and wet scrubbing procedure the gas, which is fed into exhaust system is designated clean gas.

Company's authorities informed that the efficiency of the cleaning device is 99%, which means that only 1% of NF_3 is released to the environment. According to the company's authorities NF_3 has been used only since 2013. Total NF_3 emissions from Photovoltaics for the 2015 were 0.26 kt CO_2 eqv.

Estimates of NF_3 emissions from photovoltaics are demonstrated in Figure 4-23 and Table 4-28 below.

[27] http://www.solitek.eu/en/

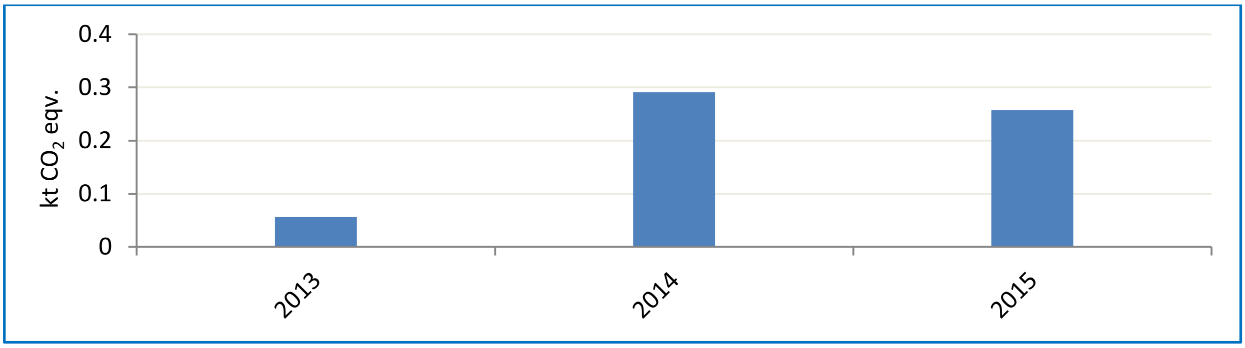


Figure 4-23. NF_3 emissions from photovoltaics production for the period 2013-2015

Table 4-28. NF_3 emissions from photovoltaics production for the period 2013-2015

Year	Emissions, kt CO_2 eqv.
2013	0.06
2014	0.29
2015	0.26

4.6.3.3 Uncertainties and time-series consistency

Emission uncertainty was estimated using *2006 IPCC Guidelines*, Volume 3, p. 6.25. Uncertainty estimates of activity data and emission factors are presented in Table 4-29.

Table 4-29. Uncertainty (UN) estimates of fluorinated gas emissions in the sub-category of photovoltaics

Emission source	Input data UN, %	EF during operation UN, %	Total emission UN, %
CRF 2.E.3 Photovoltaics	5	20	21

4.6.3.4 Category-specific QA/QC and verification

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

4.6.3.5 Category-specific recalculations

No recalculations have been done.

4.6.3.6 Category-specific planned improvements

Category-specific improvements are not planned.

4.6.4 Heat Transfer Fluid (CRF 2.E.4)

FC emissions from heat transfer fluid production are not occurring in Lithuania so for the category "CRF 2.E.4 Heat Transfer Fluid" notation key "NO" is used.

4.6.5 Other (CRF 2.E.5)

FC emissions from other production are not occurring in Lithuania so for the category "CRF 2.E.5 Other" notation key "NO" is used.

4.7 Product Uses as Substitutes for Ozone Depleting Substances (CRF 2.F)

Hydrofluorocarbons (HFCs) are used as alternatives to chlorofluorocarbons (CFCs), ozone depleting substances being phased out under the Montreal Protocol. Emissions of HFCs occur as leakage from the charge of equipment, its use and from the destruction of such equipment at the end of life.

The main data source for halocarbons calculations is Environmental Protection Agency (EPA) database. According order of Minister of Environment D1-12/2006 and D1-394/2015 operators are obliged to report on fluorinated gases and mixtures, they had used imported/exported and put on the market last year. The operators also notifies about the equipment with fluorinated gases or blends of fluorinated gases.

As there still are drawbacks in some sub-sectors, this is the reason why studies were carried out for specific sub-sectors and used as a supplementary data source for calculations. A study "Analysis of the Use of Fluorinated Greenhouse Gases in Lithuania in 1990-2011" was carried out in 2012. The project was financed from the national sources. The results of the study were partly used for the preparation of the present report.

The share of GHG emissions from the consumption of halocarbons is increasing. In 2015 the emissions were estimated at 478.36 kt CO_2 eqv. (or 14% from the aggregated emissions from Industrial processes).

Based on the current knowledge, the major source of GHG emissions in the sub-sector "Product Uses as Substitutes for ODS" is Commercial Refrigeration (CRF 2.F.1.a) and Mobile air-conditioning (CRF 2.F.1.e) account for 36.45% and 23.86% of the 2015 emissions respectively (as CO_2 eqv.).

Estimated emissions from consumption of halocarbons in 1993-2015 are shown in Figure 4-24.

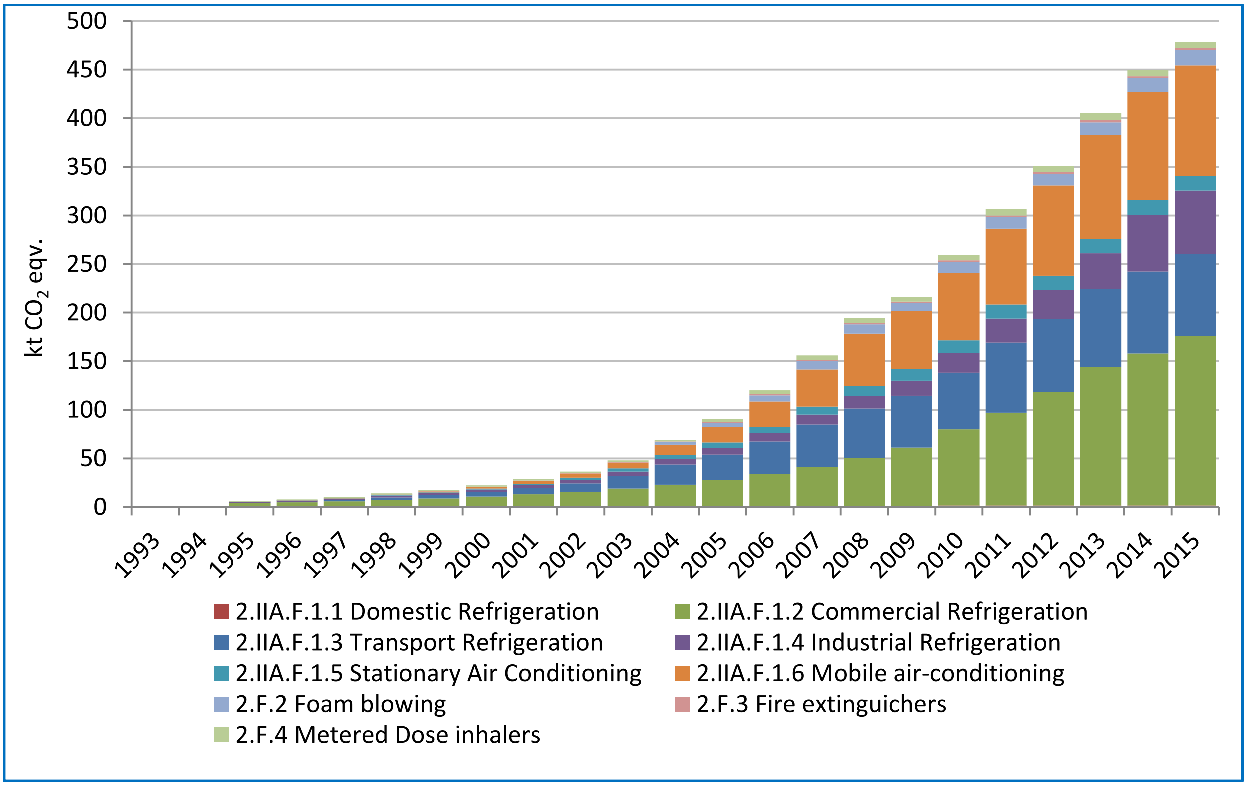


Figure 4-24. Estimated emissions from consumption of Halocarbons in 1993-2015

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

This section covers emissions of halocarbons from: commercial refrigeration (CRF 2.F.1.a), domestic refrigeration (CRF 2.F.1.b), industrial refrigeration (CRF 2.F.1.c), transport refrigeration (CRF 2.F.1.d), mobile air-conditioning (CRF 2.F.1.e) and stationary air-conditioning (CRF 2.F.1.f).

4.7.1.1 Category Description

Commercial Refrigeration (CRF 2.F.1.a) and Industrial Refrigeration (CRF 2.F.1.c)

The main fluorinated gases in this category are HFC-125 and HFC-143a, also small amounts of HFC-32 and HFC-134a are occurring. 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 commercial and industrial refrigeration equipment is 15 years, which is in the range of lifetime values provided in *2006 IPCC Guidelines*. The end-of-life emissions were estimated for 2010-2015 years taking into account that HFCs have been used in commercial and industrial refrigeration in Lithuania since 1995.

The main data source for Commercial Refrigeration (CRF 2.F.1.a) and Industrial Refrigeration (CRF 2.F.1.c) categories is Environmental Protection Agency (EPA) database.

Furthermore, F-gases recovery in Lithuania is taking place also in UAB EMP Recycling, which has the single refrigerator recycling unit in Baltic countries since 2007. The company has certificated refrigerator recycling line, where ozone depleting substances (ODS) and F-gases are collected from pipes and walls of refrigerators. According to the company specialists, more than 90% of F-gases are collected during the process. All collected ODS and F-gases are exported for further recycling/destruction to Germany. Amount of intentional destruction is considered to be zero, as F-gases destruction is not taking place in Lithuania.

Domestic Refrigeration (CRF 2.F.1.b)

The predominant refrigerant in domestic refrigeration equipment is R-134a, a small number of the appliances are also filled with the refrigerant R-125. Over the past decade, the use of these refrigerants has been limited, so more and more of new equipment is charged with isobutane R600a which does not contain fluorinated gases.

There is only one company manufacturing domestic refrigerators in Lithuania. According to the company data, all domestic refrigerators manufactured by the company are being filled with the refrigerant R600a since 2011. The company started using isobutane (R600a) in 2000. Over the period 2000-2010, part of refrigerators manufactured by company were charged with the refrigerant R-134a, which resulted in fluorinated gas emissions during their assembly/manufacturing process when refrigerators were being filled with the refrigerant. The company provided annual data on sales/production of domestic refrigerators for 2000-2011, specifying number refrigerators filled with R-134a. The use of the refrigerant R-134a for the charging of new equipment during the said period was continuously going down and was completely discontinued from 2011.

According to the study Analysis of the Use of Fluorinated Greenhouse Gases in Lithuania conducted in 2008, the HFCs were not collected in Lithuania until 2007. The first company to start this activity in 2007 was UAB EMP Recycling. Following the company data, refrigerators collected by UAB EMP Recycling account for up to 50% of the total amount of refrigerators discarded in Lithuania. The remaining refrigerators are collected by various companies, however, part of the collected refrigeration equipment is transferred to UAB EMP Recycling.

Following the afore-mentioned Study Analysis of the Use of Fluorinated Greenhouse Gases in Lithuania (2008) and expert judgement, over the period 1986-2002 the refrigerant R12 in domestic refrigeration compressors was gradually replaced by R-134a. The use of R-134a at the beginning of the said period was very insignificant, meanwhile the period 1994-1995 the use of R-134a increased considerably in domestic refrigeration equipment, as witnessed by the experience of other European countries in the production of these domestic appliances. According to the situation described, fluorinated gas emissions from domestic refrigeration equipment have been estimated since 1995.

Since 2015 it is forbidden to supply new domestic refrigeration equipment with HFC's which has greater GWP than 150 (Regulation EU 517/2014). The peak emissions for this category were reached in 2014 and started to decrease (Figure 4-28).

Transport Refrigeration (CRF 2.F.1.d)

Emission sources in transport refrigeration category are refrigerated road vehicles and refrigerated rail vehicles. It is considered that refrigerated road vehicles are: refrigerated trucks, refrigerated vans and refrigerated semi-trailers. HFC gases in refrigeration units in vehicles have been used since 1993. The refrigerant R-404a is a blend, consisting of HFC-125 (44%), HFC-143a (52%) and HFC-134a (4%).

The following companies were surveyed for the 2012 study on the use of HFCs in Lithuania:

1. State enterprise Regitra – in order to obtain missing data on vehicles with refrigeration units registered in Lithuania by class and year of manufacture;

2. companies servicing vehicles with refrigeration units in order to obtain more specific data on the variety of refrigerants used in refrigeration equipment, average charge of refrigerated vehicles by vehicle class, and factors of emission during equipment operation;

3. joint stock company AB Lietuvos geležinkeliai (Lithuanian Railway) – in order to collect data on refrigerated freight wagons and to assess fluorinated gas emissions from refrigeration on the basis of this information;

4. companies which operate shipping containers and reefers – in order to obtain data for the assessment of fluorinated gas emissions.

The EPA database could not be used for the assessment of fluorinated gas emissions from refrigerated vehicles for the following reasons:

- there is no such category of gas use in the EPA 2009-2010 database (it covers both stationary and mobile equipment classified by refrigerant weight); also, not all companies servicing refrigeration units in vehicles submitted reports in 2015 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 (2009-2015) is too short to be able to create an accurate database of the EPA, and assessment of the missing period by way of extrapolation does not show the actual/factual annual consumption and emissions of fluorinated gases (the accuracy would be higher if suppliers and servicing companies provided relevant information);

- information provided by individual companies servicing refrigeration equipment in vehicles does not allow formulating country-specific assumptions and emission factors.

Mobile Air-Conditioning (CRF 2.F.1.e)

Road vehicles with air conditioning are: passenger vehicles, buses and freight vehicles. According to the information provided in the 2012 study on the use of HFCs in Lithuania and the EPA's F-gases database, the refrigerant R-134a has been used in mobile air-conditioning systems since 1993.

The refrigerant R-134a in passenger carriages equipped with air conditioning has been used since 2006. According to the data provided by joint-stock company AB Lietuvos geležinkeliai, at present this company has 27 passenger carriages equipped with air conditioning, with each carriage having a UKV-type air conditioner. The company performs regular maintenance of air conditioners but does not recycle end-of-life equipment. The lifetime of air conditioners is 28 years.

Stationary Air-Conditioning (CRF 2.F.1.f)

Stationary air-conditioning category is divided to air-conditioning and ventilation equipment sub-category and heat pumps sub-category. Main fluorinates gases in this category are: HCF-32, HFC-125 and HFC-134a. Small amounts of HFC-143a also are occurring in stationary air-conditioning.

Data of other countries demonstrate that stationary air conditioning has been used since approximately 1995, therefore, in the absence of other information source, it is reasonable to assume that Lithuania also started using such systems charged with fluorinated gases not earlier than in 1995.

4.7.1.2 Methodological issues

Commercial Refrigeration (CRF 2.F.1.a) and Industrial Refrigeration (CRF 2.F.1.c)

Activity data for 2013-2015 emission calculation are used from annual reports by F-gases operators. According the 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, with the changes made in 2012 every company shall report annually to the Lithuanian Environmental Protection Agency (EPA) on the amount of F-gases charged into the new equipment that year; and the amount of F-gases refilled into equipment in operation that year as well as imported, exported, recycled, regenerated, disposed amounts. All used blends are broken into constituent substances by the companies. Furthermore, company marks sub-category for which substance was used (industrial, commercial, air conditioning etc.).

The following factors and assumptions were used to estimate the emissions from commercial and industrial refrigeration:

- refrigerants charged in the equipment are HFC-125, HFC-143a, HFC-134a and HFC-32;
- the average lifetime of equipment is 15 years;
- emission factor during the initial charging is 3% (*2006 IPCC Guidelines*, Volume 3, part 2, p. 7.52);

- the emission factor during the operation of the equipment is 22.5% for commercial and 16% for industrial refrigeration (it is an average of default factors provided in *2006 IPCC Guidelines*, Volume 3, part 2, p. 7.52);
- initial charge remaining – 90%, recovery efficiency – 70% (*2006 IPCC Guidelines*, Volume 3, part 2, p. 7.52);
- the amount of HFCs refilled into the systems was assumed to be equal to emitted amount that year;
- since the data on amount of HFCs in operating equipment is not known for transparency reasons the data was estimated according to statistical HFCs refill data from EPA database;
- 2013-2015 data were used as a basis for estimation of emissions for 1995-2012 period. The gradual increase of emissions since year 1995 has been used considering the trends in other EU countries.

Estimates of fluorinated gas emission from commercial refrigeration are demonstrated in Figure 4-25 below.

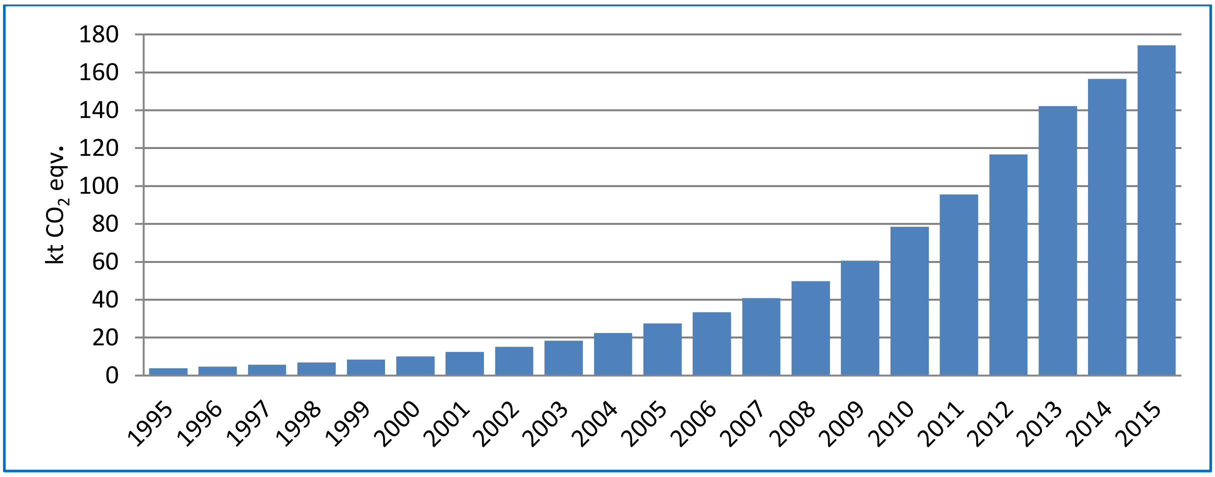


Figure 4-25. Fluorinated gas emissions from commercial refrigeration for 1995-2015

Estimates of fluorinated gas emissions from industrial refrigeration are demonstrated in Figure 4-26 below.

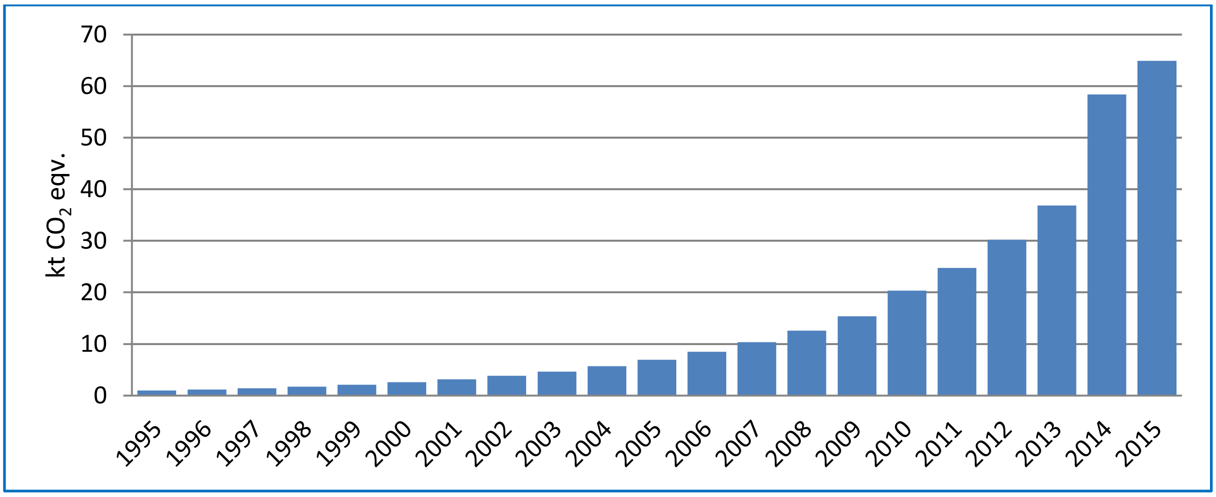


Figure 4-26. Fluorinated gas emissions from industrial refrigeration for 1995-2015

The emissions of fluorinated gases from commercial and industrial refrigeration are provided in Table 4-30.

Table 4-30. Total emissions of fluorinated gases from commercial and indsutrial refrigeration for 1995-2015

Year	Emissions from commercial refrigeration, kt CO_2 eqv.	Emissions from industrial refrigeration, kt CO_2 eqv.
1995	3.77	0.95
2000	10.17	2.57
2005	27.42	6.94
2010	78.44	20.31
2011	95.66	24.77
2012	116.66	30.21
2013	142.27	36.84
2014	156.51	58.40
2015	174.36	64.93

Domestic Refrigeration (CRF 2.F.1.b)

Emissions of fluorinates gas from the charging process of new equipment were estimated using following factors and assumptions provided by company:

- the average charge of the equipment with refrigerant is 120 g;
- the emission factor during the initial charging of new equipment k – 0.5%.

Emissions of HFCs due to the charging process of new equipment were calculated using the following equation (*2006 IPCC Guidelines*, Volume 3, part 2, p. 7.50):

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

where:

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

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

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

Estimates demonstrated in Figure 4-27.

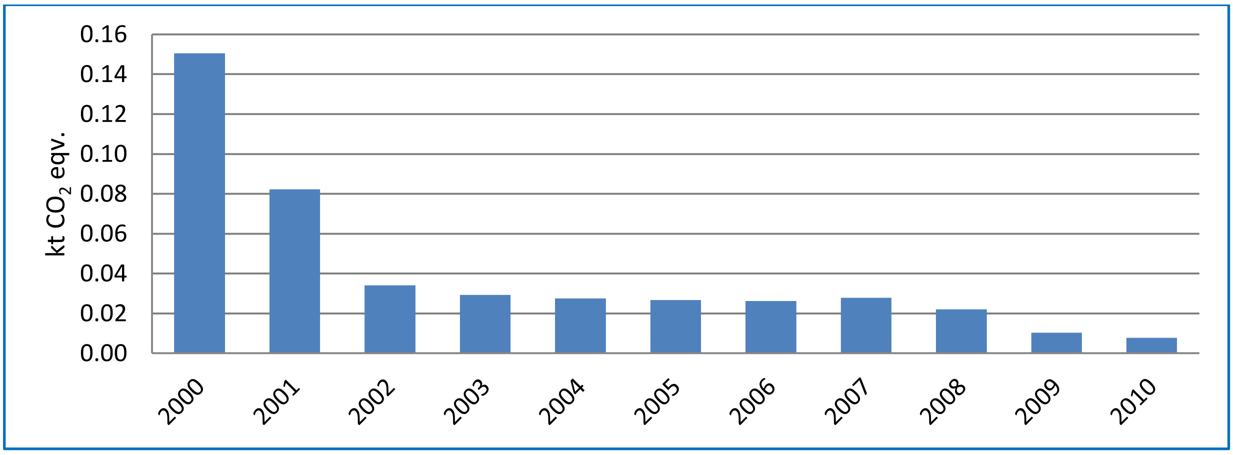


Figure 4-27. Fluorinated gas emissions during the initial charging of refrigerant into domestic refrigerators manufactured by company for 2000-2010

The largest amounts of fluorinated gases (0.15 kt CO_2 eqv.) were emitted in 2000 as a result of rather extensive use of the refrigerant R-134a for the initial charging of domestic refrigerators at the company (about 80% of the total amount used). The use of this refrigerant in the subsequent years gradually went down. The use of the refrigerant R-134a for the charging of new equipment was completely discontinued from 2011.

The following data from Statistics Lithuania was used for the estimation of emissions from the stock of HFCs in existing domestic refrigerators:

- the number of inhabitants in Lithuania;
- the average size of households in Lithuania;
- the percentage of households using domestic refrigerators.

Due to absence of sufficient data for estimating the amount of HFCs charged in domestic refrigerators and the percentage of domestic refrigerators containing HFCs, the following assumptions based on expert judgment were made:

- the average amount of refrigerant charged in a refrigerator is 120 g (data source: AB Snaigė);
- the average amount of refrigerant charged in a freezer is 150 g (according to the data of UAB EMP Recycling, the charge is 30% higher than in refrigerators);
- 13% of refrigerators (of the total number) used to be filled with HFC-134a until 1995. The same assumption is applied to freezers (based on laboratory analysis of gases collected from recycled domestic refrigerators, data source: UAB EMP Recycling);
- 5% of refrigerators (of the total number) used to be filled with HFC-125 until 1995. The same assumption is applied to freezers (based on laboratory analysis of gases collected from recycled domestic refrigerators, data source: UAB EMP Recycling);
- average annual refrigerant loss/leakage is 0.4% of the quantity in stock (emission factor during the operation of the equipment) (revised according to 2006 IPCC Guidelines, Volume 3, part 2, p. 7.52);
- 30% of new refrigerators in 1995-2009 were filled with HFC-134a and since 2010 it started to decrease. The same assumption is applied to freezers;
- 7% of new refrigerators in 1995-2009 were filled with HFC-125 and since 2010 it started to decrease. The same assumption is applied to freezers.

Annual leakage from the stock in the domestic refrigerators was calculated using the following equation (*2006 IPCC* Guidelines, Volume 3, part 2, p. 7.50):

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

where:

$E_{lifetime,\,t}$ – amount of HFCs banked in existing systems in year t, t;

B_t – amount of HFCs banked in existing systems in year t, t;

x – emission factor of HFCs of each sub-application bank during operation, accounting for average annual leakage and average annual emission during servicing, %.

Emissions at system disposal were calculated from 2010 using the following factors and assumptions:

- the average lifetime of the refrigerator and freezers is 20 years (data source: UAB EMP Recycling);
- the recovery efficiency at disposal for refrigerators and freezers is 60 % (data source: UAB EMP Recycling);
- the residual gas amount at system disposal (refrigerators and freezers) is 80% 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*, Volume 3, part 2, p. 7.51):

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

where:

$E_{end\text{-}of\text{-}life,\ t}$ – amount of HFCs emitted at system disposal in year t, t;

$M_{t\text{-}d}$ – 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:

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

Estimated total emissions of fluorinated gases from domestic refrigeration and freezers are provided in Table 4-31.

Table 4-31. Total fluorinated gas emissions from domestic refrigeration for 1995-2015

Year	Emissions from manufacturing kt CO_2 eqv.	Emissions from operation (refrigerators) kt CO_2 eqv.	Emissions from disposal (refrigerators) kt CO_2 eqv.	Emissions from operation (freezers) kt CO_2 eqv.	Emissions from disposal (freezers) kt CO_2 eqv.	Total, kt CO_2 eqv.
1995	NO	0.22	NO	0.02	NO	0.24
2000	0.15	0.31	NO	0.05	NO	0.51
2005	0.03	0.43	NO	0.08	NO	0.55
2010	0.01	0.47	0.91	0.10	0.05	1.52
2011	NO	0.42	0.91	0.09	0.05	1.46
2012	NO	0.43	0.91	0.09	0.05	1.48
2013	NO	0.44	0.91	0.09	0.05	1.48
2014	NO	0.44	0.91	0.09	0.05	1.48
2015	NO	0.43	0.91	0.07	0.05	1.46

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

Estimates of fluorinated gas emissions from domestic refrigerators in Lithuania for 1995-2015 are demonstrated in Figure 4-28 below.

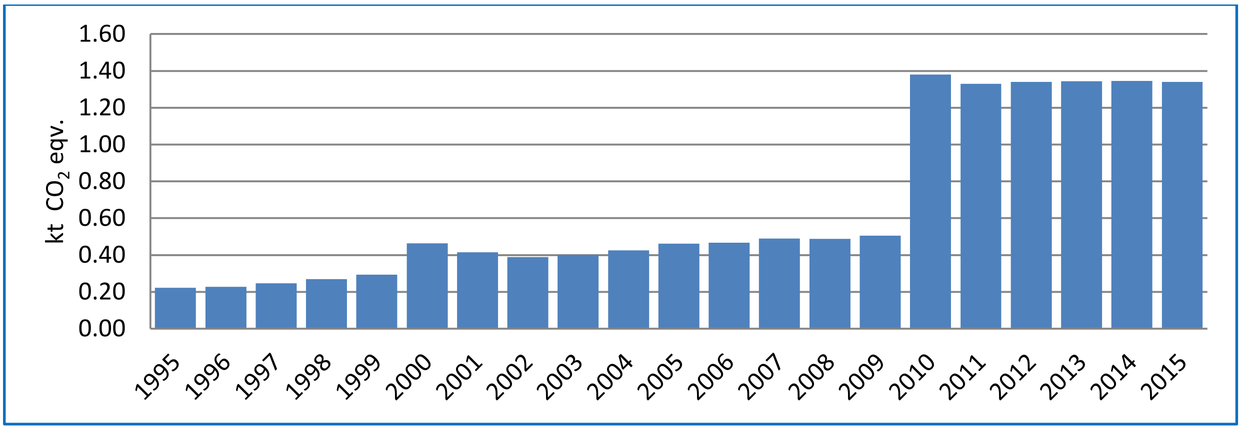


Figure 4-28. Fluorinated gas emissions from domestic refrigerators in Lithuania for 1995-2015

Estimates of fluorinated gas emissions from domestic freezers are demonstrated in Figure 4-29 below.

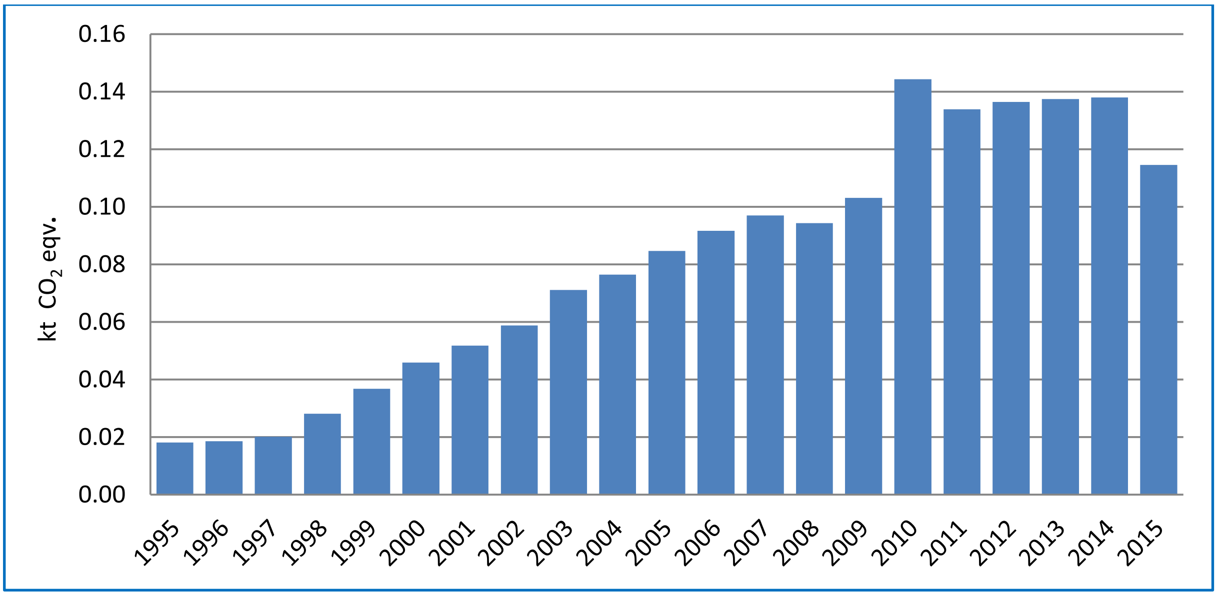


Figure 4-29. Fluorinated gas emissions from domestic freezers in Lithuania for 1995-2015

Transport Refrigeration (CRF 2.F.1.d)

Transport refrigeration category is divided to refrigerated road vehicles and refrigerated rail vehicles sub-categories.

Refrigerated road vehicles

Fluorinated gas emissions from refrigerated road vehicles equipment are assessed following the *2006 IPCC Guidelines*. Assessments are based on the number of refrigerated vehicles registered on the territory of the Republic of Lithuania. The data on vehicles with refrigeration units registered in Lithuania in 1992-2015 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 1993-2015 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 provided below.

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

The emission factor during the operation of the equipment is 30% (2006 IPCC Guidelines, Volume 3, part 2, p. 7.52);
there is no data available for the assessment of the emission factor during equipment servicing, therefore this factor was assumed to be included in the emission factor during operation.

Emissions during lifetime were calculated using the following equation (*2006 IPCC Guidelines*, Volume 3, part 2, p. 7.50):

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

where:

B_t – amount of HFCs banked in existing systems in year t, t;

x – emission factor of HFCs for each sub-application bank during operation, %.

The assessment of emissions of fluorinated gases at system disposal was based on the following assumptions:

the initial charge remaining is 50% (2006 IPCC Guidelines, Volume 3, part 2, p. 7.52);

there is no data available on recycling processes of refrigerated vehicles, therefore recovery efficiency was not assessed.

Emissions at end-of-life were calculated using the following equation (*2006 IPCC Guidelines*, Volume 3, part 2, p. 7.51):

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

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 4-30 below.

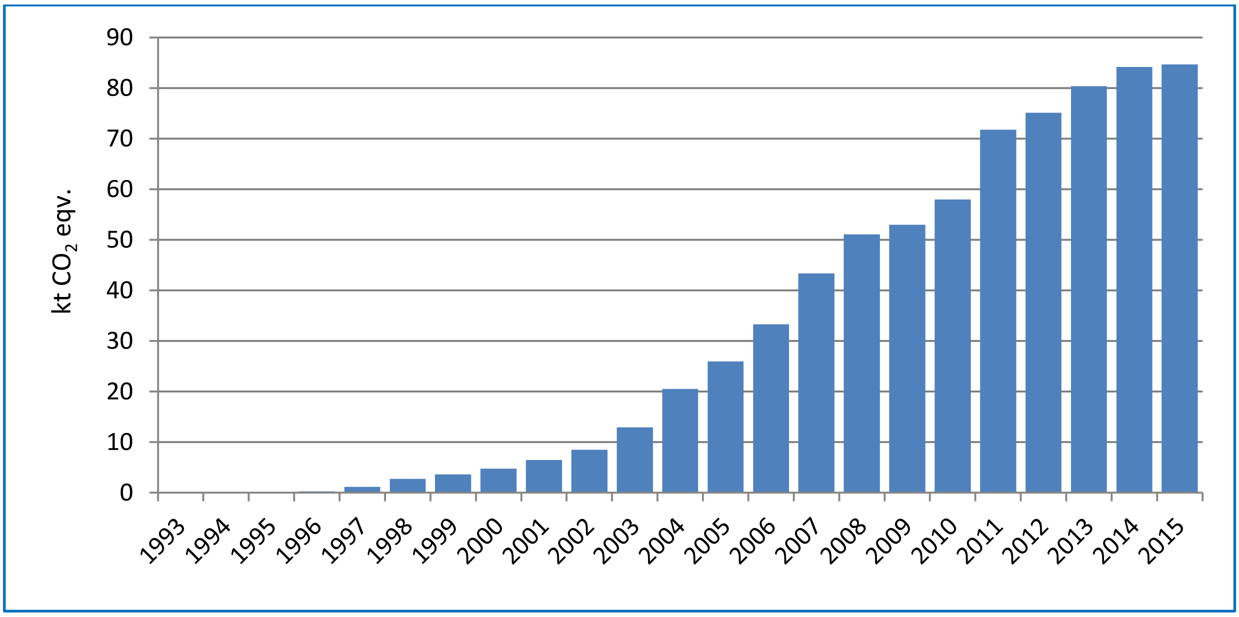


Figure 4-30. Fluorinated gas emissions from refrigerated road vehicles for 1993-2015

Train – freight wagons

The refrigerant R-134s has been used in refrigerated freight wagons since 2006. The number of freight wagons was continuously going down during the period 2006-2012. Radviliškis freight wagon depot of the joint-stock company AB Lietuvos geležinkeliai was contacted to obtain necessary data.

AB Lietuvos geležinkeliai provided the number of refrigerated freight wagons operated in 2006-2013 pointing out that every wagon has two refrigeration equipments. The refrigerant used in most wagons is R-134a. In addition, a small percentage of R-22 is also used, its use is assumed to be around 20%.

There is no data available on the original factory charge therefore the emission factor during the initial charging and the emissions were not assessed.

Freight wagons of Radviliškis freight wagon depot carry goods to Eastern countries riding in Lithuania only a short segment of the whole trip. Upon consultation of the head of the company, it was assumed that only 10% of fluorinated gas emissions during the operation of the refrigeration equipment shall attributed to Lithuania.

The assessment of the emissions during equipment operation was based on the following factors and assumptions provided below.

Pursuant to the data of Radviliškis freight wagon depot of AB Lietuvos geležinkeliai:

- the average amount of refrigerant charged in the equipment is 5 kg;
- the emission factor during the operation of the equipment is 10%.

Other assumptions:

- 80% of all freight wagons are charged with the refrigerant R-134a for the period 2006-2011;
- there is no data available for the assessment of the emission factor during equipment servicing, therefore this factor was assumed to be included in the total emission factor.

Emissions during the lifetime were calculated using the following equation (*2006 IPCC Guidelines*, Volume 3, part 2, p. 7.50):

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

where:

B_t – amount of HFCs banked in existing systems in year t, t;

x – emission factor of HFCs for each sub-application bank during operation, %.

Despite the fact, that the refrigeration equipment in freight wagons is fairly new – operated since 2006 and its lifetime is about 28 years and according to data provided by AB Lietuvos Geležinkeliai some wagons were modernized by removing refrigeration equipment during the period 2009-2012.

The assessment of emissions of fluorinated gases at system disposal was based on the following assumptions:

- the residual charge in the system being disposed is 50% (is calculated according to data provided by AB Lietuvos Geležinkeliai);
- recovery efficiency at disposal is 25% (is calculated according to data provided by AB Lietuvos Geležinkeliai);

Emissions at system disposal were calculated using the following equation (*2006 IPCC Guidelines*, Volume 3, part 2, p. 7.51):

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

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, %. Estimates of fluorinated gas emissions from freight wagons are demonstrated in Figure 4-31 below.

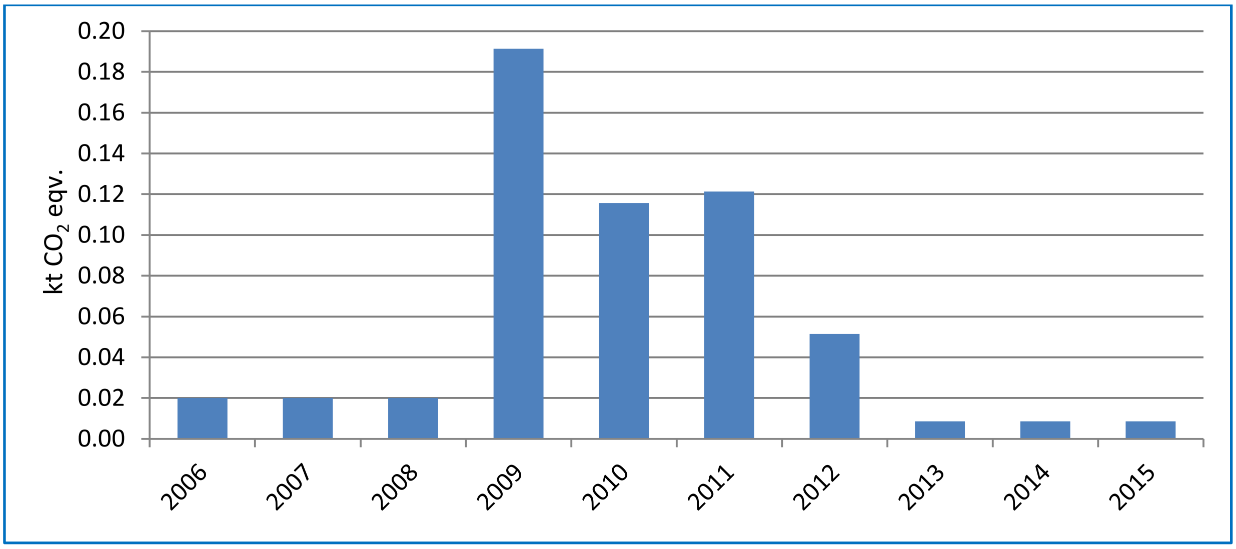


Figure 4-31. Fluorinated gas emissions from freight wagons for 2006-2015

As seen in Figure 4-31 emissions over the period of 2009-2012 were higher than in the period of 2006-2008 and 2013-2015. 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:

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

Estimates of the total fluorinated gas emissions from transport refrigeration are provided in Table 4-32.

Table 4-32. Total fluorinated gas emissions from transport refrigeration for 1995-2015

Year	Emissions from refrigerated road vehicles, kt CO_2 eqv.	Emissions from refrigerated rail vehicles, kt CO_2 eqv.	Total HFC emissions in sub-category, kt CO_2 eqv.
1995	0.14	NO	0.14
2000	4.75	NO	4.75
2005	25.95	NO	25.95
2010	58.01	0.12	58.13
2011	71.77	0.12	71.89

2012	75.11	0.05	75.16
2013	80.41	0.01	80.42
2014	84.18	0.01	84.19
2015	84.66	0.01	84.67

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 2000-2015 is provided by Statistics Lithuania is presented in Figure 4-32.

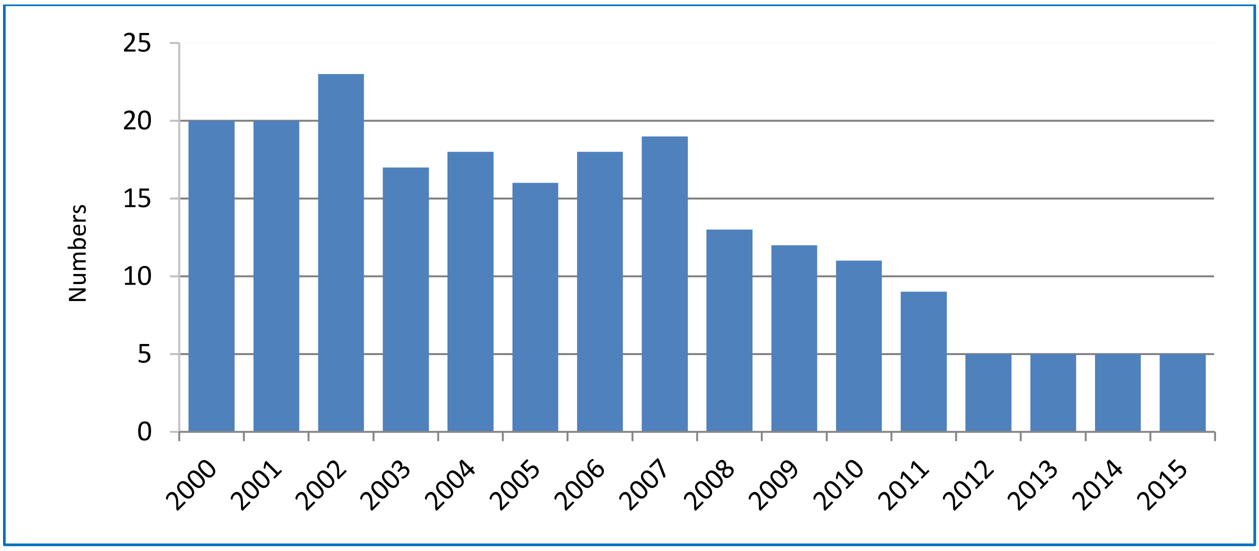


Figure 4-32. Reefer vessels registered in Lithuania in 2000-2015

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.

Mobile Air-Conditioning (CRF 2.F.1.e)

Road vehicles with air-conditioning

Fluorinated gas emissions from this equipment were estimated following the *2006 IPCC Guidelines* and on the basis of the statistical data on vehicles registered in the Republic of Lithuania.

The data on vehicles registered in 1991-2015 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 1993-2015 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 4-33).

Table 4-33. Estimated percentage of vehicles equipped with air conditioning in the stock

Year of manufacture	M1	M2	M3	N1	N2	N3
1990	0%	0%	0%	0%	0%	0%
1995	15%	0%	0%	0%	0%	12%
2000	50%	30%	30%	25%	25%	28%
2005	70%	40%	40%	40%	40%	54%
2010	84%	60%	60%	50%	50%	82%
2011	85%	60%	60%	50%	50%	86%
2012	88%	60%	60%	50%	50%	88%
2013	90%	60%	60%	50%	50%	90%
2014	92%	60%	60%	50%	50%	92%
2015	92%	60%	60%	50%	50%	92%

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 provided below.

Data of a vehicle maintenance company UAB Sadomaksa on the average annual amount of refrigerant in the equipment:

- M2 – buses ≤ 5 t – 8 kg;
- M3 – buses > 5 t – 13 kg;

According to *2006 IPCC Guidelines*, Volume 3, part 2, (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%.

Other assumptions:

- there is no data available for the assessment of the emission factor during equipment maintenance, therefore this factor was assumed to be included in the emission factor during operation.

Emissions of HFCs during the lifetime of the equipment were calculated using the following equation (*2006 IPCC* Guidelines, Volume 3, part 2, p. 7.50, Tier 2a):

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

where:

B_t – amount of HFCs banked in existing systems in year t, t;

x – emission factor of HFCs for each sub-application bank during operation, accounting for average annual leakage and average annual emission during servicing, %.

The assessment of emissions at system disposal was based on the following factors and assumptions:

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.

Other assumptions:

- the residual gas amount in the system being disposed is 50% (*2006 IPCC Guidelines* Volume 3, part 2, p.7.52, Table 7.9);
- there is no data available on recycling of vehicle air-conditioning systems, therefore the factor of recovery efficiency was not estimated.

Emissions at system end-of-life were calculated using the following equation (*2006 IPCC Guidelines*, Volume 3, part 2, p. 7.51):

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

where:

M_{t-d} – amount of HFCs initially charged into new systems installed in year (t-d), t;

p – residual charge of HFCs in equipment being disposed of expressed in percentage of full charge, %.

There are calculated emissions from disposal passenger car (M1), buses ≤ 5 t (M2) and freight vehicles above 12 t – 1.2 kg (N3) with air-conditioning systems filled with HFC-134a in this report. Air conditioning systems of freight vehicles (M3, N1, N2) are also filled with HFC-134a gases, but their lifetime is 21-23 years and emissions at system end-of-life were not calculated.

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 4-33 below.

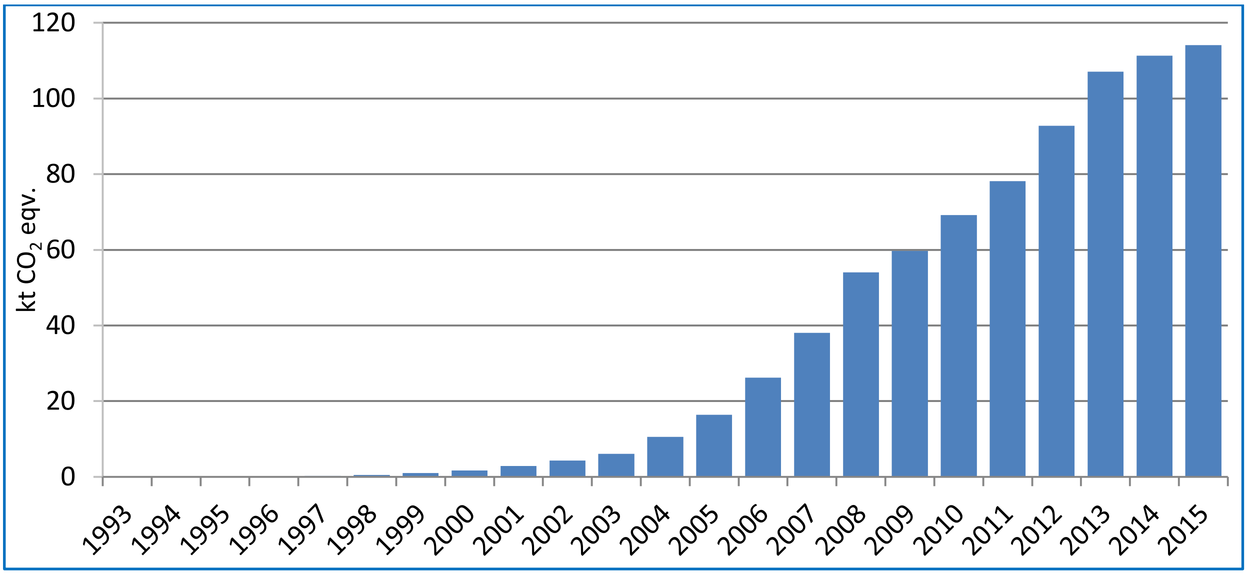


Figure 4-33. Fluorinated gas emissions from vehicles with air conditioning for 1993-2015

Trains – passenger carriages with air conditioning

There is no data available on the original factory charge, therefore the emission factor during the initial charging and the emissions were not assessed.

The assessment of the emissions during the operation of the equipment was based on the following factors and assumptions provided below.

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%.

Other assumptions:

- there is no data available for the assessment of the emission factor during equipment maintenance, therefore this factor was assumed to be included in the emission factor during operation.

Emissions of HFCs during the lifetime of the equipment were calculated using the following equation (*2006 IPCC Guidelines*, Volume 3, part 2, p. 7.50):

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

where:

B_t – amount of HFCs banked in existing systems in year t, t;

x – emission factor of HFCs for each sub-application bank during operation, accounting for average annual leakage and average annual emission during servicing, %.

The air-conditioning equipment installed in passenger carriages which belongs to the company AB Lietuvos geležinkeliai is rather new – it has been used since 2006, its lifetime has not expired yet and so emissions at system disposal were not estimated.

Estimates of fluorinated gas emissions from passenger carriages are demonstrated in Figure 4-34 below.

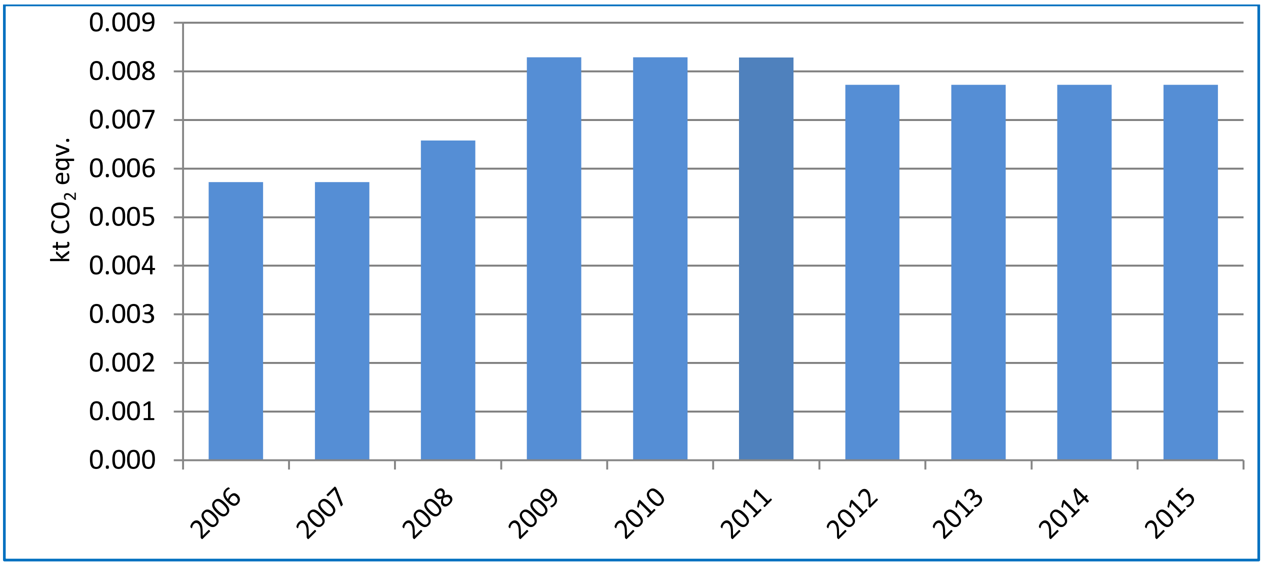


Figure 4-34. Fluorinated gas emissions from passenger carriages for 2006-2015

Total emissions:

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

Estimates of fluorinated gas emissions from mobile air-conditioning systems are presented in Table 4-34.

Table 4-34. Total HFC emissions from mobile air conditioning for the period 1995-2015

Year	Emissions from vehicles with air conditioning, kt CO_2 eqv.	Emissions from rail vehicles with air conditioning, kt CO_2 eqv.	Total emissions, kt CO_2 eqv.
1995	0.12	NO	0.12

2000	1.66	NO	1.66
2005	16.39	NO	16.39
2010	69.15	0.008	69.16
2011	78.14	0.008	78.15
2012	92.81	0.008	92.82
2013	107.11	0.008	107.12
2014	111.32	0.008	111.33
2015	114.14	0.008	114.15

Stationary Air-Conditioning (CRF 2.F.1.f)

Air-conditioning and ventilation equipment

Taking into account the EPA database analysis results obtained during the 2012 study on the use of HFCs in Lithuania, emissions from stationary air-conditioning systems were estimated observing the following recommendations:

- the amounts of HFC-125, HFC-134a, HFC-143a, HFC-32 declared in the EPA database of 2015 are deemed to be annual recharge amounts in air-conditioning systems;
- the amount of gases contained in air-conditioning systems in 2015 = annual recharge *10 (assumption that the annual amount of gases in the systems is ten times larger than the amount of recharge);
- pursuant to the information that refrigerants have been used in stationary air-conditioning systems since 1995 (information provided in national reports of other countries), it was assumed that the initial amount of refrigerants in the systems was 1% as compared to the year 2012. The amounts of refrigerants for 1996-1999 were estimated by way of direct interpolation;
- the emission factor during the operation of the equipment is 10% (upper range limit of the factor given in the *2006 IPCC Guidelines*).

Emissions of HFCs during the lifetime of the equipment were calculated using the following equation (*2006 IPCC Guidelines*, Volume 3, part 2, p. 7.50, Tier 2a):

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

where:

B_t – amount of HFCs banked in the existing systems in year t, t;

x – emission factor of HFCs for each sub-application bank during operation, accounting for average annual leakage and average annual emission during servicing, %.

Emissions from the stationary A/C equipment initial charging and decommissioning were calculated taking into account the following assumptions:

- Based on study „Analysis of the use of fluorinated GHG in Lithuania in 1990-2011" results, it was considered that the lifetime of the stationary A/C equipment is 15 years, which is in the range of lifetime values provided in 2006 IPCC Guidelines (10-20 years). Taking into account that HFCs have been used in stationary A/C equipment in Lithuania since 1995, end-of-life emissions were estimated for 2010-2015years.
- Emissions during the initial charging of stationary A/C were estimated for all-time series, using emission factor 0.6%, which is based on 2012 study on F-gases experts

recommendations (average range limit of the factor given in the 2006 IPCC Guidelines, Volume 3, part 2, Table 7.9, p. 7.52).

- initial charge remaining factor – 80% (2006 IPCC Guidelines, Volume 3, part 2, p. 7.52).
- Recovery efficiency at disposal – 80% is based on expert judgement. After consultations with several refrigeration and A/C equipment servicing companies it was concluded that as a common practice in Lithuania refrigerants from A/C equipment are usually extracted before decommissioning and reused in other systems.

Emissions from end-of-life stationary A/C equipment were estimated using equation (*2006 IPCC Guidelines*, Volume 3, part 2, p. 7.51):

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

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, %.

Estimates of fluorinated gas emissions from stationary air-conditioning systems are demonstrated in Figure 4-35 below.

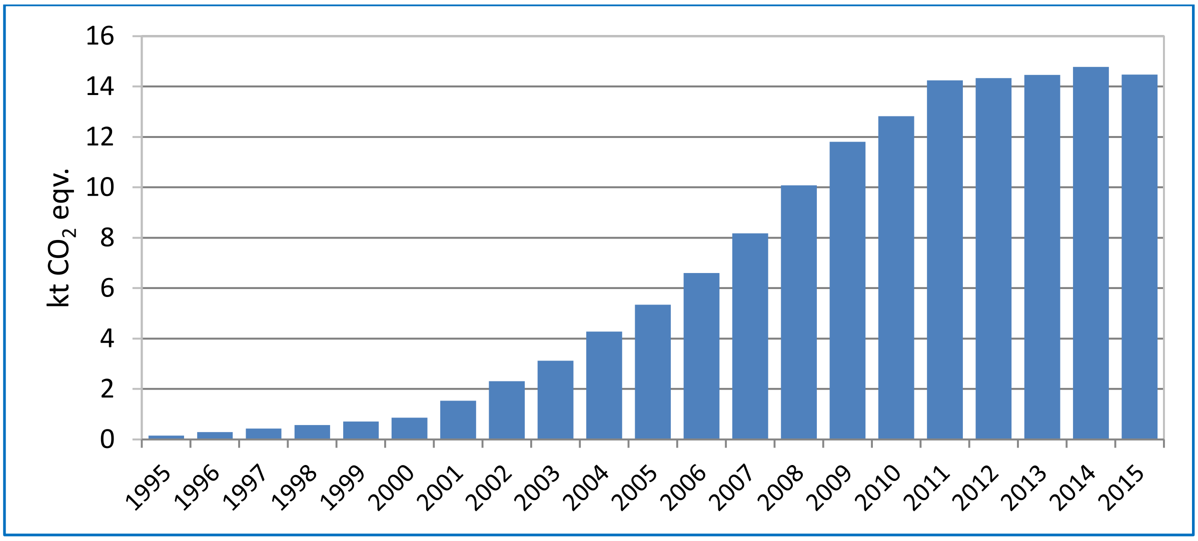


Figure 4-35. Fluorinated gas emissions from stationary air conditioning for 1995-2015

Heat pumps

Lithuanian Geothermal Association and companies which are engaged in installation and service heat pumps were contacted with a request to provide necessary data.

The Lithuanian Geothermal Association provided the following information:

- in Lithuania heat pumps have been installed since 2005, the largest number was installed in 2007 m., (about 700 units), approximately 400 units were installed in 2008;
- the average amount of refrigerant charged in the equipment is about 3 kg, though 6 kg is also possible;

- the main refrigerants are HFC-407C and HFC-410A;
- the lifetime of the equipment is around 15 years;
- there are no leakages of emission during the operation of the equipment.

Companies installing heat pumps consider information on the number of installed heat pumps as confidential information, therefore the only source of information is summary data provided by EurObserv'ER (http://www.eurobserv-er.org/default.asp) (2009-2015) and by Lithuanian Geothermal Association (2005-2008). Following the data provided by private liability companies and by the Lithuanian Geothermal Association, the following assumptions were formulated:

- the proportion of new geothermal/aerothermal pumps installed until 2010 was 75% : 25%, from 2010 – 50% : 50% (the company data) and from 2013 – 70% : 30% (based on EurObserv'ER data);
- the average amount of refrigerant charged in the equipment is 3 kg;
- R-407C accounts for about 80% and R-410A – for approximately 20% of the total amount of refrigerants in geothermal pumps, meanwhile 100% of aerothermal pumps are filled with R-410A;
- in Lithuania heat pumps have been installed since 2005, their lifetime is 15 years, therefore emissions at system disposal were not estimated.

The calculations of emissions during the charging and operation of the equipment were made using the factors in the lower range limit given in the *2006 IPCC Guidelines*:

- the emission factor during the initial charging is 0.2%;
- the emission factor during the operation of the equipment is 1%.

Emissions of HFCs during the initial charging of new equipment were calculated using the following equation (*2006 IPCC Guidelines*, Volume 3, part 2, p. 7.50, Tier 2a):

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

where:

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

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

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

Emissions during lifetime:

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

where:

B_t – amount of HFCs banked in existing systems in year t, t;

x – emission factor of HFCs for each sub-application bank during operation, accounting for average annual leakage and average annual emission during servicing, %

Total emissions:

$$E_{total,t} = E_{charge,t} + E_{lifetime,t}$$

Emissions in this sector were calculated for 2005-2015 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 4-36 below.

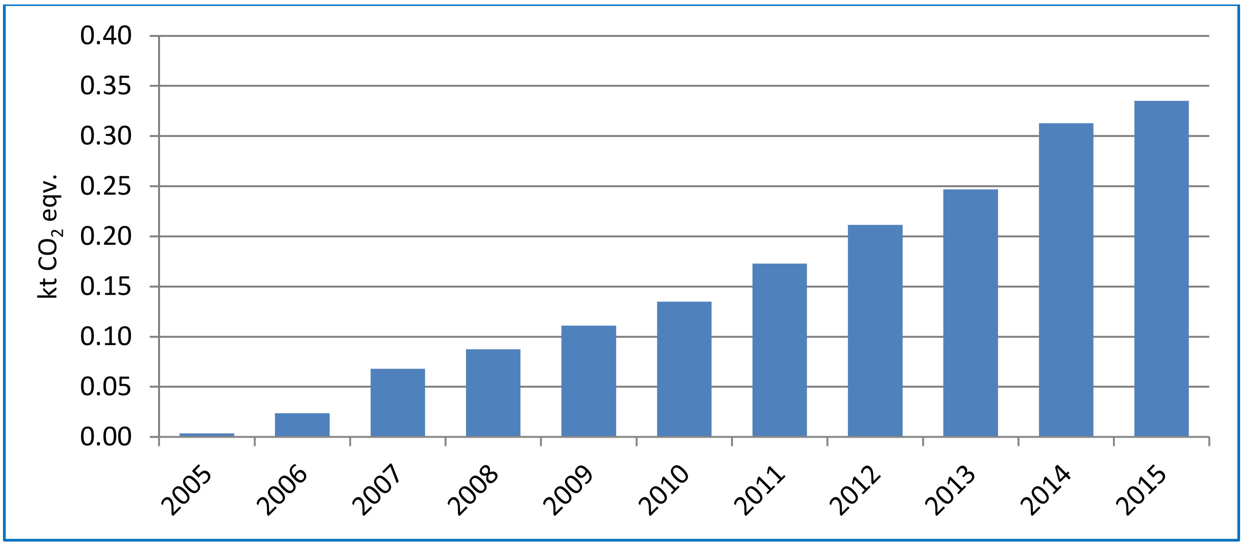


Figure 4-36. Fluorinated gas emissions from heat pumps for 2005-2015

Estimates of total fluorinated gas emissions from stationary air conditioning and heat pumps are provided in Table 4-35. There was increase in number of installed heat pumps according Study carried out by EurObser'ER in 2015, due to the reinstallation of the equipment.

Table 4-35. Total HFC emissions from stationary air conditioning and heat pumps for the period 1995-2015

Year	Emissions from stationary air conditioning, kt CO_2 eqv.	Emissions from heat pumps, kt CO_2 eqv.	Total HFC emissions, kt CO_2 eqv.
1995	0.15	NO	0.15
2000	0.87	NO	0.87
2005	5.34	0.00	5.34
2010	12.83	0.13	12.96
2011	14.25	0.17	14.42
2012	14.33	0.21	14.54
2013	14.46	0.25	14.71
2014	14.78	0.31	15.09
2015	14.48	0.34	14.82

4.7.1.3 Uncertainties and time-series consistency

Uncertainties of acivity data were estimated using Approach 1 of the *2006 IPCC Guidelines* Volume 3 (p. 3.27). Uncertainty activity data is 20% and emission factors uncertainty is 50%.

4.7.1.4 Category-specific QA/QC and verification

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

4.7.1.5 Category-specific recalculations

No recalculations have been done.

4.7.1.6 Category-specific planned improvements

It is planned to continue to review and update the assumptions used to estimate the emissions of F-gases fom 2. F.1 Refrigeration and air conditioning category.

4.7.2 Foam Blowing Agents (CRF 2.F.2)

The 2012 study on the use of HFCs in Lithuania verified the information provided in the last year's National Report that HFCs are not used for foam manufacture in Lithuania. A number of producers of foams for construction or packaging are using BASF technology in which foams are blown by the steam. Lithuanian producer of domestic refrigerators AB Snaigė uses cyclopentane for production of insulation foams.

4.7.2.1 Category Description

Foam blowing agent category is divided into two sub-categories: closed cells (CRF 2.F.2a) and open cells (CRF 2.F.2.b).

Closed Cells (CRF 2.F.2.a)

In this sector HFCs are emitted only from the use of imported foam products containing fluorinated gases. Eleven biggest companies importing foam products were interviewed in 2013. Two companies using closed cell polyurethane (PU) foams (insulation spray) have confirmed the use of products containing F-gases and provided data on the total amount of material used and composition of the F-gases (HFC-365mfc, HFC-134a, HFC-245fa, HFC-227ea). According to the data provided by UAB Termomontažas, actual amounts of F-gases used for the foam blowing constitute 7.5% of the foam material by weight.

Open Cells (CRF 2.F.2.b)

The 2012 study on the use of HFCs in Lithuania verified that HFCs are not used for foam manufacture in Lithuania, so for the category "CRF 2.F.2.b Open Cells" notation key "NO" is used.

4.7.2.2 Methodological issues

Closed Cells (CRF 2.F.2.a)

The following assumptions and calculations were made on the basis of summary information provided by companies and in national reports and literature of other countries:

1. The amounts (import and export) used in Lithuania were estimated following the statistical data on PU foam import and export for 2004-2015provided 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:

a. Variant I: 93% HFC-365mfc, 7% HFC-227ea;
b. Variant II: 95% HFC-365mfc, 5% HFC-245fa;
c. 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 Inventory 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* Volume 3, part 2 (p. 7.35):

d. the first year loss emission factor is 10%;
e. the annual loss emission factor is 4.5%;
f. the lifetime of the system is 20 years, therefore emissions at system disposal were not estimated.

Emissions of HFCs from closed cell foam were calculated using the following equation (*2006 IPCC Guidelines*, Volume 3, part 2, p. 7.33, Tier 2a):

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

where:

M_t *– total HFCs used in manufacturing new closed-cell foam in year t, t;*

EF_{FYL} *– first year loss emission factor, fraction;*

$Bank_t$ *– HFC charge blown into closed-cell foam manufacturing between year t and year t-n, t;*

EF_{AL} *– annual loss emission factor, fraction.*

According to the information received from companies, HCF 141b was used until 2004 (which is verified by data from other countries and literary sources). When the use of this gas was prohibited, other blowing agents were started to be used (HFC-365mfc, HFC-227ea, HFC-245 fa, HFC-134a), therefore emissions in Lithuania were estimated for the period 2004-2015

Estimations of fluorinated gas emissions from closed cell foam are demonstrated in Figure 4-37 below.

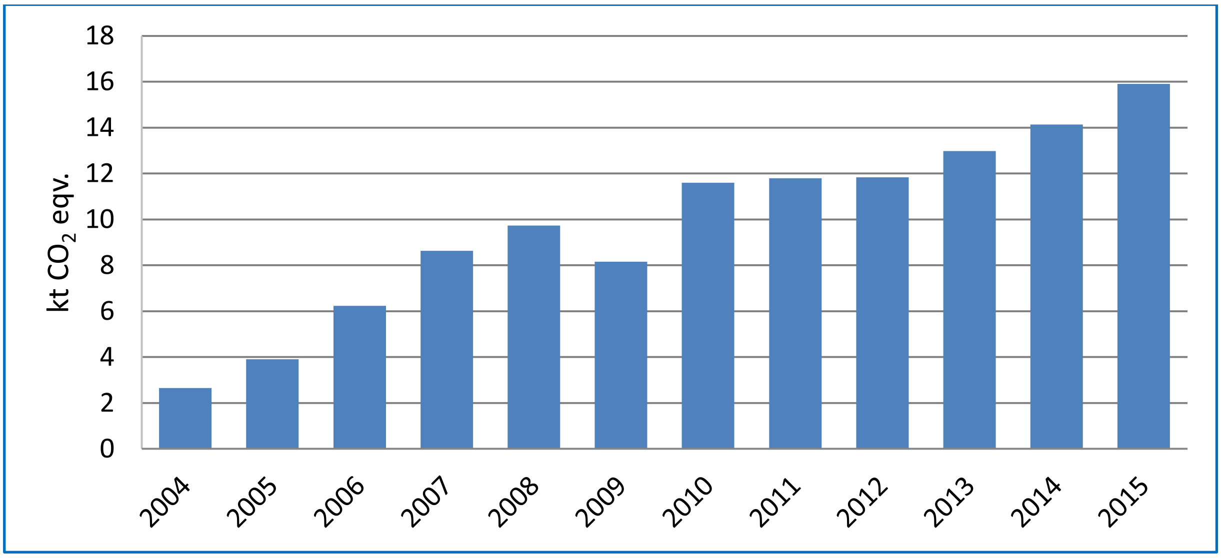


Figure 4-37. Emissions from closed cell foam for 2004-2015

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 4-36.

Table 4-36. Total HFC emissions from foam blowing for the period 2005-2015

Year	Emissions, kt CO_2 eqv.
2005	3.91
2010	11.60
2011	11.79
2012	11.84
2013	12.97
2014	14.14
2015	15.90

4.7.2.3 Uncertainties and time-series consistency

Emission uncertainty was estimated using Approach 1 of the *2006 IPCC Guidelines* (Volume 3, p. 3.27). Uncertainty estimates of activity data and emission factors are presented in Table 4-37.

Table 4-37. Uncertainty (UN) estimates of fluorinated gas emissions in the sub-category of foam blowing

Emission source	Input data UN, %	EF during operation UN, %	Input data UN, %	Recovery EF UN, %	Total emission UN, %
CRF 2.F.2 Foam blowing	30	30	-	-	42

4.7.2.4 Category-specific QA/QC and verification

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

4.7.2.5 Category-specific recalculations

No recalculations have been done.

4.7.2.6 Category-specific planned improvements

Category-specific improvements are not planned.

4.7.3 Fire Protection (CRF 2.F.3)

4.7.3.1 Category Description

The following information on fluorinated gas use in fire protection systems was provided as a result of the Study 2012 and EPA database:

- the main source of fluorinated gases in fire extinguishers is automatic gas systems;
- the main gas is FM 200 (HFC-227ea), which has been used since 1996;
- small amounts of HFC-23 have also been used;
- the average amount of gas contained in one system totals 100 kg, however, the range is 50-500 kg (or even 1.000 kg), therefore it is not appropriate to estimate gas amounts on the basis of the number of installed systems;

- as from the year 2008, basically only FM 200 is use meanwhile FS49C2 (R866) is no longer in use;
- fluorinated gases are not used in new installed fire extinguishing systems;
- systems were triggered by fire or accidentally, when all gasses are emitted into the atmosphere, only once or twice a year, therefore the emission factor used for emission calculations was the one recommended in the *2006 IPCC Guidelines* (1.5%);
- there are no recovery systems yet.

The Ministry of National Defence provided data on the amounts of HFC-236fa contained in fire protection systems installed in vehicles. So far these systems have not been triggered. Emissions were estimated using the emission factor recommended in the *2006 IPCC Guidelines* (1.5%).

4.7.3.2 Methodological issues

Emissions were calculated using the methodology described below. The amounts of FS49C2 and emissions were estimated on the basis of the EPA data because no other data was available. The annual amounts for 2000-2015 were estimated on the basis of the following assumptions:

- the gas has been used since 2000;
- the amount of the gas in 2000 comprised 20% of the amount in 2011;
- the amount of the gas in 2012-2015 is estimated on the basis of the EPA data;
- the gas has not been used in systems since 2007;
- the emission factor is 1.5% (*2006 IPCC Guidelines*).

The annual amounts of HFC-227ea were estimated on the basis of:

- information provided by companies;
- assumption that installation of the systems depends on construction trends (data of Statistics Lithuania on the useful floor area of completed buildings for 2000-2010);
- the amount of the gas in 2011-2015 is estimated on the basis of the EPA data;
- the emissions factor is 1.5% (*2006 IPCC Guidelines*).

The lifetime of the equipment is 20 years (the lifetime of military equipment is longer, 25-30 years) therefore emissions at system disposal were not estimated.

Emissions of HFCs from fire protection systems were calculated using the following equation (*2006 IPCC Guidelines*, Volume 3, part 2, p. 7.61):

$$Emissions_t = Bank_t \times EF$$

where:

$Bank_t$ – bank of agent in fire protection equipment in year t, t;

EF – fraction of agent in equipment emitted each year.

Estimates of fluorinated gas emissions from fire protection systems are demonstrated in Figure 4-38 below.

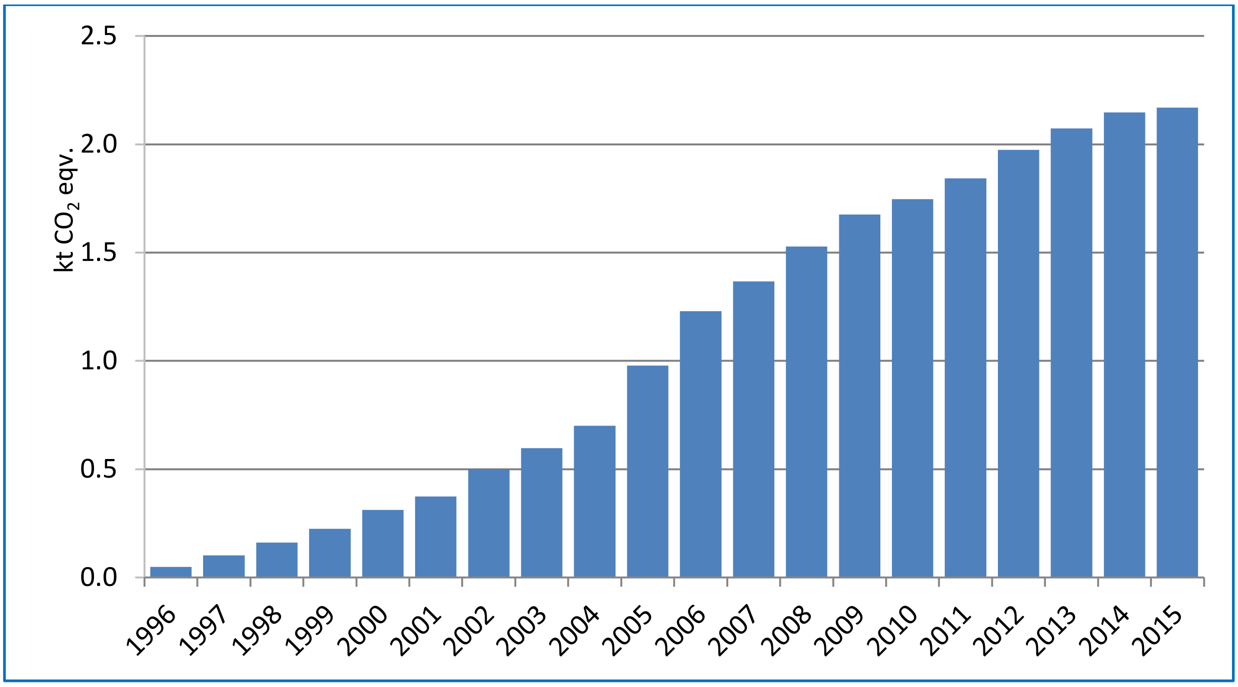


Figure 4-38. Fluorinated gas emissions from fire protection systems for 1996-2015

Emissions were estimated for the period 1996-2015 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 4-38.

Table 4-38. Total HFC emissions from fire protection systems for the period 1996-2015

Year	Emissions, kt CO_2 eqv.
2000	0.31
2005	0.98
2010	1.75
2011	1.84
2012	1.97
2013	2.07
2014	2.15
2015	2.17

4.7.3.3 Uncertainties and time-series consistency

Emission uncertainty was estimated using Approach 1 of the *2006 IPCC Guidelines* (Volume 3, p. 3.27). Uncertainty estimates of activity data and emission factors are presented in Table 4-39.

Table 4-39. Uncertainty (UN) estimates of fluorinated gas emissions in the sub-category of fire protection

Emission source	Input data UN, %	EF during operation UN, %	Total emission UN, %
CRF 2.F.3 Fire Protection	20	20	28

4.7.3.4 Category-specific QA/QC and verification

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

4.7.3.5 Category-specific recalculations

No recalculations have been done.

4.7.3.6 Category-specific planned improvements

Category-specific improvements are not planned.

4.7.4 Aerosols (CRF 2.F.4)

Based on the results of the study "Analysis of the use of fluorinated greenhouse gases in Lithuania in 1990-2011", there are no production of aerosols containing F-gases in Lithuania, all aerosols are imported and products containing F-gases have not been identified. Therefore, only emissions from metered dose inhalers are reported under this sector.

4.7.4.1 Category Description

Aerosols category are divided into two sub-categories metered dose inhalers (CRF 2.F.4.a) and other (CRF 2.F.4.b).

Metered Dose Inhalers (CRF 2.F.4.a)

Data on total annual sales of metered dose inhalers containing HFCs and a specific amount of HFC-134a initially charged in product was obtained from the State Medicines Control Agency under the Ministry of Health of the Republic of Lithuania.

The data was available for the period 2004-2015. Emissions for the period 1995-2003 were extrapolated, taking into account that metered dose inhalers containing F-gases started to be registered in Lithuania's Register of Medicinal Products from 1994 year and making an assumption that emissions in 1995 constituted 50% of emissions in 2004.

Other (CRF 2.F.4.b)

HFC emissions from other aerosols production is not occurring in Lithuania so for the category "CRF 2.F.4.b Other" notation key "NO" is used.

4.7.4.2 Methodological issues

Metered Dose Inhalers (CRF 2.F.4.a)

Emissions of HFCs from metered dose inhalers were calculated using the following equation (*2006 IPCC Guidelines*, Volume 3, part 2, p. 7.28):

$$E_t = S_t \times EF + S_{t-1} \times (1 - EF)$$

where:

S_t – quantity of HFCs contained in aerosol products sold in year t, t;

S_{t-1} – quantity of HFCs contained in aerosol products sold in year t-1, t;

EF – emission factor (fraction of chemical emitted during the first year).

Estimates of fluorinated gas emissions from metered dose inhalers are demonstrated in Figure 4-39 below.

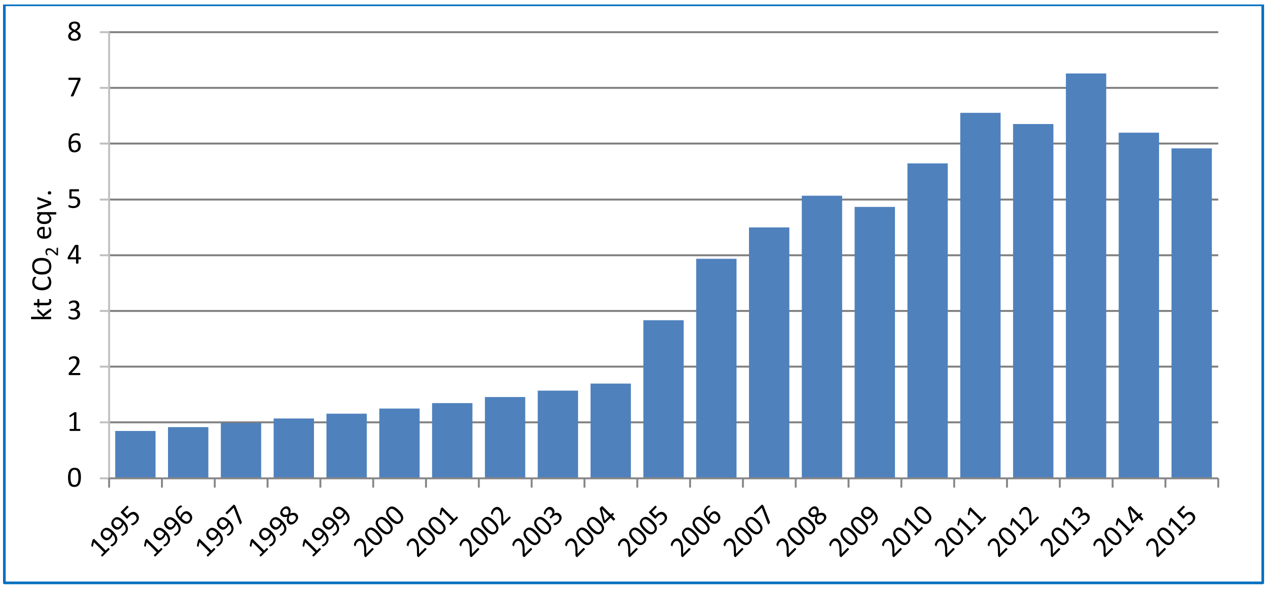


Figure 4-39. Fluorinated gas emissions from metered dose inhalers for 1995-2015

Estimates of HFC emissions from metered dose inhalers are presented in Table 4-40.

Table 4-40. Total HFC emissions from metered dose inhalers for the period 1995-2015

Year	Emissions, kt CO_2 eqv.
1995	0.85
2000	1.25
2005	2.84
2010	5.65
2011	6.55
2012	6.35
2013	7.26
2014	6.20
2015	5.92

4.7.4.3 Uncertainties and time-series consistency

Emission uncertainty was estimated using Approach 1 of the *2006 IPCC Guidelines* (Volume 3, 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 metered dose inhalers

Emission source	Input data UN, %	EF during operation UN, %	Total emission UN, %
CRF 2.F.4.a Metered dose inhalers	5	5	7

4.7.4.4 Category-specific QA/QC and verification

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

4.7.4.5 Category-specific recalculations

No recalculations have been done.

4.7.4.6 Category-specific planned improvements

Category-specific improvements are not planned.

4.7.5 Solvents (CRF 2.F.5)

The two studies of the use of fluorinated gases (2008 and 2012) have not identified any potential area for application for the solvents containing fluorinated gases. Taking into account the experience from other countries it is very unlikely that solvents containing fluorinated gases are used in significant quantities in Lithuania. Therefore notation keys „NA“ (1990-1994) and „NO“ (1995-2015) are used.

4.7.6 Other Applications (CRF 2.F.6)

HFC emissions from other applications are not occurring in Lithuania so for the category "CRF 2.F.6.a Emissive" and "CRF 2.F.6.b Contained" notation key "NO" is used.

4.8 Other product manufacture and use (CRF 2.G)

This section covers emissions of sulphur hexafluoride (SF_6) and nitrious oxide (N_2O). SF_6 is used for electrical insulation and current interruption in equipment used in the transmission and distribution of electricity and in hospitals providing oncological treatment. In 2015 SF_6 emissions were estimated at 0.8 kt CO_2 eqv. N_2O is used for anesthesia and aerosol cans. In 2015 N_2O emissions were estimated at 4.9 kt CO_2 eqv. Emissions of the category were 0.17% of the emissions of the industrial processes sector.

4.8.1 Electrical Equipment (CRF 2.G.1)

4.8.1.1 Category Description

Sulphur hexafluoride (SF_6) is used for electrical insulation and current interruption in equipment used in the transmission and distribution of electricity. Most of the SF_6 used in electrical equipment is used in gas insulated switchgear and substations and in gas circuit breakers.

The Lithuanian energy management system is on continual reorganization. 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 3 companies:

- AB Litgrid, operator of the electricity transmission system;
- AB Lesto, operator of the electricity distribution network;
- AB Lietuvos Energijos gamyba, operator of electrical equipment.

As for 2015, high voltage equipment, which suffers operational losses and requires annual recharge is managed by the company AB Litgrid, AB Lesto and AB Lietuvos Energijos gamyba. Medium voltage equipment is leak proof and will be returned to the manufacturer after the expiry of its lifetime.

These 3 companies 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. SF_6 containing units used in medium voltage grid are hermetic. Leak proof is guaranteed and serviced by the producer. At the end of the service period the units will be returned to the producer. Up until now the companies operating medium voltage grid were not asked to provide any measurements or tests to proof emissions from sealed units.

All companies maintained that the lifetime of their equipment has not expired yet therefore there have been no emissions at system disposal (but even in such case the equipment would be forwarded to the manufacturer).

Private limited liability company UAB Orlen Lietuva and joint stock company AB Lifosa also declared the use of the SF_6 gas in their equipment:

- the SF_6 gas has been contained in high voltage power equipment of AB Lifosa since 2000, no operating losses have been registered so far;
- the SF_6 gas has been contained in many facilities operated by AB Orlen Lietuva for about 15 years, the equipment is hermetic, no maintenance has been required so far (in such case the equipment would be forwarded to the manufacturer).

4.8.1.2 Methodological issues

Following the *2006 IPCC Guidelines*, emissions were estimated using Tier 3 method (on the basis of the data directly obtained from each company) for the period 1995-2015 (first operating losses were registered in 1995).

Estimates of SF_6 emissions in the sub-category of electrical equipment are demonstrated in Figure 4-40 below.

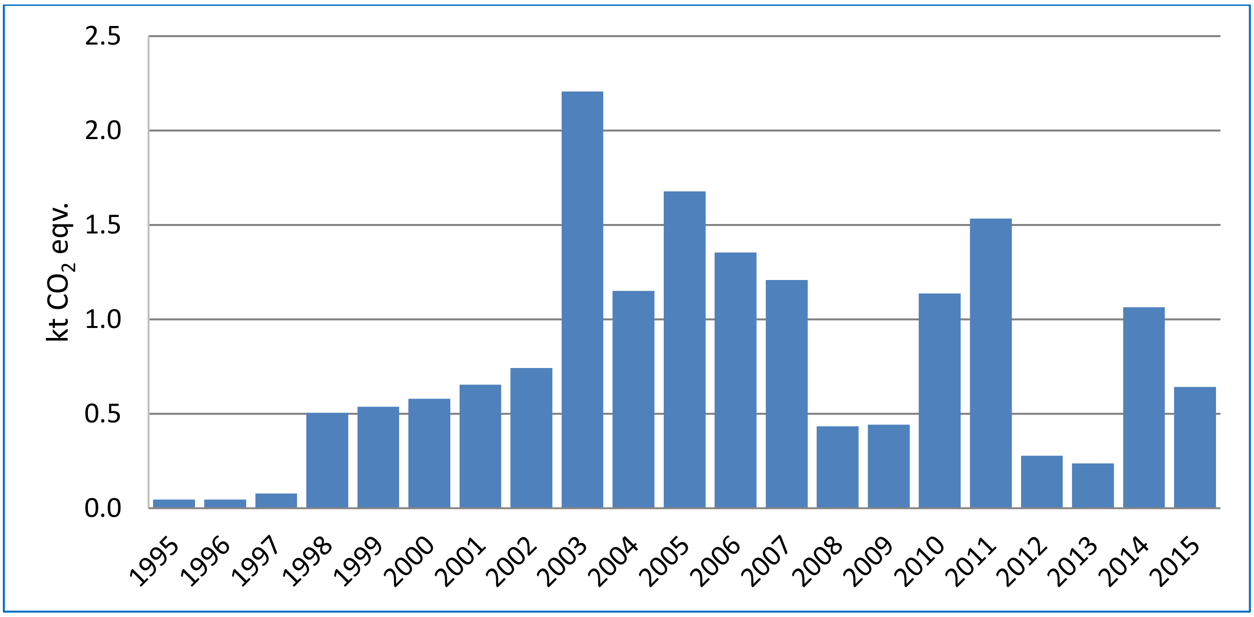


Figure 4-40. SF_6 emissions from electrical equipment for 1995-2015

Operating companies were 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 4-42.

Table 4-42. Total SF_6 emissions from electrical equipment for the period 1995-2015

Year	Emissions, kt CO_2 eqv.
1995	0.05
2000	0.58
2005	1.68
2010	1.14
2011	1.53
2012	0.28
2013	0.24
2014	1.06
2015	0.64

4.8.1.3 Uncertainties and time-series consistency

Emission uncertainty was estimated using Approach 1 of the *2006 IPCC Guidelines* (Volume 3, p. 3.27). Uncertainty estimates of activity data and emission factors are presented in Table 4-43.

Table 4-43. Uncertainty (UN) estimates of SF_6 emissions in the sub-category of electrical equipment systems

Emission source	Input data UN, %	EF during operation UN, %	Total emission UN, %
CRF 2.G.1 Electrical equipment	5	5	7

4.8.1.4 Category-specific QA/QC and verification

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

4.8.1.5 Category-specific recalculations

No recalculations have been done.

4.8.1.6 Category-specific planned improvements

Category-specific improvements are not planned.

4.8.2 SF_6 and PCFs from other Product Use (CRF 2.G.2)

4.8.2.1 Category Description

The entities surveyed during the 2012 study on the use of HFCs in Lithuania also included:

- largest manufacturers of double-glazed windows;
- hospitals providing oncological treatment.

Manufacturers of sound-proof double-glazed windows confirmed that the SF_6 gas is not used in Lithuania. The gas used instead is inert argon (in rare cases – crypton).

The surveyed hospitals which apply radiation therapy for cancer treatment confirmed the use of accelerators containing the SF_6 gas:

- Kauno klinikos, Hospital of Lithuanian University of Health Sciences (5 units);

- Institute of Oncology Vilnius University (4 units);
- Šiauliai County Hospital (1 unit);
- Klaipėda University Hospital (1 unit).

SF_6 gas emissions were estimated based on the data provided directly by the hospitals for 1999-2011 (the first devices were put into operation in 1999).

Emissions increased in 2000, 2003, 2006, 2009, and 2011 due to the use of the equipment Mevatron MD2 in the hospital Kauno klinikos when the total amount of the SF_6 gas was emitted during the replacement of the magnetron. According explanation received from the hospital Kauno klinikos, during the change of magnetron due the specifics of the operation all amount of SF_6 gas is emitted directly to atmosphere. There is no information on the specific years when the magnetron was replaced; however, it is known that it was replaced four times from the start of its operation, so it was assumed that the replacements took place at regular intervals. This equipment was dismantled in 2011.

Estimates of SF_6 emissions from accelerators (in radiation therapy facilities) are demonstrated in Figure 4-41 below.

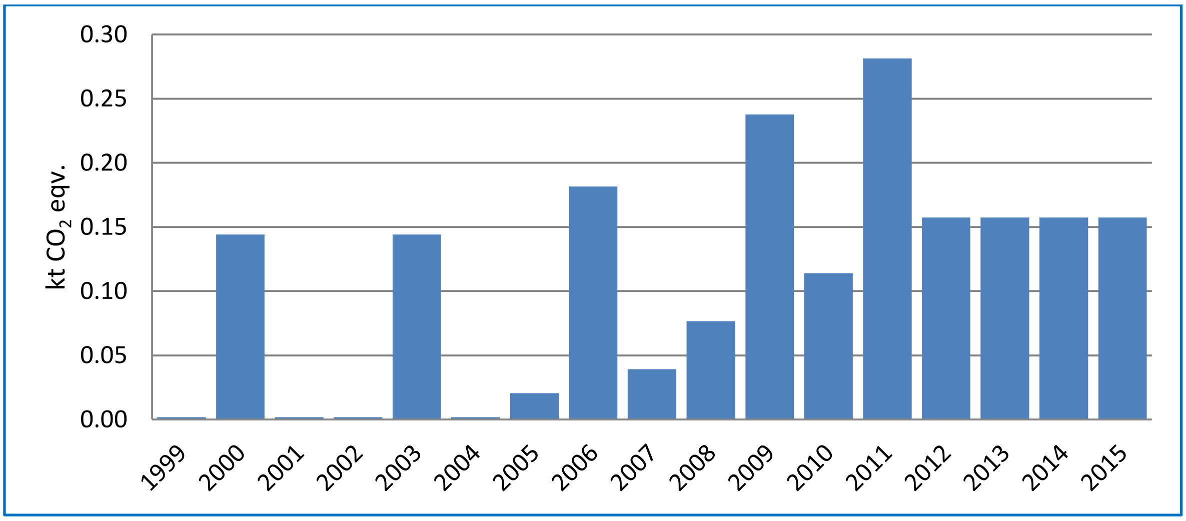


Figure 4-41. SF_6 emissions from accelerators (in radiation therapy facilities) for 1999-2015

Estimates of SF_6 emissions from accelerators (in radiation therapy facilities) are presented in Table 4-44.

Table 4-44. Total SF_6 emissions from accelerators (in radiation therapy facilities) for the period 2000-2015

Year	Emissions, kt CO_2 eqv.
2000	0.14
2005	0.02
2010	0.11
2011	0.28
2012	0.16
2013	0.16
2014	0.16
2015	0.16

4.8.2.2 Uncertainties and time-series consistency

Emission uncertainty was estimated using Approach 1 of the *2006 IPCC Guidelines* (Volume 3, p. 3.27). Uncertainty estimates of activity data and emission factors are presented in Table 4-45.

Table 4-45. Uncertainty (UN) estimates of fluorinated gas emissions from accelerators (in radiation therapy facilities)

Emission source	Input data UN, %	EF during operation UN, %	Total emission UN, %
CRF 2.G.2 SF_6 and PCFs from other Product Use	5	5	7

4.8.2.3 Category-specific QA/QC and verification

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

4.8.2.4 Category-specific recalculations

No recalculations have been done.

4.8.2.5 Category-specific planned improvements

Category-specific improvements are not planned.

4.8.3 N_2O from Product Uses (CRF 2.G.3)

4.8.3.1 Category Description

This category includes emissions from the use of N_2O for anesthesia and N_2O emissions from aerosol cans.

The data from anesthesia on the N_2O sales was available since 2005. Activity data was provided by the State Medicines Control Agency, which collects data from the wholesale companies. Emissions for 1990-2004 were extrapolated with the increasing trend accordingly. Decrease in N_2O emissions since 2008 is related to decreasing number of inhalational anesthesia (N_2O is used only during inhalational anesthesia) comparing with injection anaesthesia, which is more widely used in recent years in Lithuania (Table 4-45).

Currently there is no possibility to collect data from N_2O emissions from aerosol cans in Lithuania. However, N_2O emissions from aerosol cans in Lithuania was estimated based on Belgium data (Belgium greenhouse inventory report, 2014).

4.8.3.2 Methodological issues

N_2O emissions from N_2O used in anesthesia were estimated taking into account amount of N_2O sold in Lithuania. Following the *2006 IPCC*, it was assumed that 100 % of N_2O sold for anesthesia was emitted to the air, therefore activity data is equal to estimated emissions.

According to Belgium inventory report the N_2O emission from aerosol cans was estimated on the basis of the average European consumption (number of food aerosol can/inhab) obtained from DETIC (Belgian-Luxembourg Association of producers and distributors of soaps, cosmetics, detergents, cleaning products, hygiene and toiletries, glues, and related products) for the year 2012. Because of a lack of activity data before 2012, this average consumption is assumed to be constant over time. The activity data (number of aerosol cans) is then calculated for the complete time series on the basis of the number of inhabitant. The emission factor for N_2O is 7.6 g/can (as estimated in the Netherlands on the basis of data provided by one producer) and is assumed to be constant over time. When compared to several countries estimated emissions show comparable value (Figure 4-42).

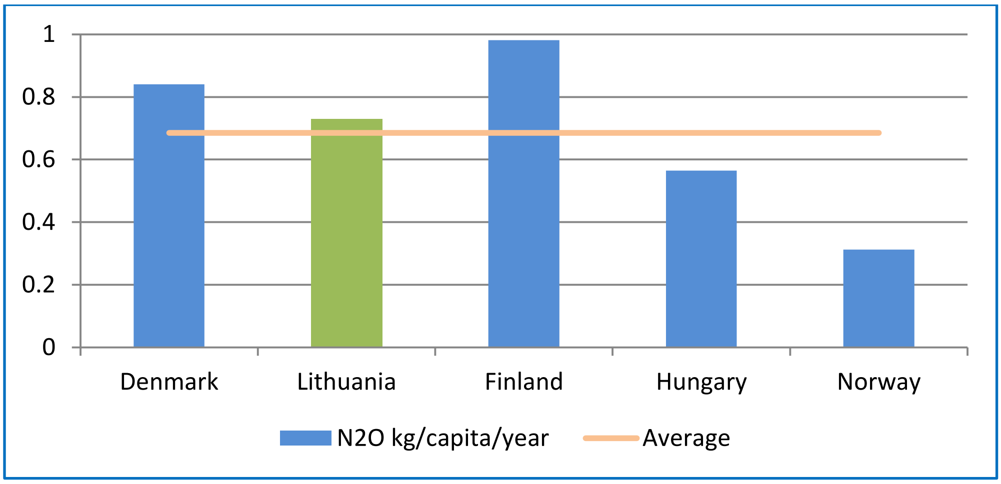


Figure 4-42. Comparison of estimated N_2O kg/capita/year from aerosol cans data with other countries

N_2O emissions from medical applications and from aerosol cans are shown in Table 4-46.

Table 4-46. Estimated N_2O emissions from medical applications and aerosol cans, kt/year

Year	N_2O emissions from anesthesia, kt CO_2 eqv	N_2O emissions from aerosol cans, kt CO_2 eqv
1990	93.35	2.70
1995	84.41	2.65
2000	75.47	2.55
2005	66.53	2.43
2010	3.24	2.26
2011	3.52	2.21
2012	2.50	2.18
2013	2.60	2.16
2014	3.05	2.14
2015	2.77	2.12

4.8.3.3 Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- Uncertainty of activity data is assumed to be 5% for N_2O emissions from N_2O used in anesthesia and 20 % for N_2O emissions from aerosol cans.
- Emission factor uncertainty is assumed to be 5% for N_2O emissions from N_2O used in anesthesia and 100 % for N_2O emissions from aerosol cans.
- Combined uncertainty is 41%.

4.8.3.4 Category-specific QA/QC and verification

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

4.8.3.5 Category-specific recalculations

No recalculations have been done.

4.8.3.6 Category-specific planned improvements

Category-specific improvements are not planned.

4.8.4 Other (CRF 2.G.4)

HFC emissions from other sources are not occurring in Lithuania so for the category "CRF 2.G.4 Other" notation key "NO" is used.

4.9 Other (CRF 2.H)

4.9.1 Pulp and paper industry (CRF 2.H.1)

4.9.1.1 Category Description

In Lithuanian inventory this category includes non-fuel emissions of NOx, NMVOC and SO_2 from paper and pulp production. Pulp was produced in 1990-1993 in a single paper mill. Data on the pulp production was provided by company. Variations of pulp production are shown in Figure 4-43. Pulp is not produced in Lithuania since 1993. From 1994 to 2012 paper and corrugated board used for manufacturing of sanitarian and domestic products are made in the process of recycling the secondary raw material – waste-paper. Paper is produced in two companies in Lithuania.

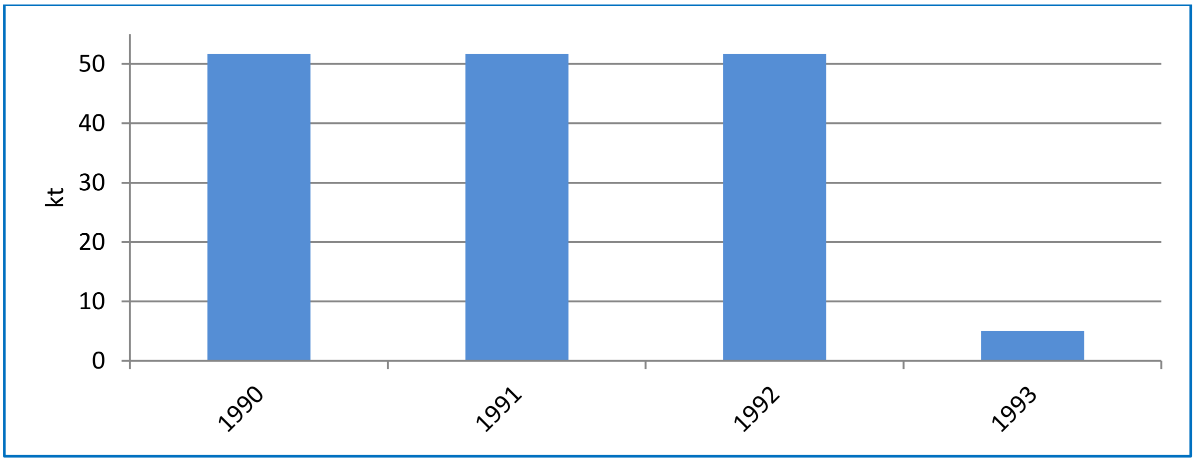


Figure 4-43. Pulp production

4.9.1.2 Methodological issues

Emissions of NO_x, NMVOC and SO_2 from pulp and paper manufacturing were calculated using *EMEP/EEA* emission inventory guidebook 2013. The company used acid sulphite pulping process for production of pulp. NO_x, NMVOC and SO_2 emissions were calculated from pulp production data using default emission factors shown in Table 4-47 (*EMEP/EEA*, 2H1. Pulp and paper industry, Table 3.3, p. 17).

Table 4-47. Emission factors for pulp production

Pollutant	EF, kg/tonne dried pulp
NO_x	2
NMVOC	0.2
SO_2	4

Estimated NMVOC emissions from pulp and paper production were converted to CO_2 using method provided in *2006 IPCC Guidelines* (Volume 1, Chapter 7, box 7.2, p. 7.6). Estimated NOx, NMVOC, CO_2 and SO_2 emissions from pulp production are shown in Table 4-48.

Table 4-48. Estimated emissions from pulp and paper production, kt/year

Year	NO_x	NMVOC	CO_2 eqv.	SO_2
1990	0.103	0.010	0.023	0.207
1991	0.103	0.010	0.023	0.207
1992	0.103	0.010	0.023	0.207
1993	0.010	0.001	0.002	0.020
1994-2015	NO	NO	NO	NO

4.9.1.3 Uncertainties and time-series consistency

All uncertainty estimates of activity data and emission factors have so far been based on expert judgment:

- Uncertainty of activity data is assumed to be 10%;
- Emission factor uncertainty is assumed to be 5%;
- Combined uncertainty is 11.2%.

Historical data on production of pulp was obtained from production company and covers period 1990-1993. Production of pulp was stopped in 1993.

4.9.1.4 Category-specific QA/QC and verification

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

4.9.1.5 Category-specific recalculations

No recalculations have been done.

4.9.1.6 Category-specific planned improvements

Category-specific improvements are not planned.

4.9.2 Food and beverages industry (CRF 2.H.2)

NMVOC emissions from food and beverages industry are from biogenic carbon so for the category "CRF 2.H.2 Food and beverages industry" notation key "NA" is used.

4.9.3 Consumption of carbonates use in flue gas desulphurisation (CRF 2.H.3)

4.9.3.1 Category Description

Information on CO_2 emissions from limestone used for flue gas desulphurization is included in Energy sector (CRF 1.A.1.a) of the NIR.

5 AGRICULTURE (CRF 3)

5.1 Overview of sector

Greenhouse gas (GHG) emissions from agriculture sector in Lithuania include: methane (CH_4) emissions from enteric fermentation of domestic livestock; CH_4 and nitrous oxide (N_2O) (direct and indirect) emissions from manure management; direct and indirect N_2O emissions from managed soils; carbon dioxide (CO_2) emissions from soil liming and application of urea. Direct N_2O emissions from agricultural soils include emissions that occur from application of synthetic nitrogen (N) containing fertilizers, application of organic fertilizers (manure, sewage sludge and compost), N deposited on pasture, range and paddock soils by grazing animals, N that is returned to soil with crop residues, including N-fixing crops and forages, N mineralized from loss in soil organic C, and cultivation of histosols. Indirect N_2O emission sources include emissions from atmospheric deposition and from nitrogen leaching and run-off. Source of CO_2 emissions is liming of soils (lime and dolomite) and application of urea. Rice is not cultivated and savannahs do not exist in Lithuania, therefore reported as "NO" in CRF tables. Field burning of agricultural residues is prohibited by the legislation and reported as "NO".

Key categories analysis was performed using Approach 1 and Approach 2. The results of both analyses are presented in Table 5-1. Analysis showed that thirteen relevant categories from agriculture sector were indicated as the key categories.

Table 5-1. Key category from Agriculture sector in 2015

IPCC Category	*Greenhouse gas*	*Identification criteria*	*Comments **
3.A.1 Enteric Fermentation - Cattle	CH_4	L1,L2,T1,T2	
3.B.1.1 Manure Management - Cattle	CH_4	L1	
3.B.1.3 Manure Management - Swine	CH_4	T1	
3.B.2 Manure Management - Cattle	N_2O		L1sub
3.B.2 Manure Management - Indirect N_2O Emissions	N_2O	L2, T1,T2	
3.D.1.1 Direct N_2O Emissions From Managed Soils - Inorganic N Fertilizers	N_2O	L1,L2,T2	
3.D.1.2 Direct N_2O Emissions From Managed Soils - Organic N Fertilizers	N_2O	L1, T2	
3.D.1.3 Direct N_2O Emissions From Managed Soils - Urine and dung deposited by grazing animals	N_2O	L1,L2,T1,T2	
3.D.1.4 Direct N_2O Emissions From Managed Soils - Crop Residues	N_2O	L1,L2	
3.D.1.6 Direct N_2O Emissions From Managed Soils -Cultivation of organic soils	N_2O	L1,L2,T1,T2	
3.D.2.1 Indirect N_2O Emissions From Managed Soils - Atmospheric deposition	N_2O	L2	

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

Emissions were evaluated using methodology of *2006 IPCC Guidelines*.

In 2015 – 4,600 kt CO_2 eqv. of GHG emissions originated from Agriculture sector. The major part of these emissions (52.9%) comprised from managed soils (Figure 5-1).

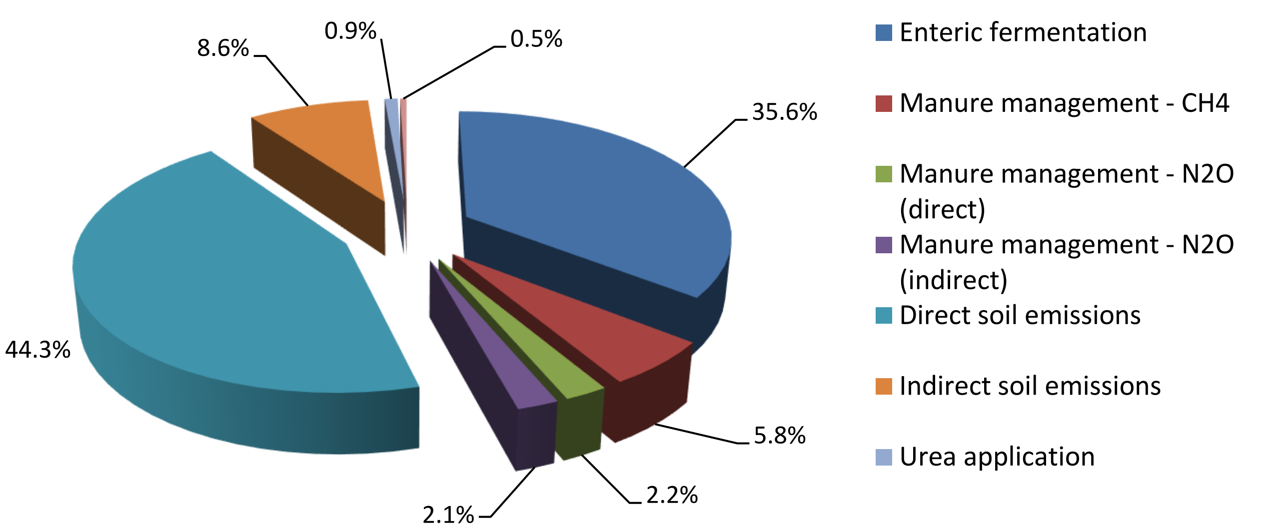


Figure 5-1. The share of emissions by categories from key sources within the sector in 2015, %

In 2015 N_2O emissions contributed 57.2% of the total GHG emission from Agriculture sector. The major part of CH_4 emissions from agriculture sector originates from digestive processes. Enteric fermentation constituted 86.0% of the total CH_4 emissions comprising from Agriculture sector. From 1990 to 2015 emissions from agriculture sector have decreased by 48% (Figure 5-2, Table 5-2). Figure below also presents CO_2 emissions from liming and urea application. These categories contributed 1.4% to the total emissions from Agriculture sector in 2015.

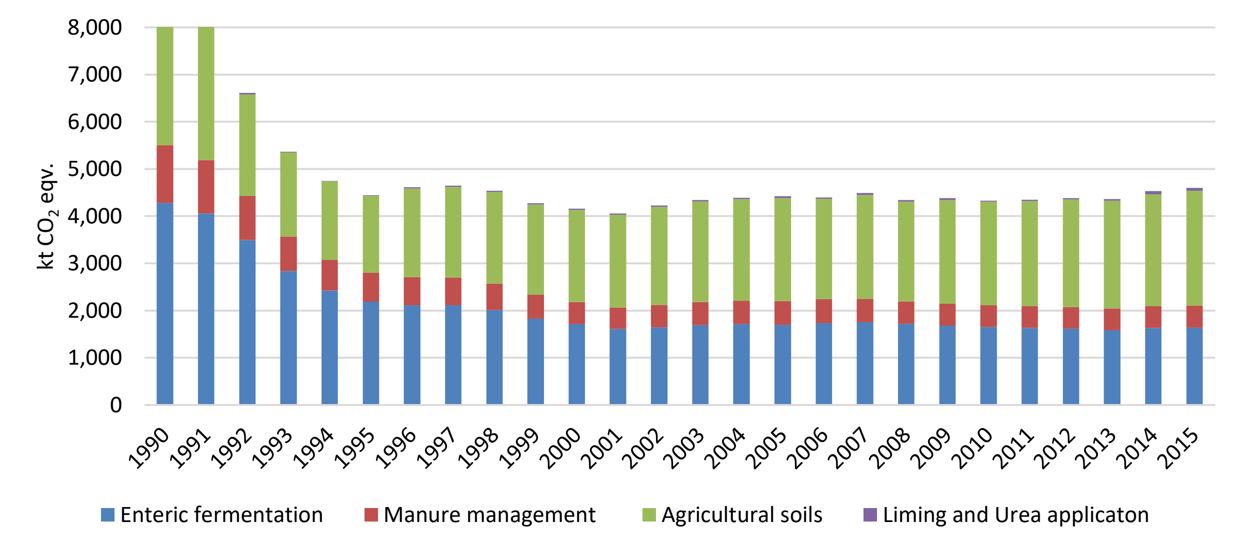


Figure 5-2. Emissions by category during the period 1990-2015

Emissions from Agriculture sector decreased substantially in the beginning of 90's. The agriculture sector contributed 24% of the national GDP in 1992 and employed 19% of the labour force. Lithuania's agriculture, efficient according to the past soviet standards, produced a huge surplus that could not be consumed domestically. Lithuania was producing crops, developing livestock farming and food processing industry. Crops accounted for 1/3 and livestock for 2/3 of the total value of agricultural output. Lithuanian agricultural production was high enough to allow the export of about 50% of the total output.

Significant reforms were introduced in the early 90s, particularly after the restoration of independence. The reform included the re-establishment of private ownership and management in the Agriculture sector. Legislation defined dismemberment of the collective farms, but they did not definitively ensure their replacement by at least equally productive private farms or corporations. Agricultural production decreased by more than 50% from 1989 to 1994. The farms were broken into small holdings, averaging 8.8 ha in size, often not large enough to be economically viable.

Table 5-2. GHG emissions from agriculture sector by sources during the period 1990-2015, kt CO_2 eqv.

Year	Enteric fermentation	Manure management			Agricultural soils		Liming	Urea application	Total
			Direct	Indirect	Direct	Indirect			
	CH_4	CH_4	N_2O	N_2O	N_2O	N_2O	CO_2	CO_2	CO_2 eqv.
1990	4,282.3	622.0	329.6	264.7	2,693.0	629.4	35.7	20.6	8,853.5
1995	2,184.0	343.4	150.1	125.0	1,415.3	213.8	6.7	4.0	4,442.4
2000	1,715.2	266.6	105.1	93.6	1,685.3	267.1	16.5	7.6	4,157.0
2005	1,701.1	290.8	107.1	102.2	1,875.8	305.1	31.5	6.9	4,420.5
2010	1,651.0	269.7	94.2	99.9	1,863.3	329.0	15.8	6.3	4,329.2
2011	1,632.0	266.7	92.6	98.4	1,893.9	338.8	14.2	8.7	4,345.4
2012	1,617.2	264.5	92.6	97.3	1,929.1	352.0	15.8	10.9	4,379.5
2013	1,585.9	265.7	94.1	96.4	1,926.8	356.0	15.8	16.7	4,357.3
2014	1,628.9	264.6	99.6	97.5	1,990.5	382.9	41.0	24.7	4,529.7
2015	1,637.4	266.5	102.9	98.3	2,035.9	395.8	42.5	20.9	4,600.3

After 1990 agricultural companies and enterprises were prevailing types of farming in Lithuania. During the land reform implementation process, the number of agricultural companies and their produced agricultural production amount was constantly decreasing, but the most effective farms were formed during this period. On the contrary, during this period the number of livestock kept in private farms was increasing. In 1996-1997 dairy cattle productivity in private farms was about 3,296-3,301 kg per cow and reached 3,444 kg in 1998, but in 1999 decreased to 3,223 kg and was lower than in agricultural companies and enterprises (3,266 kg). The purchase prices of milk decreased by 8% in 1999 comparing to 1998 and could have an impact on milk productivity indicators. Overall, during 1990-2015 dairy cattle productivity increased by 50.9% calculating whole milk or 53.4% calculating 4% fat corrected milk. Data on average milk yield per year per cow are presented in Table 5-13.

5.2 Enteric fermentation (CRF 3.A)

5.2.1 Category description

CH_4 emission from enteric fermentation of domestic livestock includes emissions from cattle (dairy cattle and non-dairy cattle), sheep, goats, horses, swine, rabbits, fur-bearing animals (minks, foxes and polar foxes) and other (nutria). Under CRF 3.A.4 Other livestock subcategory Other falls nutria. Methods for treating poultry in this context are not yet developed. Population of poultry is presented in Table 5-3 as it is used for calculations in subsector of Manure management. Activity data have been obtained from Statistics Lithuania.

The population of dairy cattle in 2015 has decreased by 63.6% comparing with 1990. In the same time non-dairy cattle population decreased by 72.3%, population of horses decreased by 77.5%, swine population – by 72.8%. The population of sheep increased by 114.0%, goats – by 191.4%. Generally decline of the livestock population was caused by the changes in economy due to collapse of the Soviet Union. However the population of sheep in the past few years increased due to promotion of farming in poorer lands.

Table 5-3. The average annual number of livestock population per year, thous. heads

Year	Dairy cattle	Non-dairy cattle	Sheep	Goats	Horses	Swine	Rabbits	Other (Nutria)	Fur-bearing animals	Poultry
1990	844.9	1,531.2	72.2	4.6	78.9	2,574.6	71.8	39.2	596.6	17,800.6
1995	600.5	545.4	43.0	13.5	77.9	1,264.9	86.1	21.3	387.9	8,715.9
2000	466.3	385.9	15.1	23.9	71.7	901.9	83.9	5.0	175.9	5,614.3
2005	425.2	395.0	30.6	24.5	63.1	1,094.0	98.2	3.5	608.2	8,524.4
2010	367.2	406.4	66.0	15.4	46.8	928.8	105.5	3.1	571.3	10,961.1
2011	354.7	413.2	70.8	15.5	40.5	859.9	100.8	1.9	712.3	10,748.7
2012	340.3	415.8	85.2	14.3	32.9	798.9	98.8	1.0	962.0	10,460.9
2013	323.4	412.3	108.5	13.7	25.8	781.1	101.1	1.4	1,248.4	10,212.7
2014	314.9	423.5	130.0	13.4	20.2	734.4	111.6	1.4	1,496.5	10,414.2
2015	307.3	433.9	154.5	13.3	17.8	701.0	122.8	1.0	1,736.4	10,173.2

CH_4 emissions are primarily related to cattle, which, in 2015 contributed almost 95.3% of the total emission from enteric fermentation (Table 5-4). In 2015 dairy cattle produced 58.3% and non-dairy cattle – 36.8% of CH_4 emissions from enteric fermentation. Emission from swine comprised 1.3 %, horses – 0.5%, sheep and goats –2.6% of the total emission from enteric fermentation.

CH_4 emission from enteric fermentation comprised around 86.0% of the total CH_4 emission from livestock and 41.4% of the total emissions from agriculture sector. In 2015, comparing with 2014, CH_4 emission from enteric fermentation increased by 0.5%. During the period 1990-2015 CH_4 emission from enteric fermentation decreased by 61.8% (Table 5-4).

Table 5-4. CH_4 emissions from enteric fermentation by livestock categories, kt

Year	Cattle		Sheep	Goats	Horses	Swine	Fur-bearing animals, Rabbits and Other (Nutria)
	Dairy	Non-dairy					
1990	85.05	80.88	0.75	0.02	1.42	3.06	0.12
1995	55.69	28.16	0.44	0.07	1.40	1.50	0.10
2000	46.71	19.19	0.16	0.12	1.29	1.07	0.07
2005	45.52	19.55	0.32	0.12	1.14	1.28	0.12
2010	42.04	21.21	0.68	0.08	0.84	1.07	0.12
2011	41.13	21.47	0.73	0.08	0.73	1.01	0.13
2012	40.52	21.54	0.88	0.07	0.59	0.94	0.15
2013	38.86	21.82	1.12	0.07	0.46	0.92	0.18
2014	39.29	23.02	1.35	0.07	0.36	0.86	0.22
2015	38.34	24.10	1.61	0.07	0.32	0.82	0.25

The overall reduction of CH_4 emission was caused by decrease in livestock population, having the greatest impact on emissions (excluding sheep, goats, rabbits and minks). Although the number of sheep, rabbits, minks, partially goats has increased, this augmentation did not have a substantial effect to the reduction in CH_4 emissions. In case of dairy cattle the decrease of population was partly counterbalanced by an increase in productivity of livestock resulting in higher emission per animal.

5.2.2 Methodological issues

5.2.2.1 Choice of methods

Cattle are the most important producer of CH_4 among all domestic animals due to their digestive system, relatively high weight and population comparing to other livestock population. Cattle are the key source due to the contribution to the total GHG emissions. Therefore Tier 2 method was applied in order to estimate CH_4 emission factors (EF) from enteric fermentation of dairy and non-dairy cattle. Tier 2 method was also used for CH_4 EF estimation from enteric fermentation of sheep and swine (Table 5-5). To estimate CH_4 EF from enteric fermentation of goats, horses, rabbits, nutria and fur-bearing animals (minks, foxes and polar foxes) the Tier 1 method was used.

Table 5-5. Information on methods and EF used for estimation of emissions from enteric fermentation

Animal category	Sub-categories			Method applied	Emission factor
Dairy cattle	High-producing			Tier 2	CS
	Low-producing			Tier 2	CS
Non-dairy cattle	Suckling cows			Tier 2	CS
	Less than 1 year old	Calves for slaughter		Tier 2	CS
		For breeding	Bulls	Tier 2	CS
			Heifers	Tier 2	CS
	From 1 to 2 years old	Bulls		Tier 2	CS
		Heifers	For slaughter	Tier 2	CS
			For breeding	Tier 2	CS
	2 years old and older	Bulls		Tier 2	CS
		Heifers	For slaughter	Tier 2	CS
			For breeding	Tier 2	CS
		Other cows		Tier 2	CS
Sheep	Mature Breeding ewes			Tier 2	CS
	Other Mature Sheep (>1 year)			Tier 2	CS
	Ewe over 1 years			Tier 2	CS
	Lambs to 1years			Tier 2	CS
Swine	Breeding sows			Tier 2	CS
	Replacement sows			Tier 2	CS
	Piglets < 2 months (< 20 kg)			Tier 2	CS
	Growing pigs (20-50 kg)			Tier 2	CS
	Growing pigs (50-80 kg)			Tier 2	CS
	Growing pigs (80-110 kg)			Tier 2	CS
	Pigs > 110 kg (8 months and >)			Tier 2	CS
	Gilts for breeding			Tier 2	CS
	Boars			Tier 2	CS
Goats				Tier 1	IPCC
Horse				Tier 1	IPCC
Rabbits				Tier 1	Russian emission factor
Other (Nutria)				Tier 1	Russian emission factor

Fur-bearing animals	Tier 1	Norwegian emission factor

5.2.2.2 Characterization of livestock population

Livestock population data were obtained from the database and publications of Statistics Lithuania (as of 1st of January)[28]. The data given in the database and publications of Statistics Lithuania is collected by applying continuous accountability for agriculture companies and applying sampling methods for farmers and households.

In order to estimate GHG emissions resulting from livestock species (enteric fermentation, CH_4 and N_2O from manure management, and, the direct and indirect N_2O emissions from agricultural soils associated with livestock) livestock population data based on Statistics Lithuania as of 1st of January of each year were recalculated into annual average livestock population according to *2006 IPCC Guidelines* recommendations. For adult animals, population data were based on the average between two years of data on the 1st of January. Annual average population data of growing (grown up to one year and marketed or slaughtered for human consumption) animals were calculated using the equation[29]:

$$AAP = Days\_alive \times \left(\frac{NAPA}{365}\right)$$

where:
AAP – annual average population;
NAPA – number of animals produced annually.

CRF 3.A.4 Other category consists of fur-bearing animals, rabbits and other (nutria) livestock categories. The reason why nutria is called "Other" is that there is no possibility in CRF to rename it to nutria. Therefore, for the clarity purpose, it was decided near Other category in bracket write nutria.

In Lithuanian inventory livestock category cattle (CRF 3.A) consists of dairy cattle and non-dairy cattle. When calculating CH_4 emissions, dairy cattle are divided in to two (high- and low-productivity) subcategories. The number of low productivity cows was determined based on expert judgement.

Non-dairy cattle category, according to database of Statistics Lithuania, consists of 11 subcategories (Tables 5-5, 5-6). For the period 1990-1996 not all information on relevant 11 sub-categories was available in the database of Statistics Lithuania. At that period non-dairy cattle category was divided in to the following sub-categories: bulls, dairy cattle, heifers from 1 to 2 years old, and heifers 2 years and older, therefore the data for this period was calculated proportionally, based on the data of the subsequent years.

[28] Data on livestock population Statistics Lithuania reports as of 1st of January for the previous year, e.g. data reported 1st of January 2015 would represent data of 2014. *Note: this reporting format might, in some cases, be the cause of disparities between national and international databases.*

[29] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, eq. 10.1, p. 10.8

Table 5-6. The annual average number of non-dairy cattle by sub-categories in Lithuania, thous. heads

Year	Cattle sub-categories										
	Suckling cows	Cattle less than 1 year old			Cattle from 1 to 2 years old			Cattle 2 years old and older			Other cows
		For slaughter	Bulls for breeding	Heifers for breeding	Bulls	Heifers for slaughter	Heifers for breeding	Bulls	Heifers for slaughter	Heifers for breeding	
1990	-	360.0	50.4	310.6	236.0	65.3	276.8	58.5	24.6	123.1	25.9
1995	-	155.5	16.8	103.4	78.5	21.7	92.1	19.5	8.2	41.0	8.6
2000	0.2	126.5	14.2	74.6	52.5	18.8	57.7	10.4	4.9	22.0	4.3
2005	3.4	111.4	15.9	91.4	43.1	13.4	74.8	8.5	3.9	26.2	2.9
2010	14.5	84.9	20.0	96.4	44.6	8.1	94.8	6.2	2.4	32.3	2.1
2011	15.8	81.0	21.5	105.6	42.9	7.2	95.9	6.6	2.4	32.2	2.1
2012	17.6	74.2	23.1	115.0	40.6	6.5	97.4	6.3	2.6	30.5	2.1
2013	23.0	70.0	23.3	110.8	41.5	6.3	96.4	6.4	2.4	29.9	2.1
2014	30.4	69.9	23.8	109.1	45.6	5.5	95.3	6.9	2.2	32.4	2.5
2015	36.4	72.7	24.3	103.3	48.6	4.7	97.4	7.1	2.2	34.1	3.2

The average weight of dairy cattle in 1990 was based on expert judgment. Recently, with the aim to increase cow productivity, genetic potential of external breeds, especially Holstein breed bulls has been used more and more widely. Therefore in 2015 the average–weight of most common Lithuanian breeds – black-and-white and red dairy cattle, has been updated and was calculated on the basis of expert judgment. The average weight of other dairy cattle breeds has been calculated using available references[30]. The average weight of dairy cattle during the period 1991-2015 was interpolated (Table 5-7).

Table 5-7. The average weight of dairy cattle during the period 1990-2015, kg

Year	**1990**	**1995**	**2000**	**2005**	**2010**
Weight	575	584	594	603	613
Year	**2011**	**2012**	**2013**	**2014**	**2015**
Weight	615	617	619	621	622

The average weight of suckling cows has been calculated using available data on number of bred breeds of animals and their typical weight, indicated in the reference sources[31]. Weight and weight gain of non-dairy cattle in each sub-category were estimated based on data provided by the expert. Average weight of non-dairy cattle was calculated in accordance with the average weight of each non-dairy cattle sub-category proportionally to its population:

$$m_{average} = \frac{(\sum m_i \cdot population_i)}{population_{total}}$$

where:

$m_{average}$ – average weight of non-dairy cattle, kg;
m_i – average weight of each non-dairy cattle sub-category, kg;
$population_i$ – population of each non-dairy cattle sub-category, thous. heads;
$population_{total}$ – total population of non-dairy cattle sub-category, thous. heads.

Data on average weight of non-dairy cattle is presented in table below (Table 5-8).

Table 5-8. The average weight of non-dairy cattle during the period 1990-2015, kg

Year	**1990**	**1995**	**2000**	**2005**	**2010**
Weight	325	308	290	293	312
Year	**2011**	**2012**	**2013**	**2014**	**2015**
Weight	311	311	317	325	333

Based on expert judgement the average weight gain was estimated for each non-dairy cattle subcategory which remains constant for the whole time period. Basing on this data average weight gain of non-dairy cattle was estimated:

$$w_{average} = \frac{(\sum w_i \cdot population_i)}{population_{total}}$$

where:

$w_{average}$ – average weight gain of non-dairy cattle, kg/day;
w_i – average weight gain of each non-dairy cattle sub-category, kg/day;
$population_i$ – population of each non-dairy cattle sub-category, thous. heads;

[30] Gyvulininkystės žinynas. Baisogala (en. Livestock manual. Institute of Animal Science of LVA), 2007, p. 38-45
[31] Gyvulininkystės žinynas. Baisogala (en. Livestock manual. Institute of Animal Science of LVA), 2007, p. 67-71
Jukna Č., Jukna V. Mėsinių galvijų auginimas (en. Beef cattle rearing), 2004, Kaunas

population$_{total}$ – total population of non-dairy cattle sub-category, thous. heads.

Calculated average weight gain of non-dairy cattle except mature cattle is presented in Table 5-9.

Table 5-9. The average weight gain of non-dairy cattle excluding mature cattle during the period 1990-2015, kg

Year	**1990**	**1995**	**2000**	**2005**	**2010**
Weight gain	0.75	0.75	0.76	0.74	0.73
Year	**2011**	**2012**	**2013**	**2014**	**2015**
Weight gain	0.73	0.72	0.72	0.73	0.73

Total swine population and swine population by sub-categories were obtained from Statistics Lithuania. The annual average population of swine and population by sub-categories were estimated based on 10.1 eq. of *2006 IPCC Guidelines* (vol. 4, ch. 10.2.2 p.10.8). This data are presented in Table 5-3 (total population of swine) and Table 5-10.

Table 5-10. The annual average population of swine by sub-categories in Lithuania, thous. heads

Year	**Sows**		**Piglets till 2 months (20 kg)**	**Growing pigs**			**Pigs > 8 months**	**Boars**	**Gilts for breeding**
	Main*	**Repla-cement**		**20-50 kg**	**50-80 kg**	**80-110 kg**			
1990	136.2	52.8	476.0	621.7	621.2	413.4	190.7	8.6	53.9
1995	65.1	24.9	233.8	304.9	304.6	203.0	97.0	4.2	27.4
2000	44.7	17.0	160.9	213.8	223.1	143.3	76.0	3.5	19.5
2005	65.0	16.2	210.5	267.8	232.2	212.2	72.1	2.0	16.1
2010	57.3	10.6	200.4	225.0	208.0	155.6	55.7	1.4	14.8
2011	49.9	10.6	155.3	228.1	206.9	137.9	55.3	1.2	14.7
2012	42.6	9.8	139.5	214.6	210.7	115.7	51.5	1.0	13.5
2013	41.3	88	133.7	214.4	203.3	116.7	51.0	0.9	11.2
2014	39.6	8,.0	125.7	200.4	174.0	118.9	57.0	0.8	10.1
2015	38.1	7.0	122.3	187.9	169.9	111.9	53.4	0.8	9.6

*Selected for second and subsequent farrowing

The average weight of swine (Table 5-11) was estimated based on the same method as for average weight of non-dairy cattle, based on the weight of market and breeding swine indicated in *2006 IPCC Guidelines*.

Mostly, Western breeds of swine are grown in Lithuania, also significant part of swine is grown in the Danish swine farms. Therefore, swine weigh that is applied in Western Europe was used to calculate the average weight of swine. For marked swine 50 kg and for breeding - 198 kg weight was used[32].

Table 5-11. The average weight of swine during the period 1990-2015, kg

Year	**1990**	**1995**	**2000**	**2005**	**2010**
Weight	64.6	64.2	63.9	63.4	63.4
Year	**2011**	**2012**	**2013**	**2014**	**2015**
Weight	63.2	62.4	61.8	61.8	61.7

[32] 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Vol. 4, Ch. 10, Table 10A-7-10A-8, p.p. 10.80-10.81.

The annual average population of sheep for the period 1990-2015 is reported in Table 5-3. Since the population of sheep by sub-categories in 1990-2006 was not available, it is calculated according to the average data of herd structure in 2007-2015 (Table 5-12).

Table 5-12. The annual average population of sheep by sub-categories, thous. heads

Year	Sheep sub-category				
	Mature ewe	Ewe over 1 years	Ewe lambs to 1 years	Baa-lambs to 1 years	Rams over 1 year
1990	27.0	19.3	14.4	11.5	6.7
1995	16.1	11.5	8.6	6.9	4.0
2000	5.6	4.0	3.0	2.4	1.4
2005	11.4	8.2	6.1	4.9	2.8
2010	24.7	17.6	13.2	10.5	6.1
2011	26.4	18.9	14.1	11.3	6.5
2012	31.8	22.7	17.0	13.6	7.9
2013	40.5	29.0	21.7	17.3	10.0
2014	48.4	35.2	25.8	20.7	12.3
2015	56.3	43.9	30.1	24.1	14.9

5.2.2.3 Calculation of CH_4 emission factors for cattle, swine and sheep

CH_4 emissions from enteric fermentation were calculated using the following equation[33]:

$$CH_{4\,emissions} = \frac{EF_{(T)} \cdot N_{(T)}}{10^6}\ (kt\ CH_4\ yr^{-1})$$

where:
$EF_{(T)}$ – emission factor for each animal category, kg head^{-1} yr^{-1};
$N_{(T)}$ – the number of head of livestock species/category in the country;
T – species/category of livestock.

National emission factors for dairy and non-dairy cattle were calculated in accordance with *Tier 2* method using the following equation[34]:

$$EF = \frac{(GE \cdot (\frac{Y_m}{100}) \cdot 365)}{55.65}$$

where:
EF – emission factor, kg CH_4 head^{-1} yr^{-1};
*G*E – gross energy intake, MJ head^{-1} day^{-1};
Y_m – methane conversion factor, percent of gross energy in feed converted to methane (for high productivity dairy cattle and non-dairy cattle were assumed to be 6.5%[35], for low productivity dairy cattle and suckling cows were assumed to be 7.5%, for mature sheep and lambs to 1 year – 6.5% and 4.5%[36] respectively, for swine – 0.6%). CH_4 conversion factor for calves up to ten[37], lambs up to five[38] and piglets up to five-seven[39] days were assumed to be zero as they are consuming only milk;

[33] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, eq. 10.19, p. 10.28
[34] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, eq. 10.21, p.
[35] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Table 10.12, p. 10.30
[36] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Table 10.13, p. 10.31
[37] Gyvulininkystės žinynas. Baisogala (en. *Livestock manual. Institute of Animal Science of LVA*), 2007, p. 104

55.65 – energy content of methane, MJ/kg CH_4.

Estimated average values of methane conversion factor for cattle, swine and sheep are presented in Annex VII, Table A. 5-1.

Inter-annual CH_4 EF for dairy cattle in the enteric fermentation, as well as fluctuation in the GE values, are mainly determined by the milk yields. Milk yield, gross energy, and EF are closely related. Strong positive relationships between milk yield and gross energy as well as between milk yield and emission factors (Pearson r=0.999, P<0.0005) were estimated. Positive relationship (r=1.0, P<0.0005) between gross energy and EF was estimated.

Feeding situation, milk yield and fat content in milk were used in calculations of CH_4 EF for dairy cattle. GE for entire period was calculated on the basis of feed accumulation standards[40].

Average milk yield per cow are presented in Table 5-13.

Table 5-13. Average milk yield and milk fat content during the period 1990-2015

Year	Milk yield (kg head^{-1} year^{-1})	Milk yield (kg head^{-1} day^{-1})	Fat content (%)
1990	3.734	10.23	4.10
1995	3.010	8.25	4.10
2000	3.673	10.06	4.13
2005	4.312	11.81	4.11
2010	4.901	13.43	4.17
2011	5.026	13.77	4.17
2012	5.227	14.32	4.20
2013	5.315	14.56	4.21
2014	5.665	15.52	4.20
2015	5.636	15.44	4.21

Calculating gross energy for dairy and non-dairy cattle, gross energy for 1 kg of separate forage was calculated according to the equation[41]:

$$GE = 0.0239 \cdot CP + 0.0398 \cdot C_{Fat} + 0.0201 \cdot C_{Fiber} + 0.0175 \cdot NFE$$

where:
GE – gross energy, MJ / kg in DM;
CP – crude protein, g/kg in DM;
C_{Fat} – crude fat, g/kg in DM;
C_{Fibre} – crude fibre, g/kg in DM;
NFE – nitrogen-free extracts, g/kg in DM.

GE of each feed was estimated by multiplying GE per kg of respective feed with amount of dry matter of that feed[42].

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[38] Zapasnikienė, B. Mitybos normos avims ir ožkoms (en. *Nutrition rates for sheep and goats*). 2 lentelė, p. 11
[39] Gyvulininkystės žinynas. Baisogala (en. *Livestock manual*. *Institute of Animal Science of LVA*), 2007, p. 281
[40] Gyvulininkystės žinynas. Baisogala (en. *Livestock manual*. *Institute of Animal Science of LVA*), 2007, p. 616
[41] Kulpys H., Šeškevičienė J., Jeroch H. Žemės ūkio gyvulių ir paukščių mitybos fiziologinės reikmės (en. *Agriculture livestock and poultry nutrition physiological needs*). Kaunas, 2004, p. 30
[42] Kulpys H., Šeškevičienė J., Jeroch H. Žemės ūkio gyvulių ir paukščių mitybos fiziologinės reikmės (en. *Agriculture livestock and poultry nutrition physiological needs*). Kaunas, 2004.

$$GE_{EachFeed} = \frac{GE \cdot (F_{quantity} \cdot DM)}{365}$$

where:
$GE_{EachFeed}$ –gross energy of the total amount of respective feed
GE – the amount of gross energy for 1 kg of respective feed, MJ/kg feed;
$F_{quantity}$ DM – the amount of forage during the year, kg (expressed in dry matter).

To receive total feed GE the amounts of GE of each feed consumed per day was summed. Nutrition standards for dairy cattle depends on productivity[43] (Table 5-14).

Table 5-14. Nutrition standards for dairy cattle

Item	Quantity of milk/4% of milk fat/day		
	10	**15**	**20**
Dry matter, kg	12.7	15.1	17.0
Crude protein, g	1,524	2,038	2,550
Crude fat, g	279	362	459
Crude fiber, g	3,048	3,473	3,740
Nitrogen-free extract (in accordance by used feeds, identifeed based on the study data)	6,350	7,420	8,990

Intermediate values were interpolated

The diet nutrition parameters for dairy cattle that were used to estimate gross energy are presented in Annex VII, Table A. 5-2. Impact of milk yield on GE and EFs are presented in Annex VII, Figure A. 5-1. Estimated average gross energy intake for dairy cattle is presented in Table 5-15.

Table 5-15. Average gross energy intake for dairy cattle, MJ/head/day

Year	**1990**	**1995**	**2000**	**2005**	**2010**
Gross energy	233.9	215.0	232.2	248.9	267.1
Year	**2011**	**2012**	**2013**	**2014**	**2015**
Gross energy	270.7	278.0	280.8	291.6	291.5

The average daily feed intake for each subcategory of non-dairy cattle was calculated on the basis of amount of feed which are fed to cattle[44] and according to the feed accumulation standards. These data is indicated in the national reference book of livestock production[45] according to national zootechnical activity data – weight and weight gain.

The diet nutrition parameters for non-dairy cattle used to estimate gross energy are given in Table 5-16. The information on the composition of rations for non-dairy cattle are given in Annex VII, Table A. 5-3. – Table A. 5-13.

Inter-annual fluctuations of CH_4 EF for non-dairy cattle is mainly determined by the fluctuations of average weight of non-dairy cattle. Negative relationship between EF and weight gain: Pearson $r=-0.87$ ($P<0.0005$) was estimated. However, positive relationship ($r=0.969$, $P<0.0005$) between EF and weight of non-dairy cattle was estimated.

[43] Gyvulininkystės žinynas. Baisogala (en. *Livestock manual*. *Institute of Animal Science of LVA*), 2007, p. 616
[44] Juška, R. *et al.* Studija „Lietuvos mėšlo tvarkymo sistemose susidarančių metano ir azoto suboksido kiekio tyrimai ir įvertinimas" (en. *Survey and evaluation of methane and nitrous oxide emission content in manure management systems of Lithuania. Study*), 2012
[45] Gyvulininkystės žinynas. Baisogala (en. *Livestock manual*. *Institute of Animal Science of LVA*), 2007, p. 616

Table 5-16. Average diet nutrition indicators for non-dairy cattle, kg/kg DM

Sub-category	Crude protein	Crude fat	Crude fiber	Nitrogen free extracts	DM kg/day
Suckling cows	1.473	0.319	3.472	5.928	12.44
Cattle to 1 year for slaughter	0.754	0.201	0.941	2.190	4.48
Bulls to 1 year for breed	0.748	0.197	0.129	2.788	5.59
Heifers to 1 year for breed	0.704	0.179	0.977	2.002	4.26
Bulls from 1 to 2 years	1.476	0.322	2.496	4.755	10.15
Heifers from 1 to 2 years for slaughter	1.229	0.299	2.279	3.701	8.65
Heifers from 1 to 2 years for breed	1.020	0.237	2.272	3.302	7.66
Bulls at 2 years	1.238	0.238	2.333	5.217	9.64
Heifers at 2 years for slaughter	1.409	0.317	2.664	4.133	11.49
Heifers at 2 years for breed	1.430	0.295	2.224	4.602	9.43
Dairy cattle for slaughter	1.681	0.418	3.425	4.902	13.0

Average gross energy intake for non-dairy cattle subcategories are given in Table 5-17.

Table 5-17. Calculated average gross energy intake for non-dairy cattle subcategories, MJ/head/day

Cattle sub-categories		Gross Energy
Suckling cows		221.4
Cattle less than 1 year old	For slaughter	83.3
	Bulls for breeding	100.4
	Heifers for breeding	78.6
Cattle from 1 to 2 years old	Bulls	181.5
	Heifers for slaughter	151.8
	Heifers for breeding	137.3
Cattle 2 years old and older	Bulls	177.3
	Heifers for slaughter	171.2
	Heifers for breeding	171.2
Other cows		211.5

The pasture-cowshed time estimations are based on the data of the national zootechnical activity data[46,47]. Estimated CH_4 EF for enteric fermentation of dairy cattle using country specific data and *Tier 2* method are presented in Table 5-18.

Table 5-18. Calculated average emission factors for dairy cattle, kg CH_4/head/year

Year	**1990**	**1995**	**2000**	**2005**	**2010**
EF	100.66	92.75	100.17	107.05	114.48
Year	**2011**	**2012**	**2013**	**2014**	**2015**
EF	115.97	119.06	120.18	124.77	124.78

Estimated EF for dairy cattle vary across the time period due to the changes in milk yield and feed consumption (Annex VII, Table A. 5-14). During the period 1990-2015 emission factor increased 24%, however total emission decreased by 55% due to the decrease in dairy cattle

[46] Gyvulininkystės žinynas (en. *Livestock manual*). Mokslas, Vilnius, 1976, p. 98-99
[47] Tarvydas V. *et al.* Šėrimo normos, pašarų struktūra ir sukaupimas galvijams (en. *Feeding rate, feed composition and accumulation for cattle*). Vilnius, 1995, p. 4.

population by 64%. The values of CH_4 EF's during the period 1990-1993 has decreased due to the reduced productivity of dairy cattle. During the period 1994-1998 EF has increased however in 1999 EF has decreased again as productivity of milk per head has decreased.

EF for non-dairy cattle subcategories are presented in Table 5-19.

Table 5-19. EF from enteric fermentation of non-dairy cattle sub-categories, kg CH_4/head/year

Cattle sub-categories		Emission factor
Suckling cows		108.91
Cattle less than 1 year old	For slaughter	34.53
	Bulls for breeding	41.63
	Heifers for breeding	32.59
Cattle from 1 to 2 years old	Bulls	77.38
	Heifers for slaughter	64.72
	Heifers for breeding	58.53
Cattle 2 years old and older	Bulls	75.57
	Heifers for slaughter	72.99
	Heifers for breeding	72.99
Other cows		90.17

Estimated EF for non-dairy cattle vary across the time period due to the distribution of animals in subcategories (Table 5-20).

In estimation of EF for enteric fermentation of non-dairy cattle it was determined that weaning age of calves is up to ten days[48]. At this age they are nourished by milk only, therefore CH_4 conversion factor was assumed to be zero.

Table 5-20. Calculated emission factors for non-dairy cattle, kg CH_4/head/year

Year	**1990**	**1995**	**2000**	**2005**	**2010**
EF	53.46	50.14	48.10	48.23	51.12
Year	**2011**	**2012**	**2013**	**2014**	**2015**
EF	51.08	51.52	51.31	51.40	51.28

In estimation of CH_4 emission from swine, gross energy was estimated on the basis of feed accumulation standards presented in the national reference book for animal production[49].

Gross energy for swine was estimating using the same method as for cattle. Average diet nutrition indicators used to estimate gross energy for subcategories of swine are provided in Table 5-21.

Table 5-21. Average diet nutrition indicators for swine used to calculate gross energy, kg/kg DM

Sub-category		**Crude protein**	**Crude fat**	**Crude fibre**	**Nitrogen-free extracts**	**DM kg/day**
Sows mated	Main	0.274	0.069	0.175	1.207	1.85
	Replacement	0.313	0.080	0.158	1.287	1.74
Sows nursing young	Main	0.919	0.342	0.330	2.944	5.02
	Replacement	1.056	0.397	0.384	3.431	5.83
Piglets to 28 days (<10 kg)		0.004	0.001	0.0005	0.001	0.02

[48] Gyvulininkystės žinynas. Baisogala (en. *Livestock manual*. *Institute of Animal Science of LVA*), 2007, p. 104
[49] Gyvulininkystės žinynas. Baisogala (en. *Livestock manual*. *Institute of Animal Science of LVA*), 2007, p. 263-298.

Growing pigs		0,315	0.060	0.084	1.138	1.63
Boars	Mature	0.366	0.083	0.173	1.367	2.1
	Young for breed	0.385	0.093	0.543	1.359	2.13
Pigs for breed		0.320	0.080	0.144	1.215	1.83

Tables showing chemical composition of diets for swine are provided in Annex VII, Table A. 5-15 – Table A. 5-23.

Estimated average gross energy intakes and EF for swine subcategories are provided in Table 5-22. Estimated average gross energy intake and EF for total swine category are presented in Table 5-23.

Table 5-22. Calculated average gross energy intake and emission factors for swine sub-categories

Sub-category		**GE (MJ/head/day)**	**EF (kg CH_4/head/year)**
Sows mated	Main	33.27	1.31
	Replacement	36.35	1.43
Sows nursing young	Main	93.74	3.69
	Replacement	108.79	4.28
Boars	Mature	39.44	1.55
	Young for breed	39.96	1.57
Piglets (to 28 days)	Nursery (to 28 days)	0.32	0.01
Growing-finishing		31.41	1.24
Pigs for breed		34.99	1.38

Table 5-23. Average gross energy intake and EF for swine

Year	**GE (MJ/head/day)**	**EF (kg CH_4/head year)**
1990	30.28	1.19
1995	30.11	1.18
2000	30.08	1.18
2005	29.82	1.17
2010	29.35	1.15
2011	29.83	1.17
2012	29.83	1.17
2013	29.84	1.17
2014	29.83	1.17
2015	29.77	1.17

In estimation of EF for enteric fermentation of swine it was determined that weaning age of piglets is up to five-seven days[50]. At this age they are nourished by milk only and CH_4 conversion factor was assumed to be zero. Estimated EF for swine vary across the time period due to distribution of animals in subcategories.

The diet nutrition indicators for sheep are provided in Table 5-24. Gross energy was estimated using the same method as for cattle. Estimated average gross energy intake and EF for sheep are provided in Table 5-25. In estimation of EF for enteric fermentation of sheep it was determined that weaning age of lambs is up to five days[51]. At this age they are nourished by milk only and CH_4 conversion factor was assumed to be zero. Chemical composition of diets for sheep are provided in Annex VII, Table A. 5-24 – Table A. 5-27.

[50] Gyvulininkystės žinynas. Baisogala (en. *Livestock manual. Institute of Animal Science of LVA*), 2007, p. 281

[51] Zapasnikienė, B. Mitybos normos avims ir ožkoms (en. *Nutrition rates for sheep and goats*). 2 lentelė, p. 11

Table 5-24. Average diet nutrition indicators for sheep used to calculate gross energy, kg/kg DM

Sub-category	Crude protein	Crude fat	Crude fiber	Nitrogen-free extracts	DM kg/day
Mature Breeding ewes	0.244	0.055	0.504	0.864	1.82
Ewe over 1 years	0.198	0.047	0.468	0.753	1.60
Lambs	0.15	0.03	0.22	0.469	0.94
Rams	0.273	0.061	0.549	0.942	2.01

Table 5-25. Average gross energy intake and EF of sheep

Sub-category	GE (MJ/head/day)	EF (kg CH_4/head/year)
Mature ewes	33.07	14.10
Ewe over 1 years	28.07	11.97
Lambs to 1years	15.80	4.28
Rams over 1 years	36.44	15.54

5.2.2.4 Calculation of CH_4 emission factors for other animals

Contribution of other livestock category to the whole CH_4 emission from enteric fermentation is very small compared to cattle category, therefore CH_4 emission from enteric fermentation of goats and horses are estimated using *Tier 1* method. As no default *2006 IPCC* or national EF for fur-bearing animals, rabbits and Other (nutria) are available, the Norwegian EF for fur-bearing animals and Russian emission factors for rabbits and other (nutria) categories were used in calculations (Table 5-26).

Table 5-26. Default EF for other livestock categories used for CH_4 calculations from enteric fermentation

Livestock category	EF (kg CH_4/head/year)	Reference
Goats	5	*2006 IPCC*. Table 10.10, p. 10.28
Horses	18	*2006 IPCC*. Table 10.10, p. 10.28
Rabbits	0.59	Russian NIR 2014. Table 6.6, p. 199
Other (Nutria)	0.35	Russian NIR 2014. Table 6.6, p. 199
Fur-bearing animals (foxes, polar foxes, minks)	0.1	Norway's NIR 2014. Table 6.7, p. 259

5.2.3 Uncertainties and time-series consistency

Uncertainties of CH_4 emissions from enteric fermentation are estimated based on the uncertainty of livestock population and emission factors uncertainty.

Activity data uncertainty

Activity data on livestock population for the whole time period was collected from Statistics Lithuania. Data provided by Statistics Lithuania is collected by applying continuous accountability for agriculture companies and applying sampling methods for farmers and households. The subject of research is about 10 thousand farms what constitutes about 4% of registered farms in the statistical database. The simple random stratified sampling has been chosen from the elements of population list for the research. If the livestock population is smaller than 1,000 thousand heads, or if the population of cattle is smaller than 500 thousand heads, 5% accuracy requirements are applied according to the regulation of the European Parlament and of the Council No 1165/2008 concerning livestock and meat statistics requirements.

Complete data on swine and non-dairy cattle herd structure is available only since 1997-1998 from the statistical sources, therefore for the calculations of gross energy intake of swine and non-dairy cattle categories the constant values of 1997-1998 herd structure data were used in order to estimate and fill the gap of 1990-1996 period.

Overall uncertainty for activity data for enteric fermentation is assumed to be ±5%.

Emission factor uncertainty

Emission factors which are not based on country-specific data may be highly uncertain. Emission factors estimated using simple *Tier 1* method may be uncertain to ±30-50%[52]. Emission factors estimated using the *Tier 2* method is likely to be in the order of ±20%[53].

The uncertainty of emissions factors of dairy cattle, calculated according to *2006 IPCC Guidelines* eq. 3.1. It is estimated that uncertainty of emission factor for dairy cattle category is likely to be in order of ±11.2%, for non-dairy cattle - ±12.7%, for sheep - ±18.1%, for swine - ±12.9%.

Overall uncertainty

Combined uncertainty was calculated using *2006 IPCC Guidelines* eqv. 3.1[54]. This approach requires uncertainty values of the main activity data used and uncertainty of emission factor. Combined uncertainty was estimated to be ±20.6%.

5.2.4 Category-specific QA/QC and verification

Quality control procedures were conducted by performing checks in activity data for the whole time period, consistency check of data entered in CRF with calculation sheets, trends of emissions for each category, relevance of methodology applied. The results for the year 2014 as well as data quality and reliability were evaluated by comparing them to the 2014 data of neighbouring countries.

The gross energy intake for dairy-cattle's was verified using values reported by the neighbouring countries (Table 5-27). Comparing results obtained in 2014 it can be seen that CH_4 emission factor from enteric fermentation of dairy cattle category is approximately comparable to Latvia's EF's. Also, Latvia showed similar productivity of cows. Estonia showed higher emission factors, however Estonia also showed higher productivity of dairy cattle. The CH_4 emission factor from enteric fermentation of swine (1.03 kg CH_4/head/year) is approximately comparable to Estonia's EF's (0.99 CH_4/head/year). Latvia and Poland used *2006 IPCC* default emission factor.

Table 5-27. Comparison of EF and other parameters of CH_4 emissions calculation from enteric fermentation of dairy cattle

Country	Milk yield (kg/head/day)	GE intake (MJ/head/day)	EF (kg CH_4/head/year)
Estonia	22.56	337	143
Latvia	19.06	318.68	135.86
Lithuania (in 2014)	15.52	291.63	124.77
Poland	-	261.59	111.52

[52] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, p. 10.28
[53] *2000 IPCC Agriculture, p. 4.28*
[54] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 3, eq. 3.1, p. 3.28

5.2.5 Category-specific recalculations

In order to increase consistency of used methodologies for calculation of emissions from enteric fermentation, the gross energy intake and emission factor of dairy cattle for the period 1990-2014 has been recalculated considering productivity of dairy cattle subcategories (Table 5-28).

Table 5-28. Reported in previous submission and recalculated gross energy (MJ/head/day) and CH_4 EF (kg CH_4/head/year) from enteric fermentation of dairy cattle

Year	2016 submission		2017 submission		Absolute difference		Relative difference	
	Gross energy (MJ/head /day)	CH_4 EF (kg CH_4/head /year)	Gross energy (MJ/head /day)	CH_4 EF(kg CH_4/hea d/year)	Gross energy (MJ/head /day)	CH_4 emission factors (CH_4/head/ year)	Gross energy, %	CH_4 emission factors, %
1990	233.86	100.66	233.86	100.66	0.00	0.00	0.00	0.00
1991	226.83	97.61	226.81	97.64	-0.02	0.03	-0.01	0.03
1992	216.60	93.27	216.59	93.30	-0.01	0.03	0.00	0.03
1993	211.92	91.29	211.89	91.35	-0.03	0.06	-0.01	0.07
1994	212.63	91.64	212.60	91.71	-0.03	0.07	-0.01	0.08
1995	215.00	92.66	214.96	92.75	-0.04	0.09	-0.02	0.10
1996	216.60	93.28	216.54	93.40	-0.06	0.12	-0.03	0.13
1997	219.77	94.60	219.72	94.72	-0.05	0.12	-0.02	0.13
1998	224.49	96.65	224.45	96.75	-0.04	0.10	-0.02	0.10
1999	220.56	94.94	220.50	95.07	-0.06	0.13	-0.03	0.14
2000	232.30	100.07	232.25	100.17	-0.05	0.10	-0.02	0.10
2001	237.80	102.36	237.71	102.51	-0.09	0.15	-0.04	0.15
2002	240.21	103.31	240.12	103.47	-0.09	0.16	-0.04	0.15
2003	241.04	103.58	240.95	103.74	-0.09	0.16	-0.04	0.15
2004	245.82	105.57	245.74	105.73	-0.08	0.16	-0.03	0.15
2005	249.02	106.89	248.93	107.05	-0.09	0.16	-0.04	0.15
2006	253.77	108.86	253.67	109.04	-0.10	0.18	-0.04	0.17
2007	260.94	111.83	260.82	112.03	-0.12	0.20	-0.05	0.18
2008	263.64	112.90	263.50	113.08	-0.14	0.18	-0.05	0.16
2009	264.55	113.26	264.43	113.41	-0.12	0.15	-0.05	0.13
2010	267.20	114.36	267.08	114.48	-0.12	0.12	-0.04	0.10
2011	270.84	115.87	270.71	115.97	-0.13	0.10	-0.05	0.09
2012	278.17	118.96	278.04	119.06	-0.13	0.10	-0.05	0.08
2013	280.91	120.08	280.76	120.18	-0.15	0.10	-0.05	0.08
2014	291.84	124.68	291.63	124.77	-0.21	0.09	-0.07	0.07

Livestock population were recalculated to annual average population, due to this recalculation average weight of livestock has changed. The impact of recalculation on CH_4 emissions is shown in Table 5-29.

Table 5-29. Reported in previous submission and recalculated CH_4 emissions from enteric fermentation

Year	2016 submission	2017 submission	Absolute difference, kt	Relative difference,%
1990	168.78	171.29	2.51	1.49
1991	158.88	162.30	3.42	2.15
1992	124.01	139.82	15.81	12.75
1993	103.11	113.55	10.44	10.13
1994	88.47	96.96	8.49	9.60

1995	83.21	87.36	4.15	4.99
1996	83.03	84.56	1.53	1.84
1997	81.49	84.45	2.96	3.63
1998	74.92	80.41	5.49	7.33
1999	70.60	73.21	2.61	3.70
2000	62.26	68.61	6.35	10.20
2001	63.64	64.44	0.8	1.26
2002	65.56	65.80	0.24	0.37
2003	67.71	67.67	-0.04	-0.06
2004	66.77	68.62	1.85	2.77
2005	67.04	68.04	1.00	1.49
2006	69.29	69.30	0.01	0.01
2007	68.11	70.05	1.94	2.85
2008	67.10	68.69	1.59	2.37
2009	65.50	67.18	1.68	2.56
2010	64.69	66.04	1.35	2.09
2011	64.01	65.28	1.27	1.98
2012	63.07	64.69	1.62	2.57
2013	62.21	63.43	1.22	1.96
2014	65.50	65.16	-0.34	-0.52

Recalculated livestock population data for dairy cattle, non-dairy cattle, swine, poultry, fur-bearing, rabbits and other (nutria) to annual average population are provided in Annex VII, Table A. 5-31 – Table A. 5-32. CH_4 emissions from enteric fermentation by livestock category were recalculated due to recalculated livestock population data. Recalculations are provided in NIR Annex VII, Table A. 5-33 – Table A. 5-34.

5.2.6 Category-specific planned improvements

Category-specific improvements are not planned.

5.3 Manure management – CH_4 emissions (CRF 3.B.1)

5.3.1 Category description

CH_4 is produced from the decomposition of organic matter remaining in the manure under anaerobic decomposition. The amount of CH_4 produced from manure depends on: manure characteristics linked to animal type and diets, the amount of feed consumed, the digestibility of the feed, the type of waste management system and the climate conditions during the storage.

Calculations of GHG emission from manure management were performed using the same annual average livestock population data as described in chapter Enteric fermentation (see Chapter 5.2).The information on manure management systems was collected during the investigation[55], also taking into account expert judgement.

Total CH_4 emissions from manure management of domestic livestock contributed 5.8% to the total agricultural emissions or 14.0% of the total CH_4 emissions in 2015. In 2015, comparing

[55] Juška, R. *et al.* Studija „Lietuvos mėšlo tvarkymo sistemose susidarančių metano ir azoto suboksido kiekio tyrimai ir įvertinimas" (en. *Survey and evaluation of methane and nitrous oxide emission content in manure management systems of Lithuania. Study*), 2012

with 2014, CH_4 emissions from manure management increased by 0.7%. In 1990-2015 the highest CH_4 emission from manure management systems among different categories of domestic animals was determined in swine breeding category (Table 5-30). The use of anaerobic digester for biogas-treatment in 2004-2011 and 2014-2015 slightly reduced CH_4 emission.

Table 5-30. CH_4 emission from manure management by animal category, kt

Year	Dairy cattle	Non-dairy cattle	Sheep	Goats	Horses	Swine	Poultry	Fur-bearing animals, rabbits and other (nutria)
1990	5.05	4.96	0.029	0.001	0.12	11.48	2.80	0.44
1995	3.50	1.88	0.017	0.002	0.12	5.73	2.20	0.29
2000	3.11	1.39	0.006	0.003	0.11	4.17	1.74	0.13
2005	3.20	1.54	0.012	0.003	0.10	4.93	1.42	0.42
2010	3.12	1.91	0.027	0.002	0.07	4.18	1.08	0.40
2011	3.08	1.97	0.029	0.002	0.06	4.03	1.00	0.49
2012	3.07	2.01	0.034	0.002	0.05	3.85	0.91	0.66
2013	2.97	2.14	0.044	0.002	0.04	3.76	0.81	0.86
2014	3.04	2.37	0.053	0.002	0.03	3.33	0.74	1.03
2015	2.99	2.57	0.063	0.002	0.03	3.16	0.66	1.19

Comparing to 1990 CH_4 emissions from manure management decreased by 57.2% in 2015 (Figure 5-3). In 2005-2015 CH_4 emission from manure management decreased by 8.3%.

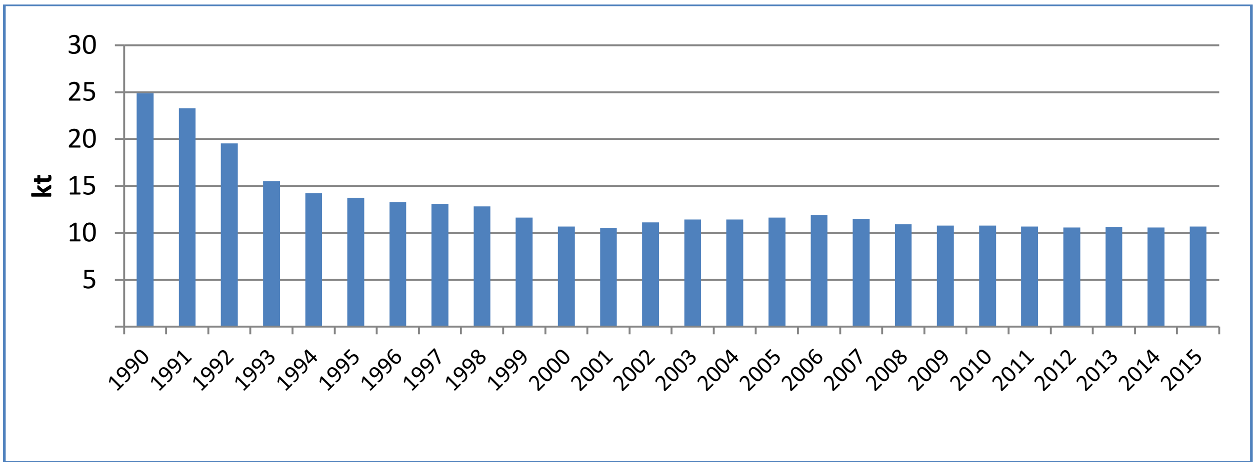

Figure 5-3. CH_4 emission from manure management during the period 1990-2015

The overall reduction of CH_4 emissions from manure in 1990-2015 is caused by decrease in total number of livestock population (excluding sheep, goats, rabbits and minks), however in case of dairy and non-dairy cattle the attrition of animals is partly counterbalanced by an increase in emissions per animal. Emission increase was caused by the growth of volatile solid excretion which is related to gross energy intake.

5.3.2 Methodological issues

5.3.2.1 Choice of methods

CH_4 emissions from manure management systems of cattle, swine and sheep were calculated using *Tier 2* method. Emissions from cattle and swine subcategories represent 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, other (nutrias), fur-bearing animals and poultry have a minor impact to the total CH_4 emission from manure management, therefore *Tier 1* method has been applied to estimate CH_4 emissions from these livestock categories. The summary of methods that were used for calculation of CH_4 emission from manure management is presented in Table 5-31.

Table 5-31. Methods and emission factors used to estimate CH_4 emission from manure management

Animal category	Method applied	Emission factor
Dairy cattle	Tier 2	CS
Non-dairy cattle	Tier 2	CS
Sheep	Tier 2	CS
Goats	Tier 1	*2006 IPCC*
Horses	Tier 1	*2006 IPCC*
Swine	Tier 2	CS
Poultry	Tier 1	*2006 IPCC*
Rabbits	Tier 1	*2006 IPCC*
Other (nutria)	Tier 1	*2006 IPCC*
Minks	Tier 1	*2006 IPCC*
Foxes	Tier 1	*2006 IPCC*
Polar foxes	Tier 1	*2006 IPCC*

5.3.2.2 Characterization of manure management systems

Assumption on manure fraction that remains on pasture was based on dairy and non-dairy cattle grazing time period. Bulls, partly calves and cows for slaughter, normally are kept in stalls throughout the year. Calves, heifers for breeding and milk production and beef cattle are grazed in pastures for approximately 145 days per year, the same as dairy cattle[56, 57].

In 2015 during the stable period 38.24% of cow manure was treated in the solid manure management systems and 21.8% in the liquid manure management systems. About 40% of cow manure was deposited on pastures.

Manure from other cattle categories distributed as follows: 39.0% in solid manure management systems, 21.4% in liquid manure management systems and 8.6% in deep bedding manure management systems. About 31.1% of manure was deposited on pastures.

The most common manure management system for swine manure treatment is liquid manure management system, which accounts for 87.4% of the total manure management systems.

[56] Gyvulininkystės žinynas (en. *Livestock manual*). Mokslas, Vilnius, 1976, p. 98-99

[57] Tarvydas V. et al. Šėrimo normos, pašarų struktūra ir sukaupimas galvijams (en. *Feeding rate, feed composition and accumulation for cattle*). Vilnius, 1995, p. 4

Around 10.5% of manure is managed in solid manure including 2% manure managed in deep bedding.

When the number of small farms who used solid manure management systems relatively decreased, the number of animals kept in the bigger herds, where the liquid manure management systems are used, relatively increased. Therefore it is assumed that the share of liquid manure management system increased in 2015, thus, based on this assumption, the data on manure management systems for cattle and swine categories have been extrapolated.

Since 1990 almost all fur-bearing animals, rabbits and other (nutrias) breeders used solid manure management systems. Liquid manure management systems was started to used only during the past few years in four fur-bearing animals' farms.

Methane conversion factors (MCF) for cattle, swine, sheep and goats in manure management systems were taken as default values from *2006 IPCC* (Table 5-32). For anaerobic digester *2006 IPCC* gives MCF value range from 0 to 100%. In calculation Lithuania uses 0% MCF value as the single company that was treating manure (during the period 2004-2011 and 2014-2015) in anaerobic digesters states that there is no leakage or release of CH_4 from the system and all CH_4 is combusted for energy production. In experts opinion there is no CH_4 emissions from power plants which started run in 2014 and 2015. Manure from livestock housing comes directly to the plants. If manure is left in the reservoir, before it goes in to the plant, it spends no longer than half a day.

MCF values by temperature for MMS for the whole period has been taken from column '10ºC' of table 10.17 from *2006 IPCC Guidelines*, these values where chosen because it is in line with countries nationals conditions (Figure 1-1).

Table 5-32. MCF values for manure management systems[58], %

Manure management systems					
Pasture/Range/ Paddock	**Solid storage**	**Liquid/Slurry**		**Anaerobic digester**	**Cattle and Swine deep bedding > 1 month**
		With natural crust cover	**Without natural crust cover**		
1	2	10	17	0	17

Data on manure management systems used in calculations for dairy cattle, non-dairy cattle and swine are provided in Figures 5-4, 5-5 and 5-6 respectively.

[58] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Table 10.17, p. 10.44-10.47

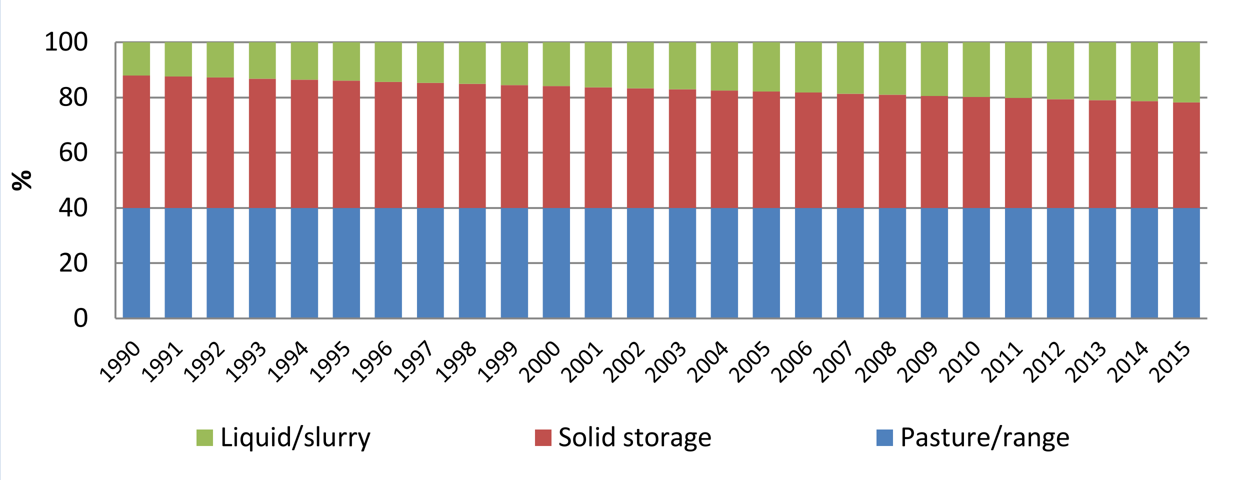

Figure 5-4. Data on manure management systems for dairy cattle

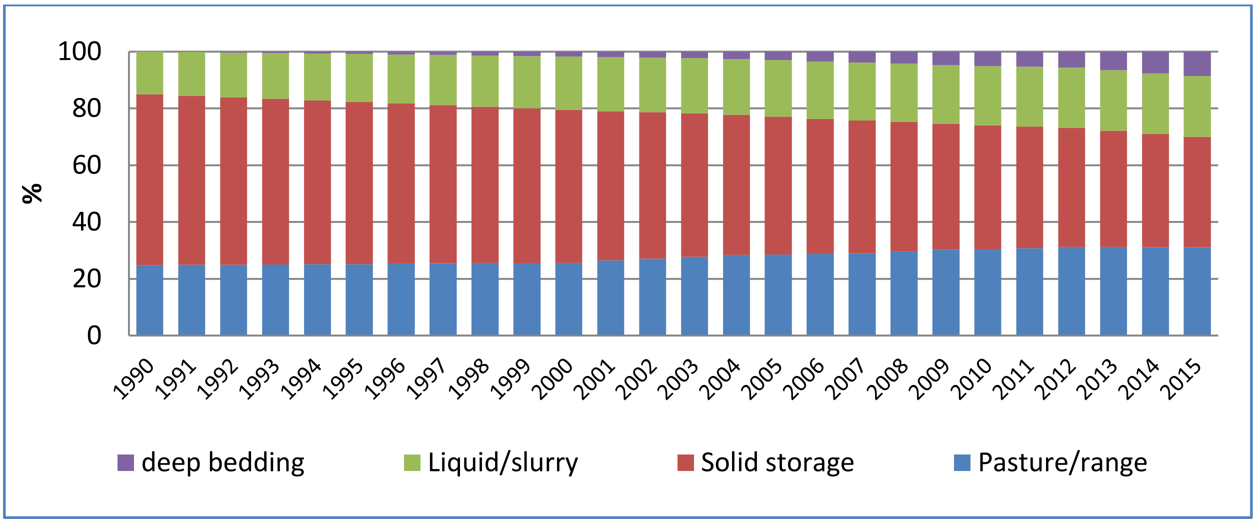

Figure 5-5. Data on manure management systems for non-dairy cattle

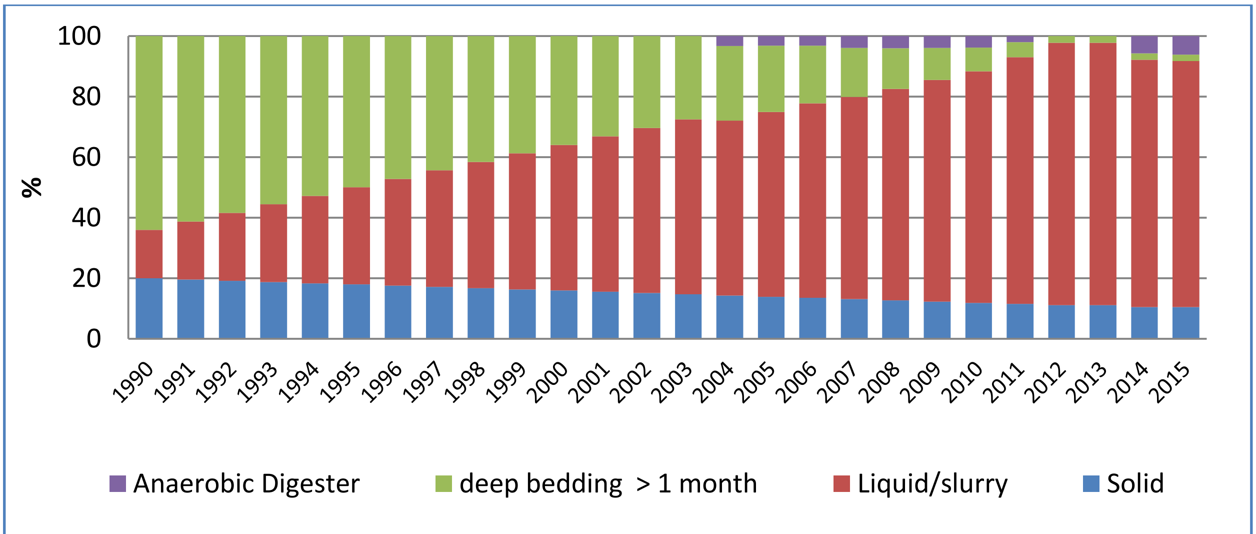

Figure 5-6. Data on manure management systems for swine

5.3.2.3 Calculation of CH_4 emissions

CH_4 emission from manure management was calculated using the following eq.[59]:

$$CH_{4\,manure} = \sum_{(T)} \frac{\left(EF_{(T)} \cdot N_{(T)}\right)}{10^6}$$

Where:
$CH_{4\,manure}$ – CH_4 emissions from manure management, for a defined population, kt CH_4 yr^{-1};
$EF_{(T)}$ – emission factor for the defined livestock population, kg CH_4 $head^{-1}$ yr^{-1};
$N_{(T)}$ – the number of head of livestock species/category T in the country;
T – species/category of livestock.

CH_4 emission factors for cattle, swine and sheep were determined using the fallowing eq.[60]:

$$EF_{(T)} = \left(VS_{(T)} \cdot 365\right) \cdot \left[B_{0(T)} \cdot 0.67kg/m^3 \cdot \sum_{S,k} \frac{MCF_{S,k}}{100} \cdot MCF_{(T,S,k)}\right]$$

where:
$EF_{(T)}$ – annual CH_4 emission factor for livestock category *T*, kg CH_4 $animal^{-1}$ yr^{-1};
$VS_{(T)}$ – daily volatile solid excreted for livestock category *T*, kg dry matter $animal^{-1}$ day^{-1};
365 – basis for calculating annual VS production, days yr^{-1};
$B_{0(T)}$ – maximum methane producing capacity for manure produced by livestock category *T*, m^3 CH_4 $kg^{-1}$of VS excreted;
0.67 – conversion factor of m^3 CH_4 to kg CH_4;
$MCF_{(S,\ k)}$ – methane conversion factors for each manure management system *S* by climate region *k*, %;
$MS_{(T,\ S,\ k)}$ – fraction of livestock category *T's* manure handled using manure management system *S* in climate region *k*.

The VS excretion rate, calculated for dairy and non-dairy cattle, sheep and swine were estimated from feed intake levels[61]:

$$VS = \left[GE \cdot \left(1 - \frac{DE\%}{100}\right) + (UE \cdot GE)\right] \cdot \left[\left(\frac{1 - ASH}{18.45}\right)\right]$$

where:
VS – volatile solid excretion per day on a dry-organic matter basis, kg VS day^{-1};
GE – gross energy intake, MJ day^{-1};
DE% – digestibility of the feed in percent;
(UE • GE) – urinary energy expressed as fraction of GE;
ASH – the ash content of manure calculated as a fraction of the dry matter feed intake;
18.45 – conversion factor for dietary GE per kg of dry matter, MJ kg^{-1}.

Gross energy consumption values for dairy cattle, non-dairy cattle, swine and sheep were estimated using same method as described in Chapter 5.2. Volatile solid excretion rate for cattle was calculated using digestible energy of the feed (65% for cattle, 75% for swine and 60%

[59] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Eq. 10.22, p. 10.37
[60] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Eq. 10.23, p. 10.41
[61] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Eq. 10.24, p. 10.42

for sheep), ash content of manure (8% for cattle, 2% for swine and 8% for sheep)[62]. The urinary energy expressed as fraction of gross energy was 0.04 for cattle and sheep, 0.02 for swine[63].Estimated daily VS excretions for dairy cattle, other cattle, swine and sheep are shown in Table 5-33.

Table 5-33. Daily VS excretions for dairy, non-dairy cattle, swine and sheep, kg-dm/day

Year	Cattle		Swine	Sheep
	Dairy	Non-dairy		
1990	4.55	2.43	0.43	0.56
1995	4.18	2.38	0.43	0.56
2000	4.52	2.29	0.43	0.56
2010	5.19	2.38	0.42	0.56
2011	5.26	2.37	0.43	0.56
2012	5.41	2.36	0.43	0.56
2013	5.46	2.40	0.43	0.56
2014	5.67	2.45	0.43	0.56
2015	5.67	2.50	0.43	0.56

Estimated VS value for sheep shown in Table 5-33 are higher than the default value in the *2006 IPCC Guidelines*, Vol. 4, Table 10A-9 (0.40 kg dm/head/day). The VS calculation formula includes GE value, which is based on sheep nutrition norms and feed nutrition Tables provided in the national literature[64], therefore the difference between default and country-specific VS value is influenced by national nutritional standards. Also lambs are usually weaned at 4 months old in Lithuania, and on this basis more feed is needed for ewes, which leads to a higher GE value.

The CH_4 EF also depends on the maximum methane producing capacity of the manure (B_o). For dairy cattle, beef cattle and other cows the methane producing capacity (B_o) 0.21 m^3 CH_4/kg VS has been used[65]. The B_o for dairy cattle was obtained using a standardized method and is based on the total excreted VS and typical cattle rations.

The majority of swine in Lithuania are grown under industrial production conditions on large farms where liquid manure management technologies are applied. However, there are low number of small farms, where swine are grown on the litter, and solid manure technologies are applied. *2006 IPCC Guidelines* recommended methane producing capacity (B_o) is 0.45 m^3 CH_4/kg VS, however, on investigation of Matulaitis (2014) was found that swine liquid manure methane producing capacity in Lithuanian conditions is 0.29 m^3 CH_4/kg VS, what is significantly lower than that indicated by *2006 IPCC Guidelines*. Studies have been carried out using a standardized method and is based on the total excreted VS and typical swine rations.

The *2006 IPCC Guidelines* methane producing capacity default value (0.45 $m^3 CH_4$/kg VS) for swine originated from the USA where large amounts of maize constitute the feed composition. However, Dämmgen et al., (2012) pointed out that swine feed composition in Central Europe

[62] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Table 10A-9, p. 10.82; p. 10.42
[63] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, p. 10.42
[64] Gyvulininkystės žinynas. Baisogala (en. Livestock manual. Institute of Animal Science of LVA), 2007. P. 394-402.
[65] Matulaitis, R. *The effectiveness of implements on mitigation of greenhouse gas emission and pollution reduction from manure*. Summary of Doctoral Dissertation. Kaunas, 2014

differs significantly from the US feeds and suggest using (B_o) 0.30 m^3CH_4/kg VS [66]. Morken et al., (2013)[67] for Norway also recommends to use methane producing capacity of 0.30 m^3CH_4/kg VS.

As mention above, that the methane producing capacity is not dependent on manure management system, in Lithuanians inventory report the methane producing capacity of 0.30 m^3CH_4/kg VS has been used.

Methane producing capacity (B_0) for sheep (0.19 m^3 CH_4/kg VS) was taken from *2006 IPCC Guidelines*[68].

Each year more high productivity cattle are brought from the Western Europe countries. Therefore, higher quality forage is needed to meet nutrition needs of the high productivity livestock. The forage is produced using innovative technologies which are used in Western countries. Therefore, Western countries methane producing capacity (B_0) for non-dairy cattle (0.18 m^3 CH_4/kg VS) was used instead of Eastern countries. Methane producing capacity was taken from *2006 IPCC Guidelines* Table 10A-5 p. 10.78.

Regarding, increasing milk yield and changes in housing types of animals when solid manure management was replaced by slurry-based system, EF of dairy cattle has increased (Table 5-34). Methane conversion factor for slurry manure is higher than solid manure MCF.

Inter-annual changes of CH_4 EF for dairy and non-dairy cattle in the manure management category mainly are determined by the GE intake and at the same time volatile solid excretion, as well as the allocation of manure per animal in manure management system. Positive relationships were estimated between CH_4 EF for manure management and VS (r=0.989, P<0.0005 for dairy and r=0.384, P=0.214 for non-dairy cattle) and between CH4 EF and average MCF for manure management (r=0.978, P<0.0005 for dairy and r=0.968, P=0.0001 for non-dairy cattle).

Table 5-34. Estimated EF for dairy cattle, kg CH_4/head/year

Year	**1990**	**1995**	**2000**	**2005**	**2010**
EF	5.98	5.83	6.66	7.53	8.49
Year	**2011**	**2012**	**2013**	**2014**	**2015**
EF	8.69	9.02	9.19	9.64	9.73

Tables 5-35 and 5-36 present EF for non-dairy cattle and swine. Estimated EF for sheep during the whole reporting period was constant – 0.46 kg CH_4/head/year, due to proportional distribution of animals in subcategories.

[66] Dämmgen U., Amon B., Hutchings N. J.,. Haenel H.-D, Rösemann C. Data sets to assess methane emissions from untreated cattle and pig slurry and solid manure storage systems in the German and Austrian emission inventories. Landbauforschung, Agriculture and Forestry Research. 2012: (62):1-20.

[67] Morken J., Ayoub S., Sapci Z. Revision of the Norwegian model for estimating methane emission from manure management. IMT-RappoRT nR. 54/2013. Available at: https://www.researchgate.net/publication/284247299_Revision_of_the_Norwegian_model_for_estimating_methane_emission_from_manure_management

[68] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Tables 10A-5, 10A-9.p. 10.78, 10.82

Table 5-35.Calculated EF used for calculation of CH_4 emission from manure management of non-dairy cattle subcategories during the period 1990-2015, kg CH_4/head/year

Year	Cattle sub-categories										
	Suckling cows	Cattle less than 1 year old			Cattle from 1 to 2 years old			Cattle 2 years old and older			Other cows
		For slaughter	Bulls	Heifers for breeding	Bulls	Heifers for slaughter	Heifers for breeding	Bulls	Heifers for slaughter	Heifers for breeding	
1990	-	2.20	3.09	1.72	5.59	4.00	3.01	5.46	4.51	3.75	6.51
1995	-	2.41	3.35	1.86	6.06	4.39	3.26	5.92	4.86	4.11	7.00
2000	23.44	2.63	3.61	2.01	6.53	4.79	3.51	6.39	5.21	4.47	7.50
2005	23.44	2.84	3.86	2.15	7.00	5.18	3.76	6.85	5.55	4.82	8.00
2010	23.44	3.06	4.12	2.29	7.47	5.57	4.00	7.31	5.90	5.18	8.50
2011	23.44	3.10	4.17	2.32	7.57	5.65	4.05	7.40	5.97	5.25	8.60
2012	23.44	3.14	4.22	2.35	7.66	5.73	4.10	7.50	6.04	5.32	8.70
2013	23.44	3.18	4.27	2.38	7.76	5.80	4.15	7.59	6.11	5.39	8.80
2014	23.44	3.23	4.33	2.41	7.85	5.88	4.20	7.68	6.17	5.47	8.90
2015	23.44	3.27	4.38	2.43	7.94	5.96	4.25	7.77	6.24	5.54	9.00

Table 5-36. Estimated EF used for calculation of CH_4 emission from manure management of swine, kg CH_4/head/year

Year	**1990**	**1995**	**2000**	**2005**	**2010**
EF	4.46	4.53	4.63	4.48	4.50
Year	**2011**	**2012**	**2013**	**2014**	**2015**
EF	4.69	4.81	4.81	4.54	4.50

EF for non-dairy cattle and swine has increased as a result of increasing number of housing variety for livestock when solid manure management system are being replaced by liquid manure management system.

Inter-annual changes of CH_4 EF for swine in manure management category is mainly determined by the volatile solid excretion, which reflects the higher or smaller quantity of breeding or market swine (%) in the population, also by the allocation of manure per animal in manure management system. The allocation of manure per animal in manure management system reflects the average methane conversion factors (MCF) for country manure management. Positive weak relationship between CH_4 EF for manure management and VS ($r=0.102$, $P=0.160$) was estimated. Positive strong relationship between CH4 EF and average MCF ($r=0.926$, $P=0.167$) was estimated.

Anaerobic digesters, which were operating in 2004-2011 and 2014-2015 affected the CH_4 emission factor from manure management systems (MMS) (Annex VII, Table A.5-28). The magnitude of the emission factor was also influenced by the ratio of breeding and market swine in the population (Annex VII, Table A.5-29).

For estimation of CH_4 emissions from horses, goats, poultry, rabbits, other (nutria) and fur-bearing animals default *2006 IPCC Guidelines* EF were used. CH_4 EF for geese is not available in either *2006 IPCC Guidelines* or in the Revised *1996 IPCC Guidelines*, therefore EF of "other poultry", provided in the Revised *1996 IPCC Guidelines*[69] was used. This EF is also used for "other poultry" (Table 5-37).

Table 5-37. EF used for calculation of CH_4 emission from manure management, kg CH_4/head/year[70][71]

Livestock category	**Emission Factor**
Goats	0.13
Horses	1.56
Layers (dry)	0.03
Layers (wet)	1.20
Broilers	0.02
Turkeys	0.09
Ducks	0.02
Geese	0.078
Other poultry	0.078
Rabbits	0.08
Other (Nutria)	0.68
Fur-bearing animals	0.68

[69] Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual.Vol. 3, Table B-7, p.4.47.
[70] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Table 10.15, p. 10.40
[71] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Table 10.16, p. 10.41

5.3.3 Uncertainties and time-series consistency

CH_4 emission from manure management was calculated based on activity data and emission factors. Overall uncertainties result from uncertainty of livestock population (Chapter 5.2.3), uncertainty of emission factors and uncertainty values of other relevant parameters. However, the data on excretion and distribution of manure among the management systems are less reliable.

Activity data uncertainty

As elaborated in Chapter 5.2.3 uncertainty value for livestock population is ±5%. The uncertainty of the manure management system usage data can be ±10% or less[72]. Uncertainties in estimates of methane producing capacity (B_0) for cattle are ±15%[73]. In study on evaluation of country specific B_0 in Lithuania uncertainty of B_0 for dairy cattle for solid manure was estimated ±19%, for liquid manure – ±30%[74]. It was estimated that uncertainty value of B_0 for non-dairy cattle is ±18%. In study on evaluation of country specific B_0 uncertainty of B_0 for swine for liquid manure was estimated ±21%[75].

Emission factor uncertainty

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 EF is estimated to be ±30%. Improvements achieved by *Tier 2* methodologies are estimated to reduce uncertainty ranges in emission factors to ±20%.

The uncertainties in emissions factors of CH_4 emissions from manure management was calculated according to *2006 IPCC Guidelines* eq. 3.1. It is estimated that uncertainty of emission factor for dairy cattle category is likely to be in order of ±34.1%, for non-dairy cattle - ±14.8%, for sheep - ±14.8%, for swine - ±34.5%.

Overall uncertainty

Combined uncertainty was calculated using *2006 IPCC Guidelines* eq. 3.1[76]. This approach requires uncertainty values of the main activity data used and uncertainty of EF. Combined uncertainty was estimated to be ±27.4%.

5.3.4 Category-specific QA/QC and verification

Same general QC procedures as applied for category Enteric fermentation were applied for category Manure management – check of activity data for the whole time period, consistency check of data entered in CRF with calculation sheets, trends of emissions for each category, relevance of methodology applied, etc.

The results for the year 2015 as well as data quality and reliability were evaluated by comparing them to 2014 data of neighbouring countries.

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[72] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, p. 10.48

[73] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Table 10A-4, p. 10.77

[74] Matulaitis, R. *The effectiveness of implements on mitigation of greenhouse gas emission and pollution reduction from manure*. Summary of Doctoral Dissertation. Kaunas, 2014

[75] Matulaitis, R. *The effectiveness of implements on mitigation of greenhouse gas emission and pollution reduction from manure*. Summary of Doctoral Dissertation. Kaunas, 2014

[76] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 3, eq. 3.1, p. 3.28

National VS excretion (kg dm/day) of dairy cattle category differs slightly from the one provided in Poland's NIR (Table 5-38). However, CH_4 EF is lowest compared to neighbouring countries. Higher CH_4 EF's are seen in Latvia's and Poland's inventory reports. However, these countries have used higher (B_o) value.

Table 5-38. Comparison of VS and other parameter for CH_4 emission calculation from manure management of dairy cattle

Country	VS excretions (kg-dm/day)	CH_4 producing potential (m^3 CH_4/kg VS)	EF (kg CH_4/head/yr)
Latvia	6.20	0.24	14.98
Lithuania (in 2014)	5.67	0.21	9.64
Poland	5.36	0.24	11.12

5.3.5 Category-specific recalculations

Recalculations of methane EF for non-dairy cattle, swine, poultry, fur-bearing animals, rabbits and other (nutria) have been made due to recalculated animal population. Recalculations are provided in Annex VII, Table A. 5-35 – Table A. 5-38.

CH_4 emissions from manure management by livestock category were recalculated due to recalculated livestock population data (Table 5-39).

Table 5-39. Reported in previous submission and recalculated CH_4 emissions from manure management

Year	2016 submission	2017 submission	Absolute difference, kt	Relative difference, %
1990	22.37	24.88	2.51	11.22
1991	20.89	23.27	2.38	11.39
1992	15.43	19.41	3.98	25.79
1993	13.50	15.53	2.03	15.04
1994	12.82	14.21	1.39	10.84
1995	12.52	13.74	1.22	9.74
1996	11.95	13.26	1.31	10.96
1997	12.17	13.11	0.94	7.72
1998	11.43	12.81	1.38	12.07
1999	10.34	11.65	1.31	12.67
2000	9.42	10.66	1.24	13.16
2001	10.10	10.55	0.45	4.46
2002	10.43	11.11	0.68	6.52
2003	10.62	11.43	0.81	7.63
2004	10.47	11.44	0.97	9.26
2005	10.71	11.63	0.92	8.59
2006	10.94	11.92	0.98	8.96
2007	10.01	11.49	1.48	14.79
2008	9.91	10.92	1.01	10.19
2009	9.78	10.77	0.99	10.12
2010	9.89	10.79	0.90	9.10
2011	9.39	10.67	1.28	13.63
2012	9.52	10.58	1.06	11.13
2013	9.37	10.63	1.26	13.45
2014	9.43	10.59	1.16	12.30

5.3.6 Category-specific planned improvements

Category-specific improvements are not planned.

5.4 Manure management – N_2O emissions (CRF 3.B.2)

5.4.1 Direct N_2O emission (CRF 3.B.2)

5.4.1.1 Category description

During manure storage and handling manure emits nitrous oxide (N_2O) through nitrification or denitrification. The amount of emitted N_2O depends on: nitrogen and carbon content in manure, type of manure storage system, duration of time manure is stored, climatic condition during the storage. N_2O is the most potent agricultural GHG with warming potential 298 times greater than that of CO_2.

The emission of N_2O is calculated based on the amount of nitrogen excretion per animal and manure management system. Emission estimates from manure deposited during grazing period are calculated and described in the section "Urine and dung deposited by grazing animals" (Chapter 5.6.1.2).

Direct N_2O emissions from manure management constituted 106 kt CO_2 eqv. or 4% of the total Agriculture sector emissions in 2015. In 2015 comparing with 1990 direct N_2O emissions from manure management decreased by 67.8% (Figure 5-7). From 2005 to 2015 direct N_2O emissions decreased 1.0%. Estimated direct N_2O emissions from different manure management systems are provided in the Table 5-40.

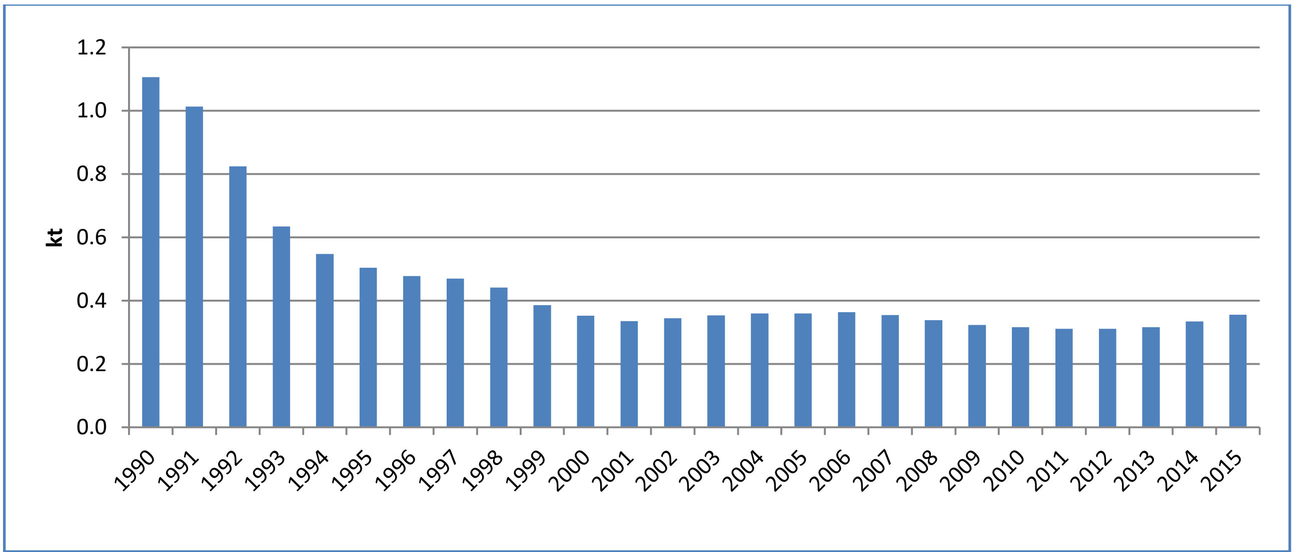

Figure 5-7. Direct N_2O emission from manure management during the period 1990-2015

Table 5-40. Estimated direct N_2O emissions from different manure management systems, kt

Year	Manure management system		
	Liquid system	Solid storage and dry lot	Other systems
1990	0.14	0.64	0.33
1995	0.07	0.30	0.13
2000	0.07	0.22	0.07
2005	0.07	0.23	0.06
2010	0.08	0.21	0.03

2011	0.08	0.20	0.03
2012	0.08	0.21	0.02
2013	0.08	0.21	0.03
2014	0.09	0.22	0.03
2015	0.09	0.23	0.03

5.4.1.2 Methodological issues

To estimate N_2O emissions from manure management of cattle and sheep *Tier 2* method was used. For calculation of N_2O emission from other livestock categories (swine, goats, horses, poultry, rabbits, other (nutria) and fur-bearing animals) *Tier 1* method was used.

Activity data

The data on populations of livestock were obtained from the database of Statistics Lithuania (1990-2015) and was recalculated into annual average population according to *2006 IPCC Guidelines*. More detailed information on annual average livestock population and distribution of livestock subcategories is provided in Chapter 5.2.2.

Fractions on the total annual excretion of livestock managed in specific manure management systems are provided in Figure 5-5, Figure 5-6 and Figure 5-7 in section above as well as in Table 5-41 and Figure 5-8.

Table 5-41. Percentage of manure production per animal waste management systems, %

Year	Solid storage and dry lot	Liquid system	Pasture, range and paddock	Other systems
Sheep				
1990-2015	54.8	-	45.2	-
Goats				
1990-2015	54.8	-	45.2	-
Horses				
1990-2015	8	-	92	-
Rabbits				
1990-2015	100	-	-	-
Fur-bearing animals				
1990-2006	100	-	-	-
2007	92.7	7.3	-	-
2008	85.3	14.7	-	-
2009-2015	78	22	-	-
Other (Nutria)				
1990-2015	100	-	-	-

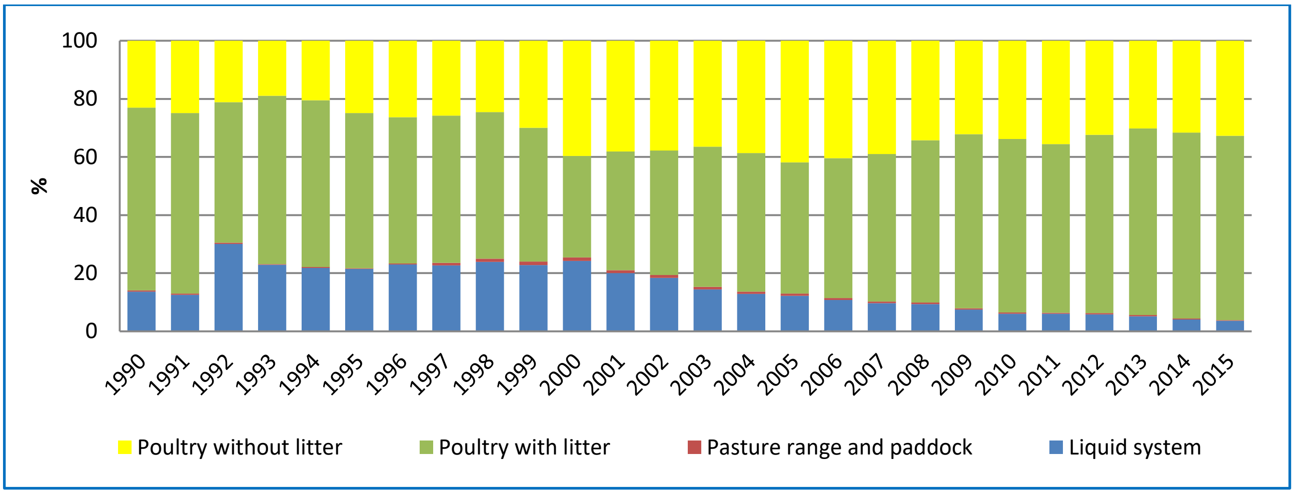

Figure 5-8. Poultry manure production per animal waste in manure management systems

Calculation of N_2O emissions

N_2O emissions from manure management are calculated by multiplying the total amount of N excretion (from all livestock categories) in each type of manure management system by an EF for that type of manure management system. Emissions are then summed over all manure management system[77]:

$$N_2O_{D(mm)} = \left[\sum_S \left[\sum_T \left(N_T \cdot Nex_{(T)} \cdot M_{(T,S)}\right)\right] \cdot EF_{3(S)}\right] \cdot \frac{44}{28}$$

where:

$N_2O_{D(mm)}$ – direct N_2O emissions from manure management, kg N_2O yr^{-1};

$N_{(T)}$ – number of head of livestock species/category *T* in the country;

$Nex_{(T)}$ – annual average N excretion per head of species/category *T* in the country, kg N $animal^{-1}$ yr^{-1};

$MS_{(T,S)}$ – fraction of total annual nitrogen excretion for each livestock species/category *T* that is managed in manure management system *S* in the country, dimensionless;

$EF_{3(S)}$ – emission factor for direct N_2O emissions from manure management system *S* in the country, kg N_2O-N/kg N in manure management system *S*;

S – manure management system;

T – species/category of livestock;

44/28 – conversion of $(N_2O\text{-}N)_{(mm)}$ emissions to $N_2O_{(mm)}$ emissions.

The annual amount of N excreted for dairy and non-dairy cattle as well as sheep categories were estimated using the following eq.[78]:

$$N_{excretion} = N_{intake} - N_{retention}$$

where:

Nex – annual N excretion rates, kg N $animal^{-1}$ yr^{-1};

N_{intake} – the annual N intake per head of animal, kg N $animal^{-1}$ yr^{-1};

$N_{retention}$ – fraction of annual N intake that is retained by animal, kg N $animal^{-1}$ yr^{-1}.

Annual nitrogen intake for cattle, sheep and swine categories was calculated according to eq.[79]:

[77] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, eq. 10.25, p. 10.54

[78] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, eq. 10.31, p. 10.58

$$N_{intake} = \frac{CP}{6.25} \cdot 365$$

where:
N_{intake} – the annual N intake per head of animal, kg N animal^{-1} yr^{-1};
CP – amount of crude protein in diet of animal, kg/day animal^{-1} day^{-1};
6.25 – conversion from kg of dietary protein to kg of dietary N, kg feed protein (kg N)$^{-1}$.

The nitrogen retained in dairy and non-dairy cattle was estimated using the following eq.[80]:

$$N_{retention(T)} = \left[\frac{Milk \cdot \left(\frac{MilkPR\%}{100}\right)}{6.38}\right] + \left[\frac{WG \cdot \left[268 - \left(\frac{7.03 \cdot NE_g}{WG}\right)\right]}{\frac{1000}{6.25}}\right]$$

where:
$N_{retention(T)}$ – daily N retained per animal of category *T*, kg N animal^{-1} day^{-1};
Milk – milk production, kg animal^{-1} day^{-1};
MilkPR% – percent of protein in milk, calculated as [1.9 + 0.4 * % Fat], where %Fat is an input, assumed to be 4%;
6.38 – conversion from milk protein to milk N, kg protein (kg N)$^{-1}$;
WG – weight gain, input for each livestock category, kg day^{-1};
268 and 7.03 – constants;
NE_g – net energy for growth, calculated in livestock characterisation, based on current weight, mature weight, rate of weight gain, and *2006 IPCC* constants, MJ day^{-1};
6.25 – conversion from kg dietary protein to kg dietary N, kg Protein (kg N)$^{-1}$.

Mature body weight and rate of weight gain of non-dairy cattle, used for estimation of net energy for growth are provided in Annex VII, Table A. 5-30.

Values of nitrogen retention for sheep were accepted as default values for the fraction of N intake that retained by the animal per year (0.10) multipled by N intake per animal per year[81].

Net energy for growth (NE_g) for non-dairy cattle was calculated according eq.[82]:

$$NE_g = 22.2 \cdot \left(\frac{BW}{C \cdot MW}\right)^{0.75} \cdot WG^{1.097}$$

where:
NE_g – net energy needed for growth, MJ day^{-1};
BW – the average live body weight of the animals in the population, kg;
C – a coefficient with a value of 0.8 for females, 1.0 for castrates and 1.2 for bulls;
MW – the mature live body weight of an adult female in moderate body condition, kg;
WG – the average daily weight gain of the animals in the population, kg day^{-1}.

The annual amount of N excreted for swine, horses, goats and poultry were calculated using eq.[83]:

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[79] Gyvulininkystės žinynas. Baisogala (en. *Livestock manual. Institute of Animal Science of LVA*), 2007
[80] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, eq. 10.33, p. 10.60
[81] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, Table 10.20, p. 10.60
[82] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, eq. 10.6, p. 10.17
[83] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, eq. 10.30, p. 10.57

$$Nex_{(T)} = N_{rate(T)} \cdot \frac{TAM}{1000} \cdot 365$$

where:

$Nex_{(T)}$ – annual N excretion for livestock category T, kg N animal^{-1} yr^{-1};

$N_{rate(T)}$ – default N excretion rate[84], kg N (1,000 kg animal mass)$^{-1}$ day^{-1};

$TAM_{(T)}$ – typical animal mass for livestock category T, kg animal^{-1}.

The expert data on goats weight used in calculation of N excretion is 33.8 kg. For other livestock categories country specific average weight used in estimations of nitrogen excretion are provided in Tables 5-42 and 5-43. The default weigth data for breeding and market swine were taken from *2006 IPCC*[85]. Estimated average swine weight used for estimation of N excretion are provided in Table 5-44.

Table 5-42. Average weight of horses used for estimation of N excretion, kg

Year	**1990**	**1995**	**2000**	**2005**	**2010**
Weight	520	491	462	433	403
Year	**2011**	**2012**	**2013**	**2014**	**2015**
Weight	398	392	386	386	386

During the 1990-2015 period, the decrease of average weight of horses resulted in a relatively faster decrease population of working horses and growing population of pony horses. Average weight of horses has been estimated using available data on population of bred breeds of horses and their typical weight, indicated in the reference sources[86]. Distribution of horses by breeds is shown in Annex VII. Figure A. 5-2.

Table 5-43. Average weight of poultry used for estimation of N excretion, kg

Layer hens	**Broilers**	**Turkeys**	**Ducks**	**Geese**	**Other poultry**
1.56	0.89	7.76	1.58	6.0	1.36

The annual amount of N excretion per animal for dairy cattle, non-dairy cattle and sheep were estimated based on the total annual N intake and total annual N retention of the animal. Annual N intake per animal for cattle, sheep and swine were calculated in accordance with the Tables[87] of forage sustenance and ration. Estimated annual N excretion per cattle, horses, swine, goats and poultry per year is provided in the Tables 5-44 and 5-45.

Table 5-44. Estimated N excretion factors for cattle, horses and swine, kg N/head/yr

Year	**Livestock category**			
	Cattle		**Horses**	**Swine**
	Dairy	**Non-dairy**		
1990	79.9	40.1	56.9	12.3
1995	70.6	38.3	53.8	12.3
2000	79.0	35.5	50.6	12.2
2005	87.5	35.3	47.4	12.1
2010	96.1	37.9	44.2	12.1
2011	97.8	37.6	43.5	12.1
2012	101.4	37.4	42.9	12.0

[84] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, Table 10.19, p. 10.59

[85] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Table 10A-7, 10A-8, p. 10.80-10.81

[86] Gyvulininkystės žinynas. Baisogala (en. *Livestock manual. Institute of Animal Science of LVA*), 2007, p. 328-374.

[87] Gyvulininkystės žinynas. Baisogala (en. *Livestock manual. Institute of Animal Science of LVA*), 2007, p. 584-601

2013	102.6	38.4	42.3	11.9
2014	107.8	39.7	42.3	11.9
2015	107.9	40.9	42.3	11.9

Table 5-45. Estimated N excretion factors for goats and poultry (excl. geese and other poultry), kg N/head/yr

Goats	**Poultry**			
	Layer hens	**Broilers**	**Turkeys**	**Ducks**
15.81	0.47	0.36	2.09	0.48

Gross energy and crude protein for the period of 1990-2013 for sheep was calculated using the structure of sheep herd in 2013. New data on sheep herd structure was received in 2014, with the 0.2% and in 2015 with the 0.9% decreased population of sheep up to 1 year subcategory. This resulted in higher amount of proteins as well as higher N excretion. Therefore, estimated N excretion for sheep in 1990-2014 was 9.70 kg N/head/year, in 2015 – 9.71 kg N/head/year.

The default N excretion for geese and other poultry as well as nutria, rabbits and fur-bearing animals were taken from *2006 IPCC Guidelines*[88] (Table 5-46).

Table 5-46. Default N excretion for livestock categories, kg N/head/yr

Livestock categories	**N excretion**
Rabbits	8.10
Minks, nutria	4.59
Foxes, polar foxes	12.09
Geese and other poultry	0.60

Default EF for direct N_2O emissions from manure management systems is reported in Table 5-47.

Table 5-47. Default EF for N_2O emission estimation from manure management, kg N_2O-N/kg N excreted[89]

Manure management system		**EF**
Liquid / slurry	with natural crust cover	0.005
	without natural crust cover	0.000
Solid storage and dry lot		0.005
Pasture/range/paddock	for cattle, poultry and swine	0.020
	for sheep and 'other animals'	0.010
Poultry manure	with litter	0.001
	without litter	0.001
Other system	deep bedding	0.010
	anaerobic digester	0.000

Inter-annual changes of N_2O EF fluctuation for the swine category is mainly determined by the N excretion ($r=0.843$, $P<0.0005$), and the share of manure which falls into solid or liquid manure management systems. Strong positive relationship between N_2O EF and amount of manure, that falls into solid manure management sytems ($r=1.0$, $P<0.0005$) was estimated. Strong negative relationship between N_2O EF and the amount of manure, that falls into liquid manure management sytems ($r=-1.0$, $P<0.0005$) was estimated.

[88] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Table 10.19, p. 10.59
[89] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Table 10.21, p.p. 10.62-10.64.

5.4.1.3 Uncertainties and time-series consistency

N_2O emission from manure management was calculated based on activity data and emission factors. Overall uncertainties result from uncertainty of livestock population (Chapter 5.2.3), uncertainty of emission factors and uncertainty values of other relevant parameters.

Activity data uncertainty

As elaborated in Chapter 5.2.3 uncertainty value for livestock population is ±5%. The uncertainty of the manure management system usage data can be ±10% or less (Chapter 5.3.3). The uncertainty ranges for the default N excretion rate calculating N excretion for goats, swine, horses, rabbits, nutria and fur-bearing animals as well as poultry (excluding subcategories geese and other poultry) is ±50%. N excretion rate for cattle and sheep were estimated using *Tier 2* method and based on expert judgment it was assumed that uncertainty is ±20%. Overall uncertainty for direct N_2O emissions from MMS activity data was estimated to be ±55%.

Emission factor uncertainty

The uncertainty of EF for estimation of N_2O emissions in accordance with the data of *2006 IPCC* are in the range of -50 – +100%, therefore value of ±100% was taken.

Overall uncertainty

Combined uncertainty was calculated using *2006 IPCC Guidelines* eqv. 3.1[90]. This approach requires uncertainty values of the main activity data used and uncertainty of emission factor. Combined uncertainty was estimated to be ±93%.

5.4.1.4 Category specific QA/QC and verification

General QC procedures applied for this category – check of activity data for the whole time period, consistency check of data entered in CRF with calculation sheets, trends of emissions for each category, relevance of methodology applied, etc.

5.4.1.5 Category-specific recalculations

N excretion rates were recalculated due to updated animal numbers in subcategories and due to recalculated Net energy for animal growth. Recalculation is provided in the Annex VII, Table A. 5-39.

N_2O emissions have been recalculated due to recalculation of N excretion rates. Recalculation is provided in the Table 5-48.

Table 5-48. Reported in previous submission and recalculated direct N_2O emissions from manure management

Year	2016 submission	2017 submission	Absolute difference, kt	Relative difference, %
1990	1.04	1.11	0.07	6.73
1991	0.95	1.01	0.06	6.32
1992	0.68	0.82	0.14	20.59
1993	0.56	0.63	0.07	12.50
1994	0.50	0.55	0.05	10.00
1995	0.47	0.50	0.03	6.38
1996	0.45	0.48	0.03	6.67

[90] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 3, eq. 3.1, p. 3.28

1997	0.45	0.47	0.02	4.44
1998	0.40	0.44	0.04	10.00
1999	0.36	0.39	0.03	8.33
2000	0.32	0.35	0.03	9.37
2001	0.33	0.34	0.01	3.03
2002	0.34	0.34	0.00	0.00
2003	0.35	0.35	0.00	0.00
2004	0.34	0.36	0.02	5.88
2005	0.34	0.36	0.02	5.88
2006	0.35	0.36	0.01	2.86
2007	0.33	0.35	0.02	6.06
2008	0.32	0.34	0.02	6.25
2009	0.31	0.32	0.01	3.23
2010	0.30	0.32	0.02	6.67
2011	0.29	0.31	0.02	6.90
2012	0.29	0.31	0.02	6.90
2013	0.29	0.32	0.03	10.34
2014	0.30	0.33	0.03	10.00

5.4.1.6 Category-specific planned improvements

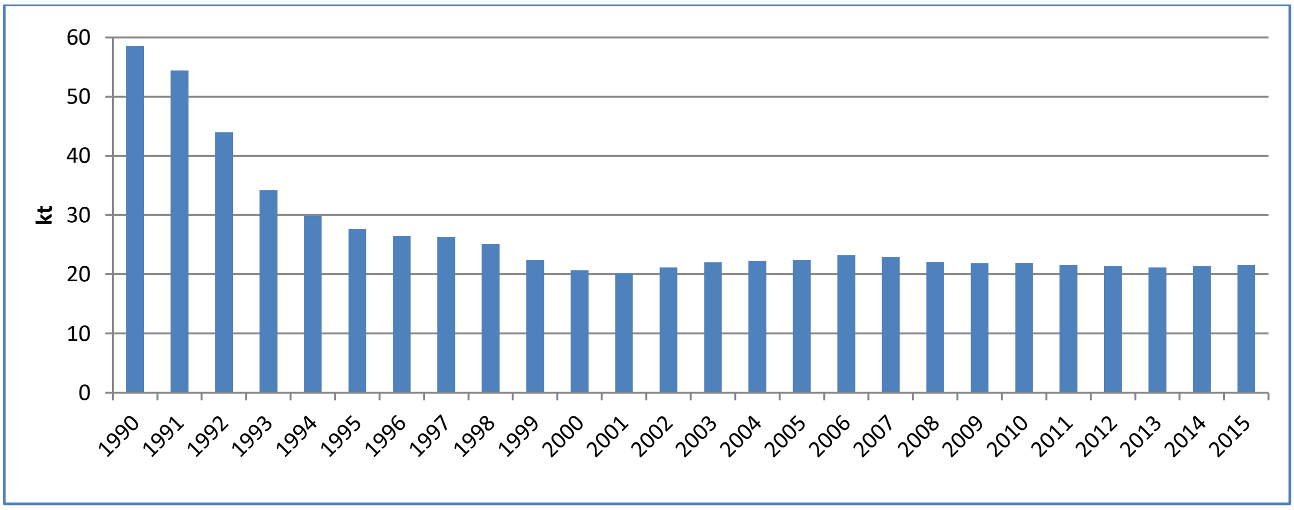
Category-specific improvements are not planned.

5.4.2 Indirect N_2O emission (CRF 3.B.2.5)

5.4.2.1 Category description

Indirect emissions result from volatile nitrogen losses that occur primarily in the forms of ammonia (NH_3) and nitrogen oxides (NO_x). Nitrogen losses begin at the point of excretion in housings and other animal production areas[91].

Average N loss from manure management systems due to volatilization and leaching and run-off were 21.38 kt in 2015. Compared to 1990, average N loss from manure management decrease by 63.6% in 2015. Average N loss from manure management decreased by 6.1% during the period 2005-2015 (Figure 5-9).



[91] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, p. 10.52

Figure 5-9. N losses due to volatilization of NH_3 and NO_x and leaching during the period 1990-2015

N loss due to volatilization in forms of NH_3 and NO_x and due to leaching from different manure management systems are presented in Table 5-49.

Table 5-49. Calculated N losses due to volatilization and leaching from different manure management systems, kt N/yr

Year	N losses due to volatilization			N losses due to leaching	
	AWMS				
	Liquid system	Solid storage	Other systems	Solid storage	Other systems
1990	9.82	29.90	10.76	5.58	2.47
1995	6.52	12.96	4.38	2.81	0.98
2000	6.20	9.26	2.53	2.15	0.51
2005	7.88	9.15	2.81	2.14	0.50
2010	8.52	8.40	2.60	1.96	0.45
2011	8.67	8.16	2.46	1.89	0.41
2012	8.74	8.08	2.26	1.89	0.39
2013	8.71	7.99	2.20	1.85	0.40
2014	8.57	8.23	2.28	1.91	0.42
2015	8.57	8.30	2.36	1.91	0.44

Indirect N_2O emissions from manure management due to volatilization and leaching in 2015, comparing with 1990, decreased by 63.6%. From 2005 to 2015 indirect N_2O emissions from manure management decreased by 6.1% (Figure 5-10). Estimated indirect N_2O emissions due to volatilization of N from different manure management systems are presented in Table 5-50.

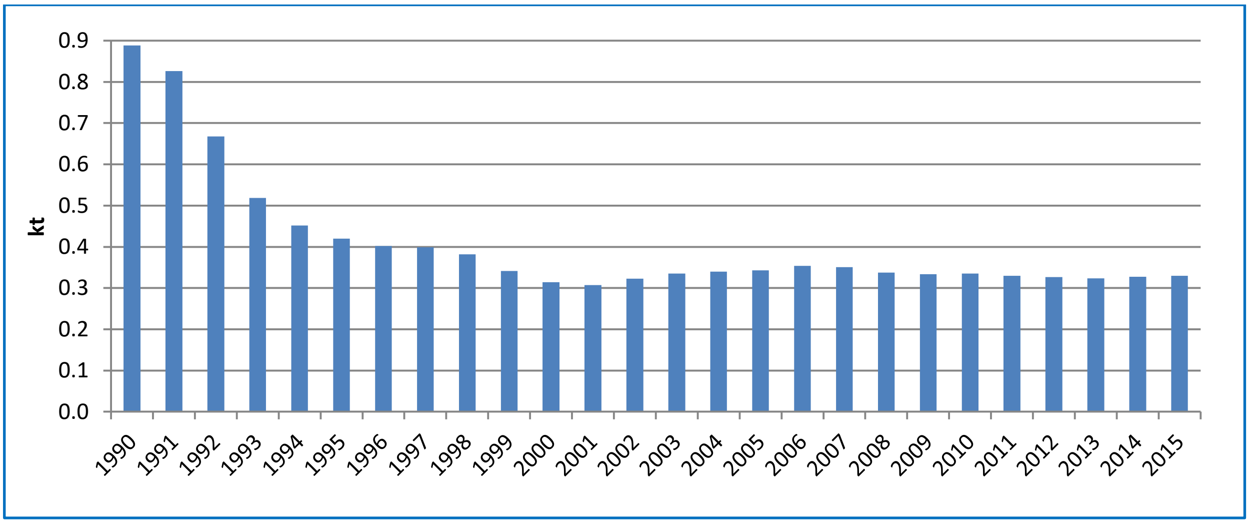


Figure 5-10. Indirect N_2O emission from manure management due to volatilization and leaching

Indirect N_2O emissions due to volatilization of N from different manure management are provided in table 5-50.

Table 5-50. Calculated indirect N_2O emissions from different manure management systems, kt N_2O

Year	AWMS		
	Liquid system	Solid storage	Other systems
1990	0.15	0.54	0.20
1995	0.10	0.24	0.08
2000	0.10	0.17	0.05

2005	0.12	0.17	0.05
2010	0.13	0.16	0.05
2011	0.14	0.15	0.04
2012	0.14	0.15	0.04
2013	0.14	0.15	0.04
2014	0.13	0.15	0.04
2015	0.13	0.15	0.04

5.4.2.2 Methodological issues

To estimate indirect N_2O emissions from manure management the *Tier 1* method was used.

N loss due to volatilization in forms of NH_3 and NO_x from manure management systems was calculated multiplying the amount of nitrogen excreted from all livestock categories and managed in each manure management system by a fraction of volatilized nitrogen[92].

$$N_{volatalization-MMs} = \sum_S \left[\sum_T \left[\left(N_{(T)} \cdot Nex_{(T)} \cdot MS_{(T,S)} \right) \cdot \left(\frac{Frac_{GasMS}}{100} \right)_{(T,S)} \right] \right]$$

where:
$N_{volatilization-MMS}$ – amount of manure nitrogen that is lost due to volatilization of NH_3 and NO_x, kg N yr^{-1};
$N_{(T)}$ – number of head of livestock species/category *T* in the country;
$Nex_{(T)}$ – annual average N excretion per head of species/category *T* in the country, kg N $animal^{-1}$ yr^{-1};
$MS_{(T,S)}$ – fraction of total annual nitrogen excretion for each livestock species/category *T* that is managed in manure management system *S* in the country, dimensionless;
$Frac_{GasMS}$ – percent of managed manure nitrogen for livestock category *T* that volatilizes as NH_3 and NO_x in the manure management system *S*, % (Table 5-51).

The *Tier 1* method was applied for calculations indirect N_2O emissions due to volatilization of N in forms of NH_3 and NO_x from manure management[93].

$$N_2O_{G(mm)} = (N_{volatalization-MMS} \cdot EF_4) \cdot \frac{44}{28}$$

where:
$N_2O_{G(mm)}$ – indirect N_2O emissions due to volatilization of N from Manure Management in the country, kg N_2O yr^{-1};
EF_4 – emission factor for N_2O emissions from atmospheric deposition of nitrogen on soils and water surfaces, kg N_2O-N (kg NH_3-N + NO_x-N volatilized)$^{-1}$; default value is 0.01 kg N_2O-N[94] (kg NH_3-N + NO_x-N volatilized)$^{-1}$.

Nitrogen that leaches into soil and/or run-off during solid storage of manure at outdoor areas or in feedlots can be estimated using the following eq.[95]:

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[92] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, eq. 10.26, p. 10.54
[93] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, eq. 10.27, p. 10.56
[94] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 11, Table 11.3, p. 11.24
[95] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, eq. 10.28, p. 10.56

$$N_{leaching-MMS} = \sum_{S}\left[\sum_{T}\left[\left(N_{(T)} \cdot Nex_{(T)} \cdot MS_{(T,S)}\right) \cdot \left(\frac{Frac_{leachMS}}{100}\right)\right]\right]$$

where:

$N_{leaching\text{-}MMS}$ – amount of manure nitrogen that leached from manure management systems, kg N yr^{-1};

$N_{(T)}$ – number of head of livestock species/category *T* in the country;

$N_{ex(T)}$ – annual average N excretion per head of species/category *T* in the country, kg N $animal^{-1}$ yr^{-1};

$MS_{(T,S)}$ – fraction of total annual nitrogen excretion for each livestock species/category *T* that is managed in manure management system *S* in the country, dimensionless;

$Frac_{leachMS}$ – percent of managed manure nitrogen losses for livestock category *T* due to runoff and leaching during solid storage of manure.

The value of $Frac_{leachMS}$, used in calculation of indirect N_2O emission from Leaching and run-off was estimated as the difference between total N loss from MMS (*2006 IPCC* Chapter 10 Table 10.23 p. 10.67) and N loss from MMS due to volatilisation of N-NH_3 and N-NO_x (*2006 IPCC* Chapter 10 Table 10.22 p. 10.65).

Table 5-51. Default values for N loss due to volatilization of NH_3 and NO_x and leaching from manure management, %

Livestock category	Manure management system	N loss from MMS	
		$Frac_{GasMS}$	$Frac_{LeachMS}$
Dairy cattle	Liquid	40	0
	Solid	30	10
Non-dairy cattle	Liquid	40	0
	Solid	45	5
	Other (Deep bedding)	30	10
Swine	Liquid	48	0
	Solid	45	5
	Other (Deep bedding)	40	10
Poultry (layer hens-wet)	Liquid	48	0
	Without litter	55	0
	With litter	40	10
Horses, sheep, goats, rabbits, other (nutria), fur-bearing	Solid	12	3
Fur-bearing	Other	25	10
	Liquid	48	0

According to expert opinion, there is no leaching neither from liquid manure storage devices. The majority of liquid manure storage devices are constructed according to respective requirements. The majority of liquid manure storage facilities are newer than 10 years and constructed according to respective project requirements.

The indirect N_2O emissions from leaching and run-off of nitrogen from manure management systems are estimated using the following eq.[96]:

[96] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 10, eq. 10.29, p. 10.57

$$N_2O_{L(mm)} = \left(N_{leaching-MMS} \cdot EF_5\right) \cdot \frac{44}{28}$$

where:
$N_2O_{L(mm)}$ – indirect N_2O emissions due to leaching and runoff from manure management in the country, kg N_2O yr^{-1};
EF_5 – emission factor for N_2O emissions from nitrogen leaching and runoff, kg N_2O-N/kg N leached and run-off (default value 0.0075 kg N_2O-N[97] (kg N leaching/run-off)$^{-1}$.

5.4.2.3 Uncertainties and time-series consistency

Indirect N_2O emission from manure management was calculated based on activity data and emission factors. Overall uncertainties result from uncertainty of livestock population (Chapter 5.2.3), uncertainty of emission factors and uncertainty values of other relevant parameters.

Activity data uncertainty

As elaborated in Chapter 5.2.3 uncertainty value for livestock population is ±5%. The uncertainty of the manure management system usage data can be ±10% or less (Chapter 5.3.3). The uncertainty ranges for the default N excretion rate calculating N excretion for goats, swine, horses, rabbits, nutria and fur-bearing animals as well as poultry (excluding subcategories of geese and other poultry) is ±50%. N excretion rate for cattle and sheep were estimated using *Tier 2* method and based on expert judgement it was assumed that uncertainty is ±20%. Overall uncertainty for direct N_2O emissions from MMS activity data was estimated to be ±55%.

Emission factor uncertainty

The uncertainty of EF_4 and EF_5 for estimation of indirect N_2O emissions from volatilization and leaching in accordance with the range given in *2006 IPCC Guidelines* was estimated to be ±240% and ±163% respectively.

Overall uncertainty

Combined uncertainty was calculated using *2006 IPCC Guidelines* eq. 3.1[98]. This approach requires uncertainty values of the main activity data used and uncertainty of emission factor. Combined uncertainty was estimated to be ±246% for N_2O emissions from volatilization and ±172% for N_2O emissions from leaching and run-off.

5.4.2.4 Category-specific QA/QC and verification

General QC procedures applied for this category – check of activity data for the whole time period, consistency check of data entered in CRF with calculation sheets, trends of emissions for each category, relevance of methodology applied, etc.

5.4.2.5 Category-specific recalculations

Recalcualtions of indirect N_2O emissions from manure management due to volatilization of N and leaching and run-off from manure management was performed due to N excretion recalculation and application of new values of $Frac_{LeachMS}$. N excretion recalculation was made due to revision of non-dairy cattle herd structure and revision of GE for swine and sheep categories. Recalculation results are provided in the Table 5–52.

[97] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 11, Table 11.3, p. 11.24
[98] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 3, eq. 3.1, p. 3.28

Table 5-52. Reported in previous submission and recalculated indirect N_2O emissions from manure management due to volatilization of N and leaching from manure management

Year	2016 submission	2017 submission	Absolute difference, kt	Relative difference, %
1990	0.76	0.89	0.13	11.71
1991	0.71	0.83	0.12	11.69
1992	0.50	0.67	0.17	13.40
1993	0.42	0.52	0.10	12.38
1994	0.37	0.45	0.08	12.16
1995	0.36	0.42	0.06	11.67
1996	0.34	0.40	0.06	11.76
1997	0.35	0.40	0.05	11.43
1998	0.32	0.38	0.06	11.88
1999	0.29	0.34	0.05	11.72
2000	0.26	0.31	0.05	11.92
2001	0.28	0.31	0.03	11.07
2002	0.29	0.32	0.03	11.03
2003	0.30	0.34	0.04	11.33
2004	0.30	0.34	0.04	11.33
2005	0.31	0.34	0.03	10.97
2006	0.32	0.35	0.03	10.94
2007	0.30	0.35	0.05	11.67
2008	0.29	0.34	0.05	11.72
2009	0.29	0.33	0.04	11.38
2010	0.29	0.34	0.05	11.72
2011	0.28	0.33	0.05	11.79
2012	0.28	0.33	0.05	11.79
2013	0.27	0.32	0.05	11.85
2014	0.27	0.33	0.06	12.22

5.4.2.6 Category-specific planned improvements

Category-specific improvements are not planned.

5.5 Rice cultivation (CRF 3.C)

Rice is not cultivated in Lithuania therefore reported as NO.

5.6 Agricultural soils (CRF 3.D)

Agricultural soils include direct and indirect nitrous oxide (N_2O) emissions (Table 5-2). Managed soils represent a large source of N_2O emissions. N_2O emission from managed soils contributed 52.9% of the total GHG emission from agriculture sector and 68.4% from the total N_2O emissions in Lithuania. N_2O emissions from agricultural soils were also identified as a key category (see Table 5-1).

5.6.1 Direct N_2O emissions from managed soils (CRF 3.D.1)

5.6.1.1 Category description

Lithuania uses *2006 IPCC Tier 1* methodology for the calculation of N_2O emissions from agriculture soils. All assessed direct N_2O emissions from agriculture soils categories, emission factors and uncertainty range are provided in the table below.

Table 5-53. Reported direct N_2O emissions categories, emissions factors and uncertainty range for agriculture soils category

Category	**Emission Factor kg N_2O-N (kg N)$^{-1}$**	**Uncertainty range**	**Source**
3.D.1 Direct N_2O emission from Managed soils			
1. Inorganic N fertilizers (F_{SN})	0.01	0.003-0.03	*2006 IPCC*, Table 11.1
2. Organic N applied as fertilizer (F_{ON}) a. animal manure applied to soils (F_{AM}) b. sewage sludge applied to soils (F_{SEW}) c. other organic fertilizer applied to soils (F_{SOM})	0.01	0.003-0.03	*2006 IPCC*, Table 11.1
3. Urine and dung from grazing animals (F_{PRP})			*2006 IPCC*, Table 11.1
For cattle, poultry and pigs	0.02	0.007-0.06	
For sheep and other animals	0.01	0.003-0.03	
4. Crop residues (F_{CR})	0.01	0.003-0.03	*2006 IPCC*, Table 11.1
5. Mineralization/immobilization associated with loss/gain of soil organic matter (F_{SOM})	0.01	0.003-0.03	*2006 IPCC*, Table 11.1
6. Cultivation of organic soils (F_{OS})	8	2-24	*2006 IPCC*, Table 11.1

Application of inorganic N fertilizer and crop residues leads to substantial emissions of N_2O from agricultural soils (Figure 5-11). The trend of N_2O emissions from direct N_2O emissions from managed soils are presented in figure below.

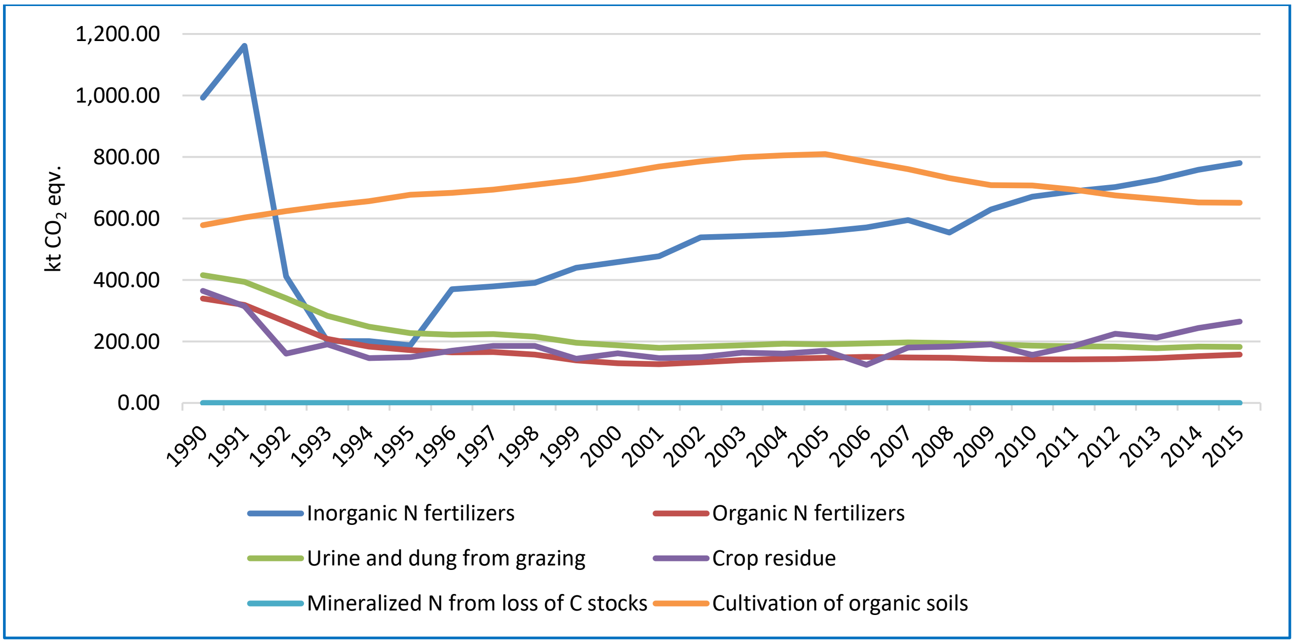

Figure 5-11. N_2O emissions from sub-categories of agricultural soils during the period 1990-2015

Comparing with 1990 N_2O emissions have decreased by 32.2% in 2015 mainly due to reduction in consumption of synthetic N fertilizers. Comparing with 2014 N_2O emission from managed soils has increased by 2.2%. The figure below shows the share of each sub-category of direct N_2O emissions from managed soils in 2015.

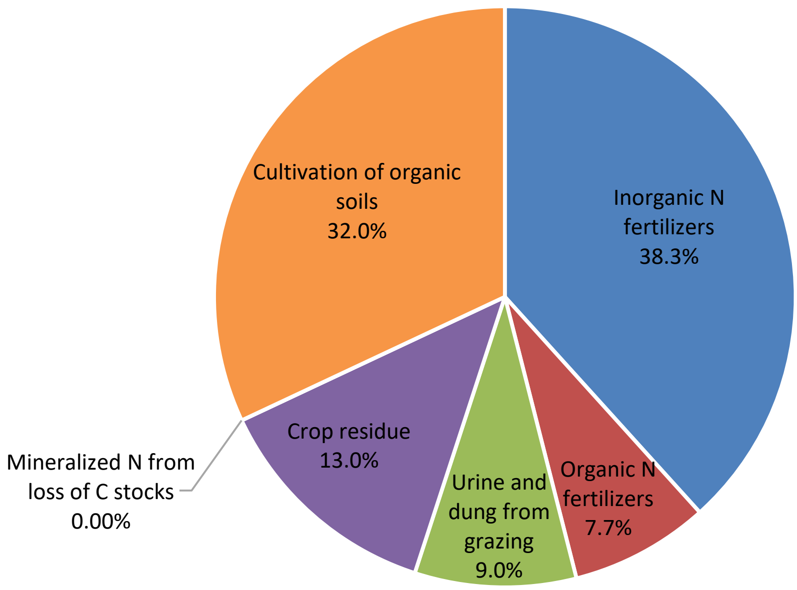

Figure 5-12. The share of N_2O emissions from direct N_2O emissions from managed soils by sub-category in 2015, %

The major part of emissions originates from consumption of inorganic N fertilizers (38.3%) and from cultivation of organic soils (32%).

5.6.1.2 Methodological issues

Direct N_2O emissions from managed soils were estimated using 2006 *IPCC Guidelines* Tier 1 method. The following eq. was used to estimate direct N_2O emissions from managed soils[99]:

$$N_2O_{Direct} - N = N_2O - N_{N\ inputs} + N_2O - N_{OS} + N_2O - N_{PRP}$$

Where:

$$N_2O - N_{N\ inputs} = [(F_{SN} + F_{ON} + F_{CR} + F_{SOM}) \cdot EF_1]$$

$$N_2O - N_{OS} = [(F_{OS,CG,Temp} \cdot EF_{2CG,Temp}) + (F_{OS,CG,Trop} \cdot EF_{2CG,Trop}) + (F_{OS,F,Temp,NR} \cdot EF_{2F,Temp,NR}) + (F_{OS,F,Temp,NP} \cdot EF_{2F,Temp,NP}) + (F_{OS,F,Trop} \cdot EF_{2F,Trop})$$

$$N_2O - N_{PRP} = [(F_{PRP,CPP} \cdot EF_{PRP,CPP}) + (F_{PRP,SO} \cdot EF_{PRP,SO})]$$

where:

$N_2O_{Direct–N}$ – annual direct N_2O–N emissions produced from managed soils, kg N_2O–N yr^{-1};

$N_2O–N_{N\ inputs}$ – annual direct N_2O–N emissions from N inputs to managed soils, kg N_2O–N yr^{-1};

[99] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, eq. 11.1, p. 11.7

$N_2O–N_{OS}$ – annual direct $N_2O–N$ emissions from managed organic soils, kg $N_2O–N$ yr^{-1};
$N_2O–N_{PRP}$ – annual direct $N_2O–N$ emissions from urine and dung inputs to grazed soils, kg $N_2O–N$ yr^{-1};
F_{SN} – annual amount of inorganic fertilizer N applied to soils, kg N yr^{-1};
F_{ON} – annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N yr^{-1};
F_{CR} – annual amount of N in crop residues (above-ground and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils, kg N yr^{-1};
F_{SOM} – annual amount of N in mineral soils that is mineralized, in association with loss of soil C from soil organic matter as a result of changes to land use or management, kg N yr^{-1};
F_{OS} – annual area of managed/drained organic soils, ha (subscripts CG, F, Temp, Trop, NR and NP refer to Cropland and Grassland, Forest Land, Temperate, Tropical, Nutrient Rich, and Nutrient Poor, respectively);
F_{PRP} – annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr^{-1} (the subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and Other animals, respectively);
EF_1 – emission factor for N_2O emissions from N inputs, kg $N_2O–N$ (kg N input)$^{-1}$ (default);
EF_{1FR} – emission factor for N_2O emissions from N inputs to flooded rice, kg $N_2O–N$ (kg N input)$^{-1}$ (default);
EF_2 – emission factor for N_2O emissions from drained/managed organic soils, kg $N_2O–N$ ha^{-1} yr^{-1} (the subscripts CG, F, Temp, Trop, NR and NP refer to cropland and grassland, forest land, temperate, tropical, nutrient rich, and nutrient poor, respectively) (default);
EF_{3PRP} – emission factor for N_2O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals, kg $N_2O–N$ (kg N input)$^{-1}$ (the subscripts CPP and SO refer to cattle, poultry and pigs, and sheep and other animals, respectively) (default).

Conversion of N_2O-N emissions to N_2O emissions for reporting purposes is performed by using the following eq.:

$$N_2O = N_2O - N \cdot 44/28$$

Applied inorganic N fertilizers (F_{SN}) (CRF 3.D.1.1)

The main data required to estimate amount of nitrogen that is being deposited on soil is consumption of nitrogen containing inorganic fertilizers. There is no national data available for consumption of nitrogen fertilizers in Lithuania (except for the period 1990-1994). In order to fill in the gap Lithuania was using several different data sources (including Eurostat data and data of JSC Agrochema), but eventually data was recalculated using a single data source – International Fertilizer Industry Association (IFA)[100]. IFA statistics provides data for the whole time period and this assures consistency in time series (Figure 5-13). However, data for the 2015 on inorganic N fertilizer consumption in the IFA database will be available in September of 2017. Therefore, to obtain missing activity data for the year 2015 extrapolation was used.

[100] Available from: *http://ifadata.fertilizer.org/ucSearch.aspx*

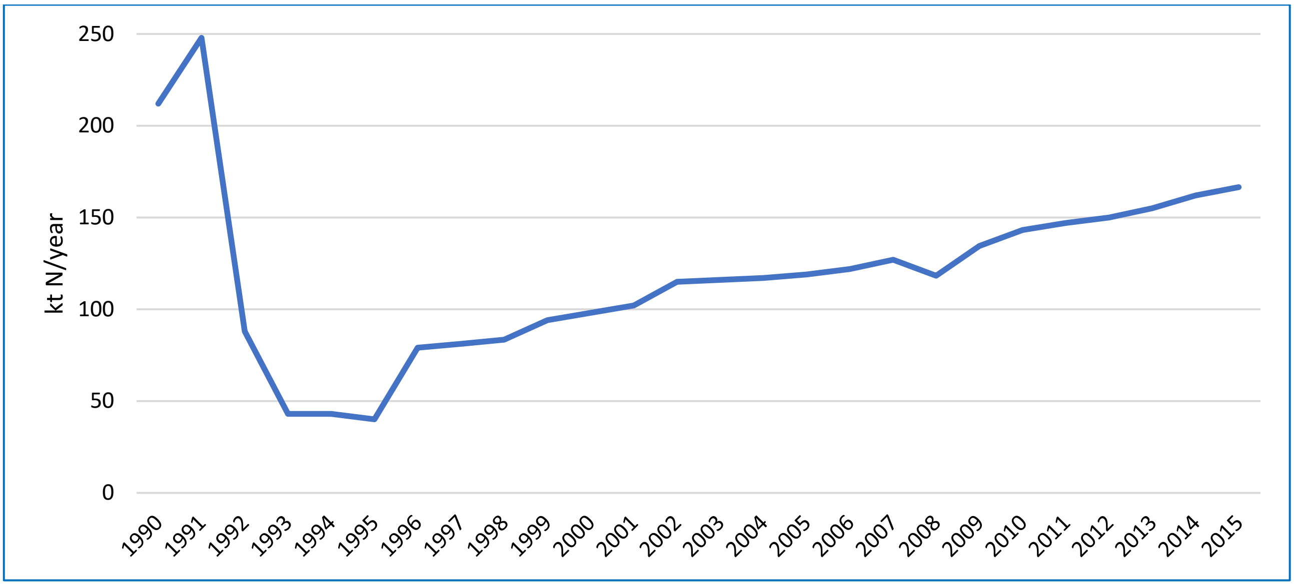

Figure 5-13. Inorganic N fertilizers consumption in Lithuania during the period 1990-2015

After the restoration of Lithuanian independence consumption of fertilizers drastically declined up to 40 kt per year in 1995. During the following years consumption rose as the economy was progressing together with the growth of agriculture, demand of crops and vegetables. The consumption dropped somewhat in 2008 due to economic crisis.

To calculate N_2O emissions from consumption of inorganic N fertilizers default emission factor (Table 5-53) was used. To convert N_2O-N emissions to N_2O emissions value was multiplied by 44/28.

Applied organic N fertilizers (F_{ON}) (CRF 3.D.1.2)

Amount of organic N inputs to soil in Lithuania refers to applied animal manure (other than by grazing animals), sewage sludge that is used as soil amendment and compost application as soil fertilizer. Overall organic N input to soil is calculated using *Tier 1* method[101]:

$$F_{ON} = F_{AM} + F_{SEW} + F_{COMP}$$

where:

F_{ON} – total annual amount of organic N fertiliser applied to soils other than by grazing animals, kg N yr^{-1};
F_{AM} – annual amount of animal manure N applied to soils, kg N yr^{-1};
F_{SEW} – annual amount of total sewage N that is applied to soils, kg N yr^{-1};
F_{COMP} – annual amount of total compost N applied to soils, kg N yr^{-1}.

Animal manure applied to soils (F_{AM}) (CRF 3.D.1.2.a)

The main data used for calculation of animal manure nitrogen is described in category Manure management (Chapter 5.4). This data includes average annual population of livestock, fraction

[101] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, eq. 11.3, p. 11.12

of total annual nitrogen excretion for each livestock category that is managed in different manure management systems[102], annual average N excretion per animal category, etc.

Animal manure in Lithuania is applied to soil as organic fertilizers. N inputs to soil were estimated using the following eq.:

$$F_{AM} = N_{MMS\_Avb} \cdot [1 - (Frac_{FEED} + Frac_{FUEL} + Frac_{CNST})]$$

To estimate $N_{MMS,Avb}$ 10.34 equation from *2006 IPCC Guidelines* was modified, due to lack of sufficient scientific data on amount of nitrogen from bedding material. As amount of nitrogen from bedding was excluded from animal manure applied to soils estimations, however it was included in the nitrogen returned to soils as crop residues.

$$N_{MMS_{Avb}} = \sum_{S} \left\{ \sum_{(T)} \left[\left[\left(N_{(T)} \cdot Nex_{(T)} \cdot MS_{(T,S)} \right) \cdot \left(1 - \frac{Frac_{LossMS}}{100} \right) \right] + \right] \right\}$$

where:

N_{MMS_Avb} – amount of managed manure nitrogen available for application to managed soils or for feed, fuel, or construction purposes, kg N yr^{-1};
$N_{(T)}$ – number of head of livestock species/category *T* in the country;
$Nex_{(T)}$ – annual average N excretion per animal of species/category *T* in the country, kg N $animal^{-1}$ yr^{-1};
$MS_{(T,S)}$ – fraction of total annual nitrogen excretion for each livestock species/category *T* that is managed in manure management system *S* in the country, dimensionless;
$Frac_{LossMS}$ – amount of managed manure nitrogen for livestock category *T* that is lost in the manure management system *S*, %;
S – manure management system;
T – species/category of livestock.

As there is no data available on the fraction of manure that is being used as feed, fuel or material for construction therefore $F_{AM} = N_{MMS\_Avb}$.

Activity data used in calculations is presented in previous chapters: average annual livestock population (Table 5-3), N excretion values were calculated in sub-category Manure management – N_2O (Chapter 5.4.1.2), fraction of annual nitrogen excreted for each livestock category from each MMS type was indicated in sub-category Manure management and is presented in Chapter 5.3.2.2. Amount of managed manure nitrogen for each livestock category that is lost in the MMS ($Frac_{LossMS}$) were taken from *2006 IPCC Guidelines*.[103]

Sewage sludge applied to soils (F_{SEW}) (CRF 3.D.1.2.b)

Sewage sludge from wastewater treatment plants is used as soil amendment in Lithuania. According to the national database of waste – sewage sludge with recovery code R10 is being

[102] Juška, R., *et al Survey and evaluation of methane and nitrous oxide emission content in manure management systems of Lithuania*. Study (*Lietuvos mėšlo tvarkymo sistemose susidarančių metano ir azoto suboksido kiekio tyrimai ir įvertinimas*. Studija). Lietuvos sveikatos mokslų universitetas, Gyvulininkystės institutas. Baisogala, 2012
[103] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 10, Table 10.23, p. 10.67

treated as useful amendment for agricultural soil[104]. Only municipal sewage sludge is applied to soils.

Data on the quantities of sewage sludge applied to soils for the periods 1991-1999 and 2004-2012 were obtained from Lithuanian Environmental Protection Agency (EPA) which collects information and manages waste database. The data on quantities of sewage sludge for the years 1990, 2000-2003 are not reliable. It is not clear how much sewage sludge has been used on agricultural soils during these years. As a result, it was decided to use interpolation in order to fill in the gap of data for the period 2000-2003. It was assumed that annual amount of sewage sludge in 1990 is similar to that of 1991 based on this assumption the same amount of sewage sludge was used both in 1990 and 1991.

To calculate the nitrogen input from application of sewage sludge the data of nitrogen concentration (%) was used (EPA's data). The data on nitrogen concentration is available for the period 2004-2015. 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. To fill the gaps of missing information on N concentration in sewage sludge for the period 1990-2003 arithmetic average value of the years 2004-2009 was used (3.75%).

The following eq. was used for calculation of nitrogen input from sewage sludge application to agricultural soils:

$$F_{SEW} = S_{SLUDGE} \cdot \frac{S_N}{100}$$

where:

F_{SEW} – annual amount of total sewage N that is applied to soils, kg N yr^{-1};
S_{SLUDGE} – annual amount of sewage sludge applied to agricultural soils, kg d.m. yr^{-1};
S_N – nitrogen content in dry matter, %.

Compost applied to soils (F_{COMP})(CRF 3.D.1.2.c)

Using the financial resources of 2004-2006 EU ISPA/Cohesion funds Lithuania started improving municipal solid waste management system. The main task was to build 11 modern regional landfills and to close all the old landfills and dumps. This project also included construction of green waste composting sites (GWCS). The period 2004-2006 financed construction of 13 GWCS in different regional landfills. Second part of the project was implemented using finances from 2007-2013 EU Structural funds continuing projects started during 2004-2006. The period 2007-2013 financed construction of 39 GWCS in different regional landfills. Most of these GWCS have started accepting green waste in 2011 and producing compost in 2013. Few of the 11 regional waste management centres (RWMC) provided data on quantities of compost that was sold as organic fertilizers. As required these RWMC also provided data on dry matter (DM) content and compost composition that includes amount of N (kg/kg). Average DM content in compost in 2015 was 58.8% and average content of N in DM – 0.0099 kg/kg.

To calculate amount of N that was deposited on soil using compost as organic fertilizer the following eq. was used:

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[104] 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

$$F_{COMP} = (S_{COMP} \cdot \frac{DM}{100}) \cdot C_N$$

where:

F_{COMP} – annual amount of total compost N that is applied to soils, kg N yr^{-1};
S_{COMP} – annual amount of compost applied to soils, kg yr^{-1};
DM – dry matter content in compost, %;
C_N – nitrogen content in compost, kg/kg.

Unfortunately until the GWCS were started operating no data on compost use in Lithuania was available therefore reported as NO. No data on amount of compost used in private farms is available.

Urine and dung from grazing animals (F_{PRP}) (CRF 3.D.1.3)

Annual amount of N deposited on pasture, range and paddock soils by grazing animals (F_{PRP}) was estimated using parameters estimated in category Manure management. The main data used was: annual average livestock population by category, fraction of total annual N excretion of each livestock category that was deposited on pasture, range and paddock soils, and annual average N excretion per head of livestock category. To estimate N deposited on pasture, range and paddock soils the following eq. was used:

$$F_{PRP} = \sum_{T} \left[\left(N_{(T)} \cdot Nex_{(T)} \right) \cdot MS_{(T,PRP)} \right]$$

where:

F_{PRP} – annual amount of urine and dung N deposited on pasture, range, paddock and by grazing animals, kg N yr^{-1};
$N_{(T)}$ – number of head of livestock species/category *T* in the country;
$Nex_{(T)}$ – annual average N excretion per head of species/category *T* in the country, kg N animal^{-1} yr^{-1};
$MS_{(T,PRP)}$ – fraction of total annual N excretion for each livestock species/category *T* that is deposited on pasture, range and paddock.

Crop residues (F_{CR}) (CRF 3.D.1.4)

The amount of nitrogen that is returned to soil by crop residue is calculated according *2006 IPCC Guidelines* with small amendments. Plants are divided into 3 categories:

1) Non-N-fixing grain crops: winter wheat, spring wheat, triticale, rye, barley, oats, flax, buckwheat, mixed cereals, other cereals, grain maize, maize for silage, silage crops (excl. maize), winter rape, spring rape, vegetables;
2) Root and tuber: potatoes, fodder beet, sugar beet;
3) N-fixing pulses and forage crops: peas, beans, soya beans, mixed dried pulses, lupines, vetches, lucerne, clover and clover mixture; annual grasses, perennial grasses, other perennial grasses, meadows pasture, meadows and natural pastures.

Lithuanian Statistics provide data on harvest of total perennial grasses from 1993-2014. However, from 2003 Statistics disaggregate total perennial grasses into: 1. Lucerne; 2. Clover and their mixture; 3. Other perennial grasses categories. In order to avoid double counting data of total perennial grasses for 2003-2014 period was excluded from the estimation.

Non-N-fixing grain crops and root/tuber

In order to estimate amount of N (F_{CR}) returned to soil with crop residues from non-N-fixing grain crops and root/tuber categories it was assumed that crop consists of grain (product), above-ground and below-ground residues. In order to quantify the amount of above-ground and below-ground residue left on the field data on harvesting index (HI)[105] and ratio of product and above-groun were used. Total crop biomass produced was identified using data on crop harvested (thous. tones) provided by Statistic Lithuania and HI of each crop type. This data let to identify the amount of above-ground and below-ground residue left on the field. For each crop type country specific dry matter values were applied.

For all plants categories national data of crop harvest and harvested area of crops[106], dry matter[107] were used. To estimatimate the amount of N that was returned to soil from non-N-fixing grain crops and Root/tuber was decided to use available national data such as: harvesting index[108], N content in above-ground residue[109], DM of above-ground residue[110] and DM below-ground residue[111]. For wheat and rape national data on N content in below-ground residues[112] were used. National parameters used in non-N-fixing grain crops estimations is provided in the table below.

Table 5-54. Parameters used to estimate nitrogen from crop residues returned to soil from non-N-fixing grain crops

Crop	Harvesting Index (d.u.)	Product/ Above ground residue ratio (d.u.)	Dry matter (%)			N concentration in crop residues	
			Crop DM	Above ground DM	Below ground DM	Above ground (kg N)	Below ground (kg N)
Wheat	0.40	1	0.85	0.83	0.40	0.0051	0.0031
Triticale	0.45	1.1	0.85	0.83	0.40	0.0051	0.0031
Rye	0.35	0.9	0.85	0.81	0.40	0.0067	0.0031
Barley	0.45	1	0.85	0.81	0.40	0.0096	D
Oats	0.45	1.1	0.85	0.82	0.40	0.0074	D
Flax*	-	-	0.915	-	-	0.0061	D
Buckwheat*	-	-	0.85	-	-	0.0064	D
Grain maize	0.40	1	0.85	0.70	0.40	0.0090	D
Maize for silage	0.40	1	0.35	0.70	0.40	0.0073	D
Silage crops	-	-	0.35	-	-	0.0073	D

105 Slapauskas *et al.* Augalu produktyvumas (en. *Productivity of plants*), 2008. 1.3 lentele, p. 18
106 Statistics Lithuania
107 Gyvulininkystės žinynas. Lietuvos Gyvulininkystės institutas. Baisogala. (en. *Livestock Manual. Institute of Animal Science of LVA.*), 2007; University of Aleksandras Stulginskis recommendations.
108 Slapauskas et al. Augalu produktyvumas (en. Productivity of plants), 2008. 1.3 lentele, p. 18; Doc. Dr. A. Siuliausko tyrimai;
109 Maisto medžiagų išnešamų iš dirvožemio su auginamų pagrindinių lauko augalų ir daržovių derliumi, kiekio dinamikos tyrimai. Atasakita (en. Nutritions taken out from soil with the main agricultural crop and vegetable harvests, content-dynamic study) 2014. p. 132-133.
110 Gyvulininkystės žinynas. Lietuvos Gyvulininkystės institutas. Baisogala. (en. *Livestock Manual. Institute of Animal Science of LVA.*), 2007.; Augalinės kilmės atliekų panaudojimo tręšimui, jų normų nustatymo, kitų augalinių trąšų žemės ūkyje naudojimo būdų tyrimai, analizė ir įvertinimas. Ataskaita (en. *Analysis and assessment of crop residues application as soil fertilizers, identification of their norms, and usage of other plant waste as fertilizers in agriculture. Report*), 2011, p. 3; Komposto, naudojamo žemės ūkyje, kokybės reikalavimų analizė ir įvertinimas. Ataskaita, 2011. 3 lentele, p. 12 (en. *Quality analysis and assessment of comport used in agriculture*. Report, 2011, Table 3, p. 12);
111 Prof. L. Špokas. Straipsnis. Sėkmingai javapjūtei pamatai klojami iš anksto. Mano ūkis 2009/4. (en. Article. *Foundation for successful harvest are laid in atvance*).
112 Doc. Dr. V. Liako tyrimai;

excl. maize*							
Winter rape	0.30	1.4	0.915	0.70	0.40	0.0062	0.0045
Spring rape	0.30	1.3	0.915	0.70	0.40	0.0086	0.0055
Vegetables*	-	-	0.22	-	-	D	D

D – Default value taken from *2006 IPCC Guidelines* Table 11.2, p. 11.17
*Default values were used as no national data is available

Similar methodology was applied estimating N retuned to soil with residues of beet and root vegetables. It was assumed that all top mass was left as residues (i.e. leaves). Country specific data on production and residues ratio[113] was used to estimate the amount of residues left on the field as well as CS data on N amount in the residues[114].

Table 5-55. Parameters used to estimate N from root and tuber returned to soil

Vegetable type	Residue: product ratio (d.u.)	Conversion to dry matter (%)		N in residues (kg N)
		Crop DM	Top DM	
Potatoes	0.2	0.22	0.24	0.0014
Sugar beet	0.6	0.23	0.17	0.0025
Fodder beet	0.4	0.12	0.15	0.0025

N-fixing pulses and forage crops

To estimate nitrogen amount returned to soil from N-fixing pulses and forage crops category *2006 IPCC Guidelines* equation 11.6 was used. National data of dry matter and $Frac_{RENEW}$ were used to estimate the amount of N return to soil from N-fixing pulses and forages (showed in the Tables 5-55 and 5-57). As there is lack of sufficient and reliable scientific data on amount of above-ground residue removed annually for purposes such as feed, bedding and construction, no removal was assumed ($Frac_{REMOVE}$ 0 kg N). There is no field burning of agricultural residue in Lithuania (Chapter 5.8), therefore annual area of crop burnt was assumed to be zero. The default values for each crop type from *2006 IPCC Guidelines*[115] were taken for ratio of above-ground residues, ratio of below-ground residues, N content of above-ground residues and N content of below-ground.

Table 5-56. Parameters used to estimate nitrogen from crop residues returned to soil

N-fixing pulses and forages	Dry matter
Peas	0.84
Beans	0.87
Soya Beans	0.83
Mixed dried pulses	0.91
Lupines	0.15
Vetches	0.23
Grasses hey	0.86
Grasses green fodder	0.22

Table 5-57. $Frac_{RENEW}$ used in estimation[116]

[113] Komposto, naudojamo žemės ūkyje, kokybės reikalavimų analizė ir įvertinimas. Ataskaita, 2011, lentelė 3, p. 12 (en. *Quality analysis and assessment of comport used in agriculture*. Report, 2011, Table 3, p. 12)

[114] Maisto medžiagų išnešamų iš dirvožemio su auginamų pagrindinių lauko augalų ir daržovių derliumi, kiekio dinamikos tyrimai. Atasakita (en. Nutritions taken out from soil with the main agricultural crop and vegetable harvests, content-dynamic study) 2014. p. 132-133.

[115] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, Table 11.2, p. 11.17

[116] Zekoniene V., Daugeliene N., Bakutis B.,Mokslinių rekomendacijų taikymo ekologiniame ūkyje pagrindai (en. The basic applications of scientific recommendations in the organic farming), 2006., p.76;

Parameter	Year
$Frac_{RENEW}$ Annual	1
$Frac_{RENEW}$ Perennial grasses	5
$Frac_{RENEW}$ Meadows pastures and permanent pastures/meadows	8

N returned to soil from N-fixing pulses and forage/ pasture renewal was estimated using the following equation[117]:

$$F_{CR} = \sum_{T} \{Crop_{(T)} \cdot Frac_{Renew(T)} \cdot [(Area_{(T)} - Area\ burnt_{(T)} C_f) \cdot R_{AG(T)} \cdot N_{AG(T)} \cdot (1 - Frac_{Remove(T)}) + Area_{(T)} \cdot R_{BG(T)} \cdot N_{BG(T)}]\}$$

where:
F_{CR} – annual amount of N in crop residues (above and below ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually, kg N yr^{-1};
$Crop_{(T)}$ – harvested annual dry matter yield for crop *T*, kg d.m. ha^{-1};
$Area_{(T)}$ – total annual area harvested of crop *T*, ha yr^{-1};
Area burnt $_{(T)}$ – annual area of crop *T* burnt, ha yr^{-1};
C_f – combustion factor (dimensionless);
$Frac_{Renew\ (T)}$ – fraction of total area under crop *T* that is renewed annually;
$R_{AG(T)}$ – ratio of above-ground residues dry matter ($AG_{DM(T)}$) to harvested yield for crop *T* ($Crop_{(T)}$), kg d.m. (kg d.m.)$^{-1}$;
$N_{AG(T)}$ – N content of above-ground residues for crop *T*, kg N (kg d.m.)$^{-1}$;
$Frac_{Remove(T)}$ – fraction of above-ground residues of crop *T* removed annually for purposes such as feed, bedding and construction, kg N (kg crop-N)$^{-1}$;
$R_{BG(T)}$ – ratio of below-ground residues to harvested yield for crop *T*, kg d.m. (kg d.m.)$^{-1}$;
$N_{BG(T)}$ – N content of below-ground residues for crop *T*, kg N (kg d.m.)$^{-1}$;
T – crop or forage type.

Amount of N returned to soil and N_2O emission from non-N-fixing grain crops, roots/tuber and N-fixing pulses and forage crops categories are showed in Table 5-55.

Table 5-58. The amount of nitrogen returned to soil and N_2O emission from crop residue

Year	N returned to soil, kg N/yr	N_2O emission, kt CO_2 eqv.
1990	77,842,602	364.53
1995	31,977,450	149.75
2000	34,574,054	161.91
2005	36,363,032	170.28
2010	33,497,382	156.86
2011	39,633,292	185.60
2012	48,194,049	225.69
2013	45,535,007	213.23
2014	52,180,666	244.35
2015	56,525,150	264.70

Mineralization/Immobilization associated with loss/gain of soil organic matter (F_{SOM}) (CRF 3.D.1.5)

[117] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, eq. 11.6, p. 11.14

The amount of N mineralized from loss in soil organic C in mineral soils through land use change or management practices was estimated using the following eq.[118]:

$$F_{SOM} = \sum_{LU} \left[\left(\Delta C_{Mineral,\ LU} \cdot \frac{1}{R} \right) \cdot 1000 \right]$$

where:
F_{SOM} – the net annual amount of N mineralized in mineral soils as a result of loss of soil carbon through change in land use or management, kg N;
$\Delta C_{Mineral,\ LU}$ – average annual loss of soil carbon for each land-use type (LU), tones C;
R – C:N ratio of the soil organic matter;
LU – land-use and/or management system type.

Average annual loss of soil carbon due to land use change or management systems was obtained from LULUCF sector Cropland remaining cropland subcategory. The C:N ratio value was taken from *2006 IPCC Guidelines*, default value of 10 for management of mineral soils[119].

Cultivation of organic soils (F_{OS}) (CRF 3.D.1.6)

To estimate N_2O emission from cultivation of organic soils the data on organic soils area of Cropland and Grassland were taken from LULUCF sector. The definitions of Cropland and Grassland are provided in the NIR Chapters 6.3 and 6.4. The activity data on organic soils of Cropland and Grassland area is provided in the Table 5-59. This area is than multiplied by emission factors for each land use category: Cropland and Grassland – $EF_{2\ CG,Temp,Org}$ (8 kg N_2O-N/ha). Emission factors were obtained from *2006 IPCC Guidelines*[120].

Table 5-59. Area of Cropland and Grassland organic soils

Year	Cropland area, ha	Grassland area, ha
1990	16,982	137,306
1995	15,584	165,159
2000	14,161	185,124
2005	12,816	203,201
2010	14,560	174,224
2011	14,605	170,609
2012	14,773	165,486
2013	14,910	162,318
2014	15,075	159,089
2015	14,966	158,958

During the whole period Cropland organic soils area decreased by 12%, Grassland organic soils area increased by 16%.

5.6.1.3 Uncertainty and time-series consistency

Activity data uncertainty

It is very difficult to estimate the actual uncertainty of activity data used to estimate direct N_2O emissions from managed soils. Most of uncertainty values were estimated based on expert

[118] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, eq. 11.8, p. 11.16
[119] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, p. 11.16
[120] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, Table 11.1, p. 11.11

assumptions. Activity data uncertainty values are provided in the table below for each sub-category of direct N_2O emissions from managed soils.

Table 5-60. Uncertainty values for each direct N_2O emissions from managed soils sub-category

Activity data	Uncertainty value
Consumption of Synthetic N fertilizers	±15%
Manure N applied to soils	±20%
Sewage sludge N applied to soils	±30%
Compost N applied to soils	±15%
N deposited on pasture, range and paddock by grazing animals	±20%
N returned to soil by crop residues, including N-fixing crops and forage/pasture renewal,	±30%
Mineralization associated with loss of soil organic matter	±10%
Cultivation of organic soils	±10%

Emission factor uncertainty

For the *Tier 1* method there is a larger uncertainty range for the default factors. For *Tier 1* method uncertainty of N_2O EF were estimated basing on EF uncertainty range: EF_1 – ±135%; $EF_{2\ CG,\ Temp}$ – ±137.5%; $EF_{2F,\ Temp,\ Org,\ R}$ – ±66.7%; $EF_{2F,\ Temp,\ Org,\ P}$ – ±140%; $EF_{3PRP,\ CPP}$ – ±132.5%; $EF_{3PRP,\ SO}$ – ±135%.

5.6.1.4 Category-specific QA/QC and verification

General quality control procedures where applied estimating direct N_2O emissions from managed soils: analysis of activity data trends, consistency check of calculated emissions and imported data to CRF Reporter, consistency check of activity data sources, completeness check and etc. For 3.D.1 Direct N_2O emissions from agriculture soils category (inorganic N fertilizers, organic N fertilizer, urine and dung deposited by grazing animals, crop residue, mineralization/immobilization associated with loss/gain of soil organic matter and cultivation of organic histosols) calculation spreadsheets were assessed if used activity data, emissions factors and units are correct.

The amounts of nitrogen were crosschecked between 3.D.1.2.a Animal manure applied to soils and 3.D.1.4 Crop residues categories. The results showed that fraction of nitrogen in above-ground crop residues removed annually as bedding material is not consistent with calculated N amounts of bedding materials in Animal manure applied to soils. Due to lack of sufficient scientific data on amount of nitrogen from bedding material default values were used, however N amounts in bedding were only applied for cattle and swine categories as the *2006 IPCC Guidelines* provide N amounts in bedding only for these two livestock categories. However, in the 2016 NIR submission for the estimation of Crop residue category $Frac_{REMOVE}$ of 45% was used (the value was taken from national study). Therefore, due to the lack of sufficient and reliable scientific data on N amounts in bedding for different livestock categories, it was chosen to not include N amounts from bedding into Animal manure applied to soils estimation and to assume no removal for Crop residue category ($Frac_{REMOVE}$ 0).

Comparison between activity data and other parameters used in estimation in 3.D.1. Direct N_2O emissions from managed soils (Animal manure applied to soils and Urine and dung deposited by grazing animals) and 3.B.2 N_2O and NMVOC emission from manure management categories were made to ensure data consistency. The same procedure was applied to the 3.D.1.5 Mineralization associated with gain/loss of soil organic matter and 3.D.1.6 Cultivation of organic soils categories to ensure activity data consistency with 4.B Cropland and 4.C Grassland categories.

All parameters used in estimation of N_2O emission from 3.D.1.4 Crop residue category were reviewed. Plants dry matter and N content in above-ground residue were updated according to recent scientific literature. CS parameters of plants dry matter and N content in above-ground residue were compared with default parameters provided in the *2006 IPCC Guidelines* (Vol. 4 Ch. 11, Table 11.2) and between neighbouring countries (Latvia, Estonia and Poland). Results showed a slight difference. Country specific $Frac_{RENEW}$ value has been applied and for consistency reasons it was compared to neighbouring countries (Latvia and Estonia), results showed that Estonia for herbaceous plants pastures also uses 8 years average pastures renewal period. Moreover, an analysis of data of Statistics Lithuania on plants grown in Lithuania has been performed and it showed that few categories were missing, therefore missing plant categories were included into estimations.

Aiming to improve GHG inventory preparation process the Ministry of Environment of the Republic of Lithuania and Norwegian Environment Agency initiated and implemented project "Partnership project on greenhouse gas inventory". One of the project activities was quality assurance procedure of 3.D Agriculture soils category, performed in 2016 by Norwegian Environment Agency experts. During this QA few inconsistencies/errors in estimation of agricultural soils GHG emissions have been identified (emissions from organic soils and crop residues) and recommendations how to improve transparency of NIR were provided. All review findings and recommendations were taken into consideration and where possible implemented in this submission.

Furthermore, in 2015 and 2016 European Commission had organized a comprehensive technical review of EU Member States' GHG inventories to ensure that the European Commission has accurate, reliable and verified information on annual GHG emissions to determine compliance with the EU Effort sharing decision and to strengthen Member States' capacity in managing GHG inventories. In 2015 review Lithuania had indicated as a priority area to review 3.D Agricultural soils category and received number of valuable findings from EU experts which helped to improve GHG inventory report quality.

5.6.1.5 Category-specific recalculation

In 3.D.1.2.c Other organic fertilizers applied to soils recalculation for 2013 and 2014 was done due to update of activity data and correction of typing error of dry matter.

Table 5-61. Reported in previous submission and recalculated N_2O emissions from Other organic fertilizers applied to soils

Year	2016 submission	2017 submission	Absolute difference, kt CO_2 eqv.	Relative difference, %
2013	0.042	0.037	-0.01	-12.14
2014	0.108	0.129	0.02	19.56

In 3.D.1.2.b Sewage sludge applied to soils recalculation was made due to update of activity data and data on nitrogen concentration in sewage sludge for 2011-2015 period become available.

Table 5-62. Reported in previous submission and recalculated N_2O emissions from Sewage sludge applied to soils

Year	2016 submission	2017 submission	Absolute difference, kt CO_2 eqv.	Relative difference, %
2004	2.15	2.12	-0.03	-1.47
2005	2.20	2.18	-0.02	-0.98
2006	1.26	1.35	0.09	7.08
2007	3.51	1.75	-1.76	-50.26
2008	3.85	4.61	0.76	19.65
2009	3.94	3.94	0.00	0.01
2010	1.57	2.74	1.17	74.29
2011	1.97	3.03	1.06	53.72
2012	1.51	1.94	0.43	28.28
2013	1.52	2.47	0.95	62.37
2014	0.29	3.14	2.86	992.30

Due to recalculation made in CRF 3.B.2 Manure management category, emission from 3.D.1.2.a Animal manure applied to soils (Table 5-63) and 3.D.1.3 Urine and dung deposited by grazing animals (Table 5-64) were also recalculated. Also for 3.D.1.2.a Animal manure applied to soils $frac_{LossMS}$ for minks was corrected.

Table 5-63. Reported in previous submission and recalculated N_2O emissions from Animal manure applied to soils

Year	2016 submission	2017 submission	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	425.42	340.58	-84.85	-19.94
1991	390.13	319.74	-70.39	-18.04
1992	301.64	264.14	-37.50	-12.43
1993	238.91	209.66	-29.25	-12.24
1994	210.68	183.61	-27.07	-12.85
1995	201.14	170.68	-30.46	-15.14
1996	195.25	164.54	-30.71	-15.73
1997	191.35	164.36	-26.98	-14.10
1998	179.92	156.32	-23.61	-13.12
1999	161.37	137.98	-23.39	-14.49
2000	142.84	128.21	-14.64	-10.25
2001	144.71	125.39	-19.32	-13.35
2002	151.70	131.28	-20.42	-13.46
2003	158.48	138.15	-20.33	-12.83
2004	160.25	142.74	-17.51	-10.92
2005	163.54	145.63	-17.91	-10.95
2006	168.54	149.85	-18.69	-11.09
2007	160.65	147.27	-13.38	-8.33
2008	155.49	142.54	-12.95	-8.33
2009	151.40	139.16	-12.24	-8.08
2010	150.44	139.01	-11.43	-7.60
2011	149.53	138.64	-10.89	-7.28
2012	149.72	140.67	-9.05	-6.05
2013	152.66	143.09	-9.57	-6.27

2014	159.74	148.53	-11.21	-7.02

Table 5-64. Reported in previous submission and recalculated N_2O emissions from Urine and dung deposited by grazing animals

Year	2016 submission	2017 submission	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	417.99	416.40	-1.59	-0.38
1991	388.79	394.18	5.39	1.39
1992	316.32	340.90	24.58	7.77
1993	267.29	283.15	15.85	5.93
1994	236.20	248.10	11.90	5.04
1995	222.94	227.53	4.60	2.06
1996	221.77	222.57	0.80	0.36
1997	221.38	224.68	3.29	1.49
1998	210.76	216.41	5.65	2.68
1999	194.21	195.58	1.37	0.71
2000	180.83	187.95	7.12	3.94
2001	179.83	179.71	-0.11	-0.06
2002	184.81	183.38	-1.43	-0.77
2003	190.01	188.22	-1.79	-0.94
2004	191.82	192.79	0.98	0.51
2005	191.88	191.15	-0.74	-0.38
2006	196.44	193.58	-2.86	-1.46
2007	194.38	197.02	2.64	1.36
2008	194.86	195.52	0.66	0.34
2009	190.67	191.07	0.40	0.21
2010	186.40	186.89	0.49	0.26
2011	184.81	184.40	-0.41	-0.22
2012	182.03	183.09	1.06	0.58
2013	177.81	178.19	0.38	0.21
2014	185.07	183.21	-1.86	-1.00

Recalculation of 3.D.1.4 Crop residue category was made due to:

1. inclusion of silage crops (excl. maize), flax, buckwheat, triticale, soya, mixed dry pulses, mixed cereals, other cereals and vegetables categories into estimation of N_2O emission from crop residue.

2. updated data on: dry matter, N content in above-ground residue and N content in below-ground residue parameters according to recent scientific data.

3. as there is a lack of sufficient and reliable scientific data on what amount of N in above-ground residue were removed annually for purposes such as feed, bedding and construction, no removal was assumed ($Frac_{REMOVE}$ 0 kg N).

4. $Frac_{RENEW}$ for meadows pastures and permanent pastures/meadows were applied.

Table 5-65. Reported in previous submission and recalculated N_2O emissions from Crop residue

Year	2016 submission	2017 submission	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	333.06	364.53	31.46	9.45

1991	461.61	315.05	-146.56	-31.75
1992	208.83	160.18	-48.64	-23.29
1993	217.15	190.99	-26.17	-12.05
1994	196.72	145.77	-50.95	-25.90
1995	216.61	149.75	-66.86	-30.87
1996	227.30	170.29	-57.01	-25.08
1997	245.27	185.47	-59.80	-24.38
1998	258.78	185.95	-72.84	-28.15
1999	211.96	144.46	-67.50	-31.84
2000	219.98	161.91	-58.07	-26.40
2001	209.04	146.09	-62.95	-30.11
2002	195.15	149.28	-45.87	-23.51
2003	233.50	163.64	-69.86	-29.92
2004	214.55	160.21	-54.34	-25.33
2005	200.20	170.28	-29.92	-14.94
2006	154.37	123.92	-30.45	-19.72
2007	223.87	180.80	-43.07	-19.24
2008	220.48	183.36	-37.12	-16.84
2009	206.51	190.78	-15.73	-7.62
2010	175.42	156.86	-18.56	-10.58
2011	193.00	185.60	-7.40	-3.84
2012	218.95	225.69	6.74	3.08
2013	211.47	213.23	1.76	0.83
2014	237.08	244.35	7.28	3.07

Due to recalculations of Cropland and Grassland organic soils area made in LULUCF sector, emission from 3.D.1.6 Cultivation of organic soils was recalculated.

Table 5-66. Reported in previous submission and recalculated N_2O emissions from Cultivation of organic soils

Year	2016 submission	2017 submission	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	578.19	578.01	-0.03	-0.18
1991	603.58	603.45	-0.02	-0.13
1992	624.43	624.40	-0.01	-0.04
1993	646.15	641.61	-0.70	-4.54
1994	661.62	657.00	-0.70	-4.61
1995	681.70	677.12	-0.67	-4.58
1996	687.85	683.50	-0.63	-4.35
1997	698.29	693.81	-0.64	-4.48
1998	714.52	710.12	-0.62	-4.40
1999	730.17	725.74	-0.61	-4.43
2000	750.99	746.58	-0.59	-4.41
2001	773.85	769.41	-0.57	-4.44
2002	789.94	785.43	-0.57	-4.52
2003	803.21	798.78	-0.55	-4.43
2004	808.25	805.21	-0.38	-3.04
2005	812.26	809.26	-0.37	-2.99
2006	787.90	784.86	-0.39	-3.04

2007	763.14	760.18	-0.39	-2.96
2008	734.15	731.24	-0.40	-2.91
2009	711.05	708.22	-0.40	-2.83
2010	710.21	707.24	-0.42	-2.96
2011	696.82	693.87	-0.42	-2.95
2012	678.13	675.30	-0.42	-2.83
2013	663.78	663.95	0.02	0.17
2014	652.46	652.47	0.00	0.01

5.6.1.6 Category-specific planned improvements

Continue investigation of missing parameters such as N content in above-ground and below-ground residues in order to evaluate N amount returned to soils with crop residue more accurate. Investigate possibility obtain more accurate data on how much above-ground residue is removed from the field for bedding, feed and construction purposes.

5.6.2 Indirect N_2O emissions from managed soils (CRF 3.D.2)

5.6.2.1 Category description

In order to estimate indirect N_2O emissions from managed soils the following sources where included: application of synthetic N fertilizers, organic N fertilizers, urine and dung N deposited from grazing animals, N in crop residues and N mineralization associated with gain/loss of soil organic matter resulting from change of land use or management on mineral soils. N_2O emissions occurs from the volatilization of N as NH_3 and oxides of N (NOx), and the deposition of these gases and their products NH_4^+ and NO_3^- onto soils and the surface of lakes and other waters, and leaching and runoff from land of N from different N input sources mentioned above.

5.6.2.2 Methodological issues

Both volatilization and leaching and run-off N_2O emissions were estimated using *Tier 1* method. Default emission factors and fraction values from *2006 IPCC Guidelines* were used (Table 5-67).

Table 5-67. Default EF and fraction values used to estimate indirect N_2O emissions from managed soils

Parameter	Value	Uncertainty range
EF_4 (N volatilization and re-deposition), kg N_2O–N (kg NH_3–N + NOx–N volatilized)$^{-1}$	0.010	0.002-0.05
EF_5 (leaching / runoff), kg N_2O–N (kg N leaching/runoff)$^{-1}$	0.0075	0.0005-0.025
$Frac_{GASF}$ (Volatilization from synthetic fertilizer], (kg NH_3–N + NOx–N) (kg N applied)$^{-1}$	0.10	0.03-0.3
$Frac_{GASM}$ (Volatilization from all organic N fertilizers applied , and dung and urine deposited by grazing animals), (kg NH_3–N + NOx–N) (kg N applied or deposited)$^{-1}$	0.20	0.05-0.5
$Frac_{LEACH-(H)}$ (N losses by leaching/runoff for regions where Σ(rain in rainy season) - Σ(PE in same period) > soil water holding capacity, OR where irrigation (except drip irrigation) is employed), kg N (kg N additions or deposition by grazing animals)$^{-1}$	0.30	0.1-0.8

Atmospheric deposition of N volatilized from managed soils (CRF 3.D.2.1)

N_2O emissions from atmospheric deposition of N volatilized from managed soil were estimated using the following eq.[121]:

$$N_2O_{(ATD)} - N = \left[(F_{SN} \cdot Frac_{GASF}) + \left((F_{ON} + F_{PRP}) \cdot Frac_{GASM}\right)\right] \cdot EF_4$$

where:
$N_2O_{(ATD)}$–N – annual amount of N_2O–N produced from atmospheric deposition of N volatilized from managed soils, kg N_2O–N yr^{-1};
F_{SN} – annual amount of inorganic fertilizer N applied to soils, kg N yr^{-1};
$Frac_{GASF}$ – fraction of inorganic fertilizer N that volatilizes as NH_3 and NOx, kg N volatilized (kg of N applied)$^{-1}$ (Table 5-67);
F_{ON} – annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N yr^{-1};
F_{PRP} – annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr^{-1};
$Frac_{GASM}$ – fraction of applied organic N fertilizer materials (F_{ON}) and of urine and dung N deposited by grazing animals (F_{PRP}) that volatilizes as NH_3 and NOx, kg N volatilized (kg of N applied or deposited)$^{-1}$ (Table 5-67);
EF_4 – emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, (kg N–N_2O (kg NH_3–N + NOx–N volatilized)$^{-1}$) (Table 5-67).

Fraction $Frac_{GASF}$ defines fraction of N that volatilised from inorganic N fertilizers. The value of $Frac_{GASF}$ depends on the inorganic fertilizer mixture used during the relevant year. To evaluate amount of NH_3 and NO that volatiles from inorganic N fertilizer emission factors were obtained from 2016 EMEP/EEA methodology[122]. The emission factor of 0.04 kg NO/kg N for NO that volatiles from inorganic N fertilizers were used. The emission factors used to evaluate amount of NH_3 that volatiles from inorganic fertilizers is shown in Table below.

Table 5-68. EFs for NH_3 emission from different fertilizers types[123]

Inorganic fertilizer by types	**Volatilised as NH_3, kg NH_3/kg N applied**
Ammonium sulphate	0.09
Urea	0.155
Ammonium nitrate	0.015
Calc. amm. nitrate	0.008
Nitrogen solutions	0.098
Ammonium phosphate (N)	0.05
Other NP (N)	0.05
N P K compound (N)	0.05

IFA provide data on inorganic N fertilizers by type only from 2008, therefore CS $Frac_{GASF}$ were estimated from 2008. Average $Frac_{GASF}$ value of the 2008-2014 period was used to estimate emissions for the 1990-2007 period. The amount of nitrogen in inorganic N fertilizers and estimated $Frac_{GASF}$ values are shown in the Table below. However, $Frac_{GASF}$ were estimated after all estimations was done due to completion of CRF 3.D Agriculture Soils category Additional Information Table Fraction of synthetic fertilizer N applied to soils that volatilises as NH_3 and NO_X.

Table 5-69. Amount of N in different types of inorganic fertilizers (tonnes) and $Frac_{GASF}$

[121] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, eq. 11.9, p. 11.21
[122] EMEP/EEA air pollutant emission inventory guidebook 2016. 3.D Crop production and agriculture soils, Table 3.1, p. 14.
[123] EMEP/EEA air pollutant emission inventory guidebook 2016. 3.D Crop production and agriculture soils, Table 3.2, p. 17.

Year	Ammonium sulphate	Urea	Ammonium nitrate	Calc.amm. nitrate	Nitrogen solutions	Ammonium phosphate	Other NP	N P K	$Frac_{GASF}$
1990-2007	-	-	-	-	-	-	-	-	0.063
2008	12,500	12,300	50,500	7,900	15,000	14,100	3,000	3,000	0.063
2009	16,800	23,000	54,500	4,900	5,400	3,900	9,700	16,200	0.067
2010	10,000	10,000	60,000	5,000	20,200	5,000	10,000	23,000	0.060
2011	9,000	9,000	62,000	5,000	20,000	10,000	10,000	22,000	0.059
2012	10,000	9,000	63,000	3,000	20,000	5,000	15,000	25,000	0.060
2013	8,000	10,000	61,000	5,000	20,000	5,000	15,000	31,000	0.060
2014	12,600	26,000	56,900	6,000	16,800	4,000	17,000	22,700	0.069
2015	12,959	26,740	58,520	6,171	17,278	4,114	17,484	23,346	0.069

N leaching and run-off from managed soils (CRF 3.D.2.2)

N_2O emissions from N leaching and run-off from managed soil were estimated using the following equation[124]:

$$N_2O_{(L)} - N = (F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}) \cdot Frac_{LEAC-(H)} \cdot EF_5$$

where:

$N_2O_{(L)}$–N – annual amount of N_2O–N produced from leaching and runoff of N additions to managed soils in regions where leaching/runoff occurs, kg N_2O–N yr^{-1};

F_{SN} – annual amount of synthetic fertilizer N applied to soils, kg N yr^{-1};

F_{ON} – annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N yr^{-1};

F_{PRP} – annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr^{-1};

F_{CR} – amount of N in crop residues, including N-fixing crops, and from forage/pasture renewal, returned to soils annually in regions where leaching/runoff occurs, kg N yr^{-1};

F_{SOM} – annual amount of N mineralized in mineral soils associated with loss of soil C from soil organic matter as a result of changes to land use or management in regions where leaching/runoff occurs, kg N yr^{-1};

$Frac_{LEACH-(H)}$ – fraction of all N added to/mineralized in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff, kg N (kg of N addition)$^{-1}$ (Table 5-67);

EF_5 – emission factor for N_2O emissions from N leaching and runoff, kg N–N_2O (kg N leached and runoff)$^{-1}$ (Table 5-67).

According to country scientific literature average annual amount of precipitation in Lithuania in 1981-2010 was 695 mm (CN was 675 mm)[125], this lets imply that country belongs to humid region, therefore the default $Frac_{LEACH-H}$ 0.30 kg N was used.

[124] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, eq. 11.10, p. 11.21

[125] Lithuanian Hydro meteorological Service under the Ministry of Environment, Climate Atlaso f Lithuania, 2013, ISBN 978-9955-9758-5-4

5.6.2.3 Uncertainty and time-series consistency

Activity data uncertainty

Same data used in category direct N_2O emission are applied in category indirect N_2O emission from managed soils. Uncertainty for activity data of category Atmospheric deposition – ±20%; Nitrogen Leaching and Run-off – ±20%.

Emission factor uncertainty

For the *Tier 1* method there is a larger uncertainty range for the default factors. For *Tier 1* method uncertainty values of indirect N_2O EF were estimated basing on EF uncertainty range: EF_4 – ±240%; EF_5 – ±163.3%.

5.6.2.4 Category-specific QA/QC and verification

General quality control procedures where applied estimating indirect N_2O emissions from managed soils: analysis of activity data trends, consistency check of calculated emissions and imported data to CRF reporter, consistency check of activity data sources, completeness check and etc. For 3.D.2 Indirect N_2O emissions from agriculture soils category (atmospheric deposition from N that volatilized from managed soils and N leaching and run-off from managed soils) calculation spreadsheets were assessed if used activity data, emissions factors and units are correct.

5.6.2.5 Category-specific recalculation

Due to recalculations made in 3.D.1 Direct N_2O emissions from managed soils category (Chapter 5.6.1.5) recalculation has been made in 3.D.2 Indirect N_2O emissions from managed soils atmospheric deposition and N leaching and run-off from managed soil categories. Recalculations of indirect N_2O emissions from managed soils categories provided in tables below. Also fraction $Frac_{GASF}$ in the 3.D.2.1 Atmospheric deposition of N volatilized from managed soils category was recalculated based on 2016 EMEP/EEA methodology.

Table 5-70. Reported in previous submission and recalculated indirect N_2O emissions from atmospheric deposition

Year	2016 submission	2017 submission	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	228.40	174.15	-54.25	-23.75
1991	235.31	178.34	-56.96	-24.21
1992	135.43	114.98	-20.45	-15.10
1993	96.74	84.95	-11.79	-12.19
1994	88.18	76.43	-11.75	-13.33
1995	83.76	71.13	-12.63	-15.08
1996	100.50	80.61	-19.89	-19.79
1997	100.76	81.49	-19.27	-19.12
1998	98.29	79.53	-18.76	-19.09
1999	97.81	76.81	-21.00	-21.47
2000	94.55	75.18	-19.38	-20.49
2001	96.57	74.84	-21.74	-22.51
2002	104.47	80.10	-24.37	-23.32
2003	106.81	82.25	-24.56	-22.99
2004	107.90	84.01	-23.90	-22.15

2005	109.49	85.00	-24.50	-22.37
2006	112.13	86.76	-25.37	-22.62
2007	113.06	88.06	-25.00	-22.11
2008	108.00	84.97	-23.03	-21.32
2009	114.24	91.32	-22.92	-20.07
2010	117.18	88.67	-28.51	-24.33
2011	118.57	88.48	-30.09	-25.38
2012	119.52	89.60	-29.92	-25.04
2013	121.94	91.06	-30.89	-25.33
2014	127.07	101.69	-25.38	-19.97

Table 5-71. Reported in previous submission and recalculated indirect N_2O emissions from N leaching and run-off from managed soil

Year	2016 submission	2017 submission	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	443.58	431.39	-12.19	-2.75
1991	499.24	451.04	-48.20	-9.66
1992	245.71	229.09	-16.61	-6.76
1993	180.35	169.67	-10.68	-5.92
1994	166.13	149.91	-16.21	-9.76
1995	164.05	142.67	-21.38	-13.03
1996	205.83	186.19	-19.65	-9.54
1997	211.27	192.12	-19.15	-9.07
1998	212.75	191.69	-21.06	-9.90
1999	207.25	186.96	-20.29	-9.79
2000	207.50	191.94	-15.56	-7.50
2001	209.42	190.90	-18.52	-8.84
2002	222.03	206.95	-15.08	-6.79
2003	233.81	213.32	-20.49	-8.76
2004	231.30	215.24	-16.06	-6.94
2005	230.92	220.07	-10.85	-4.70
2006	225.15	213.80	-11.35	-5.04
2007	244.47	231.68	-12.80	-5.23
2008	233.43	222.41	-11.02	-4.72
2009	245.79	239.55	-6.24	-2.54
2010	246.73	240.31	-6.42	-2.60
2011	254.26	250.35	-3.92	-1.54
2012	262.75	262.45	-0.30	-0.11
2013	266.42	264.93	-1.49	-0.56
2014	281.64	281.20	-0.44	-0.15

5.6.2.6 Category-specific planned improvements

Improvements planned in category direct N_2O emissions from managed soils will be applied to category indirect N_2O emissions.

5.7 Prescribed burning of savannas (CRF 3.E)

Savannas do not exist in Lithuania therefore emission from prescribed burning of savannas is reported as "NO".

5.8 Field burning of agricultural residues (CRF 3.F)

Field burning of agricultural residues is prohibited by the legislation (Order of the Minister of Environment No 269 concerning the environmental protection requirements for burning of dry grass, reeds, straw and garden waste as amended, In force from September 9, 1999)[126], therefore emission from field burning of agricultural residues is reported as "NO".

5.9 CO_2 emissions from liming (CRF 3.G)

5.9.1 Category description

Starting with 30s in Lithuania, like in most of the Europe, intensive analysis on liming standards and soils had started. Technique on liming dust spreading in Lithuania was established in 70s based on scientific research and systematic analysis of soil liming. Following this in 80s every year around 200 thousand ha of acid soils were limed. However in the first years of independence (early 90s) liming was almost suspended due to lack of energetic resources. Later liming was restricted due to lack of financial resources. In mid 90s only 1/10 of acid soils were limed[127].

There are a lot of studies and scientific research conducted analysing efficiency of different liming products, impact on soil pH, fertility and other parameters. Unfortunately there are no official data sources that collect data on limestone or dolomite consumption in Lithuania. For this reason data was collected from the major companies that sell liming products. These products include special fertilizers for soil liming, by-products of production or waste products that are generated during production process. Major providers of liming products are companies that operate quarries and extracts constructions material (crashed stones, granite, limestone etc.). Other providers of liming products are sugar producers. During production of sugar the lime mud is generated as waste which later is used as a liming product for acid soils.

The data provided by the companies varied in time period as it depends on the year when companies began to produce products for soil liming. The actual data for soil liming products used is available for the period 1993-2014 (data provided by the companies). However the period 1990-1992 is not fulfilled with data that's why assumptions were made based on the literature and expert judgement.

As mentioned above after the independence liming drastically reduced due to lack of financial and technical resources. Before the 90s liming had exceeded 200 thous. ha per year and was aiming to reach 270 – 300 thous. ha per year. The standard rate was also growing and reached 4,5 t/ha (straight $CaCO_3$) during 70s and early 80s[128]. The extant of area limed in early 90s was estimated to be around 10.4 thous. ha. Based on this information and standard rate of 4.5 t/ha estimates for the period 1990-1992 were calculated in order to fulfil the data gap.

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[126] 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

[127] Ežerinskas, V. Kalkinės medžiagos ir kalkinimas (en. *Liming products and liming*). Lietuvos žemdirbystės institutas, 1999. ISBN 9986-527-60-0

[128] Knašys, V. Dirvožemių kalkinimas (en. *Soil liming*). Mokslas, 1985

The figure below shows trend of CO_2 emission from liming of agricultural soils. As emission depend on the quantity of liming products consumed it has a direct link to data availability. Data provided by the companies varies through the time period and is strongly related to the economic factors e.g. economic crisis, demand of construction material, production of sugar etc. One of the companies which provides data of sold liming products has changed production technology and no cement dust was produce in 2015, therefore emission decrease in the latest year can be seen in the figure below.

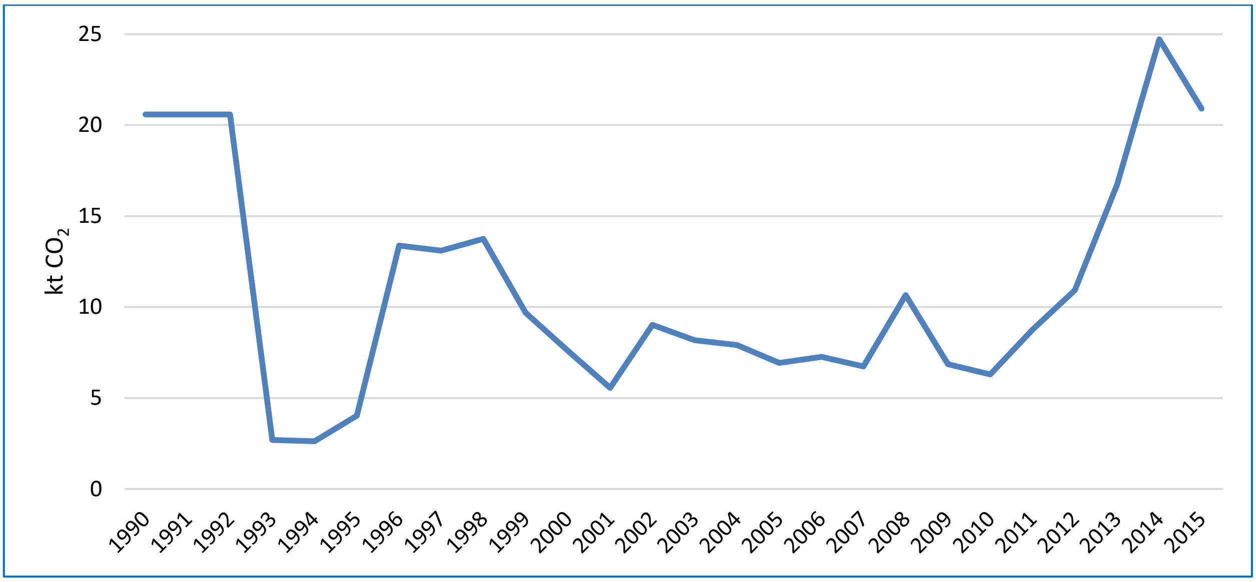

Figure 5-14. CO_2 emissions from application of liming products in agricultural lands

5.9.2 Methodological issues

Estimating CO_2 emission from agricultural soils liming was very important to know the actual percentage of $CaCO_3$ + $MgCO_3$ in product used for liming. Other important parameter is the dry matter of product as some products (e.g. lime mud) contains high percentage of humidity.

Depending on data availability and analysis done companies provided data on main parameters which were used in calculations. The following eq. was used to estimate the annual amount of limestone ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$):

$$M_{Limestone\ or\ dolomite} = M_{Product} \cdot \frac{C}{100} \cdot \frac{DM}{100}$$

where:

$M_{Limestone\ or\ dolomite}$ – amount of limestone ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$), tonnes d.m. yr^{-1};
$M_{Product}$ – amount of product used for soil liming, tonnes yr^{-1};
C – amount of $CaCO_3$ + $MgCO_3$ in the product, %;
DM – dry matter of product used for soil liming, %.

The main parameters of liming products that were used to estimate CO_2 emission for soil liming are provided in Table 5-72.

Table 5-72. Parameters used for estimation of CO_2 emission from liming

Parameter	Dolomite	Cement dust	Limestone	Crushed limestone	Lime mud
	%				

$CaCO_3 + MgCO_3$	86.9 - 100	76.2 – 82.4	95 - 97	90*	77.5* - 83.9
Average	**93.5**	**79.3**	**96**	**90**	**80.7**
Dry matter	78.2 – 98.6	98.5	98.5*	90*	40 – 67
Average	**88.4**	**98.5**	**98.5**	**90**	**53.5**

* Theoretical recommended value[129]

CO_2 emissions from additions of limestone or dolomite to agriculture soils are calculated using eq.[130]:

$$CO_2 - C\ Emissions = (M_{Limestone} \cdot EF_{Limestone}) + (M_{Dolomite} \cdot EF_{Dolomite})$$

To convert CO_2-C emissions to CO_2 emissions the amount was multiplied by 44/12.

5.9.3 Uncertainty and time-series consistency

Activity data uncertainty

The main activity data used for calculations was lime and dolomite consumption for agricultural land liming. All data was collected from the main distributors of liming products with data indicated dry matter content and $CaCO_3 + MgCO_3$ content in the product based on laboratorial measurements. Knowing that not necessary all amount of sold liming products were used at the year they were sold and also knowing that there could be some other products in the market assumption was made that uncertainty of activity data is ±10%.

Emission factor uncertainty

Uncertainty of EF is ±50% as given in *2006 IPCC Guidelines*[131].

Overall uncertainty

Combined uncertainty was calculated using *2006 IPCC Guidelines* eqv. 3.1[132]. This approach requires uncertainty values of the main activity data used and uncertainty of emission factor. Combined uncertainty for CO_2 emissions from liming was estimated to be ±51%.

5.9.4 Category-specific QA/QC and verification

General quality control procedures where applied estimating CO_2 emissions from liming of soils: analysis of activity data trends, consistency check of calculated emissions and imported data to CRF reporter, consistency check of activity data sources, completeness check and etc.

5.9.5 Category-specific recalculations

In 3.G Dolomite $CaMg(CO_3)_2$ sub-category recalculation for 1999 was done due to correction of typing error in activity data.

Table 5-72. Reported in previous submission and recalculated CO_2 emissions from dolomite $CaMg(CO_3)_2$

Year	2016 submission	2017 submission	Absolute difference, kt CO_2 eqv.	Relative difference, %
1999	0.03	0.31	0.28	1028.57

[129] Ežerinskas, V. Kalkinės medžiagos ir kalkinimas (en. *Liming products and liming*). Lietuvos žemdirbystės institutas, 1999. ISBN 9986-527-60-0

[130] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, eq. 11.12 p. 11.27

[131] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, p. 11.27

[132] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 3, eq. 3.1, p. 3.28

5.9.6 Category-specific planned improvements

Category-specific improvements are not planned.

5.10 CO_2 emissions from urea application (CRF 3.H)

5.10.1 Category description

Emissions from urea application in agricultural soils constituted 42.5 kt CO_2 eqv. It is around 0.9% from the total emissions originating from agriculture sector.

5.10.2 Methodological issues

As there is no national data source for consumption of inorganic N fertilizers the data was obtained from database of IFA. This database gives consumption of inorganic N fertilizers for the whole time period (1990-2014) and consumption of inorganic N fertilizers by type since 2008 including data on consumption of urea. At the time of inventory preparation data for the year 2015 was not available therefore to obtain missing activity data extrapolation was used. Data for 2015 will be updated in the next submission as this data at IFA database will be available only in the September of 2017. Data on consumption of urea during the period 2005-2007 was taken from the study on fertilizers[133]. The gap of data for the period 1990-2004 was filled by taking average percentage of urea in total amount of inorganic N fertilizers in the 2005-2013 period. This percentage on average was 10.68%.

CO_2 emission from urea fertilization were estimated using the following eq.[134]:

$$CO_2 - C\ Emission = M \cdot EF$$

where:
CO_2–C Emission – annual C emission from urea application, tonnes C yr^{-1};
M – annual amount of urea fertilization, tonnes urea yr^{-1};
EF – emission factor, tonnes of C (tonnes of urea)$^{-1}$.

Emission factor of 0.20 for urea was applied[135]. Estimated CO_2–C emission multiplied by 44/12 to convert CO_2–C emission into CO_2.

5.10.3 Uncertainty and time-series consistency

Activity data uncertainty

Main activity data is consumption of urea fertilizer. As most of the data was obtained based on assumptions the uncertainty value for activity data was assumed to be around ±30%.

Emission factor uncertainty

Uncertainty of EF is ±50% as given in *2006 IPCC Guidelines*[136].

Overall uncertainty

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133 Taikomojo mokslinio tyrimo „Lietuvos ūkyje naudojamų trąšų analizė ir pasiūlymai dėl nacionalinio reglamentavimo pakeitimų, atsižvelgiant į agrochemijos, saugumo ir sveikatos reikalavimus" ataskaita (en. *Analysis on fertilizers used in Lithuanian and recommendations in pursuance of changes in national legislation, taking in to account agrochemical, safety and health requirements*). Lietuvos agrarinių ir miškų mokslo centro agrocheminių tyrimų laboratorija, Kaunas, 2010
134 *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, eq. 11.13 p. 11.32
135 *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, p. 11.32
136 *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 4, Ch. 11, p. 11.32

Combined uncertainty was calculated using *2006 IPCC Guidelines* eq. 3.1[137]. This approach requires uncertainty values of the main activity data used and uncertainty of emission factor. Combined uncertainty for CO_2 emissions from urea application was estimated to be ±58.3%.

5.10.4 Category-specific QA/QC and verification

General quality control procedures where applied estimating CO_2 emissions from urea application to soils: analysis of activity data trends, consistency check of calculated emissions and imported data to CRF reporter, consistency check of activity data sources, completeness check and etc.

5.10.5 Category-specific recalculations

IFA provided data on urea consumption for 2014 only in September of 2016, therefore data for 2014 was recalculated. As IFA updated data on inorganic N fertilizers for 2013, the average percentage of urea in total amount of inorganic N fertilizers for the period of 2005-2013 was updated. Percent of nitrogen in urea was updated due to more recent information provided by main fertilizer producer. Recalculation results is provided in the table below.

Table 5-73. Reported in previous submission and recalculated CO_2 emissions from urea application

Year	2016 submission	2017 submission	Absolute difference, kt CO_2 eqv.	Relative difference, %
1990	35.68	35.71	0.03	0.09
1991	41.74	41.77	0.04	0.09
1992	14.81	14.82	0.01	0.09
1993	7.24	7.24	0.01	0.09
1994	7.24	7.24	0.01	0.09
1995	6.73	6.74	0.01	0.09
1996	13.29	13.31	0.01	0.09
1997	13.65	13.66	0.01	0.09
1998	14.04	14.05	0.01	0.09
1999	15.82	15.83	0.01	0.09
2000	16.49	16.51	0.01	0.09
2001	17.17	17.18	0.02	0.09
2002	19.35	19.37	0.02	0.09
2003	19.52	19.54	0.02	0.09
2004	19.69	19.71	0.02	0.09
2005	31.44	31.54	0.10	0.31
2006	18.87	18.92	0.06	0.31
2007	31.44	31.54	0.10	0.31
2008	19.34	19.40	0.06	0.31
2009	36.16	36.27	0.11	0.31
2010	15.72	15.77	0.05	0.31
2011	14.15	14.19	0.04	0.31
2012	15.72	15.77	0.05	0.31
2013	15.72	15.77	0.05	0.31
2014	15.72	41.00	25.28	160.82

[137] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 1, Ch. 3, eq. 3.1, p. 3.28

5.10.6 Category-specific planned improvements

Category-specific improvements are not planned.

6 LAND USE, LAND-USE CHANGE AND FORESTRY (CRF 4)

6.1 Overview of LULUCF

One of greenhouse gases emissions and removals report goals is to provide observations for projecting climate change mitigation action plans. GHG report provide relevant land use distribution as well as carbon stock changes and GHG emissions data in different land use categories, providing also a possibility for land use management assessments. The most important in order to mitigate climate change is to preserve and protect areas that have high carbon sequestration capacity: forests, wetlands, peatlands and grasslands. Land Use, Land Use Change and Forestry (LULUCF) sector in Lithuania plays the important role in carbon sequestration processes as it has been constantly acting as a sink during two periods of time: 1990-1995 and 1998-2015 (Figure 6-1). Only in 1996-1997 LULUCF sector was a GHG source due to severe storms followed by beetles invasions and other calamities which had a huge impact on CO_2 emissions. Storms and pests invasions had the highest influence for forest land emissions, since forests produce the biggest part of biomass, it resulted in overall GHG emissions from sector. However, LULUCF sector over the last few years in average has removed 8.2 million tonnes of CO_2 eqv., with forest land contributing to the total amount with 10 million tonnes of CO_2 eqv. The LULUCF sink in the last few years was covering approximately 40% of the total national emissions from all other sectors, excluding LULUCF.

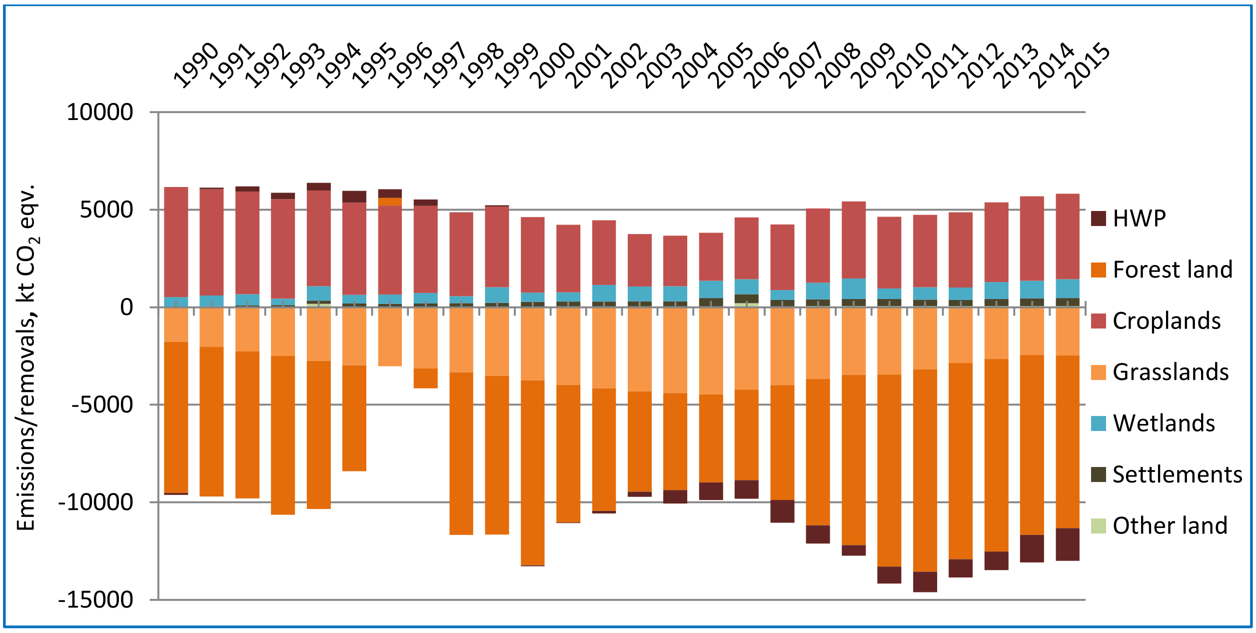

Figure 6-1. Net CO_2 eqv. emissions and removals from LULUCF sector during the period 1990-2015 by land use category.

The positive values shows emissions and negative – removals

Lithuania has improved and made its reporting system of greenhouse gases from LULUCF sector more transparent, consistent over time, complete and comparable since 2011 when practically new accounting and reporting system has been built up and today has a clear subordination among data providers and executors. There are several organizations and data providers responsible for provision of the official data related to LULUCF reporting in Lithuania. These organizations and data providers are presented below:

- **National Land Service** (*NLS*) under the Ministry of Agriculture[138] 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 Cadaster** (*LSFC*) managed by **State Forest Service** (*SFS*) provides up to date information associated with registered areas of forest land and detail information about all forest holdings regardless their ownership[139].
- **National Forest Inventory** (*NFI*)[140] executed by SFS provides objective and known accuracy data associated with forest land, forest land use and forest resources (growing stock volume, annual increment, felling, dead wood and etc.). Information for this dataset is collected by using unique sampling technique already since 1998. Data presented by NFI is used for monitoring and reporting of land use and land use changes under the Convention requirements as a continuation of the implemented Studies that were conducted in order to gather missing historical information (see Chapter 6.1.1. for description). Dataset on all land use and land use changes is collected using NFI since 2012, NFI grid covering not only forest land but also other land use categories of the whole country territory since then.

Official statistics on relevant land use categories and their changes in Lithuania are provided by:

- **Statistics Lithuania** publishes all statistical information in their annual publications "Statistical Yearbook of Lithuania" and provides numerical statistical databases on their website[141].
- Statistical data about Lithuanian forests and forestry related issues is published in annual reports "Forest assessment", annual publications – "Lithuanian Statistical Yearbook of Forestry", periodical publications of NFI and National forest resources assessment (*FRA*) reports[142].
- **National Land Service** (*NLS*) publishes annual statistical information on all land use categories in Lithuania in publication "Land Fund of the Republic of Lithuania"[143].

To ensure transparency, consistency, comparability, completeness and accuracy of the greenhouse gas accounting and reporting from LULUCF sector, several legal acts were adopted or amended in order to establish background connections between different institutions, providing data for greenhouse gas accounting:

- **Resolution on forest land conversion to other land and compensation for converted forest land** / Government resolution – regulates human induced conversion of forest land to other land and compensation for the lost forest land.
- **Regulation on National forest inventory by sampling method** / Amendment of the Order of the Minister of Environment – launches country wise sample based monitoring of all land use and land use changes.
- **Harmonized 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.

[138] Available from: *http://www.nzt.lt/go.php/lit/English*
[139] Available from: *http://www.amvmt.lt*
[140] Available from: *http://www.amvmt.lt*
[141] Available from: *http://www.stat.gov.lt/en/*
[142] Available from: *http://www.fao.org/forestry/fra/en/*
[143] Available from: *www.zis.lt/download.php/fileid/77*

- **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 Cadaster** / *Amendment of the Government resolution* – sets State Forest Cadaster 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.

These acts are constantly amended or substituted following the new requirements adopted by United Nations Framework Convention on Climate Change (UNFCCC) or EU legislation or introducing new improved methodologies for estimation of greenhouse gases emissions and removals from LULUCF sector.

Following the requirements of *2006 IPCC* Guidelines for National Greenhouse Gas Inventories (*2006 IPCC*), provision of official statistics since 2012 has been improved substantially and associated land-use area changes were assessed, constantly monitored and revised, using unique net of permanent sample plots of NFI:

1) For the period of 1990-2011 results are presented using data of the studies conducted;
2) Since 2012 all data, concerning land use and land use changes, is based on direct annual field measurements executed by NFI.

Data sources that have been used until 2012 for determination of the total land area and for monitoring its changes were not harmonized between themselves and data presented was not always precise or did not fulfil the requirements of the UNFCCC. Most of the results were fragmented and did not fully covered the required period starting with the base year 1990. Due to different inventory methodologies and definitions of land use categories for each inventory, the presented results not only did not comply but in some cases even contradicted each other. Furthermore, land use definitions used by official statistics, on which basis land area was estimated, did not comply with the previously used *2003 IPCC* nor with current *2006 IPCC* guidelines (Table 6-5). For instance, meadows and natural pastures were assigned to croplands in national definition, though it comes under grassland category under IPCC definition. Therefore, implementing UNFCCC and its Kyoto Protocol requirements in order to comprehensively identify and quantify areas specific to LULUCF activities annually in the period of 1990-2011, two studies were launched. The study "*Forest land changes in Lithuania 1990-2011*" (*Study-1*) was addressed to recover land use changes specifically to forests and study "*Changes of areas of Croplands, Grasslands, Wetlands, Settlements and Other lands in Lithuania during 1990-2011*" (*Study-2*) was addressed to track changes of croplands, grasslands, wetlands, settlements and other lands. Thus, by implementing these studies Lithuania became able to identify land use areas and to monitor their changes for the whole time series starting with 1990. The main differences of these two studies comparing with the previous practice was recalculation of all area changes (and construction of yearly land transition matrix) using single data collection instrument – uniform network of *NFI* (launched in 1998) permanent sample plots and secondly – building all the computations and assumptions based on the data, directly collected from the individual plots. Therefore, one of the fundamental outcomes of these two studies was creation of a single and comprehensive database of land use areas in Lithuania (Figure 6-2).

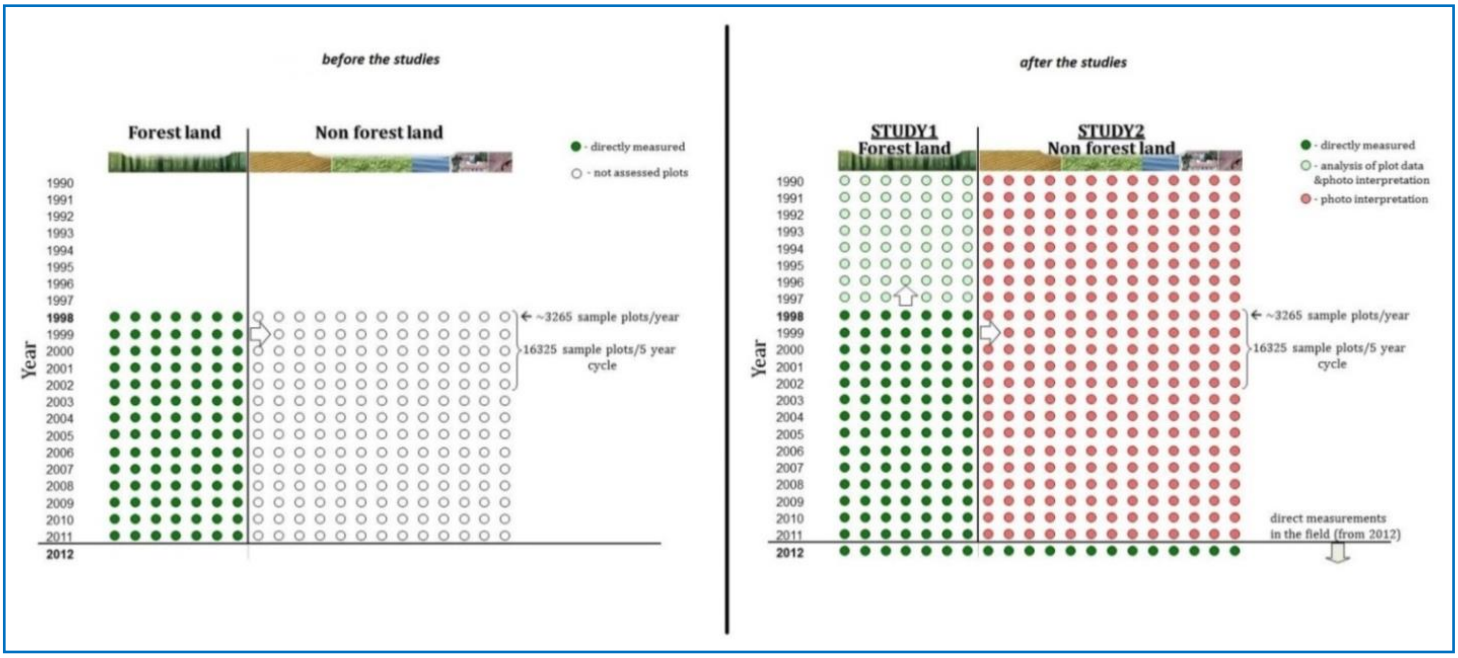

Figure 6-2. Data owned for the assessment of land-use changes before the studies were implemented (*NFI* data since 1998) and assessment of the land-use changes on *NFI* sample plots grid after the implementation of the studies for the period 1990-2011.

Filled dots represent data that was owned before/after the studies

Furthermore, during the implementation of Study-1, wall-to-wall areas of afforestation, reforestation and deforestation activities, which are obliged to report under Kyoto Protocol Art. 3.3, were mapped, identified and classified. Transition matrix of yearly changes in A/R/D activities was concluded with the help of GIS techniques, historical datasets of *LSFC*, aerial photography archives, provided by *SLF,* and other available material of historical land use changes.

According to *NLS* data total land area of Lithuania is 6,528,648.3 ha, forest land occupy 33.7%, croplands – 47.6%, grasslands – 4.9%, wetlands – 5.1%, settlements and other land covers 5.2% and 3.4% respectively, for the date 01.01.2016. According to *NFI* data, forest land occupy 33.8 %, croplands – 32.8%, grasslands – 22.6%, wetlands – 5.2%, settlements – 5.4% and other land – 0.2% of the total land area in Lithuania (Figure 6-3).

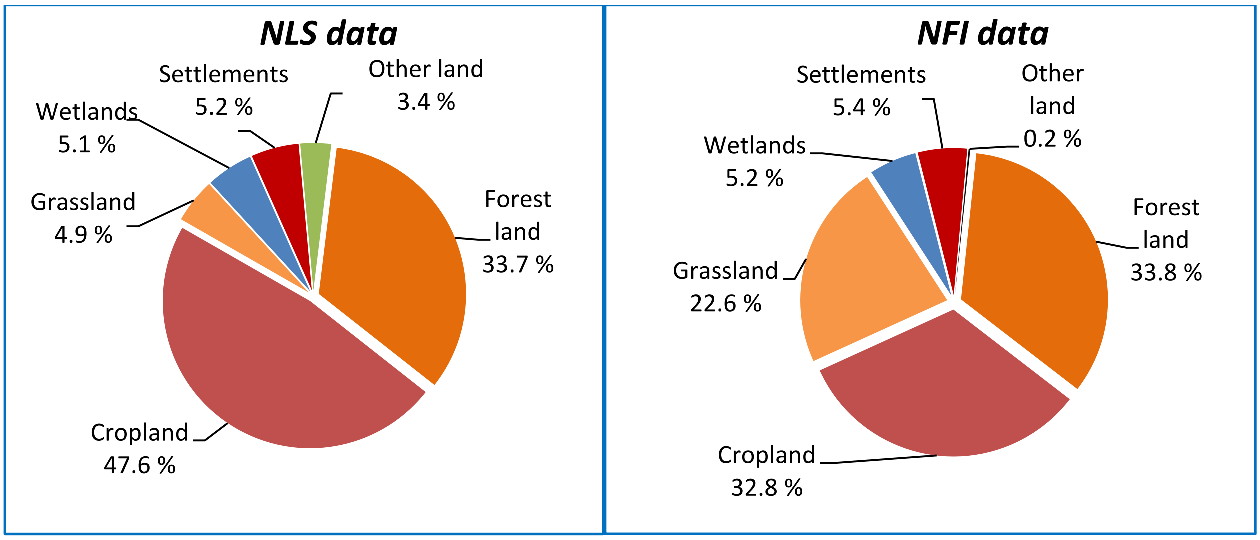

Figure 6-3. Comparison of land-use categories presented by *NLS* and latest *NFI* data. 01.01.2016

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 *2006 IPCC Guidelines*. For the greenhouse gas reporting *NFI* data been distributed among relevant land use categories, considering total land area.

Several emission sources in the LULUCF sector are identified as key categories. They are listed in Table 6-1 (Level and Trend assessment).

Table 6-1. Key category from LULUCF in 2015

IPCC Category	***Greenhouse gas***	***Identification criteria***
4.A Forest land, Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	L1,L2,T1,T2
4.A.1 Forest land remaining forest land - carbon stock change in biomass	CO_2	L1,L2,T1,T2
4.A.1 Forest land remaining forest land - net carbon stock change in dead wood	CO_2	L1
4.A.2 Land converted to forest land - carbon stock change in biomass	CO_2	L1,L2,T1,T2
4.A.2 Land converted to forest land - net carbon stock change in litter	CO_2	L1,L2,T1,T2
4.B Cropland, Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CO_2	L1
4.B Cropland	N_2O	L1, L2, T2
4.B.2 Land converted to cropland - net carbon stock change in mineral soils	CO_2	L1,L2,T1,T2
4.B.2 Land converted to cropland- carbon stock change in biomass	CO_2	L1,L2,T1,T2
4.C.2 Land converted to grassland - net carbon stock change in mineral soils	CO_2	L1,L2,T1,T2
4.D.1 Wetlands remaining wetlands -net carbon stock change in organic soils	CO_2	L1,L2,T1,T2
4.E.2 Land converted to settlements	CO_2	L1,L2,T1,T2
4.G Harvested wood products	CO_2	L1,L2,T1,T2

6.1.1 Study "Forest land changes in Lithuania during 1990-2011" (Study-1)

The *Study-1* was carried out by the team of experts of Aleksandras Stulginskis University (former Lithuanian University of Agriculture) together with *NFI* experts and Lithuanian

Association of Impartial Timber Scalers. The *Study-1* was completed in the middle of April of 2012 and explicit study results were presented in the final report[144].

The *Study-1* was split into two parts and was aimed: (a) to identify annual forest land areas and their changes which occurred in Lithuania during the period of 1990-2011, following the *2003 IPCC* (which is now in line with *2006 IPCC Guidelines*) and the requirements of UNFCCC on the unique permanent sample plots grid of *NFI*, and (b) to achieve the annual wall-to-wall mapping of afforested, reforested and deforested land areas following requirements of the UNFCCC and its Kyoto Protocol (Figure 6-7).

Forest land areas and their changes that were identified (annually in 1990-2011):

- forest land remaining forest land areas (*FF*);
- forest management areas (*FM*);
- forest land areas converted to forest land less than 20 years ago (*LF*);
- human induced afforested/reforested areas – where forest was growing before the afforestation for at least 50 years (*A1*), and where forest was growing before the reforestation for at least 50 years (*R1*) but ceased to be forest on 31 December 1989 and then converted (afforested/reforested) to forest;
- naturally afforested/reforested areas, where forest was growing before the afforestation for at least 50 years (*A2*), and where forest was growing before the reforestation for at least 50 years (*R2*), but ceased to be forest on 31st December 1989 and then converted (afforested/reforested) to forest;
- deforested areas (*D*).

To have a clear view on the forest land situation 50 years ago, GIS database was developed to store boundaries of forest land in around 1950's. Orthophotos based on the aerial photographs mainly from 1946-1949 were used as the basic source material. Orthophotos were scanned, geo-referenced and the borders of forest land were manually digitized. The scale of orthophotos was 1:10°000, simultaneously; the developed database was meeting the requirements of mapping at a scale 1:10°000. In that sense, this data base is fully compatible with the geographic database of forest compartments kept at *SFC* and integrally fits with existing databases 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 16,325 systematically distributed *NFI* sample plots, focusing on the period of 1990-2011 and using the definitions of valid versions of Lithuanian Forest Law and *2003 IPCC* (in line with *2006 IPCC Guidelines*). All available auxiliary data sets (such as *SFC* data, maps from previous stand-wise forest inventories, topographic maps, orthophotos, satellite images, etc.) with the information gathered during direct field visits were used to facilitate the identification of land cover and land-use categories in a long-term. Data captured in National Forest Inventory

[144] 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.

databases 1998-2011 were used as well. Stand and tree age, origin of stands, registered in permanent sample plots description cards, combining with cartographical data were the main sources for identification of afforested/reforested stands, especially those possibly appearing in the period of 1990-1998, before the original beginning of *NFI*. All sample plots were manually inspected and the solutions taken were based on the decisions of highly skilled engineers with the forest inventory practice.

To achieve the annual wall-to-wall mapping of forest land areas and to detect changes several types of source material were used: *SFC*, National Paying Agency's (*NPA*) information on afforested agricultural, non-agricultural and abandoned land, Lithuanian forest resource database at a scale of 1:50°000, all available country orthophotos that were developed during the analysed period, satellite maps from CORINE, USGS[145], other projects done by the contractors. The main data source used was the geographic data from the *SFC*. These data sets include borders of all forest compartments in the country (around 1.3 mill polygons) and are associated with the data describing stand characteristics in the compartment. Age of all stands was updated to fit defined datum-line – the year 2011. Then, the year of forest stand becoming forest, according to definition used in Forest Law was estimated, subtracting the age of stand from 2011 (and adding 10 years for naturally regenerated forests). After, the origin of each compartment identifying whether the forest appeared on forest or other (i.e. non-forest) land was checked, two basic and one additional criteria were used: forest was assumed to be grown on non-forest land if it was attributed in a special attribute field as grown on non-forest land. However, such identification was completely dependent on the content and quality of the previous stand-wise forest inventories and there were numerous forest compartments, actually grown on non-forest land, omitted. Therefore, special spatial overlay and selection techniques were developed and applied to identify forests, that are currently available but were missing 50 years ago (according to developed database referring to 1950's). In case of failure ancillary solution how to identify afforestation/reforestation was determined. It was intended to use stand attribute from stand register and posit that forest compartment was first time inventoried during the last stand-wise forest inventory. However, such approach faced some limitations while reflecting established forests, as the *SFC* data was based on the information originating from stand-wise forest inventory. Stand-wise forest inventories in Lithuania are carried on a 10-years cycle basis, thus, there were some regions with quite outdated information on the compartments and missing stands boundaries, established already after the stand-wise inventory. Several solutions were used to fill such gaps of information. Firstly, information from the recent stand-wise forest inventories was acquired from forest inventory contractors, which had not been officially delivered to the *SFS*. Next, all non-forest compartments stored in the *SFC* database were checked for the records on potentially established forests there. Simultaneously, State forest enterprises were asked to confirm the facts of recently established forests. And, finally, data from *NPA* was acquired to represent the borders of afforested areas that were applied for EU subsidies. Special geo-processing technique was developed to eliminate overlapping in space and time of afforested/reforested areas, resulted by repeated identification of considered areas in independent input data sets.

The decision, whether the forest stand detected growing on non-forest land was either afforested or reforested, was taken based on simple spatial queries – verifying presence or absence of the forest land at the certain area in 1950's.

[145] Available from: *http://earthexplorer.usgs.gov/*

Several techniques were used to detect deforested areas during the last two decades. First of all, deforestation accounted in the *SFC* was taken into account. Recent non-forest land areas, identified as forest stand during the previous forest inventories were also candidates to be assigned to the deforestation category. Next, there were some records in the *SFC* attributed to officially registered deforestation category. And, finally, deforestation was manually mapped using available GIS, orthophotos and satellite images data. It was assumed, that the GIS database of Lithuanian forest resources at a scale of 1:50°000 developed in 1998-1999 represents the year 1990 as it was based on SPOT satellite images from around 1990-1992 and stand-wise forest inventory maps compiled before 1991. The accuracy of forest cover identification in that database was confirmed by the *NFI* to be around 95%. Thus, the differences between the forest covers in the GIS database of Lithuanian forest resources at a scale of 1:50°000 and *SFC* were reasoned by the imperfections of the first data set or the deforestation. All such areas were visually checked and all deforestations were identified using orthophotos available for Lithuania (referring to 4 dates in the period from 1990).

GIS database was developed to store forest land-use polygons, distributed by feature classes, representing forest land remaining forest land (*F1*), forest land remaining forest land, but where forest appeared less than 20 years ago (*F2*), human induced afforestation (*A1*), natural afforestation (*A2*), human induced reforestation (*R1*), natural reforestation (*R2*) and deforestation (*D*). Such feature classes were created to represent each year in the period of 1990-2011.

The *Study-1* (with *Study-2*) report contains an annual forest land-use change table (matrix, Table 6-2) for the period 1990-2011 which fits the requirements of *2003 IPCC* (in line with *2006 IPCC*). The *Study-1* also resulted in enhancement of forest inventory, introducing mandatory registration of all forest compartments fitting the afforestation/reforestation requirements of *2003 IPCC*, and the development of GIS based forest cadaster information system following the principles of continuous forest management.

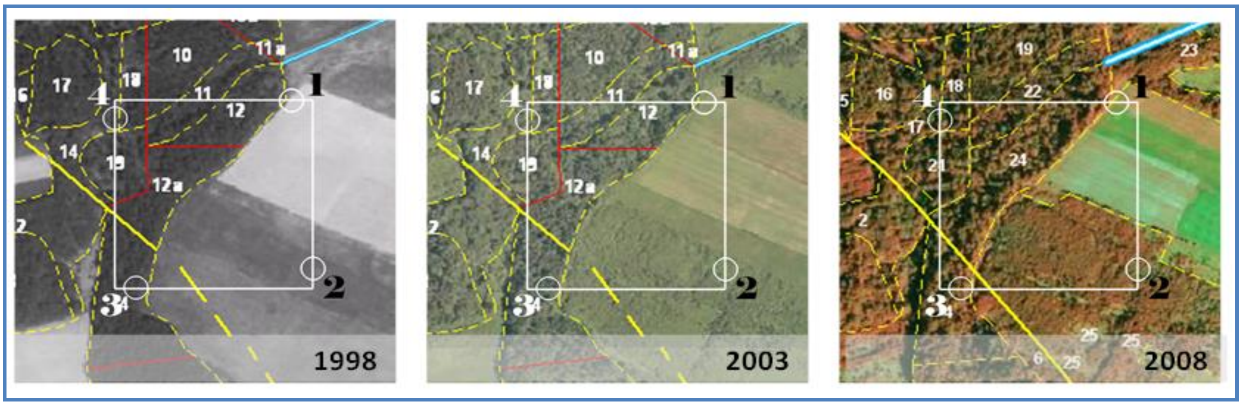

Figure 6-4. Land use changes according to *NFI* data

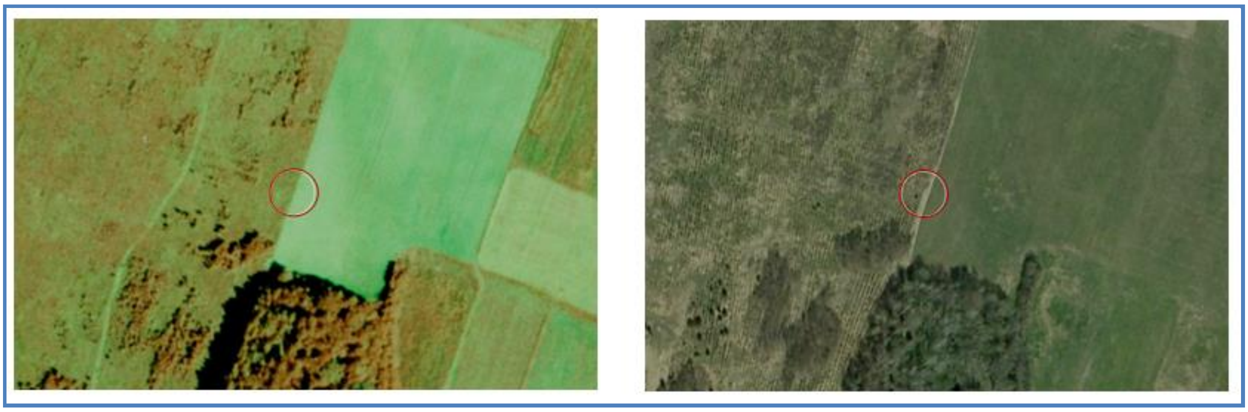

Figure 6-5. Grassland converted to Forest Land

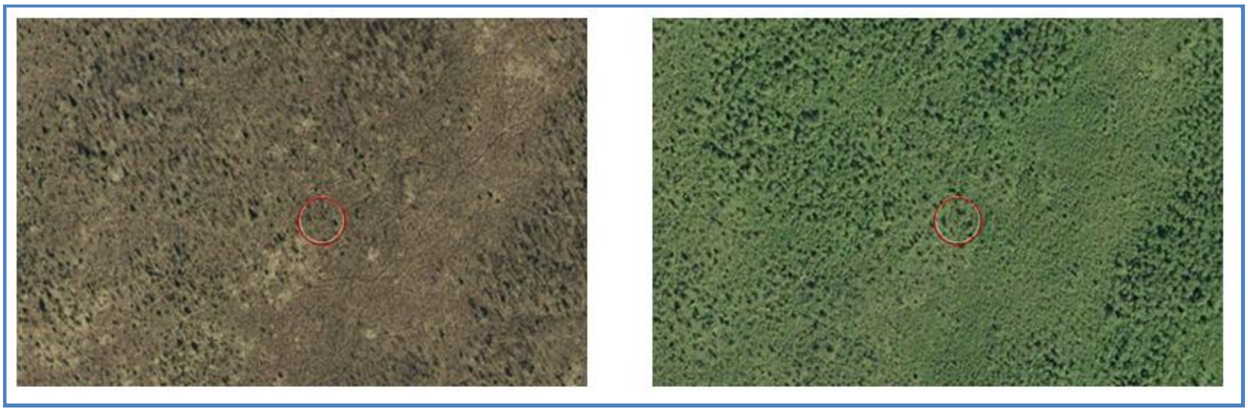

Figure 6-6. Wetland converted to Forest Land

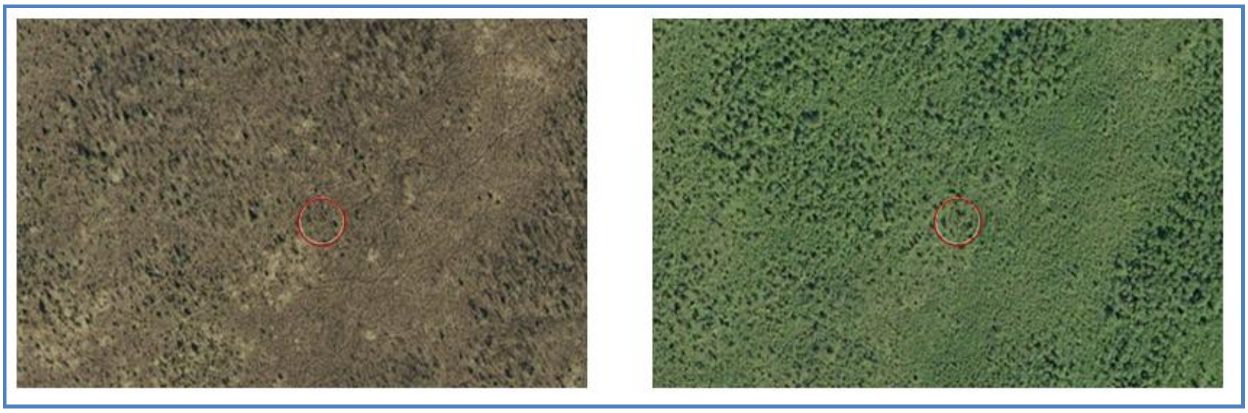

Figure 6-7. Wetland converted to Forest Land

6.1.2 Study "Changes of areas of Croplands, Grasslands, Wetlands, Settlements and Other lands in Lithuania during 1990-2011" (Study-2)

The *Study-2* was executed by the specialists of *SLF*. The study was completed in the end of April 2012. It was aimed to identify annual Croplands, Grasslands, Wetlands, Settlements and Other land areas and the changes which occurred in Lithuania during the period of 1990-2011, following the requirements of *2003 IPCC* (in line with *2006 IPCC Guidelines*).

Annual identification of different land categories was carried on 16325 systematically distributed sample plots available from Lithuanian *NFI* focusing on the period of 1990-2011. Land use changes were identified during all available historical data on land uses analysis in statistical and graphical form as well as assessing historical data collection methods. The following actions were executed:

- analysis of data sources and land use data collection;
- identification of land areas on sample plots;
- compilation of sample plots databases;
- analyses of Croplands, Grasslands, Wetlands, Settlements and Other lands statistical data;
- justification of research methodology and harmonization of applied methods.

The main data sources that were used: land areas analogical inventory plans of 1990; 1995-1998, 2005-2006, 2009-2010 digital orthophotos maps S 1:10°000 (*ORT10LT*), Lithuanian Land Fund statistical data, declaration database of land areas and croplands.

Land areas and their changes were assessed based on NFI sample plots grid and statistical data provided by Land Fund together with digital orthophotos maps, satellite images and declarations database of land areas and croplands. In depth analysis was executed on approximately 11 thous. systematically distributed permanent sample plots falling on non-forest land.

In the course of analysis (with *Study-1*) land-use change matrix (annual change of areas of Croplands, Grasslands, Wetlands, Settlements and Other lands) in Lithuania during 1990-2011 was prepared (Table 6-2). Proposals on land use definitions harmonization used in 1990-2011 and the development of the harmonized methodology for the data evaluation and estimation of removals and emissions for LULUCF sector according to the UNFCCC requirements was elaborated.

Identification of land use categories using different available historical data is presented in Figure 6-8. The same tract of sample plots is depicted in every photo but in different time periods and was assessed by *SLF* experts.

Data sources	NFI permanent plots			
	1	2	3	4
	Land use categories			
Land use plan, 1990	S	CL	GL	CL
Orthophoto map, 1995	S	CL	GL	CL
Orthophoto map, 2005	S	CL	GL	GL
Orthophoto map, 2009	S	CL	CL	GL
Land declaration database, 2010	S	CL	CL	GL

Figure 6-8. Identification of land use changes according to *NFI* permanent sample plots and cartographical data

a – land use plan, 1990; b, c and d – orthophoto maps 1995, 2005, 2009;
e – map according to land declaration database, 2010

The study resulted in the following outputs (on annual bases for the period of 1990-2011):

- area calculations made and land use change matrix prepared (with *Study-1*);
- annual change of Croplands, Grasslands, Wetlands, Settlements and Other lands areas identified;
- report, showing considered land unit changes prepared;
- proposals on land use definitions harmonization and development of the harmonized methodology for the data evaluation and estimation of removals and emissions for LULUCF sector according to the UNFCCC requirements elaborated[146].

As the result of *Study-1* and *Study-2* which are based on point sampling method (*NFI* permanent sample plots net) land transition matrix was compiled for each year for the period of 1990-2011. Since 2012 land use transition matrix is continuously updated using *NFI* data (Table 6-2; Annex VI).

Table 6-2. Yearly land transition matrix for 2015, ha (01.01.2015 - 01.01.2016)

Land category	**Forest land**	**Cropland**	**Grasslan d**	**Wetland s**	**Settlemen ts**	**Other land**	**Final**	**Net change**
Forest land	2197170	799	7189	799	0	0	2205957	8787
Cropland	0	2055778	83078	0	0	0	2138856	-15976
Grassland	0	98256	1377974	399	0	1198	1477827	6790
Wetlands	0	0	0	340699	0	399	341099	-798
Settlements	0	0	2396	0	351883	0	354279	2396
Other land	0	0	399	0	0	11583	11982	-1199
Initial	**2197170**	**2154832**	**1471037**	**341897**	**351883**	**13181**	**6530000**	

The summary of methods used for estimation of carbon stock change and GHG emissions/removals reported under the LULUCF sector is presented in Table 6-3.

Table 6-3. Reported emissions/removals and calculation methods for LULUCF sector categories

CRF category	**Stock change reported**	**Emission / removal reported**	**Methods used**
4.A Forest Land	carbon/CO_2	CO_2; N_2O	T1; T2
4.B Cropland	carbon/CO_2	CO_2; N_2O; CH_4	T1
4.C Grassland	carbon/CO_2	CO_2; N_2O; CH_4	T1
4.D Wetland	carbon/CO_2	CO_2	T1
4.E Settlement	carbon/CO_2	CO_2	T1
4.F Other Land	carbon/CO_2	CO_2	T1
4.G Harvested Wood Products	carbon/CO_2	CO_2	T1

Reconciliation of the executed studies

Necessity of the studies conducted. Both studies were launched in order to recover land use data since 1990, required by UNFCCC (*Study-2*), and to meet the requirements for the land identification under the Articles 3.3 and 3.4 of the Kyoto Protocol (*Study-1*). This was done considering available data since 1998, based on Lithuanian National Forest Inventory, which has been started at that time, and missing data for the period of 1990-1997 as it is required by UNFCCC and Kyoto Protocol for GHG reporting.

[146] Harmonized methodology for data collection and estimations of emissions and removals of greenhouse gases from LULUCF has been approved by the order of the Ministers of Environment and Agriculture, Nr. D1-819/3D-790 on 2012.10.09.

Initially annual land use and land-use changes identification, which was done on sample plots basis, is a single study divided into two parts seeking to speed up and increase the quality of plots assignment to different land use categories. Connecting element for both studies was uniform *NFI* sample plots grid covering all Lithuanian territory. *NFI* sample plots network was used as a basis for data collection on land use and land-use changes.

Solutions taken. The analysis of *NFI* sample plots could be divided into three steps that were taken by qualified experts. First of all, recorded data on sample plots of *NFI* 1998 has been considered, such as stand characteristics (age, retrieved from tree borings etc.), site description, records on previous land use before the establishment of sample plot etc. Secondly, analysis of all available orthophoto maps and data from *SFC* for the unknown period (1990-1997) has been carried out. This was done trying to trace the exact moment in time when minimal characteristics of forest, as it is required by Law on Forests, were reached. Lastly, analysis of archive land planning maps and *SFI* material was implemented with the aim to identify and to synchronize land use categories with the recorded sample plot data. This analysis of plots, identified on Forest land (~6,000) was carried out by SFS together with Aleksandras Stulginskis University and all other plots (~10,000) – by Lithuanian Land Fund. After the completion of assignment of all plots available on Lithuanian territory (16,325) to different land use categories (FL, CL, GL, WL, SL, OL) by years (1990, 1991, … 2011), final decisions and required calculations were done by *SFS*. Any overlaps were eliminated allowing only one answer (assignment to any land use category) for each plot for each year during the data processing.

The visual comparability of both studies is represented in Figure 6-9.

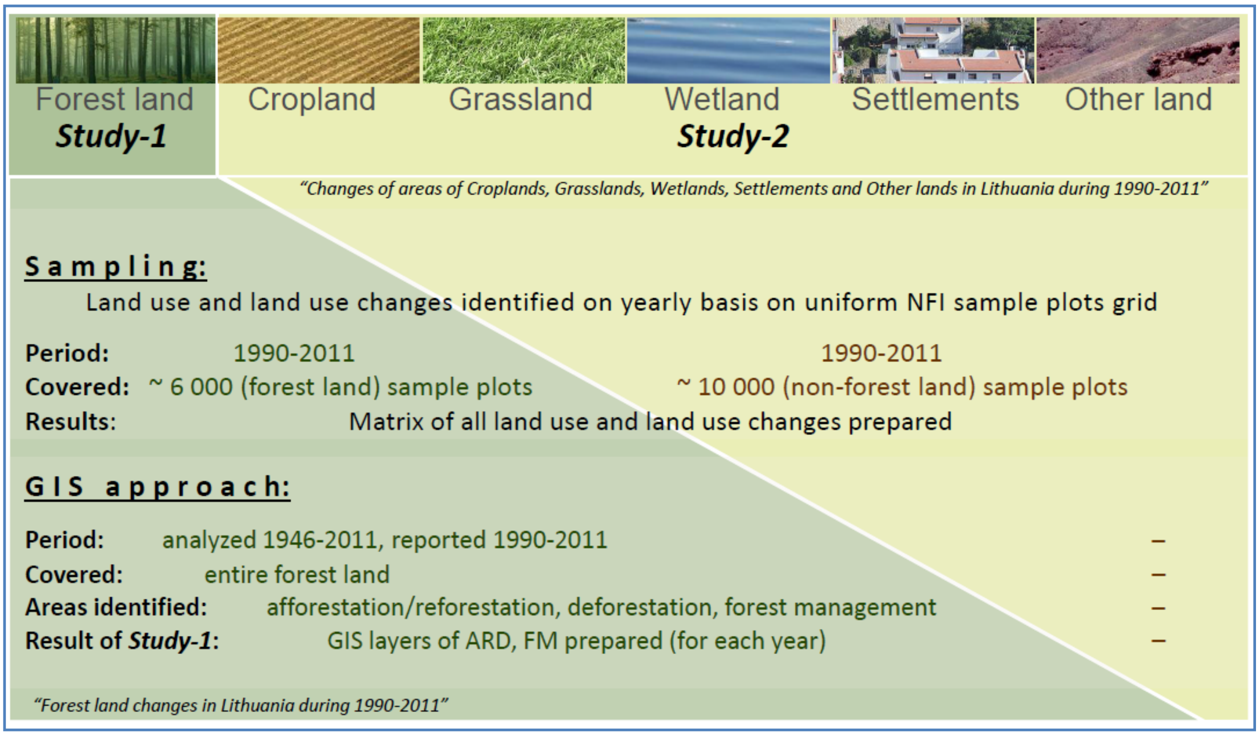

Figure 6-9. Studies on land use changes in 1990-2011

The way forward. Accomplished studies presented required data for the time period of 1990-2011 according to UNFCCC and its Kyoto Protocol requirements. It also encouraged adopting relevant legislation (legal acts were adopted in 2011-2012, see Chapter 6.1), setting the rules, and also obliging, forest owners and managers to register newly afforested, reforested and deforested areas to *SFC*, which is serving as the main data provider for ARD areas identification reported under the Kyoto Protocol from 2012.

6.1.3 National definitions of all categories used in the inventory

Even though requirements for greenhouse gas inventories methodology has changed, obliging parties to use *2006 IPCC Guidelines* instead of previously used *2003 IPCC Guidance*, but this had no impact on the definitions of land use categories that Lithuania has been constantly using since the beginning of the inventory nor to the area estimations. The land areas used in this inventory are consistent with those defined in *2006 IPCC Guidelines* as they are consistent with *2003 IPCC Guidance*. However, some of the national definitions of land-use areas are broader than those required by Good Practice Guidance so they were merged to fit *2006 IPCC Guidelines* (Table 6-5).

Forest land is defined according to the Law on Forests of the Republic of Lithuania[147]. Forest – is a land area not less than 0.1 hectare in size covered with trees, the height of which in a natural site in the mature age is not less than 5 meters, other forest plants as well as thinned or vegetation-lost forest due to the acts of nature or human activities (cutting areas, burnt areas, clearings). Tree lines up to 10 meters of width in fields, at roadsides, water bodies, in living areas and cemeteries or planted at the railways protection zones as well as single trees and bushes, parks planted and grown by man in urban and rural areas are not defined as forests. The procedures for care, protection and use of these plantings shall be established by the Ministry of Environment. Forest stands with stocking level (approximately equivalent to crown cover) less than 30% are not acceptable for high productivity forestry. This threshold is used when including land areas into afforested land areas (Table 6-4).

Table 6-4. Selected parameters defining forest in Lithuania for reporting under LULUCF

Parameter	Value
Minimum land area	0.1 ha
Minimum crown cover	30%
Minimum height at mature age	5 m

Cropland. The area of cropland comprises of the area under arable crops as well as orchards and berry plantations. According to national definitions - arable land is continuously managed or temporary unmanaged land, used and suitable to use for cultivation of agricultural crops, also fallows, inspects, plastic cover greenhouses, strawberry and raspberry plantations, areas for production of flowers and decorative plants. Arable land set aside to rest for one or several years (<5 years) before being cultivated again as part of an annual crop-pasture rotation is still included under cropland. Orchards and berry plantations are areas planted with fruit trees and fruit bushes (apple-trees, pear-trees, plum-trees, cherry-trees, currants, gooseberry, quince and others). Under this category only those orchards and berry plantations are included that are planted on other than household purpose land and mainly used for commercial purposes. Orchards and berry plantations planted in small size household areas and only used for householders' meanings are included under Settlements category. All croplands are managed land.

Grassland. Grassland includes meadows and natural pastures planted with perennial grasses or naturally developed, on a regular basis used for moving and grazing. Grasslands cultivated for

[147] Available from: *http://www3.lrs.lt/pls/inter3/dokpaieska.showdoc_l?p_id=437404&p_query=&p_tr2=2*

less than 5 years, in order to increase ground vegetation, still remain grasslands. All grasslands are considered as managed land in Lithuania.

Wetlands. Wetlands include peat extraction areas and peat lands which do not fulfil the definition of other categories. Water bodies and swamps (bogs) are also included under this category. Peat extraction areas are considered as managed land. Since 2013, in line with renewed methodology, wetlands are distributed between several groups for reporting: remaining managed peat extraction sites (there were no conversions into new peat extraction sites in recent years in Lithuania, therefore land converted to peat extraction sites are not reported), remaining managed flooded land, remaining managed (other) land, which is mainly drained damaged peatlands, remaining unmanaged and land converted to flooded land.

Settlements. All urban territories, power lines, traffic lines and roads are included under this category as well as orchards and berry plantations planted in small size household areas and only used for householders' meanings. Only the areas of settlements remaining settlements and lands converted to settlements are reported. All settlements are considered as managed land.

Other land. All other land which is not assigned to any other category such as quarries, sand - dunes and rocky areas is defined as Other land. Only area of other land is reported.

Table 6-5. National definitions for land use categories and relevant land use category defined in *2006 IPCC*

National definitions for land use categories and subcategories										
Agricultural land							Other land			
Arable land	Orchards and berry plantations	Meadows and natural pastures	Forest land	Roads	Settlements	Water bodies	Swamps (bogs)	Trees and bushes plantations in urban areas	Disturbed land	Unmanaged land
Relevant category in *2006 IPCC*										
Cropland		Grassland	Forest land	Settlements		Wetlands		Settlements	Other land	

Information on extension of reporting under Kyoto Protocol

Under the requirements of Kyoto Protocol for the second commitment period Lithuania is committed to report GHG emissions and removals under Kyoto Protocol Articles 3.3 (afforestation/reforestation/deforestation activities) and 3.4 (Forest management activities). After the second commitment period (from 2021) Article 3.4 activities cropland management and grazing land management will become obligatory as well. Therefore, European Parliament and Council decided[148] that all European Union Member States shall prepare for upcoming reporting extension with preparing and reporting on the systems to estimate emissions from cropland management and grazing land management altogether with their compliance with IPCC methodologies and UNFCCC reporting requirements.

According to the Annex of draft decision -/CMP.1 (Land use, Land-use Change and Forestry) contained in document FCCC/CP/2001/13/Add.1 definitions of forest management and grazing land management are the following:

[148] Decision No. 529/2013/EU of The European Parliament and of The Council, available from http://eur-lex.europa.eu

- **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.
- **Cropland management is the system of practices on land on which agricultural crops are grown and on land that is set aside or temporarily not being used for crop production.**
- **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, grassland and cropland in Lithuania are managed, therefore emissions/removals have to be accounted for the whole territory.

6.1.4 Land use changes

Forest coverage in Lithuania remains continuously increasing during the last decades (Figure 6-11). Natural and human induced afforestation increased forest land area by 144.6 thous. ha since 1990 (Table 6-7). If would compare todays` situation with 1946, forest area increased more than one third and in some counties forest expansion has almost doubled.

Declared croplands area in Lithuania was decreasing since 1990 to 2005. This is closely related to Lithuanian history. Significant reforms were introduced in the early 90's, particularly after the restoration of independence with the purpose of re-establishment of private ownership and management in the agriculture sector. The legislations were adopted for dismemberment of the collective farms, but they did not ensure their replacement by at least equally productive private farms or corporations. Agricultural production decreased by more than 50% from 1989 to 1994. The farms were broken into small holdings, averaging 8.8 ha in size, often not large enough to be economically viable. Area of grasslands prevailed.

Croplands and Grasslands area has changed dramatically in Lithuania since 2005. This is the result of introduced Single Area Payment Scheme (*SAPS*) since 2004. *SAPS* is a form of support whereby direct payment is made for agricultural land irrespective to the type of production carried out on the land, and this might be one of the reasons of decrease in grasslands area. Furthermore, in 2004 when Lithuania became the member of EU, communities Structural Funds became available. In order to use funding from EU Structural Funds efficiently, the Single Programming Document (*SPD*) of Lithuania for 2004–2006 was prepared. The strategy provided in the *SPD* was divided into priorities and implemented on the basis of one or several measures. Support for Rural and Fisheries development was provided under the measures of the 4th *SPD* priority. The main objective of the Rural and Fisheries Development priority is to develop an advanced agriculture, forestry, and fishery sector on the basis of natural resources and the traditions of inhabitants and by investing in alternative activities, traditional farming, and economic diversification. This support is a non-repayable grant of between 45% and 100% of eligible expenses. In 2004–2006, 191 million EUR was allocated to implement the measures of the Rural and Fisheries Development priority. According to the support contracts signed, the largest amount of funding (95 million EUR) was allocated to beneficiaries who submitted applications for the measure named "Investments into Agricultural Holdings". These measures resulted in agricultural land management, hence increase in croplands area and decrease in grasslands that were ploughed for agricultural purposes.

Table 6-6. National land use data for 1990-2015, thous. ha[149]

[149] Data for 1990 -2011: Forest Land – *Study-1*; Cropland, Grassland, Wetland, Settlement, Other Land – *Study-2*. Data for 2012 and subsequent years – *NFI*

Years	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	Total
1990	2,061.4	2,426.0	1,307.7	363.1	324.3	47.5	6,530.0
1995	2,084.9	2,233.1	1,513.4	354.7	328.7	15.2	6,530.0
2000	2,105.7	2,029.4	1,697.1	348.7	334.3	14.8	6,530.0
2005	2,134.9	1,835.3	1,862.4	347.1	337.9	12.4	6,530.0
2010	2,166.4	2,084.9	1,579.7	343.5	341.9	13.6	6,530.0
2011	2,173.2	2,090.5	1,567.7	343.1	341.9	13.6	6,530.0
2012	2,184.8	2,113.7	1,532.5	342.3	342.7	14.0	6,530.0
2013	2,189.2	2,131.3	1,506.9	342.3	346.3	14.0	6,530.0
2014	2,197.2	2,154.8	1,471.0	341.9	351.8	13.2	6,530.0
2015	2,206.0	2,138.9	1,477.8	341.1	354.3	12.0	6,530.0

Table 6-7. Land use changes between 1990 and 2015

Land use	1990	2015	LUC
	thous. ha		
Forest Land (FL)	2,061.4	**2,206.0**	144.6
Cropland (CL)	2,426.0	**2,138.9**	-287.1
Grassland (GL)	1,307.7	**1,477.8**	170.1
Wetland (WL)	363.1	**341.1**	-22.0
Settlements (SL)	324.3	**354.3**	30.0
Other Land (OL)	47.5	**12.0**	-35.5

6.1.5 GHG sinks and releases

Annual CO_2 emissions and removals for the period 1990-2015 are provided in Table 6-8 (evaluated net CO_2 emissions and removals from LULUCF sector). LULUCF sector in Lithuania has continuously been CO_2 sink with the only emissions of 3,110.82 kt CO_2 in 1996 and 1397.47 kt CO_2 in 1997. Removals were ranging from -2,360.79 kt CO_2 to -9,802.91 kt CO_2 during the accounting period. In average -5,675.80 kt CO_2 are removed every year. Removal of CO_2 mainly corresponds to forest land with the smaller share from grasslands and harvested wood products since 2000.

Table 6-8. Evaluated total emissions and removals from LULUCF sector, kt CO_2 eqv.

Year	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	Harvested wood products	Total
1990	-7,743.37	5,645.98	-1,773.90	523.29	NE,NO	NO,NE	-95.65	-3,355.22
1995	-5,430.36	4,721.99	-2,973.54	446.54	164.57	29.74	604.27	-2,360.79
2000	-9,494.85	3,871.70	-3,736.52	466.31	248.60	32.61	-40.85	-8,592.42
2005	-4,516.25	2,467.68	-4,471.21	880.00	431.96	41.49	-887.01	-6,005.73
2010	-9,845.90	3,672.42	-3,445.09	548.72	348.55	68.49	-872.11	-9,455.82
2011	-10,366.70	3,711.78	-3,194.92	639.65	316.80	68.49	-1,046.42	-9,802.91
2012	-10,068.91	3,860.68	-2,854.88	641.96	300.67	67.63	-932.97	-8,916.58
2013	-9,873.95	4,075.75	-2,652.02	883.19	360.48	56.56	-955.24	-8,033.53
2014	-9,225.22	4,345.66	-2,450.66	892.27	402.10	58.34	-1,399.35	-7,301.55
2015	-8,861.95	4,388.67	-2,458.73	965.22	412.80	57.92	-1,680.86	-7,096.39

6.2 Forest Land (CRF 4.A)

Neither definition of forest land nor reporting of GHG has changed since the 1st Commitment Period in forest land category and is used 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 temporary 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 railway 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 land in Lithuania.

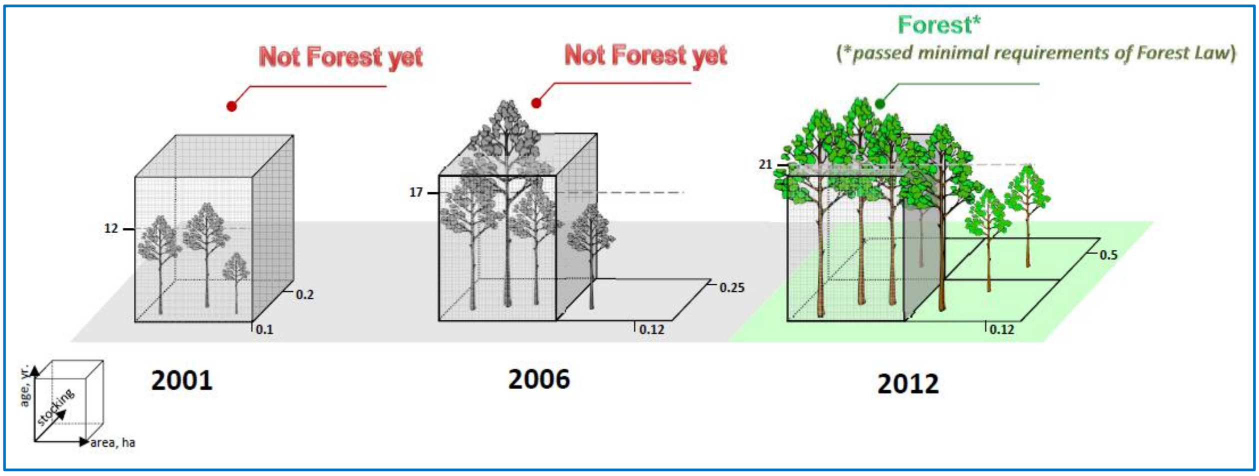

Figure 6-10. Definition of forest applied in Lithuania. Group of trees becomes forest only when reaching certain parameters

6.2.1 Category description

Forest land area

Forest coverage in Lithuania was expanding continuously since 1948 (Figure 6-11). However data on forest coverage in Lithuania during inter-war period is very limited and the exact data is still unknown.

Expert judgement made by the authors of "*The Chronicle of Lithuanian Forests. XX Century*"[150] allowed presuming forest coverage to be around 21% in 1938, even though some authors argue that only small part of heavily afforested areas of Vilnius region (south-eastern part of Lithuania) were included into this number at that time, and around 150 thous. ha could be unaccounted.

The lowest forest coverage has been accounted during the World War II and through occupation period, because of no forest preservation policy 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" (collective farms) and being less than 10 ha were disregarded as well as those belonging to small farms and being less than 1 ha.

[150] Lietuvos Respublikos Aplinkos Ministerija, Miškų departamentas. Lietuvos miškų metraštis. XX amžius. Vilnius, 2003

After restoration of independence in 1991, there were no legal obstacles for implementation of forest accounting. However, the land reform had also started at that time, so the *SFI* has been suspended or even discontinued as less important. In 1996, when the new cycle of *SFI* has been started numerous naturally afforested areas were found that were missing in the previous inventories or in State land accounting related documents.

Although forests cover a large part of Lithuanian territory and constitute to 2,206.0 thous. ha which is more than 33% of the country, it is estimated and forecasted that Lithuanian forest area should account for at least 35% considering the needs of the nature frame and landscape. Despite the fact that forest land area has increased significantly and many new forests have been planted on private and State land the need for further enlargement of forest land still remains. According to the statistical data of NLS under Ministry of Agriculture[151], there was approximately 70 thous. ha of land that is not used for agriculture or is unsuitable for that in 2015 and part of it might already be covered with woody vegetation (natural afforestation has been started). In addition to this, a target in the Master Plan[152] for the territory of the Republic of Lithuania has been set to increase afforestation of such lands and as a conclusion country forest coverage could increase up to 37-38%. However, this process is slowed down by incomplete land reform, problems related to the transfer of free land from the state land fund to managers of state-owned forests for afforestation, as well as legal restrictions linked with afforestation of land that has relatively high productivity. Therefore it is reasonable to increase forest coverage by harmonizing the scope with other land use needs.

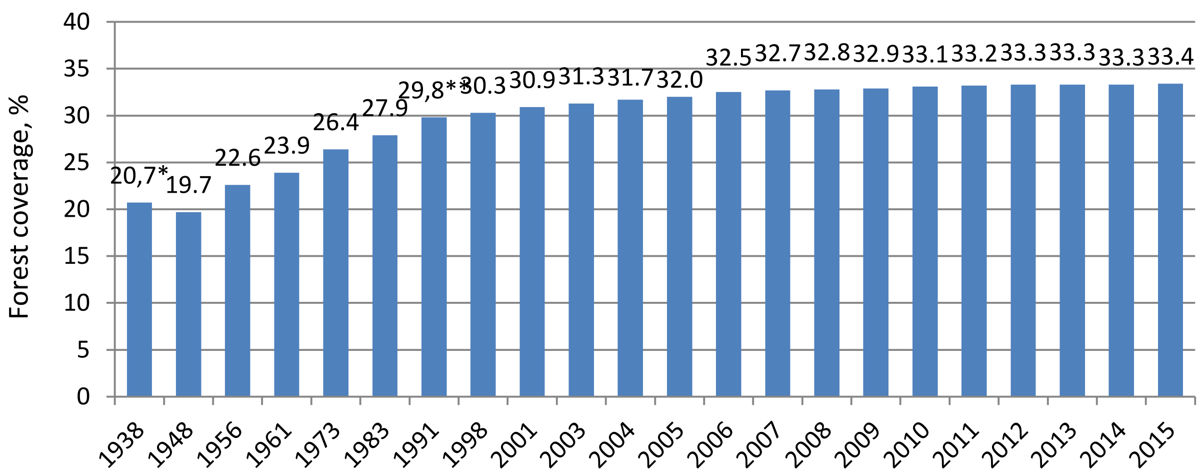

Figure 6-11. Forest coverage 1938-2016.01.01

According to Lithuanian Statistical Yearbook[153] of Forestry by 1st of January 2016, total forest land area in 2015 was 2,186.7 thous. ha, covering 33.5 % of the country's territory. Since 2003 average forest area per capita increased from 0.59 ha to 0.76 ha. Around half of all forest land in Lithuania is of State importance – 1,088.5 thous. ha. In 2015 around 838.9 thous. ha of forests were registered as private at the State enterprise Centre of Registers. However, after intersection of layers of all forests and private holdings the estimated area of private forests

151 Land Fund of the Republic of Lithuania 2016.01.01, Available from: *http:// http://www.nzt.lt/go.php/Statistika*
152 Available from: *http://www3.lrs.lt/pls/inter2/dokpaieska.showdoc_l?p_id=284951*
153 State Forest Inventory, 2016.01.01. Available at: http://www.amvmt.lt/index.php/leidiniai/valstybine-misku-apskaita/2016-01-01

was slightly readjusted to 873 thous. ha in the beginning of 2016 (according to recent SFI data, 1,098 thous. ha in the end of 2015, including private holdings and other ownerships). Since the 1st of January 2003, the forest land area has increased by 141.5 thous. ha corresponding to 2.2 % of the total forest cover. During the same period, forest stands expanded by 107.3 thous. ha to 2,053.314 thous. ha. Average annual increase in forest area is about 10 thous. ha. Following prior official data of Forest Assessment[154] annual increase was more than 10 thous. ha. Huge difference in forest coverage is explained by insufficient data previously used by Forest Assessment. As of 1st of January 2016 Forest Assessment that is based on data of *SFC* shows nearly the same forest coverage as the *NFI*, which is based on permanent sample plots data (Figure 6-12).

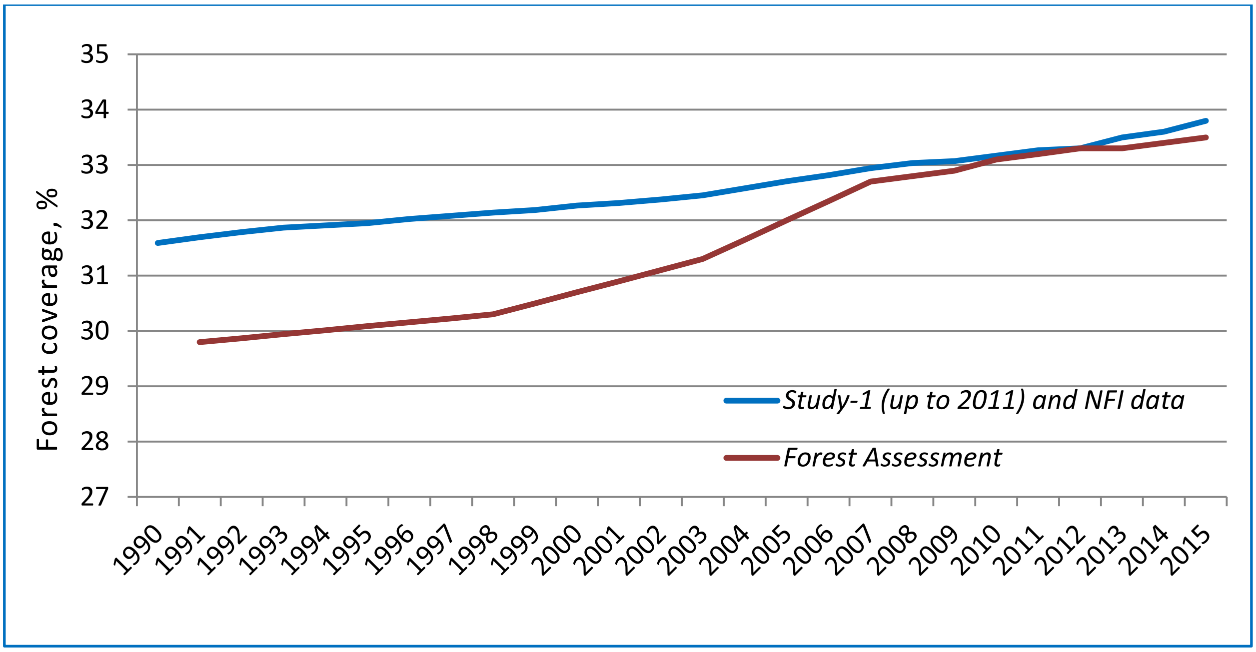

Figure 6-12. Changes in forest coverage in Lithuania 1990-2015, 2016.01.01

All Lithuanian forests are distributed into four functional groups. In the beginning of 2016, distribution of forests by functional groups was as follows: group I (strict nature reserves) – 26.5 thous. ha (1.2%); group II (ecosystems protection and recreational forests) – 266.5 thous. ha (12.2%); group III (protective forests) – 333.4 thous. ha (15.2%); and group IV (exploitable forests) – 1,560.3, thous. ha (71.4%) (Figure 6-13).

[154] Kuliešis, A., Vižlenskas, D., Butkus, A. et al. 2010. *Forest Assessment*. State Forest Service

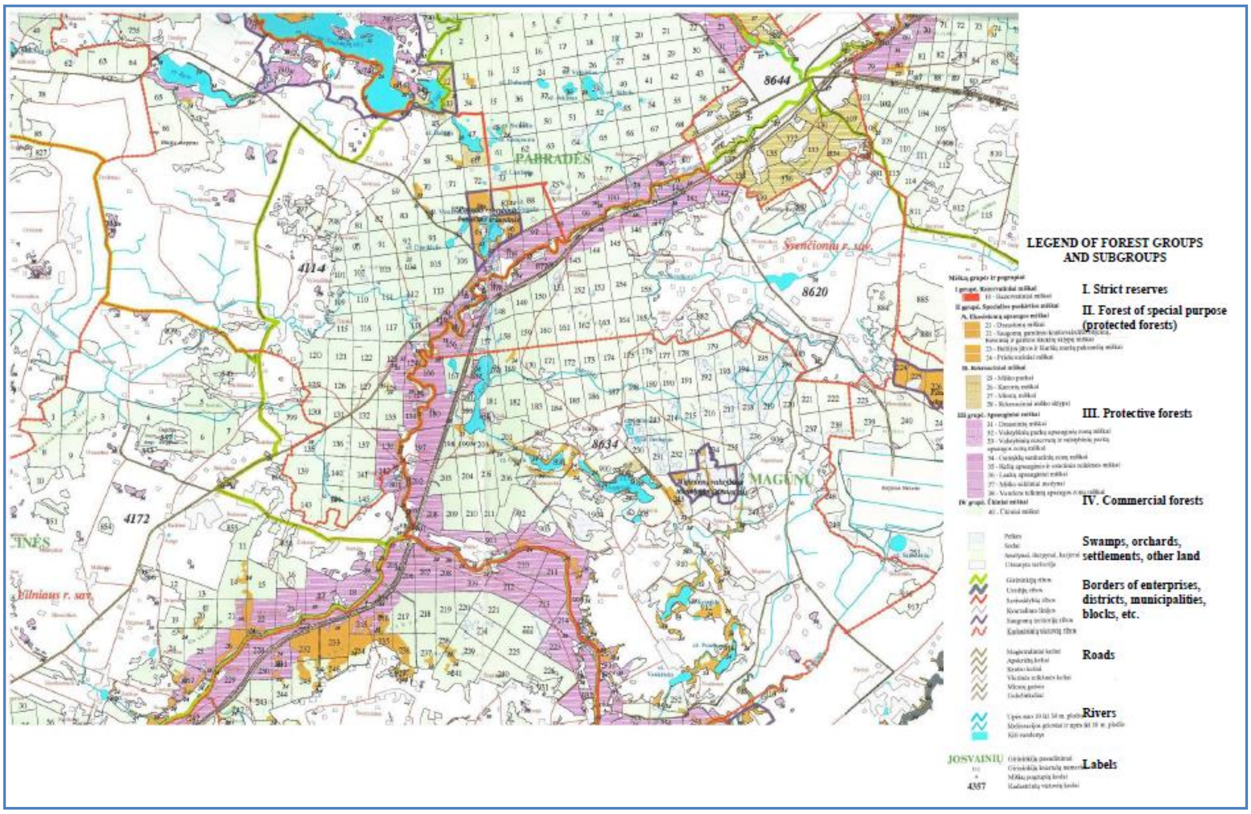

Figure 6-13. Scheme of forest distinguished by functional groups

Occupying 1,148.4 thous. ha, coniferous stands prevail in Lithuania, covering 55.8% of the forest area (Figure 6-14). They are followed by softwood deciduous forests (835.9 thous. ha, 40.6%). Hardwood deciduous forests occupy 74.0 thous. ha (3.6%). Over the last 12 years total area of softwood deciduous forests increased by 137.4 thous. ha. The area of hardwood deciduous has decreased by 18.6 thous. ha over the last 12 years (mainly due to the mouth of ash woods), and coniferous forest area in last 12 years decreased by 11.5 thous. ha. Scots pine (*Pinus sylvestris*) occupies the biggest share in Lithuanian forests – 716.0 thous. ha (34.8%). Compared to 2003, the area of pine expanded by 4.5 thous. ha. Norway spruce (*Picea abies*) covers 430.0 thous. ha (20.9 %), with a reduction of 15.3 thous. ha. Birch (*Betula pendula*) covers the largest area among deciduous trees. Since 2003, it has increased by 65.5 thous. ha and reached 457.7 thous. ha by the end of 2015. Area of Black alder (*Alnus glutinosa*) increased by 33.6 thous. ha to the total of 153.1 thous. ha. The area of grey alder (*Alnus incana*) expanded by 0.6 thous. ha i.e. less than the black alder, reaching 122.6 thous. ha. The area of aspen (*Populus tremula*) stands expanded by 32.4 thous. ha to 89.7 thous. ha. Oak (*Quercus robur*) forests increased from 35.7 thous. ha to 44.9 thous. ha. The area of ash (*Fraxinus excelsior*) stands diminished by 58.2 % to 21.5 thous. ha.

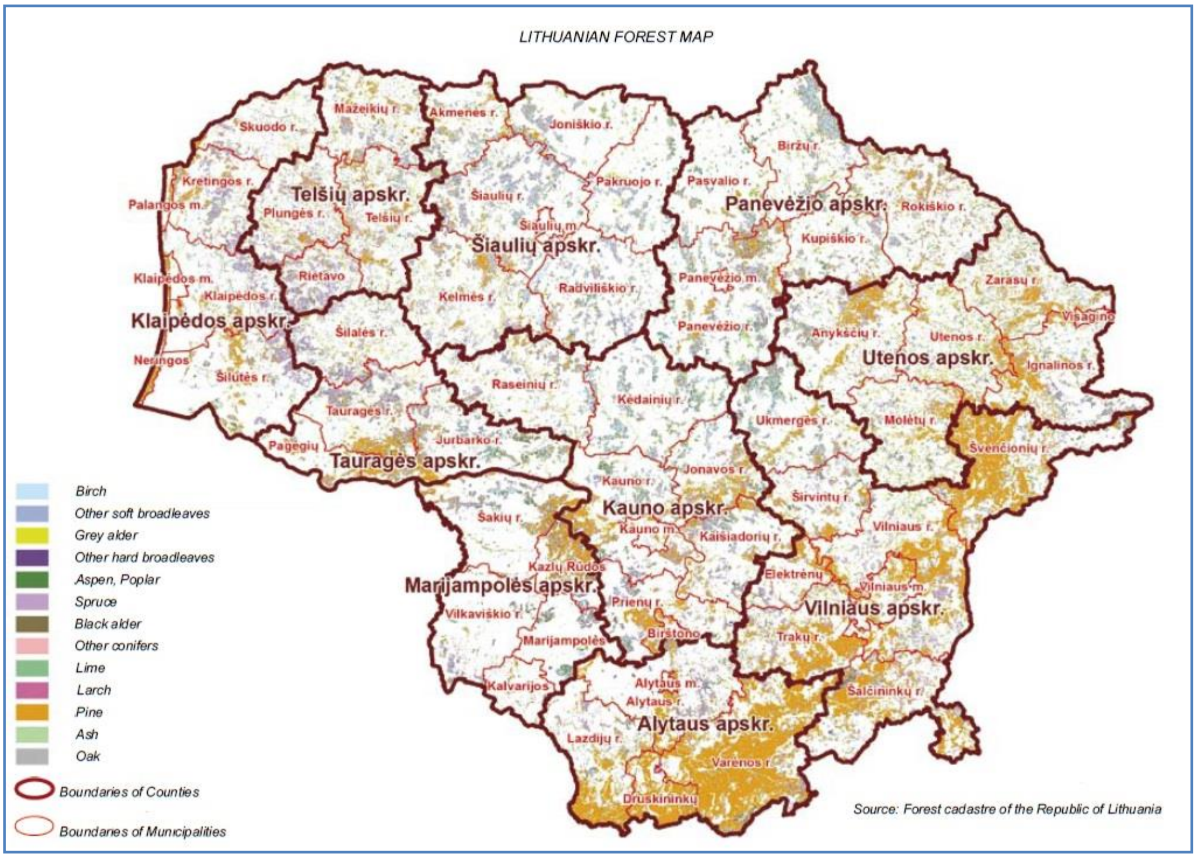

Figure 6-14. Lithuanian forest map by prevailing tree species

Forest Inventories

The traces of forest inventory in Lithuania date back to the middle of the 16th century, when Grigoryi Volovich wrote a report on ,,*The inspection of woods and game crossing tracks...*" in which he described the state of forest tracts of those times. In 19th century forest inventory on the territory of Lithuania was carried out by Russian, Polish and German specialists. Forest inventory and management planning came into existence in 1922 under the Department of Forestry at the Ministry of Agriculture. It employed 25-30 specialists. Primary inventory of state forests was completed by the year 1937. After World War II forest inventory renewed its functioning at the end of 1944. In 1955-1957 for the first time were inventoried all the forests of collective-farms and other stock – holders. Thus, in the second half of the 20th century all the forests of the Republic were inventoried. Repeated forest inventories took place in: 1958-1963, 1966-1977, 1978-1987, and 1988-2001. The methods of Lithuanian forest inventory and management planning until 1966 were based on Russian forest inventory instructions adapted to Lithuanian conditions. As a result of scientific research, experiments and soil investigations conducted in 1959-1966, forest management started to be planned on soil - typological basis. Owing to the joint efforts of forestry leaders of the Republic, researchers (*J. Kenstavičius and M. Vaičys*) and forest management planning specialists, "Rules of forest management planning on soil - typological basis" were prepared. The main principles of these regulations, being gradually improved, remained till the end of the 20th century. Aero photos were introduced into forest management planning practice in 1950, simplified soil studies with mensuration based and sampling methods as well as angle count plots started since 1966. In 1969-1971 methodical principles were elaborated, as well as preparation of programs and electronic calculating machines started to be used. In the last decade of the 20th century personal computers and geo-informational systems were introduced in forest inventories and mapping became fully automatized. Forest management planning historically had special sub-units: supervision of elaborated plans, hunting management, protected areas and recreational forests management planning, technological planning of final felling's, application of remote sensing methods and geo-information system and state assessment of forests resources. There have been certain changes in Lithuanian forestry management since Lithuania regained its independence at the end of 20th century. The Ministry of Forestry functioned until 1996 with the main aim to protect and recover Lithuanian forests, manage the use of forest resources and, in addition to this, there has been a high load of work to carry out land reform and restore ownership rights for former private forest owners. Since 1997, The Ministry of Forestry has been incorporated together with The Ministry of Agriculture and restructured into The Department of Forests, which was later incorporated under The Ministry of Environment. State Forest Service has been established in 2010 after the reorganization of several independent state services responsible for forest management, sanitary protection, genetic resources, seeds and seedlings and the functions of The Department of Forest control of State environmental protection inspection were transferred.

However, the most significant changes and improvements for the strategic planning of forestry and the development of forest management were done in 1998 with a start of national forest inventory by sampling method. The data obtained during the inventory allowed to increase the accuracy and reliability of information on forest resources of the country by ownership categories, being able to define them with a required accuracy and essentially broaden the scope of information.

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 for 90 years. *SFI* is obligatory to all ownership forms. During the inventory forest stands are singled out, their quantitative and qualitative characteristics are provided, forest health is assessed and silvicultural measures foreseen. Each year *SFI* inventoried area is nearly 200-250 thous. ha what is 10% of the total forest land area (Figure 6-15).

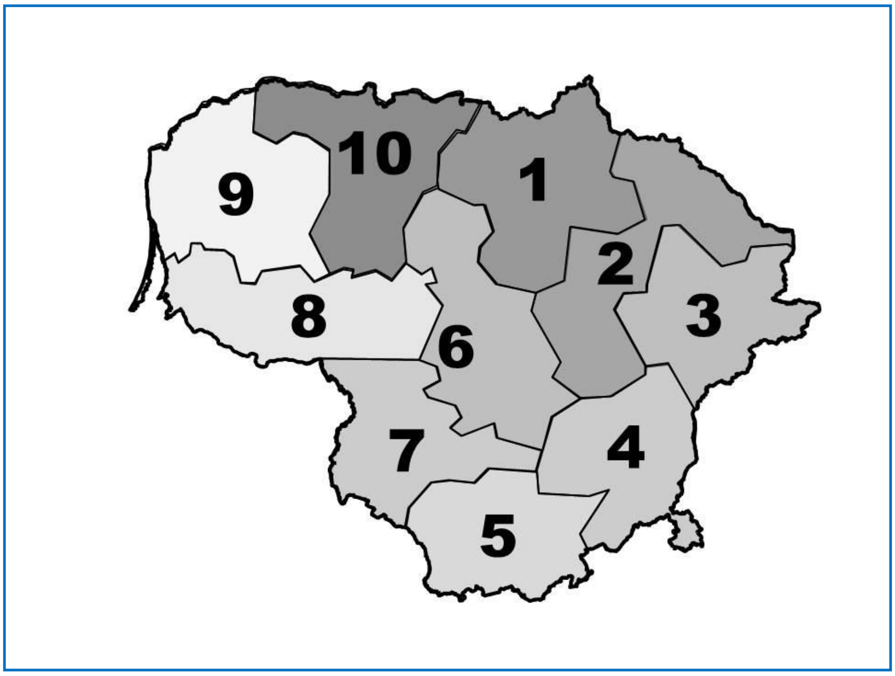

Figure 6-15. Execution of *SFI* over ten year period through the whole territory of Lithuania

Based on the inventory results forest management plans (Figure 6-16) are prepared for forest enterprises, state parks, recreational and protected areas. Some of the archived cartographical material owned by *SFI* is presented in figures below.

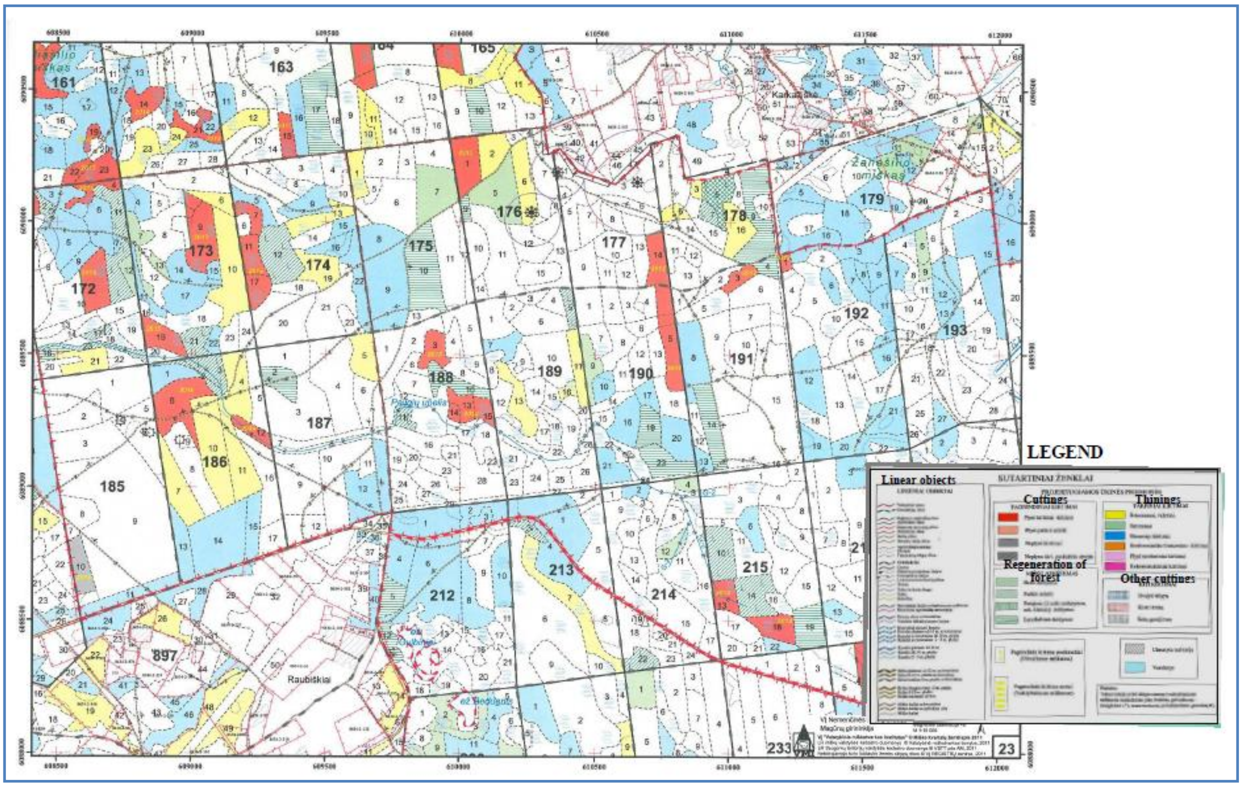

Figure 6-16. Forest management plan (planned forestry activities presented on scheme of forest blocks and compartments; S1:10°000)

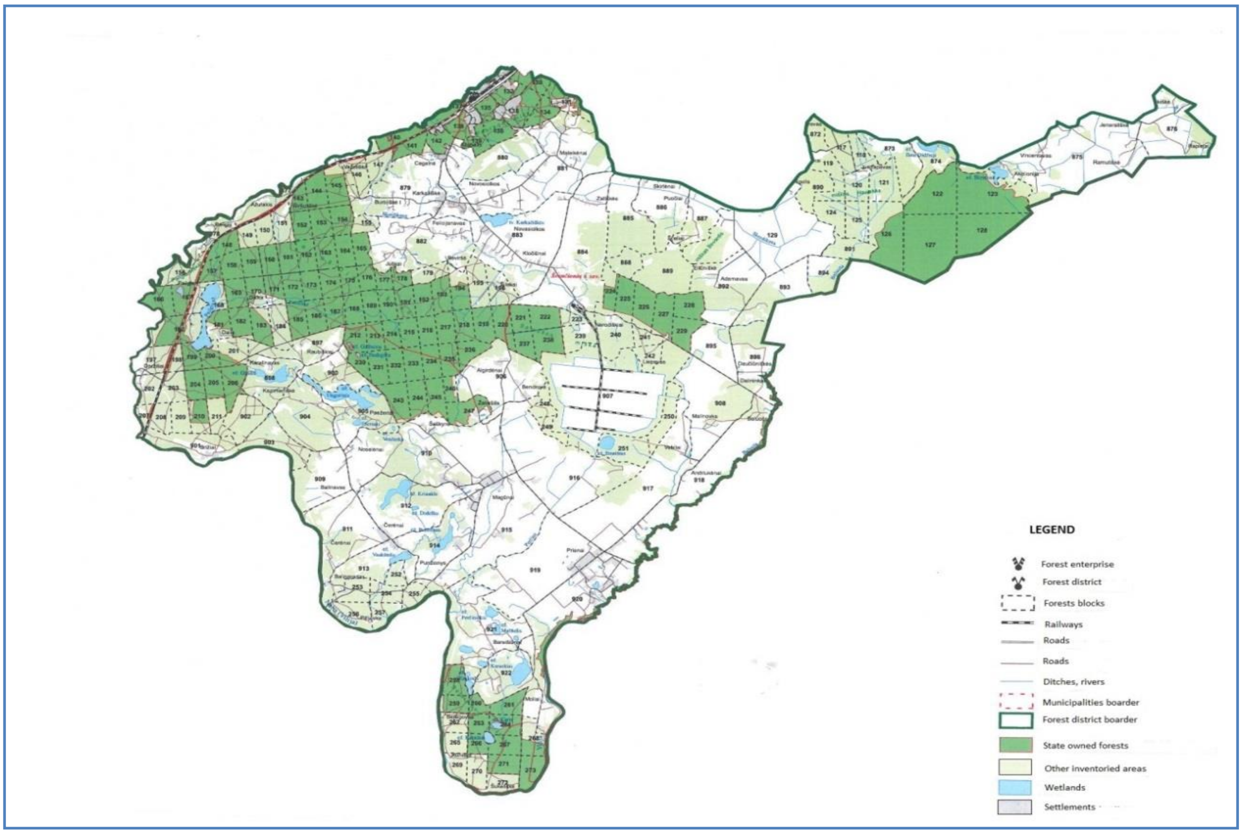

Figure 6-17. Scheme of the Forest District (S 1:10°000)

National Forest Inventory

National forest inventory was established in 1998 by the State Forest Management and Inventory Institute under the Ministry of Agriculture and Forestry and since then is one of the main forestry data providers (together with Standwise Forest Inventory, pre-cutting inventory and mature stands inventory). Its activity is consolidated by Forest Law of the Republic of Lithuania (2001, 2011, 2012 ed.) and it is conducted by the *SFS* following the Regulations of National Forest Inventory, approved in 2004 and revised in 2012. Data presented by *NFI* is used while making forest policy decisions (forestry related laws, forestry programmes etc.), planning forestry activities (large scale forest management planning, country forestry planning etc.), planning forest industry investments and modelling forestry related scenarios (forest resources development etc.). All the activity data, necessary for GHG reporting, is collected during *NFI*.

NFI is based on continuous, comprehensive multistage sampling and GIS integrated technology and is organized in the same manner to monitor all forests of Lithuania. Since 2012, the systematic grid (16,325 permanent sample plots) of the *NFI* of Lithuania covers all land categories (Figure 6-18) including inland waters.

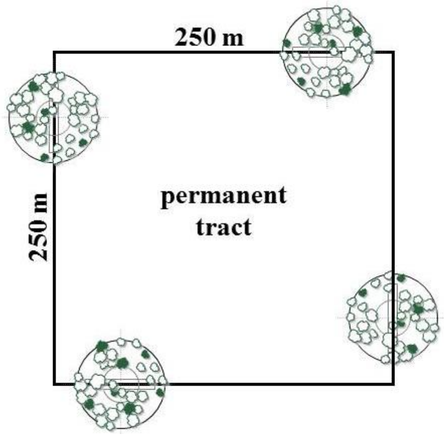

Figure 6-18. Tract of permanent sample plots

Sampling is conducted using a 4×4 km systematic grid with a random starting point. The systematic grid assures a uniform distribution of plots over the entire country and regular monitoring of conversion amongst land use categories. The sample units are arranged to square shape clusters and include four permanent, regularly measured plots (Figure 6-19).

The aim of establishment of permanent sample plots is to reliably estimate (by direct measurements) growing stock volume, gross increment, mortality and fellings, provide site and soil descriptions, to control the dynamics of forest areas in the country.

There are many different inventory parameters recorded in each of the permanent sample plots:

- Land use type (according to the position of the sample plot center;
- Stock changes in each different stands (if the stand in sample plot is not homogenous);
- Regeneration and bushes inventory;
- Natural and human induced damages of the trees, etc.

Taking into account the number of homogeneous stands (strata), minimal growing stock volume and increment estimation accuracy, 5,600 permanent sample plots were established on forest land. Approximately 1,120 permanent sample plots on forest land are re-measured each year.

Following the order of the Minister of Environment[155] and renewed Regulations of *NFI*[156], field measurements in all land use categories of Lithuania were started in 2012, resulting in more than 16 thous. permanent sample plots. The *NFI* plots annually cover the entire country with

[155] Order of the Minister of Environment No D1/27 12th January 2012 on Approval of Harmonised Principles for data collection and reporting on LULUCF

[156] Order of the Minister of Environment No D1-570 8th November 2004 on regulation of national forest inventory by sampling method

the total number of plots measured over the 5-year inventory cycle reaching a sampling intensity of one sample plot per 400 ha. The main aim of non-forest land measurements is to: (a) monitor land use changes, required by UNFCCC, provide soil descriptions and (b) to measure living trees outside the forest land in order to form a database of woody biomass accumulated in non-forest land.

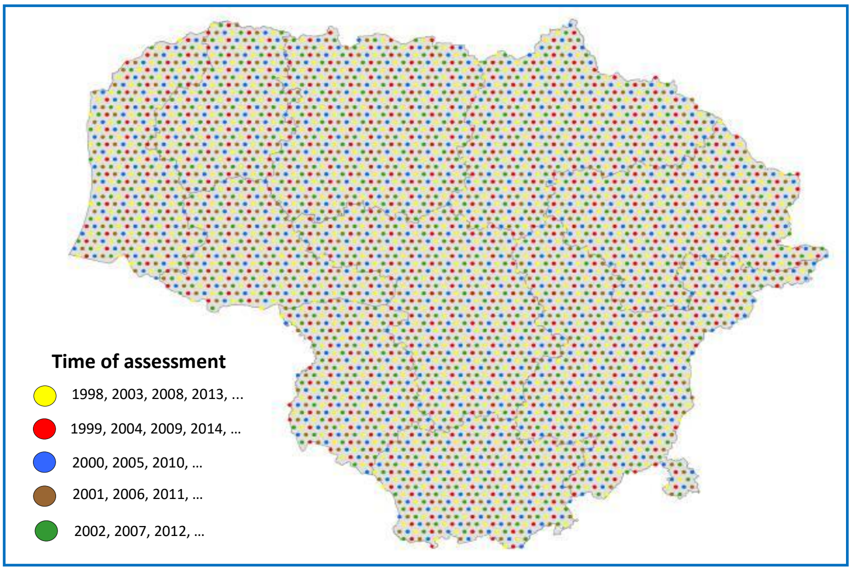

Figure 6-19. Distribution of NFI clusters of plots on Lithuanian territory

Lithuanian State Forest Cadaster

The purpose of *LSFC* is to collect, compile, process, systematize, store, use, update and provide data on Lithuanian forests. *LSFC* is a component of state registers' system. The structure of *LSFC* is based on natural-geographical principle thus forest tract is considered to be the unit of *LSFC* registration, as a result, *LSFC* is a database of forest tracts. Forest tract is considered as continuous forest land with environmental, anthropogenic boundaries or surrounded with other land use areas. State Forest Cadaster has been created employing the information of forest land compartments data base, originated from the *SFI* data.

Primary functions of *LSFC*:

1) Drawing up a technical draft of *LSFC*, including:

- regulations on separation of registration units and on attribution of code numbers to forest tracts;
- regulations on attaching and updating attributes of forest tracts;
- formulation of technical requirements for software;
- regulations on data provision to stake-holders and other cadasters.

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, according to a dominated forest tract, larger than 10,000 ha, then each district is subdivided into as many smaller districs as many forest tracts, having an area of 1,000-100 ha, until forest tract size is 10 ha or less. Each forest tract smaller than 10000 ha is subordinated to the district of dominating tract and acquires a part of its code number. Such code number of a small forest tract identifies both its geographical location and hierarchical position. Records of an identified forest tract are combined with the database of forest land compartments. Each forest land compartment receives a forest tract code number besides its own number. Information on compartments serves as a basis for forest tract information summary.

An interior numbering of blocks occur in each forest tract separately. Such approach will gradually result in a stable system of block numbers, irrespective to forest`s administrative division or its ownership category. *LSFC* database is being updated on a regular basis following the outcome of every next standwise inventory, the information from forest enterprises and other data providers about silvicultural measures applied information about ownership, administrative boundaries and other changes, information about newly planted or naturally regenerated forests during the inventory period, provided by forest enterprises and other institutions.

LSFC data are integrated with the data of other cadasters and registers such as those of real estate, protected areas, territorial administrative units, cultural values; as well as with other layers - training and experimental forests etc.

Data collection for GHG inventory reports

Organic and mineral soils

Due to the requirements of GHG inventory and reporting, *NFI* provides data on forest land distribution by forest soils (Table 6-9). According to NFI[157] 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. Organic soils in Lithuania are determined by using national definition of organic soils, provided in the book of Lithuanian soil classification[158]: soil is classified as organic if it has peat layer not thinner than 40 cm or 60 cm of poorly decomposed peat (mainly mossfibres) in bogs. In addition to this, histic horizon must contain not less than 70-75 percent of organic matter by volume. National definition of organic soils (histosols) was prepared using Food and Agriculture Organization (FAO) guidelines for soil classification (WRB, World Reference Base for soil resources).

Table 6-9. Forest land area by mineral and organic soils 1990-2015, thous. ha

Year	Mineral soils	Organic soils			Total forest land
		Not drained	Drained	Total	
1990	1,737.7	160.8	162.8	323.6	2,061.4
1995	1,757.6	162.6	164.7	327.3	2,084.9
2000	1,775.1	164.2	166.4	330.6	2,105.7
2001	1,777.8	164.5	166.6	331.1	2,108.9
2005	1,799.7	166.5	168.7	335.2	2,134.9
2010	1,826.3	169.0	171.1	340.1	2,166.4
2011	1,832.0	169.5	171.7	341.2	2,173.2
2012	1,841.8	170.4	172.6	343.0	2,184.8
2013	1,845.5	170.8	172.9	343.7	2,189.2
2014	1,852.2	171.4	173.6	345.0	2,197.2
2015	1,859.6	172.1	174.3	346.3	2,206.0

[157] Lithuanian National Forest Inventory 2003-2007, "*Forest resources and their dynamics*"
[158] Buivydaite, V., Vaicys, M., Juodis., J., Motuzas, A., 2001. Classification of Lithuanian soils. Science and Arts of Lithuania, 139 p.

Soils are classified using Forest soils classification methods, prepared by prof. M. Vaičys[159]. 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 fertility 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 1:5,000,000, 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 6-20.

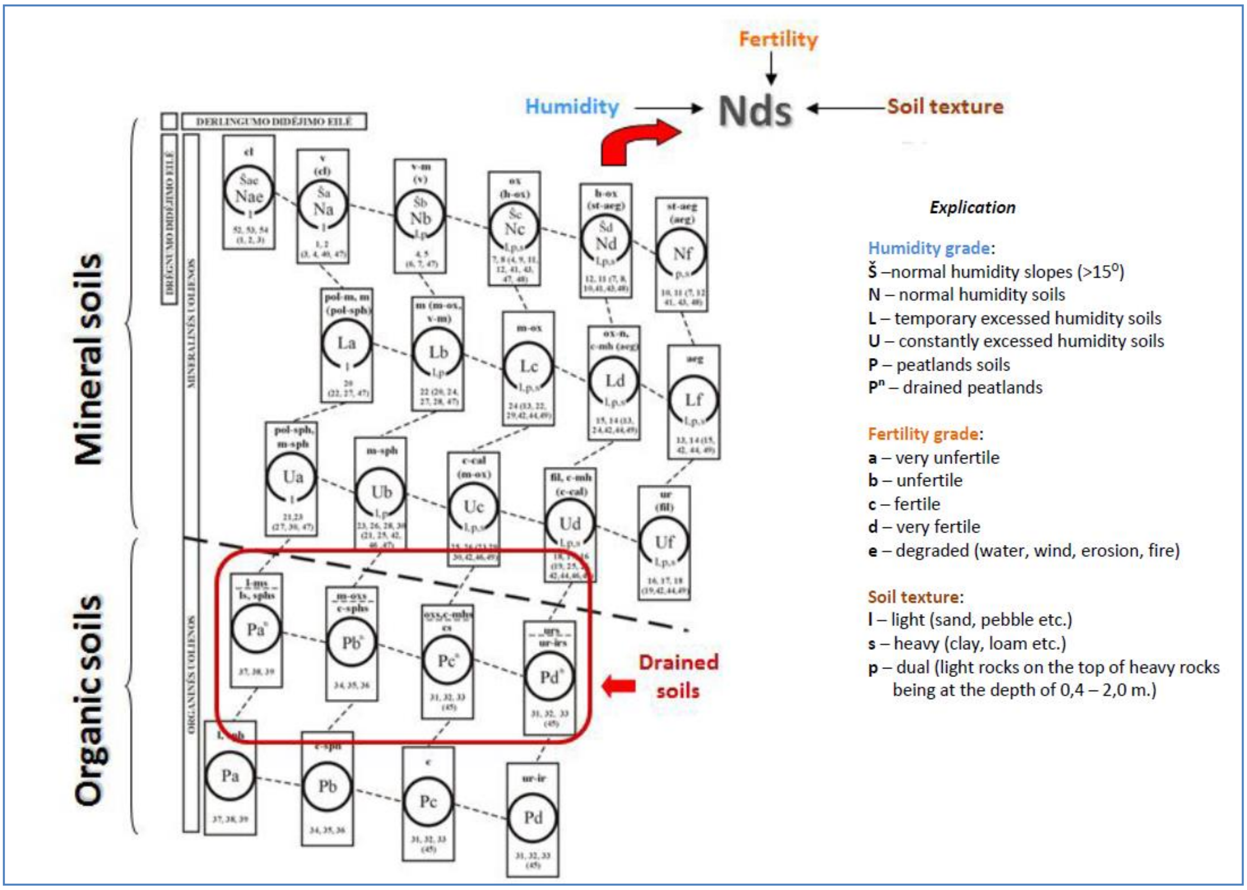

Figure 6-20. Classification of forest soil types

In this GHG inventory Lithuania defines organic soils and distributes it between drained and not 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 *2006 IPCC guidelines*, hence organic soils are identified as soils with peat and peaty soil layer equal to or more than 30 cm of the total thickness. Drained organic soils are defined as soils with peat and peaty soil layer equal to or more than 20 cm of the total thickness.

[159] M.Vaičys *et al.,* 2006. *Miško augaviečių tipai* (en. Forest soil types)

Carbon stock changes in biomass

Carbon stock changes in biomass are accounted separately for living and dead trees, both above-ground and belowground biomass. In order to account for carbon stock changes in biomass, growing stock volume changes are measured during the inventory by sampling method. Due to the fact that holistic National Forest Inventory was launched in 1998, prior growing stock volume data had to be obtained from available historical data sources. In order to gain reliable data, study on forest land changes and growing stock volume data was carried out in 2012.

Living trees volume (growing stock volume) in forest stand areas was estimated corresponding to *Study-1* "Forest Land changes in Lithuania during 1990-2011" and latest *NFI* data. For estimation of changes in growing stock volume, all the inventory years were divided in two time series: 1990-2002 and 2003-2015.

Total growing stock volume in the period of 1990-2001 was estimated using the following data sources: forest land area determined during the *Study-1*, percentage of forests stands area from total forest land area and mean growing stock volume of stands (Table 6-10). Forest stands area from total forest land area varied from 96.5% to 97% depending on the assessment year. This percentage is presenting forest land area without dead stands, clear-cut areas, forest blanks, forest roads, forest block lines, technological and fire-break belts and other small areas related to forest facilities.

Using available data six time points were selected to identify mean growing stock volume in stands: 1988, 1992, 1995, 1997, 1999 and 2000. However, growing stock volume data with known accuracy is available only since 2002, after the first cycle of NFI was finished. Therefore volumes for the unknown years from the period of 1988-2001 were modelled using available data in the mentioned time points. Mean growing stock volume per hectare in stands for 1988 and 1999 was used from the research[160]. Forest stand yield was estimated based on *SFI* data and data on fellings during the period 1922-1999. To demonstrate reliability of *SFI* data during 1958-1999, forest stand yield balance model and data from *SFI* by sampling method in 1969 was applied. Based on earlier mentioned methods mean growing stock volume in 1988 resulted to be 194 m^3/ha, in 1999 - 214 m^3/ha. Data on mean growing stock volume per hectare for 1992 and 1995 was used from Lithuanian forest resources assessment[161]. Mean growing stock volume for 1997 was taken from Lithuanian forest statistics[162]. Data for the year 2000 was obtained from Lithuanian Statistical Yearbook of Forestry[163]. 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[164] for 1988 and 1999 together with *NFI* data for 2002, it was adjusted by 13%.

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160 Kuliešis, A. 2000. *Lietuvos miškų našumo apskaita, reguliavimas ir naudojimas*. *Mokslas ir miškininkystė XXI amžiaus išvakarėse*, p 127-133 [en. *Stand yield inventory, regulation and using in Lithuanian forests*. *Science and forestry on the eve of XXI century*]

161 Valstybinis miškotvarkos institutas. 1993 (1996) *Lietuvos miško ištekliai*. 1993 (1996). [en. Forest Inventory and Management Institute. *Lithuanian Forest resources*]

162 Valstybinis miškotvarkos institutas. 1998. *Lietuvos miškų statistika*. [en. Forest Inventory and Management Institute. *Lithuanian Forest statistics*]

163 Valstybinė miškų tarnyba. *Lietuvos miškų ūkio statistika*. 2009. [en. State Forest Service. *Lithuanian Statistical Yearbook of Forestry*]

164 Kuliešis, A. 2000. *Lietuvos miškų našumo apskaita, reguliavimas ir naudojimas*. *Mokslas ir miškininkystė XXI amžiaus išvakarėse*, p 127-133 [en. *Stand yield inventory, regulation and using in Lithuanian forests*. *Science and forestry on the eve of XXI century*]

Total growing stock volume for the period of 2003-2015 was estimated based on permanent NFI sample plots data. In 2002 Lithuanian *NFI* has finished establishment of permanent sample plots as well as first cycle of forest land inventory and started providing objective annual data on wood resources in Lithuanian forests (Chapter 6.2.1).

Increase in mean annual volume in 2000-2002 has been caused by accumulation of volume in stands due to restricted main use fellings after the spruce dieback in 1999[165].

Table 6-10. Growing stock volume identified according to Study-1, Forest assessment data and results of other researches

Year	Mean volume identified, m^3/ha	Mean annual volume change, m^3/ha	Forest land area, thous. ha.	Percentage of forest stands area, %	Total growing stock volume, thous. m^3
1988	194.0	-	-	-	-
1989	196.4	2.3	-	-	-
1990	198.7	2.3	2,061.4	97.0	397,614.2
1991	201.1	2.3	2,068.6	97.0	403,640.9
1992	203.4	2.3	2,074.6	97.0	409,540.9
1993	205.7	2.3	2,079.7	97.0	415,127.3
1994	207.9	2.3	2,082.5	97.0	420,253.1
1995	210.2	2.3	2,084.9	96.5	423,117.2
1996	209.1	-1.1	2,090.1	96.5	421,889.8
1997	207.9	-1.1	2,093.7	97.0	422,508.5
1998	211.0	3.0	2,097.3	97.0	429,503.3
1999	214.0	3.0	2,100.1	97.0	436,273.0
2000	218.1	4.1	2,105.7	96.5	443,412.2
2001	222.4	4.3	2,108.9	96.5	452,850.6
2002	226.7	4.3	-	-	-

Based on data presented above, total growing stock volume for the period of 1990-2015 was estimated (Table 6-11).

Table 6-11. Total growing stock volume estimated on growing stock volume analysis during 1988-2002 and NFI permanent sample plots data during 2003-2015

Year	Growing stock volume, thous. m^3
1990	397,306.4
1995	422,874.2
2000	443,159.8
2005	467,095.0
2010	494,285.3
2011	503,565.7
2012	511,532.6
2013	521,272.4
2014	528,887.6
2015	537,045.6

[165] Kuliešis, A., Kulbokas, G. 2008. *Dubravos miško medynų pokyčiai nepalankių gamtinių veiksnių poveikio laikotarpiu*. Miškininkystė, Nr. 2(65), p 55-67 [en. *Changes in Dubrava forest stands during the impact of adverse natural factors*]

Main differences in growing stock volume appear to be in the period of 1990-2000, especially in 1996-1999. On the earlier submission total growing stock volume estimations were based mainly on expert assumptions and the rough linear trend. As the one of result of the executed *Study-1*, data on total forest area was presented, which has made an impact on total growing stock volume data as well. Decrease in annual volume change in 1996-1997 (-1,226 and 619 thous. m^3) is the result of spruce dieback, caused by bark beetle *Ips Typographus* which resulted in a huge damages for spruce stands[166]. 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 in all forest land use category (42 thous. m^3).

Table 6-12 presents annual growing stock volume and growing stock volume changes by tree species. The partition of total growing stock volume was made using the data of tree species composition determined during *NFI* permanent sample plots inventory. For the period of 2003-2015 annual *NFI* data was used, and for the period 1990-2002 data was modelled using *NFI* data for 2002, due to the lack of accurate annual statistical data.

This year there were certain changes done in growing stock volume estimation from NFI data. After the finish of Norwegian Partnership project, which was funded by the Norway Grants programme under the "Partnership project on Greenhouse gas inventory" in the framework of the programme LT10 "Capacity-building and institutional cooperation between beneficiary State and Norwegian public institutions, local and regional authorities", interpolation-extrapolation tool was used for more accurate growing stock volume changes representation. As a result of applied interpolation-extrapolation tool, growing stock volume changes in years when NFI measurements were available (2001-2014) were recalculated. Differences between submissions due to the recalculation after interpolation-extrapolation tool was applied are presented in ch. 6.2.6 Category - specific recalculations. Interpolation-extrapolation tool was used for NFI data only – annual change of growing stock volume between each permanent sampling group (remeasured every 5th year) between two remeasurements was calculated using linear interpolation (Figure 6-21). For the estimation of annual growing stock volume change in 2015 linear interpolation for the 1st, 2nd and 3rd sampling groups data was used, linear interpolation with preliminary NFI data of 4th sampling plot group data was used and extrapolation of NFI data of 5th sampling plot group data with adjustment on the basis of growing stock volume change trend was used. Growing stock volume change trend for the 5th sampling group is -0.19 %. For the transition period (2001 and 2002), growing stock volume changes were calculated using both study assessed growing stock volume change and growing stock volume change data assessed from NFI measurements in order to avoid deviations due to different methodology - study and NFI samplings - used.

Differences between growing stock volume change data used for 2017 and 2016 National GHG Inventory Report are presented in Figure 6-22.

[166] Kuliešis, A., Kulbokas, G. 2008. *Dubravos miško medynų pokyčiai nepalankių gamtinių veiksnių poveikio laikotarpiu*. Miškininkystė, Nr. 2(65), p 55-67 [en. *Changes in Dubrava forest stands during the impact of adverse natural factors*]

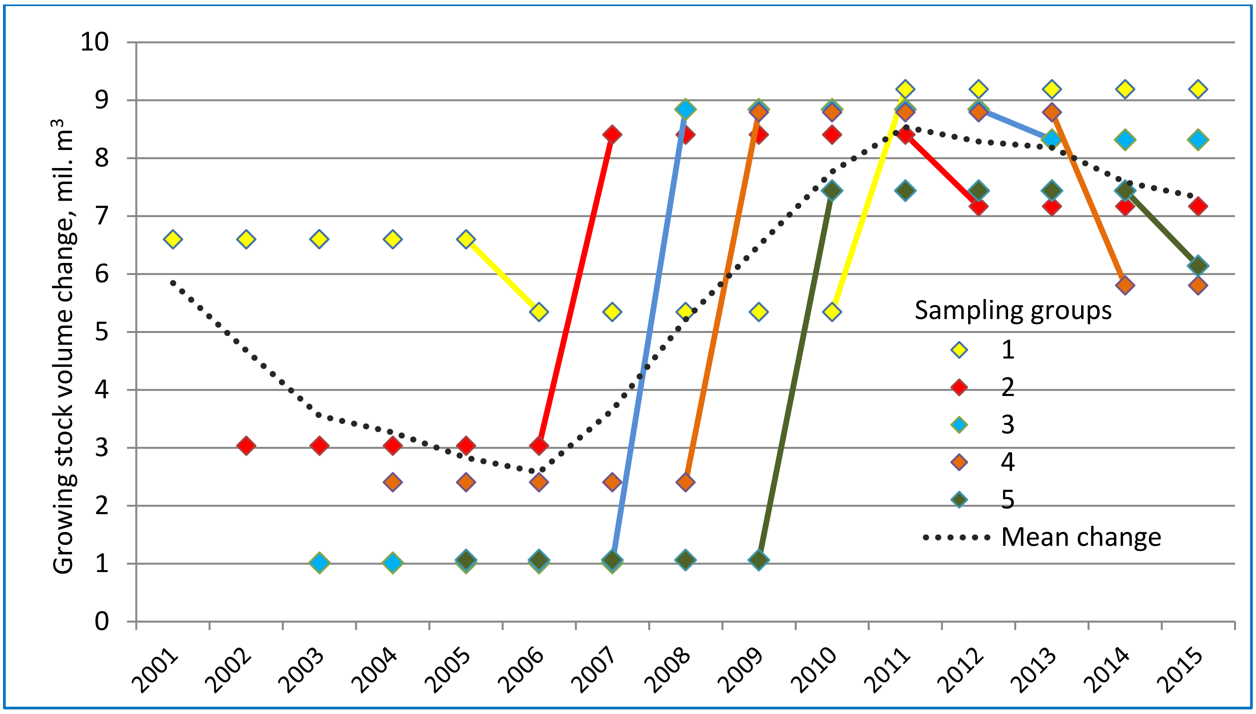


Figure 6-21. Interpolation-extrapolation of growing stock volume changes, mil. m^3

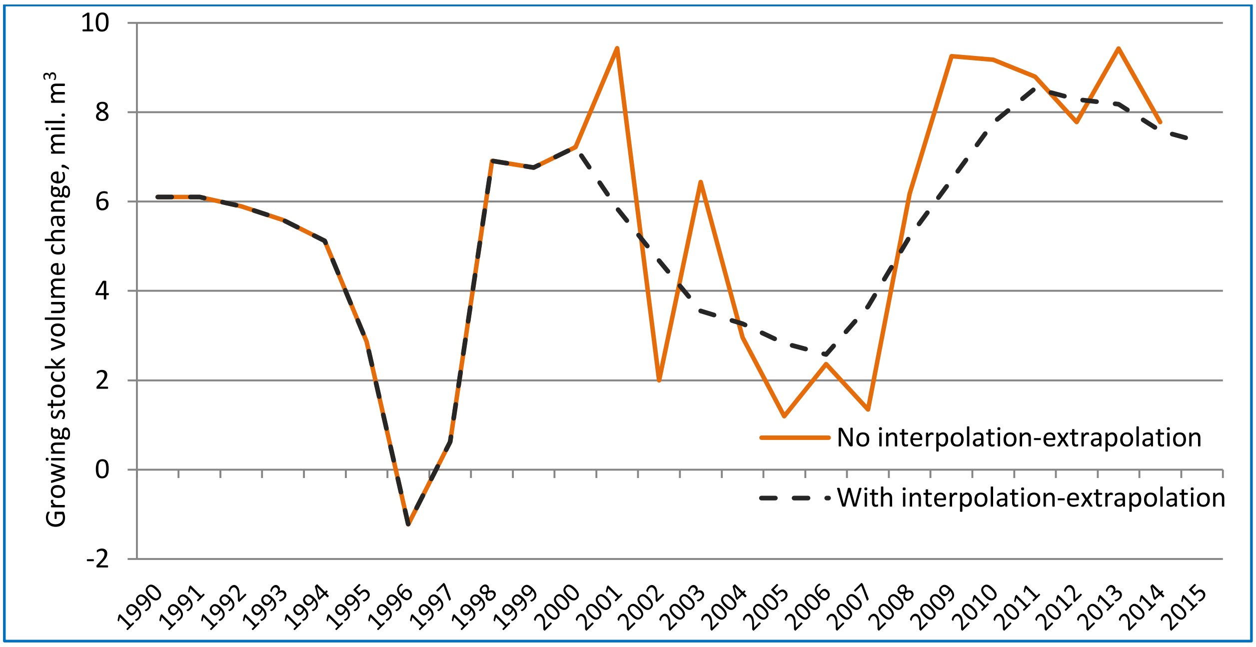


Figure 6-22. Differences in total growing stock volume changes between methods, mil. m^3

Table 6-12. Annual change of growing stock volume, thous. m^3

Year	Growing stock volume			Annual change of growing stock volume		
	Coniferous	Deciduous	Total	Coniferous	Deciduous	Total
1990	224,296.6	173,009.8	397,306.4	3,444.2	2,656.7	6,100.9
1995	238,730.8	184,143.4	422,874.2	1,616.3	1,246.7	2,863.0
2000	250,182.9	192,976.9	443,159.8	4,075.1	3,143.3	7,218.4
2005	264,417.7	202,677.3	467,095.0	4,213.4	999.9	5,213.3
2010	285,687.8	208,597.5	494,285.3	5,264.5	2,917.8	8,182.3

2011	290,992.9	212,572.8	503,565.7	5,205.9	2,378.6	7,584.5
2012	295,457.0	216,075.6	511,532.6	5,090.1	2,235.2	7,325.3
2013	302,116.8	219,155.7	521,272.4	3,527.7	2,317.4	5,845.1
2014	307,301.8	221,585.7	528,887.5	3,135.3	1,543.4	4,678.7
2015	312,393.9	224,651.8	537,045.6	2,688.8	863.2	3,552.0

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[167].

For the period 2003-2015 total standing and lying volume of dead tree stems was estimated using accurate data of *NFI* permanent sample plots. Deciduous and coniferous were separated using *NFI* data of dead tree stems species composition.

The foliage and needles biomass for separate tree species was estimated as a percentage from the total stem volume, using models designed by V. Usolcev. Models were adapted to Lithuanian stands taking into account forest area by dominant tree species (Lithuanian Statistical Yearbook of Forestry, 2011). Computations resulted that needles take 7% from the total stem volume and foliage share is 3% from the total stem volume. Estimated volumes of needles and foliage biomass were not included into total dead tree stems biomass (Table 6-13).

Table 6-13. Total and mean dead tree stems volume changes during 1990-2015, thous. m^3

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	10,740.1	5,139.9	5,600.1	5.2
1995	13,221.2	7,586.2	5,635.0	6.3
2000	12,032.1	6,341.0	5,691.1	5.7
2005	15,155.2	7,374.2	7,812.1	7.1
2010	21,462.2	9,622.3	11,843.4	9.9
2011	22,369.8	10,002.0	12,370.8	10.3
2012	22,803.0	10,093.6	12,709.3	10.4
2013	22,954.7	10,122.2	12,832.5	10.5
2014	23,381.6	10,238.9	13,142.6	10.6
2015	23,036.9	10,278.2	12,758.7	10.4

Volumes of standing and lying dead tree stems in forests were continuously increasing since 1990. The peak was recorded in the period of 1994-1997. This peak could be explained by spruce dieback, caused by the bark beetle *Ips Typographus*, when more than 13,000 thous. m^3 of dead tree stems were accumulated in forests (Table 6-13). Volume of dead tree stems was stabilized only after 1998 for several years. Another steady increase of dead tree stems has started since 2001. There are several reasons for that: storm damages in 2000-2005[168], low number of commercial thinning, endorsed international environmental agreements committing

[167] Kuliešis, A., Kulbokas, G. 2008. *Dubravos miško medynų pokyčiai nepalankių gamtinių veiksnių poveikio laikotarpiu*. Miškininkystė, Nr. 2(65), p 55-67 [en. *Changes in Dubrava forest stands during the impact of adverse natural factors*]
[168] Available from: *http://www.msat.lt/lt/miskai/misku-bukle/vejo-pazeidimai-istorija-ir-prognoze/*

to leave more deadwood in stands to maintain biodiversity (Natura 2000[169], etc.). In 2015 10.4 m^3/ha of merchantable dead tree stems were accumulated in stands to decay, what is actually twice more if comparing with 1990.

Table 6-14. Total dead tree stems volume and their changes during 1990-2015, thous. m^3

Year	Dead tree stems volume			Annual change of dead tree stems volume		
	Coniferous	Deciduous	Total	Coniferous	Deciduous	Total
1990	5,139.9	5,600.1	10,740.1	218.6	19.5	238.1
1995	7,586.2	5,635.0	13,221.2	777.5	-22.7	754.8
2000	6,341.0	5,691.1	12,032.1	-219.6	-14.3	-233.9
2005	7,371.2	7,784.0	15,155.2	303.9	1,027.8	1,331.6
2010	9,622.3	11,839.9	21,462.2	213.5	127.4	341.0
2011	10,002.0	12,367.8	22,369.8	379.7	527.9	907.6
2012	10,093.6	12,706.3	22,803.0	91.6	341.6	433.2
2013	10,122.2	12,832.5	22,954.7	28.6	126.2	154.8
2014	10,238.9	13,142.6	23,381.6	116.7	310.1	426.8
2015	10,278.2	12,758.7	23,036.9	39.3	-383.9	-344.7

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 felling were decreasing to 7.71 mill. m^3 of living trees felled in 1997 and then started to increase again. 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). Over the past years, marginal increase in forest felling is observed (8.67 mill. m^3). Changes in total forest felling (living trees) for the period of 1990-2015 are presented in the Figure 6-23.

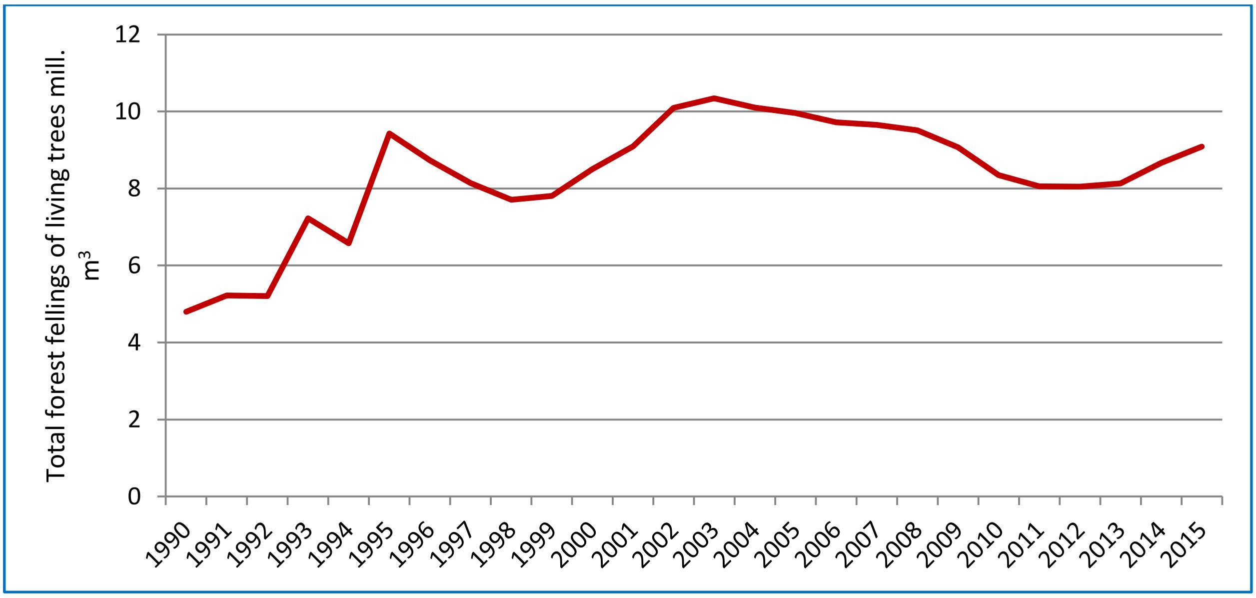


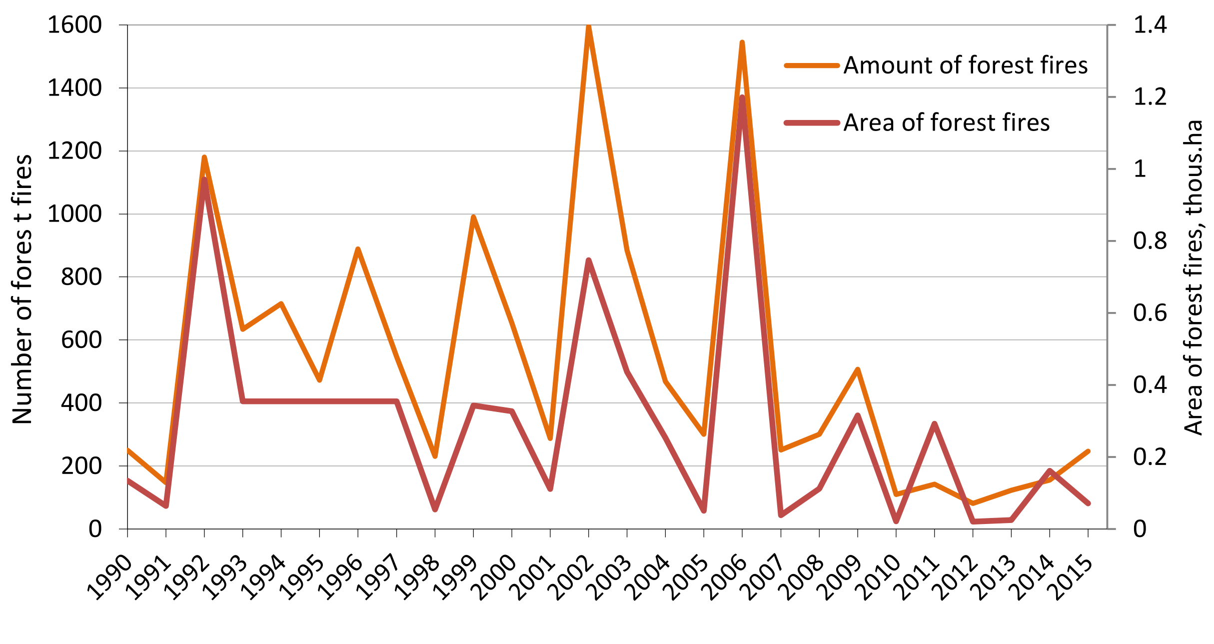
Figure 6-23. Total forest fellings (living trees) in all forests respectful of their ownership, 1990-2015

Biomass burning

[169] Available from: *http://www.natura.org/sites.html*

Data on areas affected by forest fires is provided by the Directorate General of State Forests (*DGSF*). Directorate General of State Forests under the Ministry of Environment performs the functions of a 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. It should be mentioned that all forest fires occurring in Lithuania are considered as forest wildfires as no prescribed burning of forest biomass is used, nor is allowed in Lithuania.

Lithuania is one of the few countries in Europe that has uniform system of state fire prevention measures, comprising monitoring, preventive and fire control measures that are established and maintained in forests irrespective of the forest ownership type. Every forest enterprise presents data on forest fires to the *DGSF* every year, which has the obligation to combine all the data into a single database. The amount of forest wildfires could be seen in Figure 6-24. It could be seen, that in recent years it was possible to reduce not only the number of forest fires but also the area of forest burnt in the event of wildfire, one of the reasons of such results could be the uniform and well-functioning fire prevention system in forests.



Source: Directorate General of State Forests

Figure 6-24. Number of forest fires and area of forest fires in Lithuania during the period 1990-2015

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. All forests in Lithuania are distributed between three fire potentiality classes: I – high potentiality (38% of the total forest area), II – medium potentiality (22% of the total forest area) and III – low potentiality (40% of the total forest area). The distribution of forests according to natural fire potentiality classes is presented in Figure 6-25.

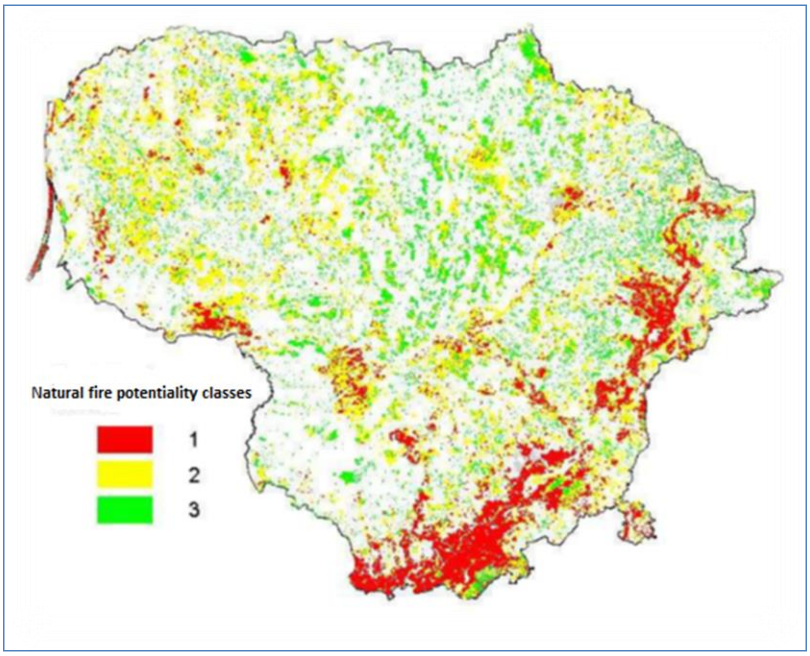


Figure 6-25. Lithuanian forests according to natural fire potentiality classes

Considering natural fire potentiality classes, which all Lithuanian forests are distributed amongst, highest number of forest wildfires also occur due to the higher natural fire potentiality class (Figure 6-26).

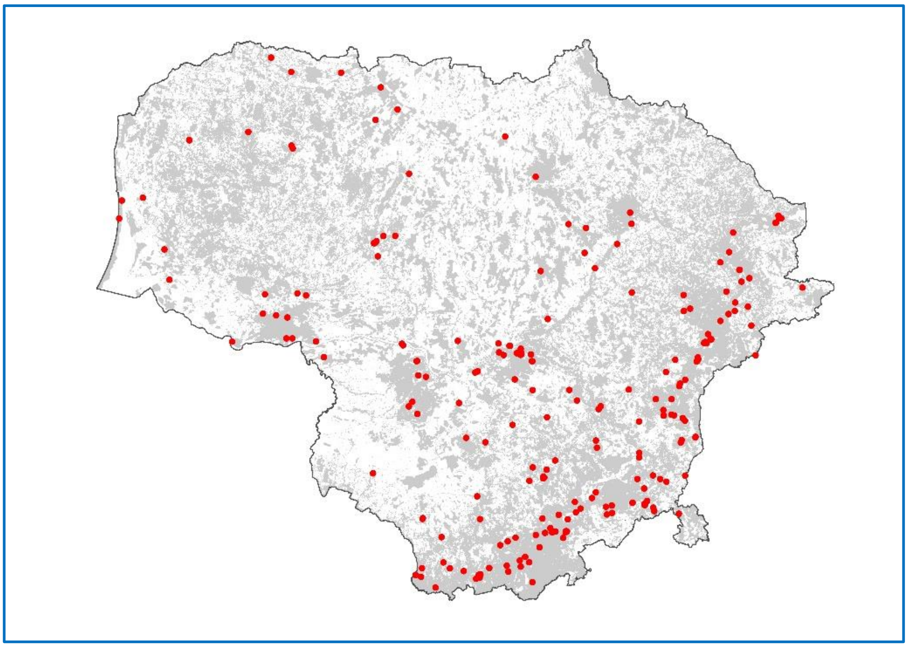


Figure 6-26. Locations of forest fires in 2015

In order to improve the GHG inventory reports under the purpose to report GHG released due to biomass burnt in forest wildfires, a unique fire assessment system has been established in Lithuania since 2013. State Forest Service together with General Directorate of State Forests has worked out a methodology to assess forest fire after-effects in terms of greenhouse gas accounting directly in situ.

Special assessment table (Table 6-15) has been established with detail information on fire. The table contains information which allows locating the event of forest fire, to determine area that was burnt and to assess damage that has been done in terms of greenhouse gases accounting. In the table below only partial information that should be filled in the forest fire assessment table is presented. The first part of this table contains information on owner of forest (State forest enterprise), unique forest fire number, date, forest district, block number, site number and coordinates.

Table 6-15. Example of fire assessment table

Area of forest fire	Type of fire	Burnt biomass (*enter code only*)*					Burnt peat (depth of burnt peat, cm)
		Merchantable wood	Dead-wood	Needles, leaves, shoots	Bark of living trees	Forest litter	

Table 6-16 listed below is presenting percentage of burnt biomass expressed by codes that are used by fire damages assessing experts from State forest enterprises or local forest districts.

Table 6-16. Codes table

Degree of burnt biomass	Intensity	Code
No burnt biomass	0%	0
Low	1-25%	1
Moderate	26-60%	2
Strong	61-99%	3
Completely burnt biomass	100%	4

Volume of burnt biomass from the area affected by forest fire is estimated by overlapping GIS layers of the center coordinate of fire location and data of the total growing stock volume and dead biomass data provided by *SFI;* afterwards burnt biomass is calculated into carbon released due to the wildfire. Burnt peat depth is expressed in centimeters of average burnt peat layer over the fire site and is estimated by persons, assessing forest fire areas. The amount of carbon released from litter and peat layer was calculated using default values of carbon in litter and peat (t/ha) from 2006 IPCC Guidelines (Vol. 4, Ch. 3, Table 3.2.1, p.3.36 and Vol. 4, Ch. 2, Table 2.3, p.2.31). Due to the lack of relevant data on biomass burnt in wildfires in 1990 - 2012, average of 2013 - 2014 mass of fuel available for combustion and combustion factor were used. Due to this evaluation, emissions from forest wildfires could be small, comparing to other years, despite the size of the area wildfire took place. Area of forest wildfires in 2015 was relatively small with much smaller proportion of biomass burnt during the wildfire, comparing to 2014, therefore amount of GHG emissions (CO_2, N_2O, CH_4) released during the forest wildfires was also small, which resulted in smaller IEF (implied emission factor in CRF) for 2015, comparing to the average.

Figure 6-27. Forest stand before and after fire

Windbreaks and windfalls

Statistical Yearbook of Forestry provides data on windbreaks and windfalls. However, according to the data collection principles used by *NFI*, volumes of windbreaks and windfalls are included in volumes of dead trees, or removals by sanitary or other fellings. Therefore, to avoid double counting, windbreaks and windfalls were not included separately 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[170].

Fertilization of forest land with other mineral fertilizers is still not economically efficient due to high prices of fertilizers and unclear benefit on forest growth in our climatic conditions.

6.2.2 Methodological Issues

6.2.2.1 Forest land remaining Forest land

The GHG inventory for Forest land remaining Forest land involves estimations of changes in carbon stock in five carbon pools (above-ground biomass, below-ground biomass, dead wood and litter, and soil organic matter) as well as estimations of non-CO_2 gases from those pools. The algorithm for assessment of carbon stock changes in carbon pools is given below:

$$\Delta C_{LU_i} = \Delta C_{AB} + \Delta C_{BB} + \Delta C_{DW} + \Delta C_{LI} + \Delta C_{SO} + \Delta C_{HWP}$$

ΔC_{LUi} – carbon stock changes for a stratum of a land-use category;
ΔC_{AB} – annual change in carbon stock in above-ground biomass, t C yr^{-1};
ΔC_{BB} – annual change in carbon stock in below-ground biomass, t C yr^{-1};
ΔC_{DW} – annual change in carbon stock in deadwood, t C yr^{-1};
ΔC_{LI} – annual change in carbon stock in litter, t C yr^{-1};
ΔC_{SO} – annual change in carbon stock in soil, t C yr^{-1};

170 Ozolinčius R., Armolaitis K., Mikšys V., Varnagirytė-Kabašinskienė I. 2010. *Recommendations for compensating wood ash fertilization* (2nd revised edition)

ΔC_{HWP} – annual change in carbon stock in harvested wood products, t C yr^{-1}.

Carbon stock changes in living biomass

Living biomass pool in 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 *2006 IPCC Guidelines*, 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[171]:

$$\Delta C_{LB} = \frac{(C_{t_2} - C_{t_1})}{(t_2 - t_1)} \quad \text{and} \quad C = (\Delta AGB + \Delta BGB) \cdot CF \quad (\textit{modified eq. 2.8})$$

where:
ΔC_{LB} – annual change in carbon stock in living biomass (includes above- and belowground biomass) in total forest land, t C yr^{-1};
C_{t2} – total carbon in biomass calculated at time t_2, t C;
C_{t1} – total carbon in biomass calculated at time t_1, t C;
ΔAGB – above-ground biomass change, t d. m.;
ΔBGB – below-ground biomass change, t d. m.;
CF – carbon fraction of dry matter (broadleaves – 0.48; coniferous – 0.51), t C (tonne d. m.)$^{-1}$.[172]

Annual growing stock volume (GSV) changes starting with 2003 for category Forest land remaining forest land was estimated based on *NFI* data using the following steps:

1. Annual GSV changes in all forest areas (total forest management and afforested/reforested area) are estimated using sampling method. This estimation is based on the change in GSV on the same area (re-measured permanent sample plots data $V_{rem_{t2}} - V_{rem_{t1}}$) and adding GSV increment (ΔV_{new}) of the first measurement of permanent sample plots i.e. new afforested areas or other plots which have no re-measurement data;
2. Annual GSV changes of afforested/reforested areas are estimated combining wall-to-wall and sampling methods. Area estimation is based on assessment by wall-to-wall method and mean GSV changes assessment is done using results from sampling method; average annual GSV changes are derived using relationship between mean GSV and age of forest in permanent plots of afforested/reforested areas (Figure 11-14);
3. Estimation of annual GSV change in Forest Management area is based on the difference between all forests annual GSV changes (*step 1*) and annual GSV change of afforested/reforested areas (*step 2*).

The equations presenting calculations on growing stock volume change in Forest land remaining Forest land are shown below:

$$\Delta FF_t = \left(\left(V_{rem_{t2}} - V_{rem_{t1}}\right) + \Delta V_{new}\right) - \Delta F_2$$

where:
ΔFF_t – growing stock volume change for Forest land remaining Forest land for the defined year, m^3;

[171] *2006 IPCC Guidelines for National Greenhouse Gas Inventories. Vol. 4, Ch. 2, eq. 2.8, p. 2.12*
[172] *2006 IPCC Guidelines for National Greenhouse Gas Inventories. Vol. 4, Ch. 4, Table 4.3, p. 4.48*

V_{remt1} – growing stock volume calculated at time t_1, m^3;
V_{remt2} – growing stock volume calculated at time t_2, m^3;
ΔV_{new} – growing stock volume change of the new measured sample plots, m^3;
ΔF_2 – growing stock volume change of new forest areas, m^3.

Above-ground biomass

Above ground biomass refers to all living biomass above the soil including stem, stump, bark, branches, seeds and foliage. Calculation of above-ground biomass is based on volume of living trees stems with bark, basic wood density and biomass expansion factor. However, *2006 IPCC* guidelines requires to use biomass conversion and expansion factor (BCEF), which is based on country specific data, but while Lithuania has no country specific values we are using previous methodology with default values to estimate above and below ground biomass. Above-ground biomass is calculated by employing slightly modified eq. 2.8, (p. 2.12) of *2006 IPCC*:

$$\Delta AGB = (\Delta GS) \cdot WD \cdot BEF$$

where:
ΔAGB – above-ground biomass change, t d. m.;
ΔGS – change of tree stems volume with bark, m^3;
WD – basic wood density, t d. m. m^{-3};
BEF – biomass expansion factor.

Basic wood density (WD) was estimated on the basis of data provided in Table 4.14 of the *2006 IPCC Guidelines* (p. 4.71). Density values for coniferous and deciduous were calculated using species values as weighted average values related to GSV (Table 6-17).

Above ground biomass was calculated for broadleaves and coniferous separately. For the period of 2003-2015 growing stock volume data of *NFI* was used, and for the period of 1990-2002 mean value for the known time period was used.

Table 6-17. Total growing stock volume (NFI, 2015) and average basic wood density values

Species	**Total growing stock volume (mill m^3).**	**Basic wood density, tonnes d. m. m^{-3}**	
		By species	**Weighted average**
Pine	221.0	0.42	
Spruce	91.2	0.40	
Total coniferous	**312.0**		**0.41**
Birch	88.7	0.51	
Aspen	37.6	0.35	
Black alder	52.3	0.45	
Grey alder	22.3	0.45	
Oak	11.8	0.58	
Ash	3.2	0.57	
Total deciduous	**215.9**		**0.47**
Overall total	**527.9**		**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[173]). 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 *2006 IPCC Guidelines* in Table 4.5 (p. 4.50), what shows the consistency between the chosen methods.

Below-ground biomass

Below-ground biomass refers to all living biomass, which is live roots. Below-ground biomass is calculated by using modified eq. 2.8 (p. 2.12) of the *2006 IPCC* guidelines which requires data for above-ground biomass and root-to-shoot ratio. Default values of root-to-shoot ratios R were estimated using data of Usolcev and Table 4.4 (*2006 IPCC*, p. 4.49): for coniferous – 0.26; for deciduous – 0.19:

$$\Delta BGB = \Delta AGB \cdot R$$

where:
ΔBGB – below-ground biomass change, t d. m.;
ΔAGB – above-ground biomass change, t d. m.;
R – root-to-shoot ratio, dimensionless.

Carbon fraction of dry matter

Carbon fraction (CF) value of above ground forest biomass for broadleaves forest equal to 0.48 tonne C (tonne d. m.)$^{-1}$ and 0.51 tonne C (tonne d. m.)$^{-1}$ for coniferous, provided in the *2006 IPCC Guidelines* (Table 4.3, p. 4.48), was used for estimation of CF in dry biomass matter.

Carbon stock change in dead organic matter

For the greenhouse gas inventory Lithuania defines dead organic matter (DOM) as it is described in *2006 IPCC Guidelines* (Ch. 4.2.2), which provides two types of dead organic matter pools: dead wood and litter.

Lithuania assumes that there are no changes in carbon stocks in litter in forest land remaining forest land, assuming that the amount of litter after the conversion period in forest remains stable with insignificant changes. Therefore notation key „NO“ is used in the CRF.

Annual change in carbon stocks in dead organic matter in Forest Land remaining Forest Land is calculated following the summarizing equation for calculation of changes in dead organic matter carbon pools which is equal to the sum of carbons stock in dead wood (measured available dead wood) and carbon stock in dead wood that is left on site after fellings (BGB). Dead wood that is left on site after fellings is assumed to be below-ground biomass which is roots. It is assumed that BGB decays in equal parts in 5 years. Modified eq. 2.17 (p. 2.21) of *2006 IPCC Guidelines* has been used to calculate carbon stock change in dead organic matter:

$$\Delta C_{DOM} = \Delta C_{DW} + \Delta C_{DWH}$$

where:
ΔC_{DOM} – annual change in carbon stocks in dead organic matter, t C yr^{-1};
ΔC_{DW} – change in carbon stocks in dead wood (measured dead stems), t C yr^{-1};
ΔC_{DWH} – change in carbon stocks in dead wood (BGB left on site after fellings), t C yr^{-1}.

[173] Усольцев В.А. 2001. *Фитомасса лесов Северной Евразии. База данных и география*. 707с., Екатеринбург. Усольцев В.А. 2002. *Фитомасса лесов Северной Евразии. Нормативы и элементы географии*. 762с. Екатеринбург. Усольцев В.А. 2003. *Фитомасса лесов Северной Евразии. Предельная продуктивность и география*. 405 с., Екатеринбург.

Annual change of biomass of dead trees stems is calculated by using stock change method and employing equation 2.19 (p. 2.23) of *2006 IPCC Guidelines*:

$$\Delta C_{FF_{DW}} = \left[\frac{A \cdot \left(B_{t_2} - B_{t_1}\right)}{T}\right] \cdot CF$$

where:
ΔC_{FFDW} – annual change in carbon stocks in dead wood in forest land remaining forest land, t C yr^{-1};
A – area of managed forest land remaining forest land, ha;
B_{t1} – dead wood stock at time t_1 for managed forest land remaining forest land, t d. m. ha^{-1};
B_{t2} – dead wood stock at time t_2 (the second time) for managed forest land remaining forest land, t d. m. ha^{-1};
T (= t_2 - t_1) – time period between time of the second stock estimate and the first stock estimate, yr.;
CF – carbon fraction in dry biomass matter (broadleaves – 0.48; coniferous – 0.51), tonnes C $(\text{tonne d. m.})^{-1}$ (*2006 IPCC Guidelines*, Table 4.3, p. 4.48).

$$\Delta C_{FF_{DW}} = \frac{\Delta B}{T} \cdot CF$$

where:
ΔC_{FFDW} – annual change in carbon stocks in dead wood in forest land remaining forest land, t C yr^{-1};
ΔB – dead wood stock change for managed forest land remaining forest land, t d. m. ha^{-1};
T (= t_2 – t_1) – time period between time of the second stock estimate and the first stock estimate, yr.;
CF – carbon fraction in dry biomass matter (broadleaves – 0.48; coniferous – 0.51), tonnes C (tonne d. m.)-1 (*2006 IPCC Guidelines*, Table 4.3, p. 4.48).

$$\Delta B = B_{t_2} - B_{t_1}$$

where:
ΔB – dead wood stock change for managed forest land remaining forest land, t d. m. ha^{-1};
B_{t1} – dead wood stock at time t_1 for managed forest land remaining forest land, t d. m. ha^{-1};
B_{t2} – dead wood stock at time t_2 (the second time) for managed forest land remaining forest land, t d. m. ha^{-1}.

$$B_t = AGB + BGB$$

where:
AGB – above-ground biomass, t d. m.;
BGB – below-ground biomass, t d. m.

$$AGB = V_{dw} \cdot WD \cdot BEF$$

where:
V_{dw} – available dead wood volume, m^3;
WD – basic wood density, t d. m. m^{-3};
BEF – biomass expansion factor.

$$BGB = AGB \cdot R$$

where:
AGB – above-ground biomass, t d. m.;
R – root-to-shoot ratio, dimensionless.

Carbon stock change in soil organic matter

Lithuania reports carbon stock changes in soil organic matter occurring due to the drainage of organic forest soils. Carbon stock change in drained organic forest soils was calculated using equation 2.26 (p. 2.35 of *2006 IPCC Guidelines*):

$$\Delta C_{FOS} = A_{Drainage} \cdot EF_{Drainage}$$

where:
ΔC_{FOS} – CO_2 emissions from drained organic forest soils, t C yr^{-1};
$A_{Drainage}$ – area of drained organic forest soils, ha;
$EF_{Drainage}$ – emission factor for CO_2 from drained organic forest soils, t C ha^{-1} yr^{-1}.

Default value of emission factor for drained organic soils in managed forests provided in Table 4.6 (p. 4.53 of *2006 IPCC Guidelines*) was used in calculations. Default $EF_{Drainage}$ for temperate forests is 0.68 tonnes C ha^{-1} yr^{-1}.

Non-CO_2 emissions from drainage of forest soils

For estimation of non-CO_2 emissions from drained forest soils Lithuania uses default *Tier 1* method. *Tier 1* eq. 11.1 (p. 11.7 of *2006 IPCC, which is equal to equation 2.26 p.2.35 of 2006 IPCC Guidelines*) is applied with a simple disaggregation of drained forest soils into *nutrient rich* and *nutrient poor* areas and default emission factors are used.

$$N_2O_{emissions_{FF}} = \sum((A_{FF_{organic\,IJK}} \cdot EF_{FF_{drainage,\ organic\,IJK}}) + (A_{FF_{mineral}} \cdot EF_{FF_{drainage,\ mineral}})) \cdot \frac{44}{28} \cdot 10^{-6}$$

where:
N_2O emissions $_{FF}$ – emission of N_2O in units of nitrogen, kg N;
$A_{FF_{organic}}$ – area of drained forest organic soils, ha;
$A_{FF_{mineral}}$ – area of drained forest mineral soils, ha;
$EF_{FF_{drainage,\ organic}}$ – emission factor for drained forest organic soils, kg N_2O-N ha^{-1} yr^{-1};
$EF_{FF\ drainage,\ mineral}$ – emission factor for drained forest mineral soils, kg N_2O-N ha^{-1} yr^{-1};
IJK – soil type, climate zone, intensity of drainage, etc. (depends on the level of disaggregation).

NFI provides data on forest land distribution by forest soils (Table 6-9). According to *NFI*[174] 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 is using default emission factors from *2006 IPCC Guidelines* (Table 11.1, p. 11.11, Ch. 11.2 of *2006 IPCC Guidelines*) for N_2O emission estimation due to the drainage of organic soils:

$EF_{FF_{drainage,\ organic}}$ for nutrient rich forest soils - 0.6 kg N_2O-N ha^{-1} yr^{-1}

$EF_{FF_{drainage,\ organic}}$ for nutrient poor forest soils - 0.6 kg N_2O-N ha^{-1} yr^{-1}

[174] Lithuanian National Forest Inventory 2003 – 2007. Forest resources and their dynamics

However, currently due to the lack of data and sufficient knowledge to provide default equations for *Tier 1* method of other non-CO_2 greenhouse gases emission, only N_2O emissions are accounted.

Lithuania has no data on drained mineral forest soils (no drainage of mineral soils occurred in forest land), therefore emissions or removals from drained mineral forest soils are not estimated. In the emissions and removals estimation of drained organic forest soils areas of land converted to forest land are also included.

Biomass Burning

There is no prescribed biomass burning in Lithuania therefore only the events of forest wildfires are reported. Data on areas affected by forest fires on areas under the category Forest land remaining Forest land is provided by the *DGSF*. However, data on wildfires on lands converted to Forest land is not so accurate, therefore Lithuania, following recommendations made by ERT 2012, subdivides the total forest area burnt on the basis of the proportional contribution of each category to the total forest land area.

Carbon release from burnt biomass was calculated using eq. 2.27 (p. 2.42 of *2006 IPCC*):

$$L_{fire} = A \cdot M_B \cdot C_f \cdot G_{ef} \cdot 10^{-3}$$

where:
L_{fire} – quantity of GHG released due to fire, t of GHG;
A – area burnt, ha;
M_B – mass of 'available' fuel, tonnes ha^{-1};
C_f – combustion factor (or fraction of biomass combusted), dimensionless;
G_{ef} – emission factor, g (kg d. m.)$^{-1}$.

M_B value of 71 t/ha for 1990-2012 has been used, being estimated annually afterwards due to findings resulting from national forest fire assessment project: 88.2 t/ha for 2013, 69.30 t/ha for 2014 and 80.80 t/ha for 2015. C_f equals to 0.64 for 1990-2012 period and has been estimated annually afterwards: 0.2 for 2013, 0.73 for 2014 and 0.29 for 2015.

Average values of emission factor G_{ef} for CO_2, N_2O and CH_4 gases were calculated based on the values presented in the Table 2.5 (p. 2.47 of the *2006 IPCC Guidelines*) and are equal to:

CO_2 – 1,569 g (kg d. m.)$^{-1}$;
CH_4 – 4.7 g (kg d. m.)$^{-1}$;
N_2O – 0.26 (kg d. m.)$^{-1}$.

6.2.2.2 Land converted to Forest land

Land use area calculations of Land converted to Forest land are further described in chapter 6.2.1. The total area of land converted to Forest land between 1990 and 2015 were computed by using sample plots data of *NFI*.

The land-use categories from which areas have been converted to Forest land are the following: Croplands, Grasslands, Wetlands, Settlements and Other land.

Yearly land transition matrixes of conversions from one land use category to Forest land were created based on year of the conversion and the category converted. Annual land transition matrix for conversion of Croplands to Forest land is presented in the table below.

Table 6-18. Yearly land transition matrix for Croplands converted to Forest Land

Years after conversion	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
1	NO	NO	399.4	798.8	399.4	1,997.1	1,997.1	798.8	1,997.1	**798.8**
2	NO	NO	399.4	399.4	NO	399.4	1,997.1	1,997.1	798.8	**1,997.1**
3	NO	**1,198.2**	NO	798.8	1,597.7	NO	399.4	1,997.1	1,997.1	**798.8**
4	**399.4**	399.4	798.8	NO	2,795.9	1,597.7	NO	399.4	1,997.1	**1,997.1**
5	NO	399.4	399.4	798.8	798.8	2,795.9	1,597.7	NO	399.4	**1,997.1**
6	NO	NO	NO	399.4	798.8	798.8	2,795.9	1,597.7	NO	**399.4**
7	NO	NO	NO	399.4	399.4	798.8	798.8	2,795.9	1,597.7	**NO**
8	NO	NO	**1,198.2**	NO	798.8	399.4	798.8	798.8	2,795.9	**1,597.7**
9	NO	**399.4**	399.4	798.8	NO	798.8	399.4	798.8	798.8	**2,795.9**
10	NO	NO	399.4	399.4	798.8	NO	798.8	399.4	798.8	**798.8**
11	NO	NO	NO	NO	399.4	798.8	NO	798.8	399.4	**798.8**
12	NO	NO	NO	NO	399.4	399.4	798.8	NO	798.8	**399.4**
13	NO	NO	NO	**1,198.2**	NO	399.4	399.4	798.8	NO	**798.8**
14	NO	NO	**399.4**	399.4	798.8	NO	399.4	399.4	798.8	**NO**
15	NO	NO	NO	399.4	399.4	798.8	NO	399.4	399.4	**798.8**
16	NO	NO	NO	NO	NO	399.4	798.8	NO	399.4	**399.4**
17	NO	NO	NO	NO	NO	NO	399.4	798.8	NO	**399.4**
18	NO	NO	NO	NO	**1,198.2**	NO	NO	399.4	798.8	**NO**
19	NO	NO	NO	**399.4**	399.4	**1,198.2**	NO	NO	399.4	**798.8**
20	NO	NO	NO	NO	399.4	399.4	**1,198.2**	NO	NO	**399.4**
	399.4	2,396.5	4,393.5	7,189.4	12,381.8	13,979.4	15,577.1	15,177.7	17,174.8	**17,794.0**

Carbon stock changes in living biomass

For the estimation of carbon stock changes in living biomass, growing stock volume of Lands converted to Forest land was estimated using data of *NFI* permanent sample plots on mean growing stock volume of non-forest Lands converted to Forest land according to the year of conversion (Figure 6-28). 2nd order polynomial trend was used to come up with mean growing stock volume and mean growing stock volume increment of lands converted to Forest land. It should be noted, that according to definition of forest in Lithuania, stands are becoming forest when reaching certain requirements for forest (e.g. age), therefore mean growing stock volume for lands converted to forest at year 1 are not equal to zero, because it is more likely that these stands will contain growing stock volume accumulated in stands for 10 or more years (presumed time-frame for reaching certain requirements for forest) (Table 6-19).

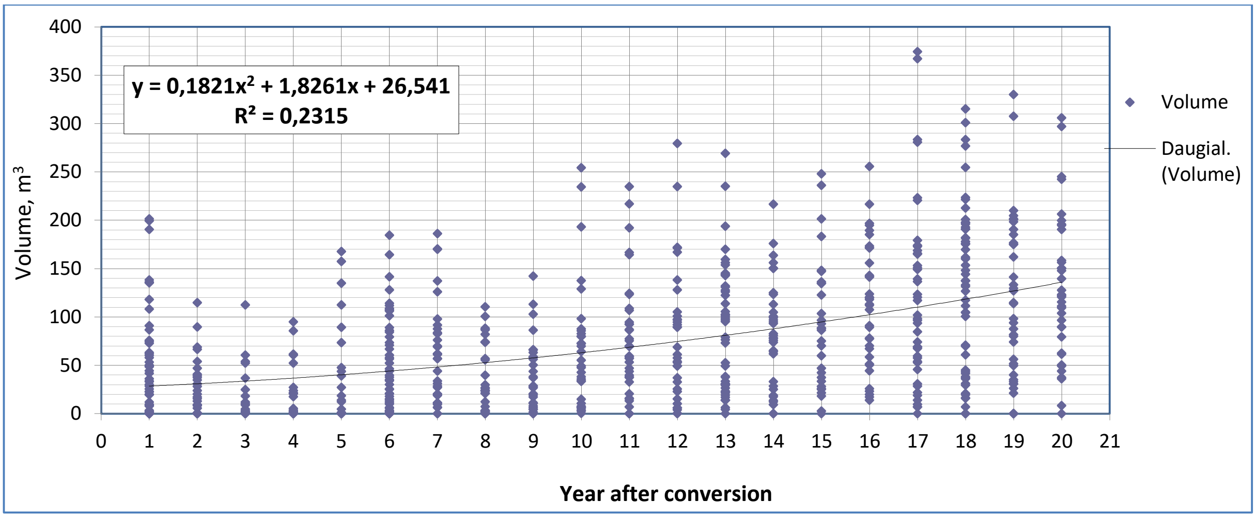


Figure 6-28. NFI data on growing stock volume of non-forest lands converted to forest land at the year of conversion to Forest land

Table 6-19. Mean GSV and GSV increment based on NFI data on lands converted to Forest land at the year of conversion

Year after conversion	Mean growing stock volume, m³/ha	Growing stock volume change, m³/ha
1	28.5	2.0
2	30.9	2.4
3	33.7	2.7
4	36.8	3.1
5	40.2	3.5
6	44.1	3.8
7	48.2	4.2
8	52.8	4.6
9	57.7	4.9
10	63.0	5.3
11	68.7	5.7
12	74.7	6.0
13	81.1	6.4
14	87.8	6.7
15	94.9	7.1
16	102.4	7.5

17	110.2	7.8
18	118.4	8.2
19	127.0	8.6
20	135.9	8.9

GSV change for land converted to Forest land was estimated by using equation presented below:

$$\Delta V = \sum \left(A_i \cdot (V_{t_2} - V_{t_1}) \right)$$

where:
ΔV – GSV change on land converted to Forest land, m^3;
A_i – area according to land use category, ha;
V_{t1} – GSV at time t_1, m^3;
V_{t2} – GSV at time t_2, m^3.

Annual change in carbon stocks in living biomass in land converted to Forest land was calculated by using eq. 2.15 (p. 2.20 of *2006 IPCC Guidelines*):

$$\Delta C_B = \Delta C_G + \Delta C_{Conversion} - \Delta C_L$$

where:
ΔC_B – annual change in carbon stocks in living biomass in land converted to forest land, tonnes C yr^{-1};
ΔC_G – annual increase in carbon stocks in living biomass due to growth in land converted to forest land, tonnes C yr^{-1};
$\Delta C_{Conversion}$ – annual change in carbon stocks in living biomass due to actual conversion to forest land, tonnes C yr^{-1};
ΔC_L – annual decrease in carbon stocks in living biomass due to losses from harvesting, fuel wood gathering and disturbances in land converted to forest land, tonnes C yr^{-1}.

Annual change in carbon stocks in living biomass due to actual conversion to forest land was calculated employing equation 2.16 (p. 2.20 of *2006 IPCC Guidelines*):

$$\Delta C_{Conversion} = \sum_i \left\{ \left[B_{After_i} - B_{Before_i} \right] \cdot \Delta A_{To\ forest_i} \right\} \cdot CF$$

where:
$\Delta C_{Conversion}$ – change in carbon stocks in living biomass in land annually converted to forest land, tonnes C yr^{-1};
$B_{Before\,i}$ – biomass stocks on land type *i* immediately before conversion, tonnes d. m. ha^{-1};
$B_{After\,i}$ – biomass stocks that are on land immediately after conversion of land type *i*, tonnes d. m. ha^{-1} (in other words, the initial biomass stock after artificial or natural regeneration);
$\Delta A_{To\ forest\,i}$ – area of land-use i annually converted to forest land, ha yr^{-1};
CF – carbon fraction of dry matter (broadleaves – 0.48; coniferous – 0.51), tonnes C (tonne d. m.)$^{-1}$ (Table 4.3, p. 4.48 of *2006 IPCC Guidelines*);
i – represent different types of land converted to forest.

B_{After} value was modelled by using Figure 6-28.

Above-ground biomass

Above ground biomass refers to all living biomass above the soil including stem, stump, bark, branches, seeds and foliage. Calculation of above-ground biomass is based on volume of living trees stems with bark, basic wood density and biomass expansion factor. However, *2006 IPCC Guidelines* requires to use biomass conversion and expansion factor (BCEF), which is based on country specific data, but while Lithuania has no country specific values we are using previous methodology to estimate above and below ground biomass. Above-ground biomass is calculated by employing slightly modified eqv. 2.8, (p. 2.12 of *2006 IPCC Guidelines*):

$$\Delta AGB = (\Delta GS) \cdot WD \cdot BEF$$

where:
ΔAGB – above-ground biomass change, t d. m.;
ΔGS – change of tree stems volume with bark, m^3;
WD – basic wood density, t d. m. m^{-3};
BEF – biomass expansion factor.

Basic wood density (WD) was estimated on the basis of data provided in Table 4.14 (p. 4.71 of *2006 IPCC Guidelines*). Density values for coniferous and deciduous were calculated as weighted average values related to growing stock volume (Table 6-20).

Above ground biomass was calculated for broadleaves and coniferous separately. For the period of 2003-2015 data of *NFI* was used, and for the period of 1990-2002 mean value for the known time period was used.

Table 6-20. Total growing stock volume and average basic wood density values

Species	Total growing stock volume (mill m^3). Average 2002-2009	Basic wood density, tonnes d. m. m^{-3}	
		By species	Weighted average
Pine	190.6	0.42	
Spruce	76.4	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[175]). Rate of BEF for coniferous was estimated to be 1.221 and 1.178 for deciduous. The rates of BEF estimated for Lithuania are very close to the rates presented in Table 34.5 (p. 4.50 of *2006 IPCC Guidelines*), what is showing the consistency between the chosen methods.

Below-ground biomass

[175] Усольцев В.А. 2001. *Фитомасса лесов Северной Евразии.База данных и география*. 707с., Екатеринбург. Усольцев В.А. 2002. *Фитомасса лесов Северной Евразии. Нормативы и элементы географии*. 762с. Екатеринбург.

Below ground biomass refers to all living biomass of live roots. Below-ground biomass is calculated by using modified eq. 2.8 (p. 2.12 of *2006 IPCC Guidelines*) which requires data for above-ground biomass and root-to-shoot ratio. Default values of root-to-shoot ratios R were estimated using data of Usolcev and Table 4.4 (p. 4.49 of *2006 IPCC*): for coniferous – 0.26, for deciduous – 0.19.

$$\Delta BGB = \Delta AGB \cdot R$$

where:
ΔBGB – below-ground biomass change, t d. m.;
ΔAGB – above-ground biomass change, t d. m.;
R – root-to-shoot ratio, dimensionless.

Carbon fraction of dry matter

Default value of 0.5 tonne C (tonne d. m.)$^{-1}$ provided in *2006 IPCC Guidelines* (Table 4.3, p. 4.48) was used for estimation of carbon fraction (CF) in dry biomass matter.

Change in carbon stock in dead organic matter

It was assumed that carbon stock in litter in land converted to Forest land accumulates in 20 years period and then it remains stable. The average value of carbon stock in litter is 24 t per ha per 20 years (after the conversion period finishes carbon stock in litter remains the same – 24 t per ha per yr for all subsequent years). This value was accepted for Forest land, using values for cold temperate dry and moist region from Table 2.2 (p. 2.27 of *2006 IPCC Guidelines*). 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, accumulated dead organic matter equals to the amount of dead wood used for biomass use, decayed, etc., therefore no carbon stock changes in dead organic matter in Land converted to Forest land are reported. After the conversion period dead organic matter starts to accumulate and carbon stock changes in dead organic matter is reported in Forest Land remaining Forest Land (after land is converted to permanent forest land).

Change in carbon stock in soil organic matter

NFI provides data on forest land distribution by forest soils (Table 6-9). According to *NFI*[176] data, area of mineral soils amounts to 84.3% and area of organic soils – 15.7% of the total forest area. Drained organic forest soils constitute to 7.9% of the total forest land. Due to the lack of accurate data on drained organic soils in land converted to Forest land, it was assumed that the same proportion of drained organic soils as it is accepted for Forest land remaining Forest land category refers also to lands converted to Forest land.

Carbon stock change in drained organic forest soils was calculated using eq. 2.26 (p. 2.35 of *2006 IPCC Guidelines*):

$$\Delta C_{FOS} = A_{Drainage} \cdot EF_{Drainage}$$

where:

[176] Lithuanian National Forest Inventory 2003 – 2007. Forest resources and their dynamics

ΔC_{FOS} – CO_2 emissions from drained organic forest soils, t C yr^{-1};
$A_{Drainage}$ – area of drained organic forest soils, ha;
$EF_{Drainage}$ – emission factor for CO_2 from drained organic forest soils, t C ha^{-1} yr^{-1}.

Default value of emission factor for drained organic soils in managed forests provided in Table 4.6 (p. 4.53 of *2006 IPCC Guidelines*) was used in calculations. Default $EF_{Drainage}$ for temperate forests is 0.68 tonnes C ha^{-1} yr^{-1}.

Data on areas affected by forest fires on areas under the category Forest land remaining Forest land is provided by the *DGSF*. However, data on wildfires on lands converted to Forest land is not so accurate, therefore Lithuania, following recommendations made by ERT 2012, subdivides the forest area burned on the basis of the proportional contribution of each category to the total forest land area.

Carbon release from burnt biomass on lands converted to Forest land was calculated using the same methodology as it was used for Forest land remaining Forest land and employing equation 2.27 (p. 2.42 of *2006 IPCC Guidelines*):

$$L_{fire} = A \cdot M_B \cdot C_f \cdot G_{ef} \cdot 10^{-3}$$

where:
L_{fire} – quantity of GHG released due to fire, t of GHG;
A – area burnt, ha;
M_B – mass of 'available' fuel, tonnes. ha^{-1};
C_f – combustion factor (or fraction of biomass combusted), dimensionless;
G_{ef} – emission factor, g (kg d. m.)$^{-1}$.

M_B value of 71 t/ha for 1990-2012 has been used, 88.2 t/ha for 2013, 69.30 t/ha for 2014 and 80.80 t/ha for 2015 considering results presented from the national forest fire assessment Project.

C_f equals to 0.64 for 1990-2012 period, 0.2 for 2013, 0.73 for 2014 and 0.29 for 2015.Average values of emission factor G_{ef} for CO_2, N_2O and CH_4 gases were calculated based on the values presented in the Table 2.5 (p. 2.47 of *2006 IPCC Guidelines*) and are equal to:

CO_2 – 1,569 g (kg d. m.)$^{-1}$;
CH_4 – 4.7 g (kg d. m.)$^{-1}$;
N_2O – 0.26 g (kg d. m.)$^{-1}$.

Non-CO_2 emissions from drainage of forest soils

Non-CO_2 emissions from drainage of lands converted to forest land were included into calculations of non-CO_2 emissions of Forest land remaining Forest land.

6.2.3 Quantitative overview of carbon emissions/removals from the sector

The total area of forest land, Forest Land remaining Forest Land, and area of Land converted to Forest Land are provided in the Table 6-21 below.

Table 6-21. Forest land area changes (cumulative) during the period 1990-2015, 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	2,061.4	1,959.5	0.4	66.3	34.0	NO	1.2	101.9
1995	2,084.9	1,975.9	2.4	69.9	34.4	0.8	1.6	109.0
2000	2,105.7	2,002.3	4.4	64.7	31.2	0.8	2.4	103.4
2005	2,134.9	2,025.4	7.2	71.9	26.8	1.2	2.4	109.4
2010	2,166.4	2,058.2	12.4	72.3	20.4	1.2	2.0	108.2
2011	2,173.2	2,065.4	14.0	73.1	18.0	0.8	2.0	107.8
2012	2,184.8	2,071.4	15.6	78.7	16.8	0.8	1.6	113.5
2013	2,189.2	2,076.5	15.2	78.3	16.8	0.8	1.6	112.6
2014	2,197.2	2,079.7	17.2	79.5	18.8	0.4	1.6	117.4
2015	2,206.0	2,082.1	18.0	85.1	18.8	0.4	1.6	123.8

Carbon stock change in living biomass

Area and growing stock volume in Forest Land remaining Forest Land was increasing annually since 1990 to 2015 except 1996 when total growing stock volume resulted in losses comparing to previous years due to spruce dieback (Table 6-22). Annual change in area converted to Forest land was ranging from 0 ha change in the period 1996-1997 to the highest decrease of 4.0 thous. ha in the periods 2008-2009 and 2009-2010 (Table 6-21). The changes of growing stock volume are also related to area changes in Land converted to Forest Land.

Table 6-22. Annual change in growing stock volume in Forest Land remaining Forest Land and Land converted to Forest Land categories

Year	Forest land remaining forest land			Land converted to forest land (≤ 20 years stands)			Total, thous. m^3
	Coniferous thous. m^3	Deciduous, thous. m^3	Total, thous. m^3	Coniferous thous. m^3	Deciduous, thous. m^3	Total, thous. m^3	
1990	223,337.4	167,462.0	390,799.4	959.2	5,547.7	6,506.9	397,306.3
1995	237,596.2	177,581.5	415,177.7	1,134.6	6,562.0	7,696.6	422,874.3
2000	249,053.9	186,447.3	435,501.2	1,129.0	6,529.6	7,658.6	443,159.8
2005	263,191.3	195,811.7	459,003.0	1,226.4	6,865.6	8,092.0	467,095.0
2010	284,695.7	202,232.2	486,927.9	992.1	6,365.3	7,357.4	494,285.3
2011	290,293.9	206,163.3	496,457.2	699.0	6,409.5	7,108.5	503,565.7
2012	294,736.9	209,639.2	504,376.1	720.1	6,436.4	7,156.5	511,532.6
2013	301,383.0	212,765.3	514,148.3	733.8	6,390.3	7,124.1	521,272.4
2014	306,381.0	215,020.6	521,401.6	920.8	6,565.2	7,486.0	528,887.6
2015	311,383.9	217,646.0	529,030.0	1,010.0	7,005.7	8,015.7	537,045.6

The total living biomass was fluctuating in Forest land remaining Forest Land from -881.8 thous. t d. m. (1996) up to 5,104.64 thous. t d. m. (2011) during the period of 1990-2015. Living biomass losses of 881.4 thous. t d. m. were inventoried in 1996, caused by huge areas of spruce dieback. The mean value of annual carbon stock change is about 1,568.52 kt. The largest living biomass decrease for Land converted to Forest land was observed in 1999-2003 and 2008-

2009. This is related to decrease in area of Lands converted to Forest Land category. The carbon stock change values are varying between 159.8 and 197.4 kt per year (Table 6-23).

Table 6-23. Annual carbon stock change due to living biomass change in Forest Land (emissions – negative sign, removals – positive sign)

Year	Forest land remaining forest land				Land converted to forest land (≤ 20 years stands)				Total Carbon stock change, kt
	Above-ground biomass stock change, kt d. m.	Below-ground biomass stock change, kt d. m.	Total living biomass stock change, kt d. m.	Carbon stock change, kt	Above-ground biomass stock change, kt d. m.	Below-ground biomass stock change, kt d. m.	Total living biomass stock change, kt d. m.	Carbon stock change, kt	
1990	2,977.61	684.38	3,662.0	1,821.82	275.13	54.88	330.01	159.81	1,981.63
1995	1,378.18	317.34	1,695.52	843.82	323.51	64.53	388.04	187.91	1,031.72
2000	4,061.68	917.18	4,978.86	2,468.40	319.12	63.65	382.77	185.36	2,653.77
2005	1,094.37	296.77	1,391.14	715.72	330.64	66.04	396.68	192.14	907.86
2010	3,715.94	885.97	4,601.91	2,306.09	306.97	60.98	367.95	178.05	2,484.13
2011	4,125.32	979.32	5,104.64	2,555.80	300.51	58.99	359.50	173.58	2,729.38
2012	3,992.08	949.10	4,941.18	2,474.69	304.21	59.76	363.97	175.76	2,650.45
2013	3,945.75	932.16	4,877.91	2,439.93	305.18	60.00	365.18	176.37	2,616.30
2014	3,603.51	864.58	4,468.09	2,241.83	319.56	63.23	382.80	185.1	2,426.93
2015	3,445.36	830.24	4,275.60	2,147.12	340.33	67.41	407.74	197.2	2,344.32

Carbon stock change in dead organic matter

Dead wood is inventoried for Forest Land remaining Forest Land, as it is assumed that before the end of conversion period (Land converted to forest land category) dead wood accumulation is insignificant and therefore reported as NO. Dead wood pool not only includes dead trees biomass (above and below-ground), but also below-ground biomass which has left on site during forest fellings (stumps and roots of felled trees). Above-ground biomass of dead wood which is available during forest fellings is assumed to be removed.

Table 6-24 provides values of stock change in biomass and carbon stock change in dead wood. The data represents tendency of annual accumulation of dead wood in forest land since 1990 to 2015.

Table 6-24. Annual carbon stock change in Forest Land remaining Forest Land due to change in dead organic matter

Year	Dead wood				Dead wood from forest fellings		Total carbon stock change in dead organic matter, kt
	Above-ground biomass stock change, kt d. m.	Below-ground biomass stock change, kt d. m.	Total biomass stock change, kt d. m.	Carbon stock change, kt	Below-ground biomass stock change, kt d. m	Carbon stock change, kt	
1990	113.53	28.78	142.30	72.20	114.52	57.08	129.28
1995	354.00	92.90	446.90	228.36	432.06	215.37	443.73
2000	-111.20	-28.37	-139.57	-70.91	17.42	8.68	-62.22
2005	497.22	107.46	604.68	297.26	39.81	19.87	317.13
2010	450.16	97.99	548.15	269.84	-145.75	-72.48	197.36
2011	279.18	62.49	341.67	169.10	-142.53	-70.96	98.14
2012	228.45	51.52	279.97	138.77	-104.54	-52.08	86.69
2013	157.66	36.67	194.33	96.91	-56.52	-28.10	68.81
2014	67.69	19.25	86.94	45.18	40.97	32.63	77.81
2015	32.15	10.11	42.26	22.44	109.06	54.00	76.44

Dead wood biomass changes as well as carbon stock in dead wood biomass changes depend on the rate of felling in each year, therefore total carbon stock changes vary from -134.94 kt C to 442.14 kt C. 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.

Carbon stock change in soil

Data on organic soils is presented by *NFI*, which is assessing soil type during inventory process by using Forest soils classification methodology prepared by prof. M. Vaičys. For more detailed information see chapter 6.2.1. Due to the results of Biosoil project, it is assumed that carbon stock changes in mineral soils in forest land remaining forest land are minor and insignificant, thus carbon stock changes in mineral soils in forest land remaining forest are not accounted. Whereas, carbon stock changes in organic soils in categories forest land remaining forest land and land converted to forest land occur due to the drainage, as a result emissions from organic soils in forest land category are reported. Carbon stock changes in mineral soils in land converted to forests land are not reported due to the lack of sufficient and reliable data on initial carbon stocks and C stock after the conversion for reliable calculations of carbon stock gains or losses in soil. Lithuania is planning to apply country-specific carbon stock change estimates in mineral soils in land converted to forest land from other land uses in the next submission due to the project on carbon stock changes estimation in different land uses, funded by the Norway Grants programme under the "Partnership project on Greenhouse gas inventory" in the framework of the programme LT10.

Table 6-25. Annual carbon loss in Forest land remaining Forest land and land converted to Forest land from drained organic soils

Year	Forest land remaining Forest land	Land converted to Forest land						Total area of drained organic soils, thous. ha	Total emissions, kt CO_2
		Area of drained organic soils , thous. ha							
	Area of drained organic soils, thous. ha	Cropland	Grassland	Wetlands	Settlements	Other land	Total		
1990	154.8	0.03	5.2	2.7	NO	0.09	8.02	162.8	406.04
1995	156.1	0.19	5.5	2.7	0.06	0.13	8.58	164.7	410.68
2000	158.2	0.35	5.1	2.5	0.06	0.19	8.21	166.4	414.77
2005	160.0	0.57	5.7	2.1	0.09	0.19	8.65	168.7	420.51
2010	162.6	0.98	5.7	1.6	0.09	0.16	8.53	171.1	426.73
2011	163.2	1.10	5.8	1.4	0.06	0.16	8.52	171.7	428.06
2012	163.6	1.23	6.2	1.3	0.06	0.13	8.92	172.5	430.35
2013	164.0	1.20	6.2	1.3	0.06	0.13	8.89	172.9	431.21
2014	164.3	1.36	6.3	1.5	0.03	0.13	9.32	173.6	432.78
2015	164.5	1.42	6.7	1.5	0.03	0.13	9.78	174.3	434.52

Carbon stock changes due to biomass burning

There is no prescribed burning in Lithuania, thus only emissions from forest wildfires are reported. The default mean burned biomass values per hectare, established after the forest fire assessment, conducted by State Forest Service together with Directorate General of State Forests, were used. Carbon emissions are related with burned area (Table 6-26). The largest carbon emissions were observed in 1992 (29.9 kt CO_2) and in 2006 (36.9 kt CO_2). This is the result of repetitive draughts (1992, 1994, 2002, 2006)[177] and irresponsible human behaviour

[177] Lithuanian Hydrometeorological Service. Available from: *www.meteo.lt*

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. In order to avoid double reporting, it is assumed that emissions from burnt biomass (living or previously living trees) were included either in reporting of changes of living biomass or dead wood (reported as IE), therefore only carbon stock losses in litter and organic soils (peat layer) are reported.

Table 6-26. Annual carbon stock change due to litter and organic soils burning in forest land

Year	Area burned, ha	Emissions, kt CO_2
1990	134.0	4.50
1995	355.0	11.92
2000	327.1	10.98
2005	50.8	1.71
2010	21.5	0.72
2011	292.8	9.83
2012	20.25	0.68
2013	24.70	0.58
2014	161.5	5.67
2015	70.9	1.78

6.2.4 Uncertainty assessment

Lithuanian reporting system is mostly based on sampling method therefore national methodology was employed while estimating overall uncertainty.

Information obtained during *NFI* is based on the data of especially small sampling area 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 8,000 trees. Several indices are important characterizing statistical information, namely, data accuracy and validity. Data accuracy depends on the variation of parameters of the measured object, sampling volume and measurement accuracy. Measurement accuracy may be increased by applying advanced measuring devices, more precise (often even more time saving) 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 3,000 ha forest area error in the whole country. However, forest land identified in a satellite image map failed to comply with the reality. According to ground *NFI* estimation even in 9.8% of cases, i.e. so many times forest land was not detected in nature. And on the contrary, by ground method additionally 6.6% of plots on forest land were identified, which were not recognized in the satellite image. Thus, the assessment of forest land according to satellite images is of a comparatively low accuracy and in this phase it was eliminated.

Total forest land area according to yearly measurements of plots or according to the data of plots measured over a certain number of years is estimated by using the following equations:

$$Q_m = Q \cdot p_m \quad \text{or} \quad Q_m = K_m \cdot q_R; \quad Q_m = \frac{p_m \cdot q_R}{500}$$

where:
Q – total area of Lithuanian territory (6,530,000 ha);
Q_m – forest land area, ha;
p_m – part of forest land area.

Part of forest land area is calculated using the following equation:

$$p_m = \frac{K_m}{K}$$

where:
K_m – sum of plots or their parts on forest land, ascertained during inventory;
K – total number of plots in Lithuania.

Number of sample plots is estimated:

$$K = \frac{Q}{q_R}$$

where:
Q – total area of Lithuanian territory;
q_R – area, represented by one sample plot (399.41 ha).

The error of forest land assessment is estimated:

$$P_{Q_m} = \sqrt{\frac{1 - p_m}{(K-1)p_m}} \cdot 100$$

where:
p_m – part of forest land area;.
K – total number of plots in Lithuania.

Estimation accuracy of different stand parameters depends on the variation of estimated parameter (expressed by variation coefficient $V_{\%}$) in the 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 *2006 IPCC Guidelines*, which is also known as simple error propagation method.

To estimate uncertainty of a product of several quantities eq. 3.1 (p. 3.28 of *2006 IPCC*) 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 *2006* IPCC was used (eq. 3.2, p. 3.28):

$$U_E = \frac{\sqrt{(U_E \cdot E_1)^2 + (U_2 \cdot E_2)^2 + \cdots (U_n \cdot E_n)^2}}{|E_1 + E_2 + \cdots E_n|}$$

where:
U_E – percentage uncertainty of the sum;
U_i – percentage uncertainty associated with source/sink I;
E_i – emission/removal estimate for source/sink i.

The growing stock volume per 1 ha of all Lithuanian forests, based on permanent and temporary sample plots, was estimated with 0.9% accuracy. The lowest standard error (1.3%) was estimated for pine stands (dominant tree species in Lithuania) and the highest (5.1%) for ash and oak stands (lowest prevalence). To be consistent with *2003 IPCC* uncertainties should be reported as a confidence interval giving the range within which the underlying value of an uncertain quantity is through to lie for a specific probability. 95% confidence interval is used by Lithuania in uncertainty estimations.

For Forest Land remaining Forest Land it was assumed that uncertainty of area is 2.3%. Uncertainties of emission factor were estimated using *Tier 1* error propagation method described in eq. 3.2 (*2006 IPCC Guidelines*). For Forest Land remaining Forest land uncertainty of emission factor was assumed to be about 31.1%.

For Land converted to Forest Land it was assumed that uncertainty of area is 12.2%. Uncertainty of emission factor was assumed to be about 38.4%.

Table 6-27. Uncertainty values

Indicator	**Land Use Category**	**Unit**	**Uncertainty, %**
Growing stock	Forest Land remaining Forest land	m^3	2.6

Indicator	Land Use Category	Unit	Uncertainty, %
volume	Land converted to Forest Land	m^3	12.8
Area	Forest Land remaining Forest land	ha	2.3
	Land converted to Forest Land	ha	11.8
Emission factor	Forest Land remaining Forest land	kt CO_2	35.5
	Land converted to Forest Land	kt CO_2	35.2

6.2.5 Category-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.

NFI department is managed by 15 well educated, experienced employees who are periodically trained and examined, participate in international workshops, seminars etc. 6 persons are responsible for collection of data on forest land and 4 persons on non-forest land, 2 employees are responsible for LULUCF and KP LULUCF data analysis, provision of methodological guidance and preparation of GHG reports, 2 persons are responsible for independent internal check assessments - inventory control group.

QA/QC for data collection, data processing issues, preparation of reporting tables achieved by State Forest Service, elaborated control routines of executed LULUCF activities are ensured with the help of procedures established by Environmental Protection Agency. Every GHG emissions and removals submission is presented to scientific-advisory board, where chosen methods, activity data, emission factors and other parameters are discussed and approved.

The following procedures were carried out to ensure QC/QA procedures described in *2006 IPCC* (Ch. 4.4.3, p. 4.44):

- periodical trainings of field crews and individual training of new staff;
- data consistency and completeness control – carried out during measurements by field crews while entering data, and during processing of data after field works;
- independent internal check assessments – carried out on 5% of measured sample plots by *NFI* Control team;
- independent external check assessments and judgements 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 *2006 IPCC Guidelines*. Additional QA procedure covered subcategories of direct N_2O emissions estimation and estimation of GHG emissions released during forest fires (wildfires). Issues were clarified after QA procedure performed by Norwegian LULUCF GHG inventory experts under the "Partnership project on Greenhouse gas inventory" in the framework of the programme LT10.

6.2.6 Category-specific recalculation

Recalculation of GHG emissions/removals in forest land occurred due to the newly applied interpolation-extrapolation tool for annual growing stock volume change estimation in forest land remaining forest land between NFI sampling plot remeasurements. Annual growing stock volume change was recalculated for NFI growing stock volume data only (2001 – 2014 inventory years), annual growing stock volume change obtained from national studies (1990 – 2000 inventory years) was not affected. Due to the recalculation of annual growing stock volume change, not only volume of living trees, but also dead organic matter amount on forest land remaining forest land was affected. Reported in previous submission and recalculated carbon stock changes are presented in the tables below.

Table 6-28. Reported in previous submission and recalculated carbon stock change in living trees in forest land remaining forest land subcategory, kt C

Year	2016 submission	2017 submission	Absolute difference	Relative difference, %
2001	2,988.41	1,681.32	-1,307.09	-43.74
2002	656.45	1,312.18	655.73	99.89
2003	1,880.35	956.72	-923.63	-49.12
2004	759.30	859.66	100.36	13.22
2005	187.40	715.72	528.32	281.92
2006	568.02	636.68	68.66	12.09
2007	246.93	977.82	730.89	296.00
2008	1,776.63	1,474.22	-302.41	-17.02
2009	2,778.57	1,903.14	-875.43	-31.51
2010	2,764.02	2,306.09	-457.93	-16.57
2011	2,636.07	2,555.80	-80.27	-3.05
2012	2,308.34	2,474.69	166.35	7.21
2013	2,841.90	2,439.93	-401.97	-14.14
2014	2,303.90	2,241.83	-62.07	-2.69

Table 6-29. Reported in previous submission and recalculated carbon stock change in dead organic matter in forest land remaining forest land subcategory, kt C

Year	2016 submission	2017 submission	Absolute difference	Relative difference,%
2001	60.29	57.34	-2.95	-4.89
2002	250.67	225.34	-25.33	-10.10
2003	190.80	267.29	76.49	40.09
2004	367.50	308.78	-58.72	-15.98
2005	429.17	317.14	-112.03	-26.10
2006	501.85	442.14	-59.71	-11.90
2007	449.86	424.27	-25.59	-5.69
2008	528.66	360.27	-168.39	-31.85
2009	248.16	296.33	48.17	19.41
2010	31.51	197.35	165.84	526.31
2011	206.95	98.14	-108.81	-52.58
2012	80.15	86.68	6.53	8.15
2013	19.53	68.81	49.28	252.33
2014	163.72	77.80	-85.92	-52.48

6.2.7 Category-specific planned improvements

In 2017 Lithuania is planning to apply the results of several studies performed to improve GHG report through using national instead of *2006 IPCC Guidelines* default values. It is expected to develop and apply national values for carbon stocks in soil and forest litter in forest land and non-forest land, estimate carbon stock changes in soil after the afforestation/reforestation of non-forest land, carbon stocks in dead-wood in different decay phases as well as to form consistent and sufficient historical harvested wood products database together with data collection system.

6.3 Cropland (CRF 4.B)

Historically Lithuania is treated as an agricultural country with high proportion of agricultural lands among other land use types – according to State Land Fund agricultural lands (croplands, grasslands) covered approximately 70% of country territory in 1991 and more than 50% in 2015. Solely cropland covers more 45% of total country area in recent years (2012-2015). Furthermore, it was established that since 2004 agricultural lands in use are constantly increasing approximately 24 thous. ha per year, whereas abandoned agricultural land areas are decreasing[178]. After the collapse of Soviet Union in 1990, cropland area has been gradually decreasing from to 2,426.0 thous. ha to 1,835.30 thous. ha in 2005, thereafter it again gradually started to increase, usually substituting grassland areas (Figure 6-27) and only in 2015 the total area of cropland slightly decreased, comparing to the 2014. Substitution of grassland with cropland areas has a negative impact if concerning greenhouse gases – organic carbon stocks in soils are decreasing, resulting in increased CO_2 and direct N_2O emissions from mineral soils. However, in order to balance the processes Lithuania has adopted Rural development programme for 2014 -2020[179], with the aim to support not only cropland, but also grassland management.

The area of cropland comprises of the area under arable crops as well as commercial orchards and berry plantations. According to the national definition – arable land is continuously managed or temporary unmanaged land, used and suitable to use for cultivation of agricultural crops, also fallows, cold frames and plastic cover greenhouses, strawberry and raspberry plantations, areas for production of flowers and decorative plants. Arable land set aside for one or several years (<5 years) before being cultivated again as part of an annual crop-pasture rotation is still included under cropland. Orchards and berry plantations are areas planted with fruit trees and fruit bushes (apple-trees, pear-trees, plum-trees, cherry-trees, currants, gooseberry, quince and others). Under this category only those orchards and berry plantations are included that are planted on other than household purpose land and mainly used for commercial purposes. Orchards and berry plantations planted in small size household areas and only used for householders' needs are included under Settlements category. All croplands are considered as managed lands in Lithuania. Several carbon stocks are considered as the most important for GHG accounting, those include biomass of woody cropland - perennial orchard plantations mainly - and organic carbon accumulated in soils - both mineral and organic.

The total net emissions from cropland had tendency to decrease since 1990 in Lithuania (Figure 6-27). In 1990 net emissions from cropland were 5,645.98 kt CO_2 eqv. Thus, in 2005 had

[178] Bykoviene, A., Pupka, D., Alenkavicius, A., 2014. Analysis of agricultural land area registration and its changes in Lithuania. Agricultural science, T.21, Nr.4, p. 250-264.

[179] Lithuanian Rural Development Programme for 201 -2020, 2015. Approved by European Commission Decision No.C(2015)842. Available from: https://www.nma.lt/index.php/parama/lietuvos-kaimo-pletros-20142020-m-programa/apie-programa/4911

decreased more than twice (emissions reached 2,467.68 kt CO_2 eqv.). However, net emissions started to increase again after 2005 (turning point between cropland conversion to grassland and grassland conversion to cropland) and reached 4,388.67 kt CO_2 eqv. in 2015. Changes in CO_2 emissions from cropland could by large extent be explained by changes in land conversion trends, when increased conversion to cropland leads to higher emissions from category resulting from carbon loss due to loss of biomass and soil organic carbon stock disturbance, whereas decreased conversions result in decreased emissions as well.

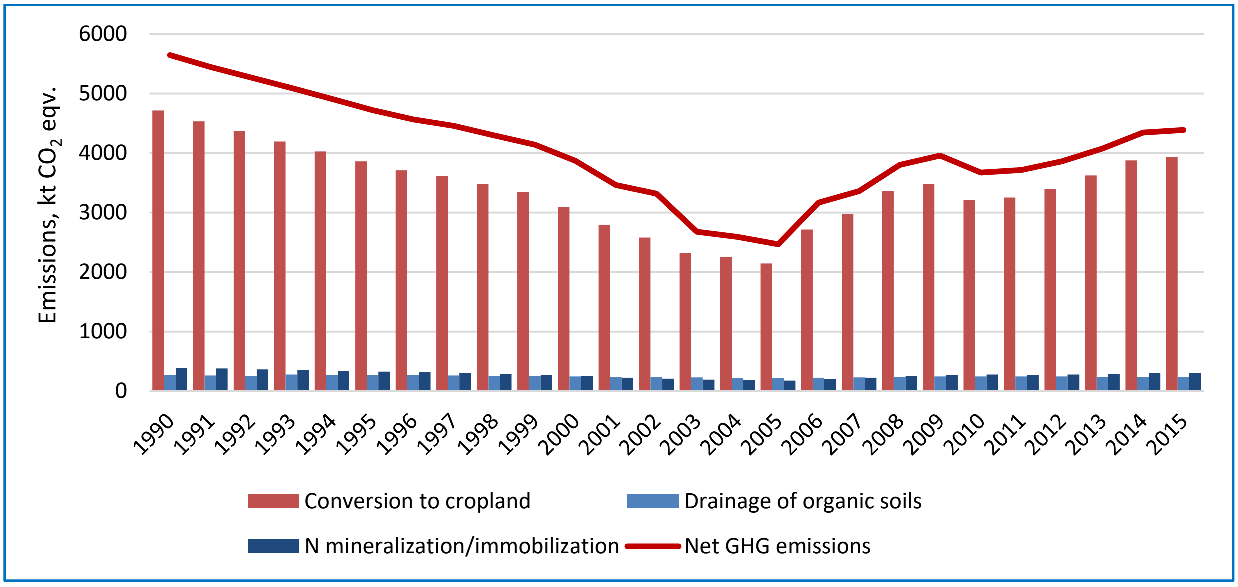


Figure 6-29. Greenhouse gas emissions in cropland, kt CO_2 eqv.

Mainly grassland conversion to cropland has been increasing the net CO_2 emissions (Table 6-29). CO_2 emitted in grassland converted to cropland have ranged from 2,177.08 to 4,713.87 kt CO_2 eqv. during the years with highest scale in conversions among grassland and cropland and in 2015 CO_2 emissions have again reached almost 4,000 kt CO_2 eqv. There was only one conversion from wetlands to settlements in the reporting period, therefore CO_2 emissions due to the loss of biomass are reported in 1993 only; emissions from drainage of organic soils in wetlands converted to cropland were reported in CRF Table 4(II). However, small areas of settlements and other land converted to cropland has induced the CO_2 accumulation. Higher amounts of accumulated CO_2 have recorded in the period of 1994-2000. Thus, in 2015 the conversion was minor and amount of CO_2 accumulated reached only 3.98 ktCO_2 eqv. In both settlements and other land converted to cropland, being 4 times lower comparing with the periods of more intensive conversions.

Table 6-30. Emissions and removals from land converted to cropland, kt CO_2 equivalent

Year	Land conversion to cropland			
	Grassland	Wetlands	Settlements	Other
1990	4,713.87	NO	NO	NO
1995	3,914.25	NO,IE	-15.93	-39.82
2000	3,143.80	NO,IE	-15.93	-35.84
2005	2,177.08	NO,IE	-11.95	-23.89
2010	3,254.32	NO,IE	-15.93	-23.89
2011	3,282.37	NO,IE	-7.96	-23.89
2012	3,418.37	NO,IE	-7.97	-15.93

2013	3,633.80	NO	-3.98	-7.97
2014	3,886.81	NO	-3.98	-7.97
2015	3,936.38	NO	-3.98	-3.98

6.3.1 Source category description

Two source categories are accounted under this category: emissions from Cropland remaining Cropland and emissions from Land converted to Cropland. Carbon stocks, which are included in calculations of emissions and removals due to carbon stock losses and gains, are presented in the table below.

Table 6-31. Reported carbon stocks under Cropland land use category

Land Use Category	**Carbon stock change in biomass**	**Carbon stock change in dead organic matter**	**Changes in soil C stocks**	
			Mineral soils	**Organic soils**
Cropland remaining Cropland (CC)	√	NO	√	√
Land converted to Cropland (LC)	√	NO	√	√

Due to the lack of sufficient and reliable scientific data on dead wood and litter accumulation in orchards, Lithuania selected to use *Tier 1* method with the assumption that dead wood and litter are not present or are at equilibrium in agroforestry (which is not present in Lithuania) and orchards. Due to substantial soil disturbance with full inversion there is assumed that no litter accumulation occur in annual crop fields.

Information on data sources used for activity data collection are presented in Table 6-32.

Table 6-32. Information on data sources used for estimation of cropland area

Sources used	**Source data used**
Soviet kolkhozzes' land use plans	1990
Orthophoto maps	NLF: 1995-1998; 2005, 2009, 2010
Land areas and croplands declarations database	2010-2011
National Forest Inventory database	2012 and beyond

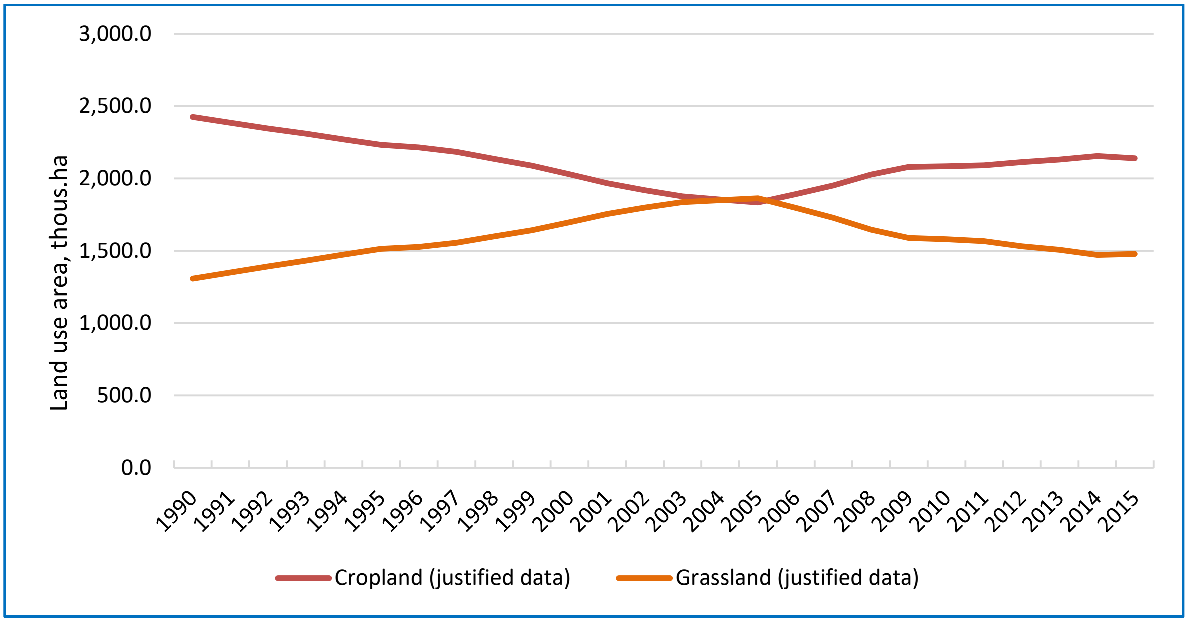


Figure 6-30. Comparison between estimated cropland and grassland area based on historical study and NFI data

By seeking methodological correctness and trying to avoid high range data jumps (with the main aim to reduce the inter-annual variations), data adjustment has been made based on the reference points (1990, 1995, 2005, 2009) for which topographical data was obtained (Figure 6-30). As is apparent from data analysis, cropland area has been constantly decreasing after the collapse of Soviet Union until 2006 (turning point after which area of cropland started to increase again - mainly due to grassland conversion to cropland) and in 2005 it had already been decreased more than 500.0 thous. ha. Such changes were beneficial for climate change mitigation as grassland area was increasing at the similar rate as cropland decreasing resulting in more carbon stored in grassland biomass, unfortunately vice versa after 2006.

6.3.2 Methodological issues

6.3.2.1 Cropland remaining Cropland

Cropland remaining cropland comprise areas continuously managed as Croplands and areas converted to Croplands after 20 consecutive years followed conversion and are reported in the category Cropland remaining Cropland (CC). The annual greenhouse gas emissions and removals from this category include:

- Estimates of annual change in C stocks from all C pools and sources;
- Estimates of annual emission of non-CO_2 GHG from all pools and sources.

C pools and sources CO_2 emissions/removals are accounted from contain carbon stock in living biomass (perennial woody crops – orchard plantations), carbon stocks in mineral and organic soils. Non-CO_2 GHG estimation comprise non-CO_2 GHG estimation from biomass burning (wildfires in the fields), direct N_2O emissions due to N mineralization/immobilization resulting from loss of carbon stock after conversion from one land use to cropland, indirect N_2O emissions from leaching and runoff after N mineralization/immobilization resulting from loss of carbon stock after conversion from other land uses to cropland.

Carbon stock changes in living biomass

The change in biomass is only estimated for perennial woody crops, as carbon stored in annual crops biomass is assumed to be equal to carbon stock loses from harvest, therefore carbon stock changes in annual biomass is assumed to be zero. Statistics Lithuania reports total area of orchards and berry plantations in Lithuania being ~45 thous. ha in 1990 to ~30 thous. ha in recent years. Lithuania reports only perennial woody biomass accumulated in commercial orchards (apple, pears, plums and cherries) and Salix plantations (because of significant expansion since 2012-2013), as small household gardens are included under settlements category, certain methodological issues still remain concerning carbon stock change inventory in such stands. Since 1999 reliable statistical data on areas of commercial orchards in Lithuania is obtained from annual statistical reports of the State enterprise Agricultural Information and Rural Business Centre (AIRBC)[180]. Area of commercial orchards in 1990 obtained from scientific publication of Venskutonis[181]. Data on area of commercial orchards during the period 1990-1998 was obtained using data interpolation between reliable data of 1990 and 1999 and beyond. Area of fruit-trees commercial orchards had stabilized at about 3.3 thous. ha in recent years, with apple plantations covering over 90%.

Above-ground woody biomass

Default *Tier 1* method was used to estimate carbon stock changes in woody biomass in commercial orchards. The area of perennial woody cropland was multiplied by a net estimate of biomass accumulation from growth and losses associated with harvest or gathering (gain-loss method) (eq. 2.7, Ch. 2 of *2006 IPCC Guidelines*).

$$\Delta C_B = \Delta C_G - \Delta C_L$$

ΔC_B - annual change in carbon stocks in biomass (considering only above-ground biomass in the case of changes in woody crop biomass accounting), considering total area, tonnes C yr^{-1}

ΔC_G - annual increase in carbon stocks due to biomass growth, considering the total area, tonnes C yr^{-1}

ΔC_L - annual decrease in carbon stock due to biomass loss, considering the total area, tonnes c yr^{-1}

Losses are estimated by multiplying default value of carbon stock loss due to harvesting by the area of cropland on which perennial woody crops are being harvested, using the default values of harvest cycle and carbon stock at harvest, given in *2006 IPCC Guidelines*.

Default coefficients for above-ground woody biomass growth rate were used (Table 5.1, Ch. 5 of *2006 IPCC Guidelines*):

- Above-ground biomass carbon stock at harvest – 63 tonnes C ha^{-1};
- Harvest/maturity cycle – 30 years;
- Biomass accumulation rate (G) – 2.1 tonnes C ha^{-1} yr^{-1};
- Biomass carbon loss (L) – 63 tonnes C ha^{-1} yr^{-1}.

Below-ground biomass

The default assumption for *Tier 1* is that there is no change in below-ground biomass of perennial trees in agricultural systems therefore default values for below-ground biomass for

[180] Available from: *http://www.vic.lt/*
[181] Venskutonis, V. *Sodininkystė*. Vilnius 1999 [en. *Horticulture*]

agricultural systems are not available and no carbon stock changes can be accounted in below-ground biomass. Carbon stock changes in below-ground biomass are reported as NO.

Carbon stock change in dead organic matter

The default *Tier 1* method for estimation of carbon stock changes in dead organic matter was elected (*2006 IPCC Guidelines*). It is assumed that dead wood and litter stocks are not present in annual crops in Cropland category or are at equilibrium in agroforestry systems and orchards. Thus, carbon stock changes for these pools were not estimated and reported as NO.

Carbon stock change in soil organic matter

Soil carbon stock change inventory includes estimations of soil organic C stock changes in mineral soils due to the land management and CO_2 emissions from organic soils due to enhanced microbial decomposition caused by drainage and associated management activity. CO_2 emissions from soils depends on many factors, however mainly on soil disturbance, soil tillage practice, organic matter input as well as on soil properties and climatic conditions (*2006 IPCC Guidelines*).

Land conversion processes result in largest changes in carbon stock in soil (Figure 6-31). It is evident that management practices have significantly smaller impact on carbon stock changes comparing with the impact of land use changes while decreasing land conversion to cropland resulted in decreasing carbon loss and emissions as well, whilst when conversions from grassland (mainly) to cropland started to increase after 2005, carbon stock losses likewise started to increase. Carbon stock changes in organic soils are directly related to land area changes, as emissions from organic soils in cropland remaining cropland and land converted to cropland categories are accounted due to the impact of enhanced microbial decomposition after drainage and cultivation, therefore emissions are directly linked to increased cultivation area.

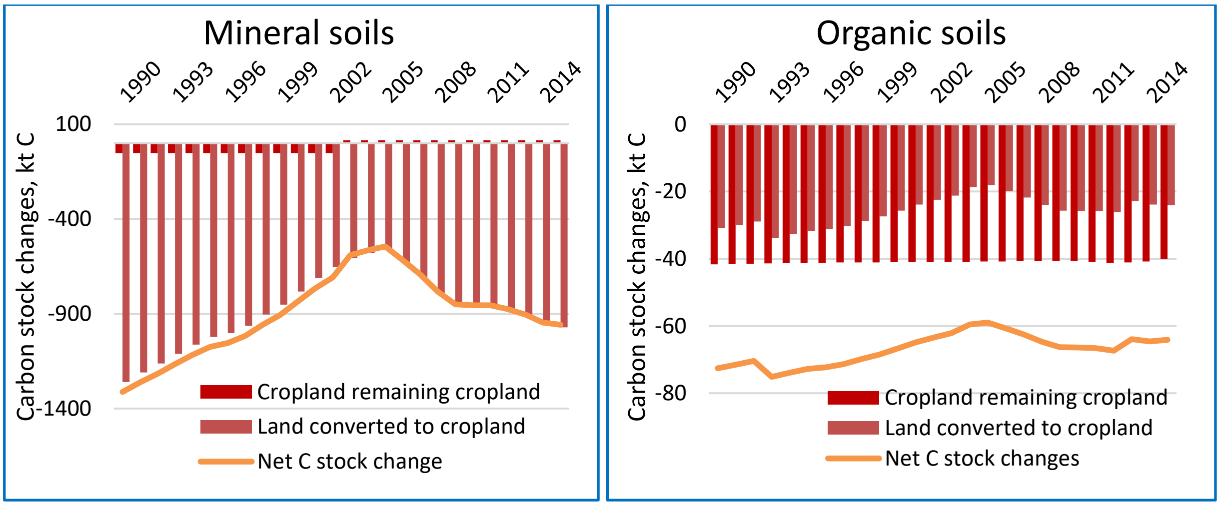


Figure 6-31. Carbon stock changes in mineral and organic soil in cropland

Mineral soils

Emissions and removals from mineral soils carbon stock changes are based on assumptions of soil carbon stock changes during the time, having in mind the impact of management practices, C input to the soil, etc.

Lithuania do not track individual land transitions, therefore uses *Tier 1* approach (equation 2.25, p. 2.30 of *2006 IPCC Guidelines*) and soil organic carbon stock (SOC) changes are computed for inventory time periods (i.e. 1990-2002 and 2003-2013).

$$\Delta C_{Mineral} = \frac{(SOC_0 - SOC_{(0-T)})}{D}$$

$$SOC = \sum_{c,s,i}(SOC_{REF_{c,s,i}} \times F_{LU_{c,s,i}} \times F_{MG_{c,s,i}} \times F_{I_{c,s,i}} \times A_{c,s,i})$$

$\Delta C_{Mineral}$ - annual change in carbon stocks in mineral soils, tonnes C yr^{-1}

SOC_0 - soil organic carbon stock change in the last year of an inventory time period, tonnes C

$SOC_{(0-T)}$ - soil organic carbon stock change at the beginning of the inventory time period, tonnes C

SOC_0 and $SOC_{(0-T)}$ are calculated using the SOC equation where the reference carbon stocks and stock change factors are assigned according to the land-use and management activities and corresponding areas at each of the points in time (time = 0 and time = 0-T)

T - number of years over a single inventory time period, yr

D = Time dependence of stock change factors which is the default time period for transition between equilibrium SOC values, yr

C - represents the climate zones, s - the soil types, i - the set of management systems that are present in a country

SOC_{REF} - the reference carbon stock, tonnes C ha^{-1}

F_{LU} - stock change factor for land-use systems or sub-system for a particular land-use, dimensionless

F_{MG} - stock change factor for management regime, dimensionless

F_I - stock change factor for input of organic matter, dimensionless

A - land area of the stratum being estimated, ha

SOC have been estimated for 1990, 2003 and 2013 inventory years using JRC estimated carbon stocks (SOC_{REF}) of agricultural soils[182] and default stock change factors: Land use F_{LU}, management F_{MG}, input F_I, from Table 5.5 of *2006 IPCC Guidelines* (presented in the Table 6-33). Annual rates of carbon stock change are estimated as the difference in stocks at two points in time divided by the time dependence of the stock change factors. The default 20 year time period was used for calculations of stock changes.

The Climatic Zone layer is defined based on the classification of *2006 IPCC Guidelines*. Lithuania is in a single – cool temperate moist climate zone.

Country has limited and/or defragmented specific data on Cropland management systems. For instance national statistics provide annual bare-fallowing areas, but it is not known if it's frequent. According to overviews the area under reduced tillage has been increased in the

[182] Available from: *http://eusoils.jrc.ec.europa.eu/library/Themes/SOC/CAPRESE/*

period 1999-2004[183], but reliable statistics for such land accounting is not available and therefore not included into calculations.

Stratification of management systems have been made based on national statistics for woody crops and available data of arable land certified as organic in *Faostat*[184]and ecological agricultural land in Statistics Lithuania[185]. Perennial and Organic management systems were specified for Croplands and the relevant factors were used in calculations. Default carbon stock change factors used for cropland mineral soil organic carbon stock changes estimation is presented in Table 6-33 (Table 5.5 p.5.17 of *2006 IPCC Guidelines*).

Table 6-33. Information on carbon stock change factors used for organic carbon stock changes calculation

Carbon stock change factor \ Crop type	Perennial crops	Certified organic crops	Other crops
Land use F_{LU}	1.0	0.69	0.69
Input F_I	1.0	1.02	1.0
Management F_{MG}	1.15	1.0	1.0

Croplands in Lithuania represent area that has been continuously managed over 20 years and predominantly it is annual crops. Main tillage practice is full tillage, described as substantial soil disturbance with full inversion and frequent tillage operations as well as small part of the surface covered by residues at planting time. Land mainly has medium residue return when all crop residues are returned to the field. Removals of residues are usual compensated by organic matter supplements from green manure or other type of manure.

Organic soils

Methodology for estimating GHG emissions from organic soils in cropland remaining cropland category is based on assumption of drainage stimulating oxidation of organic matter (resulting in emissions of CO_2). Data on distribution between mineral and organic soils in Cropland category was obtained from permanent sample plots measured by National Forest Inventory in 2012, when the database of all land use categories in country has been established. Organic soils constitute 0.7% of the total cropland area and it was assumed that this value is applicable to both categories – Cropland remaining Cropland and Land converted to Cropland.

For carbon stock change calculation in organic soils *Tier 1* method was used (eq. 2.26 of *2006 IPCC*) and CO_2 emissions due to the drainage of organic soils were estimated.

$$L_{Organic} = \sum_c (A \times EF)_c$$

$L_{Organic}$ - annual carbon loss from drained organic soils, tonnes C yr^{-1}

A - land area of drained organic soils in climate type c, ha

EF - emissions factor for climate type c, tonnes C ha^{-1} yr^{-1}

183 Šiuliauskas A., Liakas V. *Beplūgė žemdirbystė Lietuvos ūkiuose* (en. *Ploughless agriculture in Lithuanian farms*). Žemės ūkis. 2005. Nr. 2, p. 4-5
184 Available from: *http://faostat.fao.org/site/377/default.aspx*
185 Available from: *https://osp.stat.gov.lt/statistiniu-rodikliu-analize1*

Area of organic soils, determined by the data of NFI 2012, was multiplied with default emission factor from Table 5.6 (p. 5.19 of *2006 IPCC Guidelines,* 5 tonnes C ha^{-1} yr^{-1}) for drained organic soils in cold temperate climate region.

Non-CO_2 greenhouse gas emissions from biomass burning

According to *2006 IPCC Guidelines*, CO_2 emissions from biomass burning do not need to be reported as it is assumed that emissions released from burning is reabsorbed by the vegetation in next growing season, whereas only non-CO_2 GHG emissions are reported: CH_4, N_2O.

There is no controlled burning of Cropland in Lithuania, emissions of non-CO_2 only results from wildfires. Cropland wildfires are infrequent and burnt area normally are small (0.2-0.3 thous. ha), but peak values can exceed 1 thous. ha (in 2005).

Emissions from Cropland category were estimated employing the eq. 2.27 (Ch. 2, p. 2.42 of *2006 IPCC Guidelines*).

$L_{fire} = A \times M_B \times C_f \times G_{ef} \times 10^{-3}$

L_{fire} - amount of greenhouse gas emissions from fire, tonnes of each GHG

A - area burnt, ha

M_B - mass of fuel available for combustion, tonnes ha^{-1}

C_f - combustion factor, dimensionless (default value, Table 2.6 of *2006 IPCC Guidelines, 0.9*)

G_{ef} - emissions factor, g kg-1 dry matter burnt (default value, Table 2.5 of *2006 IPCC Guidelines*)

Table 6-34. Default emission factors used for calculation of non-CO_2 GHG emissions, g kg^{-1}, means ± SD

Category	**CO**	**CH_4**	**N_2O**	**NO_x**
Agricultural residues	92 ±84	2.7	0.07	2.5 ±1.0

National estimates of M_B (mass of fuel available for combustion (tonnes ha^{-1})) developed by Lithuanian agriculture scientists for agricultural residues (post-harvest field burning) are in a range of 1.92-2.27 t ha^{-1} dry matter for main grown cereal crops. Mean value of 2.08 (t ha^{-1}) was used for calculations along with default emission factors given in guidelines (Table 2.5, p.2.47 of *2006 IPCC Guidelines*).

Activity data on Cropland area burnt, required for emission estimation is obtained from statistics of Fire and rescue department[186].

6.3.2.2 Land converted to Cropland

Estimation of annual greenhouse gas emissions and removals from Land Converted to Cropland includes the following estimates from all other land categories except forest (grassland, wetland, settlements, other land):

- Estimates of annual change in C stocks from C pools and sources: biomass (above-ground biomass); dead organic matter (dead wood and litter) and soils (soil organic matter in mineral and organic soils);

[186] Fire and Rescue Department under the Ministry of the Interior of the Republic of Lithuania. Available from: *http://www.vpgt.lt/*

– Estimates of non-CO_2 gases (CH_4, CO, N_2O, NO_x) from burning of above-ground biomass and direct N_2O emissions due to N mineralization.

The cumulative areas over a 20-year transition period (reported as cropland remaining cropland) and under a 20-year transition period (reported as land converted to cropland) are reported in the figure below (Figure 6-32).

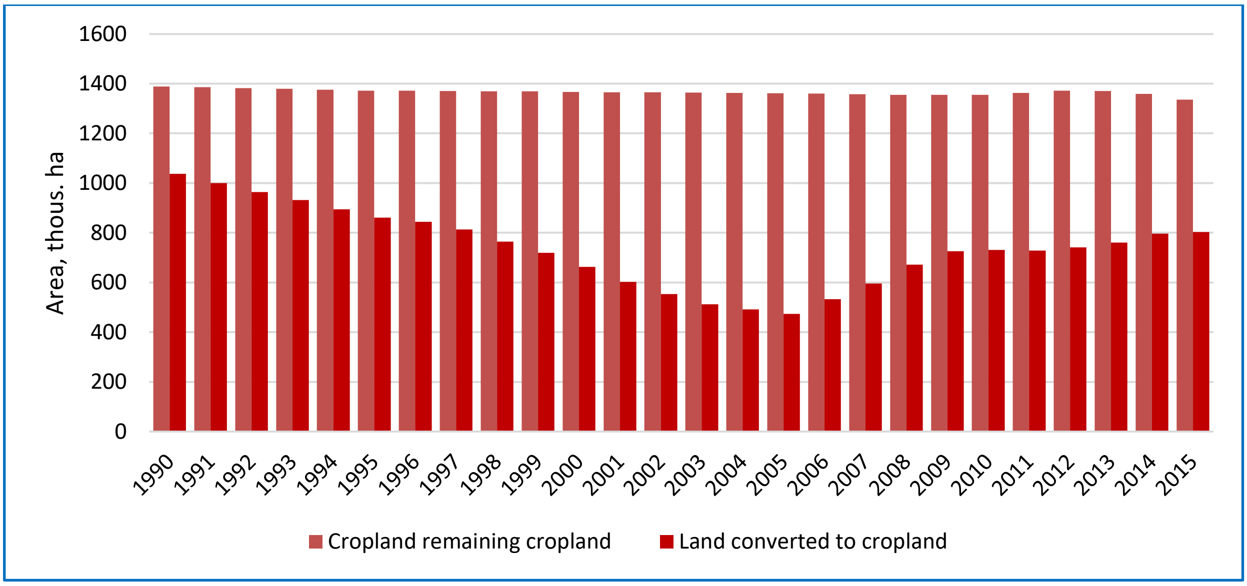


Figure 6-32. Cropland area changes during 1990-2015, thous. ha

For each year, the cumulative total area reported under the category Land converted to Cropland category is accounted as equal to the cumulative area that has been converted to that land use during the last 20 years, areas of second land-use change during the 20-year conversion period are subtracted by the cumulative total. The most part of conversions had been estimated from grassland to cropland in the period straight after Lithuania gained its Independence in 1990 until 2005 and vice versa from 2006.

According to the information obtained from *NFI*, during the last decades there have been no conversions of Forest land to Cropland, therefore no carbon stock changes in pools and sources resulting in emissions or removals from forest land converted to cropland were reported.

Carbon stock changes in living biomass

Tier 2 method was elected to estimate annual change in carbon stocks in living biomass on Land converted to Cropland employing the eq. 2.15 and 2.16 (Ch. 2, p. 2.20 of *2006 IPCC Guidelines*). Area estimates for Land Converted to Cropland were disaggregated according to prevailing vegetation. Average carbon stock change per hectare has been estimated for each type of conversion. Biomass carbon stock in initial land-use categories (B_{BEFORE}) are assumed to be 2.4 t ha^{-1} d. m. in Grasslands, Wetlands and Settlements, 0.0 t ha^{-1} d. m. in Other Land.

$$\Delta C_B = \Delta C_G + \Delta C_{CONVERSION} - \Delta C_L$$

ΔC_B - annual change in carbon stocks in biomass on land converted to other land-use category, in tonnes C yr^{-1}

ΔC_G - annual increase in carbon stocks in biomass due to growth on land converted to another land-use category, in tonnes C yr^{-1}

$\Delta C_{CONVERSION}$ - initial change in carbon stocks in biomass on land converted to other land-use category, in tonnes C yr^{-1}

ΔC_L - annual decrease in biomass carbon stocks due to the losses from harvesting, fuel wood gathering and disturbances on land converted to other land use category, in tonnes C yr^{-1}

$$\Delta C_{CONVERSION} = \sum_i \{(B_{AFTERi} - B_{BEFOREi}) \times \Delta A_{TO\_OTHERSi}\} \times CF$$

$\Delta C_{CONVERSION}$ - initial change in biomass carbon stocks on land converted to another land category, tonnes C yr^{-1}

B_{AFTERi} - biomass stocks on land type *i* immediately after the conversion, tonnes d. m. ha^{-1}

$B_{BEFOREi}$ - biomass stocks on land type *i* before the conversion, tonnes d. m. ha^{-1}

$\Delta A_{TO\_OTHERSi}$ - area of land-use *i* converted to other land-use category in a certain year, ha yr^{-1}

CF - carbon fraction of dry matter, tonnes C (tonnes d. m.)$^{-1}$

i - type of land use converted to another land-use category

It is assumed that the prevailing vegetation is removed entirely, resulting in almost zero amount of biomass and carbon remaining in converted land area, which leads to the emissions from certain category converted to cropland. Carbon stocks in biomass are assumed to be zero immediately after conversion (B_{AFTER}), however in subsequent years change in biomass of annual crops is also considered to be zero because it is assumed that carbon gains in biomass from annual growth are offset by losses from harvesting.

Carbon stock change in dead organic matter

Lithuania has no sufficient and reliable estimates of the dead wood and litter in the initial land-use systems (except FL) prior to the conversion. Therefore it is assumed that dead wood and litter stocks are not present or are at equilibrium after the conversion and are reported as NO.

Carbon stock change in soil organic matter

Estimations of change in C stocks in mineral and organic soils in Lands converted to Cropland were based on same methodological approaches as for Cropland remaining Cropland (Tier 1 method, described in section of cropland remaining cropland GHG emission estimation from mineral soils). The same guidance, provided in Section 2.3.3 of Chapter 2 in guidelines (*2006 IPCC Guidelines*), based on assumptions of carbon stock changes in soil during the time period occurs concerning impact of land-use, management practices, C input to the soil and drainage of organic soils, was used for estimating changes in soil C stocks.

Mineral soils

Calculations of carbon stock changes in mineral soils on Lands converted to Cropland were made in order to estimate carbon stock gains or losses due to different conversion. It is estimated that mineral soils of grassland have larger organic carbon stocks comparing to cropland, while carbon stocks in mineral soils of settlements and other land are assumed to be 0. Carbon stock changes in mineral soils were calculated due to the conversions of grassland, settlements and other land to cropland.

Calculations were based on equation 2.25 (p. 2.30, Ch. 2 of *2006 IPCC Guidelines*). Country-specific reference C stocks (SOC_{REF} - 54.38 t C ha^{-1} (cropland), 78.81 t C ha^{-1} (grassland)), developed by the Joint Research Centre, the European Commission's science service, default stock change factors (Table 5.5, p. 5.17, of *2006 IPCC*) and default 20 year time period for stock changes were used for calculations.

$$\Delta C_{Mineral} = \frac{(SOC_0 - SOC_{(0-T)})}{D}$$

$\Delta C_{Mineral}$ - annual change in carbon stocks in mineral soils, tonnes C yr^{-1}

SOC_0 - soil organic carbon stock in final land use category (cropland), tonnes C

$SOC_{(0-T)}$ - soil organic carbon stock in initial land use category, tonnes C

Joint Research Centre estimated SOC_0 and $SOC_{(0-T)}$ values were used at each of the points in time (time = 0 (first year after conversion period - 20 years) and time = 0-T (first year of the beginning of conversion period)). Due to the lack of reliable data it is assumed that there are no organic carbon stock accumulated in settlements and other land categories soils, therefore $SOC_{(0-T)}$ for settlements and other land were indicated as 0 in calculations.
T - number of years over a conversion period, yr

D = Time dependence of stock change factors which is the default time period for transition between equilibrium SOC values, yr

Value of annual organic carbon stock change in mineral soils was multiplied by the activity data of each year. Activity data was obtained from NFI estimations, executed by State Forest Service.

Organic soils

CO_2 emissions from carbon stock changes in organic soils were calculated due to the drainage of organic soils, in purpose to make it suitable for agricultural crop cultivation. CO_2 emissions from drainage of organic soils are the result of enhanced microbial activity, when the microorganisms decompose greater amounts of organic matter accumulated in organic soils.

According to the data of NFI (year 2012), area of organic soils was assumed to be 0.7% of all conversions to Croplands. Calculation of carbon stocks in organic soils on Lands converted to Cropland were based on same methodological approaches as for Cropland remaining Cropland, described in chapter 6.3.2.1. Equation used for calculation of emissions resulting from organic soil drainage is presented below.

$$L_{Organic} = \sum_c (A \times EF)_c$$

$L_{Organic}$ - annual carbon loss from drained organic soils, tonnes C yr^{-1}

A - land area of drained organic soils in climate type c, ha

EF - emissions factor for climate type c, tonnes C ha^{-1} yr^{-1}

Emissions from organic cropland soils were calculated using activity data obtained from NFI estimations, multiplying total grassland converted to cropland area with 0.7 % (it was assumed that all settlements and other land area converted to cropland is mineral soils) and adding total wetland converted to cropland area (all wetlands are considered as organic soils) and default emission factor was used (Table 5.6 of *2006 IPCC Guidelines*, EF - 5.0 t C ha^{-1} yr^{-1}).

Non-CO_2 greenhouse gas emissions from biomass burning

The approach used to estimate non-CO_2 emissions from biomass burning in Land Converted to Cropland is essentially the same as for Cropland Remaining Cropland, Lithuania uses Tier 1 method and default emission factors for each non-CO_2 greenhouse gas, provided in the Table 6-32.

Statistics of Fire and rescue department do not provide details on Cropland area burnt to separate areas of Cropland remaining Cropland and Land converted to Cropland, therefore all non-CO_2 greenhouse gas emissions from wildfires in cropland category (including land converted to cropland subcategory) are accounted under the subcategory Cropland remaining Cropland. Non-CO_2 greenhouse gas emissions from biomass burning in land converted to cropland subcategory in CRF reported are reported with notation key IE.

Direct N_2O emissions from N mineralization/immobilization

Direct N_2O emissions are produced naturally in soils through the processes of nitrification and denitrification, however, management of soils could have an impact to increase such emissions. Changes in inorganic N pool in soils, resulting in direct or indirect emissions of N_2O, could be affected by human induced net N additions to the soils (synthetic and organic fertilizers, etc.), changes of soil organic carbon (due to the drainage/management of organic soils, cultivation/land-use change on mineral soils), resulting in changes of soil C:N ratio, which in turn leads to emissions.

Direct N_2O emissions from mineral soils in LULUCF sector are resulting from changes of soil organic carbon due to the land-use change, calculating the amount of N_2O released to the atmosphere as the result of the organic N mineralization after carbon stock in soil has decreased (loss of soil organic carbon occurs after conversion). Direct N_2O emissions due to the cultivation of mineral soils (cropland remaining cropland) and drainage of organic soils in cropland and grassland categories are accounted under Agriculture sector, therefore only land converted to other land activity data is considered while calculating emissions due to carbon stock loss in mineral soils.

For the accounting of direct N_2O emissions from LULUCF sector default *2006 IPCC Guidelines Tier 1* methodology was used (with *Tier 2* requirements of disaggregation of individual land-use types while accounting direct N_2O emissions due to the loss of soil organic carbon resulting from land-use changes). Slightly modified (reduced) equation 11.1 (p. 11.7 of *2006 IPCC Guidelines*) was implemented:

$$N_2O_{Direct} - N = N_2O - N_{N\ Inputs}$$

$N_2O_{Direct} - N$ – annual direct N_2O-N emissions, produced from managed soils, kg N_2O-N yr^{-1}

$N_2O - N_{N\ Inputs}$ – annual direct N_2O-N emissions from N inputs to managed soils, kg N_2O-N yr^{-1}

$$N_2O - N_{N\ Inputs} = F_{SOM} \times EF_1$$

F_{SOM} – annual amount of N in mineral soils that is mineralized, in association with loss of soil C from soil organic matter as a result of changes to land use or management, kg N yr^{-1}

EF_1 – emission factor for N_2O emissions from N inputs, kg N_2O-N (kg N input)$^{-1}$

Equation 11.8 (p. 11.16 *of 2006 IPCC Guidelines*) was used for estimation of amount of N in mineral soils that is mineralized in association with loss of soil C from soil organic matter:

$$F_{SOM} = \sum_{LU}\left[\left(\Delta C_{Mineral,LU} \times \frac{1}{R}\right) \times 1000\right]$$

$\Delta C_{Mineral,LU}$ – average annual loss of soil carbon for each land-use type (*LU*), tonnes C (according to Tier 2 methodology, value was disaggregated by individual land-uses)

R - C:N ratio of the soil organic matter. A default value of 15 (uncertainty range from 10 to 30) for the C:N ratio (R) may be used for situations involving land-use change from Forest land or Grassland to Cropland, in the absence of more specific data for the area.

LU - land-use type

Default emission factor used in calculations of direct N_2O emissions due to the loss of soil organic carbon:

- EF_1 – 0.01 kg N_2O-N (kg N input)$^{-1}$ (Table 11.1, p. 11.11 of *2006 IPCC Guidelines*)

Carbon stock loss after other land uses conversion to cropland was used as activity data for direct N_2O emissions estimation from N mineralization/immobilization.

Indirect N_2O emissions from leaching and runoff

Lithuania is located in surplus precipitation zone, therefore a certain amount of precipitation forms both surface and underground runoff annually. According to "Geography of Lithuanian waters"[187], runoff in Lithuania varies among 25 – 50 percent of precipitation, on the basis of terrain, soil, etc. In addition to the direct N_2O emissions resulting from carbon stock change (loss) after land use change, indirect N_2O emissions also take place through runoff. Some of the inorganic (mineralized due to the carbon stock decrease after land use change) N does not take part in biological retention processes, therefore is removed with surface water flow (runoff) or through soil and afterwards is transformed into N_2O. Indirect N_2O emissions for all land use categories where direct N_2O emissions from N mineralization/immobilization due to carbon stock change after land use change occur are calculated using the same default *2006 IPCC* methodology – equation 11.10 (*Tier1* method).

$$N_2O_{(L)}\text{-}N = F_{SOM} \times Frac_{LEACH\text{-}(H)} \times EF_5$$

$N_2O_{(L)}$-N – annual amount of N_2O-N produced from leaching and runoff of N additions to managed soils in regions where where leaching/runoff occurs, kg N_2O-N yr^{-1}

F_{SOM} – annual amount of N mineralized in mineral soils associated with loss of soil C from soil organic matter as a result of changes in to land use or management in regions where leaching/runoff occurs, kg N yr^{-1} (from equation 11.8)

$Frac_{LEACH-(H)}$ – fraction of all N added to/mineralized in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff, kg N (kg of N additions)$^{-1}$, default value, 0.3 (Table 11.3, p. 11.24 of *2006 IPCC*).

EF_5 – emission factor for N_2O emissions from N leaching and runoff, kg N_2O-N (kg N leached and runoff)$^{-1}$, default value, 0.0075 (Table 11.3, p. 11.24 of *2006 IPCC*).

[187] Kilkus K., Stonevicius E., 2011. Geography of Lithuanian waters, textbook. Available at: http://www.hkk.gf.vu.lt/publikacijos/2011_Lietuvos_vandenu_geografija.pdf

6.3.3 Uncertainty assessment

The activity data were obtained from The National Land Service (NLS) and State enterprise Agricultural Information and Rural Business Centre (AIRBC).

The emission factors were employed from *2006 IPCC Guidelines*.

The uncertainty rates for activity data and emission factors used in the estimates are reported in Table below (Table 6-35).

Table 6-35. Values of uncertainties for Cropland

Input	**Uncertainties, %**	**References**
Activity data		
Cropland area	±2.0	*Study 2, NFI*
Emission factors		
G (biomass accumulation)	±75	p. 5.9, *2006 IPCC*
L (biomass loss)	±75	p. 5.9, *2006 IPCC*
F_{LU} F_{MG} F_I	NA	
EF (organic soils)	±90	p. 5.19, *2006 IPCC*
EF_1 (N_2O emissions from N inputs)	-70/+300	p. 11.11*, 2006 IPCC*

6.3.4 Category-specific QA/QC and verification

The QC/QA is based on quality control activities described in *2006 IPCC Guidelines* (Vol 1, Chapter 6, Table 6.1). Quality control and quality assurance objectives and procedures for Lithuanian GHG inventory at the national level are presented in Chapter 1.2.3 Quality assurance, quality control and verification plan. The QA/QC of activity data from State Forest Service is explained in Chapter 6.2.5, the use of country specific data is described in the inventory report.

The QC procedures are performed according to the QA/QC plan in order to attain these quality objectives in LULUCF, the comments received after QA/QC procedures while reviewing the report are taken into account and errors found were corrected. Some obscurities concerning direct N_2O emissions estimation were clarified after QA procedure performed by Norwegian LULUCF GHG inventory experts under the "Partnership project on Greenhouse gas inventory" in the framework of the programme LT10.

6.3.5 Category-specific recalculation

Changes between year 2016 and 2017 submissions occur due to the error in calculations of CO_2 emissions from drainage of organic soils in cropland remaining cropland and land converted to cropland subcategories. There was misinterpretation of share of organic drained soils in total cropland area, therefore emissions occurring from drainage of organic soils were overestimated. Differences between 2016 and 2017 submission of drained organic soils also occurred due to the different estimation of drained organic soils in land converted to cropland: it was assumed that settlements and other land converted to cropland are only under mineral soils, however wetlands converted to cropland are only organic soils, therefore in certain years there was an overestimation or underestimation of emissions from drainage of organic soils. In the submission of 2017 carbon stock change resulting from drainage of organic soils in cropland remaining cropland and land converted to cropland subcategories was corrected (Tables 6-35, 6-36).

Calculation error in estimation of carbon stock changes in living biomass in settlements converted to cropland was also corrected this year. There were no carbon stock changes reported in 1991 in settlements converted to cropland subcategory, however -0.96 kt C was lost and it resulted in additional emissions of 3.52 kt CO_2 eqv. (0.06 % share of total cropland emissions in 1991). Additionally, in 1993 carbon stock change in settlements converted to cropland was reported -1.44 kt CO_2 eqv., however it actually was -0.96, this correction resulted in total cropland emissions decreased by 1.76 kt CO_2 eqv. (0.03 % of total cropland emissions).

Table 6-36. Reported in previous submission and recalculated carbon stock change due to the drainage of organic soils, kt C (cropland remaining cropland)

Year	2016 submission	2017 submission	Absolute difference	Relative difference, %
1990	-48.59	-41.65	6.94	-14.29
1991	-48.52	-41.59	6.93	-14.29
1992	-48.38	-41.47	6.91	-14.29
1993	-48.27	-41.38	6.90	-14.29
1994	-48.13	-41.26	6.88	-14.29
1995	-48.02	-41.16	6.86	-14.29
1996	-48.01	-41.15	6.86	-14.29
1997	-47.96	-41.11	6.85	-14.29
1998	-47.94	-41.09	6.85	-14.29
1999	-47.91	-41.06	6.84	-14.29
2000	-47.84	-41.00	6.83	-14.29
2001	-47.80	-40.97	6.83	-14.29
2002	-47.77	-40.94	6.82	-14.29
2003	-47.74	-40.92	6.82	-14.29
2004	-47.71	-40.90	6.82	-14.29
2005	-47.64	-40.84	6.81	-14.29
2006	-47.60	-40.80	6.80	-14.29
2007	-47.50	-40.72	6.79	-14.29
2008	-47.43	-40.66	6.78	-14.29
2009	-47.42	-40.64	6.77	-14.29
2010	-47.40	-40.63	6.77	-14.29
2011	-47.68	-40.87	6.81	-14.29
2012	-48.02	-41.16	6.86	-14.29
2013	-47.96	-41.11	6.85	-14.29
2014	-47.54	-40.75	6.79	-14.29

Table 6-37. Reported in previous submission and recalculated carbon stock change due to the drainage of organic soils, kt C (land converted to cropland)

Year	2016 submission	2017 submission	Absolute difference	Relative difference, %
1990	-36.32	-30.91	5.41	-14.89
1991	-34.96	-29.97	4.99	-14.29
1992	-33.68	-28.87	4.81	-14.29
1993	-32.42	-33.78	-1.36	4.20
1994	-31.08	-32.63	-1.55	4.99
1995	-29.90	-31.62	-1.72	5.75
1996	-29.31	-31.12	-1.80	6.15
1997	-28.22	-30.18	-1.96	6.94

1998	-26.53	-28.73	-2.20	8.29
1999	-24.97	-27.39	-2.42	9.71
2000	-22.97	-25.68	-2.71	11.80
2001	-20.87	-23.88	-3.01	14.42
2002	-19.21	-22.45	-3.25	16.91
2003	-17.77	-21.22	-3.45	19.43
2004	-17.04	-18.60	-1.56	9.15
2005	-16.44	-18.09	-1.65	10.01
2006	-18.51	-19.86	-1.35	7.29
2007	-20.69	-21.73	-1.04	5.02
2008	-23.33	-23.99	-0.66	2.83
2009	-25.23	-25.62	-0.39	1.54
2010	-25.40	-25.77	-0.37	1.44
2011	-25.34	-25.72	-0.37	1.47
2012	-25.85	-26.15	-0.30	1.17
2013	-26.59	-22.79	3.80	-14.29
2014	-27.83	-23.86	3.98	-14.29

6.3.6 Category-specific planned improvements

Lithuania has finished research on carbon stock evaluation in forest land, cropland and grassland soils, which was funded by the Norway Grants programme under the "Partnership project on Greenhouse gas inventory" in the framework of the programme LT10 "Capacity-building and institutional cooperation between beneficiary State and Norwegian public institutions, local and regional authorities". The aim of the research was to obtain national carbon stock values in soils in different land uses (SOC_{REF}) and is planning to include national values for estimation of carbon stock changes in soils in the next submission.

6.4 Grassland (CRF 4.C)

According to national definition – grassland includes meadows and natural pastures planted with perennial grasses or naturally developed, on a regular basis used for moving and grazing. Grasslands cultivated for less than 5 years, in order to increase soil vegetation (only certain plant species suitable for grassland improvement can be planted - e. g. clover, lucerne; no wheat, barley, rape seed, etc. crops are considered as grassland improvement - wheat, barley and other crop cultivation is considered as management of cropland), still remain grasslands. All grasslands are considered as managed land in Lithuania, therefore emissions/removals are accounted for the whole area.

The area of grassland in Lithuania has been changing with different extent (Figure 6-31). Since 1990 the grassland area was increasing and 15 years later grassland area was about 1.5 times higher and reached 1,862 kha of the country land. From 2006 area of grassland has started to decrease and is still decreasing. Thus in 2015 grassland occupied 1,478 kha of total country area. The obtained data indicates that during all the period there were no emissions accounted from grassland category, however, GHG removals vary depending on land use changes (Figure 6-33). Net CO_2 absorption was increasing along the grassland area increment. In 2005 the net CO_2 absorption was 4,620.36 kt CO_2 eqv. and almost 2.5 times higher comparing with 1990. In 2015 the net CO_2 absorption reached 2,575.61 kt CO_2 eqv. and the tendency of lower CO_2 absorption since 2006 could be predicted. However, CO_2 emissions from the land remained grassland were not changing significantly and the average of CO_2 emissions from drainage of organic soils were 60.7 kt CO_2 eqv. The most significant CO_2 accumulation was in cropland converted to grassland. The highest amount of accumulated CO_2 was 4,147.13 kt CO_2 eqv. (in 2005). Thus, in 2015 the CO_2 accumulation was 2,501.09 kt CO_2 eqv. and almost 2 times decreased in comparison with intensive CO_2 accumulation period. Having in mind National Rural Development Programme for 2014 – 2020, the situation with grasslands should at least remain in the stable phase (the total area of grasslands should remain not smaller than in recent years) or even be improved. Area of grassland is expected to increase with special financial measures, encouraging cropland conversion to grassland in ecologically sensitive and important areas.

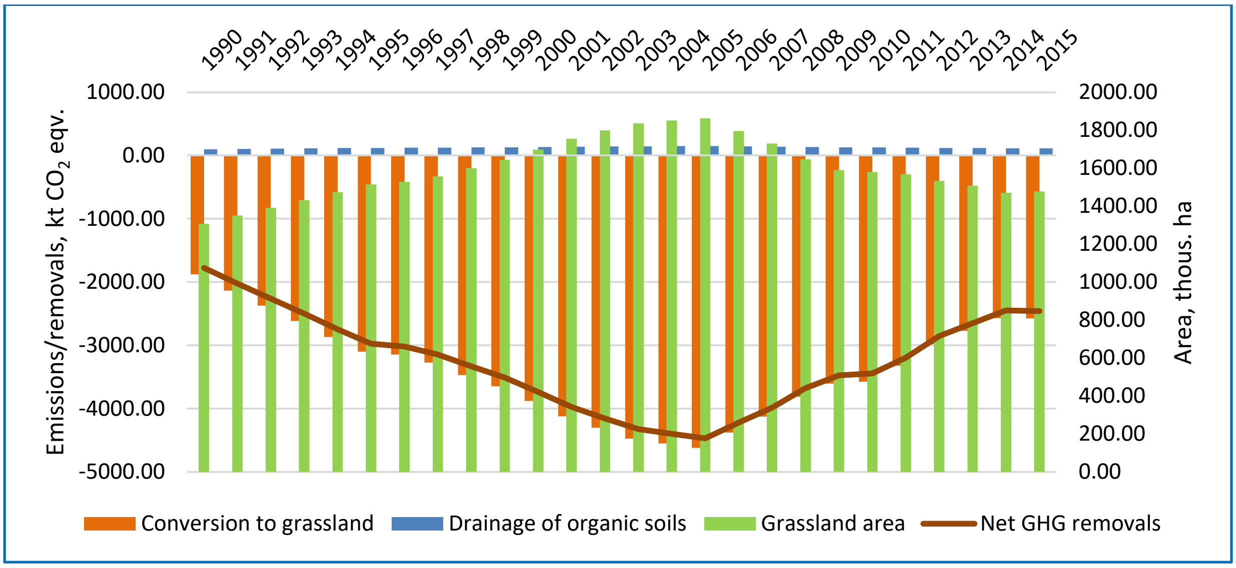


Figure 6-33. Grassland area and emissions/removals changes in 1990-2015

6.4.1 Category description

Two source categories are accounted under this category: emissions from Grassland remaining Grassland and emissions from Land converted to Grassland. Carbon stock changes estimated from the subcategories are presented in the table below.

Table 6-38. Estimated carbon stock changes under Grassland category

Land Use Category	CS change in biomass	CS change in dead organic matter	CS 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*

6.4.2 Methodological issues

6.4.2.1 Grassland remaining Grassland

Areas continuously managed as Grassland and areas converted to Grassland after 20 consecutive years followed conversion are reported in the category Grassland remaining Grassland (GG).

The annual greenhouse gas emissions and removals from Grassland Remaining Grassland include:

- Estimates of annual change in C stocks from C pools and sources – carbon stock changes in organic soils;
- Estimates of annual emission of non-CO_2 gases from above-ground biomass.

Carbon stock changes in living biomass

Grassland management practices in Lithuania mainly are static; therefore it do not have significant impact on biomass changes and biomass remains in an approximate steady-state. Default *Tier 1* method (p. 6.6 of *2006 IPCC Guidelines*) was elected assuming that no significant change in biomass in Grassland Remaining Grassland occurs during the years of management, therefore carbon stock changes in living biomass in grassland remaining grassland subcategory are reported as NO.

Carbon stock change in dead organic matter

Default *Tier 1* method was elected for evaluation of carbon stock changes in dead organic matter, assuming that the dead wood and litter stocks are at equilibrium in grassland remaining grassland, so there is no need to estimate the carbon stock changes for this pool and it is reported as NO.

Carbon stock change in soil organic matter

Carbon stock changes in soil organic matter are reported only as changes occurring due to the drainage of organic soils, *Tier 1* method for carbon stock changes accounting was elected.

Area of organic and mineral soils was determined by using data of *NFI* permanent sample plots measured in 2012, according to the measurements area of organic soils constitute to 10.5% and area of mineral soils 89.5% of total grassland remaining grassland area.

Grassland management data are limited in Lithuania, country expert's report[188] that due to domestic political-economic circumstances, about 50% of grasslands are abandoned and have been turning into natural habitats/climatic ecosystems during last two decades. Therefore using *Tier 1* method organic C stocks changes in mineral soil over a 1990-201 period estimated to be close to 0 and have been reported as NO.

Mineral Soils

Grasslands in Lithuania mainly represents non-degraded and sustainably managed grasslands, but without significant management improvements and impacts on soil organic carbon emissions/sequestration during the last decades.

Soil organic C stocks has been estimated for the inventory period of 1990-2015 using JRC estimated carbon stocks (SOC_{REF} = 78.81 t C ha^{-1}) for agricultural soils[189] and the relevant stock change factors. Factors for F_{LU}, F_I and F_{MG} for different management activities on Grassland were taken from Table 6.2 (p. 6.16 of *2006 IPCC*). Relative stock change factors for grassland management used in estimations are presented in the Table below.

Table 6-39. Relative stock change factors for grassland management used in estimations

[188] Balezentiene, L., Bleizgys, R. 2011. *Short-term inventory of GHG fluxes in semi-natural and anthropogenized grassland*. Polish Journal of Environmental Studies. 20:255-262

[189] Available from: *http://eusoils.jrc.ec.europa.eu/library/Themes/SOC/CAPRESE/*

Relative stock change factors \ Management practices	Nominally managed	Moderately degraded grassland
Land use F_{LU}	1.0	1.0
Management F_{MG}	1.0	0.95
Input F_I	1.0	1.0

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, therefore could be reported as NO.

Organic soils

Using data presented by National Forest Inventory permanent sample plots measured in 2012, organic soils constitute 10.5% from the total Grasslands area, and it was assumed that this value is equally correct to Grasslands remaining Grasslands and to Lands converted to Grasslands.

Tier 1 method was used in order to calculate carbon stock changes in organic soils in grassland remaining grassland (eq. 2.26, p. 2.35 of *2006 IPCC Guidelines*).

$$L_{Organic} = \sum_c (A \times EF)_c$$

$L_{Organic}$ - annual carbon loss from drained organic soils, tonnes C yr^{-1}

A - land area of drained organic soils in climate type c, ha

EF - emissions factor for climate type c, tonnes C ha^{-1} yr^{-1}

Default emission factor of 0.25 tonnes C ha^{-1} yr^{-1} for a cold temperate climate has been used for calculations (Table 6.3, p. 6.17 of *2006 IPCC Guidelines*).

Inorganic C

No method is provided for estimation of the change in soil inorganic C stocks due to limited scientific data for derivation of stock change factors; thus the net flux for inorganic C stocks is assumed to be zero (p.2.29 of *2006 IPCC Guidelines*).

Non-CO_2 greenhouse gas emissions from biomass burning

CO_2 emissions from biomass burning in grasslands are not reported as it is assumed that all the emissions released during combustion are usually reabsorbed in the rest of biomass during the photosynthesis activity. Therefore, only non-CO_2 GHG emissions are reported: CH_4, N_2O.

In Lithuania there is no controlled burning of Grassland and emissions of non-CO_2 only results from wildfires. Grassland wildfires are infrequent and burnt area normally averaged at ≤5 thous. ha, but peak value can exceed 32.6 thous. ha (in 2006).

Emissions from Grassland category were estimated employing the eq. 2.27 (Ch. 2, p. 2.42 of *2006 IPCC Guidelines*).

$$L_{fire} = A \times M_B \times C_f \times G_{ef} \times 10^{-3}$$

L_{fire} - amount of greenhouse gas emissions from fire, tonnes of each GHG

A - area burnt, ha

M_B - mass of fuel available for combustion, tonnes d. m. ha^{-1} (default value, Table 2.4 of *2006 IPCC Guidelines*, 4.1 tonnes d. m. ha^{-1})

C_f - combustion factor, dimensionless (default value, Table 2.6 of *2006 IPCC Guidelines, 0.86*)

G_{ef} - emissions factor, g kg^{-1} dry matter burnt (default value, Table 2.5 of *2006 IPCC Guidelines*)

Default emission factors used for calculation of different non-CO_2 GHG gases resulting from grassland wildfires are presented in the Table below.

Table 6-40. Default emission factors used for calculation of non-CO_2 GHG emissions, g kg-1, means ± SD

Category	**CO**	**CH_4**	**N_2O**	**NO_x**
Agricultural residues	65 ±20	2.3 ±0.9	0.21 ±0.10	3.9 ±2.4

National estimates of Mass of Fuel Available for Combustion (M_B) are not available, therefore default data provided in Table 2.4 (Ch. 2, p. 2.45 of *2006 IPCC Guidelines*) for the mass of fuel consumed were used which equals to 4.1 tonnes d.m. ha^{-1}.

Activity data on Grassland area burnt was obtained from statistics of Fire and rescue department[190].

6.4.2.2 Land converted to Grassland

The cumulative areas of land converted to grassland during a 20-year transition period are reported in Figure 6-34. For each year, the cumulative total area reported under Land converted to Grassland (LG) category is accounted as equal to the cumulative area that has been converted to that land use over the last 20 years, areas of second land-use change during the 20-year conversion period are subtracted by the cumulative total.

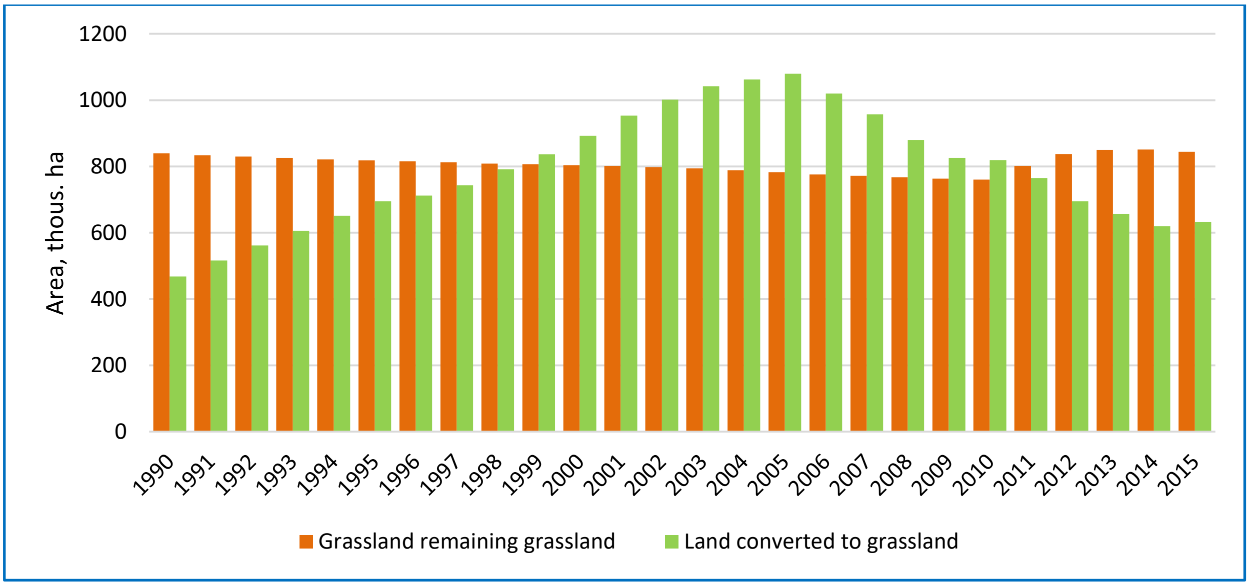


Figure 6-34. Grassland area changes during 1990-2015, thous. ha

According to the information obtained from *Study-1* and *Study-2* during the last decades there have been no conversions from Forest land to Grasslands and main conversions from 1990 to

190 Fire and Rescue Department under the Ministry of the Interior of the Republic of Lithuania. Available from: *http://www.vpgt.lt/*

2005 were from cropland to grassland, since 2006 conversions from cropland to grassland decreased with increasing vice versa conversions – from grassland to cropland.

Estimation of annual greenhouse gas emissions and removals from Land Converted to Grassland involves estimation of changes of carbon stock in pools: above-ground biomass and soil organic matter.

All emissions of non-CO_2 GHG resulting from biomass burning are reported under Grasslands remaining Grasslands category, because of lack of statistical data of wildfires distributed between grassland remaining grassland and land converted to grassland area.

Carbon stock changes in living biomass

Carbon stock changes in land converted to grassland contain changes in above-ground biomass. For land converted to Grassland, CO_2 emissions and removals are based on estimating the effects of previous vegetation type being replaced by grassland vegetation (Ch. 6, p. 6.5 of *2006 IPCC Guidelines*).

Tier 2 method was used to estimate annual change in carbon stocks in living biomass on Land converted to Grassland employing eq. 2.15 and 2.16 (Ch. 2, p. 2.20 of *2006 IPCC Guidelines*). Area estimates for Land Converted to Grassland were disaggregated according to original vegetation and average carbon stock change per hectare is estimated for each type of conversion.

$$\Delta C_B = \Delta C_G + \Delta C_{CONVERSION} - \Delta C_L$$

ΔC_B - annual change in carbon stocks in biomass on land converted to other land-use category, in tonnes C yr^{-1}

ΔC_G - annual increase in carbon stocks in biomass due to growth on land converted to another land-use category, in tonnes C yr^{-1}

$\Delta C_{CONVERSION}$ - initial change in carbon stocks in biomass on land converted to other land-use category, in tonnes C yr^{-1}

ΔC_L - annual decrease in biomass carbon stocks due to the losses from harvesting, fuel wood gathering and disturbances on land converted to other land use category, in tonnes C yr^{-1}

$$\Delta C_{CONVERSION} = \sum_i \{(B_{AFTERi} - B_{BEFOREi}) \times \Delta A_{TO\_OTHERSi}\} \times CF$$

$\Delta C_{CONVERSION}$ - initial change in biomass carbon stocks on land converted to another land category, tonnes C yr^{-1}

B_{AFTERi} - biomass stocks on land type *i* immediately after the conversion, tonnes d. m. ha^{-1}

$B_{BEFOREi}$ - biomass stocks on land type *i* before the conversion, tonnes d. m. ha^{-1}

$\Delta A_{TO\_OTHERSi}$ - area of land-use *i* converted to other land-use category in a certain year, ha yr^{-1}

CF - carbon fraction of dry matter, tonnes C (tonnes d. m.)$^{-1}$

i - type of land use converted to another land-use category

It is assumed that all biomass is lost immediately from the previous ecosystem after conversion and residual biomass (B_{AFTER}) is thus assumed to be zero.

Biomass carbon stock in initial land-use categories (B_{BEFORE}) is assumed to be 2.4 t ha^{-1} d. m. in Croplands, Wetlands and Settlements, 0.0 t ha^{-1} d. m. in Other Land.

Default value of 2.4 t ha^{-1} d. m. carbon stock in biomass after conversion for cold temperate wet climate zone has been used (Table 6.4, p. 6.27 of *2006 IPCC Guidelines*). Carbon stocks in biomass are assumed to be zero immediately after conversion (B_{AFTER}), annual change in biomass of grassland vegetation is considered to be 2.4 t d. m. ha^{-1}.

According to *2006 IPCC Guidelines*, default annual biomass increment values for cropland, grassland, wetland and settlements are equal - 1.2 t C ha^{-1} (calculated using default value of carbon content of the dry biomass - 0.50 tonne of C per tonne of dry biomass weight, p. 6.9 of *2006 IPCC Guidelines*). Whereas, almost no significant changes in biomass in land converted to grassland category were established, only certain other land conversions to grassland resulted in gains of total grassland biomass stock.

Carbon stock changes in dead organic matter

Lithuania has no estimates of the dead wood and litter in the initial land-use systems (except FL) prior to conversion. Therefore it is assumed that dead wood and litter stocks are not present or are at equilibrium and it is reported as NO.

Carbon stock changes in soil organic matter

Estimations and assumptions of change in C stocks in mineral and organic soils on Lands converted to Grassland were based on same methodological approaches as for Grassland remaining Grassland and guidance for estimating changes in soil C stocks are provided in Section 2.3.3 (Ch. 2 of *2006 IPCC Guidelines*). Activity data is provided by State Forest Service executed NFI.

Mineral soils

Calculations of carbon stock changes in mineral soils on Lands converted to Grassland were made in order to estimate carbon stock gains or losses due to different conversion. It is estimated that mineral soils of grassland have larger organic carbon stocks comparing to cropland, while carbon stocks in mineral soils of settlements and other land are assumed to be 0. Carbon stock changes in mineral soils were calculated due to the conversions of cropland, settlements and other land to cropland.

Calculation of carbon stocks in mineral soils on Lands converted to Grassland were based on eq. 2.25 (Ch. 2, p. 2.30 of *2006 IPCC Guidelines*). Country-specific reference C stocks (SOC_{REF} - 54.38 t C ha^{-1} yr^{-1} (cropland), SOC_{REF} - 78.87 t C ha^{-1} yr^{-1} (grassland)), estimated by the *JRC* and default 20 year time period for stock changes were used for calculations.

$$\Delta C_{Mineral} = \frac{(SOC_0 - SOC_{(0-T)})}{D}$$

$\Delta C_{Mineral}$ - annual change in carbon stocks in mineral soils, tonnes C yr^{-1}

SOC_0 - soil organic carbon stock in final land use category (grassland), tonnes C

$SOC_{(0-T)}$ - soil organic carbon stock in initial land use category, tonnes C

Joint Research Centre estimated SOC_0 and $SOC_{(0-T)}$ values were used at each of the points in time (time = 0 (first year after conversion period - 20 years) and time = 0-T (first year of the begining of conversion period)). Due to the lack of reliable data it is assumed that there are no

organic carbon stock accumulated in settlements and other land categories soils, therefore $SOC_{(0-T)}$ for settlements and other land were indicated as 0 in calculations.
T - number of years over a conversion period, yr

D - Time dependence of stock change factors which is the default time period for transition between equilibrium SOC values, yr

Activity data for accounting of CO_2 emissions due to carbon stock changes resulting from land use changes were obtained from NFI estimations.

Carbon stock changes in mineral soil in land converted to grassland resulted in carbon sink (Figure 6-35), when after the conversion more carbon was stored in grassland soil, comparing to other land uses. The net change in carbon sink in mineral soils was the highest in cropland converted to grassland (in 2005 carbon stock change in cropland converted to grassland reached its peak and was 1,131.03 kt C). However, the lowest carbon stock increase was in settlement converted to grassland (carbon stock changes from 1991 till 2015 was in average of 25 kt C).

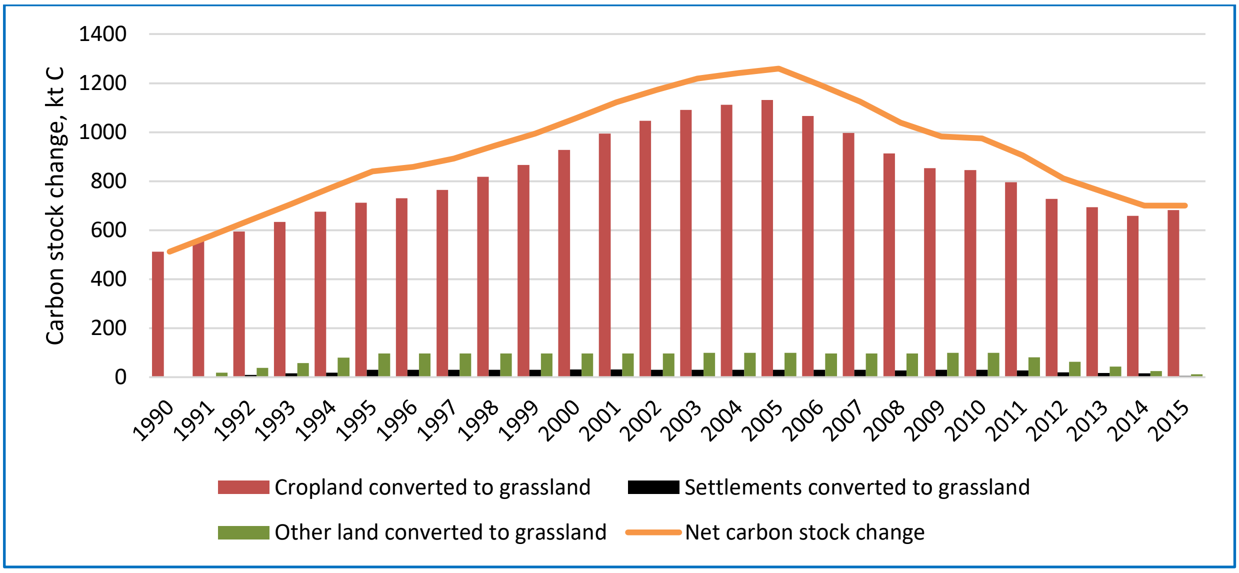


Figure 6-35. Carbon stock changes in mineral soil in land converted to grassland

Organic soils

CO_2 emissions from organic soils were accounted as occurring due to the drainage of organic soils only. Drainage of organic soils have an impact to microbial activity which results in greater decomposition of organic matter accumulated in organic soils, which in turn leads to CO_2 emissions.

Activity data for accounting of CO_2 emissions due to the drainage of organic grassland soils was estimated based on NFI data. It was assumed that Croplands converted to Grasslands has 0.7% share of organic soils from total area of cropland converted to grassland, according to the data of NFI 2012, whereas Settlements and Other Land converted to Grasslands area contain only mineral soils, and finally Wetlands converted to Grasslands contain area exceptionally of organic soils.

Tier 1 method was used in order to calculate carbon stock change in organic soils due to the drainage of organic soils (eq. 2.26, p. 2.35 of *2006 IPCC Guidelines*).

$$L_{Organic} = \sum_c (A \times EF)_c$$

$L_{Organic}$ - annual carbon loss from drained organic soils, tonnes C yr^{-1}

A - land area of drained organic soils in climate type c, ha

EF - emissions 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 climate has been used for calculations (Table 6.3, p. 6.17 of *2006 IPCC Guidelines*).

Non-CO_2 greenhouse gas emissions from biomass burning

Same *Tier 1* approach was used to estimate non-CO_2 emissions from biomass burning in Land Converted to Grassland as for Grassland Remaining Grassland.

Statistics of Fire and rescue department on Grassland area burnt do not provide details to separate Grassland remaining Grassland and Land converted to Grassland, therefore all non-CO_2 greenhouse gas emissions accounted in Grassland remaining Grassland.

Direct N_2O emissions from N mineralization/immobilization

Direct N_2O emissions in land converted to grassland sub-category are resulting from land-use change induced organic carbon stock changes in mineral soils, calculating the amount of N_2O released to the atmosphere as the result of the organic N mineralization after carbon stock in soil has decreased (loss of soil organic carbon occurs after conversion). Direct N_2O emissions due to the drainage of organic soils in grassland are accounted under Agriculture sector, therefore only land converted to grassland activity data is considered while calculating emissions due to carbon stock loss in mineral soils.

There were no other land uses conversions to grassland which could have resulted in carbon stock loss in mineral soils during the whole reporting period, therefore no direct N_2O emissions from N mineralization/immobilization after land use conversion were reported. Carbon stock in grassland mineral soils are greater than in cropland in Lithuania, according to the default values estimated by JRC, therefore no carbon stock loss was reported during inventory period.

6.4.3 Uncertainty assessment

Activity data was obtained from *NLS* and *NFI Study-2*. Default emission factors were employed from *2006 IPCC Guidelines*. The uncertainty rates for activity data and emission factors are reported in the table below.

Table 6-41. Values of uncertainties for Grassland category

Input	Uncertainties, %	References
Activity data		
Grassland area	±2.5	*Study 2, NFI*
Emission factors		
F_{LU} F_{MG} F_I	NA	*2006 IPCC*, p. 6.16
EF (organic soils)	±90	*2006 IPCC*, p. 6.17
EF_1 (N_2O emissions from N inputs)	-70/+300	p. 11.11, *2006 IPCC*

6.4.4 Category-specific QA/QC and verification

The QC/QA includes the quality control activities described in *2006 IPCC Guidelines* and are reported in Chapter 6.2.5. Quality control and quality assurance objectives and procedures for Lithuanian GHG inventory at the national level are presented in Chapter 1.2.3 Quality assurance, quality control and verification plan. The QA/QC of activity data from State Forest Service is explained in Chapter 6.2.5, the use of country specific data is described in the inventory report. Country specific data used in inventory was included in the report. The QC procedures are performed according to the QA/QC plan in order to attain these quality objectives in LULUCF, the comments received after QA/QC procedures while reviewing the report are taken into account and errors found were corrected.

Some obscurities concerning direct N_2O emissions estimation were clarified after QA procedure performed by Norwegian LULUCF GHG inventory experts under the "Partnership project on Greenhouse gas inventory" in the framework of the programme LT10.

6.4.5 Category-specific recalculation

Differences between 2016 and 2017 year submissions occur due to the misinterpretation of organic soil share in total land converted to grassland area (cropland converted to grassland area). Recalculation of organic soil share in total cropland converted to grassland area resulted both in differences of carbon stock changes in mineral and organic soils in land converted to grassland category in different submission years. In addition to this, emissions from drained organic soils in grassland remaining grassland category were recalculated. Recalculations were done due to the fact that not all organic grassland soils are drained in Lithuania as it was reported previously, which caused overestimation of emissions from drained organic grassland soils. Errors in calculations of carbon stock changes and emissions/removals from mineral and organic soils were corrected and reported in this submission (Tables 6-42, 6-43, 6-44).

Table 6-42. Reported in previous submission and recalculated net carbon stock changes in mineral soils, kt C (cropland converted to grassland)

Year	2016 submission	2017 submission	Absolute difference	Relative difference, %
1990	567.85	511.80	-56.04	-9.87
1991	614.84	554.16	-60.68	-9.87
1992	659.42	594.34	-65.08	-9.87
1993	703.02	633.64	-69.38	-9.87
1994	749.54	675.56	-73.97	-9.87
1995	790.23	712.25	-77.99	-9.87
1996	810.58	730.59	-80.00	-9.87
1997	848.86	765.09	-83.77	-9.87
1998	907.49	817.93	-89.56	-9.87
1999	961.75	866.84	-94.92	-9.87
2000	1,029.58	927.97	-101.61	-9.87
2001	1,102.74	993.91	-108.83	-9.87
2002	1,160.88	1046.32	-114.57	-9.87
2003	1,209.82	1090.42	-119.40	-9.87
2004	1,234.05	1112.26	-121.79	-9.87
2005	1,254.88	1131.03	-123.85	-9.87
2006	1,183.17	1066.40	-116.77	-9.87
2007	1,106.62	997.41	-109.21	-9.87

2008	1,013.59	913.56	-100.03	-9.87
2009	947.22	853.73	-93.48	-9.87
2010	938.49	845.87	-92.62	-9.87
2011	882.78	795.65	-87.12	-9.87
2012	808.16	728.40	-79.76	-9.87
2013	770.37	694.34	-76.03	-9.87
2014	731.12	658.97	-72.16	-9.87

Table 6-43. Reported in previous submission and recalculated net emissions/removals from drained organic soils, kt CO_2 (grassland remaining grassland)

Year	2016 submission	2017 submission	Absolute difference	Relative difference, %
1990	80.81	63.11	-17.70	-21.90
1991	80.27	62.69	-17.58	-21.90
1992	79.92	62.42	-17.51	-21.90
1993	79.46	62.06	-17.41	-21.90
1994	79.08	61.76	-17.32	-21.90
1995	78.81	61.55	-17.26	-21.90
1996	78.50	61.31	-17.20	-21.90
1997	78.19	61.07	-17.13	-21.90
1998	77.85	60.80	-17.05	-21.90
1999	77.66	60.65	-17.01	-21.90
2000	77.39	60.44	-16.95	-21.90
2001	77.19	60.29	-16.91	-21.90
2002	76.81	59.99	-16.83	-21.90
2003	76.46	59.71	-16.75	-21.90
2004	75.89	59.26	-16.62	-21.90
2005	75.35	58.84	-16.51	-21.90
2006	74.70	58.33	-16.36	-21.90
2007	74.35	58.06	-16.29	-21.90
2008	73.81	57.64	-16.17	-21.90
2009	73.47	57.37	-16.09	-21.90
2010	73.16	57.13	-16.03	-21.90
2011	77.19	60.29	-16.91	-21.90
2012	80.62	62.96	-17.66	-21.90
2013	81.81	63.89	-17.92	-21.90
2014	81.96	64.01	-17.95	-21.90

Table 6-44. Reported in previous submission and recalculated emissions/removals from drained organic soils, kt CO_2 (cropland converted to grassland)

Year	2016 submission	2017 submission	Absolute difference	Relative difference, %
1990	45.06	35.19	-9.87	-21.90
1991	48.78	38.10	-10.69	-21.90
1992	52.32	40.86	-11.46	-21.90
1993	55.78	43.56	-12.22	-21.90
1994	59.47	46.44	-13.03	-21.90
1995	62.70	48.97	-13.73	-21.90
1996	64.32	50.23	-14.09	-21.90
1997	67.35	52.60	-14.75	-21.90
1998	72.00	56.23	-15.77	-21.90

1999	76.31	59.59	-16.72	-21.90
2000	81.69	63.80	-17.89	-21.90
2001	87.50	68.33	-19.17	-21.90
2002	92.11	71.93	-20.18	-21.90
2003	95.99	74.97	-21.03	-21.90
2004	97.92	76.47	-21.45	-21.90
2005	99.57	77.76	-21.81	-21.90
2006	93.88	73.32	-20.56	-21.90
2007	87.80	68.57	-19.23	-21.90
2008	80.42	62.81	-17.62	-21.90
2009	75.16	58.69	-16.46	-21.90
2010	74.47	58.15	-16.31	-21.90
2011	70.04	54.70	-15.34	-21.90
2012	64.12	50.08	-14.05	-21.90
2013	61.13	47.74	-13.39	-21.90
2014	58.01	45.30	-12.71	-21.90

6.4.6 Category-specific planned improvements

Lithuania has finished research on carbon stock evaluation in forest land, cropland and grassland soils, which was funded by the Norway Grants programme under the "Partnership project on Greenhouse gas inventory" in the framework of the programme LT10 "Capacity-building and institutional cooperation between beneficiary State and Norwegian public institutions, local and regional authorities". The aim of the research was to obtain national carbon stock values in soils in different land uses (SOC_{REF}) and Lithuania is planning to include national values for estimation of carbon stock changes in soils in the next submission.

6.5 Wetland (CRF 4.D)

Wetlands include peat extraction areas and peatlands which do not fulfil the definition of other categories. Water bodies, such as natural rivers and lakes, as well as reclamation canals, ponds and meres, and swamps (bogs) are also included under this category. Peat extraction areas and flooded land 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[191]. However, according to the historical studies of land use changes in 1990-2011 and recent NFI data, wetland area has slightly decreased from 363.07 thous. ha in 1990 to 341.1 thous. ha in 2015.

The total CO_2 emissions from wetlands have been ranging since 1990. Even though the area of wetlands was slightly decreasing till 2015, there was the tendency of increasing CO_2 emissions. The CO_2 emissions in wetlands were 965.2 kt CO_2 in 2015, however, despite the tendency of slightly increasing emissions, in 2009 emissions in wetland were the highest and reached 1,042.1 kt CO_2, while until 2015 it again decreased around 7 %. The largest emissions from wetlands category originate from wetlands remaining wetlands – peat extraction areas (in 2015 emissions were 960.15 kt CO_2). Emissions from conversion of grassland, cropland and forest land to flooded land were not assessed annually and were minor comparing to the total emissions.

[191] 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

There were minor changes made in wetland category in latest reporting. Total wetland area was changed from reporting only managed wetland area (unmanaged wetlands excluding), to reporting of total wetland area in a country, including both managed and unmanaged wetlands. Total wetland area corrections resulted neither in carbon stock changes in pools, nor in changes of total CO_2 emissions from sources and removals by sinks, as emissions and removals were calculated from managed wetland area only as in previous submissions.

6.5.1 Category description

Two source categories are accounted under this category: emissions from Wetlands remaining Wetlands and emissions from Land converted to Wetlands.

Data on wetland area were taken from the *Study-2* (1990-2011) and *NFI* (since 2012). Wetlands remaining Wetlands area distributed into separate groups of unmanaged, peat extraction areas (monitored by Lithuanian Geological Service), managed flooded and other managed (degraded drained bogs). Estimated emissions are summarized in Table 6-45, emissions from unmanaged Wetlands were not estimated.

Table 6-45. Estimated GHG emissions from managed Wetlands

Land Use Category	CO_2	CH_4	N_2O
Peatlands Remaining Peatlands	√	NO	√
Land Being Converted for Peat Extraction	NO	NO	NO
Flooded Land Remaining Flooded Land	NO	NO	NO
Land Converted to Flooded Land	√	NO	NO

6.5.2 Methodological issues

6.5.2.1 Peatlands remaining Peatlands

CO_2 emissions

Default *Tier 1* method was used to estimate emissions from peatlands with undergoing active peat extraction (eq. 7.3, p. 7.9 of *2006 IPCC*). On-site emissions were estimated using eq. 7.4 (p. 7.11 of *2006 IPCC Guidelines*), off-site emissions from peat extraction were estimated using eq. 7.5 (p. 7.11 of *2006 IPCC Guidelines*).

$$CO_2 - C_{WW_{peat}} = CO_2 - C_{WW_{peat_{off-site}}} + CO_2 - C_{WW_{peat_{on-site}}}$$

$CO_2 - C_{WW_{peat}}$ - CO_2-C emissions from managed peatlands, Gg C yr^{-1}

$CO_2 - C_{WW_{peat_{off-site}}}$ - off-site emissions from peat removed for horticultural use, Gg C yr^{-1}

$CO_2 - C_{WW_{peat_{on-site}}}$ - on-site emissions from peat deposits (all production phases), Gg yr^{-1}

$$CO_2 - C_{WW_{peat_{on-site}}} = \left[\frac{\left(A_{peatRich} \times EF_{CO_{2}{}_{peatRich}}\right) + \left(A_{peatPoor} \times EF_{CO_{2}{}_{peatPoor}}\right)}{1000}\right] + \Delta C_{WW_{peat_B}}$$

$A_{peatRich}$ – area of nutrient-rich peat soils managed for peat extraction (all production phases), ha

$A_{peatPoor}$ – area of nutrient-poor peat soils managed for peat extraction (all production phases), ha

$EF_{CO_{2peatRich}}$ – CO_2 emission factors for nutrient-rich peat soils managed for peat extraction or abandoned after peat extraction, tonnes C ha^{-1} yr^{-1}

$EF_{CO_{2peatPoor}}$ – CO_2 emission factors for nutrient-poor peat soils managed for peat extraction or abandoned after peat extraction, tonnes C ha^{-1} yr^{-1}

$\Delta C_{WW_{peat_B}}$ – CO_2-C emissions from change in carbon stocks in biomass due to vegetation clearing, Gg C yr^{-1}

$$CO_2 - C_{WW_{peat_{off-site}}} = \frac{(Wt_{dry\_peat} \times Cfraction_{wt\_peat})}{1000}$$

Wt_{dry_peat} – air-dry weight of extracted peat, tonnes yr^{-1}

$Cfraction_{wt\_peat}$ – carbon fraction of air-dry peat by weight, tonnes C (tonne of air-dry peat)$^{-1}$

Default emission factors from Table 7.4 (p. 7.13 of *2006 IPCC Guidelines*) were used:

- 0.2 t C ha^{-1} yr^{-1} for nutrient poor peatlands,
- 1.1 t C ha^{-1} yr^{-1} for nutrient rich peatlands.

Default emission factors from Table 7.5 (p. 7.13 of *2006 IPCC Guidelines*) were considered while estimating and using national C fraction value for peatlands of air-dry peat by weight – 0.43 tonnes C (tonne air-dry peat)$^{-1}$:

- 0.45 tonnes C (tonne air-dry peat) for nutrient poor peatlands,
- 0.40 tonnes C (tonne air-dry peat) for nutrient rich peatlands.

Off-site emissions were estimated using eq. 7.5 (p. 7.11 of *2006 IPCC Guidelines*), along with expert judgement made on weight conversion factor 0.43 tonnes C. Area of managed peatlands is continuously decreasing since 1990 (no new peat extraction sites established since then), therefore changes in C stocks in living biomass on managed peatlands are assumed to be zero.

Non-CO_2 emissions

Default *Tier 1* method was applied to estimate non-CO_2 emissions from Peatlands remaining Peatlands. CH_4 emissions are assumed to be insignificant in these drained peatlands.

N_2O emissions from drained wetlands estimated using eq. 7.7 (p. 7.15 of *2006 IPCC*). Default emission factor from Table 7.6 (p. 7.16 of *2006 IPCC Guidelines*) has been used – 1.8 kg N_2O-N ha^{-1} yr^{-1} for nutrient rich peatlands.

$$N_2O_{WW_{peatExtraction}} = \left(A_{peatRich} \times EF_{N_2O-N_{peatRich}}\right) \times \frac{44}{28} \times 10^{-6}$$

$N_2O_{WW_{peatExtraction}}$ – direct N_2O emissions from peatlands managed for peat extraction, Gg N_2O yr^{-1}

$A_{peatRich}$ – area of nutrient-rich peat soils managed for peat extraction, including abandoned areas in which drainage is still present, ha

$EF_{N_2O-N_{peatRich}}$ – emission factor for drained nutrient-rich wetlands organic soils, kg N_2O-N ha^{-1} yr^{-1}

Tier 1 method only considers nutrient-rich peatlands.

6.5.2.2 Land Being Converted for Peat Extraction

The area of managed peatlands is continuously decreasing since 1990, therefore no new areas of Land converted for peat extraction have been reported.

6.5.2.3 Flooded Land Remaining Flooded Land

The area of flooded lands covers more than 90,000 ha in Lithuania. Neither default *2006 IPCC Guidelines* methodology is provided for Flooded Land remaining Flooded Land emissions estimation, nor preliminary estimates of CH_4 emissions from this source have been developed in Lithuania, therefore no emissions or removals were reported under the subcategory of flooded land remaining flooded land.

6.5.2.4 Other wetlands Remaining Other wetlands

Other wetlands remaining other wetlands consists of unmanaged wetlands and previously managed wetlands which are damaged and currently not managed. Since no active management takes place in such areas and no default estimation methods are provided, no carbon stock changes are reported in this category.

6.5.2.5 Land Converted to Flooded Land

The area of sub-category land converted to wetland in country has been increasing with higher extent with flooding of areas with organic soils than areas with mineral soils. Mineral soil conversion to wetland was mainly related with small areas of forest and other land flooding. As for the other land-use categories, for land converted to flooded land 20 year conversion period is required to account for flooded land remaining flooded land, therefore each area of land converted to flooded land up to 20 years since conversion is accounted for land converted to flooded land sub-category. Area of land converted to flooded land is relatively small in Lithuania, consisting of 3.60 thous. ha (0.05% of country area) in 1990 and 9.98 thous. ha (0.15% of country area) in 2015.

CO_2 emissions

Carbon stock change due to land conversion to permanently flooded land was estimated employing eq. 7.10 (p. 7.20 of *2006 IPCC Guidelines*). Area estimates for Land Converted to Flooded Land were disaggregated according to prevailing vegetation and average carbon stock change in biomass per hectare was estimated for each type of conversion. It was assumed that carbon stock in biomass after conversion is zero (default value of *2006 IPCC Guidelines* was used).

$$\Delta C_{LWflood_{LB}} = \left[\sum_i A_i \times \left(B_{After_i} - B_{Before_i}\right)\right] \times CF$$

$$CO_{2\_LWflood} = \Delta C_{LWflood_{LB}} \times -\frac{44}{28}$$

$\Delta C_{LWflood_{LB}}$ – annual change in carbon stocks in biomass on Land converted to Flooded land, tonnes C yr^{-1}

A_i – area of land converted annually to *Flooded land* from original land use *i*, ha yr^{-1}

B_{After_i} – biomass immediately following conversion to *Flooded land*, tonnes d. m. ha^{-1} (default = 0)

B_{Before_i} – biomass in land immediately before conversion to *Flooded land*, tonnes d. m. ha^{-1}

CF - carbon fraction of dry matter (default = 0.5), tonnes C (tonne d. m.)$^{-1}$

2006 IPCC Guidelines does not provide methodology on estimations of carbon stock changes in soils due to land conversion to Flooded Land.

Non-CO_2 emissions

No preliminary estimates of CH_4 emissions from this source have yet been developed in Lithuania.

Direct N_2O emissions from N mineralization/immobilization

Direct N_2O emissions are produced naturally in soils through the processes of nitrification and denitrification, however, management of soils could have an impact to increase such emissions. Changes in inorganic N pool in soils, resulting in direct or indirect emissions of N_2O, could be affected by human induced net N additions to the soils (synthetic and organic fertilizers, etc.), changes of soil organic carbon (due to the drainage/management of organic soils, cultivation/land-use change on mineral soils), resulting in changes of soil C:N ratio, which in turn leads to emissions. The amount of N_2O released to the atmosphere is calculated as the result of the organic N mineralization after carbon stock in soil has decreased (loss of soil organic carbon occurs after conversion).

Direct N_2O emissions from mineral soils in wetlands category are resulting only from changes of soil organic carbon due to forest land converted to wetlands. Direct N_2O emissions due to the drainage of organic soils in wetland (peat extraction sites) are reported in Table 4 (II) as N_2O emissions from drainage of organic soils.

For the accounting of direct N_2O emissions from LULUCF sector default *2006 IPCC Guidelines Tier 1* methodology was used (with *Tier 2* requirements of disaggregation of individual land-use types while accounting direct N_2O emissions due to the loss of soil organic carbon resulting from land-use changes). Slightly modified (reduced) equation 11.1 (p. 11.7 of *2006 IPCC Guidelines*) was implemented:

$$N_2O_{Direct} - N = N_2O - N_{N\ Inputs}$$

$N_2O_{Direct} - N$ – annual direct N_2O-N emissions, produced from managed soils, kg N_2O-N yr^{-1}

$N_2O - N_{N\ Inputs}$ – annual direct N_2O-N emissions from N inputs to managed soils, kg N_2O-N yr^{-1}

$$N_2O - N_{N\ Inputs} = F_{SOM} \times EF_1$$

F_{SOM} – annual amount of N in mineral soils that is mineralized, in association with loss of soil C from soil organic matter as a result of changes to land use or management, kg N yr^{-1}

EF_1 – emission factor for N_2O emissions from N inputs, kg N_2O-N (kg N input)$^{-1}$

Equation 11.8 (p. 11.16 *of 2006 IPCC Guidelines*) was used for estimation of amount of N in mineral soils that is mineralized in association with loss of soil C from soil organic matter:

$$F_{SOM} = \sum_{LU} \left[\left(\Delta C_{Mineral,LU} \times \frac{1}{R} \right) \times 1000 \right]$$

$\Delta C_{Mineral,LU}$ – average annual loss of soil carbon for each land-use type (*LU*), tonnes C (according to *Tier 2 methodology*, value was disaggregated by individual land-uses)

R - C:N ratio of the soil organic matter. A default value of 15 (uncertainty range from 10 to 30) for the C:N ratio (R) may be used for situations involving land-use change from Forest land or Grassland to Cropland, in the absence of more specific data for the area.

LU - land-use type

Default emission factor used in calculations of direct N_2O emissions due to the loss of soil organic carbon:

- EF_1 – 0.01 kg N_2O-N (kg N input)$^{-1}$ (Table 11.1, p. 11.11 of *2006 IPCC Guidelines*)

Carbon stock loss after forest land converted to wetlands was used as activity data for direct N_2O emissions estimation from N mineralization/immobilization.

Indirect N_2O emissions from leaching and runoff

Lithuania is located in surplus precipitation zone, therefore a certain amount of precipitation forms both surface and underground runoff annually. According to "Geography of Lithuanian waters"[192], runoff in Lithuania varies among 25 – 50 percent of precipitation, on the basis of terrain, soil, etc. In addition to the direct N_2O emissions resulting from carbon stock change (loss) after land use change, indirect N_2O emissions also take place through runoff. Some of the inorganic (mineralized due to the carbon stock decrease after land use change) N does not take part in biological retention processes, therefore is removed with surface water flow (runoff) or through soil and afterwards is transformed into N_2O. Indirect N_2O emissions for all land use categories where direct N_2O emissions from N mineralization/immobilization due to carbon stock change after land use change occur are calculated using the same default *2006 IPCC methodology* – eq. 11.10 (*Tier1* method).

$$N_2O_{(L)}\text{-}N = F_{SOM} \times Frac_{LEACH-(H)} \times EF_5$$

$N_2O_{(L)}$-N – annual amount of N_2O-N produced from leaching and runoff of N additions to managed soils in regions where where leaching/runoff occurs, kg N_2O-N yr^{-1}

F_{SOM} – annual amount of N mineralized in mineral soils associated with loss of soil C from soil organic matter as a result of changes in to land use or management in regions where leaching/runoff occurs, kg N yr^{-1} (from eq. 11.8)

$Frac_{LEACH-(H)}$ – fraction of all N added to/mineralized in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff, kg N (kg of N additions)$^{-1}$, default value, 0.3 (Table 11.3, p. 11.24 of *2006 IPCC Guidelines*).

[192] Kilkus K., Stonevicius E., 2011. Geography of Lithuanian waters, textbook. Available at: http://www.hkk.gf.vu.lt/publikacijos/2011_Lietuvos_vandenu_geografija.pdf

EF_5 – emission factor for N_2O emissions from N leaching and runoff, kg N_2O-N (kg N leached and runoff)$^{-1}$, default value, 0.0075 (Table 11.3, p. 11.24 of *2006 IPCC Guidelines*).

6.5.3 Uncertainty assessment

Major CO_2 emissions from Wetlands were evaluated as a result of peat extraction from peat extraction areas remaining peat extraction areas. Due to the fact that there were no new permissions issued for peat extraction activities, no conversions to peat extraction areas were detected in recent years, therefore only forest land and other land conversions to Wetlands (flooded land) are reported occasionally and have an impact to the overall emissions from the category. Converted areas are relatively small and based on expert judgment it was assumed that uncertainty of activity data is about 80%. Emission factor uncertainty was assumed to be about 20%, while uncertainty of activity data of peat extraction areas is 6.1 % approximately.

For other conversions uncertainty of activity data assumed to be 50% (p. 7.17 of *2006 IPCC Guidelines*), emission factor uncertainty assumed to be about 100% (p. 7.16 of *2006 IPCC Guidelines*).

6.5.4 Category-specific QA/QC and verification

The QC/QA is based on quality control activities described in *2006 IPCC Guidelines* (Vol 1, Chapter 6, Table 6.1). Quality control and quality assurance objectives and procedures for Lithuanian GHG inventory at the national level are presented in Chapter 1.2.3 Quality assurance, quality control and verification plan. The QA/QC of activity data from State Forest Service is explained in Chapter 6.2.5, the use of country specific data is described in the inventory report.

The QC procedures are performed according to the QA/QC plan in order to attain these quality objectives in LULUCF, the comments received after QA/QC procedures while reviewing the report are taken into account and errors found were corrected.

Some obscurities concerning direct N_2O emissions estimation were clarified after QA procedure performed by Norwegian LULUCF GHG inventory experts under the "Partnership project on Greenhouse gas inventory" in the framework of the programme LT10.

6.5.5 Category-specific recalculation

No category specific recalculations took place in the 2017 submission, however, there are some differences between 2016 and 2017 year submissions – possible double accounting was corrected. In 2016 the same N_2O emissions from peatland extraction sites (peatland remaining peatland) were reported in Table 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils and Table 4(III) Direct N_2O emissions from N mineralization/immobilization (as occurring due to the loss of soil organic carbon after drainage), therefore this year in Table 4(III) it was reported as IE (included in Table 4(II)). In addition to this, direct N_2O emissions, resulting from N mineralization/immobilization after land-use change induced carbon stock change (decrease) in mineral soils were reported in land converted to wetlands (forest land converted to wetlands category). Differences between 2016 and 2017 year submissions are presented in the table below. Largest difference in year 1997 occurred due to the error in value of GHG emissions from drainage of organic soils in peat extraction areas included in CRF reporter. Differences in years 1999, 2003, 2004 and 2009 in 2017 submission occurred due to the direct N_2O emissions from N mineralization/immobilization after forest land converted to wetland included in this year submission.

Table 6-46. Reported in previous submission and recalculated emissions/removals from wetlands, kt CO_2

Year	2016 submission	2017 submission	Absolute difference	Relative difference, %
1990	529.25	523.29	-5.96	-1.13
1991	562.20	556.24	-5.96	-1.06
1992	589.93	583.97	-5.96	-1.01
1993	346.04	340.67	-5.36	-1.55
1994	743.35	737.09	-6.26	-0.84
1995	452.80	446.54	-6.26	-1.38
1996	469.93	463.67	-6.26	-1.33
1997	545.47	488.85	-56.62	-10.38
1998	354.30	348.64	-5.66	-1.60
1999	788.33	791.64	3.31	0.42
2000	472.27	466.31	-5.96	-1.26
2001	478.69	472.73	-5.96	-1.25
2002	849.71	844.94	-4.77	-0.56
2003	756.33	761.12	4.80	0.63
2004	763.68	768.18	4.50	0.59
2005	884.76	880.00	-4.77	-0.54
2006	785.03	780.26	-4.77	-0.61
2007	524.07	519.31	-4.77	-0.91
2008	864.21	859.45	-4.77	-0.55
2009	1037.90	1042.10	4.20	0.40
2010	553.49	548.72	-4.77	-0.86
2011	644.42	639.65	-4.77	-0.74
2012	646.73	641.96	-4.77	-0.74
2013	887.95	883.19	-4.77	-0.54
2014	897.03	892.27	-4.77	-0.53

6.5.6 Category-specific planned improvements

Category-specific improvements are not planned.

6.6 Settlement (CRF 4.E)

NLS indicates two subcategories under settlements category – built-up area and roads. All urban territories, power lines, traffic lines and roads as well as orchards and berry plantations planted in small size household areas and used only 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 under settlements category.

The area of settlements in Lithuania has been increasing with low extent. In 1990 the land of settlements category had occupied 324 kha of country land, thus, till 2015 area of settlements increased almost by 30 kha. However, if to compare the intensity of area conversion to settlements, it was certain that area where settlements remained settlements was not changing distinctly and occupied on the average of 316 kha. The increase in the area of land converted to settlements was evident. In 1991 the area of land converted to settlements was 3.2 kha, thus, in 2015 distribution of area reached 29.2 kha.

Emissions/removals of CO_2 from this land-use category is accounted only for sub-category of land converted to settlements due to the lack of sufficient and reliable data of carbon stock changes in settlements remaining settlements.

6.6.1 Category description

The carbon pools estimated for Settlements include carbon stock changes in pools – above-ground biomass and soil. Two source categories are accounted under this category: emissions from Settlements remaining Settlements and emissions from Land converted to Settlements, following methodology of *2006 IPCC Guidelines* (sections 8.2 and 8.3).

6.6.2 Methodological issues

6.6.2.1 Settlements remaining Settlements

Areas continuously managed as a Settlements and areas converted to Settlements after 20 consecutive years of conversion are reported in the category Settlements remaining Settlements (SS).

Carbon stock changes in living biomass

Lithuania has no appropriate activity data and/or developed emission factors. Therefore *Tier 1* approach was used, which assumes that there is no change in carbon stocks in living biomass in Settlements Remaining Settlements; in other words, the growth and loss are in terms of balance. This method assumes that changes in biomass carbon stocks due to growth are fully offset by decreases in carbon stocks due to removals (i.e., by harvest, pruning, clipping) from both living and dead biomass (e.g. fuelwood, broken branches, etc.). Therefore, according to *Tier 1* method $\Delta C_G = \Delta C_L$ for all plant components, and $\Delta C_B = 0$ (eq. 2.7, p. 2.12 of *2006 IPCC Guidelines*).

$$\Delta C_B = \Delta C_G - \Delta C_L$$

ΔC_B - annual change in carbon stocks in biomass (considering only above-ground biomass in the case of changes in woody crop biomass accounting), considering total area, tonnes C yr^{-1}

ΔC_G - annual increase in carbon stocks due to biomass growth, considering the total area, tonnes C yr^{-1}

ΔC_L - annual decrease in carbon stock due to biomass loss, considering the total area, tonnes c yr^{-1}

Carbon stock changes in dead organic matter

Tier 1 method assumes that dead wood and litter stocks are at equilibrium, there is no need to estimate carbon stock changes for these pools, so it is reported as NO.

Carbon stock changes in soil organic matter

Mineral soils

According to *Tier 1* method inputs are equal to outputs and it means that soil C stocks do not significantly change in Settlements Remaining Settlements, therefore it is reported as NO.

Organic soils

No organic soils were estimated in this category, so it is reported as NO. Organic soils are accounted only under Forest Land, Croplands, Grassland and Wetlands categories.

6.6.2.2 Land converted to Settlement

The cumulative areas during the 20 year transition period are reported in Figure 6-36. For each year, the cumulative total area reported under Land converted to Settlements category accounted as equal to cumulative area that has been converted to that land use over the last 20 years, areas of second land-use change during the 20 year conversion period subtracted by the cumulative total.

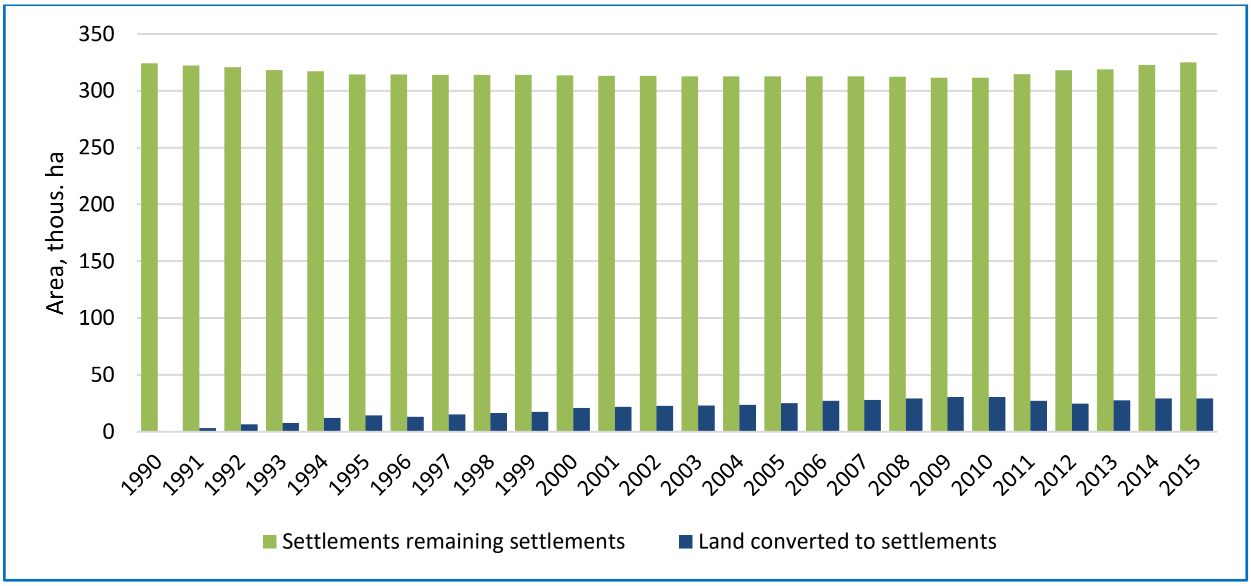


Figure 6-36. Settlements area changes during 1990 - 2015, thous. ha

All land conversions to Settlements (SL) except conversion of Forest land accounted as Land converted to Settlements.

The total CO_2 emissions from settlements in 1991 was 44.88 kt CO_2 eqv. and further have been increasing (Figure 6-37). The CO_2 emissions from settlements till 2015 increased almost 9 times (CO_2 emissions in 2015 were 412.80 kt CO_2 eqv.). Mainly cropland and grassland conversion to settlements has been increasing the net CO_2 emissions. CO_2 emissions from cropland converted to settlements have been on the average of 116.08 kt CO_2 eqv., thus, in 2015 CO_2 emissions slightly decreased due to the decreased are of cropland converted to settlements and reached 94.17 kt CO_2 eqv. The CO_2 emissions in settlements converted from grassland were ranging in higher extent, from 22.59 (in 1991) to 287.56 kt CO_2 eqv. (in 2015).

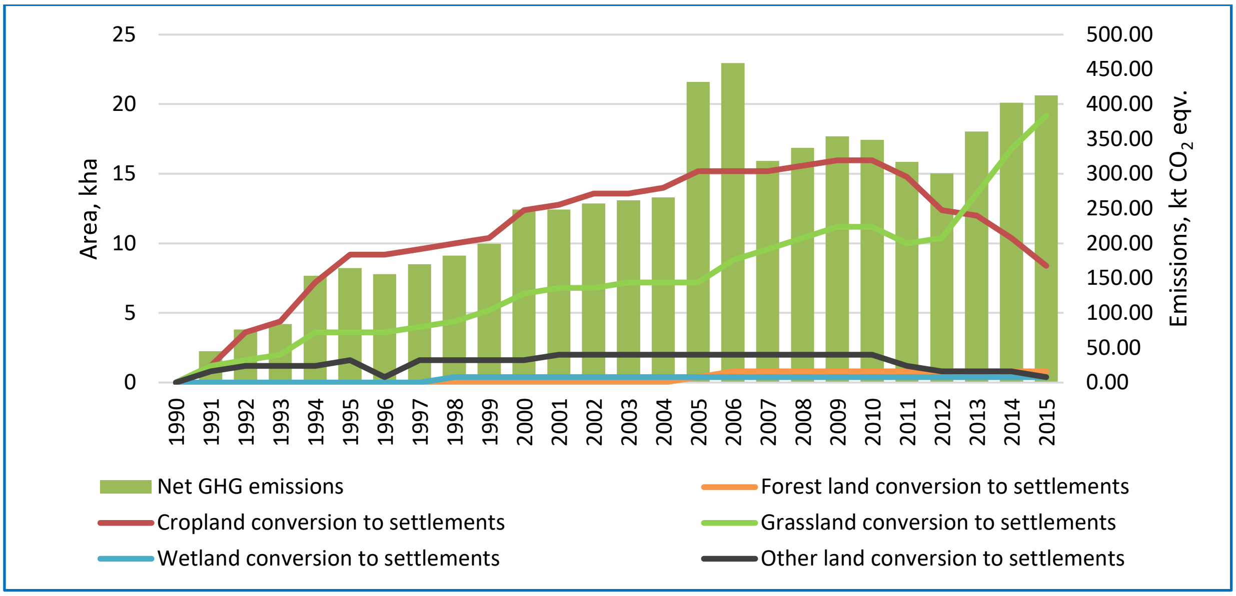


Figure 6-37. Area of land converted to settlements, thous. ha and total CO_2 emissions, kt CO_2 eqv.

Carbon stock changes in living biomass

Tier 2 was used to estimate annual change in carbon stocks in living biomass on Land converted to Settlements employing the eq. 2.15 and 2.16 (Ch. 2, p. 2.20 of *2006 IPCC Guidelines*). Area estimates for Land Converted to Settlements were disaggregated according to prevailing vegetation and average carbon stock change on a per hectare basis is estimated for each type of conversion.

$$\Delta C_B = \Delta C_G + \Delta C_{CONVERSION} - \Delta C_L$$

ΔC_B - annual change in carbon stocks in biomass on land converted to other land-use category, in tonnes C yr^{-1}

ΔC_G - annual increase in carbon stocks in biomass due to growth on land converted to another land-use category, in tonnes C yr^{-1}

$\Delta C_{CONVERSION}$ - initial change in carbon stocks in biomass on land converted to other land-use category, in tonnes C yr^{-1}

ΔC_L - annual decrease in biomass carbon stocks due to the losses from harvesting, fuel wood gathering and disturbances on land converted to other land use category, in tonnes C yr^{-1}

$$\Delta C_{CONVERSION} = \sum_i \{(B_{AFTERi} - B_{BEFOREi}) \times \Delta A_{TO\_OTHERSi}\} \times CF$$

$\Delta C_{CONVERSION}$ - initial change in biomass carbon stocks on land converted to another land category, tonnes C yr^{-1}

B_{AFTERi} - biomass stocks on land type *i* immediately after the conversion, tonnes d. m. ha^{-1}

$B_{BEFOREi}$ - biomass stocks on land type *i* before the conversion, tonnes d. m. ha^{-1}

$\Delta A_{TO\_OTHERSi}$ - area of land-use *i* converted to other land-use category in a certain year, ha yr^{-1}

CF - carbon fraction of dry matter, tonnes C (tonnes d. m.)$^{-1}$

i - type of land use converted to another land-use category

For calculation of carbon stock changes caused by conversion of Wetland, Cropland and Grassland to Settlements, it was assumed that all above ground biomass as well as dead wood and organic matter from litter was removed entirely as a result of conversion.

Biomass carbon stock in initial land-use categories (B_{BEFORE}) are assumed to be 2.4 t ha^{-1} d. m. in Croplands, Grasslands and Wetlands, 0.0 t ha^{-1} d. m. in Other Land.

Carbon stock changes in dead organic matter

Lithuania has no estimates of the dead wood and litter in the initial land-use systems (except FL) prior to conversion. Therefore it is assumed that dead wood and litter stocks are not significant before the conversion to settlements and are reported as NO.

Carbon stock changes in soil organic matter

Estimations of change in C stocks in mineral soils and organic soils in Lands converted to Settlements were based on guidance for estimating changes in soil C stocks, provided in Section 2.3.3 (Ch. 2 of *2006 IPCC Guidelines*). Carbon stock changes in land converted to settlements were accounted due to the loss of soil organic carbon after land use change, while it is assumed that organic carbon stock in settlements category is zero, CO_2 emissions from organic soils in land converted to settlements sub-category occur due to the drainage of organic soils. Activity data is obtained from State Forest Service, compiled during NFI measurements.

Mineral soils

CO_2 emissions from mineral soils are accounted as changes of soil organic carbon stocks, multiplying the area of certain land use converted to settlements with carbon stock change factor accounted as difference between two organic carbon pools (initial land use and settlements) divided by a 20 year period of conversion.

Calculation of carbon stocks in mineral soils on Lands converted to Settlements were based on eq. 2.25 (Ch. 2, p.2.30 of *2006 IPCC*). Country-specific reference C stocks (SOC_{REF} - 54.38 t C ha^{-1} yr^{-1} (cropland), SOC_{REF} - 78.87 t C ha^{-1} yr^{-1} (grassland)), estimated by the *JRC* and default 20 year time period for stock changes were used for calculations.

$$\Delta C_{Mineral} = \frac{(SOC_0 - SOC_{(0-T)})}{D}$$

$\Delta C_{Mineral}$ - annual change in carbon stocks in mineral soils, tonnes C yr^{-1}

SOC_0 - soil organic carbon stock in final land use category (grassland), tonnes C

$SOC_{(0-T)}$ - soil organic carbon stock in initial land use category, tonnes C

Joint Research Centre estimated SOC_0 and $SOC_{(0-T)}$ values were used at each of the points in time (time = 0 (first year after conversion period - 20 years) and time = 0-T (first year of the beginning of conversion period)). Due to the lack of reliable data it is assumed that there are no organic carbon stock accumulated in settlements and other land categories soils, therefore $SOC_{(0-T)}$ for settlements and other land were indicated as 0 in calculations.
T - number of years over a conversion period, yr

D = Time dependence of stock change factors which is the default time period for transition between equilibrium SOC values, yr

Activity data for accounting of CO_2 emissions due to carbon stock changes resulting from land use changes were obtained from NFI estimations.

Organic soils

CO_2 emissions from organic soils are accounted as a result of drainage enhanced microbial activity, which means greater decomposition of organic matter accumulated in organic soils and higher CO_2 emissions. Emissions from drainage of organic soils due to conversion to settlements category occur only from wetlands converted to cropland.

Tier 1 method was used in order to calculate carbon stock change in organic soils due to the drainage of organic soils (eq. 2.26, p. 2.35 of *2006 IPCC Guidelines*).

$$L_{Organic} = \sum_c (A \times EF)_c$$

$L_{Organic}$ - annual carbon loss from drained organic soils, tonnes C yr^{-1}

A - land area of drained organic soils in climate type c, ha

EF - emissions 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 climate has been used for calculations (Table 6.3, p. 6.17 of *2006 IPCC Guidelines*).

Direct N_2O emissions due to N mineralization/immobilization

Direct N_2O emissions in land converted to settlements sub-category are resulting from land-use change induced organic carbon stock loss in mineral soils, calculating the amount of N_2O released to the atmosphere as the result of the organic N mineralization after carbon stock in soil has decreased (loss of soil organic carbon occurs after conversion).

For the accounting of direct N_2O emissions from LULUCF sector default *2006 IPCC Guidelines Tier 1* methodology was used (with *Tier 2* requirements of disaggregation of individual land-use types while accounting direct N_2O emissions due to the loss of soil organic carbon resulting from land-use changes). Slightly modified (reduced) equation 11.1 (p. 11.7 of *2006 IPCC Guidelines*) was implemented:

$$N_2O_{Direct} - N = N_2O - N_{N\ Inputs} + N_2O - N_{OS}$$

$N_2O_{Direct} - N$ – annual direct N_2O-N emissions, produced from managed soils, kg N_2O-N yr^{-1}

$N_2O - N_{N\ Inputs}$ – annual direct N_2O-N emissions from N inputs to managed soils, kg N_2O-N yr^{-1}

$$N_2O - N_{N\ Inputs} = F_{SOM} \times EF_1$$

F_{SOM} – annual amount of N in mineral soils that is mineralized, in association with loss of soil C from soil organic matter as a result of changes to land use or management, kg N yr^{-1}

EF_1 – emission factor for N_2O emissions from N inputs, kg N_2O-N $(kg\ N\ input)^{-1}$

Equation 11.8 (p. 11.16 *of 2006 IPCC*) was used for estimation of amount of N in mineral soils that is mineralized in association with loss of soil C from soil organic matter:

$$F_{SOM} = \sum_{LU} \left[\left(\Delta C_{Mineral,LU} \times \frac{1}{R} \right) \times 1000 \right]$$

$\Delta C_{Mineral,LU}$ – average annual loss of soil carbon for each land-use type (*LU*), tonnes C (according to Tier 2 methodology, value was disaggregated by individual land-uses)

R - C:N ratio of the soil organic matter. A default value of 15 (uncertainty range from 10 to 30) for the C:N ratio (R) may be used for situations involving land-use change from Forest land or Grassland to Cropland, in the absence of more specific data for the area.

LU - land-use type

Carbon stock loss in mineral soils after other land uses conversion to cropland was used as activity data for direct N_2O emissions estimation from N mineralization/immobilization. Due to the lack of reliable national and default emission factors of N_2O emissions from N inputs (associated with the loss of soil organic carbon due to the land use change) and N_2O emissions from drained/managed organic soils data, the same emission factors, used for calculation of direct N_2O emissions from cropland and grassland categories were used to calculate emissions from settlement category. The same default R (C:N) ratio, used in calculations of N_2O emissions from cropland and grassland category was implemented while calculating N_2O emissions from settlements category.

Default emission factors used in calculations of direct N_2O emissions due to the loss of soil organic carbon:

EF_1 – 0.01 kg N_2O-N (kg N input)$^{-1}$ (Table 11.1, p. 11.11 of *2006 IPCC Guidelines*)

Indirect N_2O emissions from leaching and runoff

Lithuania is located in surplus precipitation zone, therefore a certain amount of precipitation forms both surface and underground runoff annually. According to "Geography of Lithuanian waters"[193], runoff in Lithuania varies among 25 – 50 percent of precipitation, on the basis of terrain, soil, etc. In addition to the direct N_2O emissions resulting from carbon stock change (loss) after land use change, indirect N_2O emissions also take place through runoff. Some of the inorganic (mineralized due to the carbon stock decrease after land use change) N does not take part in biological retention processes, therefore is removed with surface water flow (runoff) or through soil and afterwards is transformed into N_2O. Indirect N_2O emissions for all land use categories where direct N_2O emissions from N mineralization/immobilization due to carbon stock change after land use change occur are calculated using the same default *2006 IPCC* methodology – equation 11.10 (*Tier1* method).

$$N_2O_{(L)}\text{-}N = F_{SOM} \times Frac_{LEACH\text{-}(H)} \times EF_5$$

$N_2O_{(L)}$-N – annual amount of N_2O-N produced from leaching and runoff of N additions to managed soils in regions where where leaching/runoff occurs, kg N_2O-N yr^{-1}

F_{SOM} – annual amount of N mineralized in mineral soils associated with loss of soil C from soil organic matter as a result of changes in to land use or management in regions where leaching/runoff occurs, kg N yr^{-1} (from equation 11.8)

[193] Kilkus K., Stonevicius E., 2011. Geography of Lithuanian waters, textbook. Available at: http://www.hkk.gf.vu.lt/publikacijos/2011_Lietuvos_vandenu_geografija.pdf

$Frac_{LEACH-(H)}$ – fraction of all N added to/mineralized in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff, kg N (kg of N additions)$^{-1}$, default value, 0.3 (Table 11.3, p. 11.24 of *2006 IPCC*).

EF_5 – emission factor for N_2O emissions from N leaching and runoff, kg N_2O-N (kg N leached and runoff)$^{-1}$, default value, 0.0075 (Table 11.3, p. 11.24 of *2006 IPCC*).

6.6.3 Uncertainty assessment

CO_2 emissions from Settlements were evaluated as a result of Land conversions to Settlements. Converted areas are relatively small, however, according to the calculations of overall activity data uncertainty for settlements, based on NFI data, it was assumed that uncertainty of activity data is about 11.1 %. Emission factor uncertainty was assumed to be about 71 %.

Table 6-47. Uncertainty of emission factors of direct N_2O emissions estimation

Emission factors	Uncertainties, %	References
EF_1 (N_2O emissions from N inputs)	-70/+300	p. 11.11*, 2006 IPCC*

6.6.4 Category-specific QA/QC and verification

The QC/QA is based on quality control activities described in *2006 IPCC Guidelines* (Vol 1, Chapter 6, Table 6.1). Quality control and quality assurance objectives and procedures for Lithuanian GHG subcategory inventory at the national level are presented in Chapter 1.2.3 Quality assurance, quality control and verification plan. The QA/QC of activity data from State Forest Service is explained in Chapter 6.2.5, the use of country specific data is described in the inventory report.

The QC procedures are performed according to the QA/QC plan in order to attain these quality objectives in LULUCF, the comments received after QA/QC procedures while reviewing the report are taken into account and errors found were corrected.

Some obscurities concerning direct N_2O emissions estimation were clarified after QA procedure performed by Norwegian LULUCF GHG inventory experts under the "Partnership project on Greenhouse gas inventory" in the framework of the programme LT10.

6.6.5 Category-specific recalculation

Overestimation in cropland converted to settlements mineral soils was corrected this year. It was previously reported that -3.96 kt C was lost in mineral soil after cropland converted to settlements in 1991, however actual C change in mineral soil was -3.26 kt C, which resulted in emissions reduced by 2.57 kt CO_2 eqv. (5.7 % of total emissions from settlements in 1991).

6.6.6 Category-specific planned improvements

Lithuania plans to implement subdivision of land converted to settlements subcategory according to the degree soil is exposed and damaged, as not the whole surface of settlements is built up, paved or used for road construction in Lithuania, as a result in some cases soil is not fully removed after conversion from another land use to settlements.

6.7 Other Land (CRF 4.F)

6.7.1 Category description

This category is included for overall land area consistency checking. All land not classified as Forest land, Croplands, Grasslands, Wetlands and Settlements were defined as Other land and reported together as a separate category in the CRF Reporter. Disturbed land and unmanaged land subcategories were accounted under Other land category.

The area of other land category in Lithuania has been changing intensively only in the period from 1990 till 1995. The area of other land has been decreasing from 47.5 kha to 15.2 kha, further, till 2015 the area has been changing not intensively and further decreased to 11.98 kha of country land in 2015. The area of other land remaining other land was not changing significantly instead. Only slight decreases or increases in other land area were related with land conversion to other land from cropland, grassland and forest land.

The total CO_2 emissions from other land have been ranging in not a high scope but two CO_2 emissions increase peaks were denoted in 1994 and in 2006, where CO_2 emissions have reached, respectively, 183.45 kt CO_2 eqv. and 208.37 kt CO_2 eqv. Despite the peaks, CO_2 emitted from other land area was ranging from 12.83 kt CO_2 eqv. (in 1992) to 70.25 kt CO_2 eqv. (in 2009), however, the total GHG emissions in 2015 were 57.92 kt CO_2 eqv. Intense CO_2 emissions at peak events could be explained by high emissions from loss of dead organic matter accumulated in forest and intensive mineralization of forest soil organic matter, resulting in significant decrease of organic carbon in relevant carbon stocks (Table 6-48). Direct N_2O emissions resulting from N mineralization/immobilization due to the carbon stock changes in mineral soils after conversion of land use is also a part of total GHG emissions in land converted to other land subcategory and it comprise emissions ranging from 0.68 kt CO_2 eqv. In 1992 and 4.98 kt CO_2 eqv. in 2009 with the peaks of 10.66 and 12.48 kt CO_2 eqv. in 1994 and 2006.

Table 6-48. Carbon stock changes in land converted to other land, kt C

Year	Forest land conversion		Cropland conversion		Grassland conversion		Net change in biomass	Total in mineral soils
	net change in biomass	in mineral soils	net change in biomass	in mineral soils	net change in biomass	in mineral soils		
1990	NO	NO	NO	NO	NO	NO	NO	NO
1995	NO	NO	-0.48	-6.52	NO	NO	-0.48	-6.52
2000	NO	NO	NO	**-7.60**[1]	NO	NO	NO	-7.60
2005	NO	NO	NO	-6.52	NO	-3.15	NO	-9.67
2010	NO	NO	NO	-6.52	NO	-9.44	NO	-15.96
2011	NO	NO	NO	-6.52	NO	-9.44	NO	-15.96
2012	NO	NO	NO	-4.34	-0.48	**-11.01**[1]	-0.48	-15.35
2013	NO	NO	NO	**-2.17**[2]	NO	**-11.01**[1]	NO	-13.18
2014	NO	NO	NO	**-2.17**[2]	-0.48	**-11.01**[1]	-0.48	-13.19
2015	NO	NO	-0.48	**-1.08**[2]	-0.48	**-12.59**[1]	-0.96	-13.67

Data in bold indicates [1]highest and [2]lowest amounts of removals (in some case is not divided due to low data distribution), data in *Italic* correspond values <0.01 kt C

6.7.2 Methodological issues

6.7.2.1 Other Land Remaining Other Land

Changes in carbon stocks and non-CO_2 emissions and removals are not estimated according to *2006 IPCC Guidelines*.

6.7.2.2 Land converted to Other Land

Carbon stock changes in living biomass

Carbon stock changes were assumed to occur due to the change of land use - all previous vegetation is removed during land use conversion to other land. *Tier 2* method was used to estimate annual change in carbon stocks in living biomass on Land converted to Other land employing the eq. 2.15 and 2.16 (Ch. 2, p. 2.20 of *2006 IPCC Guidelines*). Area estimates for Land Converted to Other land were disaggregated according to prevailing vegetation and average carbon stock change on a per hectare basis is estimated for each type of conversion.

$$\Delta C_B = \Delta C_G + \Delta C_{CONVERSION} - \Delta C_L$$

ΔC_B - annual change in carbon stocks in biomass on land converted to other land-use category, in tonnes C yr^{-1}

ΔC_G - annual increase in carbon stocks in biomass due to growth on land converted to another land-use category, in tonnes C yr^{-1}

$\Delta C_{CONVERSION}$ - initial change in carbon stocks in biomass on land converted to other land-use category, in tonnes C yr^{-1}

ΔC_L - annual decrease in biomass carbon stocks due to the losses from harvesting, fuel wood gathering and disturbances on land converted to other land use category, in tonnes C yr^{-1}

$$\Delta C_{CONVERSION} = \sum_i \{(B_{AFTERi} - B_{BEFOREi}) \times \Delta A_{TO\_OTHERSi}\} \times CF$$

$\Delta C_{CONVERSION}$ - initial change in biomass carbon stocks on land converted to another land category, tonnes C yr^{-1}

B_{AFTERi} - biomass stocks on land type *i* immediately after the conversion, tonnes d. m. ha^{-1}

$B_{BEFOREi}$ - biomass stocks on land type *i* before the conversion, tonnes d. m. ha^{-1}

$\Delta A_{TO\_OTHERSi}$ - area of land-use *i* converted to other land-use category in a certain year, ha yr^{-1}

CF - carbon fraction of dry matter, tonnes C (tonnes d. m.)$^{-1}$

i - type of land use converted to another land-use category

For calculation of carbon stock changes caused by conversion to Other land, it was assumed that all above-ground biomass as well as dead wood and organic matter from litter was removed entirely as a result of conversion.

Biomass carbon stock in initial land-use categories (B_{BEFORE}) are assumed to be 2.4 t ha^{-1} d. m. in Croplands, Grasslands and Wetlands, 0.0 t ha^{-1} d. m. in Other Land.

Carbon stock changes in dead organic matter

Lithuania has no estimates of dead wood and litter in the initial land-use systems (except FL) prior to conversion. Therefore only conversions from forest land to other land category were reported, resulting in CO_2 emissions due to dead organic matter pool carbon stock losses. Conversions from forest land to other land category were very rare during the inventory period (1990-2015) – only 0.399 thous. ha in 1994 and 2006.

Carbon stock changes in soil organic matter

Estimations of change in C stocks in mineral soils in Land converted to Other land were based on method for estimating changes in soil C stocks, provided in Section 2.3.3 (Ch. 2 of *2006 IPCC Guidelines*). Carbon stock changes in land converted to other land were accounted due to the loss of soil organic carbon after land use change, while it is assumed that organic carbon stock in other land category is zero contrary to Joint Research Centre estimated SOC_{REF} values for Lithuanian cropland and grassland mineral soils and national data of carbon stocks in forest soils. CO_2 emissions from organic soils in land converted to settlements sub-category occur due to the drainage of organic soils. Activity data is obtained from State Forest Service, compiled during NFI measurements.

Mineral soils

CO_2 emissions from mineral soils are accounted as changes of soil organic carbon stocks, multiplying the area of certain land use converted to other land with carbon stock change factor accounted as difference between two organic carbon pools (initial land use and other land) divided by a 20 year period of conversion.

Calculation of carbon stocks in mineral soils on Lands converted to Other land were based on eq. 2.25 (Ch. 2, p. 2.30 of *2006 IPCC*). Country-specific reference C stocks (SOC_{REF} - 54.38 t C ha^{-1} yr^{-1} (cropland), SOC_{REF} - 78.87 t C ha^{-1} yr^{-1} (grassland)), estimated by the *JRC* and default stock change period of 20 years has been applied. Soil carbon stocks after conversion assumed to be zero for Land converted to Other Land.

$$\Delta C_{Mineral} = \frac{(SOC_0 - SOC_{(0-T)})}{D}$$

$\Delta C_{Mineral}$ - annual change in carbon stocks in mineral soils, tonnes C yr^{-1}

SOC_0 - soil organic carbon stock in final land use category (grassland), tonnes C

$SOC_{(0-T)}$ - soil organic carbon stock in initial land use category, tonnes C

Joint Research Centre estimated SOC_0 and $SOC_{(0-T)}$ values were used at each of the points in time (time = 0 (first year after conversion period - 20 years) and time = 0-T (first year of the beginning of conversion period)). Due to the lack of reliable data it is assumed that there are no organic carbon stock accumulated in settlements and other land categories soils, therefore $SOC_{(0-T)}$ for settlements and other land were indicated as 0 in calculations.
T - number of years over a conversion period, yr

D = Time dependence of stock change factors which is the default time period for transition between equilibrium SOC values, yr

Activity data, used for calculations of CO_2 emissions due to the loss of soil organic carbon as a result of different land use categories converted to other land, was obtained from NFI, executed by State Forest Service.

Organic soils

No organic soils were estimated under category Land converted to Other land, so it is reported as NO.

Direct N_2O emissions due to N mineralization/immobilization

Direct N_2O emissions in land converted to settlements sub-category are resulting from land-use change induced organic carbon stock loss in mineral soils, calculating the amount of N_2O released to the atmosphere as the result of the organic N mineralization after carbon stock in soil has decreased (loss of soil organic carbon occurs after conversion).

For the accounting of direct N_2O emissions from LULUCF sector default *2006 IPCC Guidelines Tier 1* methodology was used (with *Tier 2* requirements of disaggregation of individual land-use types while accounting direct N_2O emissions due to the loss of soil organic carbon resulting from land-use changes). Slightly modified (reduced) equation 11.1 (p. 11.7 of *2006 IPCC Guidelines*) was implemented:

$$N_2O_{Direct} - N = N_2O - N_{N\ Inputs} + N_2O - N_{OS}$$

$N_2O_{Direct} - N$ – annual direct N_2O-N emissions, produced from managed soils, kg N_2O-N yr^{-1}

$N_2O - N_{N\ Inputs}$ – annual direct N_2O-N emissions from N inputs to managed soils, kg N_2O-N yr^{-1}

$$N_2O - N_{N\ Inputs} = F_{SOM} \times EF_1$$

F_{SOM} – annual amount of N in mineral soils that is mineralized, in association with loss of soil C from soil organic matter as a result of changes to land use or management, kg N yr^{-1}

EF_1 – emission factor for N_2O emissions from N inputs, kg N_2O-N (kg N input)$^{-1}$

Equation 11.8 (p. 11.16 *of 2006 IPCC*) was used for estimation of amount of N in mineral soils that is mineralized in association with loss of soil C from soil organic matter:

$$F_{SOM} = \sum_{LU} \left[\left(\Delta C_{Mineral,LU} \times \frac{1}{R} \right) \times 1000 \right]$$

$\Delta C_{Mineral,LU}$ – average annual loss of soil carbon for each land-use type (*LU*), tonnes C (according to Tier 2 methodology, value was disaggregated by individual land-uses)

R - C:N ratio of the soil organic matter. A default value of 15 (uncertainty range from 10 to 30) for the C:N ratio (R) may be used for situations involving land-use change from Forest land or Grassland to Cropland, in the absence of more specific data for the area.

LU - land-use type

Default emission factors used in calculations of direct N_2O emissions due to the loss of soil organic carbon:

- EF_1 – 0.01 kg N_2O-N (kg N input)$^{-1}$ (Table 11.1, p. 11.11 of *2006 IPCC Guidelines*)

Carbon stock loss after land converted to other land was used as activity data for direct N_2O emissions estimation from N mineralization/immobilization. Due to the lack of reliable national and default emission factors of N_2O emissions from N inputs associated with the loss of soil organic carbon due to the land use change, the same emission factors, used for calculation of direct N_2O emissions from cropland and grassland categories were used to calculate emissions from settlement category. The same default R (C:N) ratio, used in calculations of N_2O emissions from cropland and grassland category was implemented while calculating N_2O emissions from settlements category.

Indirect N_2O emissions from leaching and runoff

Lithuania is located in surplus precipitation zone, therefore a certain amount of precipitation forms both surface and underground runoff annually. According to "Geography of Lithuanian waters"[194], runoff in Lithuania varies among 25 – 50 percent of precipitation, on the basis of terrain, soil, etc. In addition to the direct N_2O emissions resulting from carbon stock change (loss) after land use change, indirect N_2O emissions also take place through runoff. Some of the inorganic (mineralized due to the carbon stock decrease after land use change) N does not take part in biological retention processes, therefore is removed with surface water flow (runoff) or through soil and afterwards is transformed into N_2O. Indirect N_2O emissions for all land use categories where direct N_2O emissions from N mineralization/immobilization due to carbon stock change after land use change occur are calculated using the same default *2006 IPCC* methodology – equation 11.10 (*Tier1* method).

$$N_2O_{(L)}\text{-}N = F_{SOM} \times Frac_{LEACH\text{-}(H)} \times EF_5$$

$N_2O_{(L)}$-N – annual amount of N_2O-N produced from leaching and runoff of N additions to managed soils in regions where where leaching/runoff occurs, kg N_2O-N yr^{-1}

F_{SOM} – annual amount of N mineralized in mineral soils associated with loss of soil C from soil organic matter as a result of changes in to land use or management in regions where leaching/runoff occurs, kg N yr^{-1} (from equation 11.8)

$Frac_{LEACH\text{-}(H)}$ – fraction of all N added to/mineralized in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff, kg N (kg of N additions)$^{-1}$, default value, 0.3 (Table 11.3, p. 11.24 of *2006 IPCC*).

EF_5 – emission factor for N_2O emissions from N leaching and runoff, kg N_2O-N (kg N leached and runoff)$^{-1}$, default value, 0.0075 (Table 11.3, p. 11.24 of *2006 IPCC*).

6.7.3 Uncertainty assessment

CO_2 emissions from Other land were evaluated as a result of conversions to Other land. Default uncertainty value of 75% for estimated CO_2 emissions/removals has been used based on expert judgment, activity data uncertainty based on the NFI data is assumed to be around 30 %.

Table 6-49. Uncertainty of emission factors of direct N_2O emissions estimation

Emission factors	**Uncertainties, %**	**References**
EF_1 (N_2O emissions from N inputs)	-70/+300	p. 11.11*, 2006 IPCC*

[194] Kilkus K., Stonevicius E., 2011. Geography of Lithuanian waters, textbook. Available at: http://www.hkk.gf.vu.lt/publikacijos/2011_Lietuvos_vandenu_geografija.pdf

6.7.4 Category-specific QA/QC and verification

The QC/QA is based on quality control activities described in *2006 IPCC Guidelines* (Vol 1, Chapter 6, Table 6.1). The QA/QC of activity data from State Forest Service is explained in Chapter 6.2.5, the use of country specific data is described in the inventory report.

The QC procedures are performed according to the QA/QC plan in order to attain these quality objectives in LULUCF, the comments received after QA/QC procedures while reviewing the report are taken into account and errors found were corrected. Quality control and quality assurance objectives and procedures for Lithuanian GHG inventory at the national level are presented in Chapter 1.2.3 Quality assurance, quality control and verification plan.

Some obscurities concerning direct N_2O emissions estimation were clarified after QA procedure performed by Norwegian LULUCF GHG inventory experts under the "Partnership project on Greenhouse gas inventory" in the framework of the programme LT10.

6.7.5 Category-specific recalculation

No recalculation have been done.

6.7.6 Category-specific planned improvements

Category-specific improvements are not planned.

6.8 Harvested Wood Products (CRF 4.G)

6.8.1 Category description

Harvested Wood Products (HWP) accounting has been identified as mandatory for the second commitment period according to Decision 2/CMP.7 and Decision 2/CMP.8. Annual changes in carbon stocks and associated CO_2 emissions and removals from the HWP has to be accounted using *2006 IPCC Guidelines* and 2013 KP-Supplement's methodology (*2013 IPCC Revised Guidelines*).

Lithuania defines semi-finished commodities relevant for the application of the guidance on estimating the HWP emissions and removals in line with the Decision 2/CMP.7. Due to the requirements for Kyoto Protocol reporting Lithuania is reporting carbon stock changes in harvested wood products pool under the production approach - Approach B - both for UNFCCC and UNFCCC KP reporting, which means that only domestic harvest products are accounted under this pool (import is excluded).

Sawnwood (Decision 2/CMP.7 refers to this as "sawn wood"): Wood that has been produced from both domestic and imported round wood, either by sawing lengthways or by a profile-chipping process and that exceeds 6 mm in thickness. It includes planks, beams, joists, boards, rafters, scantlings, laths, boxboards and "lumber", etc., in the following forms: unplaned, planed, end-jointed, etc. It excludes sleepers, wooden flooring, mouldings (sawnwood continuously shaped along any of its edges or faces, like tongued, grooved, rebated, Vjointed, beaded, moulded, rounded or the like) and sawnwood produced by resawing previously sawn pieces. It is reported in cubic metres solid volume.

Wood-based panels (Decision 2/CMP.7 refers to this as "wood panels"): This product category is an aggregate comprising veneer sheets, plywood, particle board, and fibreboard. It is reported in cubic metres solid volume.

Paper and paperboards (Decision 2/CMP.7 refers to this as "paper"): Paper and paperboard category is an aggregate category. In the production and trade statistics, it represents the sum of graphic papers; sanitary and household papers; packaging materials and other paper and paperboard. It excludes manufactured paper products such as boxes, cartons, books and magazines, etc. It is reported in metric tonnes.

HWP are divided into two groups: *solid wood products* (sawnwood, wood based panels and round wood) and *paper products* (paper and paperboards). Non-CO_2 greenhouse gases from HWP pool are reported under energy sector.

The HWP model presented in *2006 IPCC Guidelines* requires activity data since 1961, which includes: production data, imports, exports of HWP. Several sources of information were used to obtain required activity data for estimation of greenhouse gas emissions and removals from HWP pool. The general activity data on defined HWP categories (round wood, sawnwood, wood-based panels, paper and paper board) were obtained from FAOSTAT databases. However, FAOSTAT databases contain information only since 1992 up to date; therefore additional national data for historic production capacities as well as share of exports and imports was included. Production capacities from 1960 until 1990 (1992) were obtained from „The Chronicle of Lithuanian Forests. XX Century“[195]. Some data presented in „The Chronicle of Lithuanian Forests. XX Century“ refers to five year time period, starting from 1955, therefore annual data was modelled (interpolated). Production capacities for 1990 – 1992 were obtained from Statistics Lithuania[196].

Noteworthy, that information provided by Statistics Lithuania almost equals data provided by FAOSTAT for the presented years, therefore doubts for data validity presented by Statistics Lithuania for 1990-1992 were rejected. Apparently differences in HWP production, imports and exports until 1992 are related with Lithuania's status of that period. Being the part of Soviet Union meant producing goods according to the plan, not to the real market demand, therefore production, import and export capacities were tremendous comparing to these days. However "The Chronicle of Lithuanian Forests. XX Century" testifies that there was no import of round wood in Lithuania until 1992.

Additionally, IPCC model requires estimating annual rate of increase for industrial round wood production as an input parameter for historic period 1900-1961. Being no activity data available for this time span, default value for Europe, 0.0151 (Table 12.3, p. 12.18 of *2006 IPCC Guidelines*) has been chosen.

[195] Lietuvos Respublikos Aplinkos Ministerija, Miškų departamentas. *Lietuvos miškų metraštis*. XX amžius. Vilnius, 2003

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

Table 6-50. Activity data used for estimations

Sawn-wood			Wood-based panels			Paper and Paperboard			Round wood			
Year	**Production, m³**	**Export, m³**	**Year**	**Production, m³**	**Export, m³**	**Year**	**Production, tonnes**	**Export, tonnes**	**Year**	**Production, m³**	**Import, m³**	**Export, m³**
1960	885,000.0	0.00	**1960**	39,800.0	14,726.0	**1960**	83,000.0	51,457.0	**1960**	1,740,000.0	968,000.0	29,637.3
1965	1,044,000.0	0.00	**1965**	58,400.0	21,608.0	**1965**	114,000.0	70,675.9	**1965**	2,420,000.0	1,080,000.0	41,219.8
1970	1,313,000.0	0.00	**1970**	91,300.0	33,781.0	**1970**	159,000.0	98,574.3	**1970**	2,814,000.0	1,066,000.0	47,930.7
1975	1,098,000.0	0.00	**1975**	133,900.0	49,543.0	**1975**	240,000.0	148,791.4	**1975**	2,587,000.0	1,161,000.0	44,064.3
1980	855,000.0	0.00	**1980**	165,500.0	61,235.0	**1980**	235,000.0	145,691.6	**1980**	2,472,000.0	699,000.0	45,000.0
1985	934,000.0	0.00	**1985**	168,100.0	62,197.0	**1985**	265,000.0	164,290.5	**1985**	2,648,000.0	693,000.0	44,000.0
1990	775,800.0	0.00	**1990**	197,900.0	73,223.0	**1990**	217,600.0	134,904.2	**1990**	2,667,000.0	456,000.0	74,000.0
1991	664,000.0	0.00	**1991**	185,500.0	68,635.0	**1991**	214,500.0	132,982.3	**1991**	2,908,000.0	228,475.5	179,739.0
1995	940,000.0	767,200.0	**1995**	156,400.0	104,600.0	**1995**	28,900.0	19,400.0	**1995**	5,960,000.0	16,200.0	1,769,900.0
2000	1,300,000.0	823,040.0	**2000**	270,290.0	211,060.0	**2000**	52,630.0	37,100.0	**2000**	5,500,000.0	60,570.0	1,202,850.0
2005	1,445,000.0	912,547.0	**2005**	398,000.0	170,966.0	**2005**	113,000.0	87,140.0	**2005**	6,045,000.0	287,906.0	1,173,919.0
2010	1,272,000.0	555,388.0	**2010**	716,000.0	311,223.0	**2010**	129,229.0	123,233.0	**2010**	7,096,860.0	332,142.0	1,441,955.0
2011	1,260,000.0	583,623.0	**2011**	823,600.0	276,974.0	**2011**	156,518.0	132,661.0	**2011**	7,004,000.0	272,055.0	1,989,937.0
2012	1,150,000.0	620,459.0	**2012**	825,000.0	306,152.0	**2012**	118,000.0	125,774.0	**2012**	6,921,000.0	310,654.0	1,593,343.0
2013	1,120,000.0	634,247.0	**2013**	855,900.0	363,405.0	**2013**	136,700.0	111,704.0	**2013**	7,053,000.0	383,973.0	2,044,876.0
2014	1,345,302.0	735,437.0	**2014**	894,612.0	244,826.0	**2014**	139,519.0	121,901.0	**2014**	7,351,000.0	377,187.0	1,934,021.0
2015	1,248,146.0	818,009.0	**2015**	888,131.0	287,495.0	**2015**	142,322.0	114,613.0	**2015**	6,414,000.0	404,945.0	1,620,910.0

The Chronicle of Lithuanian Forests. XX Century

Statistics Lithuania

FAO

Estimated changes in carbon stocks in harvested wood products consumed domestically and exported are presented in Table 6-51. According to the estimates, harvested wood products pool has been acting as a CO_2 sink in the entire reporting period from 1990 to 2015, reaching the highest amount of GHG removed in 2003 – 1,518.4 kt CO_2 eqv. Note that annual carbon balance of HWP's varies substantially, depending on the economic situation and market demand.

Table 6-51. Carbon stock changes in HWP, kt CO_2 eqv.

Year	Sawn wood		Wood panels		Paper and paper board		Total
	Consumed domestically	Exported	Consumed domestically	Exported	Consumed domestically	Exported	
1990	-153.7	NO	-70.9	-41.6	5.2	8.4	-252.5
1995	239.8	-987.6	-23.9	-127.7	38.3	31.0	-830.1
2000	-107.0	-874.5	-24.0	-238.3	-6.0	-19.0	-1,268.8
2005	-88.0	-756.4	-202.2	-123.2	6.5	-46.2	-1,209.5
2010	-268.7	-349.6	-380.3	-279.4	21.0	-60.4	-1,317.4
2011	-231.4	-380.8	-552.6	-234.6	-12.5	-59.6	-1,471.5
2012	-69.0	-409.6	-500.4	-262.8	39.3	-30.9	-1,233.5
2013	-60.4	-466.9	-500.4	-360.3	-24.8	-13.4	-1,426.2
2014	-138.2	-498.0	-618.4	-164.0	-3.6	-7.7	-1,429.8
2015	50.1	-573.8	-542.4	-211.2	-16.9	4.7	-1,289.5

6.8.2 Methodological issues

Emissions and removals from harvested wood products are estimated using stock change method, and only HWP in use are considered, obtaining the information on harvested wood production made from domestic harvest from FAO databases.

The worksheet provided in *2006 IPCC Guidelines* is a tool for estimating annual carbon balance under any of the proposed HWP approaches and was used for estimation of harvested wood products in use in Lithuania. The model consists of two elements: solid wood products and paper products. Both variables have different half-life values. Greenhouse gas accounting for HWP pool in the worksheet is based on first order decay function with default half-life values (eq. 2.8.5, p. 2.120 of *2013 IPCC Revised Guidelines*).

$$C \cdot (i+1) = e^{-k} \cdot C_{(i)} + \left[\frac{(1-e^{-k})}{k}\right] \cdot inflow(i)$$

$$\Delta C(i) = C(i+1) - C(i)$$

where:
i – year;
C(*i*) – the carbon stock in the particular HWP category at the beginning of year *i*, kt C;
k – decay constant of FOD for each HWP category (HWP_j) given in units yr^{-1} ($k = \ln(2)/HL$, where HL is half-life of the HWP pool in years);
Inflow(*i*) – the inflow to the particular HWP category (HWP) during year *i*, kt C yr^{-1};
ΔC(*i*) – carbon stock change of the HWP category during year *i*, kt C yr^{-1}.

Annual change in carbon stock in "products in use" where wood came from harvest in the reporting country, including export, was estimated using Equation 12.3 (Ch. 12.2, p. 12.12 of 2006 IPCC Guidelines).

$$\text{Inflow}_{DH} = P \times \left[\frac{IRW_H}{IRW_H + IRW_{IM} - IRW_{EX} + WCH_{IM} - WCH_{EX} + WR_{IM} - WR_{EX}}\right]$$

Where:
InflowDH - carbon in annual production of solidwood or paper products that came from wood harvested in the reporting country (that is, from domestic harvest), Gg C yr^{-1};
P - carbon in annual production of solidwood or paper products in the reporting country, Gg C yr^{-1}.
IRW_H - industrial roundwood harvest in the reporting country, Gg C yr^{-1};
IRW_{IM} , IRW_{EX} - industrial roundwood imports and exports, respectively, Gg C yr^{-1};
WCH_{IM}, WCH_{EX} - wood chip imports and exports, respectively, Gg C yr^{-1};
WR_{IM}, WR_{EX} = wood residues from wood products mills imports and exports, respectively Gg C yr^{-1}.

The HWP contribution to the total LULUCF sector emissions/removals was estimated separately for HWP produced and consumed domestically and HWP produced and exported. The annual carbon stock change was subdivided into these two groups by the proportion of exported products and total production for HWP categories, according to the data provided in FAO database:

$$C_{EXP} = C_{TOTAL} \times \frac{P_{EXP}}{P_{TOTAL}}$$

$$C_{DOM} = C_{TOTAL} \times \left(1 - \frac{P_{EXP}}{P_{TOTAL}}\right)$$

Where:
C_{EXP} - carbon stock change in HWP produced and exported;
C_{DOM} - carbon stock change in HWP produced and consumed domestically;
C_{TOTAL} - total carbon stock change in HWP category;
P_{EXP} - quantity of HWP exported;
P_{DOM} - quantity of HWP consumed domestically

Lithuania uses default half-life values for „products in use" carbon pools and associated fraction retained each year listed in the Table 6-52 (Table 12.2, p. 12.17 of *2006 IPCC Guidelines*). As Lithuania is using *Tier 1* methodology for carbon stock changes estimation in Harvested Wood Products pool, therefore default factors to convert from production units to carbon, provided in KP Supplement (2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol) (Table 2.8.1 of KP Supplement, Ch. 2.8.3.1, p. 2.122) is used. Default conversion factors used in Lithuanian Harvested Wood Product carbon stock change evaluation are provided in Table 6-52.

Table 6-52. Default half-life values for „products in use" carbon pools and associated fraction retained each year

	Sawn wood	**Wood-based panels**	**Paper and paper-board**
Half-life (years)	30	25	2
Carbon factor (per air dry	0.229 Mg (t) C m^{-3}	0.269 Mg (t) C m^{-3}	0.385 Mg (t) C Mg

volume)			(t)[-1] (per air dry tonne)

6.8.3 Uncertainty assessment

Overall activity data for HWP production, imports and exports was used from FAO databases, therefore uncertainty for such data was applied as it is suggested by *2006 IPCC Guidelines* (Table 12.6, p. 12.22) and is equal to ±15%. EF was calculated using *2006 IPCC Guidelines* (Table 12.6, p. 12.22) and is equal to ±59%.

6.8.4 Category-specific QA/QC and verification

Quality control and quality assurance objectives and procedures for Lithuanian GHG inventory at the national level are presented in Chapter 1.2.3 Quality assurance, quality control and verification plan. The activity data presented for greenhouse gas emission/removal assessment for HWP are judged to be the most reliable as there was no additional data sources founded.

The QC procedures are performed according to the QA/QC plan in order to attain these quality objectives in LULUCF, the comments received after QA/QC procedures while reviewing the report are taken into account and errors found were corrected.

6.8.5 Category-specific recalculations

Recalculations in harvested wood products were done due to the misallocation of the carbon stock changes in harvested wood products pool in CRF and different methodology applied to estimate changes in pool under "production approach". Differences between emissions/removals reported in 2016 and this year submission are presented in the tables below.

Table 6-53. Reported in previous submission and recalculated emissions/removals in sawn wood subcategory, kt CO_2 eqv.

Year	2016 submission	2017 submission	Absolute difference	Relative difference, %
1990	-26.53	-153.70	-127.17	479.30
1991	146.77	-127.97	-274.74	-187.19
1992	233.02	-220.92	-453.94	-194.81
1993	272.05	-190.79	-462.84	-170.13
1994	357.25	-577.58	-934.83	-261.67
1995	586.99	-747.78	-1,334.77	-227.39
1996	418.71	-1,054.73	-1,473.44	-351.90
1997	393.08	-742.21	-1,135.29	-288.82
1998	151.43	-666.63	-818.06	-540.23
1999	152.12	-700.35	-852.47	-560.38
2000	91.10	-981.51	-1,072.61	-1,177.39
2001	133.53	-874.10	-1,007.64	-754.61
2002	141.56	-974.37	-1,115.93	-788.28
2003	106.69	-1,073.25	-1,179.93	-1,105.96
2004	-149.82	-943.82	-794.00	529.99
2005	-270.48	-844.42	-573.94	212.19
2006	-272.18	-846.24	-574.06	210.91
2007	-288.49	-825.79	-537.30	186.24
2008	-79.56	-430.40	-350.84	440.96

2009	75.21	-300.40	-375.62	-499.40
2010	-102.32	-618.34	-516.02	504.32
2011	-93.27	-612.11	-518.84	556.28
2012	8.41	-478.63	-487.04	-5791.20
2013	17.37	-527.31	-544.68	-3135.75
2014	-199.49	-636.18	-436.69	218.90

Table 6-54. Reported in previous submission and recalculated emissions/removals in wood-based panels subcategory, kt CO_2 eqv.

Year	2016 submission	2017 submission	Absolute difference	Relative difference, %
1990	-93.31	-112.46	-19.15	20.53
1991	-81.65	-119.10	-37.44	45.86
1992	-143.52	-196.51	-52.99	36.92
1993	-57.68	-93.32	-35.64	61.79
1994	-33.22	-166.17	-132.96	400.26
1995	-27.88	-151.54	-123.67	443.63
1996	-27.77	-155.25	-127.48	459.00
1997	-57.62	-225.51	-167.89	291.40
1998	-112.89	-226.71	-113.83	100.84
1999	-69.02	-124.57	-55.55	80.49
2000	-111.30	-262.30	-151.00	135.67
2001	-135.93	-311.58	-175.65	129.22
2002	-215.09	-312.92	-97.83	45.48
2003	-343.06	-386.08	-43.02	12.54
2004	-471.15	-353.01	118.13	-25.07
2005	-544.15	-325.38	218.77	-40.20
2006	-602.82	-291.35	311.47	-51.67
2007	-832.27	-526.21	306.06	-36.77
2008	-806.12	-547.08	259.04	-32.13
2009	-649.37	-508.94	140.44	-21.63
2010	-731.84	-659.69	72.16	-9.86
2011	-878.93	-787.21	91.72	-10.44
2012	-892.94	-763.22	129.72	-14.53
2013	-862.17	-860.69	1.48	-0.17
2014	-1,090.20	-782.40	307.81	-28.23

Table 6-55. Reported in previous submission and recalculated emissions/removals in paper and paper-board subcategory, kt CO_2 eqv.

Year	2016 submission	2017 submission	Absolute difference	Relative difference, %
1990	24.19	13.61	-10.58	-43.73
1991	20.30	-16.76	-37.06	-182.56
1992	166.43	186.63	20.20	12.14
1993	126.38	162.51	36.13	28.59
1994	70.58	110.61	40.04	56.73
1995	45.16	69.27	24.11	53.37
1996	49.37	55.56	6.19	12.54
1997	2.28	50.75	48.47	2,128.57
1998	-24.05	16.33	40.38	-167.91
1999	-8.40	9.83	18.23	-216.95

2000	-20.65	-25.03	-4.38	21.19
2001	-30.74	-46.49	-15.75	51.25
2002	-58.55	-49.64	8.91	-15.21
2003	-38.96	-59.10	-20.14	51.69
2004	-73.62	-37.33	36.29	-49.29
2005	-72.38	-39.74	32.64	-45.10
2006	-75.92	-36.62	39.29	-51.76
2007	-51.98	-44.56	7.42	-14.28
2008	-61.24	-15.82	45.42	-74.17
2009	31.38	45.38	14.00	44.61
2010	-37.95	-39.42	-1.47	3.88
2011	-74.22	-72.16	2.05	-2.77
2012	-48.44	8.39	56.83	-117.32
2013	-110.44	-38.19	72.25	-65.42
2014	-109.65	-11.25	98.40	-89.74

6.8.6 Category-specific planned improvements

Lithuania participates in the "GHG inventory partnership project" through financial mechanism LT10 of Norway grants. As a result of this partnership Lithuania has launched the study for development of the national HWP accounting system in upcoming years, as well as to obtain feasible sufficient historical data on rate of increase for industrial round wood production required to run the model for accounting of HWP emissions/removals. Lithuania is planning to implement results of the study in the next submission.

7 WASTE (CRF 5)

7.1 Overview of the Sector

In Lithuania greenhouse gases (GHG) emissions from Waste Sector originate from the following sources:

- Solid Waste Disposal (including sewage sludge) (CRF 5.A).
- Biological Treatment of Solid Waste (CRF 5.B).
- Incineration and Open Burning of Waste (CRF 5.C).
- Wastewater Treatment and Discharge (CRF 5.D).

Few emission sources from Waste Sector were identified as key source category, by level and trend.

Table 7-1. Key category from Waste in 2015

IPCC Category	*Greenhouse gas*	*Identification criteria*	*Comments**
5.A Solid Waste Disposal	CH_4	L1,L2,T2	
5.B Biological treatment of waste	CH_4		T2sub
5.D Wastewater Treatment and Discharge	CH_4	L1,T1,T2	

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

GHG emissions from Waste Sector are summarized in Table 7-2.

Table 7-2. Summary of GHG emissions from Waste Sector, kt CO_2 eqv.

Year	Solid waste disposal	Sewage sludge	Biological treatment	Wastewater treatment	Waste incineration	Total
1990	984	44.7	6.92	538.2	2.7	1,577
1995	1,054	48.6	9.19	463.8	2.6	1,578
2000	1,067	69.4	4.47	399.1	1.2	1,541
2005	1,093	59.0	13.22	327.5	3.7	1,496
2010	1,021	45.3	14.43	256.9	1.5	1,339
2011	937	42.8	17.76	248.5	4.6	1,251
2012	920	42.3	19.69	228.3	1.1	1,211
2013	880	40.3	24.64	224.4	0.8	1,170
2014	823	37.4	42.31	208.7	2.0	1,113
2015	770	32.5	42.56	191.6	5.9	1,043

Solid waste disposal on land including disposal of sewage sludge is the largest GHG emission source from Waste Sector. It contributed around 76.9% of the total GHG emission from Waste Sector in 2015 (73.8% excluding disposal of sewage sludge). GHG emissions occurring due to solid waste and sewage sludge disposal on land were increasing slightly from 1990 to 2001 and then started to decrease due to reduction of disposed waste, extraction of landfill gas, anaerobic digestion of sewage sludge.

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

Variations of GHG emissions from solid waste disposal on land during the period 1990 to 2015 are shown in Figure 7-1.

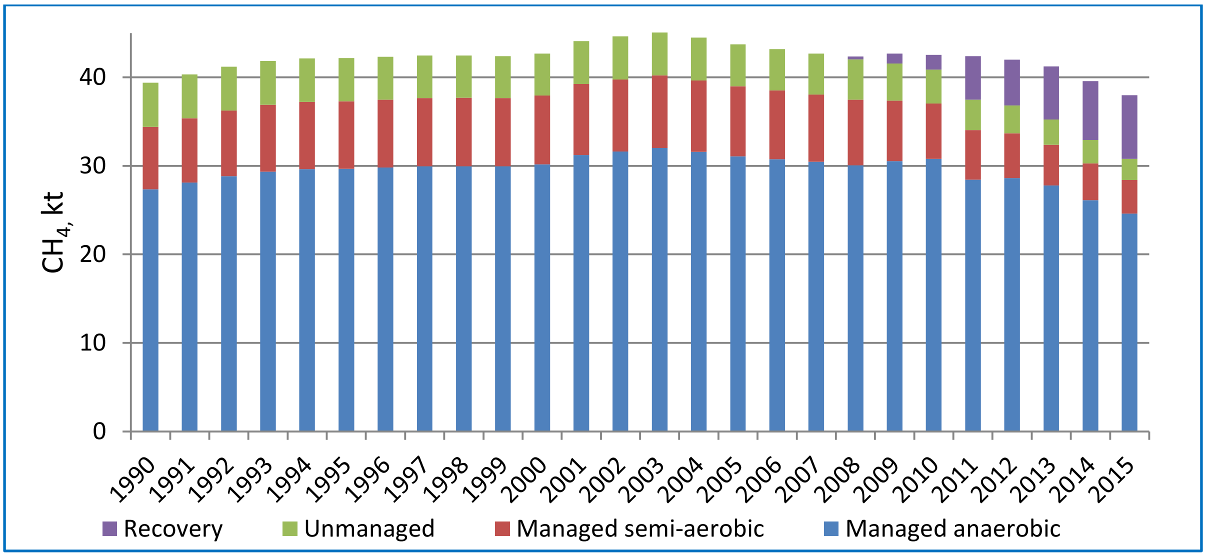


Figure 7-1.Variations of GHG emissions from solid waste disposal (1990-2015)

Wastewater treatment and discharge contributed around 18.4 % of GHG emissions from Waste Sector in 2015 including 3.1% contribution of sewage sludge management. Wastewater in Lithuania is treated in aerobic treatment systems with minimum CH_4 generation. However, significant part of population still does not have connection to public sewerage systems and emissions from sewage collected from septic tanks are significant.

Waste incineration was used in Lithuania on comparatively small scale up to 2015 contributing during the period 1990-2014 on average 0.1 % of the total waste GHG emission and slightly increasing to 0.6% in 2015.

7.2 Solid waste disposal on land (CRF 5.A)

7.2.1 Overview of waste management in Lithuania

Waste generation and disposal

The total amount of waste generated annually in Lithuania is about 5 million tonne (Table 7-3). Major part of waste is generated in industrial sector of which about 100 kt - hazardous waste. Annual municipal waste generation is a bit more than 1 million tonne.

Table 7-3. Waste collection and treatment in 2015, kt

		D1,D5	D2, D4, D6	S4	R1	D10	R2-R9	R10, R11	D8, D9, D14, R12,S5
01	Chemical compound wastes	-	-	4.73	0.04	0.47	4.13	-	2.17
02	Chemical preparation wastes	0.12	-	0.98	0.32	1.79	0.19	-	0.28
03	Other chemical wastes	0.33	8.07	0.41	0.18	1.72	37.13	0.34	17.99
05	Health care and biological wastes	0.27	-	0.38	0.09	0.31	0.01	-	0.70

06	Metallic wastes	0.00	-	356.28	-	-	93.56	-	61.91
07	Non-metallic wastes	10.29	-	89.52	30.19	0.73	240.1	2.06	49.20
08	Discarded equipment	0.13	-	5.82	0.02	0.12	4.15	-	66.98
09	Animal and vegetal wastes	0.34	-	3.93	1.58	-	174.96	1.47	1.86
10	Mixed ordinary wastes	2,875.3	5.61	21.95	183.04	0.28	15.25	13.74	413.00
11	Common sludge	-	0.53	-	-	-	16.09	18.86	10.47
12	Mineral wastes	175.5	0.15	12.74	0.22	0.28	677.09	142.65	135.64
	Total	**3,026.3**	**14.36**	**496.74**	**215.68**	**5.72**	**1,262.7**	**179.13**	**760.20**

*List of treatment operations is provided in Table 7-4 below.
Source: Lithuanian EPA

In early 1990s there were about 1000 landfills and dumps in Lithuania. In late 1990s waste management strategies were developed foreseeing development of waste management infrastructure including construction of new regional landfills complying with EU requirements closure of existing landfills and dumps and provision of necessary equipment required for safe and efficient operation of waste management facilities.

Table 7-4. List of waste treatment operations

Waste disposal operations	
D 1	Deposit into or on to land (e.g. landfill, etc.)
D 2	Land treatment (e.g. biodegradation of liquid or sludgy discards in soils, etc.)
D 3	Deep injection (e.g. injection of pumpable discards into wells, salt domes or naturally occurring repositories, etc.)
D 4	Surface impoundment (e.g. placement of liquid or sludgy discards into pits, ponds or lagoons, etc.)
D 5	Specially engineered landfill (e.g. placement into lined discrete cells which are capped and isolated from one another and the environment, etc.)
D 6	Release into a water body except seas/oceans
D 7	Release to seas/oceans including sea-bed insertion
D 8	Biological treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are discarded by means of any of the operations numbered D 1 to D 12
D 9	Physico-chemical treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are discarded by means of any of the operations numbered D 1 to D 12 (e.g. evaporation, drying, calcination, etc.)
D 10	Incineration on land
D 11	Incineration at sea
D 12	Permanent storage (e.g. emplacement of containers in a mine, etc.)
D 13	Blending or mixing prior to submission to any of the operations numbered D 1 to D 12
D 14	Repackaging prior to submission to any of the operations numbered D 1 to D 13
D 15	Storage pending any of the operations numbered D1 to D 14 (excluding temporary storage, pending collection, on the site where the waste is produced)
Waste recovery operations	
R 1	Use principally as a fuel or other means to generate energy
R 2	Solvent reclamation/regeneration
R 3	Recycling/reclamation of organic substances which are not used as solvents (including composting and other biological transformation processes)
R 4	Recycling/reclamation of metals and metal compounds
R 5	Recycling/reclamation of other inorganic materials
R 6	Regeneration of acids or bases

R 7	Recovery of components used for pollution abatement
R 8	Recovery of components from catalysts
R 9	Oil re-refining or other reuses of oil
R 10	Land treatment resulting in benefit to agriculture or ecological improvement
R 11	Use of waste obtained from any of the operations numbered R 1 to R 10
R 12	Exchange of waste for submission to any of the operations numbered R 1 to R 11
R 13	Storage of waste pending any of the operations numbered R 1 to R 12 (excluding temporary storage, pending collection, on the site where the waste is produced)

Source: Lithuanian EPA

During the reorganization of waste management infrastructure, all landfills and dumps not in line with the environmental protection and public health safety requirements were closed. The disposal of waste in the old landfills was stopped in July of 2009 and since then all waste is disposed of in 11 regional non-hazardous waste landfills.

Recovery of landfill gas started at 2 landfills in 2008. Currently landfill gas is recovered in 3 operating and 6 closed landfills[197].

In order to encourage waste recovery and recycling and to minimize disposal in the landfills, regional waste management systems were equipped with appropriate waste management facilities including bulky waste collection sites, green waste composting sites, etc.

According to data provided by municipalities[198], waste collection services were provided to 94.8% of population. Differences between provision of services in cities, towns and rural areas are decreasing. In 2012-2014, waste collection services were provided to 97% of population in towns and cities with population exceeding 1000 inhabitants and to 94% of population in small towns and villages with population less than 500 inhabitants.

Waste reporting

There was no recording or reporting of waste generation or disposal in Lithuania during the Soviet Rule.

After declaration of independence in 1990 Environmental Protection Department was established which initialized collection of statistical data on waste generation and management. Installations generating or handling waste were obliged to record waste generation, recovery and disposal activities from 1991. The first reports covering waste management activities in 1991 were submitted to the Environmental Protection Department in 1992.

Waste generation, treatment and disposal were recorded and reported according to the waste classification categories shown in Table 7-5 and waste disposal and recovery operations listed in Table 7-6.

Table 7-5. Waste classification 1990

A. Non-hazardous waste	
A.01	Manure and animal faeces
A.02	animal-tissue waste
A.03	Green waste

[197] National Waste Management Plan

[198] Data collected by Environmental Protection Agency

A.04	Forest waste
A.05	wastes from mineral excavation
A.06	Gravel, stones
A.07	Food waste
A.08	Textile waste
A.09	Natural fibre waste
A.10	Synthetic fibre waste
A.11	Wood waste
A.12	Paper and cardboard waste
A.13	Plastic and polymer waste
A.14	Rubber waste
A.15	Glass waste
A.16	Ferrous metal waste
A.17	Non-ferrous metal waste
A.18	end-of-life vehicles, household appliances
A.19	Construction material waste
A.20	Natural leather waste
A.21	Natural fur waste
A.22	Mixed municipal waste
A.23	Other waste
B. Hazardous waste	
B.01	Sanitary wastes of medicine services
B.02	Pharmaceutical wastes (unfit medicine, narcotics, veterinary remedies)
B.03	Wood preservatives wastes (wood antiseptics with heavy metals)
B.04	Biocides and phytopharmaceutical wastes (unfit pesticides, insecticides and etc.
B.05	Organic solvent wastes
B.06	Halogenated organic substances, excluding solvents
B.07	Wastes contaminated with cyanides
B.08	Oil products wastes without water
B.09	Oil/water, hydrocarbon/water (mixtures and emulsions)
B.10	Wastes containing or contaminated with polychlorinated diphenyls, triphenyls or polybrominated diphenyls
B.11	Tarry materials arising from refining, distillation and any pyrolytic treatment
B.12	Wastes of paints, dyes, pigments
B.13	Waste of resins, latex, plasticizers, glues/adhesives
B.14	Waste of chemicals, which are not identified or are new and whose effects on man and/or environment are not known
B.15	Pyrotechnics and explosive materials waste
B.16	Photographic processing materials waste (developers, fixing agents, photo-materials)
B.17	Wastes contaminated with polychlorinated dibenzofuran
B.18	Wastes contaminated with polychlorinated dibenzo dioxin
B.19	Animal soaps, fats, waxes
B.20	Non-halogenated organic substances excluding solvents (residuals of antifreeze, solvents containing formaldehydes, residuals of organic synthesis)
B.21	Inorganic waste without heavy metals
B.22	Cinders, ashes (boilers cinders, chimney ashes)
B.23	Contaminated soil (specify contaminant)
B.24	Hardening salts without cyanides
B.25	Metallic dust (specify metals)
B.26	Catalysts waste

B.27	Solutions and sludge containing heavy metals
B.28	Spent filter materials (contaminated with chemicals)
B.29	Scrubber sludges
B.30	Sewage sludges
B.31	Decarbonisation residuals
B.32	Ion-exchange column residual
B.33	Residual from cleaning and washing of equipment
B.34	Wastes of lamps and batteries
B.35	Vegetable oil waste
B.36	Radioactive residual (waste containing radionuclides or contaminated with them)
B.37	Any other hazardous waste not mentioned above in this list

Table 7-6. Waste disposal and recovery operations 1990

Waste disposal operations	
D1	Deposit onto land (in dumps)
D2	Land treatment (e.g. biodegradation of liquid or sludgy discards in soils, etc. In this case soil is only medium of wastes neutralisation. If waste is used as fertiliser, its code is R10. Biological treatment of polluted soil belongs to group D8.
D3	Deep injection (e.g. injection of pumpable discards into wells, salt domes or naturally occurring repositories, etc.)
D4	Surface impoundment (e.g. placement of liquid or sludge discards into pits, ponds or lagoons, etc.)
D5	Specially engineered landfill (e.g. placement into lined discrete cells which are capped and isolated from one another and the environment, etc.
D6	Release into a water body except seas
D7	Release into seas
D8	Biological treatment not specified elsewhere in this table
D9	Physical chemical treatment not specified in this table. The materials which are formed during this treatment must be disposed of according table 5a
D10	Incineration without energy or incineration using additional fuel when quantity of incoming energy is not higher than additional energy
Waste recovery operations	
R1	Use as a fuel or other means to generate energy
R2	Solvent regeneration
R3	Recycling of organic substances which are not used as solvents
R4	Recycling and utilisation of metals and metal compounds
R4.1	Utilisation of metals in ceramics
R4.2	Other methods of regeneration and utilisation
R5	Regeneration of other inorganic materials (except metals and metal compounds)
R6	Regeneration of acids or bases
R7	Recovery of components used for pollution abatement
R8	Recovery of components from catalysts
R9	Used oil re-refining or other reuses of previously used oil (except using for fuel) If waste from oil products are used for fuel or energy, it belongs to group R.1.
R9.1	Regeneration of waste from oil products
R9.2	Recovery of spent oil products in ceramic production
R9.3	Other methods of recovery and recycling of spent oil products
R10	Land treatment resulting in benefit to agriculture
R12	Buying and selling of wastes for recycling or recovery
R14	Wastes usage as secondary raw materials
R15	Wastes composting
R16	Waste recovery using other methods

The Environmental Protection Department was reorganized to the Ministry of Environmental Protection in 1994 which became the Ministry of Environment in 1998. The Minster of Environment approved new version of the Waste management regulation in 1999 (Order of the

Minister of Environment No. 217 from July 14, 1999) including modifications of recording and reporting procedures.

Waste management regulation 1999 transposed basic requirements of the EU Waste framework directive (75/442/EEC) including list of waste and list of hazardous waste but established national version of waste disposal and recovery operations (Table 7-7).

Table 7-7. Waste disposal and recovery operations 1999

1	Waste disposal
1.1	Disposal of non-hazardous waste into or onto land
1.2	Storage of non-hazardous waste more than a year
1.3	Incineration of non-hazardous waste without energy recovery
1.4	Disposal of non-hazardous waste by other methods
1.5	Disposal of hazardous waste into or onto land
1.6	Storage of hazardous waste more than three months
1.7	Incineration of hazardous waste without energy recovery
1.8	Disposal of hazardous waste by other methods
1.9	Export of wastes for disposal
2	Use of waste for energy recovery
2.1	Use of non-hazardous waste for energy recovery
2.2	Use of hazardous waste for energy recovery
2.3	Export of wastes for energy recovery
3	Waste recycling
3.1	Physical-chemical treatment of non-hazardous waste
3.2	Biological treatment of non-hazardous waste
3.3	Treatment of hazardous waste
3.4	Treatment of bulky waste
3.5	Waste export for recycling
4	Waste collection and transport
4.1	Collection of wastes from population and organizations which are not obliged to record wastes
4.2	Collection and transport of industrial waste
4.3	Loading, repacking and sorting of non-hazardous waste to be transported
4.4	Collection and transport of hazardous waste
4.5	Loading, repacking and sorting of hazardous waste to be transported
5	Brokerage in waste management sector

New version of the Waste Management Regulation was approved by the Minister of Environment in December 2003 (Order of the Minister of Environment No. 722 from December 30, 2003). The new Regulation contained several changes in reporting requirements including classification of waste treatment, recovery and disposal operations provided in Annex II to the directive 75/442/EEC. Waste generation and management reports in accordance with the new requirements were provided by both waste generating and waste managing undertakings in the beginning of 2005 covering year 2004.

According to the Waste Management Regulation, waste management undertakings including waste importing companies as well as waste generating industries which are obliged to have Integrated pollution prevention and control (IPPC) permits must keep records of waste generation and treatment. Waste recoding is also mandatory for enterprises involved in technical maintenance of vehicles and generating hazardous waste.

Waste recording log must be kept in the location of waste generation and must be submitted to the authorized officials of the Ministry of Environment, counties or municipalities upon their request.

Waste generation and treatment should be recorded at least once per week. If waste is generated or treated not continuously, each separate generated or treated quantity must be recorded.

Recording should include:

- geographic origin of waste,
- industrial origin of waste,
- source name,
- waste code in Waste List,
- statistical classification code,
- waste name,
- amount of generated, received, treated or dispatched waste,
- treatment method,
- receiving facility (if waste was dispatched).

Waste recovery and disposal undertakings are obliged to provide annual reports on waste management to the regional environmental protection departments (REPD) of the Ministry of Environment. Waste generating industries obliged to have IPPC permits must provide annual recording reports. Both types of reports are very similar and have only minor differences and must include summarized waste recording data.

The reports are collected by the regional environmental protection departments and transferred to the Environmental Protection Agency which is responsible for data processing and keeping waste database.

In May 2011 the Minister of Environment approved new Rules on Recoding and Reporting of Waste Generation and Management which came into force in 2012. The additional requirements were included in the new Rules: the submission of reports on recording and reporting of waste generation and management to the REPD for undertakings which collect or transport hazardous waste or act as dealers and brokers of hazardous waste. Reporting according to the new Rules started in 2013 covering waste generation and management in 2012.

7.2.2 Category description

Municipal waste generation and disposal

In the initial stages of data collection waste was not weighed and amount of waste disposed of in landfills and dumps was evaluated on volume basis. In early 1990s municipal waste was collected and transported to landfills by municipal waste collection companies and their income (as well as salaries of truck drivers) depended on the amount of waste delivered to landfills. Therefore very often they were going to landfills with half-empty collection trucks but recording full loads.

It is generally agreed that the amount of generated and disposed waste in early 90s was overestimated. In the report on the status of environment in Lithuania in 2001 published by the

Lithuanian Ministry of Environment[199] it was assumed that generation of municipal waste should be about 750 kt annually.

Starting from 1999 amount of waste disposed of in landfills has stabilized at approximately 1 million tonnes. It was agreed in the discussion at the Ministry of Environment[200] 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[201] 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 7-2) it is reasonable to assume that changes of waste generation and disposal per capita are correlated with the changes of GDP but annual changes of waste generation are approximately 10 times lower than changes of GDP.

Evaluated changes of waste generation and disposal per capita during 1991-1998 based on assumption that annual change of waste generation and disposal comprises one tenth of annual variation of GDP per capita are shown in Table 7-8.

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.

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[199] State of the Environment 2001, p. 85th Ministry of Environment of the Republic of Lithuania, Vilnius, 2002

[200] Meeting at the Ministry of Environment with the Head of Waste Division Ingrida Kavaliauskienė and senior specialist Ingrida Rimaitytė, September 25, 2009

[201] 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

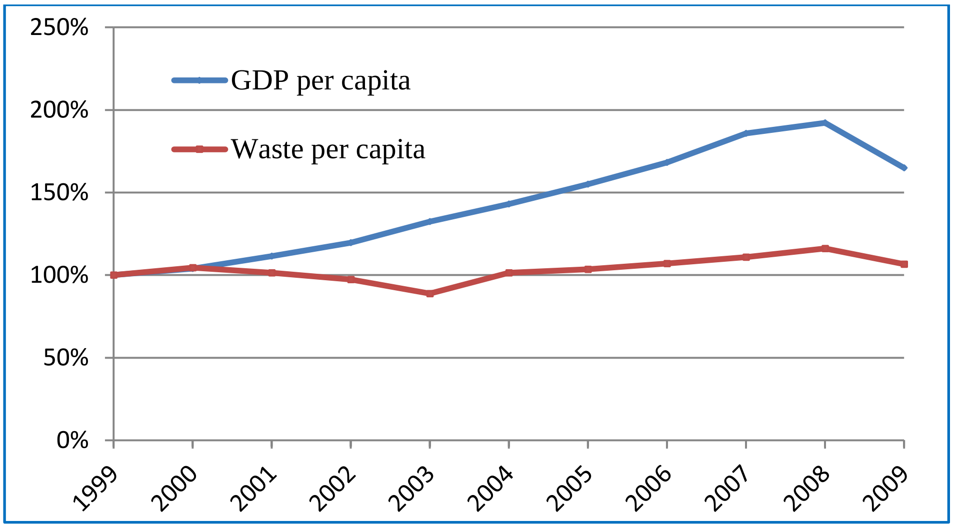


Figure 7-2. Variations of GDP and waste disposal per capita during 1999-2009

Table 7-8. 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%

Actual statistical data on municipal waste disposal to landfills were used for calculation of CH_4 emissions from landfills during 1999-2015. For the period 1990-1998 waste disposal was evaluated using estimated annual changes shown in Table 7-8 and population number provided by the Statistics Lithuania.

The first regional landfill complying with the requirements of the EU landfill directive 1999/31/EC was put into operation in 2007. Construction of regional landfills were completed in 2009 and starting from 2010 all municipal waste is disposed of in newly constructed landfills.

Biodegradable waste of industrial and commercial origin

Together with mixed municipal waste, biodegradable waste is disposed to the landfills by industries and commercial organisations.

From 1991 when collection of data of waste handling and treatment was started, waste classification and definitions of various waste disposal and treatment operations have been changed several times. Currently waste statistical data collected by the Lithuanian Environmental Protection Agency are ordered according to two classification systems: European waste list adopted by the European Commission[202] 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[203]. However, data collected prior to adoption of EU waste classification, especially during 1991-1999, cause certain difficulties in interpretation and identification of specific waste categories and disposal methods.

The following categories of industrial and commercial waste were selected from the EUROSTAT statistical nomenclature for including in calculation of CH_4 emissions from landfills:

- Paper and cardboard waste
- Wood waste
- Textile waste
- Waste of food preparation and products
- Green waste
- Sewage sludge

Data reported on disposal of biodegradable waste of industrial and commercial origin in landfills are provided in Table 7-9.

Table 7-9. Reported data on disposal of biodegradable waste of industrial and commercial origin in landfills in 1990-2015, kt

Year	Paper and cardboard wastes	Wood wastes	Textile wastes	Food waste	Green wastes	Sewage sludge	Total
1990	12.93	33.02	12.37	45.32	30.38	197.1	331.12
1995	4.68	42.83	1.04	15.98	26.24	308.9	399.67
2000	1.26	3.64	6.06	215.88	3.51	312.7	543.05
2005	0.53	24.05	2.50	1.91	22.18	135.1	186.27
2010	0.04	0.98	3.18	2.39	5.64	121.1	133.33
2011	0.00	0.94	3.77	0.00	10.96	155.2	170.87
2012	0.09	0.45	4.66	0.00	4.08	120.7	129.98
2013	0.18	0.63	3.42	0.00	1.47	91.80	97.50
2014	0.10	1.45	1.91	0.00	1.24	31.72	36.42
2015	0.01	1.27	2.15	0.00	0.34	33.84	37.61

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

[202] 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)
[203] *Official Journal L 332 , 09/12/2002 P. 0001 - 0036,*
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:332:0001:0036:EN:PDF

trucks to landfills as full as possible. Substantially smaller variations of disposed industrial wastes in early nineties also confirm that reported amounts of industrial waste were more realistic.

Higher amounts of disposed industrial waste in early 90s were caused by inadequate control and inspection during the first years of independence. Later control of waste disposal was improved and industries were forced to find other ways of waste management.

High amount of food waste in 2000-2002 were disposed in municipal landfills by sugar production plants which at that time were bought by Danish companies and increased production very significantly. Later food waste generated in sugar production plants was used as fodder for animals, mainly swine, and its disposal stopped.

Waste Composition

Average composition of municipal solid waste was evaluated in a number of cases in 1996-2003 by experimental measurements carried out during the feasibility studies of development of regional waste management system and construction of new landfills in various regions of Lithuania (Table 7-10). 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[204] (Table 7-11).

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'.

[204] Ibid.

Table 7-10. Measured waste composition of various regions of Lithuania

Waste composition	**Kaunas**				**Kaunas region 2003**			**Klaipėda**	**Vilnius**			**Utena**	**Panevėžys, 2004**			
	1996	**1997**	**1998**	**1999**	**City**	**Towns**	**Rural**	**2000**	**1999**	**2001**	**County average**	**2003**	**City**	**Towns**	**Rural**	**Overall**
Biowaste	39%	46%	35%	41%	41%	53%	34%	56%	47%	52%	42%	43%	43%	39%	28%	38%
Paper	10%	7%	12%	12%	8%	10%	10%	19%	13%	9%	13%	15%	6%	9%	1%	5%
Cardboard	6%	7%	9%	1%	8%											
Plastic	7%	10%	11%	10%	7%	5%	5%	8%	7%	13%	9%	8%	6%	8%	5%	6%
Glass	9%	6%	8%	8%	9%	7%	12%	9%	10%	6%	9%	6%	9%	5%	11%	9%
Metal	3%	3%	3%	4%	3%	3%	3%	2%	4%	4%	3%	3%	2%	2%	4%	3%
Wood	-	-	-	-	-	-	-	-	-	-	-	1%	-	-	-	-
Other burnable	14%	14%	16%	11%	14%	9%	9%	-	-	-	-	6%	-	-	-	-
Other non-burnable	12%	7%	6%	13%	5%	8%	18%	-	-	-	-	10%	-	-	-	-
Hazardous	-	-	-	-	1%	1%	1%	1%	-	-	-	0%	-	-	-	-
Other	-	-	-	-	4%	4%	8%	5%	19%	16%	24%	8%	34%	38%	52%	40%

Table 7-11. 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*

The lowest fraction of biodegradable waste was found in waste collected from rural areas in Panevėžys region. It is understandable that biodegradable waste fraction in waste collected from rural areas is substantially lower than in urban areas. Fluctuations of average waste composition including waste of both rural and urban origin are less significant. The available data doesn't show any specific trends, therefore a single set of values was selected for calculations.

The measurements were performed in the framework of feasibility studies for establishment of the regional waste management systems. Samples for analysis were collected from municipal waste, industrial waste was not sampled. Analyses were performed by companies performing feasibility studies. Analytical procedures were not described in the studies. Separate companies used different methodologies, even the components of waste composition were different. Therefore it is difficult to compare and summarize the results.

In 2011 the Minister of Environment obliged regional waste management centres responsible for landfill operation in Lithuania to carry out analysis of composition of municipal waste in all landfills.

Waste composition should be evaluated in 2012, 2013, 2016, 2018 and 2020 four times per year: in winter, spring, summer and autumn.

For sample collection, a waste collection truck from each municipality delivering waste to landfill has to be selected by landfill operator. Waste sample for analysis is collected from five spots of unloaded waste heap ("envelope" method). At least 0.5 tonne sample is to be collected from municipalities with population more than 100 thou. and 0.3 tonne from municipalities with population less than 100 thou.

Waste fractions to be identified during analysis are listed in Table 7-12.

Table 7-12. Waste fractions to be identified during municipal waste analysis

1	Paper and cardboard including packaging
2	Green waste
3	Wood waste including packaging
4	Biodegradable food production waste
5	Natural fibre waste
6	Other municipal biodegradable waste
7	Total municipal biodegradable waste
8	Plastic waste including packaging
9	Composite packaging waste
10	Metal waste including packaging
11	Glass waste including packaging
12	Inert waste (ceramics, concrete, stones, etc.)
13	Other non-hazardous waste
14	Waste electric and electronic equipment
15	Waste batteries and accumulators
16	Other hazardous waste
17	Other municipal waste

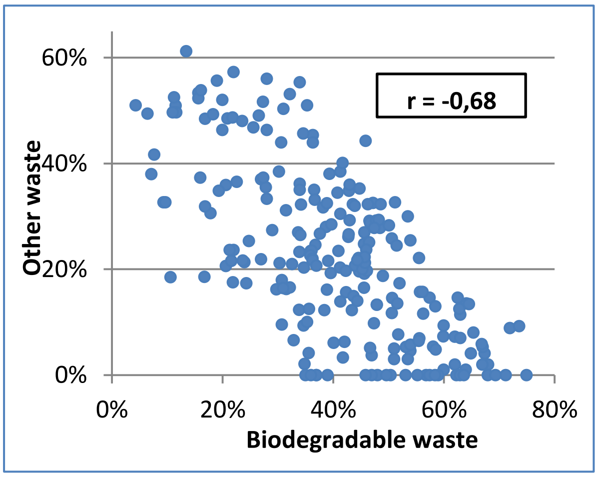
Comparison of available data obtained in 2012 and 2013 showed that significant correlation is observed between the total amount of biodegradable waste and ”other municipal waste” (fraction 17) (r = -0.68) which means that biodegradable waste was not fully segregated and certain fraction of biodegradable waste was accounted as other waste (Figure 7-3, a).

It is obvious that data showing large amount of “other municipal waste” are not reliable. Therefore data with “other municipal waste” exceeding 15% were discarded. Remaining data seemed to be more reliable showing no correlation between the amount of biodegradable waste and other waste (r = -0.13, Figure 7-3, b). These data were used for further analysis and evaluation of average waste composition.

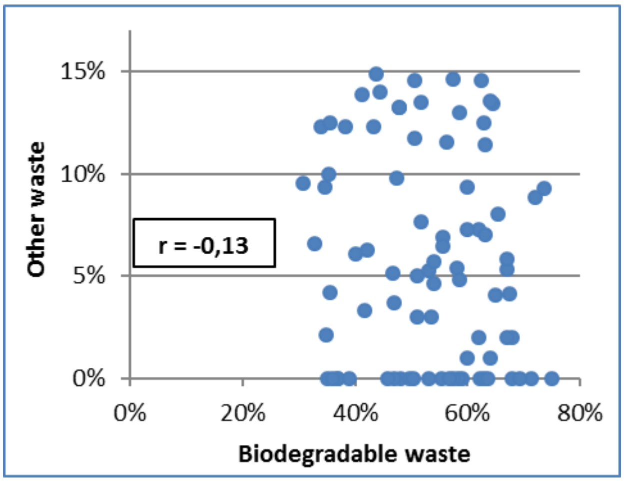
Summary of data on the total amount of biodegradable waste (fraction 7) reported by Marijampolė, Šiauliai, Panevėžys and Vilnius regional waste management centres is provided in Table 7-13.

2012

a



b



2013

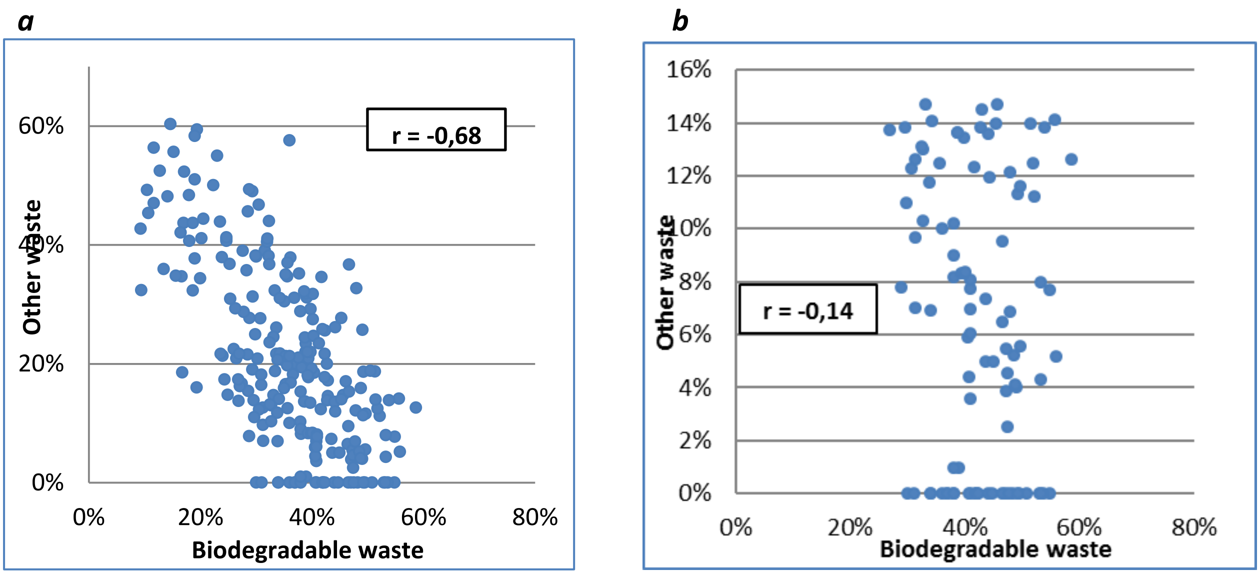


Figure 7-3. Correlation between the total fraction of biodegradable waste and unidentified fraction of "other waste" in reported data on waste composition; a - all available data, b - data from regions in which "other waste" is less than 15%

Table 7-13. Summary of data on the total amount of biodegradable waste (fraction 7) reported by Marijampolė, Šiauliai, Panevėžys and Vilnius regional waste management centres

Parameter	Total	Cities	Towns	Spring	Summer	Autumn	Winter
Number of analyses	82	15	67	25	20	19	18
Minimum	30.8%	34.8%	30.8%	33.9%	41.3%	30.8%	32.9%
Maximum	75.0%	72.0%	75.0%	75.0%	73.6%	68.0%	71.2%
Average	53.2%	56.1%	52.6%	53.2%	56.0%	55.5%	47.9%
Standard deviation	11.3%	11.1%	11.3%	11.5%	10.0%	9.5%	12.4%

The result of data analysis (Table 7-13) showed no significant difference between data on biodegradable waste established in cities and towns or in various seasons and it was decided to use average values for calculations (Table 7-14).

Table 7-14. Summary data on municipal waste composition

No	Ingredient	Minimum	Maximum	Average	Standard deviation
2012					
1	Paper and cardboard including packaging	2.0%	25.6%	9.2%	4.7%
2	Green waste	0.0%	49.4%	13.3%	12.5%
3	Wood waste including packaging	0.0%	20.3%	3.1%	3.8%
4	Biodegradable food production waste	0.0%	53.7%	15.7%	11.9%
5	Natural fibre waste	0.0%	14.6%	5.6%	3.3%
6	Other municipal biodegradable waste	0.0%	38.7%	6.3%	9.5%
7	**Total municipal biodegradable waste**	**30.8%**	**75.0%**	**53.2%**	**11.3%**
8	Plastic waste including packaging	4.3%	38.8%	15.0%	6.5%
9	Composite packaging waste	0.0%	11.1%	2.2%	2.5%
10	Metal waste including packaging	0.0%	10.9%	2.8%	2.3%

11	Glass waste including packaging	1.0%	33.0%	6.8%	4.6%
12	Inert waste (ceramics, concrete, stones, etc.)	0.0%	31.3%	10.2%	8.2%
13	Other non-hazardous waste	0.0%	26.1%	3.3%	5.6%
14	Waste electric and electronic equipment	0.0%	5.2%	0.4%	0.9%
15	Waste batteries and accumulators	0.0%	2.1%	0.1%	0.3%
16	Other hazardous waste	0.0%	3.0%	0.1%	0.5%
17	Other municipal waste	0.0%	14.9%	5.9%	5.1%
2013					
1	Paper and cardboard including packaging	1.0%	25.3%	8.9%	4.2%
2	Green waste	0.0%	24.8%	6.8%	5.7%
3	Wood waste including packaging	0.0%	7.9%	2.2%	2.2%
4	Biodegradable food production waste	2.4%	44.2%	13.9%	10.6%
5	Natural fibre waste	0.0%	20.5%	5.0%	4.5%
6	Other municipal biodegradable waste	0.0%	25.6%	5.4%	6.1%
7	**Total municipal biodegradable waste**	**24.9%**	**58.6%**	**42.3%**	**7.6%**
8	Plastic waste including packaging	6.0%	36.0%	18.1%	5.3%
9	Composite packaging waste	0.0%	14.0%	4.5%	3.6%
10	Metal waste including packaging	0.0%	27.7%	4.4%	4.3%
11	Glass waste including packaging	0.3%	24.0%	9.6%	5.0%
12	Inert waste (ceramics, concrete, stones, etc.)	0.0%	38.0%	8.8%	6.7%
13	Other non-hazardous waste	0.0%	36.3%	4.5%	6.6%
14	Waste electric and electronic equipment	0.0%	6.3%	0.9%	1.3%
15	Waste batteries and accumulators	0.0%	2.8%	0.1%	0.3%
16	Other hazardous waste	0.0%	4.6%	0.1%	0.6%
17	Other municipal waste	0.0%	14.8%	6.7%	5.3%

Composition of biodegradable waste in municipal waste stream was determined in the following way (Table 7-15):

- in 1990-2003: assumed corresponding to composition reported by the Ministry of Environment in *"Status of the Environment 2004"*
- in 2004-2011: established by linear interpolation of 2003 and 2012 data.
- in 2012 and 2013: assumed corresponding to average composition determined in 2012 and 2013 (see Table 7-14);
- in 2014 and 2015: assumed the same as in 2013.

Table 7-15. 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%
1995	14.0%	2.0%	4.0%	42.0%	0.0%
2000	14.0%	2.0%	4.0%	42.0%	0.0%
2005	12.9%	2.2%	4.4%	37.6%	3.0%
2010	10.2%	2.8%	5.2%	26.5%	10.4%

2011	9.7%	3.0%	5.4%	24.3%	11.9%
2012	9.2%	3.1%	5.6%	22.1%	13.3%
2013	8.9%	2.2%	5.0%	19.3%	6.8%
2014	8.9%	2.2%	5.0%	19.3%	6.8%
2015	8.9%	2.2%	5.0%	19.3%	6.8%

From 2008, a fraction of municipal waste has been sorted manually separating plastics, glass, and metal. Remaining waste after sorting was landfilled and reported in the EPA database under code *19 12 12 Other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11.* It was assumed that about 50% of recyclable plastics, glass, and metals were recovered. After subtracting recovered recyclables, degradable components in remaining waste to be disposed of in the landfills were recalculated based on collected composition data (see Table 7-14). The amounts of waste landfilled after manual sorting and its compositions are provided in Table 7-16.

Table 7-16. Amounts of waste remaining after manual sorting and composition of degradable components

Year	Amount, kt	Degradable waste, %				
		Paper and cardboard	Wood	Textile	Food waste	Green wastes
2008	1.28	12.8%	2.9%	5.5%	34.9%	8.4%
2009	15.14	12.2%	3.1%	5.7%	32.5%	10.1%
2010	22.60	11.6%	3.2%	5.9%	30.1%	11.8%
2011	31.29	11.0%	3.4%	6.2%	27.6%	13.5%
2012	147.63	10.5%	3.5%	6.4%	25.1%	15.2%
2013	128.97	10.6%	2.7%	6.0%	23.0%	8.1%
2014	204.02	10.6%	2.7%	6.0%	23.0%	8.1%
2015	147.51	10.6%	2.7%	6.0%	23.0%	8.1%

Table 7-17 provides data on the total amount of biodegradable waste disposed of in landfills obtained by adding biodegradable waste of manually sorted waste and waste of industrial and commercial origin (Table 7-9) to municipal biodegradable waste estimated using percentages provided in Tables 7-15 and 7-16.

It was assumed that amount and composition of waste of industrial and commercial origin in 1990 was the same as in 1991.

Table 7-17. Biodegradable components in landfilled waste evaluated for calculation of CH_4 generation (kt)

Year	Paper and cardboard	Wood wastes	Textile wastes	Food waste	Green wastes	Total
1990	13.5%	4.4%	4.6%	41.1%	2.4%	66.1%
1995	13.3%	5.6%	3.8%	40.1%	2.3%	65.0%
2000	11.6%	1.9%	3.8%	51.1%	0.3%	68.7%
2005	12.4%	4.3%	4.4%	36.0%	4.8%	61.9%
2010	10.2	2.9%	5.5%	26.5%	10.8%	55.8%
2011	9.6%	3.0%	5.7%	24.0%	12.8%	55.1%
2012	9.3%	3.2%	6.2%	22.3%	13.9%	54.9%
2013	9.1%	2.4%	5.6%	19.7%	7.2%	44.0%
2014	9.3%	2.5%	5.5%	20.2%	7.3%	44.9%
2015	9.2%	2.5%	5.5%	20.0%	7.1%	44.3%

There are no data and even no speculations on waste composition during the historic period 1950-1989. Assumption that waste composition in years 1950-1990 was the same as in later period has some, though not very firm, background, while we have no background at all for assuming that composition was different with higher or lower fraction of biodegradables. Therefore, the final composition of biodegradable waste determined for 1990 was used also for calculation of methane emissions in historic years 1950-1989.

Historic waste disposal

Using the first order decay method for calculation of CH_4 emissions from landfilled biodegradable waste requires historical data of waste disposal as the model takes into consideration long-term digestion process. Therefore information of historic waste disposal is necessary.

The amount of waste disposed to landfills during 1950-1989 was evaluated on the basis of the following considerations.

During the period of 1950–1990 Lithuanian population grew approximately 1% per year, but started to decline after the restoration of independence (Figure 7-4).

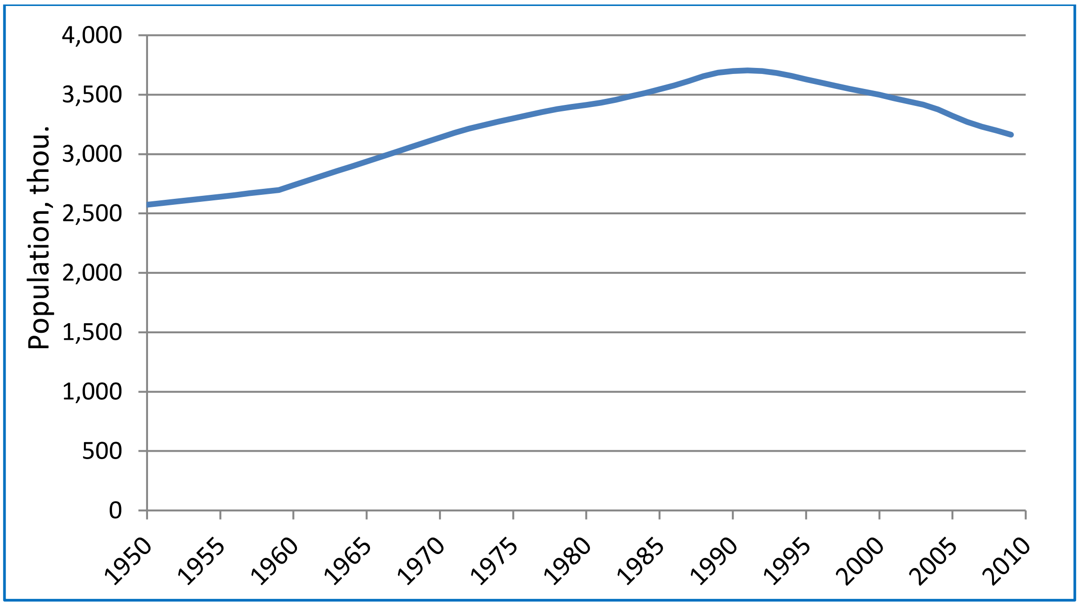


Figure 7-4. Variation of population in Lithuania in 1950-2014[205]

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[206] evaluated by the Statistics Lithuania are shown in Figure 7-5. It should be noted, however, that it was measured in current prices and did not reflect correctly the change in living standard.

[205] Statistics Lithuania

[206] GDP: Conversion from material product balances to the system of national accounts in 1980-1990 at current prices. Lithuanian Department of Statistics, Vilnius, 1994

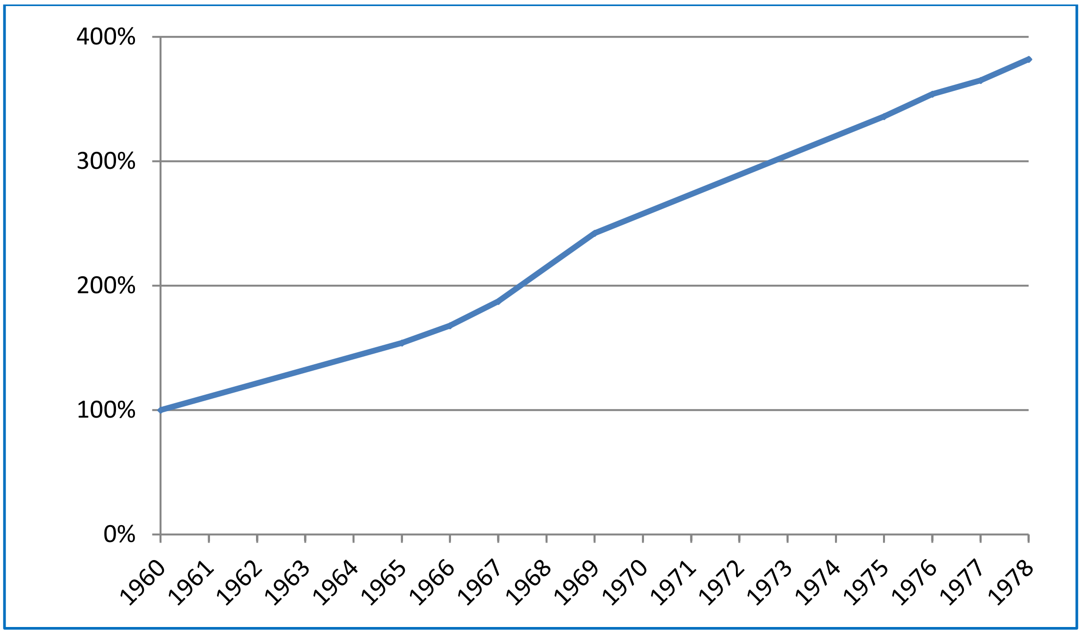


Figure 7-5. Variation of the total public product from 1960 to 1978

The Statistics Lithuania have recalculated economic indicators of the last decade of the Soviet power in Lithuania and obtained GDP values which are comparable to GDP after transition to free market economy[207]. Relative variations of population and GDP per capita from 1980 (1990 = 100%) are shown in Figure 7-6.

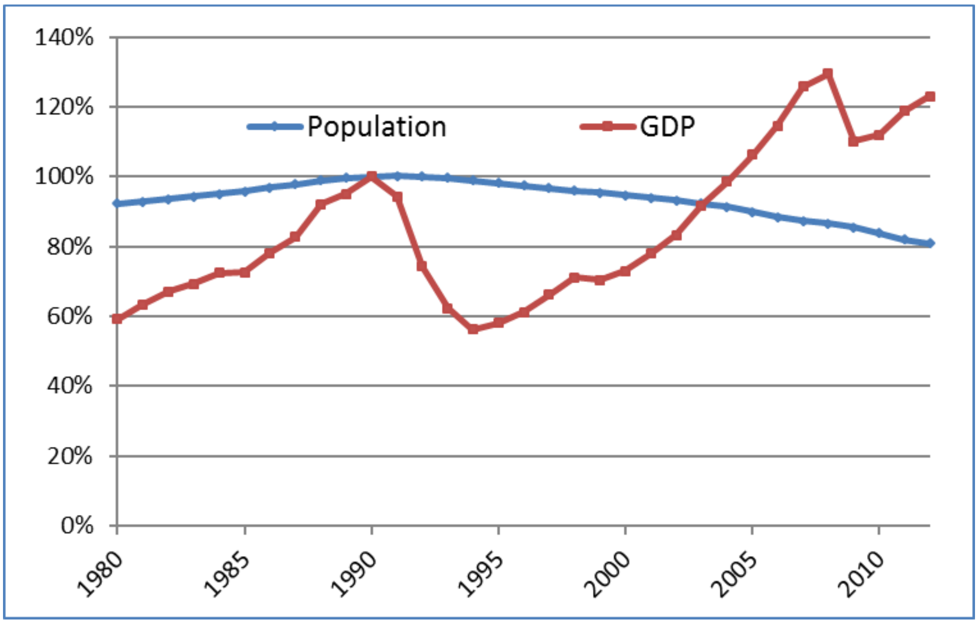


Figure 7-6. Relative variation of population and GDP per capita from 1980 (1990 = 100%)

It was assumed that the amount of waste per capita disposed of in landfills depends on consumption (standard of living) and availability of waste disposal facilities.

For evaluation of waste generation it was assumed that waste generation during the period 1950-1990 was increasing continuously and the growth rate was depending on two factors: number of 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.

[207] Ibid.

The period of 1950-1989 starts just 5 years after the World War II when the most of Lithuania was still in ruins, facilities and infrastructure for waste collection were actually non-existent. Therefore application of the same parameters for evaluation of waste disposed of in landfills in post-war period and 1990s when waste collection and disposal facilities and infrastructure were already in place, though inadequately managed, was considered not correct.

In 1950s waste collection services were provided only to small fraction of population in major cities and growth of the amount of waste disposed of in landfills was instigated not so much by increasing consumption but rather by expansion of waste collection areas and infrastructure. Therefore it was assumed that disposal of waste during this period was increasing substantially faster than in 90s.

It was assumed that expansion of provided waste management services and improvement of living standards caused increase of waste generation per capita by about 1% annually.

When extrapolating waste disposal, it was assumed that composition of degradable waste (in per cent), including both municipal and industrial waste, was the same as in 1990.

The estimated total amounts of waste were then in a next step divided over 3 types of disposal sites based on the relation between the types of disposal sites and the population in major cities, smaller towns and rural areas. From 2007 out-phasing of the old landfill sites and putting in operation of new landfills was taken into consideration.

Variation of municipal waste disposal (not including separately disposed biodegradable waste of industrial and commercial origin) from 1950 to 1990 is based on these assumptions and is shown in Figure 7-7.

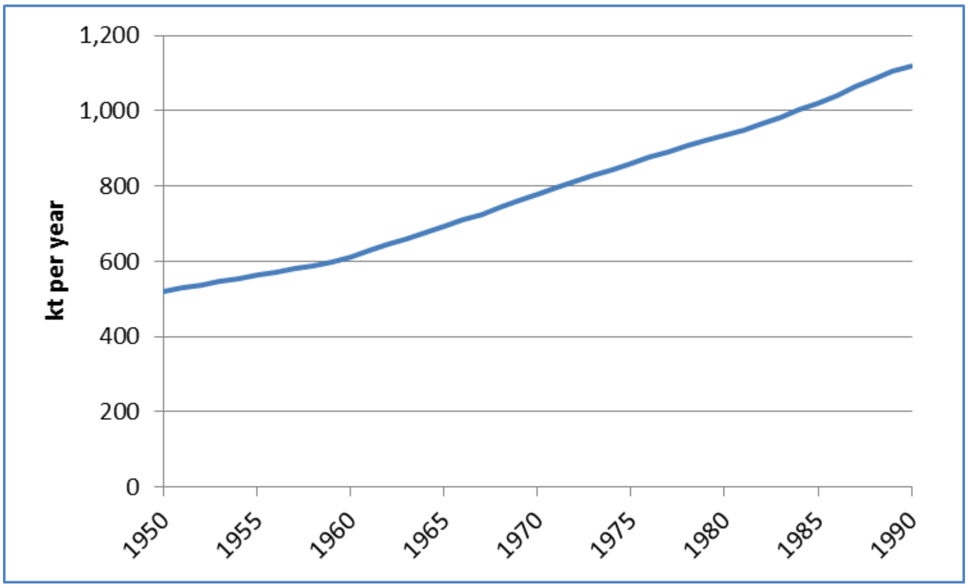


Figure 7-7. Assumed variation of municipal waste disposal from 1950 to 1990

There are no data on either municipal or industrial/commercial waste disposal during the period 1950-1990 and it was not possible to make any distinction between variation of disposed municipal and industrial/commercial wastes. Evaluation of waste disposal for the period 1950-1989 was performed applying the same methodology as for the total amount of wastes including both municipal and industrial/commercial waste.

Amount of industrial and commercial waste disposed of in 1990 was assumed to be the same as in 1991. Data on disposal of industrial and commercial waste from 1991 to 1998 were taken from the database of the Environmental Protection Agency.

The final composition of biodegradable waste (including both municipal and industrial/commercial waste) determined for 1990 was used also for calculation of methane emissions in historic years 1950-1989.

Sensitivity analysis

Assumption that the amount of waste disposed of per capita in landfills in 1950-1989 was increasing on average by 1% should be considered as very rough, most probably containing significant error, and it is very important to evaluate whether erroneous assumption could have a significant impact on the final results of methane emission.

Growth of the amount of disposed per capita waste in 1950-1989 by 1% was taken as base scenario and for comparison, methane emissions were calculated using alternative assumptions that disposed per capita waste amount in 1950-1989 was increasing by 0.5% and 2%.

It is obvious that in case of faster growth, in order to reach the same level in 1990, the initial waste amount disposed of in 1959 should be lower, and vice versa, in case of slower growth the initial amount should be higher. Evaluated initial amounts of waste that should have been disposed in 1950 in case of 0.5%, 1% and 2% average growth of disposed per capita waste are shown in Table 7-18.

Table 7-18. Evaluated initial amounts of waste that should have been disposed in 1950 in case of 0.5%, 1% and 2% average growth of disposed per capita waste

Parameter	Growth 0.5%	Growth 1%	Growth 2%
Disposal kg/person/year	277	226	151
Total disposal, kt per year	712	582	388

In case of waste growth rate reduced by halve compared to base scenario, initial waste amount increases only by 22.3%, while twice higher growth rate requires decline of initial waste amount by 33.4%.

Impact of different growth rates waste disposal in 1959-1989 on methane emissions in 1990-2014 is shown in Table 7-19.

Table 7-19. Impact of assumed different growth rates of waste disposal in 1959-1989 on methane emissions in 1990-2014 compared to base scenario (1% growth)

Year	Growth 0.5%	Growth 2%
1990	4.3%	-7.8%
1991	3.9%	-6.9%
1992	3.5%	-6.2%
1993	3.1%	-5.6%
1994	2.8%	-5.1%
1995	2.6%	-4.7%
1996	2.4%	-4.3%
1997	2.2%	-4.0%
1998	2.1%	-3.7%
1999	1.9%	-3.4%
2000	1.8%	-3.2%
2001	1.6%	-2.9%

2002	1.5%	-2.7%
2003	1.4%	-2.5%
2004	1.3%	-2.3%
2005	1.3%	-2.2%
2006	1.2%	-2.1%
2007	1.2%	-2.0%
2008	1.1%	-1.9%
2009	1.0%	-1.8%
2010	1.0%	-1.7%
2011	0.9%	-1.6%
2012	0.9%	-1.6%
2013	0.9%	-1.5%
2014	0.9%	-1.5%

As could be seen from the Table 7-19, 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 1990-2014 only 2%.

Assumption that waste disposal growth rate in 1950-1989 was twice higher than in the base scenario results in reduction of methane emissions by maximum 7.8%, on average 3.5%.

It is obvious that variations of obtained results using three various scenarios are quite small, significantly lower than uncertainty of evaluation of methane emissions, and possible error in estimating waste disposal in 1950-1989 could have only minor impact on final results.

Waste disposal practices

Historically Lithuanian landfills can be divided into three categories:

- landfills of major cities (county centres),
- landfills of smaller towns, and
- small landfills and dumps in rural areas.

Waste management in landfills of major cities include controlled placement of waste, periodic covering and mechanical compacting. These landfills correspond to the definition of anaerobic managed waste disposal sites.

Landfills of smaller towns are comparatively deep (>5 m of waste) but their management especially in the past was poor. These landfills correspond to the definition of managed semi-aerobic waste disposal sites.

Small landfills and dumps in rural areas were assigned to unmanaged waste disposal sites.

The amounts of waste disposed to the landfills of each type were evaluated in the following way.

Variations of urban and rural population in Lithuania during 2001-2011 are shown in Table 7-20. Separately data of populations in major cities and towns are not available from 1950. However, as seen from this table, the share of major cities in the total urban population is fairly constant and makes approximately 70%. It was assumed that this ratio continued for the whole discussed period starting from 1950. Estimated variations of population in major cities, towns and rural areas from 1950 are provided in Figure 7-8.

Table 7-20. Variations of urban and rural population (k) in Lithuania during 2001-2011

Year	Major cities	Towns	Total urban	Rural	Total
2001	1629	694	2323	1148	3471
2002	1622	681	2303	1140	3443
2003	1616	664	2280	1135	3415
2004	1604	645	2249	1128	3377
2005	1593	619	2212	1110	3323
2006	1585	594	2179	1091	3270
2007	1580	576	2156	1075	3231
2008	1556	579	2135	1063	3198
2009	1551	561	2112	1051	3163
2010	1531	537	2068	1029	3097
2011	1499	523	2021	1007	3028

Source: Statistics Lithuania

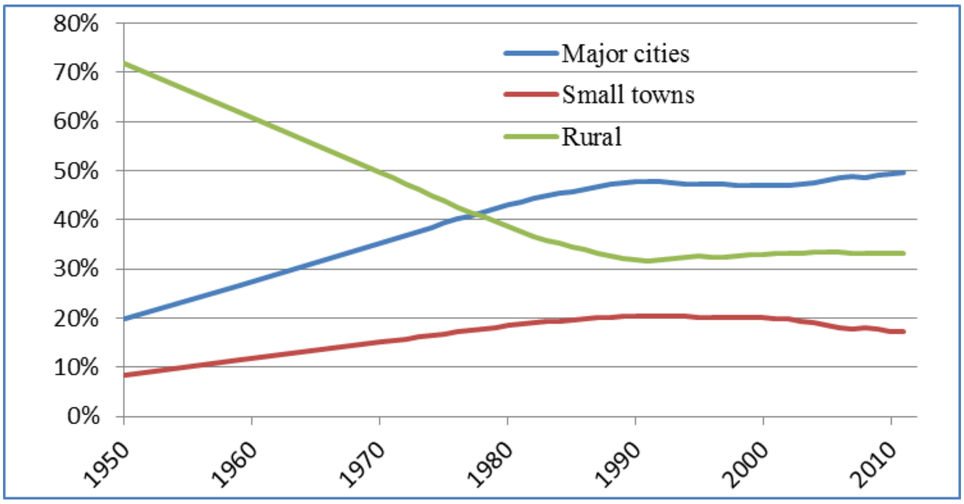


Figure 7-8. Estimated variations of population in major cities, towns and rural areas from 1950[208]

Conditions described above were applicable until 2007. From 2007 disposal practices started to change. Implementation of the Landfill directive 1999/31/EC requires construction of new solid waste landfills corresponding to the requirements set in the directive and closure of all existing landfills not complying with the requirements.

As a result, 10 municipal waste management regions were established in Lithuania and new landfills complying with the requirements of the Landfill directive were constructed. Old landfills and dumps were closed and all waste including waste from small towns and rural areas are currently disposed in a new managed landfills. The start of waste disposal in new managed regional landfills complying with the requirements of Landfill directive is shown in Table 7-21.

Table 7-21. 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

[208] Statistics Lithuania

Kaunas	July 2009
Utena	April 2008
Panevėžys	October 2009

For the transition period 2007-2009, the regional waste management companies provided data (percentage) of wastes disposed in old and new landfills. Waste disposed in old landfills was divided into 3 categories depending on population distribution in cities, towns and rural areas, waste disposed of in new landfills was assigned to deep managed category.

Evaluated disposal of municipal waste in new regional landfills are shown in Table 7-22.

Table 7-22. 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[209] 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),

[209] Meeting at the Ministry of Environment with the Head of Waste Division Ingrida Kavaliauskienė and senior specialist Ingrida Rimaitytė, September 25, 2009

WT is the total amount of disposed waste (tonne) minus waste disposed on the new regional landfills,

P_C, P_T and P_R are the number of population in cities, towns and rural areas (thousands).

The amounts of waste disposed off in anaerobic, semi-aerobic and unmanaged landfills (corresponding to waste delivered for disposal from major cities, towns and rural areas) were calculated by multiplying corresponding population number with the waste generation per capita of the corresponding category, namely for managed waste disposal sites: 2.G_R.Pc; for unmanaged deep: 1.5 . G_R.Pt; for unmanaged shallow: 1. G_R.P_R.

Data on disposal of solid municipal waste in landfills of each category are provided in Tables 7-23 and 7-24.

Table 7-23. Disposal of solid municipal waste in Lithuania

	Population, thou.	MSW disposal	
		thou. tonne	kg per capita
1991	3,704	1,122	303
1995	3,629	1,056	291
2000	3,500	1,084	310
2005	3,323	1,048	315
2010	3,097	1,073	346
2011	3,028	1020	337
2012	2,988	930	311
2013	2,958	785	266
2014	2,932	649	221
2015	2,905	673	232

Table 7-24. Disposal of solid municipal waste in landfills of different categories (kt)

Year	Old landfills			New regional landfills	TOTAL
	Managed anaerobic	Managed semi-aerobic	Unmanaged		
1990	677	218	226	-	1,120
1995	633	203	219	-	1,056
2000	648	208	228	-	1,084
2005	639	186	223	-	1,048
2010	-	-	-	1,073	1,073
2011	-	-	-	1020	1020
2012	-	-	-	930	930
2013	-	-	-	785	785
2014	-	-	-	649	649
2015	-	-	-	678	678

Sewage sludge disposal

Sewage sludge is disposed separately from solid waste on sites comparable to landfills but defined as storage sites in the EPA statistics. Statistical information on sewage sludge disposal is collected and stored in the same data base together with data on waste generation and management. Data on sewage sludge disposal were provided by the Lithuanian EPA responsible for collection and management of statistical information on waste management.

Up to 2005 wet sewage sludge generation and management data are reported and stored in the EPA database. From 2006 some companies started reporting amount of sludge expressed in dry matter. All data were carefully checked and converted to wet sludge using dry matter/wet sludge conversion factor 0.2[210]

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[211] performed in 2012 concluded that about 73% of sewage sludge are disposed on shallow (depth <5 m) unmanaged sites for which use of MCF value 0.4 is recommended. Remaining 27% are disposed on deeper (depth >5 m) semi-aerobic sites for which MCF value 0.8 was recommended.

Data on sewage sludge production and disposal are provided in Table 7-25.

Table 7-25. Sewage sludge production and disposal, kt dry substance

	2012	**2013**	**2014**	**2015**
Agricultural use (b)	7.79	7.68	15.73	18.86
Compost and other applications	12.18	10.93	14.74	16.09
Landfill	-	-	-	-
Incineration	-	-	-	-
Drying and granulation	0.99	4.46	11.20	10.47
Storage	24.13	18.36	6.34	6.77
Total	**45.09**	**41.43**	**48.02**	**52.20**

Amounts of sewage sludge (kt) disposed on land of different categories of storage sites are provided in Table 7-26.

Table 7-26. Amount of sewage sludge (kt wet weight) disposed on land sites of different categories

Year	**Semi-aerobic (MCF = 0.8)**	**Unmanaged (MCF = 0.4)**	**Total**
1990	53.2	143.9	197.1
1995	83.4	225.5	308.9
2000	84.4	228.3	312.7
2005	36.5	98.6	135.1
2010	32.7	88.4	121.1
2011	41.9	113.3	155.2
2012	32.6	88.1	120.7
2013	24.8	67.0	91.8
2014	8.6	23.2	31.7
2015	9.1	24.7	33.8

Methane recovery

Landfill gas collection started in 2008 in closed Kaunas and Utena landfills. Initially, discrete data on methane recovery from landfills were not reported by the Statistics Lithuania, and information on methane recovery was collected by sending questionnaires to the Regional Waste 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.

[210] Wet - dry conversion of sludges. ARGUS for Eurostat - Environment Statistics. Meeting of the Working Group "Statistics of the Environment", Sub-Group "Waste". Eurostat, 2008.

[211] 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

Recovered methane is used for energy purposes and emissions from landfill gas combustion are included in the energy sector report. In order to be consistent, it was decided to use the same data for evaluating GHG emissions in both energy and waste disposal sectors.

The data on landfill gas recovered and used for energy production 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.

Amount of recovered methane in kt was calculated assuming that methane lower heating value is 50 TJ/kt[212]. 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 on flared landfill gas were collected from the Regional Waste Management Centres, however, some flaring systems are not equipped with metering gadgets and the volume of flared gas was evaluated by personnel supervising the systems.

The volume of flared landfill gas was reported in volume units which were converted to mass units using equation:

$$\text{Mass of flared gas} = HV_v / LHV_m,$$

where:

HV_v is landfill gas heating value on volume bases assumed 20 $TJ/m^3 \cdot 10^6$ (average value as reported by the Statistics Lithuania which provides data both in m^3 and TJ),

LHV_m is lower heating value on mass bases = 50 TJ/kt (see above).

Data of CH_4 recovery from landfills are provided in Table 7-27.

Table 7-27. Methane recovery from landfills, kt

Year	Used for energy[213],	Flared[214]
2008	0.34	
2009	1.12	
2010	1.66	
2011	4.90	
2012	5.14	0.02
2013	5.98	0.04
2014	6.46	0.20
2015	6.86	0.33

At the municipal wastewater treatment plants methane is recovered in anaerobic digestion installations from sludge generated during wastewater treatment. Sludge for anaerobic

[212] http://www.engineeringtoolbox.com/gross-net-heating-values-d_420.html
[213] Statistics Lithuania
[214] Provided by the regional waste management centers.

digestion is collected separately and not accounted together with disposed sludge. Therefore methane recovery in anaerobic digestion plants is discussed in wastewater handling section.

Anaerobic digestion facilities for sewage sludge are operated by corresponding wastewater treatment plants. As sludge is recycled within a plant, operators are not obliged to report its generation and consumption to the EPA, and data on sewage sludge used for biogas production in anaerobic digestion facilities are not available.

7.2.3 Methodological issues

First Order Decay Model

CH_4 generation was evaluated using FOD model according to *Tier 2* approach (*2006 IPCC Guidelines*). 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[215]:

$$DDOC_m = DDOC_m(0) \times e^{-kt}$$

where:

$DDOC_m$ is the mass of decomposable degradable organic carbon (DOC) at any time,
$DDOC_m(0)$ is the mass of DOC at the start of the reaction, when t=0 and e^{-kt}=1,
t is time in years, and
k is the reaction constant.

The default assumption is that CH_4 generation from all the waste deposited each year begins on the 1st of January in the year after deposition. This is the same as an average six month delay until substantial CH_4 generation begins (the time it takes for anaerobic conditions to become well established).

The amount of degradable organic carbon disposed during a year decreases exponentially over time according to the first order decay equation resulting in corresponding exponential reduction of CH_4 generation. The total CH_4 generation at a given time *t* is a sum contributions from degradation of organic carbon disposed during the years from 1 to t.

Annual CH_4 emissions were calculated using formula (*2006 IPCC Guidelines*, Volume 5, p. 3.8):

$$CH_4Emissions = \left[\sum_x CH_4generated_{x,T} - R_T\right] \times (1 - OX_T)$$

Where:

T - inventory year,
x – waste category or type/material
R_T -recovered CH_4 in year T (kt),
OX_T - oxidation factor (assumed OX_T = 0).

[215] *2006 IPCC Guidelines*, Volume 5

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 (*2006 IPCC Guidelines*, Volume 5, p. 3.14).

Landfills of smaller towns are comparatively deep (>5 m of waste) but their management, especially in the past, was poor. These landfills correspond to the definition of deep unmanaged landfills with CH_4 correction factor = 0.8 (*2006 IPCC Guidelines*, Volume 5, p. 3.14).

Small landfills and dumps in rural areas were assigned to unmanaged shallow landfills (<5 m waste) with CH_4 correction factor = 0.4 (*2006 IPCC Guidelines*, Volume 5, p. 3.14).

Other parameters

Other parameters:

DOC (weight fraction, wet basis) (*2006 IPCC Guidelines*, Volume 5, p. 2.14):

Food waste	0.15
Paper	0.4
Wood	0.43
Textiles	0.24
Green waste	0.20

Country specific DOC value was used in calculations of methane emissions from sewage sludge. Average DOC value reported in the study[216] performed in 2012 was evaluated at 30% of sludge dry matter based on experimental analyses performed in various wastewater treatment facilities in Lithuania. Assuming that dry matter content in sewage sludge is about 20%, DOC value 0.06 was used for calculation of methane emissions from wet sludge.

CH_4 generation rate constant was chosen for the wet climate condition under the boreal and temperate climate zone provided in the *2006 IPCC Guidelines,* Volume 5, p. 3.17. The reason for selection of this value is that Lithuania is situated in the temperate climate zone, i.e. north of subtropics and south of subarctic area, and its climate is characterized as wet, i.e. precipitation exceeds evaporation.

CH_4 generation rate constant (years^{-1})(*2006 IPCC Guidelines*, Volume 5, p. 3.17)

Food waste	0.185
Paper	0.06
Wood	0.03

[216] Evaluation of methane generation from wastewater and sludge at wastewater treatment plants in Lithuania (Lietuvos nuotekų valymo įrenginių nuotekose ir dumble susidarančio metano kiekio tyrimai ir įvertinimas) Ekotermija, 2012

Textile	0.06
Green waste	0.1
Sewage sludge	0.185

DOC_f (fraction of DOC dissimilated)	0.5 (*2006 IPCC Guidelines*, Volume 5, p. 3.13)
Delay time (months)	6 (*2006 IPCC Guidelines*, Volume 5, p. 3.19)
Fraction of CH_4 in developed gas	0.5 (2006 IPCC, Volume 5, p. 3.26)
Conversion factor C to CH_4	16/12 = 1.33 (*2006 IPCC Guidelines*, Volume 5, p. 3.37)
Oxidation factor	0 (*2006 IPCC Guidelines*, Volume 5, p. 3.15)

CO2 emissions from combustion of landfill gas are of biogenic origin and comparatively very low, hence they were not taken into consideration.

7.2.4 Uncertainties and time-series consistency

Uncertainties

Uncertainty of activity data was assumed to be 30% (*2006 IPCC Guidelines*, Volume 1, Chapter 3, Table 3.5).

Uncertainties of separate input parameters for *Tier 1* uncertainty analysis were taken as average values of uncertainties provided in *2006 IPCC Guidelines*, Volume 5, Chapter 3, Table 3.5 (Table 7-28).

Table 7-28. 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%

* *2006 IPCC Guidelines*, Volume 3, Table 3.5 does not provide uncertainties for methane generation rate constant, therefore data from GPG 2000, p. 5.12, Table 5.2 were used in calculations)

Uncertainty of implied emission factor for three separate MCF values was established using *2006 IPCC Guidelines*, Volume. 1, Chapter 3, equation 3.1 (p. 3.28):

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \ldots + U_n^2},$$

Where:

U_{total} is the percentage uncertainty in the product of the quantities (half the 95% confidence interval divided by the total and expressed as a percentage);

U_i are the percentage uncertainties associated with each of the quantities.

Uncertainties of implied emission factors calculated using values from the third column of Table 7-28 are provided in Table 7-29.

Table 7-29. Overall uncertainties of implied emission factors

Methane correction factor	Uncertainties of implied emission factor
MCF = 1	172%
MCF = 0.4	175%
MCF = 0.8	174%

The overall uncertainty of emission factor for the total CH_4 emission comprising all three types of landfills was calculated using *2006 IPCC Guidelines*, Volume 1, Chapter 3, equation 3.2 (p. 3.28):

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

where:

U_{total} is the percentage uncertainty in the sum of the quantities,

x_i and U_i are the uncertain quantities and the percentage uncertainties associated with them, respectively.

Calculated overall uncertainty of implied emission factor using average CH_4 emission values of disposed solid waste and sewage sludge over the period 1990-2015 is 123.1%.

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.

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 2015. The inventory takes account of all existing landfills and dumps divided in three categories (deep managed, deep unmanaged and shallow unmanaged) and includes emissions from various types of biodegradable materials (food waste, paper, wood, textile, green waste, sewage sludge) disposed of with municipal, industrial and commercial waste.

7.2.5 Category-specific QA/QC and verification

Data collection and calculations were performed in accordance with the requirements outlined in Section 6 of the Quality Assurance (QA) and Quality Control (QC) Plan[217].

[217] National Greenhouse Gas Emission Inventory of the Republic of Lithuania. Quality Assurance and Quality control Plan 2016-2017. Vilnius, 2015.

Tier 1 General Inventory Level QC was performed based on recommendations provided in IPCC 2006 vol. 1 Chapter 6 and outlined in the QA/QC plan.

Consistency of data between NIR and CRF has been checked.

Documentation on activity data and emission factors was crosschecked with the corresponding data in calculation model.

In case of large fluctuations in data, other experts or data providers were consulted to either provide the explanation or to identify a possible inconsistency or an error.

Explanations for recalculations were checked to ensure that they are clearly documented.

After the calculation is finished, EPA waste experts not directly involved in the emissions calculation of that year have reviewed the final report and CRF data checking the applied parameters, calculation methodology, as well as trend description in the NIR.

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 7-30.

Table 7-30. Comparison of GHG emissions from solid waste disposal on land (kg per capita)

Year	Lithuania	Denmark	Latvia	Estonia	Poland
1990	10.6	13.8	5.9	5.5	11.2
1995	11.6	11.9	7.1	7.1	10.9
2000	12.2	9.6	8.1	12.8	11.4
2005	13.2	8.2	7.6	11.5	10.8
2010	13.2	6.8	9.7	9.8	10.0
2011	12.4	6.7	10.0	9.1	9.6
2012	12.3	6.4	10.3	8.5	9.4
2013	11.9	6.1	10.3	7.3	9.3
2014	11.2	5.9	10.6	6.6	9.0

As can be seen from Table 7-31, emission differences in all five neighbouring countries are not significant and evaluated emission data could be considered reliable and adequate.

Table 7-31. Comparison of minimum, maximum and average values of GHG emissions from solid waste disposal on land (kg per capita)

	Lithuania	Denmark	Latvia	Estonia	Poland
Minimum	10.6	5.9	5.9	5.5	9.0
Maximum	13.2	13.8	10.6	13.1	11.5
Average	12.2	9.6	8.1	9.6	10.7

7.2.6 Category-specific recalculations

Flaring of landfill gas emissions were evaluated in this submission for the first time, and the amount of flared methane was subtracted from the amount calculated using FOD model. In addition, MSW fraction remaining after manual sorting was added to the total amount of landfilled waste.

Impact of recalculations on CH_4 emissions is shown in Table 7-32.

Table 7-32. Impact of recalculations on methane emissions from SMW disposal on land

Year	Previous submission, kt CO_2eqv.	This submission, kt CO_2eqv.	Difference	
			kt CO_2eqv.	%
2009	1,084.9	1,085.1	0.15	0.01
2010	1,064.7	1,066.5	1.84	0.17
2011	957.7	979.8	4.14	0.42
2012	956.24	962.7	6.42	0.67
2013	900.12	920.8	20.63	2.24
2014	834.33	860.0	25.63	2.98

7.2.7 Category-specific planned improvements

Category-specific improvements are not planned.

7.3 Biological treatment of waste (CRF 5.B)

7.3.1 Category description

Biological treatment of waste includes composting and anaerobic digestion.

Methane recovered in anaerobic digestion plants is used for energy production and reported in the Energy Sector. However, leakages from anaerobic digestion facilities due to process disturbances or other unexpected events are possible and are covered in this report.

Evaluated CH_4 and N_2O emissions from waste composting and anaerobic digestion are provided in Table 7-33.

Table 7-33. Evaluated CH_4 and N_2O emissions from waste composting

Year	CH_4 emissions, kt			N_2O emissions, kt
	Composting	Anaerobic digestion	Total	
1990	0.16	NO	0.16	0.010
1995	0.21	NO	0.21	0.013
2000	0.08	0.04	0.12	0.005
2005	0.27	0.06	0.33	0.016
2010	0.26	0.13	0.39	0.016
2011	0.34	0.13	0.47	0.020
2012	0.38	0.13	0.51	0.023
2013	0.49	0.15	0.64	0.029
2014	0.82	0.29	1.11	0.049
2015	0.82	0.29	1.12	0.049

Specific data on waste composting were provided by the Lithuanian EPA for 2014 and 2015. For the period 1990 to 2013 only data on waste recovery were available including composting together with other various types of waste processing. The amount of composted waste was evaluated based on the following considerations.

As noted in the description of the Lithuanian waste reporting procedures, three classification systems were used for waste reporting since 1991.

The list of waste disposal and recovery operations during the reporting period 1991 to 1999 contained a recovery operation *R15 – composting* which was used to establish the amount of composted waste during this period.

New list of disposal and recovery operations was adopted from the year 2000 which contained entry *3.2 – biological treatment of non-hazardous waste*. It was assumed that all waste reported under this category was composted.

From 2004, waste reporting regulations changed again and list of waste disposal and recovery operations provided in the EU waste framework directive 75/442/EEC[218] was adopted. Biological treatment of waste was included in the operation *R3 - Recycling/reclamation of organic substances which are not used as solvents (including composting and other biological transformation processes)* but this category included also various other recycling operations.

In order to separate waste composting from other recycling/reclamation operations, a list of potentially compostable waste was compiled based on the European Waste Catalogue[219]:

Wastes from waste water treatment plants not otherwise specified

19 08 12 sludges from biological treatment of industrial waste water
19 08 14 sludges from other treatment of industrial waste water

Sludges and liquid wastes from waste treatment

19 06 03 liquor from anaerobic treatment of municipal waste
19 06 04 digestate from anaerobic treatment of municipal waste
19 06 05 liquor from anaerobic treatment of animal and vegetable waste
19 06 06 digestate from anaerobic treatment of animal and vegetable waste

Paper and cardboard wastes

15 01 01 paper and cardboard packaging
19 12 01 paper and cardboard from the mechanical treatment of waste
20 01 01 separately collected paper and cardboard

Wood wastes

Wastes from wood processing and the production of panels and furniture

03 01 01 waste bark and cork
03 01 05 sawdust, shavings, cuttings, wood, particle board and veneer

Wastes from pulp, paper and cardboard production and processing

03 03 01 waste bark and wood

Packaging (including separately collected municipal packaging waste)

15 01 03 wooden packaging

Construction and demolition wastes

17 02 01 wood

Wastes from the mechanical treatment of waste

19 12 07 wood other than that mentioned in 19 12 06

Separately collected fractions

20 01 38 wood

Textile wastes

20 01 10 Worn clothes
04 02 21 wastes from unprocessed textile fibres
04 02 22 wastes from processed textile fibres
15 01 09 textile packaging
19 12 08 wastes from the mechanical treatment of waste textiles
20 01 11 separately collected textile wastes

Animal waste of food preparation and products

02 01 02 animal-tissue waste
02 02 01 sludges from washing and cleaning

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[218] Directive 75/442/EEC later was repealed and substituted by the directives 2006/12/EC and 2008/98/EC but the list of disposal and recovery operations remained unchanged.

[219] The European Waste Catalogue was established by the EU Commission Decision 2008/98/EC as amended and is adopted for use in all EU member states.

02 02 02	animal-tissue waste
02 02 03	materials unsuitable for consumption or processing
02 05 01	materials unsuitable for consumption or processing
Mixed waste of food preparation and products	
02 03 02	wastes from preserving agents
02 06 02	wastes from preserving agents
19 08 09	grease and oil mixture from oil/water separation containing only edible oil and fats
20 01 08	biodegradable kitchen and canteen waste
20 01 25	edible oil and fat
Green wastes	
02 01 07	wastes from forestry
20 02 01	biodegradable waste
Vegetal waste of food preparation and products	
02 01 01	sludges from washing and cleaning
02 01 03	plant-tissue waste
02 03 01	sludges from washing, cleaning, peeling, centrifuging and separation
02 03 04	materials unsuitable for consumption or processing
02 06 01	materials unsuitable for consumption or processing
02 07 01	wastes from washing, cleaning and mechanical reduction of raw materials
02 07 02	wastes from spirits distillation
02 07 04	materials unsuitable for consumption or processing
Slurry and manure	
02 01 06	animal faeces, urine and manure (including spoiled straw), effluent, collected separately and treated off-site
Household wastes	
20 03 01	mixed municipal waste
20 03 02	waste from markets
20 03 99	municipal wastes not otherwise specified
Wastes from aerobic treatment of solid wastes	
19 05 01	non-composted fraction of municipal and similar wastes
19 05 02	non-composted fraction of animal and vegetable waste
19 05 03	off-specification compost
Sludges from treatment of public sewerage water	
19 08 05	sludges from treatment of urban waste water
Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing	
02 02 04	sludges from on-site effluent treatment
02 03 05	sludges from on-site effluent treatment
02 04 03	sludges from on-site effluent treatment
02 05 02	sludges from on-site effluent treatment
02 06 03	sludges from on-site effluent treatment
02 07 05	sludges from on-site effluent treatment
03 03 11	sludges from on-site effluent treatment other than those mentioned in 03 03 10

It was assumed that all wastes included in the list were composted except paper and cardboard wastes, wood wastes, and textile wastes which, though containing degradable matter and could be composted, frequently are recycled by other methods.

Detailed data on waste treatment companies were available for 2006 to 2013. Based on this information data on composting was separated from other recycling activities and used for evaluation of GHG emissions.

Only aggregated data on recycling were available for 2000-2005. In order to evaluate composted fractions in the total amount of recycled waste, it was assumed that composted fractions of paper and cardboard, wood and textile wastes in 2000-2005 were the same as in 2006 to 2013.

Evaluated average composted fractions in the total amount of corresponding recycled wastes in 2006-2013:

- paper and cardboard waste 2.1%
- wood waste 29.6%
- textile waste 13.1%

Reported amount of composted municipal waste is very small, less than 0.4% of the total, and is reported only a few (six) years. Therefore municipal waste was not separated from the whole waste stream and methane emissions evaluated only from all composted wastes including municipal. As the amount of composted municipal solid waste is negligible, it, if occurring, was included in "Other" waste, therefore notation key "IE" is used.

The data on waste composting provided by the Lithuanian EPA on wet basis were converted to dry weight assuming a moisture content 40% in wet waste (*2006 IPCC Guidelines*, Volume 5, Chapter 4, Table 4.1).

Evaluated amount of composted waste is shown in Table 7-34.

Table 7-34. Evaluated amount of composted waste

Year	Amount of composted waste, kt	
	Wet weight	Dry weight
1990	40.37	16.15
1995	53.59	21.44
2000	19.96	7.99
2005	68.75	27.50
2010	65.91	26.37
2011	84.74	33.90
2012	95.84	38.34
2013	121.78	48.71
2014	204.44	81.77
2015	205.27	82.11

Anaerobic digestion of MSW did not occur in 1990–2015. Mechanical-biological treatment facilities processing municipal solid waste in anaerobic digestion plants started operating in Lithuania only in 2016, therefore notation key "NO" is used in CRF Table 5.B.

Currently only sewage sludge from municipal wastewater treatment plants is used in anaerobic digestion plants for biogas production. As biogas is produced by the wastewater treatment facilities and sludge used for anaerobic digestion is processed inside the facilities, it is not reported to the EPA and corresponding data are not available. Only sludge discharged from the anaerobic digestion facilities is included in the statistical reports.

Biogas recovery from sewage sludge in anaerobic digestion facilities is reported by the Statistics Lithuania, but the amount of sludge used for anaerobic digestion is not reported neither by the Statistics Lithuania nor by the Lithuanian EPD, therefore notation key "NE" is used in CRF Table 5.B.

7.3.2 Methodological issues

The CH_4 and N_2O emissions from biological treatment can be estimated using the default method given in Equations 4.1 and 4.2 provided in *2006 IPCC Guidelines*, Volume 5, Chapter 4:

$$CH_4 Emissions = \sum (M \times EF_{CH4}) \times 10^{-3}$$

$$N_2O Emissions = \sum (M \times EF_{N2O}) \times 10^{-3}$$

Where:

CH_4 *Emissions* = total CH_4 emissions in inventory year, kt CH_4
N_2O *Emissions* = total N_2O emissions in inventory year, kt N_2O
M = mass of organic waste treated by biological treatment, kt
EF_{CH4} = emission factor, g CH_4/kg waste treated
EF_{N2O} = emission factor, g N_2O/kg waste treated

Both equations were used for calculation of emissions from waste composting. Emission factors provided in *2006 IPCC Guidelines*, Volume 5, Chapter 4, Table 4.1 were used (10 g CH_4/kg waste treated and 0.6 g N_2O/kg waste treated).

The amount of sewage sludge used in anaerobic digestion process is not reported as, according to the Lithuanian legislation, reporting of waste recycled inside the plants in which it is generated is not obligatory. Data on biogas generation in anaerobic digestion processes were taken from the Statistics Lithuania which collects corresponding information.

According to the *2006 IPCC Guidelines,* Volume 5, Chapter 4, emissions from anaerobic digestion facilities due to unintentional leakages during process disturbances or other unexpected events will generally be between 0 and 10% of the amount of CH_4. Default value 5% was used for estimating CH_4 emissions.

7.3.3 Uncertainties and time-series consistency

Uncertainty

It was assumed that uncertainty of activity data is 40%.

Uncertainties in the default emission factors were estimated using the ranges given in *2006 IPCC Guidelines,* Volume 5, Chapter 4, Table 4.1. For both CH_4 and N_2O the lower limit is close to zero and the upper limit is twice higher as average, i.e. uncertainty is 100%.

Overall uncertainties in both CH_4 and N_2O emission data are 108%.

Time-series consistency

Emissions from waste disposal on land were calculated for the whole time series using the same method and data sets. As collection of data on waste management started only in 1991, it was assumed that the amounts of generated and treated waste in 1990 were the same as in 1991.

7.3.4 Category-specific QA/QC and verification

Data collection and calculations were performed in accordance with the requirements outlined in Section 6 of the Quality Assurance and Quality Control Plan[220].

Tier 1 General Inventory Level QC was performed based on recommendations provided in *2006 IPCC Guidelines,* Volume 1 Chapter 6 and outlined in the QA/QC plan:

Consistency of data between NIR and CRF has been checked.

Documentation on activity data and emission factors was crosschecked with the corresponding data in calculation model.

In case of large fluctuations in data, other experts or data providers were consulted to either provide the explanation or to identify a possible inconsistency or an error.

Explanations for recalculations were checked to ensure that they are clearly documented.

After the calculation is finished, EPA waste experts not directly involved in the emissions calculation of that year have reviewed the final report and CRF data checking the applied parameters, calculation methodology, as well as trend description in the NIR.

7.3.5 Category-specific recalculations

CH_4 emissions due to leakages from anaerobic digestion plants were estimated for the first time. Impact of recalculations on CH_4 emissions from biological treatment is shown in Table 7-35.

Table 7-35. Impact of recalculations on CH_4 emissions from biological treatment

Year	Previous submission, kt CO_2eqv.	This submission, kt CO_2eqv.	Difference	
			kt CO_2eqv.	%
1999	6.41	6.68	0.28	4.29
2000	2.00	3.04	1.05	52.50
2001	4.76	5.83	1.06	22.34
2002	5.67	7.22	1.55	27.32
2003	5.00	6.73	1.73	34.49
2004	4.28	5.36	1.08	25.11
2005	6.87	8.30	1.43	20.73
2006	5.60	7.15	1.55	27.68
2007	6.87	8.59	1.73	25.12
2008	7.64	9.39	1.75	22.90
2009	7.59	9.81	2.23	29.33
2010	6.59	9.72	3.13	47.41
2011	8.47	11.70	3.23	38.06
2012	9.58	12.83	3.25	33.91
2013	12.18	15.93	3.75	30.79
2014	20.44	27.69	7.25	35.47

[220] National Greenhouse Gas Emission Inventory of the Republic of Lithuania. Quality Assurance and Quality control Plan 2016-2017. Vilnius, 2015.

7.3.6 Category-specific planned improvements

Category-specific improvements are not planned.

7.4 Waste incineration (CRF 5.C)

Emissions from waste incineration without energy recovery are reported in the Waste Sector, while emissions from incineration with energy recovery are reported in the Energy Sector.

Incineration of waste is a source of greenhouse gas emissions, including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Normally, emissions of CO_2 from waste incineration are more significant than CH_4 and N_2O emissions.

Evaluated non-biogenic CO_2 emissions from waste incineration are provided in Table 7-36.

Table 7-36. Non-biogenic CO_2 emissions from waste incineration, (kt)

Year	Hazardous	Clinical	Sewage sludge	Municipal	Total
1990	2.65	0.01	0.00	0.00	2.66
1995	2.50	0.01	0.00	0.00	2.51
2000	1.13	0.00	0.00	0.00	1.13
2005	3.36	0.24	0.00	0.00	3.60
2010	0.83	0.63	0.00	0.00	1.46
2011	4.09	0.36	0.00	0.00	4.45
2012	0.99	0.04	0.00	0.00	1.03
2013	0.76	0.01	0.00	0.00	0.77
2014	1.94	0.02	0.00	0.00	1.96
2015	5.38	0.35	0.00	0.00	5.73

Evaluated N_2O and CH_4 emissions from waste incineration are provided in Table 7-37.

Table 7-37. N_2O and CH_4 emissions from waste incineration, tonne

Year	CH_4			N_2O		
	Biogenic	non-biogenic	Total	Biogenic	non-biogenic	Total
1990	0.116	0.044	0.159	0.193	0.073	0.265
1995	0.109	0.041	0.150	0.181	0.068	0.250
2000	0.049	0.019	0.067	0.082	0.031	0.112
2005	0.157	0.059	0.216	0.261	0.098	0.359
2010	0.067	0.024	0.091	0.111	0.040	0.151
2011	0.194	0.073	0.267	0.323	0.121	0.445
2012	0.044	0.017	0.061	0.074	0.028	0.102
2013	0.033	0.013	0.046	0.056	0.021	0.077
2014	0.084	0.032	0.116	0.141	0.053	0.194
2015	0.249	0.094	0.343	0.415	0.156	0.572

7.4.1 Category description

Incineration of hazardous waste, clinical waste, sewage sludge and municipal waste is recorded in the database of the Lithuanian EPA. In 2015 GHG emissions from waste incineration on average comprise merely 0.6% of the total emissions in the waste sector.

Emissions from waste incineration fluctuate quite strongly. In 1990-2005 small amounts of waste were incinerated in various combustion installations not meant specifically for waste incineration. There were no dedicated waste incineration facilities in Lithuania until 2006 and waste was incinerated on random basis in existing production facilities, which means that decisions on whether to incinerate or not was taken on ad hoc basis. Incinerated waste included calorific waste such as spent oils used, for example, for heating garages, etc.

Hospital waste incineration facility with nominal capacity 200 kg per hour was put in operation in 2006 in Vilnius. The facility included rotary kiln, secondary combustion chamber and flue gas treatment unit. Temperature in the secondary combustion chamber could be raised to 1100 ^{o}C. Flue gas was treated by injecting soda ash and activated carbon into the gas stream and then separating them in a bag filter. Hospital waste incineration plant was closed in 2011 and is not operating since. There was no energy recovery in hospital waste incineration plant.

Construction of the hazardous waste incineration facility with nominal capacity 1000 kg per hour was completed in 2010 and test burning of hazardous waste started in November. Only about 820 tonnes of waste were incinerated in 2010 and about 4 kt in 2011. Because of contractual disputes plant operations in 2012 and 2013 were significantly reduced to approximately 1 and 0.75 kt. In 2014 the amount of incinerated waste was increased to approximately 2 kt and reached 5.4 kt in 2015.

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 power) recovery is foreseen in hazardous waste incineration plant but up to the end of 2015 the plant was operated with significantly reduced capacity without energy recovery.

The data on waste incineration are reported in the framework of overall waste reporting obligations in accordance with the national waste classification in 1991-1999 and EU Waste List from 2000. As data on waste management were not collected in 1990, it was assumed that the amount of waste incinerated in 1990 was the same as incinerated in 1991.

Waste incineration facilities are obliged to report data split into categories of the EU Waste List. Reported data include waste received, waste treated, waste handed over to other treatment facilities, and waste stored by the end of the year.

Activity data on waste incineration were obtained from the Environment Protection Agency (EPA) waste database. Data collection and validation procedures are described in chapter 7.1.

Types and amounts of incinerated wastes are provided in Table 7-38.

Table 7-38. Amounts of incinerated waste 1990-2015, (kt)

Year	Hazardous	Clinical Health care	Sewage sludge	Municipal	Total
1990	2.63	0.01	0.01	0.00	2.65
1995	2.48	0.01	0.00	0.01	2.50
2000	1.12	0.00	0.00	0.00	1.12
2005	3.33	0.26	0.00	0.00	3.59
2010	0.82	0.69	0.00	0.00	1.51
2011	4.06	0.39	0.00	0.00	4.45
2012	0.98	0.04	0.00	0.00	1.02

2013	0.75	0.01	0.00	0.00	0.77
2014	1.92	0.02	0.00	0.00	1.94
2015	5.34	0.38	0.00	0.00	5.72

7.4.2 Methodological issues

Carbon dioxide emissions

Carbon dioxide emissions from waste incineration were calculated using equation 5.1 provided in *2006 IPCC Guidelines*, Volume 5, p. 5.7):

$$CO_{emissions} = \sum_{\mathrm{j}} (\mathrm{WF_j} \times \mathrm{dm_j} \times \mathrm{CF_i} \times \mathrm{FCF_j} \times \mathrm{OF_j}) \times {}^{44}/_{12}$$

where:

CO_2 *Emissions* = CO_2 emissions in inventory year, kt/yr

WF_j = amount of incinerated waste type *j* (as wet weight)

dm_j = dry matter content in the waste type *j* (fraction)

CF_j = fraction of carbon in the dry matter (i.e., carbon content) of the waste type *j*

FCF_j = fraction of fossil carbon in the total carbon of the waste type *j*

OF_j = oxidation factor (fraction)

44/12 = conversion factor from C to CO_2

j = waste type: hazardous waste, clinical waste, sewage sludge or municipal waste

CO_2 emissions from hazardous waste and clinical waste incineration were calculated using fossil carbon content in wet waste provided in *2006 IPCC Guidelines*, Volume 5, Table 2.6, 25% for clinical waste and 27.5% (mean value of provided range) for hazardous waste.

The following set of parameters was used for calculation of CO_2 emissions from incineration of sewage sludge:

- Dry matter content 20%[221]
- Fraction of carbon in the dry matter 45% (*2006 IPCC*, Volume 5, Table 5.2)
- Fraction of fossil carbon in the total carbon 0% (*2006 IPCC*, Volume 5, Table 5.2)

Required parameters for calculation of CO_2 emissions from incineration of municipal waste were calculated using evaluated data on composition of MSW (see Table 7-15) and default values of dry matter content, total carbon content and fossil carbon fraction in separate waste components provided in *2006 IPCC Guidelines*, Volume 5, Table 2.4. Evaluated parameters are provided in Table 7-39.

Table 7-39. Evaluated dry matter content, total carbon content and fossil carbon fraction in MSW

Year	Dry matter content, %	Total carbon content, % of dry weight	Fossil carbon fraction, % of total carbon
1990	34.3%	25.4%	0.9%

[221] Wet - dry conversion of sludges. ARGUS for Eurostat - Environment Statistics. Meeting of the Working Group "Statistics of the Environment", Sub-Group "Waste". Eurostat, 2008.

1995	34.3%	25.4%	0.9%
2000	34.3%	25.4%	0.9%
2005	33.2%	25.0%	1.0%
2010	30.6%	23.9%	1.1%
2011	30.0%	23.7%	1.2%
2012	29.5%	23.5%	1.2%
2013	24.4%	18.4%	1.1%
2014	24.4%	18.4%	1.1%
2015	24.4%	18.4%	1.1%

Combustion efficiency for all types of wastes is assumed to be 100% (*2006 IPCC Guidelines*, Volume 5, Sec. 5.4.1.3).

Methane and nitrous oxide emissions

As quantities of incinerated waste are very low, it was decided to calculate methane and nitrous oxide emissions from the total amount of incinerated waste not dividing them into separate streams.

Methane and nitrous oxide emissions from waste incineration were calculate using equations provided in *2006 IPCC Guidelines*, Volume 5, Sec. 5.2.2 and 5.2.3:

$$CH_4 emission = (IW \times EF_{CH_4}) \times 10^{-6}$$

$$CH_4 = (IW \times EF_{N_2O}) \times 10^{-6}$$

Where:

CH_4 *emissions* = CH_4 emissions in inventory year, kt/yr
N_2O *emissions* = N_2O emissions in inventory year, kt/yr
IW = amount of incinerated waste, kt/yr
EF_{CH4} = CH_4 emission factor (kg CH_4/kt of waste)
EF_{N2O} = N_2O emission factor (kg N_2O/kt of waste)
10^{-6} = conversion from kilogram to kilo tonnes

Bearing in mind irregular waste incineration activities and small quantities of incinerated waste CH_4 emission factor for stoker batch type incinerators provided in *2006 IPCC Guidelines*, Volume 5, Table 5.3 (60 kg/kt waste incinerated on a wet weight basis) was selected for emission calculations.

The main part of incinerated waste is comprised of hazardous industrial waste, therefore it was decided that default N_2O emission factor for all types of incinerated industrial wastes (100 g N_2O/t waste incinerated on a wet weight basis) should be applied.

7.4.3 Uncertainties and time-series consistency

Uncertainties

Activity data uncertainty for waste incineration was supposed to be higher than for solid waste disposal on land, and assumed to be 40%.

Assumed uncertainties for separate input parameters used for evaluation of CO_2 emissions and calculated overall uncertainties for separate waste streams are provided in table 7-40.

Table 7-40. Assumed uncertainties for separate input parameters used for evaluation of CO_2 emissions and calculated overall uncertainties for separate waste streams

	Hazardous waste	**Clinical waste**	**Sewage sludge**	**MSW**
Dry matter content	NA	NA	30%	30%
fraction of carbon	NA	NA	40%	30%
Fraction of fossil carbon in the total carbon	40%	40%	30%	30%
Oxidation factor	2%	2%	2%	2%
Overall uncertainties	**56.6%**	**56.6%**	**70.7%**	**65.6%**

Evaluated uncertainty of the total CO_2 emission from waste incineration is 106%.

Uncertainty of emission factors for calculation of CH_4 and N_2O emissions was assumed to be 60%.

Combined uncertainties for CH_4 and N_2O emissions from waste incineration are 72%.

Time-series consistency

Emissions from waste incineration were calculated for the whole time series using the same method and data sets. As collection of data on waste management started only in 1991, it was assumed that the amounts of generated and treated waste in 1990 were the same as in 1991.

7.4.4 Category-specific QA/QC and verification

Data collection and calculations were performed in accordance with the requirements outlined in Section 6 of the Quality Assurance and Quality Control Plan[222].

Tier 1 General Inventory Level QC was performed based on recommendations provided in *2006 IPCC Guidelines,* Volume 1 Chapter 6 and outlined in the QA/QC plan:

Consistency of data between NIR and CRF has been checked.

Documentation on activity data and emission factors was crosschecked with the corresponding data in calculation model.

In case of large fluctuations in data, other experts or data providers were consulted to either provide the explanation or to identify a possible inconsistency or an error.

Explanations for recalculations were checked to ensure that they are clearly documented.

After the calculation is finished, EPA waste experts not directly involved in the emissions calculation of that year have reviewed the final report and CRF data checking the applied parameters, calculation methodology, as well as trend description in the NIR.

7.4.5 Category-specific recalculations

No recalculation have been done.

[222] National Greenhouse Gas Emission Inventory of the Republic of Lithuania. Quality Assurance and Quality control Plan 2016-2017. Vilnius, 2015.

7.4.6 Category-specific planned improvements

Category-specific improvements are not planned.

7.5 Wastewater treatment and discharge (CRF 5.D)

Wastewater is a source of methane (CH_4) when treated or disposed anaerobically. It is also a source of nitrous oxide (N_2O) emissions. Carbon dioxide (CO_2) emissions from wastewater are not considered because these are of biogenic origin.

Evaluated CH_4 and N_2O emissions from wastewater are shown in Tables 7-41 and 7-42.

Table 7-41. Evaluated CH_4 emissions from wastewater treatment and discharge, kt

Year	Total	Aerobic well managed	Aerobic not well managed	Anaerobic shallow lagoon	Untreated	Septic tanks	Latrine
1990	18.84	0.00	2.69	1.60	1.19	9.11	4.25
1995	15.88	0.00	2.07	0.12	0.58	8.94	4.17
2000	13.36	0.00	1.01	0.11	0.08	8.29	3.87
2005	10.55	0.00	0.87	0.03	0.03	6.56	3.06
2010	8.11	0.00	0.06	0.14	0.03	5.37	2.51
2011	7.90	0.00	0.07	0.01	0.03	5.31	2.48
2012	7.21	0.00	0.05	0.01	0.02	4.86	2.27
2013	7.15	0.00	0.06	0.02	0.02	4.81	2.24
2014	6.53	0.00	0.06	0.01	0.02	4.39	2.05
2015	5.86	0.00	0.07	0.00	0.01	3.94	1.84

Table 7-42. Evaluated N_2O emissions from wastewater treatment and discharge

Year	Protein consumption/ kg/person/year	N_2O emissions, kt
1990	27.7	0.23
1995	28.1	0.22
2000	28.4	0.22
2005	29.3	0.21
2010	26.7	0.18
2011	25.7	0.17
2012	24.6	0.16
2013	23.5	0.15
2014	23.5	0.15
2015	23.5	0.15

7.5.1 Category description

Methane is generated from wastewater in anaerobic conditions while nitrous oxide can be produced as nitrification and denitrification product in both aerobic and anaerobic conditions. This section covers CH_4 emissions from wastewater transportation and treatment as well as from septic tanks used by population not connected to centralized sewerage networks. CH_4 emissions from sewage sludge formed during wastewater treatment are covered in solid waste disposal on land section.

In most cases in Lithuania industrial wastewater is discharged to centralized municipal sewage collection networks and treated together with the domestic wastewater in centralized municipal treatment plants.

According to the information provided by the Lithuanian Water Suppliers Association[223] fraction of industrial wastewater exceeds 50% in six of 38 agglomerations with population equivalent more than 10 thousand. In one of them (Pasvalys) fraction of industrial wastewater comprises 87.5% of the total wastewater discharge. On average, industrial wastewater comprises about 20% of the total load of municipal wastewater treatment systems in Lithuania.

In addition, separate evaluation of CH_4 emissions from domestic and industrial wastewater is problematic because organic load in both domestic and industrial wastewater is measured predominantly as BOD.

There are close to 1800 wastewater discharge points in Lithuania registered by the Lithuanian EPA. Among them, some discharges from industries are also registered but representing only minor fraction of industrial discharges mainly from industries located in remote areas not covered by municipal sewerage collection systems. The major part of industrial wastewater is discharged into municipal sewerage networks and cannot be separated from municipal wastewater.

It is possible to identify 3 or 4 major industrial sectors with the largest potential for CH_4 emissions but COD data cannot be collected as industrial wastewater is discharged mainly together with municipal wastewater and, in addition, in most cases only BOD data are available. Default values or expert judgement for estimating COD values can be applied for these major industries but calculation of emissions based on these values will cause double counting as discharges of these industries have already been accounted for in emissions from municipal wastewater.

Expert judgements as well as default values are associated with substantial errors and uncertainties. We have country specific instrumental measurements of wastewater discharges and organic matter (BOD) content, and we are convinced that country specific instrumental measurements provide much more reliable and precise results than default data based on conditions in other, most frequently remote countries, or expert judgements.

Information of wastewater treatment and discharge in Lithuania is collected by the Lithuanian Environmental Protection Agency (EPA). Data collection is regulated by Order No. 408 of the Minister of Environment of the Republic of Lithuania of calculation of pollutant emissions to environment of 20th December 1999 as amended on 20th September 2001 and 3 January 2013. Pursuant to this legal act water users and/or wastewater dischargers must submit annual reports to institutions subordinated to Ministry of Environment - Regional Environmental Protection Departments (REPDs). REPDS perform primary data check of regional level and checked data are forwarded to the EPA. The EPA performs the final validation, processing and aggregation at national level.

Collected data include both BOD and COD, however, as seen from Table 7-43 both parameters are provided for the same samples without specification of municipal or industrial wastewater sources. Therefore, there is no possibility to separate industrial and municipal wastewater streams.

Table 7-43. 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

[223] Lithuanian Water Suppliers Association. Certificate on municipal wastewater treatment plant capacity assessment, 2011.03.04.

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

Statistics on treatment and discharge of organic pollutants collected by the EPA are available from 1991. It was assumed that wastewater generation, treatment and discharge in 1990 was the same as in 1991.

As in most cases in Lithuania industrial wastewater is discharged to centralized municipal sewage collection networks and treated together with domestic wastewater in centralized municipal treatment plants, industrial wastewater discharge and corresponding emissions are not reported separately but included in the domestic wastewater, therefore notation key "IE" is used

Discharged wastewater is treated in various types of treatment plants all of which are basically aerobic though development of anaerobic conditions enabling methane formation is possible.

All wastewater treatment facilities depending on potential for development of anaerobic conditions were divided in 4 categories:

- Aerobic treatment, well managed
- Aerobic treatment, not well managed
- Anaerobic shallow lagoon
- Untreated wastewater

Classification of wastewater treatment facilities used for reporting of pollutant discharges has been changed in 2013. Division of treatment facilities based on former and new classification is provided in Table 7-44.

Table 7-44. Assume division of wastewater treatment facilities

Classification to 2012	Classification 2013
Aerobic treatment, well managed	
• 313 Biological treatment with N and P removal • 311 Pneumatic aeration tanks • 300 Biological treatment • 304 Pneumatic aeration channels • 305 Mechanical aeration channels • 312 Mechanical aeration tanks • 302 Mechanical	• Mechanical/biological treatment with N and P removal • Biological treatment with N and P removal • Mechanical/biological treatment with P removal • Mechanical/biological treatment with N and P removal and microfiltration • Mechanical/chemical/biological treatment with

• 307 Other biological treatment facilities	N and P removal • Biological treatment with N removal • Biological treatment with N and P removal and microfiltration • Other mechanical/biological treatment • Other biological treatment
Aerobic treatment, well managed	
• 100 Mechanical treatment • 200 Physical-chemical treatment • 201 Primary physico-chemical treatment • 303 Natural treatment methods • 900 Other facilities	• Mechanical treatment • Mechanical/chemical treatment • Chemical treatment
Anaerobic shallow lagoon	
• 306 Biological ponds • 400 Infiltration fields • 500 Infiltration fields without discharge • 600 Agricultural irrigation fields	Sand filtration Microfiltration/ultrafiltration
Untreated wastewater	
• 0 Discharge without treatment	Discharge without treatment

Estimated discharge of wastewater to the treatment facilities of various types is provided in Table 7-45.

Table 7-45. Estimated discharge of wastewater to the treatment facilities of various types

Year	Aerobic well managed		Aerobic not well managed		Anaerobic shallow lagoon		Untreated	
	BOD, kt	% of total	BOD, kt	% of total	BOD, kt	% of total	BOD, kt	% of total
1990	41.33	43.1%	21.34	22.3%	13.36	14.0%	19.76	20.6%
1995	31.48	53.8%	16.47	28.1%	0.99	1.7%	9.59	16.4%
2000	50.56	83.1%	8.01	13.2%	0.93	1.5%	1.33	2.2%
2005	58.16	88.5%	6.91	10.5%	0.21	0.3%	0.45	0.7%
2010	68.87	97.0%	0.47	0.7%	1.15	1.6%	0.53	0.8%
2011	71.96	98.4%	0.54	0.7%	0.12	0.2%	0.53	0.7%
2012	75.01	99.0%	0.44	0.6%	0.05	0.1%	0.31	0.4%
2013	72.21	98.7%	0.45	0.6%	0.16	0.2%	0.37	0.5%
2014	73.80	98.8%	0.51	0.7%	0.11	0.1%	0.30	0.4%
2015	75.58	98.9%	0.53	0.7%	0.04	0.1%	0.24	0.3%

Substantial part of Lithuanian population is still not connected to centralized sewer networks as shown in Table 7-46.

Table 7-46. Fraction of population having no connection to sewerage networks

Year	Fraction, %
1999	49.5
2000	48.1
2005	40.1
2010	35.2
2011	35.6
2012	33.0
2013	33.0
2014	30.4

2015	27.6

Source: Lithuanian Water Suppliers Association, Lithuanian EPA.

Data on population connected to the sewerage network were provided by the Lithuanian Water Suppliers Association and the Lithuanian EPA (2012-2015). The number of population connected to the sewerage network depends on variation of population residing in the area covered by wastewater collection services (Figure 7-9). Hence, fluctuation of percentage of population not connected to sewerage network is caused by migration of population to and from the area covered by wastewater collection services.

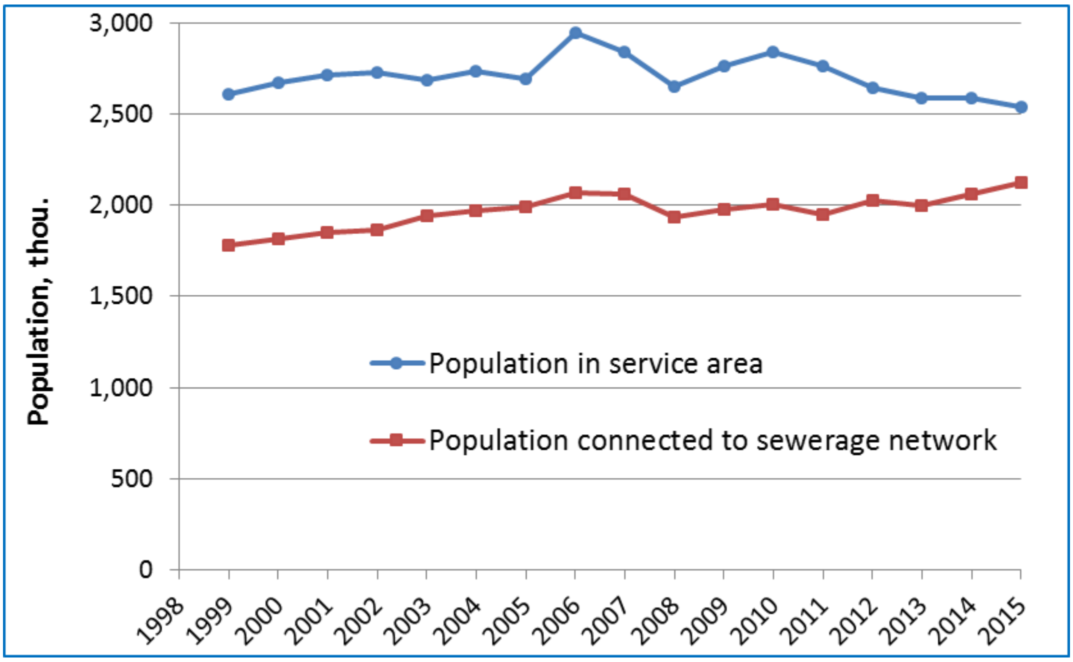

Figure 7-9. Variations of population residing in area covered by wastewater collection services and connected to sewerage network

7.5.2 Methodological issues

Methane emissions

The total amount of organically degradable material in the wastewater (TOW) is available from the EPA database.

Generation of organically degradable material by the population having no connection to sewerage networks was calculated using equation 6.3 provided in *2006 IPCC Guidelines,* Volume 5, section 6.2.2.3:

$$TOW = P \times k \times BOD \times 0.001 \times I \times 365$$

Where:

TOW = total organics in wastewater in inventory year, kg BOD/yr,

P = country population in inventory year, (person),

k = fraction of population having no connection to sewerage networks,

BOD = per capita BOD in inventory year (60 g/person/day, *2006 IPCC Guidelines*, Volume. 5, Table 6.4), 0.001 = conversion from grams BOD to kg BOD,

I = correction factor for additional industrial BOD discharged into sewers (assumed =1).

Degree of utilisation of treatment or discharge pathway among the Lithuanian population having no connection to sewers is similar to Russian rural population as provided in Table 6.5 of the *2006 IPCC Guidelines,* Volume 5, section 6.2.2.3 (60% connected to sewers, 30% using septic tanks, and 10% using latrines). Based on these data, recalculated for population having no connection to sewerage networks, it was assumed that septic tanks are used by 75% of population not connected to sewers and about 25% use latrines.

Methane emissions were evaluated using modified *2006 IPCC Guidelines,* Volume 5, section 6.2.2.1 equation 6.1:

$$CH_4 Emissions = \sum_i (EF_i \times (1-k) \times TOW_i),$$

Where:

TOW_i = total organics in specific wastewater stream *i* (aerobic well managed, aerobic not well managed, anaerobic shallow lagoon, untreated, septic tanks, and latrines) in inventory year, kg BOD/yr,
k = fraction of organic component removed as sludge in inventory year, kg BOD/yr, assumed = 0.3[224]
EF_i = emission factor, kg CH_4 / kg BOD.

The emission factor for each wastewater treatment and discharge pathway was calculated using equation 6.2 (*2006 IPCC Guidelines*, Volume 5, section 6.2.2.1):

$$EF_i = B_o \times MCF_i$$

Where:

B_o = maximum CH_4 producing capacity, kg CH_4/kg BOD,
MCF_i = methane correction factor (fraction), *2006 IPCC Guidelines*, Volume 5, Table 6.3.

Default value of B_o, 0.6 kg CH_4/kg BOD was used (*2006 IPCC Guidelines*, Volume 5, Table 6.2).

Default MCF values provided in *2006 IPCC Guidelines*, Volume 5, Table 6.3 was used (Table 7-47).

Table 7-47. MCF values used for calculation of methane emissions

Untreated wastewater discharged to rivers and lakes	0.1
Aerobic treatment, well managed	0.0
Aerobic treatment, not well managed	0.3
Anaerobic shallow lagoons	0.2
Septic systems	0.5
Latrine, wet climate	0.7

Methane recovery from sewage sludge

Anaerobic digestion installations with CH_4 recovery are operated by several water supply companies. Statistical data on biogas recovery from sewage sludge are reported by the

[224] Expert judgment by the Chief Manager of the Vilnius Wastewater Treatment Plant Mr. V. Puodžiūnas.

Statistics Lithuania in TJ. The data were converted to kt using methane Lower Heating Value (LHV) = 50 TJ/kt.

Data on recovered biogas volume provided by the Statistics Lithuania correspond well with the data provided by water supply companies starting from 2004, showing relation between mass and volume 0.4 kt per million m^3. Data on methane recovery are provided in Table 7-48.

Table 7-48. CH_4 recovery, kt

Year	Fraction, %
1999	0.22
2000	0.84
2005	1.14
2010	2.5
2011	2.58
2012	2.60
2013	3.00
2014	5.80
2015	5.88

Recovered biogas is used for energy production and is reported in the 1A sector as biogas including biogas generated from landfills, sewage sludge and manure.

Nitrous oxide emissions

The activity data that are needed for estimating N_2O emissions are nitrogen content in the wastewater effluent, country population and average annual per capita protein generation (kg/person/yr). The total nitrogen in the effluent is estimated as follows (*2006 IPCC Guidelines*, Volume 5, section 6.3.1.3, Equation 6.8):

$$N_{EFFLUENT} = P \times Protein \times F_{NPR} \times F_{NON-CON} \times F_{IND-COM} - N_{SLUDGE}$$

Where:

$N_{EFFLUENT}$ = total annual amount of nitrogen in the wastewater effluent, kg N/yr
P = human population
Protein = annual per capita protein consumption, kg/person/yr
F_{NPR} = fraction of nitrogen in protein, default = 0.16, kg N/kg protein
$F_{NON-CON}$ = factor for non-consumed protein added to the wastewater
$F_{IND-COM}$ = factor for industrial and commercial co-discharged protein into the sewer system
N_{SLUDGE} = nitrogen removed with sludge (default = zero), kg N/yr

Protein consumption per capita was evaluated by the Health education and disease prevention Centre[225] (77.4 g/capita/day in 1998, 78.1 g/capita/day in 2002, and 81.9 g/capita/day in 2007, 64.5 g/capita/day in 2013). Linear interpolation of these values was used for calculation of N_2O emissions. It was assumed that protein consumption in 2014 and 2015 was the same as in 2013.

[225] 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.

Default value 1.4 for non-consumed protein was used as defined in *2006 IPCC Guidelines*, Volume 5, section 6.3.1.3 for developed countries using garbage disposals.

Default $F_{IND\text{-}COM}$ value 1.25 was used (*2006 IPCC Guidelines*, Volume 5, section 6.3.1.3).

N_2O emissions from wastewater effluent were calculated using equation 6.7 provided in *2006 IPCC Guidelines*, Volume 5, Section 6.3.1.1:

$$N_2O\ emissions = N_{EFFLUENT} \times EF_{EFFLUENT} \times 44/28$$

Where:

N_2O *emissions* = N_2O emissions in inventory year, kg N_2O/yr
$N_{EFFLUENT}$ = nitrogen in the effluent discharged to aquatic environments, kg N/yr
$EF_{EFFLUENT}$ = emission factor for N_2O emissions from discharged to wastewater, kg N_2O-N/kg N
The factor 44/28 is the conversion of kg N_2O-N into kg N_2O.

The default emission factor for N_2O emissions from domestic wastewater nitrogen effluent is 0.005 g N_2O-N/kg N (*2006 IPCC Guidelines*, Volume 5, section 6.3.1.2).

7.5.3 Uncertainties and time-series consistency

Uncertainty

Methane emissions

The following uncertainties were assumed for activity data:

- Total organics in wastewater (TOW) 30%
- population having no connection to sewerage networks 5%
- fraction of organic component removed as sludge 40%
- per capita BOD 30%

Default uncertainty ranges provided in *2006 IPCC Guidelines*, Volume 5, p. 6.17, Table 6.7 were used for parameters determining emission factors:

- maximum CH_4 producing capacity (B_o) 30%
- MCF
    - Aerobic treatment, well managed 10%
    - Aerobic treatment, not well managed 30%
    - Aerobic treatment, shallow lagoon 50%
    - Untreated 30%

Evaluated uncertainties of GHG emissions in separate wastewater streams are the following:

- Aerobic treatment, well managed 66.3%
- Aerobic treatment, not well managed 72.1%
- Aerobic treatment, shallow lagoon 82.5%
- Untreated 72.1%
- Septic tanks and latrines 52.2

Evaluated overall uncertainty is 45.9%.

Nitrous oxide emissions

It was assumed that uncertainty of activity data is 30% and uncertainty of emission factors is 50%. Combined uncertainty for N_2O emissions from human sewage calculated using equation 3.1 from *2006 IPCC Guidelines*, Volume. 1, Chapter 3) is 58%.

Time-series consistency

Emissions from wastewater handling were calculated for the whole time series using the same method and data sets.

7.5.4 Category-specific QA/QC and verification

Data collection and calculations were performed in accordance with the requirements outlined in Section 6 of the Quality Assurance and Quality Control Plan[226].

Tier 1 General Inventory Level QC was performed based on recommendations provided in *2006 IPCC Guidelines,* Volume 1 Chapter 6 and outlined in the QA/QC plan:

Consistency of data between NIR and CRF has been checked.

Documentation on activity data and emission factors was crosschecked with the corresponding data in calculation model.

In case of large fluctuations in data, other experts or data providers were consulted to either provide the explanation or to identify a possible inconsistency or an error.

Explanations for recalculations were checked to ensure that they are clearly documented.

After the calculation is finished, EPA waste experts not directly involved in the emissions calculation of that year have reviewed the final report and CRF data checking the applied parameters, calculation methodology, as well as trend description in the NIR.

In order to verify the results based on the use of measured BOD amount in WWTP influent, obtained per capita BOD values were compared with the default values provided in *2006 IPCC Guidelines,* Volume 5, Table 6.4 (Table 7-49).

Table 7-49. Comparison of per capita BOD values obtained from statistical data with the default values provided in *2006 IPCC Guidelines*, Volume 5, Table 6.4

Year	BOD, g/person/day			Required correction factor	
	Connected to the network	Not connected to the network	Total population	Connected to the network	Total population
1999	111.79	60	86.15	1.86	1.44
2000	91.73	60	76.47	1.53	1.27
2001	104.77	60	83.84	1.75	1.40
2002	83.82	60	72.89	1.40	1.21
2003	97.43	60	81.26	1.62	1.35
2004	97.82	60	82.10	1.63	1.37
2005	90.42	60	78.23	1.51	1.30
2006	98.17	60	84.18	1.64	1.40
2007	101.80	60	86.62	1.70	1.44
2008	106.49	60	88.12	1.77	1.47
2009	97.81	60	83.63	1.63	1.39

[226] National Greenhouse Gas Emission Inventory of the Republic of Lithuania. Quality Assurance and Quality control Plan 2016-2017. Vilnius, 2015.

2010	96.94	60	83.94	1.62	1.40
2011	102.73	60	87.53	1.71	1.46
2012	108.86	60	89.31	1.81	1.49
2013	102.23	60	87.60	1.70	1.46
2014	99.43	60	88.05	1.66	1.47
2015	98.51	60	88.58	1.64	1.48
Average	**99.46**	**60**	**84.03**	**1.66**	**1.40**

BOD amount measured in WWTP influent should correspond to the sum of BOD from the population connected to the sewerage network and from the industries. Calculated per capita BOD for the total population including fraction not connected to the network divided by the per capita domestic BOD generation should correspond to the correction factor I for additional industrial BOD discharged into sewers (see *2006 IPCC Guidelines,* Volume 5, eq. 6.3).

Assuming that per capita BOD discharge in Lithuania corresponds to the default value for Europe and Russia provided in *2006 IPCC Guidelines,* Volume 5, Table 6.4 (60 g/person/day), industrial BOD discharge comprise about 68% of domestic BOD generated by the population connected to the sewerage network or 41% of BOD generated by the total population.

Evaluated industrial input is higher than recommended in *2006 IPCC Guidelines, Volume* 5,eq. 6.3 (default correction factor I = 1.25), however higher than 60 g/person/day per capita domestic BOD generation should not be excluded. The range of per capita BOD for Europe and Russia provided in *2006 IPCC Guidelines,* Volume 5, Table 6.4 is 50-70 g/person/day, in Sweden it reaches 82 g/person/day, and in the USA even 120 g/person/day.

7.5.5 Category-specific recalculations

In the previous submission, maximum CH_4 producing capacity (B_o = 0.6 kg CH_4/kg BOD) was omitted from the formula for calculation of methane emissions from latrines resulting in overestimation of emissions. Impact of recalculations on CH_4 emissions is shown in Table 7-50. In addition, new data on population connected to sewerage network provided by the Lithuanian EPA for 2012-2014 were a bit higher than previously used which also influenced the final result.

Table 7-50. Impact of recalculations on CH_4 emissions in wastewater management sector

Year	Previous submission, kt CO_2 eqv.	This submission, kt CO_2 eqv.	Difference	
			kt CO_2 eqv.	%
1990	541.86	471.00	-70.86	-13.08
1991	542.55	471.57	-70.98	-13.08
1992	495.51	424.61	-70.90	-14.31
1993	496.54	425.97	-70.57	-14.21
1994	444.22	374.14	-70.08	-15.78
1995	466.60	397.05	-69.54	-14.90
1996	460.10	391.08	-69.02	-15.00
1997	455.21	386.70	-68.51	-15.05
1998	437.52	369.51	-68.01	-15.55
1999	403.67	336.81	-66.86	-16.56
2000	398.49	334.01	-64.48	-16.18
2001	397.42	335.23	-62.19	-15.65
2002	372.61	312.06	-60.55	-16.25

2003	343.83	287.28	-56.55	-16.45
2004	337.54	283.74	-53.80	-15.94
2005	314.56	263.55	-51.01	-16.22
2006	293.78	247.84	-45.94	-15.64
2007	286.29	241.32	-44.97	-15.71
2008	297.64	249.21	-48.43	-16.27
2009	263.12	217.64	-45.48	-17.28
2010	244.44	202.67	-41.78	-17.09
2011	238.81	197.51	-41.30	-17.29
2012	238.48	180.13	-58.35	-24.47
2013	220.61	178.79	-41.82	-18.96
2014	219.90	163.39	-56.51	-25.70

7.5.6 Category-specific planned improvements

Category-specific improvements are not planned.

8 OTHER (CRF 6)

Not applicable.

9 INDIRECT CO_2 AND NITROUS OXIDE EMISSIONS

9.1 Description of sources of indirect emissions in GHG inventory

Nitrogen oxides (NO_x = NO + NO_2), non-methane volatile organic compounds (NMVOC) and carbon monoxide (CO) are not greenhouse gases, but they have an indirect effect on the climate through the formation of ozone and their effects on the lifetime of the methane emission in the atmosphere. CO via its effects on hydroxyl radical (•OH), can help to promote abundance of methane in the atmosphere as well as increase ozone formation. 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 projection.

The Informative Inventory Report (IIR) covering the inventory of air pollutant emissions from Lithuania are the source of data in this report. The report contains information on Lithuanian's inventories for 1990-2015 years. Air emission inventory is based mainly on statistics published by Statistics Lithuania (Statistical Yearbooks of Lithuania, sectoral yearbooks on energy balance, agriculture, commodities production etc.), Institute of Road Transport, Registry of Transport (State enterprise "Regitra"), emission data collected by Environment Protection Agency and other.

A large decrease in all indirect GHG emissions was caused by the structural changes in the economy after 1990 when political independence of Lithuania was restored (Figure 9-1). This led to lower emissions in energy and industrial production and to an overall decrease in the emissions from industrial processes between 1990 and 1995. In 1996 the economy began to recover and production increased. In 1994, the GDP dropped to 54% of the 1989 level but later started to increase again.

The emissions trends of indirect greenhouse gases - nitrogen oxides, carbon monoxide, non-methane volatile organic compounds and sulphur oxide (calculated as sulphur dioxide) emissions are presented in Figure 9-1.

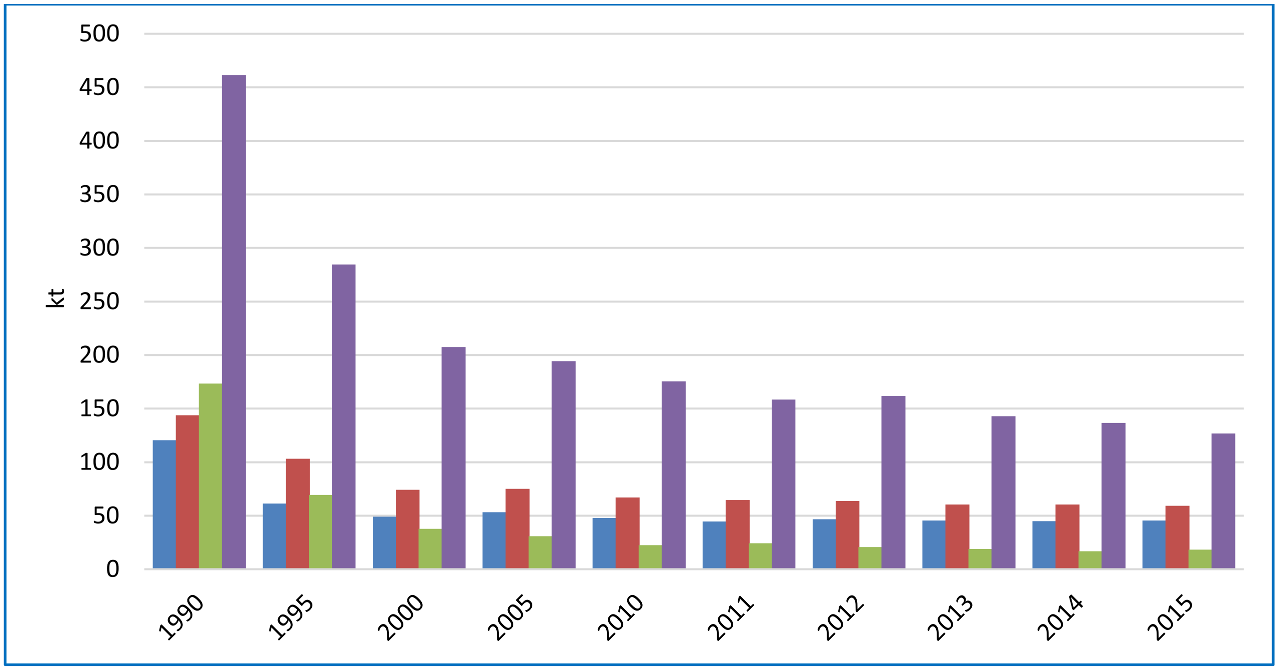

Figure 9-1. Development of non GHG gas and SO_2 emissions, 1990-2015 (*source:* LRTAP submission 2017 and NEC submission)

A rapid decrease of indirect emissions followed the decline of the country economy in the 1990s. Since 2000, the GDP has been growing continuously. Tables 9-1 and 9-2 present results from the Level Assessment of the key source for 2005 and 2015. The sources that add up to at least 80% of the national total in 2005 and 2015 are defined as being a key source for each pollutant.

Table 9-1. Key source analysis for the main pollutants in 2005

	Key categories (Sorted from high to low and from left to right)												Total (%)
SO_x	1.A.1.a Public electricity and heat production	1.A.1.b Refining/ storage	1.B.2.a. iv Fugitive emissions oil: Refining / storage	1.A.4.a.i Commercial/ institutional: Stationary									**81.9**
	32.2%	26.2%	14.7%	8.8%									
NO_x	1.A.3.b.iii Road transport: Heavy duty vehicles	1.A.3.b.i Road transport: Passenger cars	3.D.a.1 Inorganic N-fertilizers	1.A.1.a Public electricity and heat production	1.A.3.c Railways	1.A.1.b Refining / storage	1.A.4.b Residential: Stationary plants						**83.2**
	26.8%	19.6%	11.6%	9.7%	6.4%	5.1%	4.0%						
NMVOC	1.A.4.b.i Residential: Stationary plants	1.B.2.a. iv Fugitive emissions oil: Refining / storage	1.A.3.b.i Road transport: Passenger cars	2.D.3.d Coating applications	3.B.1.a Manure management - Dairy cattle	2.H.2 Food and beverages industry	2.D.3.a Domestic solvent use including fungicides	3.B.1.b Manure management - Non-dairy cattle	1.A.3.b.v Road transport: Gasoline evaporation	2.D.3.e Degreasing	1.B.2.a.v Distribution of oil products	2.D.3.g Chemical products	**82.3**
	16.1%	13.5%	10.3%	8.9%	7.3 %	5.6 %	5.3%	3.2%	3.2%	3.1%	3.0%	2.8%	
CO	1.A.4.b.i Residential: Stationary plants	1.A.3.b.i Road transport: Passenger cars											**85.8**
	50.9%	34.9%											

Table 9-2. Key source analysis for the main pollutants in 2015

	Key categories (Sorted from high to low and from left to right)											Total (%)
SO_x	1.B.2.a.iv Fugitive emissions oil: Refining / storage	1.A.1.a Public electricity and heat production	1.A.4.b.i Residential: Stationary plants	1.A.4.a.i Commercial/ institutional: Stationary	1.A.1.b Petroleum refining							**86.2**
	35.9%	22.2%	12.6%	8.2%	7.3%							
NO_x	1.A.3.b.iii Road transport: Heavy duty vehicles	3.D.a.1 Inorganic N-fertilizers	1.A.3.b.i Road transport: Passenger cars	1.A.1.a Public electricity and heat production	1.A.2.f	1.A.3.c Railways						**81.0**
	32.6%	17.2%	13.3%	7.6%	5.3%	5.0%						
NMVOC	1.A.4.b.i Residential: Stationary plants	1.B.2.a.iv Fugitive emissions oil: Refining / storage	2.D.3.d Coating applications	3.B.1.a Manure management - Dairy cattle	2.H.2 Food and beverages industry	2.D.3.a Domestic solvent use including fungicides	3.B.1.b Manure management - Non-dairy cattle	1.B.2.a.v Distribution of oil products	2.D.3.e Degreasing	2.D.3.g Chemical products	1.A.3.b.i Road transport: Passenger cars	**81.4**
	18.4%	16.1%	9.8%	6.7%	6.6%	5.9%	4.5%	4.2%	3.4%	3.2%	2.6%	
CO	1.A.4.b.i Residential: Stationary plants	1.A.3.b.i Road transport: Passenger cars	1.A.1.a Public electricity and heat production									**85.4**
	70.3%	9.1%	6.0%									

During the period 2005-2015, the emissions of sulphur dioxide has decreased by about 41.0%, from 30.9 kt in 2005 to 18.2 kt in 2015, 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 2015, the most significant sectoral source of SO_x emissions was Fugitive emissions oil: Refining/storage (1.B.2a.iv) (35.9%), followed by emissions occurring from Electricity and heat production (1.A.1.a) (22.2%), Residential: Stationary plants (1.A.4.b.i) (12.6%), Commercial/institutional: Stationary (1.A.4a.i) (8.2%) and Petroleum refining sector (1.A.1.b) (7.3%) (Table 9-2). A combination of measures has led to the reductions in SO_x emissions in 1990-2015 almost in all sectors (Figure 9-2.). This includes fuel-switching from high-sulphur solid (e.g. coal) and liquid (e.g. heavy fuel oil) fuels to low sulphur fuels (such as natural gas) for power and heat production purposes within the energy, industry and domestic sectors, improvements in energy efficiency, and the installation of flue gas desulphurisation equipment in new and existing industrial facilities. The implementation of several directives within the EU limiting the sulphur content of fuel quality has also contributed to the decrease (UNECE, 2011).

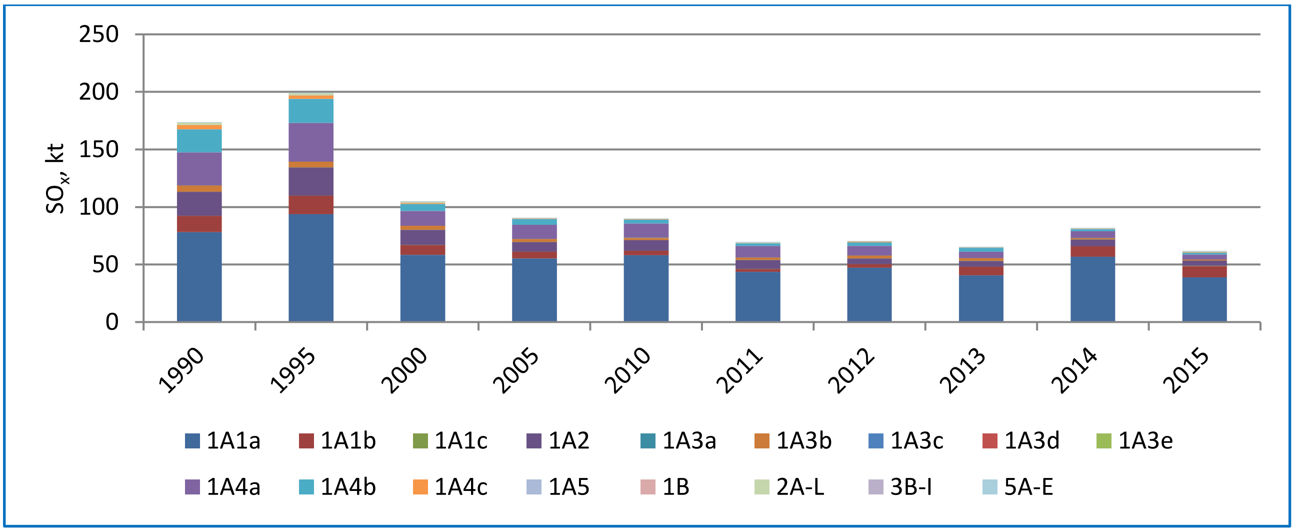

Figure 9-2. Emission trend for SO_x by sectors, 1990-2015

Total nitrogen oxides emissions have decreased by 14.6%, from 53.1 kt in 2005 to 45.3 kt in 2015 (Figure 2-14). The Road transport (1.A.3.b.i and 1.A.3.b.iii), Inorganic N-fertilizers (3.D.a.1) and Energy industry (1A1) sectors are main sources of nitrogen oxides emissions ~58.0% in 2005 and ~66.7% in 2015. The largest reduction of emissions in absolute terms since 1990 has occurred in the Stationary combustion, Electricity and heat production and Road transport sectors (Figure 9-3). 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 Standards Lithuania report an increase in NO_x emissions till 2008 (Figure 9-3).

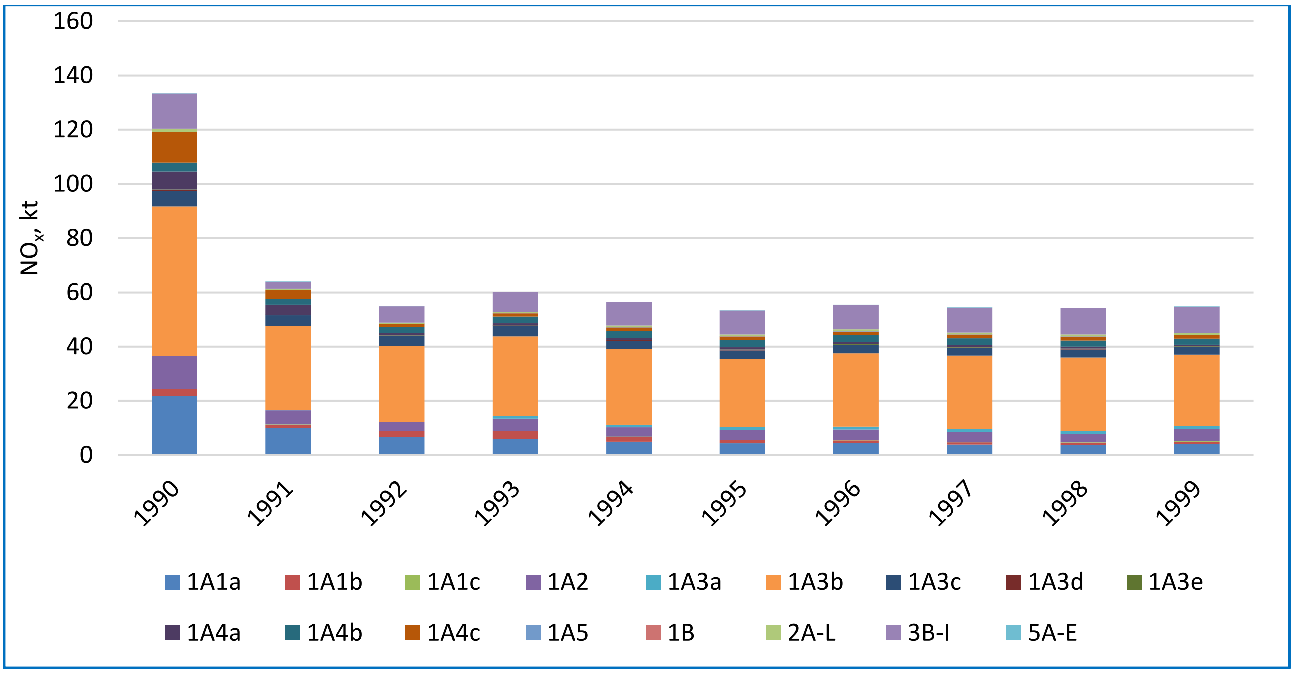

Figure 9-3. Emission trend for NOx by sectors, 1990-2015

The reductions from 2008 have been achieved despite the general increase in activity within this sector and have primarily been achieved as a result of fitting three-way catalysts to petrol fueled vehicles (the effect of catalytic degradation in newer cars was taken into account). In the electricity/energy production sector reductions have also occurred, in these instances as a result of measures such as the introduction of combustion modification technologies.

The NMVOC emissions are determined mainly by Residential (1.A.4.b), Fugitive emissions oil: Refining/storage (1.B.2.a.iv), Road Transport (1.A.3.b) and Coating application (2.D.3.d) sectors. The Residential (1.A.4) sector produced 16.1 and 18.4% of the 2005 and 2015 total of NMVOC emissions in Lithuania. NMVOC emissions have decreased by 20.9% between 2005 and 2015 (Figure 9-4).

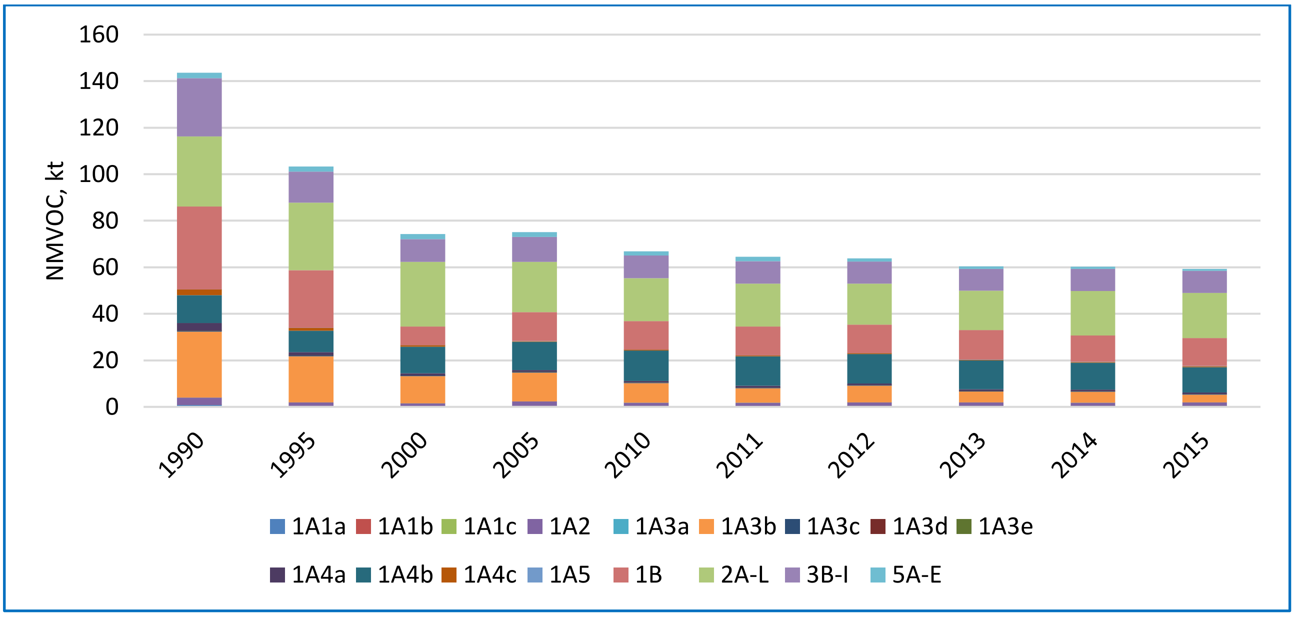

Figure 9-4. Emission trend for NMVOC by sectors, 1990-2015

Technological controls for volatile organic compounds (NMVOCs) in motor vehicles have been more successful than in the case of NO_x, and have contributed to a significant reduction in emissions from Road Transport (1.A.3.b), with the total transport sector's contribution having decreased by 72.8% between 2005 (12.3 kt (10.3%)) and 2015 (3.3 kt (2.60%)). Combustion sources in the Residential (1.A.4.b) and Fugitive emissions oil: Refining/storage (1.B.2.a.iv) combined sectors are another important source, accounting for 34.5% of national total NMVOC emissions in 2015. Share of these sectors has increased from 28.5 to 34.5%. These are the results of the increasing tendency towards wood and wood waste combustion (the NMVOC emission factor for these fuels is much higher for the domestic stoves and higher than for other fuels combustion). The decline in emissions since 1990 has primarily been due to reductions achieved in the road transport sector due to the introduction of vehicle three-way catalytic converters (oxidation-reduction) and carbon canisters on petrol cars, for evaporative emission control driven by tighter vehicle emission standards, combined with limits on the maximum volatility of petrol that can be sold in EU Member States, as specified in fuel quality directives. The second reason of this change was decrease in use of motor fuel in transport sector and increase in a share of used diesel fuel compared to gasoline.

The CO emission trend shows decrease of emissions for period 2005-2015. The total CO emission decreased from 194.2 kt in 2005 to 126.6 kt in 2015 (Figure 9-5).

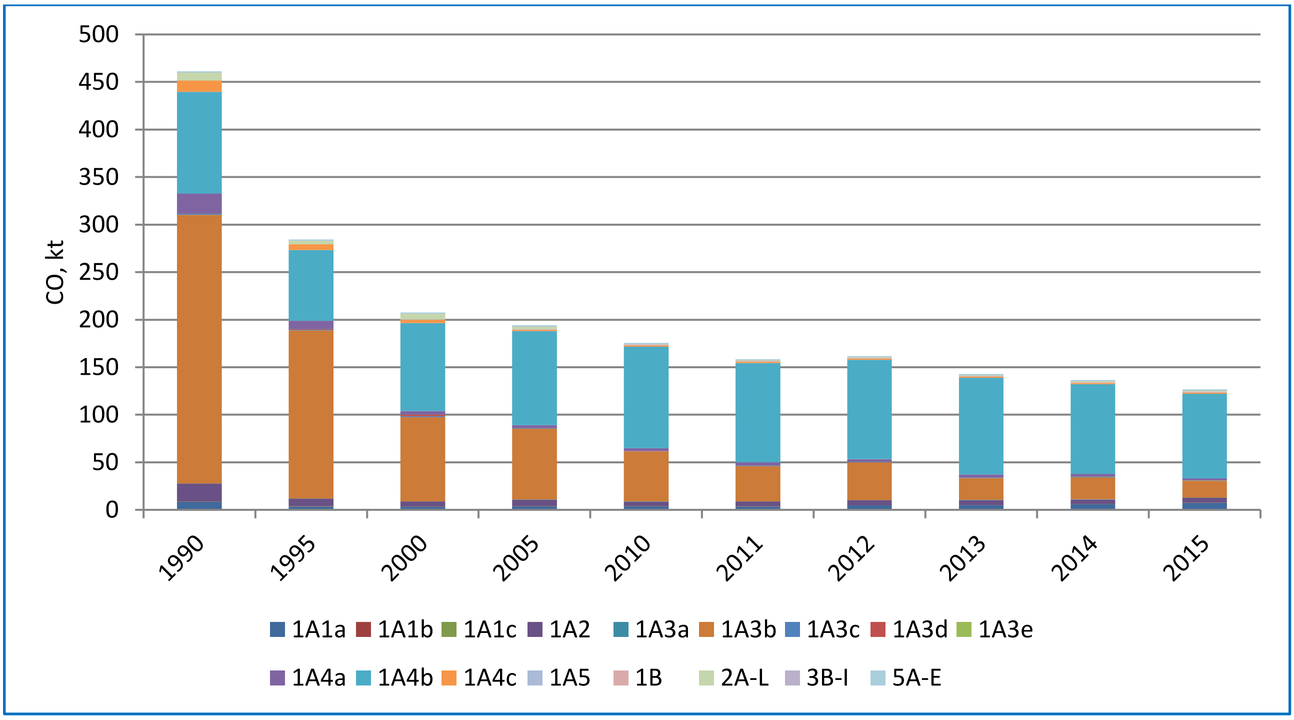

Figure 9-5. Emission trend for CO by sectors, 1990-2015

Carbon monoxide emissions, total 126.6 kt (2015), originates generally from the 1.A.4.b.i Residential: Stationary plants sector (89.0 kt). This sector generated the biggest part of the total CO emissions – 70.3% (2015). Road transport: Passenger cars (1.A.3.b.i) sector contributing by only 9.1% of national total CO emissions in 2015. 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).

9.2 Methodological issues

Air emission inventory is based mainly on statistics published by Lithuanian Statistics Department (Statistical Yearbooks of Lithuania, sectoral yearbooks on energy balance, agriculture, commodities production etc.), Institute of Road Transport, Registry of Transport (State enterprise "Regitra"), emission data collected by Environment Protection Agency and other.

The point sources information system contains data that is reported by the facilities that have a pollution permit. Each facility submits data on the emissions of polluting substances together with data regarding fuel burnt, used solvents, liquid fuel distribution, etc. Data and process SNAP code are presented on each source of pollution and on the facility. The owners of point sources directly fill their calculated or measured annual emissions into the report. With regard to the calculation of emissions from road transport, the COPERT IV v.11 model methodology and emission factors were used (Tier 3). Emission factors for livestock and poultry manure management were taken from EMEP/EEA air pollutant emission inventory guidebook 2016. Number of livestock and poultry was taken from Department of Statistics and State enterprise Agricultural Information and Rural Business Centre. Waste sector activity was taken from EPA. Emission factors for waste sector were taken from EMEP/EEA air pollutant emission inventory guidebook 2016.

The main source of data for all energy industries in the Lithuania for the period 1990-2016 is Statistics Lithuania. Tier 1 methods was used in 1.A.1.a, 1.A.1.b, 1.A.1.c, 1.A.2.f, 1.A.4.a, 1.A.4.b, 1.A.4.c, 1.B.2.a for all compounds and Tier 2 in 1.A.1.b for main pollutants (SO_x, NO_x, NMVOC, CO). The Tier 2 approach was applied with the activity data and the country-specific emission factors according to a country's fuel usage and installed combustion technologies in some energy sectors. In other sectors EMEP/EEA Emission guidebook 2016 EF for SO_x, NO_x, CO, NMVOC was used. Emissions were estimated by multiplying heat value of combusted fuel by corresponding emission factor.

International aviation, International navigation sectors are not included in national totals of SO_x, NO_x, NMVOC, CO presented in GHG inventory.

9.3 Uncertainties and time-series consistency

The uncertainty assessment has not yet been evaluated in Lithuania. Sources not estimated (NE) have not been estimated due to lack of emission factors in methodology or activity data.

9.4 Category-specific QA/QC and verification

A quality management system has been developed to support the inventory of air pollutant emissions. The Lithuanian Quality Control (QC) system is designed to provide routine and consistent checks to ensure data correctness and completeness; identify and address errors and omissions and to document and archive inventory material. QC activities include general methods such as accuracy checks on data acquisition and calculations and the use of approved standardized procedures for emission calculations, measurements, estimating uncertainties, archiving information and reporting. Before submitting data to CEIP/EEA NFR formats were checked with RepDab. Quality Assurance (QA) activities include a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process. In the inventory preparation process, general quality control procedures have been applied. Some specific quality control procedures related to check of activity data and emission factors were carried out. Before submitting IIR to CEIP/EEA, data were reviewed and approved by the Environmental Protection Agency (EPA).

9.5 Category-specific recalculations

Based on in-depth review of emission inventories submitted under the UNECE LRTAP Convention and EU National Emissions Ceilings Directive major renewals in calculations were applied in 2015. Correction of activity data and sulphur/lead content in fuels was done 1990-2015. Emission factors were reviewed and corrected. Majority of activity data within all sectors were adjusted according to data used in GHG emission inventory.

9.6 Category-specific planned improvements

Category-specific improvements are not planned.

10 RECALCULATIONS AND IMPROVEMENTS

The recalculations in 2017 submission have been mainly made due to:

- revision of emission factors based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute in 2016;
- updated activity data;
- implementation of the EU ESD and UNFCCC reviews recommendations;
- errors correction.

10.1 Explanations and justification for recalculations, including in response to the review process

Energy sector

Revision of emission factors based on the results of the study "Update of country specific GHG emission factors for energy sector" prepared by Lithuanian Energy Institute (2016) were performed for all Energy sector.

1.A.1.b Petroleum Refining

Correction of CO_2 plant specific emission factor for residual fuel oil and not liquefied petroleum gas based on EU ETS data due to typing mistake in 2012 data in previous submission.

1.A.2.c Chemicals

Correction of activity data on natural gas (for period 2005-2014) based on the newest information provided by the Lithuanian Statistics in November 2016. The Lithuanian Statistics provided the revised data on natural gas consumption in chemical industries due to revision of activity data performed by JSC Achema. JSC Achema revised activity data and reallocated part of natural gas consumption from non-energy to energy use. This reallocation of data had significant impact on recalculated GHG emissions in Chemical industries (1.A.2.c) for 2005-2014 period.

1.A.3.b Road transportation

Emissions correction for diesel oil from road transportation according to updated activity data in 2013-2014.

1.A.5.b Military aviation

Activity data and EF for CO_2 was revised.

1.B.2.a Fugitive emissions from oil

Correction of emission factors for fugitive emissions from oil based on the *2006 IPCC Guidelines* instead of emission factors based on *2000 IPCC Good Practice Guidance* following recommendations provided by the review experts.

Industrial Processes and Product Use

2.B.1. Ammonia Production

CO_2 emission was recalculated for the period 1990-2014 due to changes of the following assumptions:

- revision of CO_2 emission factor for natural gas (see Energy sector table 3-11) based on study "Update of country specific GHG emission factors for Energy sector" (performed in 2016 by Lithuanian Energy Institute);

- correction of activity data on natural gas (for period 2005-2014) based on the newest information provided by the company in October 2016. The company revised activity data and reallocated part of natural gas consumption from non-energy use to energy use. Revised activity data on natural gas consumption are taken without data of flares;

- recalculation in urea use in Agriculture (recalculated CO_2 emissions from urea application in year of 1990-2014 (see Chapter 5.10));

- correction of data on exported urea for the period 2007-2014 based on the data provided by the company.

2.D.3 Other (Solvent use)

NMVOC and CO_2 emissions were recalculated for the period 1990-2014 due to Printing and Wool sub-categories were included in Solvent use.

Different methods were used in Coating applications sub-category (after 2005 emission estimated using activity data of production, import and export (Tier 2).

Agriculture sector

Enteric fermentation

In order to increase consistency of used methodologies for calculation of emission from enteric fermentation, the gross energy intake and emission factor of dairy cattle in the period 1990-2014 has been recalculated considering productivity of dairy cattle subcategories.

Livestock population were recalculated to annual average population, due to this recalculation average weight of livestock has changed.

CH_4 emissions from enteric fermentation by livestock category were recalculated due to recalculated livestock population data.

Manure management

Recalculations of methane EF for non-dairy cattle, swine, poultry, fur-bearing animals, rabbits and other (nutria) have been made due to recalculated animal population.

CH_4 emissions from manure management by livestock category were recalculated due to recalculated livestock population data.

N excretion rates were recalculated due to updated animal numbers in subcategories and due to recalculated Net energy for animal growth.

N_2O emissions have been recalculated due to recalculation of N excretion rates.

Agricultural soils

In 3.D.1.2.c Other organic fertilizers applied to soils recalculation for 2014 was done due to update of activity data and correction of typing error of dry matter.

In 3.D.1.2.b Sewage sludge applied to soils recalculation was made due to update of activity data and data on nitrogen concentration in sewage sludge for 2011-2015 period become available.

Due to recalculation made in CRF 3.B.2 Manure management category, emission from 3.D.1.2.a Animal manure applied to soils and 3.D.1.3 Urine and dung deposited by grazing animals were also recalculated. Also for 3.D.1.2.a Animal manure applied to soils $frac_{LossMS}$ for minks was corrected.

Recalculation of 3.D.1.4 Crop residue category was made due to:

1. inclusion of silage crops (excl. maize), flax, buckwheat, triticale, soya, mixed dry pulses, mixed cereals, other cereals and vegetables categories into estimation of N_2O emission from crop residue.

2. updated data on: dry matter, N content in above-ground residue and N content in below-ground residue parameters according to recent scientific data.

3. as there is a lack of sufficient and reliable scientific data on what amount of N in above-ground residue were removed annually for purposes such as feed, bedding and construction, no removal was assumed ($Frac_{REMOVE}$ 0 kg N).

4. $Frac_{RENEW}$ for perennial grasses, meadows pastures and permanent pastures/meadows were applied.

Due to recalculations of Cropland and Grassland organic soils area made in LULUCF sector, emission from 3.D.1.6 Cultivation of organic soils was recalculated.

Due to recalculations made in 3.D.1 Direct N_2O emissions from managed soils category (Chapter 5.6.1.5) recalculation has been made in 3.D.2 Indirect N_2O emissions from managed soils atmospheric deposition and N leaching and run-off from managed soil categories. Also fraction $Frac_{GASF}$ in the 3.D.2.1 Atmospheric deposition of N volatilized from managed soils category was recalculated based on 2016 EMEP/EEA methodology.

CO_2 emissions from liming

In 3.G Dolomite $CaMg(CO_3)_2$ sub-category recalculation for 1999 was done due to correction of typing error in activity data.

CO_2 emissions from urea application

IFA provided data on urea consumption for 2014 only in September of 2016, therefore data for 2014 was recalculated. As IFA updated data on inorganic N fertilizers for 2013, the average percentage of urea in total amount of inorganic N fertilizers for the period of 2005-2013 was updated. Percent of nitrogen in urea was updated due to more recent information provided by main fertilizer producer.

Land use, land use change and forestry sector

Forest land

Recalculation of GHG emissions/removals in forest land occurred due to the newly applied interpolation-extrapolation tool for annual growing stock volume change estimation in forest land remaining forest land between NFI sampling plot remeasurements. Annual growing stock volume change was recalculated for NFI growing stock volume data only (2001 – 2014 inventory years), annual growing stock volume change obtained from national studies (1990 – 2000 inventory years) was not affected. Due to the recalculation of annual growing stock volume change, not only volume of living trees, but also dead organic matter amount on forest land remaining forest land was affected.

Cropland

Changes between year 2016 and 2017 submissions occur due to the error in calculations of CO_2 emissions from drainage of organic soils in cropland remaining cropland and land converted to cropland subcategories. There was misinterpretation of share of organic drained soils in total cropland area, therefore emissions occurring from drainage of organic soils were overestimated. Differences between 2016 and 2017 submission of drained organic soils also occurred due to the different estimation of drained organic soils in land converted to cropland: it was assumed that settlements and other land converted to cropland are only under mineral soils, however wetlands converted to cropland are only organic soils, therefore in certain years there was an overestimation or underestimation of emissions from drainage of organic soils. In the submission of 2017 carbon stock change resulting from drainage of organic soils in cropland remaining cropland and land converted to cropland subcategories was corrected.

Calculation error in estimation of carbon stock changes in living biomass in settlements converted to cropland was also corrected this year. There were no carbon stock changes reported in 1991 in settlements converted to cropland subcategory, however -0.96 kt C was lost and it resulted in additional emissions of 3.52 kt CO_2 eqv. (0.06 % share of total cropland emissions in 1991). Additionally, in 1993 carbon stock change in settlements converted to cropland was reported -1.44 kt CO_2 eqv., however it actually was – 0.96, this correction resulted in total cropland emissions decreased by 1.76 kt CO_2 eqv. (0.03 % of total cropland emissions).

Grassland

Differences between 2016 and 2017 year submissions occur due to the misinterpretation of organic soil share in total land converted to grassland area (cropland converted to grassland area). Recalculation of organic soil share in total cropland converted to grassland area resulted both in differences of carbon stock changes in mineral and organic soils in land converted to grassland category in different submission years. In addition to this, emissions from drained organic soils in grassland remaining grassland category were recalculated. Recalculations were done due to the fact that not all organic grassland soils are drained in Lithuania as it was reported previously, which caused overestimation of emissions from drained organic grassland soils. Errors in calculations of carbon stock changes and emissions/removals from mineral and organic soils were corrected and reported in this submission.

Wetland

No category specific recalculations took place in the 2017 submission, however, there are some differences between 2016 and 2017 year submissions – possible double accounting was corrected. In 2016 the same N_2O emissions from peatland extraction sites (peatland remaining peatland) were reported in Table 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils and Table 4(III) Direct N_2O emissions from N mineralization/immobilization (as occurring due to the loss of soil organic carbon after drainage), therefore this year in Table 4(III) it was reported as IE (included in Table 4(II)). In addition to this, direct N_2O emissions, resulting from N mineralization/immobilization after land-use change induced carbon stock change (decrease) in mineral soils were reported in land converted to wetlands (forest land converted to wetlands category). Differences between 2016 and 2017 year submissions are presented in the table below. Largest difference in year 1997 occurred due to the error in value of GHG emissions from drainage of organic soils in peat extraction areas included in CRF reporter. Differences in years 1999, 2003, 2004 and 2009 in 2017 submission occurred due to the direct N_2O emissions from N mineralization/immobilization after forest land converted to wetland included in this year submission.

Settlement

Differences between 2015 and 2016 year submissions occur due to the error in calculation formula of carbon stock changes in living biomass in cropland converted to settlements and grassland converted to settlements in 2013 (no conversion of cropland to settlements was reported, however, 0.399 thous. ha of croplands were converted to settlements in 2013; smaller area of grassland converted to settlements was reported - 0.399 thous. ha instead of 3.595 thous. ha). In 2016 submission errors in carbon stock changes in living biomass due to the cropland and grassland conversion to settlements were corrected.

In 2016 submission direct N_2O emissions from N mineralization/immobilization were recalculated due to the revised activity data and misinterpretation of guidelines in previous years. Mistakes from previous reporting years were corrected in this submission, therefore recalculated total emissions/removals are reported in the table below.

Other Land

Recalculations in harvested wood products were done due to the misallocation of the carbon stock changes in harvested wood products pool in CRF and different methodology applied to estimate changes in pool under "production approach".

Waste sector

5.A. Solid waste disposal on land

Flaring of landfill gas emissions were evaluated in this submission for the first time, and the amount of flared methane was subtracted from the amount calculated using FOD model. In addition, MSW fraction remaining after manual sorting was added to the total amount of landfilled waste.

5.B Biological treatment of waste

CH_4 emissions due to leakages from anaerobic digestion plants were estimated for the first time.

5.D Wastewater treatment and discharge

In the previous submission, maximum CH_4 producing capacity (B_o = 0.6 kg CH_4/kg BOD) was omitted from the formula for calculation of methane emissions from latrines resulting in overestimation of emissions. In addition, new data on population connected to sewerage network provided by the Lithuanian EPA for 2012-2014 were a bit higher than previously used which also influenced the final result.

10.2 Implication for emission levels

See in Table 10-1 below.

Table 10-1. Recalculations of GHG emissions between submission 2017 and submission 2016 by sector

	1. Energy		*2. Industrial Processes and product use*		*3. Agriculture*		*4. Land use, land-use change and forestry*		*5. Waste*	
Year	*kt CO_2 eqv.*	*%*	*kt CO_2 eqv.*	*%*	*kt CO_2 eqv.*	*%*	*kt CO_2 eqv.*	*%*	*kt CO_2 eqv.*	*%*
1990	-15.99	-0.05	3.38	0.08	-66.23	-0.74	58.42	-1.64	-70.86	-4.30
1991	-16.25	-0.05	3.06	0.07	-163.41	-1.85	-118.02	3.17	-70.98	-4.24
1992	-6.92	-0.03	4.03	0.15	377.04	6.05	-242.61	6.44	-70.90	-4.32
1993	-2.20	-0.01	4.50	0.26	238.32	4.65	-206.30	4.18	-70.57	-4.24
1994	-2.75	-0.02	3.78	0.19	134.55	2.91	-754.33	18.10	-70.08	-4.33
1995	-3.07	-0.02	3.20	0.14	-4.98	-0.11	-1,150.57	43.50	-69.54	-4.22
1996	-2.87	-0.02	2.75	0.10	-55.69	-1.19	-1,304.91	-46.26	-69.02	-4.19
1997	-2.07	-0.01	2.91	0.11	-26.63	-0.57	-1,003.82	-87.55	-68.51	-4.16
1998	-0.24	0.00	2.67	0.09	3.90	0.09	-572.19	8.13	-68.01	-4.16
1999	-0.77	-0.01	2.59	0.09	-55.52	-1.28	-543.78	8.13	-66.58	-4.14
2000	-0.04	0.00	2.48	0.08	56.03	1.37	-872.85	9.76	-63.43	-3.95
2001	2.20	0.02	2.22	0.07	-93.31	-2.25	3,981.27	-33.28	-61.13	-3.72
2002	1.80	0.02	2.03	0.06	-89.41	-2.07	-3,121.01	75.36	-59.00	-3.61
2003	-0.31	0.00	1.93	0.05	-120.84	-2.71	2,287.87	-24.21	-54.83	-3.39
2004	-5.98	-0.05	0.98	0.03	-56.15	-1.26	-364.39	5.50	-52.72	-3.33
2005	155.86	1.21	-19.11	-0.46	-55.47	-1.24	-1,423.85	29.03	-49.59	-3.21
2006	96.59	0.74	-1.94	-0.04	-88.00	-1.96	150.89	-2.73	-44.39	-2.95
2007	142.22	1.08	-6.24	-0.10	-8.12	-0.18	-2,428.72	53.43	-43.24	-2.92
2008	133.02	1.02	-22.69	-0.41	-34.32	-0.78	2,033.30	-22.40	-46.70	-3.18
2009	114.04	0.97	-19.00	-0.82	-13.26	-0.30	3,159.02	-29.71	-43.13	-3.04
2010	105.97	0.83	-18.43	-0.82	-23.38	-0.54	959.16	-8.83	-36.82	-2.68
2011	155.73	1.31	-14.14	-0.38	-17.55	-0.40	580.85	-5.37	-33.93	-2.64
2012	162.78	1.37	-11.34	-0.32	12.54	0.29	-647.91	7.56	-48.68	-3.86
2013	120.36	1.07	-7.65	-0.25	1.96	0.05	1,097.61	-11.43	-17.44	-1.47
2014	134.02	1.23	-23.13	-0.72	4.12	0.09	776.97	-9.58	-23.63	-2.08

10.3 Implications for emission trends, including time-series consistency

In submission 2016 the trend from the base year to 2014 showed a 59% decrease. The recalculation of GHG emissions in submission 2017 increased the upward trend between the base year and 2014 by 241 kt CO_2 eqv.

Table 10-2. Impact on emission trends (base year to 2014) due to recalculations of GHG emissions between submission 2017 and submission 2016, excluding LULUCF.

Gas	***Submission 2016***		***Submission 2017***		***Difference between submission 2017 and submission 2016***
	kt CO_2 eqv.	***%***	***kt CO_2 eqv.***	***%***	***kt CO_2 eqv.***
CO_2	-23,080.1	-64.4	-22,932.8	-64.0	147.3
CH_4	-3,541.9	-50.6	-3,520.9	-50.6	21.1
N_2O	-2,246.2	-41.8	-2,173.6	-41.2	72.7
Total	-28,412.5	-59.0	-28,171.4	-58.6	241.1

10.4 Planned improvements

Energy sector

The following improvements are foreseen:

- Further investigate possibilities of using the new available data provided in the EU ETS, reported by the operators for the energy sector emission estimates in 1.A.1.a.ii Combined Heat and Power Generation and 1.A.1.a.iii Heat Plants sectors.
- Road transport GHG emissions will be updated using newer COPERT 5.0 version (available since October 2016).
- It is planned to investigate possibility to apply Tier 2 method for Off-road vehicles and other machinery (1.A.4.a.ii, 1.A.4.b.ii, 1.A.4.c.ii) subcategory for the next submission.

Industrial processes and product use sector

Product uses as Substitutes for ODS

It is planned to continue to review and update the assumptions used to estimate the emissions of F-gases fom 2. F.1 Refrigeration and air conditioning category.

Agriculture sector

Agriculture soils

Continue investigation of missing parameters such as N content in above-ground and below-ground residues in order to evaluate N amount returned to soils with crop residue more accurate. Investigate possibility obtain more accurate data on how much above-ground residue is removed from the field for bedding, feed and construction purposes.

Improvements planned in category direct N_2O emissions from managed soils will be applied to category indirect N_2O emissions.

Land use, land use change and forestry sector

Forest Land

In 2017 Lithuania is planning to apply the results of several studies performed to improve GHG report through using national instead of *2006 IPCC Guidelines* default values. It is expected to develop and apply national values for carbon stocks in soil and forest litter in forest land and non-forest land, estimate carbon stock changes in soil after the afforestation/reforestation of non-forest land, carbon stocks in dead-wood in different decay phases as well as to form consistent and sufficient historical harvested wood products database together with data collection system.

Cropland, Grassland

Lithuania has finished research on carbon stock evaluation in forest land, cropland and grassland soils, which was funded by the Norway Grants programme under the "Partnership project on Greenhouse gas inventory" in the framework of the programme LT10 "Capacity-building and institutional cooperation between beneficiary State and Norwegian public institutions, local and regional authorities". The aim of the research was to obtain national carbon stock values in soils in different land uses (SOC_{REF}) and is planning to include national values for estimation of carbon stock changes in soils in the next submission.

Settlements

Lithuania plans to implement subdivision of land converted to settlements subcategory according to the degree soil is exposed and damaged, as not the whole surface of settlements is built up, paved or used for road construction in Lithuania, as a result in some cases soil is not fully removed after conversion from another land use to settlements.

Harvested Wood Products

Lithuania participates in the "GHG inventory partnership project" through financial mechanism LT10 of Norway grants. As a result of this partnership Lithuania has launched the study for development of the national HWP accounting system in upcoming years, as well as to obtain feasible sufficient historical data on rate of increase for industrial round wood production required to run the model for accounting of HWP emissions/removals. Lithuania is planning to implement results of the study in the next submission.

11 KP-LULUCF (CRF 7)

11.1 General information

Lithuania has ratified both United Nations Framework Convention on Climate Change (in 1995) and its Kyoto Protocol in 2003 (entered into force in 2005) and so committed to reduce its greenhouse gas emissions accordingly to agreements in commitment period. Lithuania has successfully implemented its commitments under the Kyoto protocol – to reduce greenhouse gas emissions by 8% below 1990 level during the first commitment period (1st CP) of 2008-2012. By 2012, the greenhouse gas emissions in Lithuania have been reduced by 56.13% compared with 1990 (excluding LULUCF), successful implementation of commitments was achieved both due to the collapse of Soviet Union in 1990, which resulted in reduction of inefficient and high emissions industry sector, as well as enhanced environmental protection policy. 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, it is especially important that constant effort is added in all sectors.

Under the commitments of Kyoto Protocol Lithuania provide estimations of anthropogenic emissions by sources and removals by sinks since 1990, associated with afforestation (A), reforestation (R) and deforestation (D) activities under Article 3.3 and Forest Management (FM) under Article 3.4 of the Kyoto Protocol. For the second commitment period (2nd CP) Lithuania uses methodology provided in 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (*2013 KP-Supplement*). The *2013 KP-Supplement* describes the supplementary methods and good practice guidance for measuring, estimating and reporting of anthropogenic greenhouse gas emissions and removals resulting from land use and land use changes and forestry activities covered by Kyoto Protocol for the second commitment period agreed by CMP 7. After the second commitment period (from 2021 and beyond) all parties will be obliged to report emissions by sources and removals by sinks from cropland management and grazing land management activities under Article 3.4; reporting emissions and removals from those activities are optional for the second commitment period (2nd CP), however Lithuania has not elected those additional activities for the 2nd commitment period.

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* (p. 2.15-2.18 of *2013 KP-Supplement*). Allocation of AR areas from land use declarations of National Paying Agency (NPA) and deforested areas registered in State Forest Cadaster is more precise and is made using slightly different methodology than monitoring land use changes under Convention reporting (sample based activity reporting). More information on restoration of historical data for 1990-2011, methods used for estimation of ARD and other areas for 1990-2011 is provided in Chapter 6.1 as well as in the text below.

Net removals from Article 3.3 activities for the 1st CP were -117.41 kt CO_2 eqv. in 2012. 2nd CP has started with total removals of -4.41 kt CO_2 eqv. in 2013. Afforestation and reforestation resulted in net removals of -219.84 kt CO_2 eqv. and deforestation – net emissions of 213.43 kt CO_2 eqv., whereas in 2015 afforestation/reforestation rates were higher and deforestation - significantly lower (A/R - net removals of -288.89 kt CO_2 eqv., D - net emissions of 26.63 kt CO_2 eqv.), which resulted in total removals of -262.26 kt CO_2 eqv. from ARD activities (Table 11-1).

Table 11-1. Net emissions/removals from ARD areas during the period 2008-2015, kt CO_2 eqv.*

Year	Afforestation/ Reforestation	Deforestation	Total
2008	-110.20	30.18	-80.02
2009	-129.89	18.43	-111.46
2010	-138.63	47.34	-91.30
2011	-157.33	18.98	-138.35
2012	-185.30	67.89	-117.41
2013	-219.84	213.43	-6.41
2014	-252.56	272.93	20.37
2015	-288.89	26.63	-262.26

*Including CO_2 emissions from wildfires

The area subjected to AR was 44.59 thous. ha in 2015. There could be two moments distinguished in the time series of 1990-2015 describing the AR trend line. The first time period of human induced afforestation/reforestation has started in 1990-2000 and is the consequence of the restoration of Independency 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 from 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 huge 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 2016, deforested area since 1st of January 1990 was 2022.8 ha (Table 11-4). Deforestation was mainly caused by the forest area conversions to Settlements (road building, cities expansion, etc.), Other lands (e.g. quarry's) and Wetlands (e.g. flooding) land use categories.

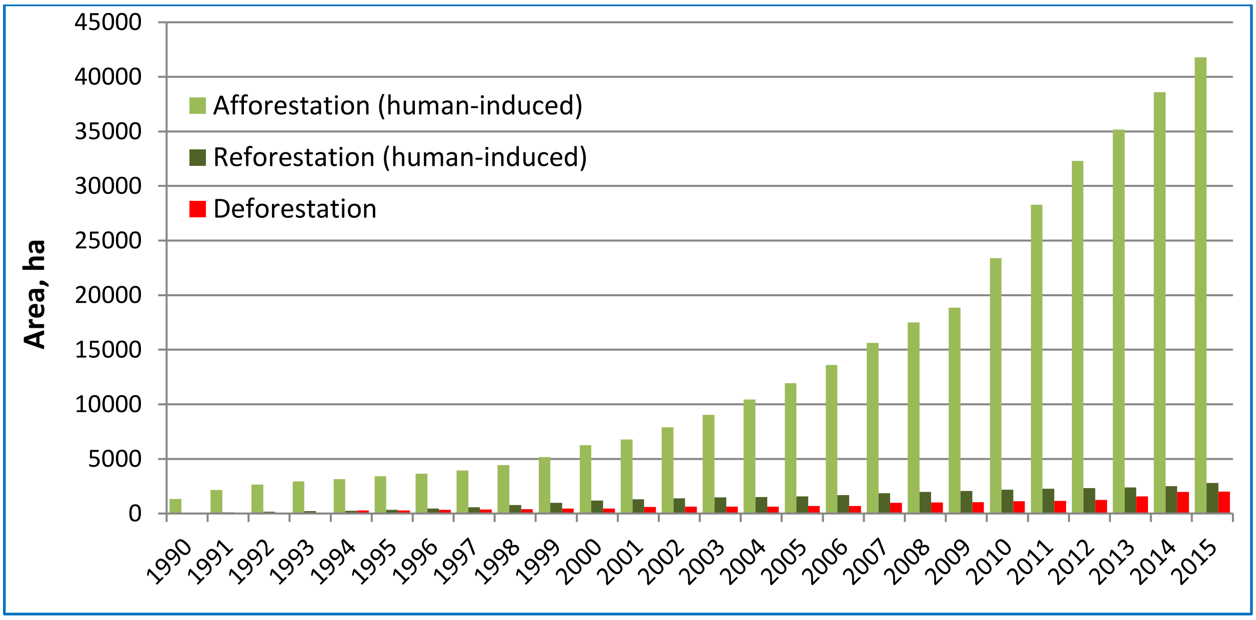

Figure 11-1. Cumulative area of afforestation, reforestation and deforestation, 1990-2015

Additionally Lithuania has distinguished naturally afforested and reforested areas combining wall-to-wall and sampling method used for Convention reporting (Figure 11-2). Neither emissions nor removals of CO_2 under the requirements of Article 3.3 of the Kyoto Protocol are calculated separately for these land areas, they are only constantly supplementing areas under Forest management (FM) and are used for overall data consistency purposes.

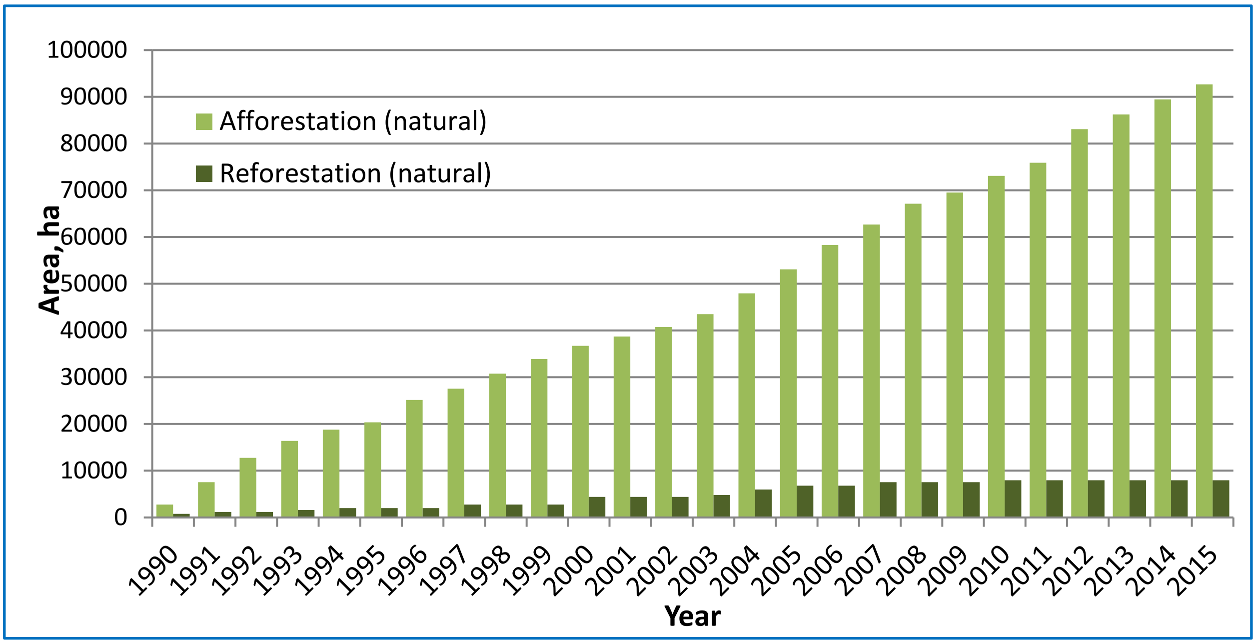

Figure 11-2. Cumulative area of naturally afforested and reforested areas, 1990-2015

Net removals from Article 3.4 activity Forest Management (FM) were -7,916.8 kt CO_2 eq. in 2015 (Table 11-17). The area subjected to FM was 2,150.2 thous. ha by the end of the 1st CP and 2,151.6 in the beginning of the 2nd CP, expanding up to 2,161.4 thous. ha in 2015 (Table 11-5).

Lithuania has elected to continue with Commitment Period accounting for KP-LULUCF.

11.1.1 Definition of forest and any other criteria

For the 2nd CP Lithuania is using the same criteria describing Forest land as was used in the 1st CP. 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 as well.

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 1990-2015, thous. ha

Years	Forest land
1990	2,061.4
1995	2,084.9
2000	2,105.7
2005	2,134.9
2010	2,166.4
2011	2,173.2
2012	2,184.8
2013	2,189.2
2014	2,197.2
2015	2,206.0

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 (A)	Reforestation (R)	Total AR	Deforestation (D)
1990	1.33	0.04	1.37	0.00
1995	0.25	0.08	0.33	0.01
2000	1.07	0.21	1.28	0.02
2005	1.48	0.06	1.54	0.05
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
2013	2.87	0.04	2.91	0.32
2014	3.46	0.12	3.57	0.41
2015	3.19	0.29	3.48	0.03
Total 1990-2015	**41.8**	**2.8**	**44.59**	**2.02**

11.1.2 Elected activities under Article 3, paragraph 4, of the Kyoto Protocol

For the 1st CP 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. For the second CP the same structure applies, except mandatory reporting of Harvested Wood Products (HWP). 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 GHG inventories. Regular information on Lithuanian forest resources is provided by *SFI* 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 and first sufficient data from sampling method on all forest land in Lithuania were obtained.

To estimate areas required to report emissions 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 (see Chapter 6.1), 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 sampling 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 Decision 16/CMP.1 and *2013 KP-Supplement*.

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[227]. In general forest conversion to other land is very rare i.e. only for road construction or settlements establishment 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. However, 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 Cadaster.

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*) (see Chapter 6.1.1) implemented in 2012 (for time series of 1990 - 2011), newly afforested/reforested area declarations from National Paying Agency and National Forest Inventory data, regarding data on Forest Management.

The main objective of the study "Forest land changes in Lithuania during 1990-2011" was to identify forest land areas and their changes in Lithuania during 1990-2011 following the

[227] Governmental Resolution of the Republic of Lithuania of 28th September 2011 No 1131 Concerning the approval of procedures of forest land conversion to other land use and compensation for forest land conversion to other land use and repealing some of the governmental resolutions

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 years 1990-2011, land use determination executed using the grid of NFI sampling plots.

The main data sources used:

– Data from *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 FM 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 3.3, which would otherwise be included in land subject to elected activities under Article 3.4 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 FM 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 FM is in accordance with *2013 KP-Supplement*. Forest land area under FM reported for KP-LULUCF calculations is provided in Table 11-5. Data source for determining area under FM activity (until 1998 when sampling based NFI started in whole forest land area in Lithuania) is *Study-1*, where FM 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 6.2.1). 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 FM area.

Table 11-5. Area of Forest Management*, thous. ha

Year	Total area	Organic soils

		Not drained	Drained	Total
1990	2,060.0	160.7	162.7	323.4
1995	2,081.2	162.3	164.4	326.7
2000	2,098.3	163.7	165.8	329.4
2005	2,121.4	165.5	167.6	333.1
2010	2,140.8	167.0	169.1	336.1
2011	2,142.7	167.1	169.3	336.4
2012	2,150.2	167.7	169.9	337.6
2013	2,151.6	167.9	169.9	337.8
2014	2,156.1	168.2	170.3	338.5
2015	2,161.4	168.6	170.7	339.3

**Natural afforestation and reforestation areas are 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

Under Article 3.4 Lithuania is reporting only FM activities therefore there is no hierarchy among Article 3.4 activities. For the consistency reasons and to be sure that reported FM activities have occurred on forest land, total land area was split 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).

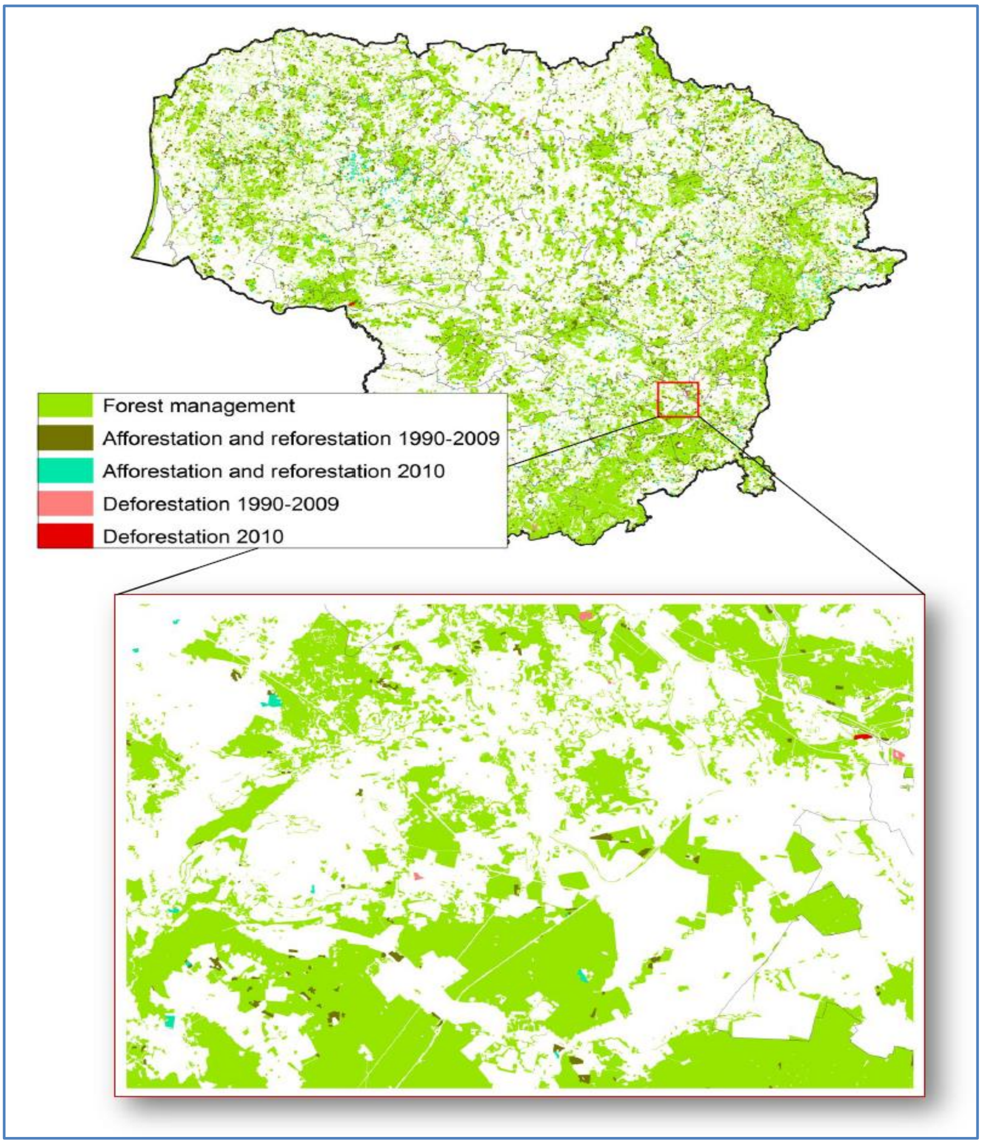

Figure 11-3. Afforestation, reforestation and deforestation activities 1990-2010

To achieve annual wall-to-wall mapping of forest land areas and to detect changes several types of source material were used. These were: SFC, 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 ortho-photos of the country, developed during the analysed period, satellite maps from CORINE, USGS[228] 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).

[228] Available from: *http://earthexplorer.usgs.gov/*

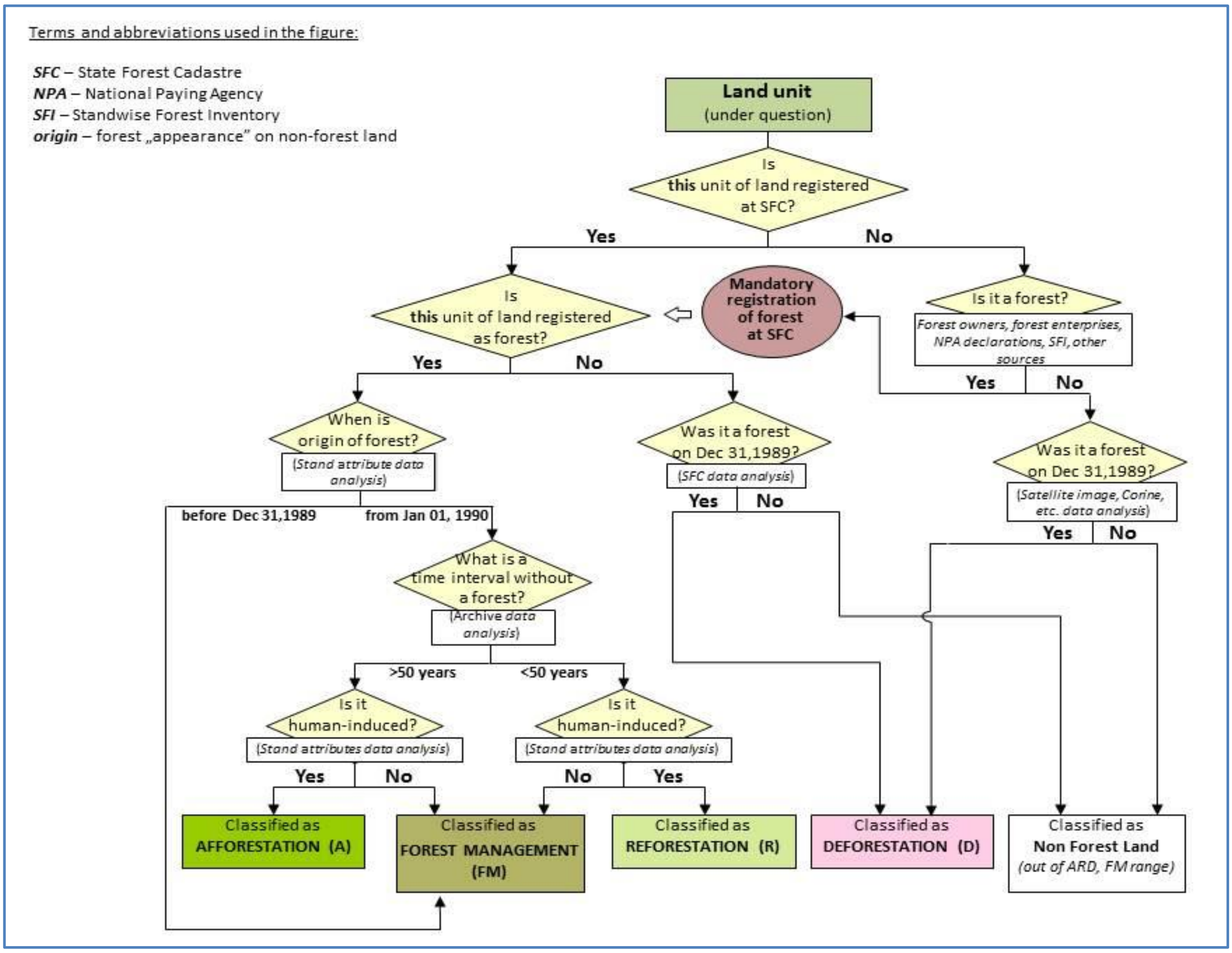

Figure 11-4. Decision tree for land units allocation to relevant land use categories

Codes that were used by experts in *Study-1* 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, with some of them being already included into *SFC* according to Forest Law of the Republic of Lithuania, therefore has the legal protection as a forest land as well as specific rules and restrictions for forestry activities apply in those areas. Such segregation is not required by *2013 KP-Supplement*, yet those 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 *SFC* or received as declarations from State Forest Enterprises (*SFE*) 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[229]. Since 2008 most of reforestation cases in Lithuania receive financial support from National Paying Agency and therefore are registered in relevant database.

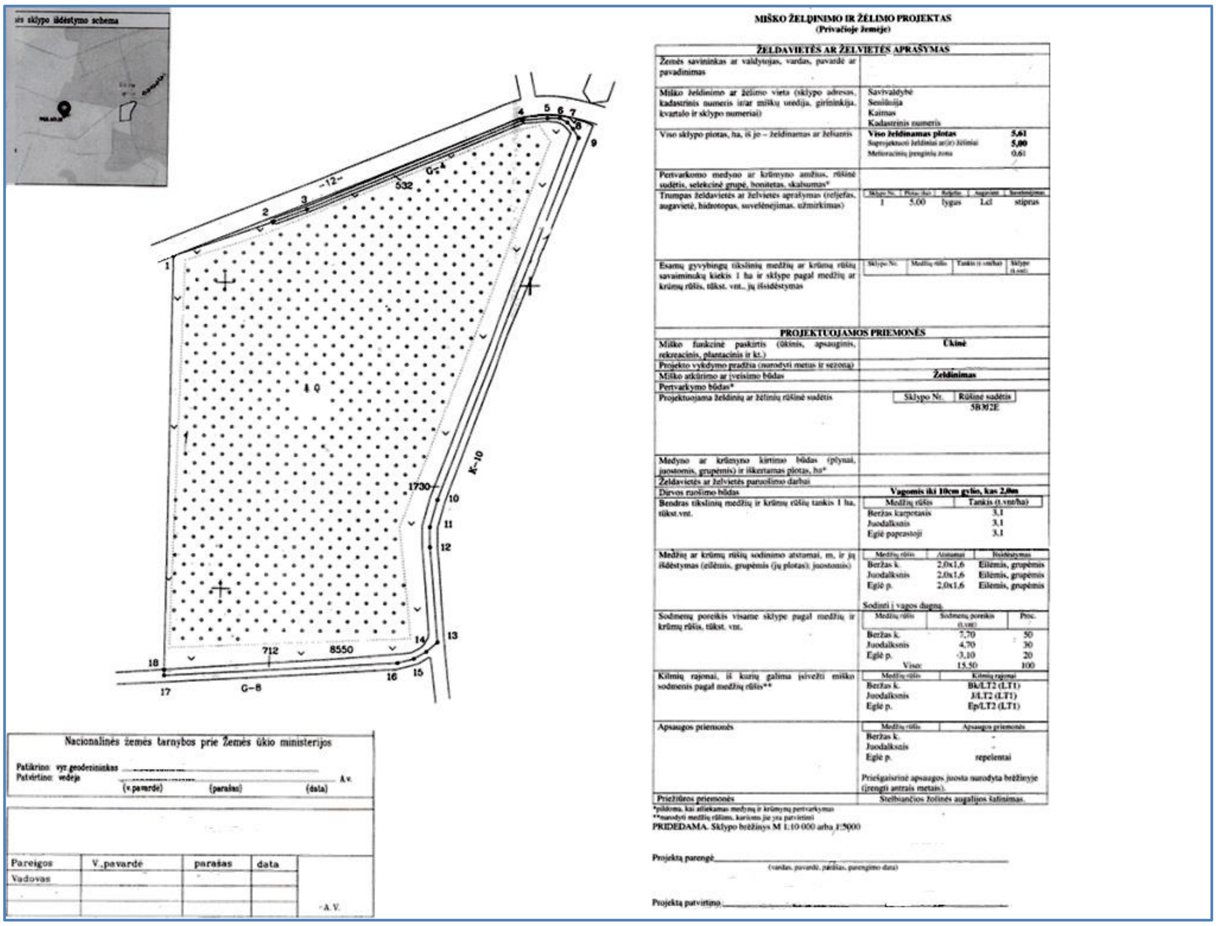

Figure 11-5. Example of forest planting (afforestation/reforestation) project provided to *SFC*

The main data source used for identification of AR and D areas was the geographic data from the *SFC*. These data sets include borders of all forest compartments in Lithuania (around 1.3 million 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 Cadaster 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

[229] Lietuvos Respublikos Seimas. 2012. [Seimas of the Republic of Lithuania]. Miško atkūrimo ir įveisimo nuostatai. [Regulations for afforestation and reforestation]. Nr. D1-1052.

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 apparently 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 *SFC* data was based on the information originating from *SFI*. *SFI* 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 *SFI* was acquired from forest inventory contractors, which had not been officially delivered to the *SFS* yet. Next, all non-forest compartments stored in the *SFC* database were checked for the records on potentially established forests there. Simultaneously, *SFE* 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 *SFC* were taken into consideration. There were also records of the officially registered deforestations in *SFC* 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, ortho-photo 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 *SFC* 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 ortho-photos 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 ortho-photos

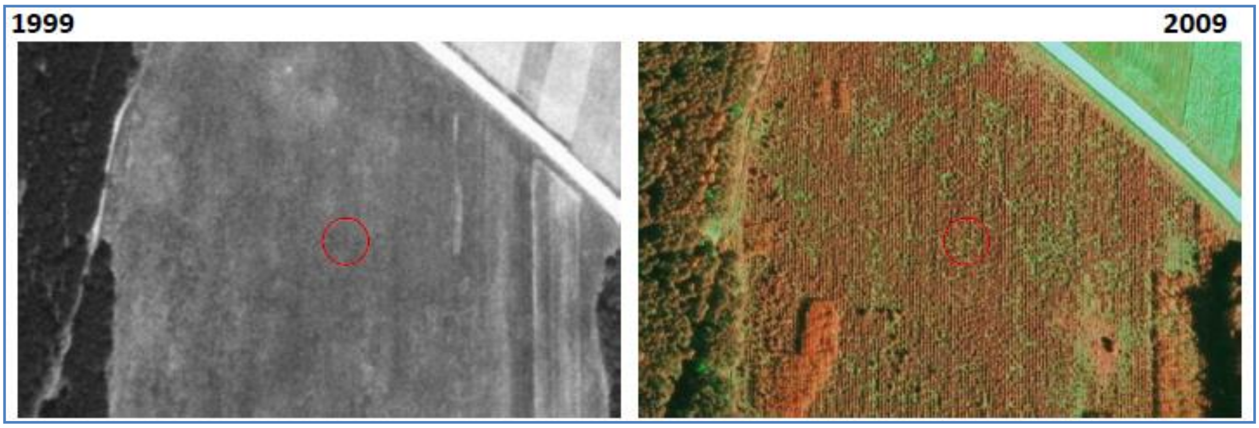

Figure 11-7. Identification of human induced afforestation (A1) based on two consecutive ortho-photos

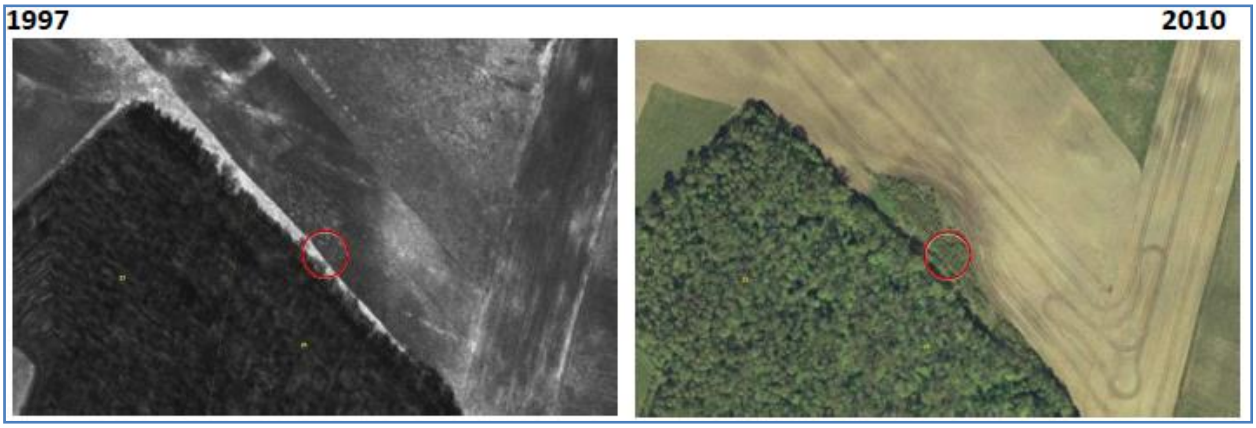

Figure 11-8. Identification of natural afforestation (A2) case using two consecutive ortho-photos

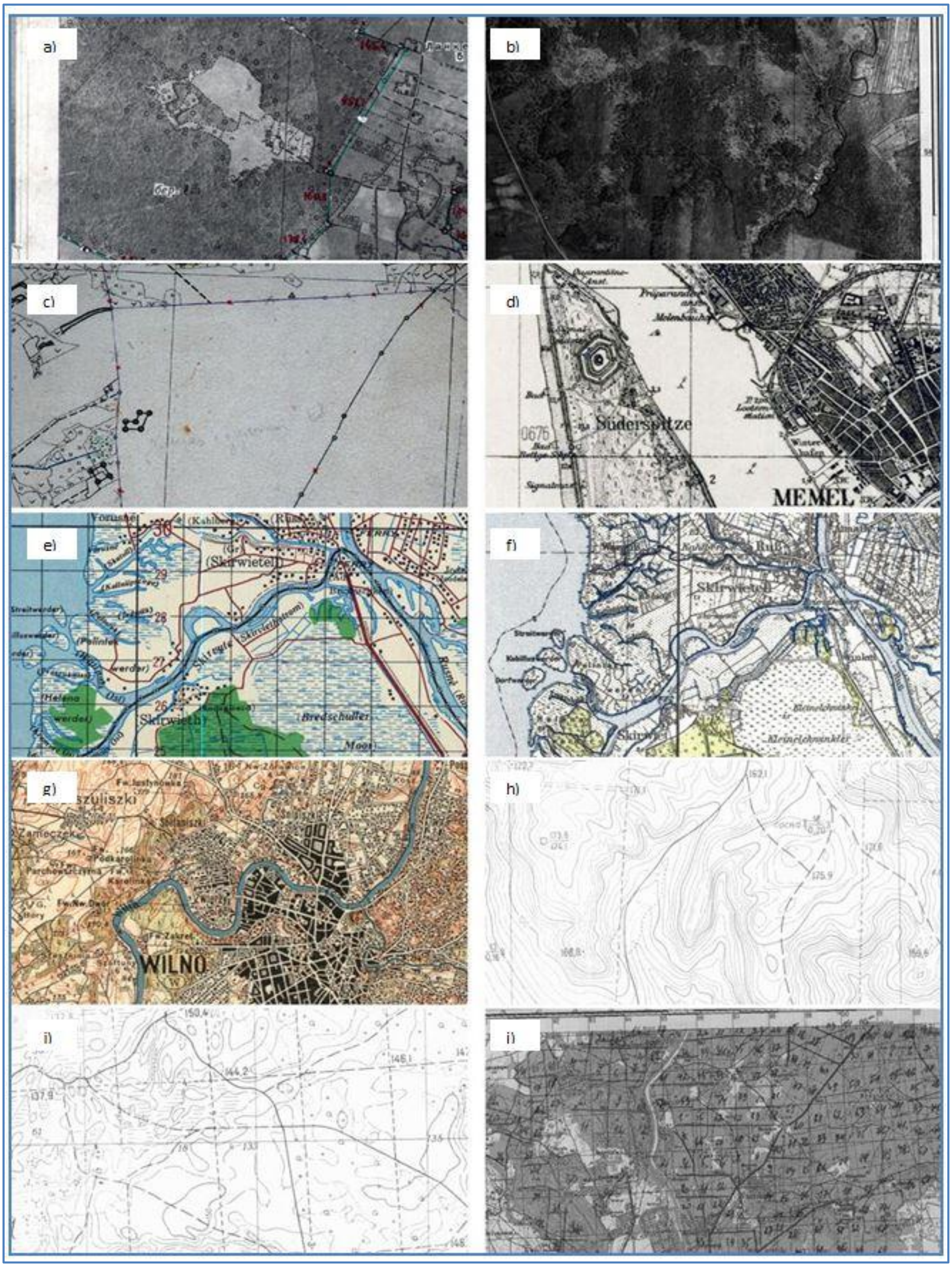

Figure 11-9. Examples of archive cartographical data used for Study-1:

a – scanned ortho-photographic map 1949-1952; b – scanned photography negative of ortho-photographic map 1949-1952; c – ground survey based map; d – German topographic maps compiled in 4-5th decade of the XX century (d - S 1:25°000; f – S1:100°000); e – US army cartography department maps compiled in 1944 (S 1:100°000); g – Polish army cartography department maps of Vilnius compiled in 1934 (S 1:25°000); h – topographical maps of different origin developed in former USSR (h – S 1:10°000; i – S 1:25°000); j – topographical maps in 1942 coordinate system (S 1:50°000)

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 confirm consistency among them. Therefore, *NFI* data serves for quality assurance as it rather well reiterates 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.

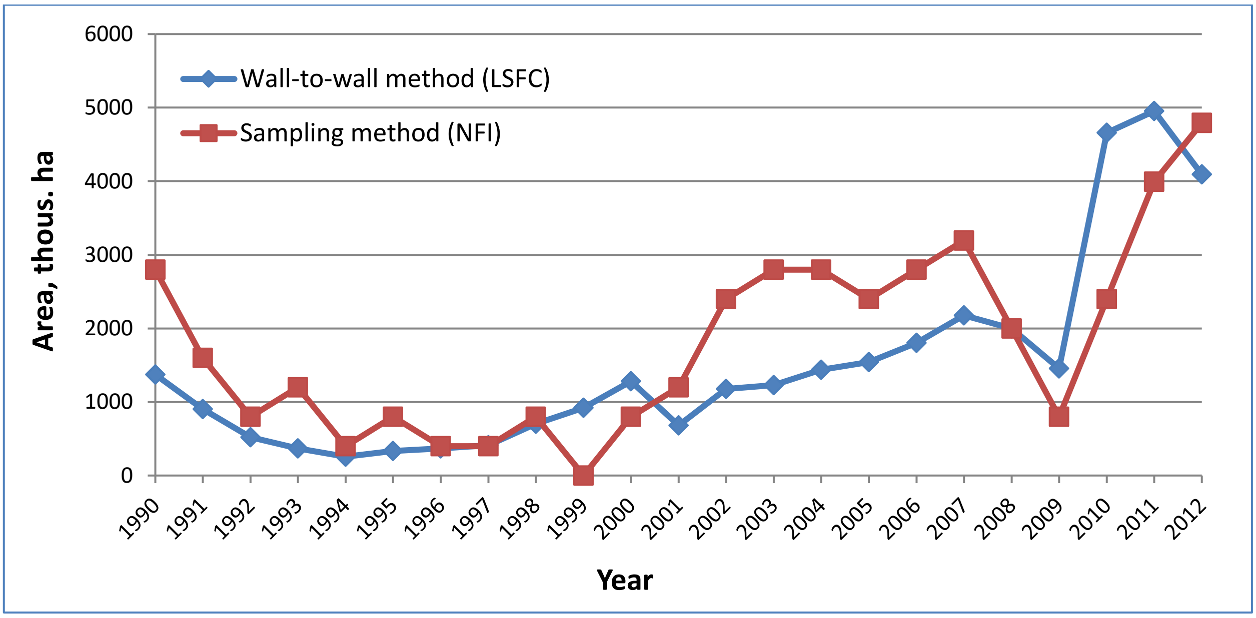

Figure 11-10. Wall-to-wall method quality assurance using *NFI* data

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 2015, thous. ha

From previous inventory year \ To current 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	41.11	0.003						41.11
	D		1.98						1.98
Article 3.4 activities	FM		0.04	2,156.06					2,156.06
	CM	NA	NA		NA	NA	NA		NA
	GLM	NA	NA		NA	NA	NA		NA
	REV	NA			NA	NA	NA		NA
Other[230]		3.48	0.00	5.30	NA	NA	NA	4,322.03	4,330.85
Total area at the end of the current inventory year		44.59	2.02	2,161.36	NA	NA	NA	4,322.03	6,530.00

During the review it was recommended that Lithuania provide additional information on the accuracy of activity data of forest land conversions to other land uses (deforestation) estimated by sampling method (NFI data) and wall-to-wall method (State Forest Cadaster data). Differences between estimated by sampling and wall-to-wall activity data of deforestation (forest land converted to other land uses) are presented in the Table below. Comparison in Table 11-8 clearly shows that deforestation activities are very rare in Lithuania, therefore it is not identified every year by sampling method (NFI data source) while it might have been already registered in State Forest Cadaster. Due to the fact that each sampling plot represents 399 ha of total country area and is distributed in 4 × 4 km grid, deforestation activity data is overestimated by sampling method comparing to wall-to-wall maping. It should be noted that because the average annual deforestation area is considerably smaller than the area represented by sampling plot (399 ha), forest conversion to other land uses cannot be reported annually for Convention reporting. Total activity data difference for the 1990 - 2015 inventory period is 1180 ha or deforested area according to NFI data is 36.9 % larger comparing to State Forest Cadaster (SFC). Average deforested area according to NFI data is 123 ha, while estimated by wall-to-wall method - 77 ha. Standard error for deforested area estimation by sampling method is 180 % for annual conversions and 36 % for the whole time series (1990 - 2015). Although all deforestation areas has to be registered In SFC according to the law, it can still be minor deforestation cases not included into it (e.g. areas under legal disputes), however accuracy of deforested areas estimated by wall-to-wall method concerning those issues cannot be clearly determined.

Table 11-8. Differences between deforestation activity data obtained by different methods, ha

Year	NFI annual AD	SFC annual AD	NFI cumulative AD	SFC cumulative AD
1990	0	0	0	0

230 "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.

1991	0	0	0	0
1992	0	0	0	0
1993	0	187	0	187
1994	399	97	399	284
1995	0	6	399	290
1996	0	50	399	340
1997	0	36	399	377
1998	0	24	399	401
1999	399	51	799	452
2000	0	16	799	468
2001	0	144	799	612
2002	0	4	799	616
2003	399	5	1,198	621
2004	399	11	1,598	632
2005	399	49	1,997	680
2006	799	0	2,796	680
2007	0	288	2,796	969
2008	0	47	2,796	1,016
2009	399	28	3,195	1,044
2010	0	72	3,195	1,117
2011	0	29	3,195	1,145
2012	0	103	3,195	1,248
2013	0	318	3,195	1,566
2014	0	410	3,195	1,975
2015	0	40	3,195	2,015

Differences in carbon stock change in deforested areas could also occur due to the use of different data sources for growing stock volume estimation. Lithuania is considering to use State Forest Cadaster data of growing stock volume from deforested areas starting from 2008. Currently growing stock volume in deforested areas is estimated using mean growing stock volume (m^3 ha^{-1}) from NFI and Study 1 (up to 2002), attributing to the deforestation area, since growing stock volume data from SFC for all deforested areas is available only from 2008 (approx. 10 % of deforestation areas growing stock volume still missing in 2008). Mean difference between growing stock volume indicated in NFI database and SFC database for 2008 - 2015 is 5.3 %, excluding 2010 with 73.5 % larger growing stock volume indicated in NFI database comparing to SFC. Comparing growing stock volume difference for years 2008 - 2015, 15 % larger GSV from NFI database was indicated.

Table 11-9. Differences between growing stock volume from different databases, m^3

Year	2008	2009	2010	2011	2012	2013	2014	2015
SFC data	9,843	6,667	4,399	6,742	22,666	64,493	89,306	9,579
NFI data	10,456	6,336	16,601	6,805	24,459	78,084	98,926	9,662
Relative difference, %	5.9	-5.2	73.5	0.9	7.3	17.4	9.7	0.9

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 FM category as well as for estimations of living biomass, deadwood, area of organic soils etc. for FM and afforestation, reforestation, deforestation activities.

After the *Study-1* which was used to recover unknown information on ARD areas for the period 1990-2011, *SFC* 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 *SFC*:

– ***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.
– ***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.

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.

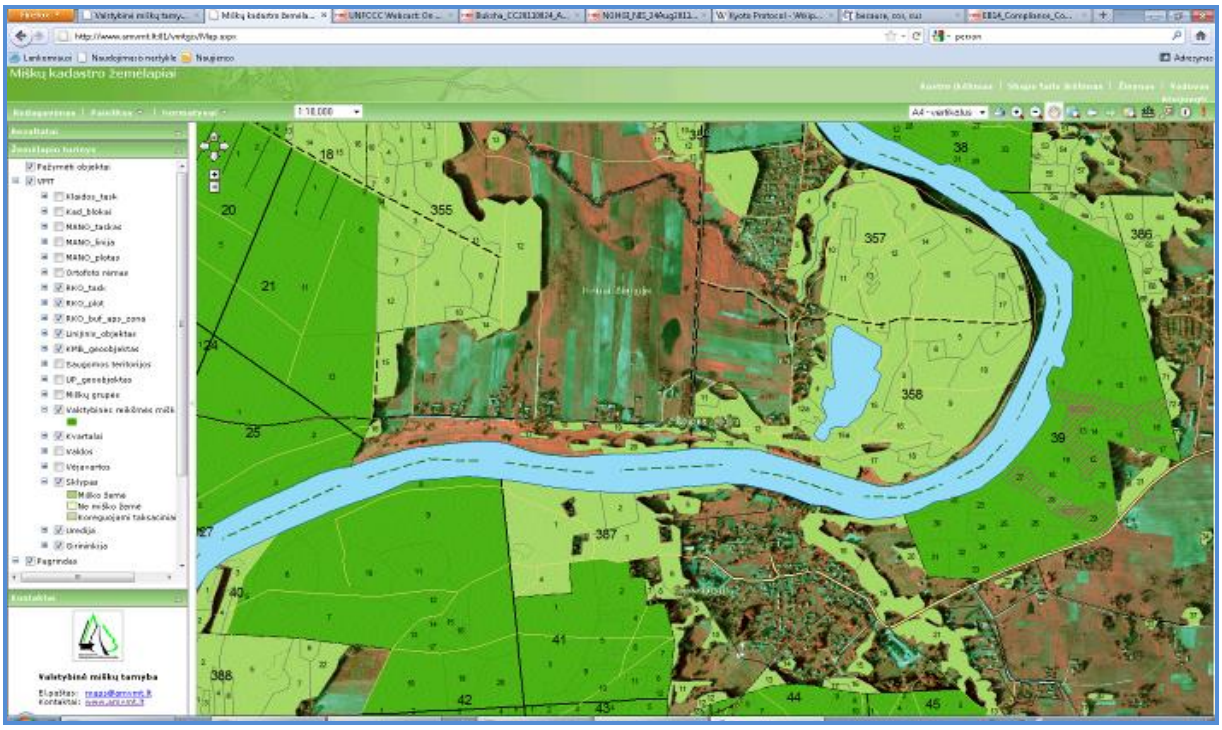

Figure 11-11. Preview of LSFC database

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 SFS 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.

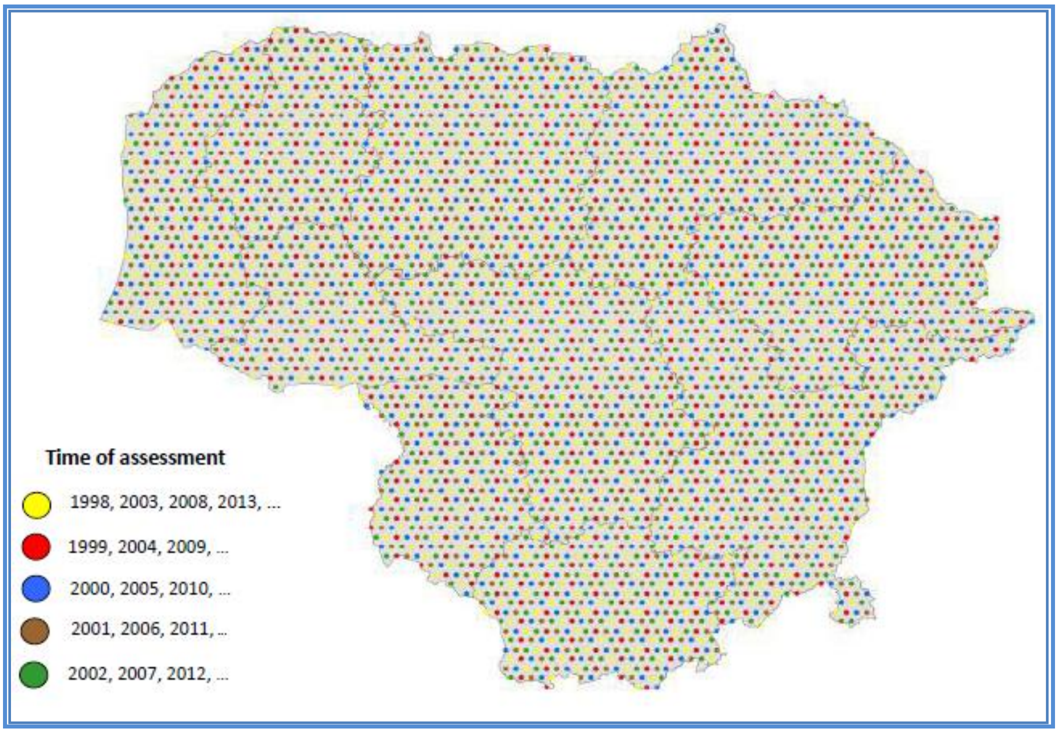

Figure 11-12. Distribution of *NFI* plots on Lithuania's territory

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 16000 permanent sample plots were established on Lithuanian territory using unique *NFI* sample plots net. 6000 sample plots are allocated on forest land and nearly 10000 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 permanent 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.

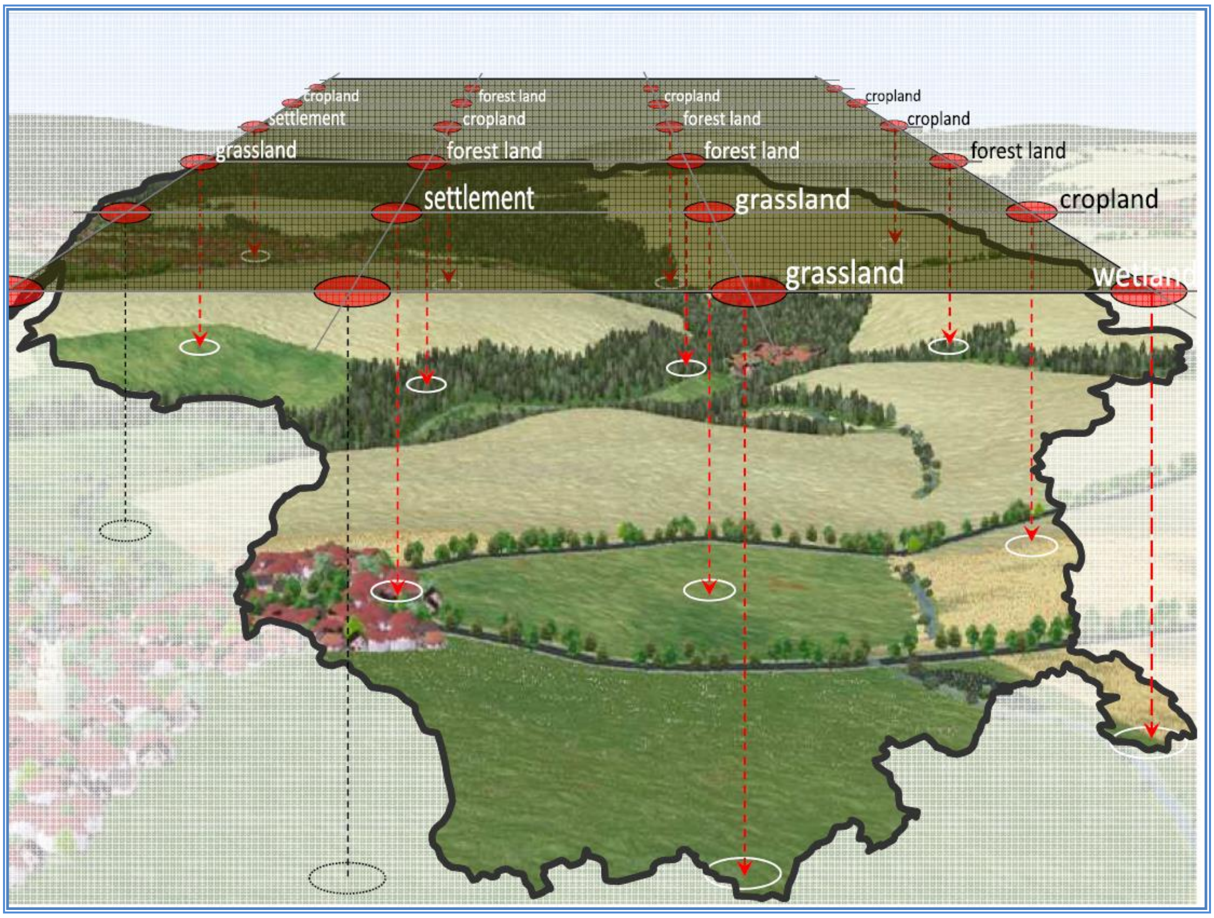

Figure 11-13. Allocation of sample plots to relevant land use category

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 GHG 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 11-11). 3rd order polynomial trend was used to come up with the mean growing stock volume and mean growing stock volume change (Table 11-10) of afforested and reforested areas per hectare.

Above and below ground biomass for deforestation was calculated separately from emissions and removals under FM.

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:

$$\Delta V = \sum \left[A_i \cdot \left(V_{t_2} - V_{t_1}\right)\right]$$

where:
ΔV – GSV change on afforested/reforested land, m^3;
A_i – area according to land use category, ha;
V_{t1} – GSV at time t_1, m^3;
V_{t2} – GSV at time t_2, m^3.

Annual change in carbon stocks in living biomass in land converted to Forest land was calculated by using eq. 2.15 (p. 2.20 of *IPCC 2006*):

$$\Delta C_B = \Delta C_G + \Delta C_{CONVERSION} - \Delta C_L$$

where:
ΔC_B – annual change in carbon stocks in living biomass in land converted to forest land, tonnes C yr^{-1};
ΔC_G – annual increase in carbon stocks in living biomass due to growth in land converted to forest land, tonnes C yr^{-1};
$\Delta C_{CONVERSION}$ – annual change in carbon stocks in living biomass due to actual conversion to forest land, tonnes C yr^{-1};
ΔC_L – annual decrease in carbon stocks in living biomass due to losses from harvesting, fuel wood gathering and disturbances in land converted to forest land, tonnes C yr^{-1}.

Annual change in carbon stocks in living biomass due to actual conversion to forest land was calculated employing eq. 2.16 (p. 2.20 of *2006 IPCC*):

$$\Delta C_{CONVERSION} = \sum_i \left\{ \left[B_{AFTER_i} - B_{BEFORE_i} \right] \cdot \Delta A_{TO_{FORESR_i}} \right\} \cdot CF$$

where:
$\Delta C_{CONVERSION}$ – change in carbon stocks in living biomass in land annually converted to forest land, tonnes C yr^{-1};
$B_{BEFOREi}$ – biomass stocks on land type i immediately before conversion, tonnes d. m. ha^{-1};
B_{AFTERi} – 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);
$\Delta A_{TO\_FORESTi}$ – area of land-use i annually converted to forest land, ha yr^{-1};
CF – carbon fraction of dry matter (broadleaves – 0.48; coniferous – 0.51), tonnes C (tonne d. m.)$^{-1}$ (Table 4.3, p. 4.48 of *2006 IPCC*);
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.

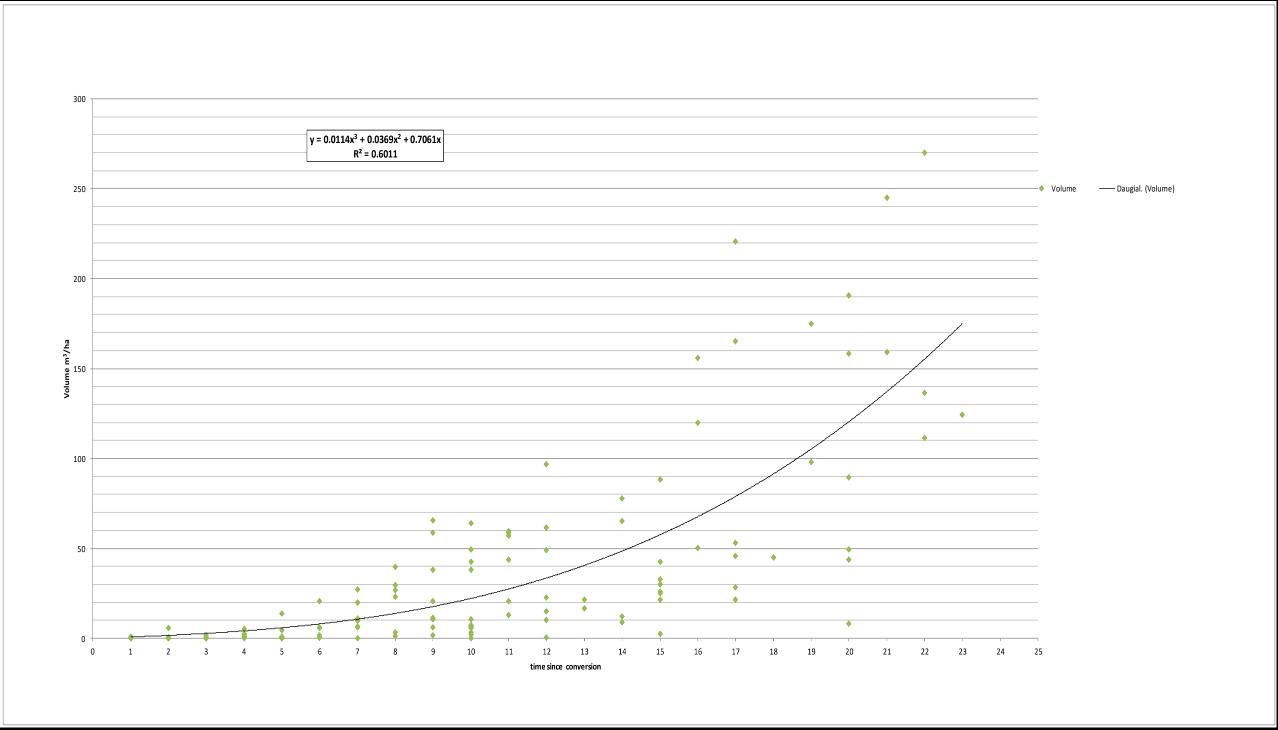

Figure 11-14. NFI data on growing stock volume of afforested and reforested (A1R1) areas

Table 11-10. Mean growing 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
24	195.7	21.2

Time since conversion	Mean growing stock volume, m^3/ha	Mean growing stock volume change, m^3/ha
25	217.0	21.2

Table 11-11. Aggregated data for AR areas and growing stock volume at the year of afforestation and reforestation

Time since afforestation/reforestation	1	2	3	4	5	6	11	16	21	22	23	24	25	26
Mean volume, m^3/ha	0.8	1.7	2.8	4.1	5.9	8.0	27.4	67.4	136.7	154.8	174.5	195.7	217.0	238.2
	1990	1991	1992	1993	1994	1995	2000	2005	2010	2011	2012	2013	2014	2015
A1R1 area, ha	1,373.5	901.0	520.3	369.3	256.2	331.1	1,280.1	1,542.1	4,659.0	4,954.0	4,093.0	2,911.9	3,573.7	3,482.8
A1R1 cumulative area, ha	1,373.5	2,274.5	2,794.8	3,164.1	3,420.3	3,751.4	7,432.6	13,494.2	25,583.4	30,537.4	34,630.4	37,542.3	39,742.5	42,324.3
ha	1,373.5	1,373.5	1,373.5	1,373.5	1,373.5	1,373.5	1,373.5	1,373.5	1,373.5	1,373.5	1,373.5	1,373.5	1,373.5	1373.5
m^3	1,036.1	2,267.6	3,788.3	5,692.2	8,073.3	11,025.4	37,640.5	92,624.6	187,720.8	212,587.0	239,670.4	268,828.0	297,985.7	327,143.4
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
m^3		679.7	1,487.6	2,485.2	3,734.3	5,296.3	19,958.9	51,691.7	108,198.6	123,150.8	139,463.7	157,231.3	176,359.7	195,488.0
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
m^3			392.5	859.1	1,435.2	2,156.5	9,186.2	25,184.0	54,598.7	62,483.2	71,117.9	80,538.4	90,798.9	101,845.2
ha				369.3	369.3	369.3	369.3	369.3	369.3	369.3	369.3	369.3	369.3	369.3
m^3				278.6	609.7	1,018.5	5,113.3	14,941.0	33,658.8	38,747.1	44,342.4	50,470.2	57,155.7	64,437.3
ha					256.2	256.2	256.2	256.2	256.2	256.2	256.2	256.2	256.2	256.2
m^3					193.3	423.0	2,731.2	8,578.5	20,155.4	23,351.0	26,881.0	30,762.8	35,014.0	39,652.1
ha						331.1	331.1	331.1	331.1	331.1	331.1	331.1	331.1	331.1
m^3						249.8	2,658.0	9,074.2	22,329.6	26,050.4	30,180.8	34,743.2	39,760.4	45,255.0
ha							367.2	367.2	367.2	367.2	367.2	367.2	366.9	366.9
m^3							2,158.5	8,134.0	21,066.4	24,764.0	28,890.5	33,471.2	38,499.5	44,059.2
ha							412.5	412.5	412.5	412.5	412.5	412.5	412.5	412.5
m^3							1,709.7	7,283.1	19,966.6	23,666.9	27,821.0	32,456.9	37,603.0	43,287.4
ha							701.4	701.4	701.4	701.4	701.4	701.4	701.4	701.4
m^3							1,934.5	9,711.8	28,377.5	33,945.0	40,235.8	47,298.0	55,179.5	63,928.3
ha							920.0	920.0	920.0	920.0	920.0	920.0	919.0	918.9
m^3							1,518.9	9,808.0	30,806.8	37,223.9	44,526.9	52,778.9	61,975.2	72,294.5
ha							1,280.1	1280.1	1,280.1	1,280.1	1,280.1	1,280.1	1,279.9	1,279.8

m^3							**965.7**	**10,276.2**	**35,082.6**	**42,866.6**	**51,795.8**	**61,957.8**	73,428.6	**86,310.0**
ha								680.6	680.6	680.6	680.6	680.6	680.1	680.1
m^3								**4,000.3**	**15,075.0**	**18,650.9**	**22,789.1**	**27,536.2**	32,914.4	**39,014.2**
ha								1,175.6	1,175.6	1,175.6	1,175.6	1,175.6	1,174.8	1,174.4
m^3								**4,872.3**	**20,755.2**	**26,041.6**	**32,218.8**	**39,367.4**	47,535.4	**56,842.1**
ha								1,227.7	1,227.7	1,227.7	1,227.7	1,227.7	1,227.5	1,226.9
m^3								**3,386.2**	**17,000.1**	**21,674.2**	**27,194.7**	**33,645.5**	41,103.9	**49,641.6**
ha								1,435.6	1,435.6	1,435.6	1,435.6	1,435.6	1,435.6	1,435.6
m^3								**2,370.1**	**15,304.6**	**19,878.6**	**25,344.1**	**31,799.3**	39,342.3	**48,071.4**
ha								1,542.1	1,542.1	1,542.1	1,542.1	1,542.1	1,542.1	1,542.1
m^3								**1,163.3**	**12,378.8**	**16,440.0**	**21,353.3**	**27,224.3**	34,158.3	**42,261.0**
ha									1,803.2	1,803.2	1,803.2	1,803.2	1,803.2	1,803.2
m^3									**10,599.3**	**14,475.2**	**19,224.1**	**24,969.5**	31,834.8	**39,943.1**
ha									2,176.0	2,176.0	2,176.0	2,176.0	2,175.7	2,175.7
m^3									**9,018.2**	**12,790.5**	**17,467.6**	**23,198.3**	30,127.4	**38410.5**
ha									1,997.0	1,997.0	1,997.0	1,997.0	1,997.0	1,995.6
m^3									**5,508.1**	**8,276.4**	**11,738.4**	**16,030.7**	21,290.0	**27,633.5**
ha									1,454.0	1,454.0	1,454.0	1,454.0	1,454.0	1,454.0
m^3									**2,400.6**	**4,010.4**	**6,026.0**	**8,546.6**	11,671.8	**15,501.1**
ha									4,659.0	4,659.0	4,659.0	4,659.0	4,657.3	4,657.2
m^3									**3,514.7**	**7,692.0**	**12,850.5**	**19,308.8**	27,375.6	**37,385.2**
ha										4,954.0	4,954.0	4,954.0	4,954.0	4,954.0
m^3										**3,737.3**	**8,179.1**	**13,664.1**	20,531.4	**29,119.6**
ha											4,093.0	4,093.0	4,092.9	4,092.9
m^3											**3,087.8**	**6,757.5**	11,289.0	**16,962.6**
ha												2,911.9	2,911.9	2,911.9
m^3												**2,196.7**	4,807.5	**8,031.6**
													3,573.7	3,573.7
													2,696.0	**5,900.2**
														3,482.8
														2,627.4
Total volume, m^3	**1,036.1**	**2,947.3**	**5,668.5**	**9,315.1**	**14,045.6**	**20,169.4**	**85,575.4**	**263,099.4**	**673,516.5**	**802,502.9**	**952,399.6**	**1,124,781.6**	**1,320,437.9**	**1,541,045.5**

The estimation of carbon stock changes in living biomass in areas referring to FM is consistent with the *Method 2* further described in the *2013 KP-Supplement*, which is also identified 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 (eq. 2.8, p. 2.12 of *2006 IPCC*):

$$\Delta C_{LB} = \frac{(C_{t_2} - C_{t_1})}{(t_2 - t_1)} \qquad \text{and} \qquad C = (\Delta A_{GB} + \Delta B_{GB}) \cdot CF \text{ (modified eq. 2.8)}$$

where:
ΔC_{LB} – annual change in carbon stock in living biomass (includes above- and belowground biomass) in total forest land, t C yr^{-1};
C_{t2} – total carbon in biomass calculated at time t_2, t C;
C_{t1} – total carbon in biomass calculated at time t_1, t C;
ΔA_{GB} – above-ground biomass change, t d. m.;
ΔB_{GB} – below-ground biomass change, t d. m.;
CF – carbon fraction of dry matter (broadleaves – 0.48; coniferous – 0.51), tonnes C (tonne d. m.)$^{-1}$ (Table 4.3, p. 4.48 of *IPCC 2006*).

Annual growing stock volume (GSV) change for FM from 2007 was estimated based on *NFI* data using the following steps:

1) Annual GSV change in all forest area (total FM 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 $V_{remt2} - V_{remt1}$) 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 FM 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 FM area are shown below:

$$\Delta FF_t = \left(\left(V_{rem_{t2}} - V_{rem_{t1}}\right) + \Delta V_{new}\right) - \Delta A1R1$$

where:
ΔFF_t – growing stock volume change for FM for the defined year, m^3;
V_{remt1} – growing stock volume calculated at time t_1, m^3;
V_{remt2} – growing stock volume calculated at time t_2, m^3;
ΔV_{new} – growing stock volume change of the new measured sample plots, m^3;
$\Delta A1R1$ – 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 are 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 1990-2015, and also presumed that dead wood pool cannot decrease, because there is actually no dead wood before the conversion. The dead wood starts to accumulate when natural mortality or thinning occur that is at the age of over 20 years.

Annual change in carbon stocks in dead organic matter in FM 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 felling (BGB). Dead wood that is left on site after felling is assumed to be below-ground biomass i.e. roots. It is assumed that BGB decays in equal parts in 5 years. Modified eq. 2.17 (p. 2.21 of *IPCC 2006*) has been used to calculate carbon stock change in dead organic matter:

$$\Delta C_{DOM} = C_{DW} + C_{DWH}$$

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_{DWH} – change in carbon stocks in dead wood (BGB left on site after felling), t C yr^{-1}.

Annual change of biomass of dead trees stems is calculated using stock change method and employing eq. 2.19 (p. 2.23 of *IPCC 2006*).

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 2.2 (p. 2.27 of *IPCC 2006*). 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 11-12).

Table 11-12. 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	2000	2005	2010	2011	2012	2013	2014	2015
Time since afforestation/ reforestation	**1**	**2**	**3**	**4**	**5**	**6**	**11**	**16**	**21**	**22**	**23**	**24**	**25**	**26**
Annual carbon stock in litter, t/ha/year	1.2	2.4	3.6	4.8	6	7.2	13.2	19.2	24	24	24	24	24	24
Year	1990	1991	1992	1993	1994	1995	2000	2005	2010	2011	2012	2013	2014	2015
A1R1 area, ha	**1,373.5**	**901.0**	**520.3**	**369.3**	**256.2**	**331.1**	**1,280.1**	**1,542.1**	**4,659.0**	**4,954.0**	**4,093.0**	**2,911.9**	**3,573.7**	**3,482.8**
Cumulative A1R1 area, ha	**1,373.5**	**2,274.5**	**2,794.8**	**3,164.1**	**3,420.3**	**3,751.4**	**7,432.6**	**13,494.2**	**25,583.3**	**30,537.3**	**34,630.33**	**37,542.27**	**39,742.5**	**42,324.3**

Annual change in carbon stocks in litter, t		1,648.2	1,648.2	1,648.2	1,648.2	1,648.2	1,648.2	1,648.2	1,648.2	0.0	0.0	0.0	0	0	0
			1,081.2	1,081.2	1,081.2	1,081.2	1,081.2	1,081.2	1,081.2	1,081.2	0.0	0.0	0	0	0
				624.4	624.4	624.4	624.4	624.4	624.4	624.4	624.4	0.0	0	0	0
					443.1	443.1	443.1	443.1	443.1	443.1	443.1	443.1	0	0	0
						307.4	307.4	307.4	307.4	307.4	307.4	307.4	307.4	0	0
							397.3	397.3	397.3	397.3	397.3	397.3	397.3	397.3	0
								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
								841.6	841.6	841.6	841.6	841.6	841.6	841.6	841.6
								1,104.0	1,104.0	1,104.0	1,104.0	1,104.0	1,104.0	1,104.0	1,104.0
								1,536.2	1,536.2	1,536.2	1,536.2	1,536.2	1,536.2	1,536.2	1,536.2
									816.7	816.7	816.7	816.7	816.7	816.7	816.7
									1,410.8	1,410.8	1,410.8	1,410.8	1,410.8	1,410.8	1,410.8
									1,473.2	1,473.2	1,473.2	1,473.2	1,473.2	1,473.2	1,473.2
									1,722.7	1,722.7	1,722.7	1,722.7	1,722.7	1,722.7	1,722.7
									1,850.5	1,850.5	1,850.5	1,850.5	1,850.5	1,850.5	1,850.5
										2,163.8	2163.8	2,163.8	2,163.8	2,163.8	2,163.8

									2,611.2	2,611.2	2,611.2	2,611.2	2,611.2	2,611.2
									2,396.4	2,396.4	2,396.4	2,396.4	2,396.4	2,396.4
									1,744.8	1,744.8	1,744.8	1,744.8	1,744.8	1,744.8
									5,590.8	5,590.8	5,590.8	5,590.8	5,590.8	5,590.8
										5,944.8	5,944.8	5,944.8	5,944.8	5,944.8
											4,911.6	4,911.6	4,911.6	4,911.6
												3,494.3	3,494.3	3,494.3
													4,288.4	4,288.4
														4,179.4
Total carbon stock change in litter, t	**1,648.2**	**2,729.4**	**3,353.8**	**3,796.9**	**4,104.4**	**4,501.7**	**8,919.2**	**16,193.0**	**29,051.8**	**33,915.4**	**38,202.58**	**41,253.74**	**45,228.64**	**48,977.79**
kt	**1.64816**	**2.72941**	**3.35381**	**3.79694**	**4.10435**	**4.50169**	**8.91916**	**16.193**	**29.0518**	**33.9154**	**38.20258**	**41.25374**	**45.22864**	**48.97779**

NFI provides data on forest land distribution by forest soils (Table 6-9, Chapter 6.2.1). According to *NFI*[231] 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 afforested/reforested 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 EF estimated by Finland (Finish NIR 2013, appendix_7g). EF for mineral soils was applied for Southern Finland considering similar climatic conditions as in Lithuania. Carbon stock changes in organic soils were estimated separately for forested Croplands, Grasslands and Wetlands. Due to the lack of information in forest planting projects at the SFC 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 11-13. 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

[231] Lithuanian National Forest Inventory 2003-2007. Forest resources and their dynamics

Carbon stock change in drained organic forest soils for FM was calculated using eq. 2.26 (p. 2.35, of *IPCC 2006*):

$$\Delta C_{FOS} = A_{Drainage} \cdot EF_{Drainage}$$

where:
ΔC_{FOS} – CO_2 emissions from drained organic forest soils, t C yr^{-1};
$A_{Drainage}$ – area of drained organic forest soils, ha;
$EF_{Drainage}$ – emission factor for CO_2 from drained organic forest soils, t C ha^{-1} yr^{-1}.

Default value of EF for drained organic soils in managed forests provided in Table 4.6 (p. 4.53, of *IPCC 2006*) was used in calculations. Default $EF_{Drainage}$ for temperate forests is 0.68 tonnes C ha^{-1} yr^{-1}.

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. 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 have not found significant changes and is not accounting for both.

A study performed by the EU all over its territory – the *Biosoil* project[232]; for Lithuanian forests shows a slightly, not significant, increase in soil carbon stocks from 1992 to 2006[233] (Table 11-14).

Table 11-14. 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 FM (including areas of natural afforestation/reforestation, which

[232] Available from: *http://ec.europa.eu/dgs/jrc/index.cfm?id=1410&obj_id=10400&dt_code=NWS&lang=en*
[233] EU-JRC: Evaluation of BioSoil Demonstration Project - Preliminary Data Analysis. Available from: *http://eusoils.jrc.ec.europa.eu/ESDB_Archive/eusoils_docs/other/EUR24258.pdf* and EU-JRC: Evaluation of *BioSoil* Demonstration Project - Soil Data Analysis Available from: *http://eusoils.jrc.ec.europa.eu/ESDB_Archive/eusoils_docs/other/EUR24729.pdf*

are included into FM, see chapter 11.2) 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 *DGSF* (Table 11-15). *DGSF* 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 have 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 *DGSF* every year.

A unique fire assessment system has been established in Lithuania since 2013. *SFS* together with General Directorate of State Forests has worked out a methodology to assess forest fire after-effects in terms of GHG accounting directly *in situ*.

Special assessment table has been established which has to be filled with detail information on the fire. The table contains information which allows allocating forest fire, to estimate area that was burnt and to assess damage that has been done in terms of GHG accounting. In the table below only partial information that should be filled in the forest fire assessment table is presented. The first part of this table contains information on owner of forest (*SFE*), unique forest fire number, date, forest district, block number, site number and coordinates.

Percentage of burnt biomass is expressed by codes that are used by fire damages assessing experts from SFE or local forest districts.

Volume of burnt biomass of the area affected by forest fire is estimated by overlapping GIS layers of the centre coordinate of fire location and data of the total growing stock volume by *SFI*. Burnt peat depth is expressed in centimetres of average burnt peat layer over the fire site and is estimated by assessing persons.

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 FM were calculated separately in this submission. Data on wildfires occurring on afforested and reforested areas was received from *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 FM was calculated by subtracting burnt area of afforested and reforested areas form the total burn forest land area.

Table 11-15. CO_2 emissions from biomass burning[234] (kt) and area of ARD and FM that was burned (ha)*

Year	Afforestation & Reforestation	Deforestation	Forest Management

[234] Note that emissions 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

	Area burned, ha	kt CO_2	Area burned, ha	kt CO_2	Area burned, ha	kt CO_2
2008	1.93	0.05	NO	NO	110.47	6.50
2009	3.06	0.08	NO	NO	312.24	18.05
2010	2.17	0.06	NO	NO	19.33	1.13
2011	2.78	0.07	NO	NO	290.02	17.09
2012	1.20	0.03	NO	NO	19.09	1.12
2013	NO	NO	NO	NO	24.70	0.58
2014	0.8	0.02	NO	NO	160.70	5.67
2015	0.68	0.01	NO	NO	70.17	1.78

* Note that emissions 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 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.

Non-CO_2 emissions from drainage of soils

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 emissions were calculated for the total forest land area, thus emissions from AR were also included.

N_2O emissions from drained organic soils were calculated employing equation 11.1 (p. 11.7 of *IPCC 2006*). Simple disaggregation of drained organic soils into "nutrient rich" and "nutrient poor" areas is applied and default emission factors are used (*Tier 1*, eq. 11.1). For „nutrient rich" areas default EF of 0.6 and for „nutrient poor" areas default emission factor of 0.1 according to Table 11.1 (p. 11.11 of *IPCC 2006*) 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 are no N_2O emissions from mineral soils (reported as 'NO').

CH_4 emissions from drainage of soils

CH_4 emissions are estimated using a simple emission factor approach further described in eq. 2.6 (Ch. 2.2.2.1, p. 2.18 of *2013 Wetlands Supplement*). CH_4 emissions are estimated for drained organic soils where ditches or drainage canals occur.

$$CH_{4\_organic} = \sum_{c,n,p} = A_{c,n,p} \cdot ((1 - Frac_{ditch}) \cdot EF_{CH4_{land\ c,n}} + Frac_{ditch} \cdot EF_{CH4_{ditch\ c,p}}))$$

where:

$CH_{4\_organic}$ – annual CH_4 loss from drained organic soils, kg CH_4 yr^{-1};

$A_{c,n,p}$ – land area of drained organic soils in a land-use category in climate zone c, nutrient status n and soil type p, ha;
$EFCH_{4\_land\ c,n}$ – emission factors for direct CH_4 emissions from drained organic soils, by climate zone c and nutrient status n, kg CH_4 ha^{-1} yr^{-1};
$EFCH_{4\_ditch\ c,p}$ – emission factors for CH_4 emissions from drainage ditches, by climate zone c and soil type p, kg CH_4 ha^{-1} yr^{-1};
$Frac_{ditch}$ – fraction of the total area of drained organic soil which is occupied by ditches (where 'ditches' are considered to be any area of man-made channel cut into the peatland).

Fertilization and liming

Information presented by *DGSF* indicates that there was no fertilization or liming of forest land in Lithuania since 1990 to 2013.

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 unfortunately there is no clear evidence on efficiency of such application[235].

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.

Windbreaks and windfalls

Accounting and data collection principles used by *SFS*, 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'.

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 estimates of emissions and removals.

11.3.1.4 Uncertainty estimates

Uncertainty values for Article 3.3 and Article 3.4 assessment are represented in Table 11-16.

Table 11-16. Uncertainty assessment values

Indicator	Category	Unit	Uncertainty
Growing stock volume	AR	m^3	15.6%

[235] Ozolinčius R., Armolaitis K., Mikšys V., Varnagirytė-Kabašinskienė I. 2010. *Recommendations for compensating wood ash fertilization* (2nd revised edition)

Indicator	Category	Unit	Uncertainty
	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	kt CO_2	39.1%
	D	kt CO_2	62%
	FM	kt CO_2	34%

11.3.1.5 Information on other methodological issues

For the 2nd CP Lithuania has continuously chosen to account for the emissions and removals under Articles 3.3 and 3.4 (forest management) and HWP at the end of CP. In the 1st CP Lithuania has made major improvements in its data collection, required for GHG assessment under Kyoto Protocol, referring to reconstruction of historical data and improved way forward for further accounting with additional requirements during the 2nd CP.

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 28th September 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 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 ARD 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 *LSFC* and is very rare. Any deforested area must follow the afforestation of three time larger area than the one was deforested.

All forest land, where forest was growing in 1990 according to *LSF* Resources Database (LTDBK50000-V) scale 1:50°000, but was not fixed in *LSFC* were visually checked, simultaneously inspecting *LSFC* data (MKAD, MKAD_ARCH and MKAD_2012 databases) as well as all ortho-photo maps compiled in the last two decades on Lithuania's territory together with satellite images from CORINE land cover database (Figure 11-14).

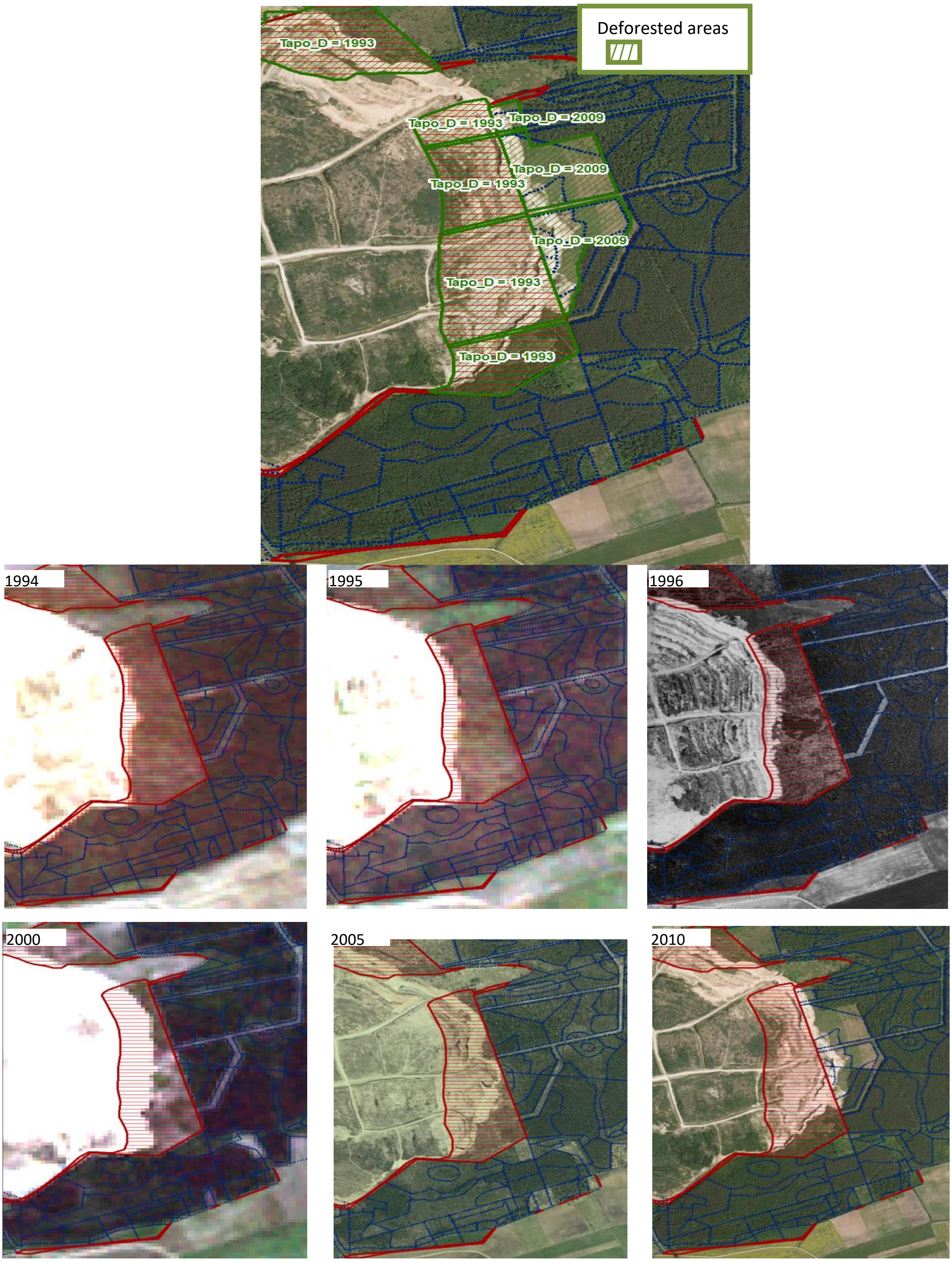

Figure 11-14. Technical procedure of identification of deforested areas 1994-2010

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 felling 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 felling[236]. 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 in total were a net sink over the 1st CP absorbing in average 151 kt CO_2 annually (Table 11-17). 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 (reported as NO). Deforestation activities were a continuous net source of in average 35.4 kt CO_2 annually (Table 11-18).

Table 11-17. Carbon stock change and emission/removals of CO_2 in afforestation and reforestation, kt

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	20.89	4.79	NO	23.36	-10.84	-6.84	31.36	-115.00
2009	24.21	5.56	NO	25.11	-10.70	-7.34	36.84	-135.03
2010	28.55	6.56	NO	29.05	-15.46	-8.99	39.71	-145.62
2011	33.50	7.70	NO	33.92	-19.13	-10.74	45.25	-165.89
2012	38.93	8.94	NO	38.20	-20.78	-12.18	53.11	-194.81
2013	44.77	10.29	NO	41.25	-20.58	-13.18	62.55	-229.35
2014	50.85	11.7	NO	45.23	-21.69	-14.42	71.67	-262.76
2015	57.29	13.18	NO	48.98	-22.41	-15.62	81.42	-298.54

Table 11-18. Carbon stock change and emission/removals of CO_2 in deforestation, kt

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	-2.72	-0.62	-0.14	-1.13	-2.85	-0.53	-7.99	29.29
2009	-1.67	-0.38	-0.09	-0.68	-1.72	-0.32	-4.86	17.84
2010	-4.34	-1.00	-0.22	-1.74	-4.39	-0.82	-12.51	45.85
2011	-1.76	-0.40	-0.09	-0.69	-1.75	-0.33	-5.02	18.39
2012	-6.32	-1.45	-0.33	-2.46	-6.22	-1.16	-17.94	65.81
2013	-19.99	-4.60	-1.04	-7.63	-19.61	-3.65	-56.52	207.17
2014	-25.56	-5.88	-1.33	-9.86	-25.03	-4.66	-72.32	265.18
2015	-2.5	-0.58	-0.13	-0.95	-2.42	-0.45	-7,03	25.74

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 6.1.1.). 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 FM category, since Lithuania considers that all forest land is managed.

[236] 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, Revegetation and Wetland Drainage and Rewetting 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 FM 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 11-19.

Table 11-19. Net emissions/removals from FM during the period 2008-2015, kt

Year	Net CO_2 removals	CH_4 emissions	N_2O emissions	Total (CO_2 eq.)
2008	-5,927.19	1.352	0.474	**-5,752.06**
2009	-7,160.54	1.396	0.477	**-6,983.58**
2010	-8,274.95	1.334	0.474	**-8,100.29**
2011	-8,745.59	1.393	0.477	**-8,568.49**
2012	-8,413.85	1.340	0.476	**-8,238.44**
2013	-9,087.83	1.338	0.476	**-8,912.50**
2014	-8,605.99	1.377	0.479	**-8,428.79**
2015	-8,093.11	1.351	0.478	**-7,916.78**

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 split into ARD and FM according to *IPCC 2006*.

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-organized, 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 No IX-240. Adopted on 10th April 2001;
- Land Law of the Republic of Lithuania No IX-1983. Adopted on 27th January 2004;
- Land reform Law of the Republic of Lithuania No VIII-370. Adopted on 2nd July 1997;
- Law on territory planning of the Republic of Lithuania No X-1962. Adopted on 15th January 2004.

Recently adopted legal acts to improve KP-LULUCF accounting:

- Order of the Minister of Environment and Minister of Agriculture No D1-987/3D-927 on Approval of Action plan to improve LULUCF reporting of Lithuania. Adopted on 16th December 2011;
- Order of the Minister of Environment No D1/27 on Approval of Harmonized Principles for data collection and reporting on LULUCF. Adopted on 12th January 2012;
- Order of the Minister of Environment No D1-59 to amend order No D1-570 on National forest inventory by sampling method. Adopted on 24th January 2012;
- Government Resolution No 570 to amend resolution No 1255 on State Forest Cadaster. Adopted on 23rd May 2012;
- Order of the Minister of Environment and Minister of Agriculture No 3D-239/D1-285 to amend order No 3D-130/D1-144 on Rules for afforestation of non-forest land. Adopted on 3rd April 2012;
- Order of the Minister of Environment and Minister of Agriculture No D1-409/3D-331 on Inventory and Registration of natural afforestation of non-forest land. Adopted on 8th May 2012.

11.6 Harvested wood products

11.6.1 Category description

Harvested Wood Products (HWP) accounting has been identified as mandatory from the beginning of the 2nd CP according to Decision 2/CMP.7 and Decision 2/CMP.8. Annual changes in carbon stocks and associated CO_2 emissions and removals from HWP removed from forests which are accounted for by a Party under Article 3.3 and Article 3.4 has to be accounted using *2013 KP-Supplement* methodology.

Lithuania defines semi-finished commodities relevant for the application of the guidance on estimating the HWP emissions and removals in line with the Decision 2/CMP.7.

Sawnwood (Decision 2/CMP.7 refers to this as "sawn wood"): Wood that has been produced from both domestic and imported round wood, either by sawing lengthways or by a profile-chipping process and that exceeds 6 mm in thickness. It includes planks, beams, joists, boards, rafters, scantlings, laths, boxboards and "lumber", etc., in the following forms: unplaned, planed, end-jointed, etc. It excludes sleepers, wooden flooring, mouldings (sawnwood continuously shaped along any of its edges or faces, like tongued, grooved, rebated, Vjointed, beaded, moulded, rounded or the like) and sawnwood produced by re-sawing previously sawn pieces. It is reported in cubic metres solid volume.

Wood-based panels (Decision 2/CMP.7 refers to this as "wood panels"): This product category is an aggregate comprising veneer sheets, plywood, particle board, and fibreboard. It is reported in cubic metres solid volume.

Paper and paperboard (Decision 2/CMP.7 refers to this as "paper"): The paper and paperboard category is an aggregate category. In the production and trade statistics, it represents the sum of graphic papers; sanitary and household papers; packaging materials and other paper and paperboard. It excludes manufactured paper products such as boxes, cartons, books and magazines, etc. It is reported in metric tonnes.

More detailed description of the activity data is presented in Chapter 6.8.

11.6.2 Methodological issues

Emissions and removals from HWP removed from forests which are accounted for by Lithuania under Article 3.3 and 3.4 are estimated using stock change method, and only HWP in use are considered. Annual change in carbon stock in HWP in solid waste disposal sites where the wood comes from domestic harvest including HWP exported to other countries are reported in this category.

The worksheet provided in *IPCC 2006* is a tool for estimating annual carbon balance under any of the proposed HWP approaches. The model consists of two elements: solid wood products and paper products. Both variables have different half-life values. GHG accounting for HWP pool in the worksheet is based on first order decay function with default half-life values (eq. 2.8.5, p. 2.120 of *2013 KP-Supplement*):

$$C(i+1) = e^{-k} \cdot C(i) + \left[\frac{(1-e^{-k})}{k}\right] \cdot Inflow(i)$$

$$\Delta C(i) = C(i+1) - C(i)$$

where:
i – year;
C*(i)* – the carbon stock in the particular HWP category at the beginning of year *i*, kt C;
k – decay constant of FOD for each HWP category (HWP_j) given in units yr^{-1} (k = ln(2)/HL, where HL is half-life of the HWP pool in years);
Inflow*(i)* – the inflow to the particular HWP category (HWP_j) during year *i*, kt C yr^{-1};
ΔC*(i)* – carbon stock change of the HWP category during year *i*, kt C yr^{-1}.

Lithuania uses default half-life values presented in Table 2.8.2 (p. 2.123 of *2013 KP-Supplement*).

Table 11-20. Default half-life values of HWP categories

HWP category	**Half-life in years**	**Fraction loss each year**
Sawn wood	35	0.0198
Wood-based panels	25	0.0289
Paper and paperboard	2	0.3466

Default aggregated conversion factors for each HWP category was employed from Table 2.8.1 (p. 2.122 of *2013 KP-Supplement*).

Table 11-21. Default conversion factors for the default HWP categories

HWP categories	**Density (oven dry mass over air dry volume) [Mg/m³]**	**Carbon fraction**	**C conversion factor (per air dry volume) [MgC/m³]**
Sawn wood	0.458	0.5	0.229
Wood-based panels	0.595	0.454	0.269
Paper and paperboard	0.9		0.368

Activity data used for carbon stock changes estimation in harvested wood products pool is presented in Table 11-22. Lithuania is using combined data sources for HWP pool evaluation - The Chronical of Lithuanian forests[237], Statistics Lithuania and, since 1995 - FAO Statistics database. Since Lithuania is using activity data from FAO databases for HWP accounting, therefore data on domestic HWP production, export and import is clearly distinguished (Table 11-22). Carbon stock change in harvested wood products pool and CO_2 emissions/removals are presented in Table 11-23.

Lithuania does not have sufficient activity data on HWP production resulting from deforestation activity, therefore all emissions/removals from HWP originating from forest land were calculated using first order decay function. Lithuania has estimated that emissions from HWP originating from deforestation areas could approximately contribute to only 0.2 percent of total emissions/removals from HWP originating from forest. Estimation was done using the amount of annual wood produced in country, obtained from FAO database, compared with average wood stored in stands per hectare multiplied by the area of deforestation.

[237] Lietuvos Respublikos Aplinkos Ministerija, Miškų departamentas. *Lietuvos miškų metraštis*. XX amžius. Vilnius, 2003

Table 11-22. Activity data used for carbon stock changes estimation in harvested wood products

Sawn-wood			Wood-based panels			Paper and Paperboard			Round wood			
Year	Production, m^3	Export, m^3	Year	Production, m^3	Export, m^3	Year	Production, tonnes	Export, tonnes	Year	Production, m^3	Import, m^3	Export, m^3
1960	885,000	0.00	**1960**	39,800	14,726	**1960**	83,000	51,457.0	**1960**	1,740,000	968,000	29,637.3
1965	1,044,000	0.00	**1965**	58,400	21,608	**1965**	114,000	70,675.9	**1965**	2,420,000	1,080,000	41,219.8
1970	1,313,000	0.00	**1970**	91,300	33,781	**1970**	159,000	98,574.3	**1970**	2,814,000	1,066,000	47,930.7
1975	1,098,000	0.00	**1975**	133,900	49,543	**1975**	240,000	148,791.4	**1975**	2,587,000	1,161,000	44,064.3
1980	855,000	0.00	**1980**	165,500	61,235	**1980**	235,000	145,691.6	**1980**	2,472,000	699,000	45,000.0
1985	934,000	0.00	**1985**	168,100	62,197	**1985**	265,000	164,290.5	**1985**	2,648,000	693,000	44,000.0
1990	775,800	0.00	**1990**	197,900	73,223	**1990**	217,600	134,904.2	**1990**	2,667,000	456,000	74,000.0
1991	664,000	0.00	**1991**	185,500	68,635	**1991**	214,500	132,982.3	**1991**	2,908,000	228,476	179,739.0
1995	940,000	767,200	**1995**	156,400	104,600	**1995**	28,900	19,400.0	**1995**	5,960,000	16,200	1,769,900.0
2000	1,300,000	823,040	**2000**	270,290	211,060	**2000**	52,630	37,100.0	**2000**	5,500,000	60,570	1,202,850.0
2005	1,445,000	912,547	**2005**	398,000	170,966	**2005**	113,000	87,140.0	**2005**	6,045,000	287,906	1,173,919.0
2010	1,272,000	555,388	**2010**	716,000	311,223	**2010**	129,229	123,233.0	**2010**	7,096,860	332,142	1,441,955.0
2011	1,260,000	583,623	**2011**	823,600	276,974	**2011**	156,518	132,661.0	**2011**	7,004,000	272,055	1,989,937.0
2012	1,150,000	620,459	**2012**	825,000	306,152	**2012**	118,000	125,774.0	**2012**	6,921,000	310,654	1,593,343.0
2013	1,120,000	634,247	**2013**	855,900	363,405	**2013**	136,700	111,704.0	**2013**	7,053,000	383,973	2,044,876.0
2014	1,345,302	735,437	**2014**	894,612	244,826	**2014**	139,519	121,901.0	**2014**	7,351,000	377,187	1,934,021.0
2015	1,379,000	829,000	**2015**	894,612	244,826	**2015**	139,519	121,901.0	**2015**	7,351,000	377,187	1,934,021.0

The Chronicle of Lithuania Forests. XX Century

Statistics Lithuania

FAO

Table 11-23. Annual change in carbon stock of HWP in use produced from domestic harvest

	$\Delta C_{HWP\ IU\ DH}$ Wood-Based Panels	$\Delta C_{HWP\ IU\ DH}$ Sawnwood	$\Delta C_{HWP\ IU\ DH}$ Paper & Paperboard	$\Delta C_{HWP\ IU\ DH}$ Total	**kt CO_2**
	kt C	**kt C**	**kt C**	**kt C**	**kt CO_2**
1990	27.72	36.95	-1.97	62.70	**-229.91**
1995	20.52	95.67	-13.95	102.24	**-374.88**
2000	45.26	159.99	-1.09	204.15	**-748.56**
2005	66.42	163.21	-0.55	229.07	**-839.92**
2010	133.77	114.25	-2.54	245.47	**-900.06**
2011	157.95	110.58	1.93	270.46	**-991.68**
2012	153.19	83.81	-3.55	233.45	**-855.97**
2013	153.09	71.64	1.10	225.83	**-828.04**
2014	159.89	119.55	-0.41	279.03	**-1,023.12**
2015	155.52	124.35	-0.29	279.58	**-1,025.12**

11.7 Other information

11.7.1 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 *2013 Revised Supplement* Table 3 (p. 2A.10).

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 11-24.

Table 11-24. Key categories in Article 3.3 and 3.4 activities

Key categories	**Gas**	**Criteria used for key category identification**	
Specify key categories according to the national level of disaggregation		**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	Yes
Afforestation and Reforestation	N_2O	Conversion to forest land	No

Deforestation	CH_4	Conversion to cropland, settlements and other land	No
Deforestation	CO_2	Conversion to cropland, settlements and other land	No
Deforestation	N_2O	Conversion to cropland, settlements and other land	No
Harvested Wood Products	CO_2	Harvested Wood Products	Yes

12 INFORMATION ON ACCOUNTING OF KYOTO UNITS

12.1 Background information

In accordance with Decision 15/CMP.1 paragraph 11 and adhering to the SEF guidelines, Parties included in Annex I are required to report from its national registry the information on unit holdings at the beginning and at the end of the reporting year as well as on transfers of units to and from registries of other Parties to the Kyoto Protocol. This information has to be reported in the Standard Electronic Format (SEF), which is an agreed format, embodied in a special report, for reporting on Kyoto units.

SEF reports for 2016 have been submitted to the UNFCCC Secretariat in electronic format:

- Information on Kyoto Protocol units for the first commitment period (CP1) for the reported year 2016 (see "RREG1_LT_2016_1_1);
- Information on Kyoto Protocol units for the second commitment period (CP2) for the reported year 2016 (see "RREG1_LT_2016_2_2).

12.2 Summary of information reported in the SEF tables

SEF reports for 2016 CP1 and 2016 CP2 include summarized information on the AAU, ERU, CER, t-CER, l-CER and RMU in the Lithuanian registry as well as information on transfers of the units in 2016 to and from other Parties of the Kyoto Protocol. Each of the report distinguishes between units belonging to CP1 and to CP2 period.

First commitment period units:

At the beginning and the end of 2016 the holdings in the Lithuanian registry per unit type remained the same and were as follows:

- a total of 169,078,667 **AAUs**: 71,822,887 in the Party holding accounts, 177,669 in the Article 3.3/3.4 net source cancellation accounts, 11,559 in other cancellation accounts and 97,066,552 in the Retirement account;
- a total of 5,805,602 **ERUs**: 633,399 in the Party holding accounts, 1,694,218 in the Entity holding accounts and 3,477,985 in the Retirement account;
- a total of 5,893,653 **RMUs** in the Retirement account;
- a total of 3,595,097 **CERs**: 229,828 in the Party holding accounts, 17,138 in the Entity holding accounts and 3,348,131 in the Retirement account.

During the year 2016, there were no internal and external transactions involving the Kyoto units. In addition, no corrective transactions relating to additions and subtractions, replacement or retirement took place either. The Lithuanian registry contained neither t-CERs nor l-CERs in any type of the account.

Full details on the accounting of Kyoto units are available in the CP1 SEF table.

Second commitment period units:

At the beginning of 2016 there were no holdings in the Lithuanian registry.

At the end of 2016 the holdings in the Lithuanian registry per unit type were as follows:

- a total of 2,327,000 **ERUs**: 633,399 in the Party holding accounts and 1,693,601 in the Entity holding accounts;

- a total of 246,966 **CERs**: 229,828 in the Party holding accounts and 17,138 in the Entity holding accounts.

During the year 2016, a total of 2,573,966 Kyoto units have been carried-over (2,327,000 ERUs, 246,966 CERs). However, no units were externally transferred to other national registries nor internally acquired involving.

Moreover, during the reporting year no transactions between PPSR accounts, no cancellations, replacements or retirements took place in the Lithuanian registry.

Full details on the accounting of Kyoto units are available in the CP2 SEF table.

12.3 Discrepancies and notifications

Referring to the respective paragraphs to Decision 15/CMP.1. and with regards to both CP1 and CP2 units, the following information is reported:

15/CMP.1. annex I.E paragraph 12 List of discrepant transactions	No discrepant transactions occurred in 2016.
15/CMP.1. annex I.E paragraph 13 and 14 List of CDM notifications	No CDM notifications were received by the National registry during the reporting period.
15/CMP.1. annex I.E paragraph 15 List of non-replacements	No non-replacements occurred in 2016.
15/CMP.1. annex I.E paragraph 16 List of invalid units	No invalid units were presented as at 31st December 2016.
15/CMP.1. annex I.E paragraph 17 Actions and changes to address discrepancies	No actions were taken or changes made to address discrepancies in 2016.

Therefore no relevant reports (R2, R3, R4, R5) have been included.

12.4 Publicly accessible information

All non-confidential information required to be publicly accessible by Section E of the annex II to Decision 13/CMP.1. is available on the Lithuanian Environmental Investment Fund website:

In Lithuanian: www.laaif.lt

In English: http://www.laaif.lt/en/public-information-about-eu-greenhouse-registry/

Public reports can be accessible at the ETS registry website: https://ets-registry.webgate.ec.europa.eu/euregistry/LT/public/reports/publicReports.xhtml

The reports include information on each account as required in paragraph 45 of the annex to Decision 13/CMP.1. Please note that publishing the contact information (paragraph 45 (d)(e)) is deemed as confidential according to Annex III and VIII (Table III-I and VIII-I) of Commission Regulation (EU) No 389/2013 and requires the consent of the account holder. The Lithuanian Environmental Investment Fund complies with the requirements stipulated in the EU legislation.

The complete documentation of the JI projects and ERUS issued as a result of the Article 6 project is presented and available in the following URL: http://www.laaif.lt/en/public-information-about-eu-greenhouse-registry/

Currently, there are no approved Joint Implementation projects in Lithuania.

Other information required to be publicly available can be found on the EUTL website: http://ec.europa.eu/environment/ets/

12.5 Calculation of the 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 7bis, 8 and 8bis, of the Kyoto Protocol, or 100 per cent of eight times its most recently reviewed inventory, whichever is lowest.

In the case of the Lithuania, the relevant size of the Commitment Period Reserve is 90 per cent of the Lithuania's assigned amount, which is calculated below:

113,600,821 x 90 % = 102,240,739 tonnes CO_2 eqv.

12.6 KP-LULUCF accounting

Not relevant for this submission.

13 INFORMATION ON CHANGES IN NATIONAL SYSTEM

No changes in national system had occurred during preparation of NIR for the period 1990-2015.

14 INFORMATION ON CHANGES IN NATIONAL REGISTRY

The following changes to the national registry of Lithuania have therefore occurred in 2016:

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	None
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	New tables were added to the CSEUR database for the implementation of the CP2 SEF functionality. Versions of the CSEUR released after 6.7.3 (the production version at the time of the last Chapter 14 submission) introduced other minor changes in the structure of the database. These changes were limited and only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan. The database model, including the new tables, is provided in Annex A. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Changes introduced since version 6.7.3 of the national registry are listed in Annex B. 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 completed in January 2017 and the test report is provided. 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	The mandatory use of hard tokens for authentication and signature was introduced for registry administrators.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No change to the list of publicly available information occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change of the registry internet address occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	Changes introduced since version 6.7.3 of the national registry are listed in Annex B. 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 January 2017 and the test report is provided.

Reporting Item	Description
1/CMP.8 paragraph 23 PPSR account	Since 16 November 2016 the Union Registry provides the technical possibility to open a PPSR account. However, prior to opening it, the PPSR account type must be first introduced into the EU legislative framework. This was done by the Annex of Commission Delegated Regulation 2015/1844. This provision, however, will become applicable, according to Article 2 of the Delegated Regulation, on "the date of publication by the Commission in the Official Journal of the European Union of a communication on the entry into force of the Doha Amendment to the Kyoto Protocol". Consequently, for the moment and until the Doha Amendment enters into force, we are not in a position to open the PPSR account in our National Registry.

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.

From 2014 the Ministry of Environment supports bilateral development cooperation projects in the field of climate change according to the *Law on Development Cooperation and Humanitarian Assistance* (approved by the Parliament) and *Directions for the Policy of Development Cooperation in 2014-2016* (approved by the Government).

In the end of 2016, the first bilateral development cooperation project by the Lithuanian company BOD group, producer of innovative solar cells, has been finished. During the project implementation two solar power plants (each 30 kW) were constructed in Perak State, Malaysia. Total project value amounts to 222.3 thous. EUR, the subsidy amount is 145 thous. EUR.

In 2016, the Ministry of Environment has finished the selection of projects submitted under the 2015 call. The support was granted to 2 projects in Moldova. Lithuanian company is planning to install 55 Kw power solar plant on the rooftop of the Government building in Kishinev. The total amount of the project is around 228 thous. EUR, subsidy amount is 140 thous. EUR. Another applicant is planning to install 4 biomass boilers in the public schools and kindergartens in the province of Moldova. The total project amount is 168 thous. EUR, subsidy amount is 98 thous. EUR. All the installed technologies will be of the Lithuanian origin.

In the beginning of 2016, the new call for the submission of new development cooperation projects was announced. The total subsidy amount for projects was 410 thous. EUR. The Ministry of Environment has received 3 applications, 2 applications were dismissed and one application has received funding. In the beginning of 2017, the Ministry of Environment is planning to sign an agreement with the Lithuanian company *Saulės grąža* to implement project in Georgia. The main goal of the project is to install solar power plants and heating systems in 6 public schools and kindergartens in Georgia, total value of the projects is approx. 317 thous. EUR, subsidy amount is approx. 191 thous. EUR.

In 2016 the Ministry of Environment has signed a Contribution Agreement with the Green Climate Fund and paid 100 thous. EUR contribution to the Green Climate Fund.

In 2016 Lithuania has contributed 50 thous. EUR to the EIB's Eastern Partnership TA Trust Fund, which directs a large part of its funds towards the Climate Action (approx. 70% of the fund are directed for climate-related purposes).

The table below summarizes the data on international climate finance provided by Lithuania in 2016:

Thous. EUR	Type of support	Recipient of support	Provider of support
100	multilateral	Green Climate Fund	Ministry of Environment
317*	bilateral	Development cooperation projects	Ministry of Environment
50	multilateral	EPTATF - Eastern Partnership Technical Assistance Trust Fund, administered by the European Investment Bank	Ministry of Finance

* planned total project value, including beneficiary's own contribution (disbursement in 2017-2018)

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