LATVIA'S
NATIONAL INVENTORY REPORT

Greenhouse Gas Emissions in Latvia from 1990 to 2020 in Common Reporting Formats (CRF)

Riga, 2022

PREFACE

Latvia's National Inventory Report (NIR) under the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol and Article 58 of Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council contains following parts:

1. Latvia's National Inventory Report is prepared using the reporting guidelines of UNFCCC (adopted by decision 24/CP.19) and relevant parts of the Guidelines for the preparation of the information required under Article 7 of the Kyoto Protocol;
2. CRF (Common Reporting Format) data tables for years 1990-2020 including KP-LULUCF data tables. CRF tables are compiled with the UNFCCC CRF Reporter software (version v6.0.8);
3. SEF (Standard Electronic Tables) for reporting of Kyoto units (AAU, ERU, CER, t-CER, l-CER, RMU) in the registry.

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UNITS AND ABBREVIATIONS

t	1 tonne (metric) = 1 megagram (Mg) = 10^6 g
Mg	1 megagram = 1 tonne (t) = 10^6 g
kt	1 gigagram = 1 kilotonne (kt) = 10^9 g
Tg	1 teragram = 1 megatonne (Mt) = 10^{12} g
TJ	1 terajoule = 1000 gigajoule = 10^{12} J
PJ	1 petajoule = 1000 terajoule = 10^{15} J

AAU – Assigned Amount Units
AR – Afforestation and reforestation
AWMS - Animal waste management systems
CER – Certified Emission Reduction Units
CH_4 – Methane
CIS – Commonwealth of Independent States
CLRTAP - Convention on Long-Range Transboundary Air Pollution
CO_2 – Carbon dioxide
CO_2 eq. – Carbon dioxide equivalent
CO – Carbon monoxide
CR – Corinair emission factor
CRF – Common Reporting Format
CS – Country specific
CSB – Central Statistical Bureau
CSC - Carbon stock change
D – Default emission factor
d.m. – Dry matter
EMEP/CORINAIR 2007 – Atmospheric emission inventory guidebook, Co-operative Programme for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe, The Core inventory of air emissions in Europe
EMEP/EEA 2016 - EMEP/EEA air pollutant emission inventory guidebook 2016
EMEP/EEA 2019 - EMEP/EEA air pollutant emission inventory guidebook 2019
ESD – Effort Sharing Decision
EU – European Union
EU ETS – European Union Emission Trading Scheme
EU MMR – European Union Monitoring Mechanism Regulation
ERT – Expert review team
ERU – Emission Reduction Units
ETR – Emission trading registry
GHG – Greenhouse Gases
GDP – Gross domestic product
HDD – Heating degree days
HFC – Hydrofluorocarbon
HWP – Harvested wood products
FM – Forest management
FMRL – Forest Management Reference Level
IE – Included elsewhere
IPCC – Intergovernmental Panel on Climate Change
IPCC 1996 – Revised 1996 IPCC Guidelines for National Greenhouse gas Inventories (1997)

IPCC GPG 2000 - IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000)
2006 IPCC Guidelines – 2006 IPCC Guidelines for National Greenhouse Gas Inventories
IPCC Wetlands Supplement - 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands
2013 IPCC Kyoto Protocol Supplement - 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol
IPE – Institute of Physical Energetics
IPPC - Integrated Pollution Prevention Control
l-CER – Long term Certified Emission Reduction Unit
LEGMC – Latvian Environment, Geology and Meteorology Centre
LSIAE – Latvian State Institute of Agrarian Economics
LULUCF – Land Use, Land Use Change and Forestry
LULST - Latvia University of Life Sciences and Technologies
MCF – Methane conversion factor
MoA - Ministry of Agriculture of the Republic of Latvia
MoE – Ministry of Economic of the Republic of Latvia
MoT - Ministry of Transport of the Republic of Latvia
MEPRD - Ministry of Environmental Protection and Regional Development of the Republic of Latvia
MoT - Ministry of Transport
MMS – Manure management system
NFI – National forest inventory
NF_3 – Nitrogen trifluoride
N_2O – Nitrous oxide
NO_x – Nitrogen oxides
NA – Not applicable
NCV – Net calorific value
NE – Not estimated
NIR – National inventory report
NMVOC - Non-methane volatile organic compounds
NO – Not occuring in Latvia
OECD - Organisation for Economic Co-operation and Development
PFC – Perfluorocarbon
QA/QC – Quality assurance and Quality control
REB – Regional Environment Boards
RMU – Removal Units
RTSD – Road Traffic Safety Department
SAM – State Agency of Medicines of the Republic of Latvia
SEF – Standart Electronic Format
SFRS – State Fire and Rescue Service of Latvia
SFS – State Forest Service
SF_6 – Sulphur hexafluoride
SNAP - Selected Nomenclature for Air Pollution
SO_2 – Sulphur dioxide
UN – United Nations
UNFCCC – United Nations Framework Convention on Climate Change

UNECE CLRTAP - United Nations Economic Commission for Europe's Convention on Long-Range Transboundary Air Pollution
TERT – Technical expert review team
t-CER – Temporary Certified Emission Reduction units

EXECUTIVE SUMMARY

ES.1 BACKGROUND INFORMATION ON GHG INVENTORIES AND CLIMATE CHANGE

ES.1.1 Background information on climate change

The analysis of long-term climatological data series in Latvia has shown that the climate has changed during the last centuries. Air temperature has increased for the whole period of observations (from the 1795); however it has been more visible during winter and spring for the last decades. Increasing trends are evident in precipitation series for the cold period, while decreasing trends were found for summer and autumn seasons. Ice and snow cover period in Latvia has become shorter during last decades. River discharge regime has been subjected to major changes in relation to climate change. Well observed regular changes of high-water and low-water periods are evident. Seasonality indices have changed: the number of days with high temperatures is increasing, especially from the beginning of the 20th century, number of frost days is decreasing, heating degree-days are reducing.

ES 1.2 Background information on greenhouse gas inventories

Latvia participates in the international climate change process and together with many other countries have signed the United Nations Framework Convention on Climate Change in Rio de Janeiro at the UN Conference on Environment and Development held in 1992. It entered into force on 21 March 1994. The Parliament of the Republic of Latvia (Saeima) ratified the UNFCCC on February 23, 1995. On May 30, 2002 the Parliament ratified the Kyoto Protocol. Latvia has also ratified the Doha Amendment to the Kyoto Protocol. The Parliament ratified the landmark Paris Agreement on climate change on February 2, 2017.

Latvia is a member of the European Union since May, 2004 and therefore it has reporting obligations under the Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council (EU Governance regulation). This regulation comprises reporting to fulfil the Decision No 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020 (EU Effort Sharing Decision 406/2009/EC) and the Decision No 529/2013/EU of the European Parliament and of the Council of 21 May 2013 on accounting rules on greenhouse gas emissions and removals resulting from activities relating to land use, land-use change and forestry, and on information concerning actions relating to those activities (EU LULUCF Decision (529/2013/EU). Commission Implementing Regulation 2020/1208 of 7 August, 2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) No 749/2014 determine implementation of the Regulation (EU) 2018/1999.

Under the above mentioned agreements Latvia is required to provide information annually on anthropogenic greenhouse gas emissions by sources and removals by sinks of all GHG not controlled by the Montreal Protocol from the following sectors: Energy, Industrial Processes and Product Use, Agriculture, Land Use, Land Use Change and Forestry, and Waste.

The annual GHG inventory contains information on trends of the national GHG emissions by sources and removals by sinks since 1990. This information is essential for monitoring and planning of climate policy.

ES 1.3 Background information on supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol

Latvia, as an Annex I Party that is also Party of the Kyoto Protocol, is required to report supplementary information in accordance with the Article 7, paragraph 1, of the Kyoto Protocol. The required information is specified in the Annex of Decision 15/CMP.1.

For the second commitment period of the Kyoto Protocol (agreement under the Article 4 of the Kyoto Protocol) until 2020, the European Union and its Member States, and Iceland, have agreed to achieve jointly their quantified emission limitation and reduction commitment (QELRC) by 20% compared to emissions in the base year, or period during the 2013-2020. The efforts of the reduction (reduction targets) are shared out as follows:

- 21% reduction compared to 2005 level for the emissions from sectors covered by the European Union Emission Trading Scheme (EU ETS); this goal is EU-wide and defines that all EU ETS operators jointly reduce the total GHG emissions;
- around 10% reduction compared to 2005 for other emitters (sectors and activities not included in the EU ETS that are regulated by Effort Sharing Decision (ESD)). Member States have taken on binding annual targets for reducing their GHG emissions from the sectors not covered by the EU ETS, such as housing, agriculture, waste and transport (excluding aviation). The national targets, covering the period 2013-2020, are differentiated according to Member States relative wealth (measured by Gross Domestic Product per capita). In accordance with the ESD (406/2009/EC) Latvia's national target is to limit emission growth to +17% above the 2005 level by 2020.

Latvia`s non-ETS emissions are calculated taking into account total national GHG emissions without LULUCF, including indirect CO_2 emissions minus the national verified emissions of installations in the EU Emission trading system. The quantity of CO_2 emissions of the inventory category '1.A.3a civil aviation' are not taken into account (considered equal to zero) when determining the annual non-ETS emissions, as these emissions are covered by the EU emissions trading scheme for aviation.

Latvia's total national GHG emissions without LULUCF with indirect CO_2 were 10459.72 kt CO_2 eq. in 2020 and 10458.24 kt CO_2 eq. without CO_2 emissions from civil aviation (1.A.3a). In 2020 Latvia`s verified ETS emissions were 2021.99 kt $CO_2$ eq. According to that Latvia`s non-ETS emissions in 2020 were 8436.25 kt CO_2 eq., that made up 80.7% from the total GHG emissions excluding LULUCF and including indirect CO_2.

Allocated emission level of Latvia for the period 2013-2020 set out in terms of the joint fulfilment for the second commitment period under the Kyoto Protocol is 76 633 439 tonnes carbon dioxide equivalent (Assigned amount). The agreement and the respective emission levels allocated to each of the members to the agreement have been described in detail in the EU's and Latvia's reports to facilitate the calculation of the assigned amount for the second commitment period of the Kyoto Protocol[1]. In addition to non-ETS emissions Latvia is responsible for the emissions/removals related to the Kyoto Protocol LULUCF activities according to decision 2/CMP.7.

According to the Regulation No. 737 of Cabinet of Ministers (12.12.2017) Ministry of Environmental Protection and Regional Development (MEPRD) is the single national entity with the overall responsibility for Latvia's GHG inventory. The main institutions involved in the compilation of Latvia's GHG inventory are the MEPRD, Latvian Environment, Geology and Meteorology Centre, Latvian State Forest Research Institute "Silava", Latvia University of Life Sciences and Technologies, Institute of Physical Energetics. Description of the national GHG inventory system including the institutional arrangements is provided in Section 1.2.

Part II of this report includes information related to Article 3, paragraph 3 (Afforestation, Reforestation, Deforestation) and paragraph 4 (Forest Management) of the Kioto Protocol in Chapter 11, and information related to Article 3, paragraph 14 (information on minimization of adverse impacts of climate change) in Chapter 15 of information on minimization of adverse impacts in accordance with Article 3, paragraph 14.

A summary information on accounting of Kyoto units is presented in Chapter 12. Information related to changes in national system and in the national registry is provided in Chapter 13 and Chapter 14.

ES.2 SUMMARY OF NATIONAL EMISSION AND REMOVAL-RELATED TRENDS

ES.2.1 GHG inventory

In 2020, Latvia's GHG emissions constituted 10459.72 kt CO_2 eq. (including indirect CO_2, without LULUCF) and 11106.30 kt CO_2 eq. (including indirect CO_2, with LULUCF). Latvia's total GHG emissions including indirect CO_2, without LULUCF showed the decrease of 59.63% comparing to base year, but GHG emissions including indirect CO_2, with LULUCF have decreased by 18.38% compared to base year.

Compared to 2019, total GHG emissions including indirect CO_2, without LULUCF have decreased by 5.91%, then including indirect CO_2, with LULUCF GHG emissions have increased by 27.51%, mostly due to a decrease in CO_2 removals in living biomass in forest lands. Fluctuations in total GHG emissions during last years (e.g. peak in 2014 and 2017) mostly are associated with annual changes in CO_2 removals in living biomass in forest land caused by changes in forest characteristics and related management (gross annual increment of living biomass, natural mortality, harvesting rate, etc.) (Figure ES.1).

[1] *Reports to facilitate the calculation of the assigned amount ('initial reports') for the second commitment period (2013–2020). Available: https://unfccc.int/process/transparency-and-reporting/reporting-and-review-under-the-kyoto-protocol/second-commitment-period/initial-reports*

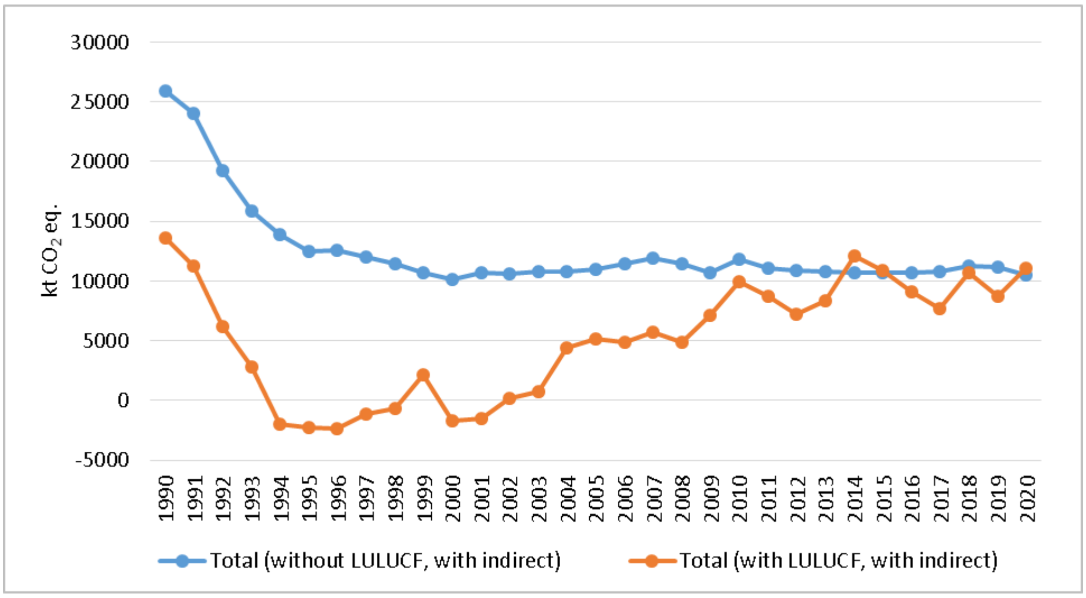

Figure ES.1 Latvia`s total GHG emissions (with and without LULUCF) 1990–2020 (kt CO_2 eq.)

Aggregated GHG emissions 1990-2020, kt CO_2 eq. by gases are reflected in Table ES.1 a and Table ES.1 b and by sectors reflected in Table ES.2 a and Table ES.2 b.

Table ES.1 a Aggregated GHG emissions by gases (1990 - 2010) (kt CO_2 eq.)

GHG EMISSIONS	1990 (base year)	1995	2000	2005	2006	2007	2008	2009	2010
kt CO_2 eq.									
CO_2 emissions excluding net CO_2 from LULUCF	19661.40	9133.78	7081.47	7810.47	8309.83	8637.10	8197.89	7456.01	8554.09
CO_2 emissions including net CO_2 from LULUCF	6259.44	-6741.08	-5815.80	892.17	583.19	1357.88	530.74	2692.01	5557.43
CH_4 emissions excluding CH_4 from LULUCF	3623.78	2179.95	1885.83	1870.14	1823.41	1868.53	1855.33	1872.33	1805.89
CH_4 emissions including CH_4 from LULUCF	4178.85	2736.88	2449.24	2379.40	2374.80	2378.51	2365.16	2397.18	2335.87
N_2O emissions excluding N_2O from LULUCF	2583.07	1117.44	1026.99	1138.28	1139.44	1189.91	1166.62	1191.00	1220.54
N_2O emissions including N_2O from LULUCF	3129.12	1689.38	1606.67	1716.94	1726.06	1770.74	1748.12	1774.03	1807.71
HFCs	NO,NA	17.13	64.60	105.20	132.80	154.49	178.32	188.60	214.05
PFCs	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
Unspecified mix of HFCs and PFCs	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
SF_6	NO,NA	0.17	0.88	3.78	4.07	4.55	5.23	7.33	7.35
NF_3	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
Total (without LULUCF)	25868.25	12448.48	10059.78	10927.87	11409.54	11854.58	11403.40	10715.26	11801.93
Total (with LULUCF)	13567.40	-2297.51	-1694.41	5097.49	4820.91	5666.17	4827.58	7059.14	9922.42
Total (without LULUCF, with indirect)	25908.66	12480.51	10084.56	10949.22	11426.12	11872.88	11421.27	10732.18	11818.20
Total (with LULUCF, with indirect)	13607.81	-2265.48	-1669.63	5118.83	4837.49	5684.47	4845.45	7076.07	9938.69

Table ES.1 b Aggregated GHG emissions by gases (2011 - 2020) (kt CO_2 eq.)

GHG EMISSIONS	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from 1990 to latest reported year (%)
	kt CO_2 eq.										
CO_2 emissions excluding net CO_2 from LULUCF	*7810.79*	*7519.41*	*7368.44*	*7171.96*	*7262.10*	*7210.32*	*7214.95*	*7859.36*	*7648.67*	*6994.11*	*-64.43*
CO_2 emissions including net CO_2 from LULUCF	*4401.83*	*2731.58*	*3830.10*	*7436.04*	*6216.77*	*4280.56*	*2784.86*	*5864.89*	*3844.95*	*6235.31*	*-0.39*
CH_4 emissions excluding CH_4 from LULUCF	*1755.17*	*1798.84*	*1821.78*	*1868.48*	*1772.69*	*1795.90*	*1826.73*	*1742.30*	*1743.03*	*1718.06*	*-52.59*
CH_4 emissions including CH_4 from LULUCF	*2294.52*	*2349.71*	*2386.75*	*2473.92*	*2412.01*	*2472.15*	*2541.12*	*2532.84*	*2518.54*	*2500.35*	*-40.17*
N_2O emissions excluding N_2O from LULUCF	*1221.39*	*1288.45*	*1314.00*	*1355.13*	*1403.93*	*1402.18*	*1413.41*	*1359.75*	*1443.00*	*1473.61*	*-42.95*
N_2O emissions including N_2O from LULUCF	*1806.83*	*1878.84*	*1909.59*	*1942.07*	*1999.44*	*2006.64*	*2026.92*	*1986.78*	*2065.33*	*2096.69*	*-32.99*
HFCs	*215.86*	*216.01*	*229.53*	*243.65*	*254.52*	*275.02*	*267.87*	*263.09*	*255.11*	*248.91*	*100.00*
PFCs	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*0.00*
Unspecified mix of HFCs and PFCs	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*0.00*
SF_6	*7.47*	*7.78*	*8.50*	*8.58*	*10.12*	*9.89*	*10.32*	*10.54*	*13.82*	*11.94*	*100.00*
NF_3	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*0.00*
Total (without LULUCF)	*11010.68*	*10830.48*	*10742.25*	*10647.80*	*10703.36*	*10693.31*	*10733.28*	*11235.04*	*11103.63*	*10446.63*	*-59.62*
Total (with LULUCF)	*8726.50*	*7183.91*	*8364.47*	*12104.26*	*10892.85*	*9044.26*	*7631.09*	*10658.15*	*8697.75*	*11093.20*	*-18.24*
Total (without LULUCF, with indirect)	*11021.60*	*10843.10*	*10757.75*	*10668.38*	*10720.39*	*10711.08*	*10752.40*	*11246.84*	*11116.30*	*10459.72*	*-59.63*
Total (with LULUCF, with indirect)	*8737.42*	*7196.52*	*8379.97*	*12124.84*	*10909.89*	*9062.02*	*7650.22*	*10669.95*	*8710.42*	*11106.30*	*-18.38*

Table ES.2 a Aggregated GHG emissions by sectors (1990 - 2010) (kt CO_2 eq.)

GHG emissions	1990	1995	2000	2005	2006	2007	2008	2009	2010
kt CO_2 eq.									
1. Energy	*19494.38*	*9578.59*	*7397.85*	*8137.43*	*8571.57*	*8905.96*	*8444.76*	*7733.32*	*8508.00*
2. IPPU	*655.98*	*227.13*	*286.55*	*371.16*	*423.70*	*445.50*	*457.00*	*455.93*	*749.44*
3. Agriculture	*4985.80*	*2004.23*	*1678.46*	*1793.20*	*1792.71*	*1874.63*	*1837.59*	*1859.29*	*1878.76*
4. LULUCF	*-12300.85*	*-14745.99*	*-11754.19*	*-5830.39*	*-6588.63*	*-6188.41*	*-6575.82*	*-3656.12*	*-1879.51*
5. Waste	*732.09*	*638.53*	*696.91*	*626.08*	*621.56*	*628.49*	*664.04*	*666.71*	*665.73*
6. Other	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
Total emissions (including LULUCF)	*13567.40*	*-2297.51*	*-1694.41*	*5097.49*	*4820.91*	*5666.17*	*4827.58*	*7059.14*	*9922.42*

Table ES.2 b Aggregated GHG emissions by sectors (2011 - 2020) (kt CO_2 eq.)

GHG emissions	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Change from 1990 to latest reported year (%)
kt CO_2 eq.											
1. Energy	*7638.44*	*7322.10*	*7244.12*	*7066.82*	*7178.05*	*7249.80*	*7234.47*	*7686.97*	*7458.18*	*6780.35*	*-65.22*
2. IPPU	*846.92*	*905.11*	*848.75*	*863.37*	*791.23*	*690.99*	*768.38*	*893.97*	*891.77*	*868.15*	*32.34*
3.Agriculture	*1890.81*	*1974.19*	*2032.98*	*2109.78*	*2158.16*	*2166.93*	*2179.77*	*2096.21*	*2201.39*	*2250.88*	*-54.85*
4. LULUCF	*-2284.18*	*-3646.58*	*-2377.78*	*1456.45*	*189.49*	*-1649.05*	*-3102.18*	*-576.89*	*-2405.88*	*646.57*	*-105.26*
5. Waste	*634.51*	*629.07*	*616.41*	*607.84*	*575.91*	*585.60*	*550.66*	*557.90*	*552.29*	*547.25*	*-25.25*
6. Other	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*0.00*
Total emissions (including LULUCF)	*8726.50*	*7183.91*	*8364.47*	*12104.26*	*10892.85*	*9044.26*	*7631.09*	*10658.15*	*8697.75*	*11093.20*	*-18.24*

ES.2.2 KP-LULUCF activities

For the LULUCF activities under the Article 3 paragraphs 3 and 4, of the Kyoto Protocol, Latvia has chosen accounting at the end of the period. Therefore, the reported accounting quantity calculated over the entire commitment period in this submission is the last one under the Kyoto Protocol. Reporting and accounting of LULUCF activities during the second commitment period (2013 to 2020) of the Kyoto Protocol, have been addressed in detail in Latvia`s report to facilitate the calculation of the assigned amount and Chapter 11 of this report.

The Article 3.3 covers human induced afforestation (A), reforestation (R) and deforestation (D) activities, that must be accounted mandatory. Under the Article 3.4 Latvia is accounting Forest Management (FM) in the second commitment period. According to appendix to the annex to decision 2/CMP.7[2] Latvia's FM reference level (FMRL) for the second commitment period is -16302 kt CO_2 eq. a year, including HWP, and -14255 kt CO_2 eq. a year, assuming instantaneous oxidation of HWP. For 2022 submission Latvia has made the technical correction to the FMRL that is 14829.11 kt CO_2 eq.; respectively FMRL after the corrections (FMRLcorr) is -1472.89 kt CO_2 eq.

The emissions/removals from ARD are added to or subtracted from the assigned amount in full, whereas the net emissions/removals from FM are subtracted from the FMRL before the corresponding addition/subtraction. Also, additions to the assigned amount resulting from FM shall not exceed 3.5% of the base year emissions times eight (FM cap). The FM cap value is 7394.54 kt CO_2 eq. and applies for the whole commitment period.

Summary table on accounting for activities under the Articles 3.3 and 3.4 of the Kyoto Protocol is shown in the Table ES.3.

Table ES.3 Emissions and removals for activities under Articles 3.3 and 3.4 of the Kyoto Protocol

GHG source and sink activities	Net emissions/removals									Accounting parameters	Accounting Quantity*
	2013	2014	2015	2016	2017	2018	2019	2020	Total		
	kt CO_2 eq.										
A. Article 3.3 activities											
A.1. Afforestation and Reforestation	*-179.80*	*-194.12*	*-208.55*	*-222.75*	*-240.68*	*-254.55*	*-273.17*	*-293.25*	*-1866.87*		*-1866.87*
Excluded emissions from natural disturbances	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*		*NA*
Excluded subsequent removals from land subject to natural disturbances	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*		*NA*
A.2. Deforestation	*1066.40*	*820.24*	*850.57*	*880.85*	*911.24*	*941.29*	*1118.63*	*1150.67*	*7739.90*		*7739.90*
B. Article 3.4 activities											
B.1. Forest management									*-22100.42*		*-10317.30*

[2] *Decision 2/CMP.7. Available: http://unfccc.int/resource/docs/2011/cmp7/eng/10a01.pdf*

GHG source and sink activities	Net emissions/removals									Accounting parameters	Accounting Quantity*
	2013	2014	2015	2016	2017	2018	2019	2020	Total		
	kt CO_2 eq.										
Net emissions/removals	*-6624.96*	*-938.46*	*-2723.06*	*-1826.03*	*-3064.03*	*-2295.19*	*-3069.94*	*-1558.75*	*-22100.42*		
Excluded emissions from natural disturbances	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*		*NA*
Excluded subsequent removals from land subject to natural disturbances	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*		*NA*
Any debits from newly established forest (CEF-ne)	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*		*NA*
Forest management reference level (FMRL)										*-16302.00*	
Technical corrections to FMRL										*14829.11*	
Forest management cap[3]										*7394.54*	*7394.54*
B.2. Cropland management	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*		*NA*
B.3. Grazing land management	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*		*NA*
B.4. Revegetation	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*		*NO,NA*
B.5. Wetland drainage and rewetting	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*		*NA*

 # The accounting quantity is the total quantity of units to be added to or subtracted from a Party's assigned amount for a particular activity in accordance with the provisions of Article 7.4 of the Kyoto Protocol.

The main factors resulting in difference in net emissions between reporting of FM during the second commitment period (2013 to 2020) of the Kyoto Protocol and the FMRL are summarized in the Table ES.4.

[3] FM cap is calculated in accordance with paragraph 13 of the annex to decision 2/CMP.7, 3.5% of the national total emissions including indirect CO_2, excluding LULUCF in the base year times eight.

Table ES.4 The main factors resulting in difference in net emissions between reporting of FM during the second commitment period (2013 to 2020) of the Kyoto Protocol and the FMRL

Parameter	Average values for the 2nd commitment period of the Kyoto Protocol (2013-2020)	
	Projected values of the FMRL	Actual values used for net emissions reporting of FM
Gross increment of biomass, $m^3\ ha^{-1}\ yr^{-1}$	*7.78*	*8.04*
Natural mortality, $m^3\ ha^{-1}\ yr^{-1}$	*2.28*	*2.03*
Harvesting stock (total excluding deforestation), 1000 $m^3\ yr^{-1}$	*16153.70*	*16844.31*

ES.3 OVERVIEW OF SOURCE AND SINK CATEGORY EMISSION ESTIMATES AND TRENDS

ES.3.1 GHG inventory

The main sources of GHG emissions are divided into the following sectors (according to Decision 24/CP.19): Energy (CRF 1), Industrial processes and Product Use (IPPU) (CRF 2), Agriculture (CRF 3), Land use, Land use change and Forestry (LULUCF) (CRF 4) and Waste (CRF 5). GHG emissions by sectors are displayed in Figure ES.2.

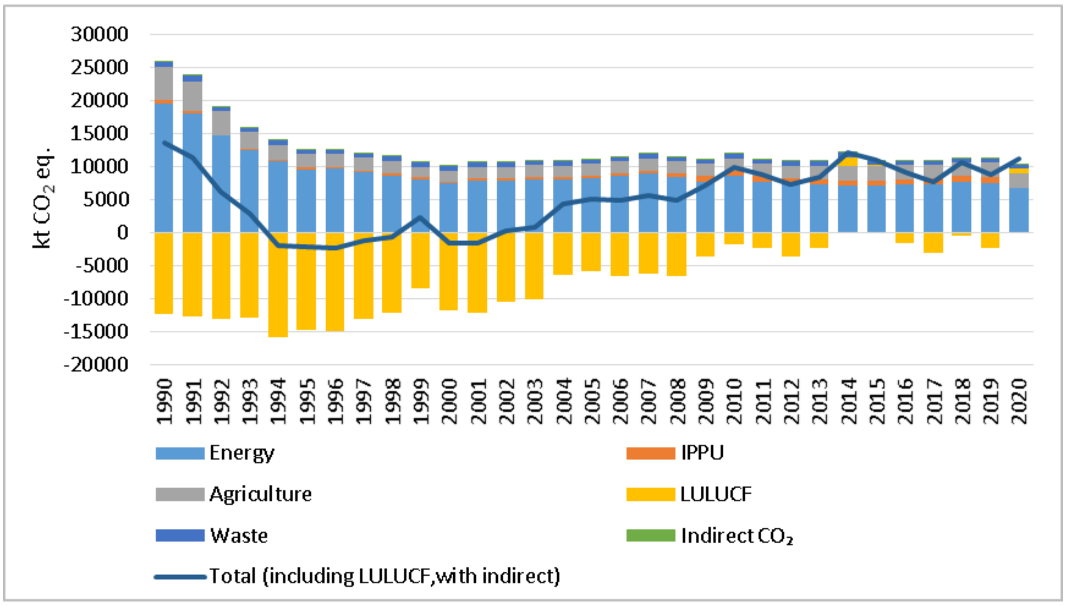

Figure ES.2 Latvia`s GHG emissions and removals by sectors 1990-2020 (kt CO_2 eq.)

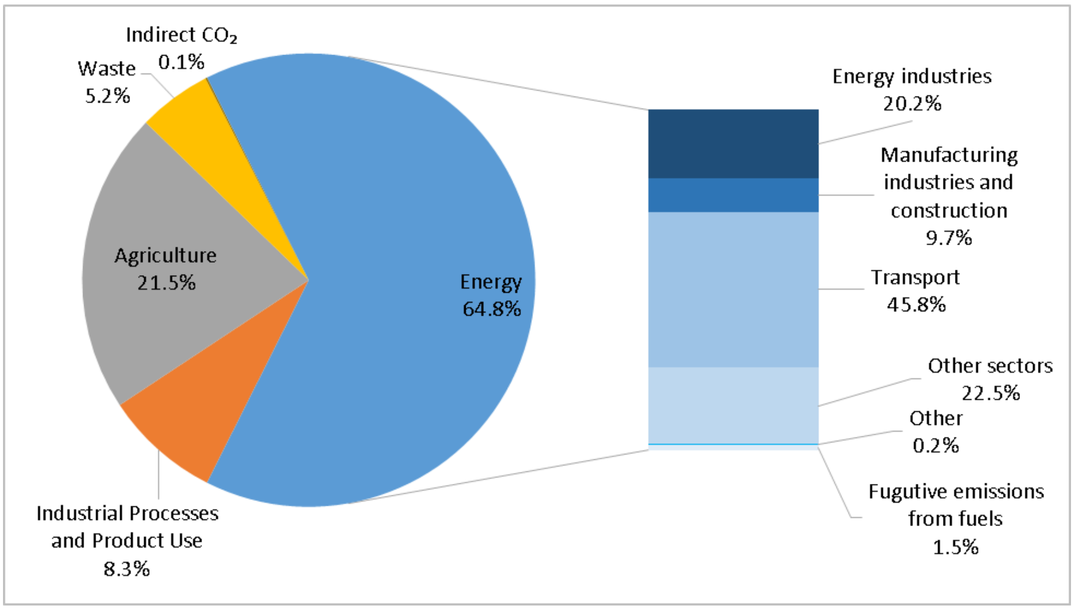

Figure ES.3 The composition of Latvian GHG emissions in 2020 (including indirect CO_2, excluding LULUCF)

The **Energy sector** is the most significant source of GHG emissions with a 64.8% share of the total emissions in 2020 (Figure ES.3). GHG emissions fluctuate in the latest years mainly due to economic trends, the energy supply structure and climate conditions. Total emissions in Energy sector in 2020 decreased by 65.2% if compared to the base year and by 9.1% if compared with previous year. In 2020, large part of the Energy sector emissions are emitted in the Transport sector (45.8%), Other Sectors (22.5%) and Energy Industries (20.2%).

Agriculture is the second most significant source of GHG emissions in 2020, with 21.5% of Latvia's total GHG emissions excluding LULUCF. Emissions from agriculture include CH_4 and N_2O emissions from enteric fermentation, manure management and agricultural soils, and CO_2 emissions from liming and urea application. In 2020, GHG emissions increased by 2.2% compared to 2019 due to the increase of livestock productivity and fertilizer use for crops. The annual emissions have reduced approximately by 54.9% since 1990 due to decrease in agricultural production. In 2020, given in kt CO_2 eq., N_2O contributed 54.9%, CH_4 contributed 41.9% of total GHG emission from the Agriculture sector, remaining 3.2% refer to CO_2 emissions from liming and urea application.

Emissions from **IPPU sector** (referred to as non-energy related ones) include CO_2, CH_4, N_2O and F-gases (HFCs and SF_6). The category constitutes 8.3% of the total GHG emissions excluding LULUCF in 2020. Compared to 1990 emissions from IPPU increased by 32.3%, but compared to 2019 emissions decreased by 2.6%.

The largest decrease in IPPU sector emissions occurred between 1991 and 1993, when industry was affected by a crisis. Emission fluctuations in product use sectors are also linked to the economic situation of the country. In the last years emissions fluctuated due to activity in industrial production processes and F-gases.

F-gases emissions from 2.F Product use as substitutes for ozone depleting substances (ODS) constitute 2.4% from total GHG emissions, including indirect CO_2, excluding LULUCF in 2020. Emissions from HFC and SF_6 have grown significantly since 1995 by 1407.7%. Compared to 2019 total F-gas emissions (including SF_6) decreased by 3.0%.

In 2020, NMVOC emissions from the Solvent Use sector decreased by 5.0%, compared to 2019. Solvent Use sector was a significant NMVOC emission source and covered 33.0% (11.09 kt) from total Latvia's NMVOC emissions.

In 2020, emissions from the **Waste sector** were 547.25 kt CO_2 eq. contributing about 5.2% of total GHG emissions (excluding LULUCF, including indirect CO_2). Solid waste disposal and wastewater handling are the main sources of GHG emissions in Waste sector producing accordingly 69.3% and 19.1% of all sector emissions. Incineration and Biological treatment of solid waste together contributes only 11.6% of GHG emissions from Waste sector in 2020. GHG emissions from Waste sector have been fluctuated from 1990-2020. Compared to 1990, emissions from Waste sector decreased by 25.2% but compared to 2019 emissions decreased by 0.9%.

Net GHG emissions from **LULUCF** in 2020 were 646.57 kt CO_2 eq. compared to -12300.85 kt CO_2 eq in the base year (1990). Change from base to the latest reported year of emissions/removals from LULUCF constitutes - 105%. This decrease of removals from LULUCF sector is associated with the increase of harvesting stock, and the increase of natural mortality due to ageing of forest stands and reduction of increment in mature forests. Increase of the GHG emissions in 1999 is associated with significant increase of harvesting stock in forest lands due to favourable economic conditions, but increase of the GHG emissions in 2014 is cumulative result of increase of the harvest rate, higher mortality rate and reduction of increment of living biomass in forest lands according to the National forest inventory (NFI) data.

Indirect CO_2 emission sources in Latvia are NMVOC emissions from the road traffic evaporation - cars, CH_4 and NMVOC emissions from natural gas leakages, as well as NMVOC emissions from gasoline distribution that are reported separately under the Energy sector in CRF Table 6. Together they constitute 13.10 kt CO_2 eq. that is 0.1% from Latvia`s total GHG emissions without LULUCF, with indirect CO_2 in 2020.

ES.4 OVERVIEW OF EMISSION ESTIMATES AND TRENDS OF PRECURSORS AND SULPHUR OXIDES

Emissions trends of precursors are presented in Figure ES.4.

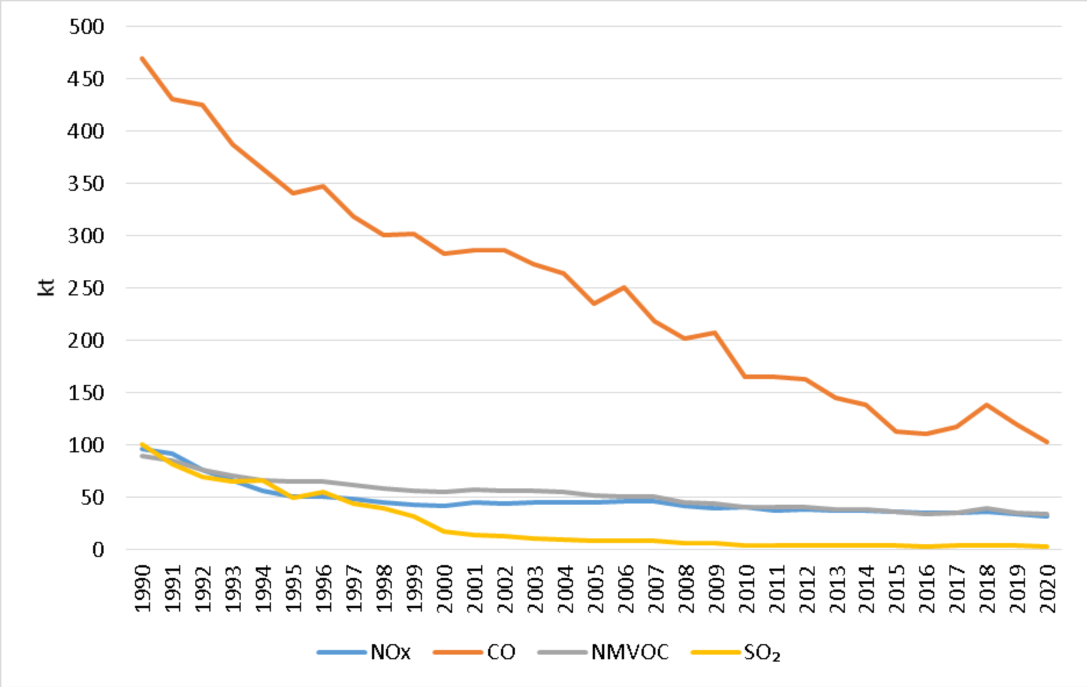

Figure ES 4. Precursors and sulphur dioxide emissions (kt)

In the period from 1990 to 2020 precursors have decreased: NO_x by 66.7%, CO by 78.1%, NMVOC by 62.4% and SO_2 by 96.5%.

Starting from 2001, fluctuations in NO_x, NMVOC and CO emissions can be observed as a reason of increasing firewood consumption in Residential sector as well as fuel consumption in Transport sector in particular years. SO_2 emissions decreased significantly because of fuel switch and approved legislation.

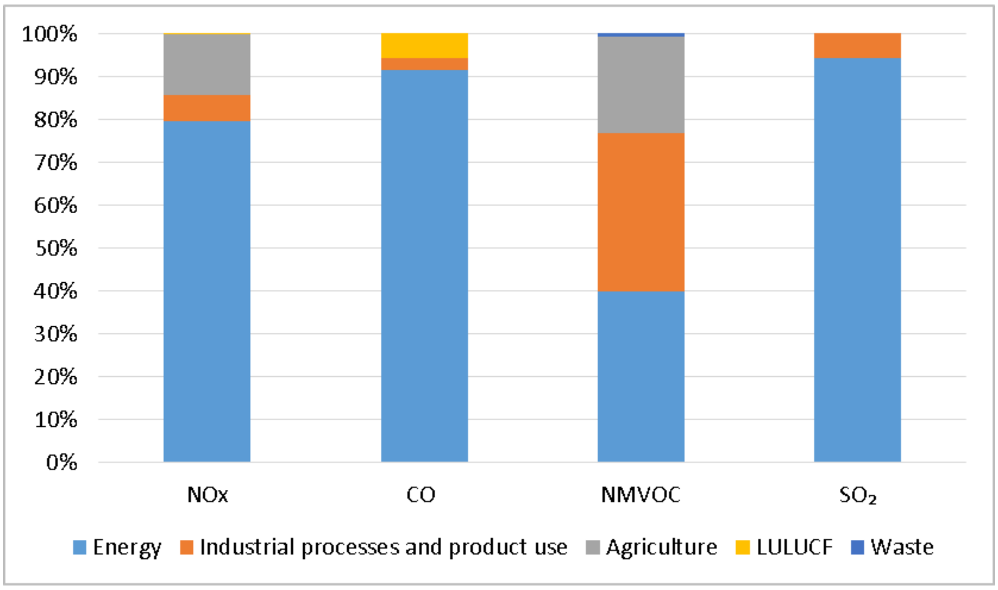

Figure ES.5. Emissions of precursors by sector in 2020 (% of total precursors and sulphur oxides in sector)

In 2020, the most important sector producing precursors (including LULUCF) was Energy sector (including fugitive emissions). Fuel combustion in Energy sector causes the largest part of NO_x emissions (79.4% from total NO_x emissions in 2020), but IPPU and Agriculture sectors make

6.1% and 14.1%, accordingly. Small part of NO_x emissions is produced in LULUCF sector (0.3% from total NO_x emissions).

91.5% of CO emissions appear in Energy sector, mainly from fuel combustion in Residential and Commercial/Institutional subsectors (72.9% from all CO emissions). The remaining part of CO emissions come from LULUCF sector (5.8%), IPPU sector (2.7%) and Waste sector (0.0006%).

The major part of SO_2 emissions (94.2%) are from Energy sector (fuel combustion), but the other sulphur dioxide emissions - from Industrial processes (5.7%) from Cement production, and a negligible part of SO_2 comes also from Waste sector (Waste incineration).

The largest amounts of NMVOC emissions are produced in Energy sector (39.8%; fuel combustion mainly in Residential sector) and 37.0% from total NMVOC emissions in 2020 are produced in IPPU sector, mainly from solvent use. In addition, 22.5% of NMVOC emissions are produced in Agriculture sector, but the remaining 0.8% in Waste sector.

In Agriculture sector, CO and SO_2 emissions, and in LULUCF sector, NMVOC and SO_2 emissions do not appear.

PART I: ANNUAL INVENTORY SUBMISSION

1 INTRODUCTION

1.1 *BACKGROUND INFORMATION ON GHG INVENTORIES AND CLIMATE CHANGE*

1.1.1 Background information on climate change

Latvia is a country by the Baltic Sea covering area of 64 589 km^2, with a population of 1 907 675 (2020) inhabitants[4]. Baltic coastline is approximately 498 km long. Since the beginning of the previous century the forest area in Latvia has almost doubled, reaching 3 259 kha (50.5% from the total area of the country in 2020). Latvia lies in a temperate climate zone where an active cyclone determine rapid changes in weather conditions (190-200 days per year), and an annual mean precipitation is 600-700 mm. The main rocks are clay, dolomite, sand, gravel, limestone and gypsum.

The analysis of long term climatological data series has shown that the climate has changed during last centuries in Latvia.

Climate change and climate variability has and will have a notable impact on inland and sea hydro ecosystems as well as to the vegetation. The increasing growth of aquatic vegetation in recent years has been related to climatic factors – higher mean temperature and earlier spring. The absence and lowering of the ice cover during winter's causes the prolonged growing season. There is a significant temporal gradient in vegetation dynamic from light nutrient-poor and species-poor forests to more nutrient-rich, more diverse species and closed forests. It is evident that climate change will have a significant effect on natural and socio-economic systems in Latvia in the future[5].

1.1.2 Background information on GHG inventories

The Parliament of the Republic of Latvia ratified the United Nations Framework Convention on Climate Change in February 23, 1995. Since March 23, 1995 Latvia is a Party to the Convention, thus undertaking implementation of series of international commitments. On May 30, 2002 the Parliament ratified the Kyoto Protocol. Latvia has also ratified the Doha Amendment to the Kyoto Protocol.

The Parliament ratified the landmark Paris Agreement on climate change on February 2, 2017.

Since May 2004 Latvia is a member of the EU and Latvia's climate change policy is based on Union`s climate policy.

As a Party of the UNFCCC, Kyoto Protocol and a Member State of the EU, Latvia is required to submit annual national GHG inventory covering emissions and removals of direct GHGs (CO_2, CH_4, N_2O, HFC, PFC, SF_6 and NF_3) from the base year to the most recent inventory year. This report is the annual submission of Latvia to the UNFCCC, Kyoto Protocol and the European Commission. It presents the GHG inventory, the process and the methods used for the

[4] *CSB database IRD010. Resident population at the beginning of the year. Available: https://stat.gov.lv/lv/statistikas-temas/iedzivotaji/iedzivotaju-skaits/tabulas/ird010-iedzivotaju-skaits-un-ipatsvars-pec*

[5] *Kļaviņš, M. Climate change in Latvia, University of Latvia, Riga (2007).*

compilation of the inventory from 1990 to 2020. The structure of NIR follows the UNFCCC Annex I inventory reporting guidelines.

The national legislation act – Regulation No. 737 of Cabinet of Ministers (12.12.2017.) determines the institutions that are responsible for the GHG inventory preparation. The Climate Change Department of the MEPRD is responsible for the coordination of the implementation and development of climate change mitigation and adaptation policies and measures. MEPRD in cooporation with an other sectoral ministries is responsible for the actions (coordination, implementation and development) to meet the international and EU emission reduction targets. MEPRD also coordinates the monitoring and reporting of GHG emission data as well as is designated as single national entity with overall responsibility for the Latvian GHG inventory.

1.1.3 Overview of inventory preparation and management, including for supplementary information under Article 7, paragraph 1, of the Kyoto Protocol

As an Annex I Party of the UNFCCC that is also part of the Kyoto Protocol, Latvia is required to report supplementary information in accordance with the Article 7, paragraph 1, of the Kyoto Protocol. The required information is consistent with relevant decisions and guidelines under the Article 7 paragraph 1.

1.2 *DESCRIPTION OF THE NATIONAL INVENTORY ARRANGEMENTS*

1.2.1 Institutional, legal and procedural arrangements

National inventory arrangements are described below. The description is prepared according to requirements for reporting on national inventory systems under the Kyoto Protocol, European Union Monitoring Mechanism Regulation (EU MMR) and UNFCCC Annex I inventory reporting guidelines. Latvian national GHG inventory system is designed and operated according to the Kyoto Protocol to ensure the transparency, consistency, comparability, completeness and accuracy of inventory. Inventory activities include planning, preparation and management. The inventory phases are:

- collecting activity data;
- selecting methods and emission factors appropriately;
- estimating anthropogenic GHG emissions by sources and removals by sinks;
- implementing uncertainty assessment and identification of key categories;
- implementing QA/QC activities.

A schematic model for the national inventory system (NIS) according to the CoM Regulation No.737 (12.12.2017) is shown in Figure 1.1.

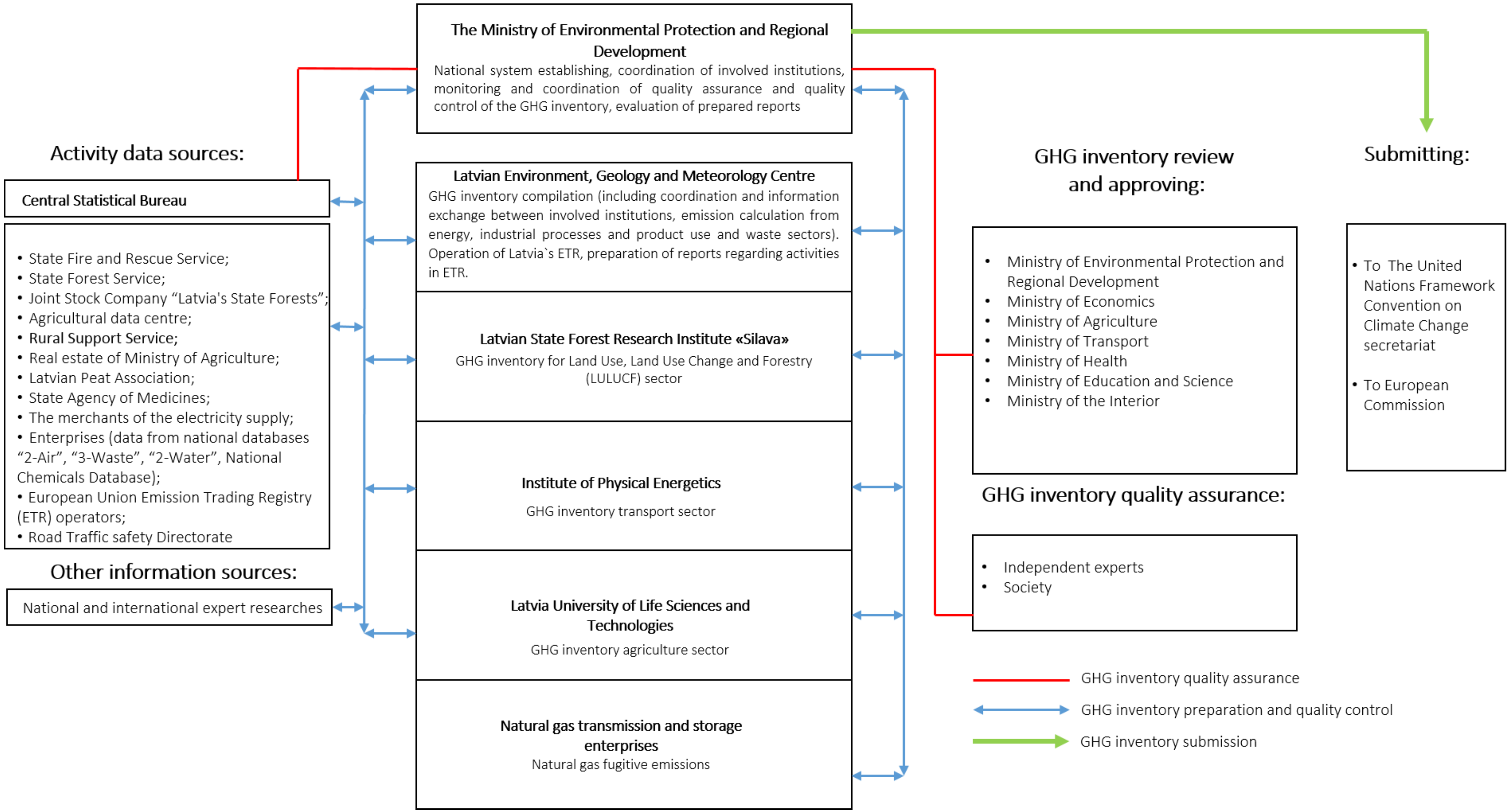

Figure 1.1 The structure of Latvia`s National Inventory System

The MEPRD Climate Change Department is responsible for:

- Preparation of legal basis for maintaining the National System;
- Informing the inventory compilers about the requirements of the national system;
- Overall coordination of GHG inventory process;
- Final checking and approving of the GHG inventory before an official submission to the EC and UNFCCC;
- Formal agreements with inventory experts and third part experts that evaluate quality assurance process;
- Coordinating the work with the involved experts, institutions, European Commission and UNFCCC (including coordination of the UNFCCC inventory reviews);
- Timely submission of GHG inventory to the UNFCCC and European Commission;
- Keeping of archive of official submissions to UNFCCC and European Commission.

Latvian Environment, Geology and Meteorology Centre is a governmental limited liability company responsible for:

- Activity data collection for Energy, Industrial Processes and Product Use and Waste sectors (activity data are mainly collected from the other institutions and LEGMC (Air and Climate division, Chemicals and Hazardous Waste division, Inland Waters division) use them to calculate emissions);
- Preparation of the emission estimates for the Energy, Industrial Processes and Product Use and Waste sectors;
- Preparation of QC procedures for relevant categories and documentation, archiving of used materials for emission calculation;
- LEGMC Air and Climate Division compiles the final NIR using information from all involved institutions as well as summarizes emission data in CRF Reporter;
- Quality manager from LEGMC Air and Climate division performs the overall QC/QA procedures for all sectors according to the QA/QC plan;
- Maintenance of archive with information for preparation of GHG inventory, official submissions to UNFCCC and European Commission;
- LEGMC is the National Emissions Trading Authority in Latvia and prepares relevant information for GHG inventory from registry – on emission reduction units, certified emission reductions, temporary certified emission reductions, long term certified emission reductions and assigned amount units for annual inventory submissions in accordance with guidelines for preparation of information under the Article 7 of the Kyoto Protocol (SEF tables).

Calculation of emissions and removals from the LULUCF, KP-LULUCF sector were done by Latvian State Forest Research Institute (LSFRI) "Silava". LSFRI "Silava" is responsible for activity data collection, estimation of emissions/removals, preparation of QC procedures as well as documentation and archiving of used materials for calculations.

Institute of Physical Energetics (IPE) calculates emissions from Transport sector. IPE is responsible for activity data collection, emission estimation from Transport, preparation of QC procedures as well as documentation and archiving of used materials for calculations.

Emission calculations from Agriculture sector were done by Latvia University of Life Sciences and Technologies (LULST). LULST is responsible for collecting of necessary activity data cooperating with Central Statistical Bureau (CSB), preparation of the emission estimates, preparation of QC procedures as well as documentation and archiving of used materials for calculations.

Natural gas enterprises are responsible for data providing and the calculation of annual gas leakage estimates for LEGMC to report 1B2b Natural gas.

The main data supplier for the Latvian GHG inventory is the CSB.

For ensuring the continuity of the functions of the national system, the delegation contracts are signed between the MEPRD, LEGMC, LSFRI "Silava", IPE and LULST.

Before the final Latvia's GHG inventory was submitted to European Commission and UNFCCC secretariat, draft GHG inventory (submitted on 15 Jaunary) was sent for comments and approval to responsible ministries. Based on received comments inventory was improved.

Several sectoral meetings were held before and during preparation of inventory, to discuss and agree on the methodological issues, problems arisen and improvements need to be implemented. There were also discussions on the different problems that came up during the last inventory preparation to find the solutions on how to improve the overall system.

The following issues for solving different problems and to improve cooperation between inventory experts and inventory compilers are:

- Discussion on methodologies and possible changes in the future;
- Discussion on QA/QC plan, available resources and possible improvements;
- Discussion on data collection;
- Agreement on recalculations;
- Archiving system, updating and possible improvements;
- Exchange of relevant information;
- Reporting on the conclusions from the meetings.

Information on the detailed responsibilities of the institutions of activity data, the main experts responsible for the sectoral inventories, the corresponding charters and annexes are summarized in the Table 1.1.

1.2.2 Overview of inventory planning, preparation and management

The inventory preparation is an annual process and divided into three stages: planning, preparation and management. The specific functions are described below.

Inventory planning is one of the main stages in national GHG inventory management system and all responsible institutions are involved in this process, that consists of:

- Establishing the national entity with overall responsibility for the national inventory;

- assigning responsibilities for inventory preparation and management;
- developing time schedule;
- making arrangements to collect data from statistical agencies, companies, industry associations, etc.;
- creating QA/QC plan;
- defining formal approval process within a government;
- developing review processes;
- implementing continuous improvements.

Inventory preparation plan is a part of the Latvia's QA/QC plan and has to be followed by all institutions defined in CoM Regulation No. 737 (12.12.2017). The responsible institutions are reflected in Table 1.1 and inventory preparation plan is presented in Table 1.2.

After the end of the annual reporting cycle in April, the institutions involved in inventory preparation start to plan the next annual inventory following planned inmprovements and received recommendations by ERT. Within the EU level the recommendations by a Technical Expert Review Team are also taken into account. Planning includes the identification of improvements to be undertaken due to revised methodologies, updated activity data or emission factors and other relevant technical elements of inventory as well as the addressing the issues and recommendations in review of the previous inventory submission.

Table 1.1 Institutions responsible for activity data and calculating emissions

CRF sectors	Data	Responsible institutions/ Responsible experts
Table 1.A(a) - Fuel Combustion Activities (Sectoral Approach)	*Activity data*	*CSB Environment and Energy Statistics Section, Road Traffic Safety Department (RTSD)*
	Calculations	*LEGMC Air and Climate division (Asnate Skrebele), Institute of Physical Energetics (Gaidis Klāvs, Larisa Gračkova)*
Table 1.A(b) – CO_2 from Fuel Combustion Activities – Reference Approach	*Activity data*	*CSB Environment and Energy Statistics Section*
	Calculations	*LEGMC Air and Climate division (Asnate Skrebele)*
Table 1.A(d) – Feedstock's and Non-Energy Use of Fuels	*Activity data*	*CSB Environment and Energy Statistics Section*
	Calculations	*LEGMC Air and Climate division (Asnate Skrebele)*
Table 1.B.2. – Fugitive Emissions from Oil and Natural Gas	*Activity data*	*CSB Environment and Energy Statistics Section*
	Calculations	*LEGMC Air and Climate Division (Asnate Skrebele), natural gas enterprises*
Table 1.D – International Bunkers and Multilateral Operations	*Activity data*	*CSB Environment and Energy Statistics Section*
	Calculations	*Institute of Physical Energetics (Gaidis Klāvs, Larisa Gračkova)*
Table 2(I).A-E,G-H – Industrial Processes and Product Use	*Activity data*	*CSB Population Statistics Section* *State Agency of Medicines;* *Research of experts;* *National database "2-Air", National Chemicals Database and CSB Industrial Statistics Section* *EU Emission Trading Scheme operators*

CRF sectors	Data	Responsible institutions/ Responsible experts
	Calculations	*LEGMC Air and Climate division (Laine Lupkina, Santija Treija)*
Table 2(II) F – Industrial Processes - HFCs, PFCs and SF_6	*Activity data*	*CSB Population Statistics Section, Environment and Energy Statistics Section* *Electricity supplying companies;* *State Agency of Medicines;* *Annual reports by operators using F-gases (reported to LEGMC)* *Data from National Chemicals Database (maintained by LEGMC)*
	Calculations	*LEGMC Air and Climate division (Laine Lupkina)*
Table 3.A – Agriculture, Enteric Fermentation	*Activity data*	*CSB Agricultural Statistics Section*
	Calculations	*Latvia University of Life Sciences and Technologies (Laima Bērziņa)*
Table 3.B.1 - Agriculture, CH_4 Emissions from Manure Management	*Activity data*	*CSB Agricultural Statistics Section*
	Calculations	*Latvia University of Life Sciences and Technologies (Laima Bērziņa)*
Table 3.B.2 - Agriculture, N_2O un NMVOC Emissions from Manure Management	*Activity data*	*CSB Agricultural Statistics Section*
	Calculations	*Latvia University of Life Sciences and Technologies (Laima Bērziņa and Olga Frolova)*
Table 3.D - Agriculture, Agricultural Soils	*Activity data*	*LEGMC database "2-Water", Latvian State Forest Research Institute "Silava"*
	Calculations	*Latvia University of Life Sciences and Technologies (Laima Bērziņa)*
Table 3 G Liming	*Activity data*	*CSB*
	Calculations	*Latvia University of Life Sciences and Technologies (Laima Bērziņa)*
Table 3 H Urea application	*Activity data*	*CSB*
	Calculations	*Latvia University of Life Sciences and Technologies (Laima Bērziņa)*
Table 4. A. Forest Land Table 4. B. Cropland Table 4. C. Grassland Table 4. D. Wetlands Table 4. E. Settlements Table 4. F. Other Land	*Activity data*	*NFI*
	Calculations	*Latvian State Forest Research Institute "Silava" (Andis Lazdiņš, Arta Bārdule, Aldis Butlers, Ieva Līcīte)*
Table 4. B. Cropland – 4.B.1 Cropland remaining Cropland	*Activity data – Area of organic soil*	*NFI, National studies*
	Calculations – Net carbon stock change in organic soils	*Latvian State Forest Research Institute "Silava"*
Table 4. C. Grassland – 4.C.1 Grassland remaining Grassland	*Activity data - Area of organic soil*	*NFI, National studies*
	Calculations – Net carbon stock change in organic soils	*Latvian State Forest Research Institute "Silava"*
Table 4. (V) Biomass Burning	*Activity data*	*State Fire and Rescue Service of Latvia (SFRS), State Forest Service (SFS)*

CRF sectors	Data	Responsible institutions/ Responsible experts
	Calculations	*Latvian State Forest Research Institute "Silava"*
KP LULUCF NIR-1 NIR-2 NIR-2.1 NIR-3 4(KP)	*Activity data*	*SFRS, SFS* *NFI* *National studies and expert judgement*
	Calculations	*Latvian State Forest Research Institute "Silava" (Andis Lazdiņš, Arta Bārdule, Aldis Butlers)* *LEGMC Air and Climate division (Vita Štelce),*
Table 5 A - Waste, Solid Waste Disposal on Land	*Activity data*	*LEGMC "3-Waste" database, Methane recovery installations*
	Calculations	*LEGMC Chemicals and Hazardous Waste Division (Intars Cakars)*
Table 5 B – Biological Treatment and Solid Waste	*Activity data*	*CSB, LEGMC Chemicals and Hazardous Waste Division*
	Calculations	*CSB, LEGMC Chemicals and Hazardous Waste Division (Intars Cakars)*
Table 5 C – Incineration and open Burning of Waste	*Activity data*	*LEGMC database "3-Waste"*
	Calculations	*LEGMC Chemicals and Hazardous Waste Division (Intars Cakars)*
5.D Wastewater Treatment and Discharge	*Activity Data*	*LEGMC "2-Water" database, CSB statistics on national population and production rates of certain industries*
	Calculations	*LEGMC Inland Waters Division (Lauris Siņics)*

<u>The inventory preparation</u> stage consists of:

- Identification of key categories, which have a significant influence on a country's total inventory in terms of level or trend in emissions;
- Selection of methods, emission factors and all necessary relevant information for estimating anthropogenic GHG emissions by sources and removals by sinks;
- Collection of activity data;
- Managing recalculations from previous submissions taking into account updates of activity data by CSB, recommendations by ERT, TERT and suggestions from the independent third-part experts etc;
- NIR compilation;
- QA/QC plan implementation (including basic checks on entire inventory (Tier 1) and more in-depth investigations into key categories (Tier 2);
- Documentation.

<u>The inventory management</u> stage consists of:

- Implementation of inventory review processes (e.g., expert review, public review);
- Obtaining formal approval of final results and reporting within government;
- Submission of the report to the UNFCCC;

- Making inventory information available to stakeholders and responding to information requests;
- Archiving all documentation and results (The special centralised folder is created where experts can upload/download and store all files and information related to inventory preparation);
- Continuous improvement feedback.

All information required pursuant to Article 7 of the Kyoto Protocol has been integrated within the reporting processes.

Latvia prepares a NIR and CRF tables annually according to requirements of the UNFCCC, the Kyoto Protocol and the EU MMR.

Table 1.2 Inventory preparation plan

Element	Activity	Responsible performers	Procedures	Due date
To reconsider the changes needed for the inventory, taking into account comments and recommendations made by the review team (ERT)	*All institutions established by Regulation of Cabinet of Ministers No.737 (Part II „National Inventory System")*		*All institutions involved in inventory preparation process to reconsider the changes needed for the inventory, taking into account comments and recommendations made by the review team (ERT) and send to national inventory compiler for summarizing.*	*Middle of May*
Annual meeting	*All institutions established by Regulation of Cabinet of Ministers No.737 (Part II „National Inventory System")*		*Participation of all institutions involved in inventory preparation and approval process. Discussions on previous submissions' review results and planned submission including necessary improvements, changes, recalculations, problems etc.*	*Till 30th June*
Activity data and description	*Submission to LEGMC*	*EU Emission Trading Scheme (EU ETS) operators*	*EU ETS operators send to LEGMC activity data, CO_2 emission factors, CO_2 emissions and descriptions as verified GHG report for enterprises involved in EU ETS annually for previous year.*	*till 30th March*
			LEGMC uses EU ETS data in GHG inventory for emission estimates in Energy and Industrial Processes sectors.	*Starting from September*
		Operators	*LEGMC (Air and Climate division, Chemicals and Hazardous Waste division, Inland Waters Division) collects information for emission calculation in following databases:* • *National database "2-Air"*	*till 15th June*

Element	Activity	Responsible performers	Procedures	Due date
			• *National database "3-Waste"* • *National database "2-Water"* • *National Chemicals Database* • *Cement producer and Iron & Steel plant send additional information for detailed CO_2 emission estimation according to National legislation.*	*till 1st October*
			LEGMC uses data from databases for emission estimates in Energy (CRF1), IPPU (CRF2), Waste (CRF5) sectors.	*Starting from September*
		JSC "Latvijas Gāze", JSC "Conexus Baltic Grid", JSC "Gaso"	*The natural-gas transmission, storage, distribution, and sales operator in Latvia sends the total fugitive emissions for previous year and short information of emission fluctuation according to the national legislation.*	*till 1st October*
			LEGMC uses data from JSC "Latvijas Gāze, JSC "Conexus Baltic Grid", JSC "Gaso" for emission estimates in Energy (CRF1) sector.	*Starting from October*
		Ministry of Health collaborating with State Agency of Medicines (SAM)	*SAM sends to LEGMC activity data – data of imported metered dose inhalers containing GHG (F gases subsector) and amount of used N_2O for Anaesthesia (Solvent and other product use sector).*	*till 1st October*
			LEGMC uses data from SAM for emission estimates in IPPU sector.	*Starting from October*

Element	Activity	Responsible performers	Procedures	Due date
Activity data and description	*Submission to LEGMC, LULST, IPE*	*Statistical Bureau of Latvia (CSB)*	*CSB send activity data regarding Energy, Agriculture, IPPU and Waste sectors according to CoM Regulation No. 737.* *Many of received and used activity data is available in CSB statistical databases: https://www.csb.gov.lv/lv/statistika/db*	*till 1st October*
			LEGMC, LULST use received data for Energy, Agriculture, IPPU and Waste sectors emission calculation	*Starting from October*
	Submission to MEPRD/ LSFRI "Silava”	*SFRS*	*SFRS send to MEPRD activity data - area of last year`s grass burning (ha).*	*till 1st October*
			LSFRI "Silava” uses received data for emission calculation from biomass burning (CRF 4 (V)).	*Starting from October*
Emissions/CO_2 removals	*Data entry in the CRF Reporter according to CRF Reporter User Manual*	*LEGMC, LULST, IPE, LSFRI "Silava”*	*Data entry in the CRF Reporter by responsible sectoral experts.*	*till 15 December*
Emissions/CO_2 removals descriptions	*Preparation of NIR chapters*	*LEGMC, LULST, IPE, LSFRI "Silava”*	*LSFRI "Silava”/ LULST (in coloboration with MoA), LEGMC, IPE and MEPRD prepare relevant chapters of NIR.*	*till 15 December*
CRF Reporter	*Data check by sectoral experts*	*LEGMC, LULST, IPE, LSFRI "Silava”*	*Sectoral experts check the data in the CRF Reporter for consistency and quality assurance (e.g. to check whether the sum of the following adds up to 100%, to check the year to year changes between values reported etc.).*	*till 15 December*

Element	Activity	Responsible performers	Procedures	Due date
			LEGMC (Quality manager) checks completeness, consistency and quality assurance.	*till 30 December*
Data in CRF, Draft NIR according to Regulation (EU) No 2018/1999 and Commission Implementing Regulation 2020/1208	*CRF, NIR, Annexes*	*MEPRD - Climate Change Department*	*After corrections in CRF tables, NIR (if necessary) MEPRD uploaded CRF tables, XML, draft NIR, relevant Annexes to the EIONET CDR.*	*15th January*
Quality control checks: *Draft NIR*	*QA*	*MEPRD - Climate Change Department* *Expert* *Public*	*According to the CoM Regulation No. 737, MEPRD send to involved institutions Draft NIR for comments and approving.* *NIR was uploaded in the LEGMC home page for review by public.*	*till 16th January*
		All institutions involved in GHG emissions and removals preparation	*Expert meetings to improve inventory, quality control activities etc.*	*January-February*
		Involved institutions	*Involved institutions send to MEPRD comments about NIR 1st draft and approval.*	*15th February*
	QC	*All institutions involved in the GHG inventory*	*Answers to the compiled questions by EU review team, which based on 15/1 submissions:* *https://emrt-esd.eionet.europa.eu/*	*28st February to 15th March*

Element	Activity	Responsible performers	Procedures	Due date
		preparation process	*MEPRD approves provided answers from experts.* *Verification of national data in EC inventory and updates if necessary and response to EC.* *This process includes collaboration with involved institutions for preparing of response to EC.*	
CRF data, *NIR according to Regulation (EU) No 2018/1999 and Commission Implementing Regulation 2020/1208*	*CRF, NIR, Annexes*	*MEPRD - Climate Change Department*	*MEPRD uploaded CRF tables, XML and NIR to the EIONET CDR.*	*15th March*
NIR and emission data in CRF to UNFCCC	*Inventory submission (CRF, NIR)*	*MEPRD - Climate Change Department*	*MEPRD uploaded approved GHG inventory to the CRF Reporter Submission module.*	*15th April*

1.2.3 Quality assurance, quality control and verification plan

QA/QC procedures are an important component in the development of GHG emission inventory preparation. The basic aim of the QA/QC process is to ensure the high-quality of the inventory and to contribute to improvement of the inventory. The quality requirements set for annual inventories (transparency, consistency, comparability, completeness, accuracy, timeliness and continuous improvement) are fulfilled by implementing the QA/QC process consistently in conjunction with the inventory process (Figure 1.2).

The quality of result depends on four main stages – planning, preparation, evaluation and improvements, and is ensured by inventory experts during compilation and reporting of inventory.

The inventory planning stage includes the setting of quality objectives and elaboration of the QA/QC plan for the coming inventory preparation, compilation and reporting work.

Based on QA/QC process, the main findings and conclusions about the quality and improvements of the inventory have to be applied into Latvia`s GHG inventory system for making decisions about the annual inventory process and next inventory preparation.

The outcomes of the QA/QC process results in a reassessment of inventory or source category uncertainty estimates. For example, if data quality is found to be lower than previously thought and this situation cannot be rectified in the timeframe of the current inventory, the uncertainty estimates are re-evaluated. Based on QC results, estimation of emissions is improved and uncertainties are reduced.

On December 12, 2017 Cabinet of Ministers approved Regulation No. 737 "Development and management of national system for greenhouse gas inventory and projections", that regulates the issues of the QA/QC plan. The main elements of QA/QC plan are:

- Quality objectives of the annual GHG inventory;
- Time frame for the preparation of the annual GHG inventory;
- Improvement plan of the annual GHG inventory;
- List of key categories (Level 1) for which sectoral experts and quality control experts must carry out quality control procedures;
- List of key categories (Level 2) that needs to be taken into account during planning of improvements and preparation of GHG inventory improvement plan;
- Quality control procedures of the annual GHG inventory;
- Quality assurance procedures of the annual GHG inventory;
- Verification procedures of the annual GHG inventory;
- Information regarding sectoral instructions for inventory preparation;
- Information regarding documentation and archiving procedures.

In 2018 QA/QC programm was updated by Order No. 1-2/160 (03.10.2018) of Ministry of Environemetal Protection and Regional Development according to CoM Regulation No. 737 (12.12.2017).

According to CoM Regulation No. 737 (12.12.2017) and MEPRD Order 1-2/160 (03.10.2018) all institutions involved in inventory process are responsible for implementing QC procedures. Mainly Tier 1 general inventory QC procedures outlined in Table 6.1 of the 2006 IPCC Guidelines are used.

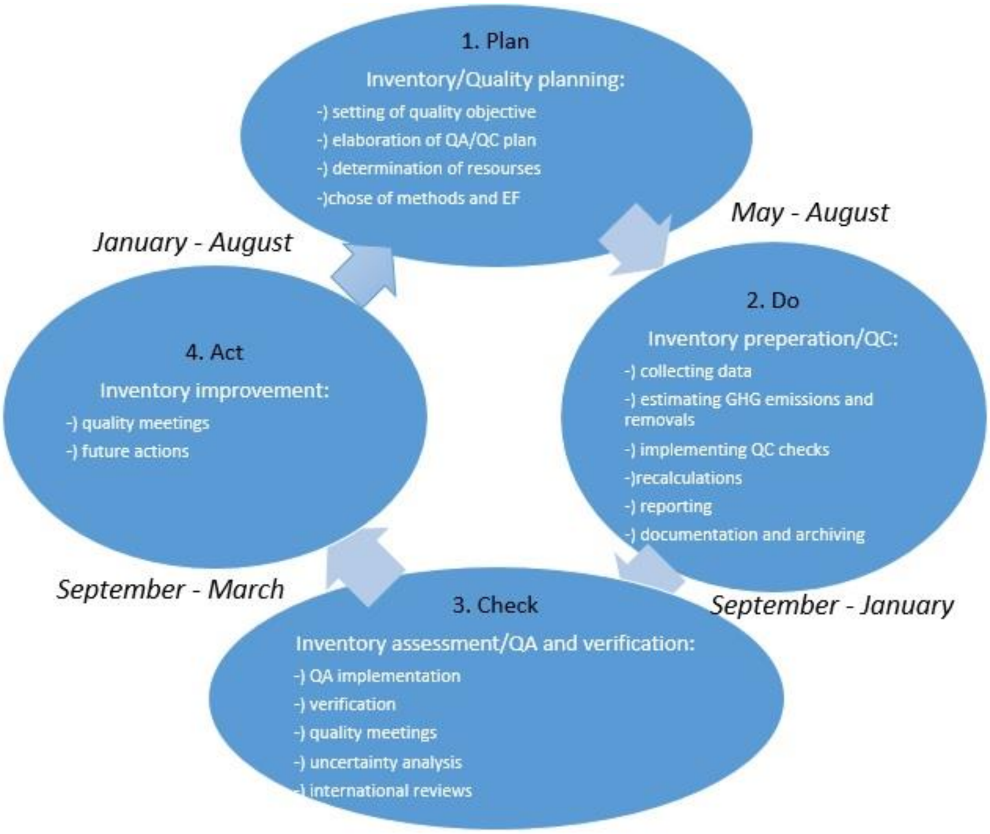

Figure 1.2 Inventory and QA/QC process of the inventory

The setting of quality objectives is based on the inventory principles taking into account the available resources.

The quality objectives for the 2022 inventory were the following:

- strengthen QA/QC procedures for the inventory and ensure the completeness of all elements included in the appendix to Annex I to Decision 24/CP.19;
- implementation of specific QC procedure in QA/QC plan that monitors the use of notation keys and ensure that the use of the notation key "IE" is explained transparently in the NIR and CRF table 9. However, there were problems to fill notation key "IE" in CRF Reporter in LULUCF sector.

In order to ensure improvements for 2022 GHG inventory:

- All improvements included in the previous NIR are carried out or ongoing;
- Feedback on reviews is systematic;
- Inventory QC procedures meet requirements.

In order to ensure transparency:

- transparent information is included in the NIR and CRF (including information regarding the used methodology, activity data and emissions in tables);
- notation keys are used according to the IPCC guidelines;

- recommendations of inventory reviews regarding transparency are taken into account as far as possible;
- documentation regarding quality control check is indicated;
- information regarding the changes since the last inventory in relation to transparency is provided in the NIR under relevant subchapters.

In order to ensure consistency:

- recommendations received during inventory reviews regarding consistency is taken into account after evaluation as far as possible;
- information regarding consistency and recalculations is provided in the NIR;
- an explanation for a decline or increase in emissions of time series is provided.

In order to ensure comparability:

- necssary to make sure that methodologies and formats used in the inventory meet comparability requirements;
- emissions and CO_2 removal is localized and distributed according to the IPCC guidelines.

In order to ensure completeness:

- emissions from all potential sources and gases is calculated;
- recommendations of the review of international experts regarding improvements is taken into account as far as possible;
- information regarding completeness is provided in the NIR;
- all reasons for recalculations and reasons why a designation NE (not evaluated) and IE (included elsewhere) is used instead of data is indicated.

In order to ensure accuracy:

- Tier 2 or a higher method is used for the main sources as far as possible;
- uncertainties are calculated and information is provided in the NIR.

In order to ensure timeliness:

- inventory reports reach the EU and UNFCCC within the set time.

1.2.3.1 Quality Control procedures

The general and category-specific QC procedures are performed by sectoral experts during inventory calculation and compilation according to the QA/QC and verification plan.

MEPRD as national entity is responsible for overall QC procedures and quality assurance of national system, including the UNFCCC and EU reviews.

For submission 2022, QC activities were carried out at the various stages of the inventory compilation process - processing, handling, documenting, cross checking and recalculations. These activities are implemented by sectoral experts and quality manager in LEGMC who is responsible for QC procedures before inventory submission for overall QC procedures and final approving in MEPRD.

The centralized archiving system (common FTP folder, maintained by LEGMC) is created where experts have to upload and download all necessary information for inventory preparation, inter alia spreadsheets that need to be filled for quality control and quality assurance. Instruction for experts how to prepare NIR to ensure comparability of NIR and CFR is prepared and available to experts.

QC system includes various activities set to ensure transparent data flow through all inventory processes:

- Assumptions and criteria for the selection of activity data and emission factors are documented;
- Transcription errors in data input and references;
- Correctness of calculations of emissions;
- Correctness of emission parameters, units, conversion factors;
- Correctness in use of notation keys (the use of the notation keys "NE" and "IE" is explained transparently in the NIR and CRF table 9);
- Integrity of database files;
- Consistency in data between the source categories.

The QC procedures comply with the 2006 IPCC Guidelines. General inventory QC checks (2006 IPCC Guidelines, Vol 1, Chapter 6, Table 6.1) include routine the checks of the integrity, correctness and completeness of data, identification of errors and deficiencies and documentation and archiving of inventory data and quality control actions.

Category-specific QC checks including reviews of the activity data, emission factors and methods are applied on a case-by-case basis focusing on key categories and on categories where significant methodological changes or data revisions have taken place.

For submission in 2022:

-) Sectoral experts entered data in the CRF Reporter software either manually or by importing MS Excel spreadsheets. Sectoral experts prepared quality control procedures according to the 2006 IPCC Guidelines. All findings were documented by using check-lists and introduced in GHG inventory. All corrections are archived in FTP folder;

-) Sectoral experts prepared relevant NIR chapters and sent to LEGMC. Sectoral experts before sending chapters of the NIR have checked if all the information is consistent with the information filled in the CRF Reporter as well as if all the relevant information according to reporting guidelines is included (including descriptions, references and sources of information for the specific methodologies, including higher-tier methods and models, assumptions, EFs and AD, as well as the rationale for their selection). It is also checked if recalculations and methodological changes are explained in the NIR and CRF Reporter. Final NIR is compiled by LEGMC according to the UNFCCC Annex I inventory reporting guidelines;

-) Meetings were held with companies to explain and clarify the IPCC requirements, thus strengthening the institutional, legal and procedural national system arrangements;

-) GHG emission data are checked with the data used to prepare inventory of air pollutants under the United Nations Economic Commission for Europe's Convention on Long-Range Transboundary Air Pollution (UNECE CLRTAP), the actual or estimated allocation of the verified emissions reported by installations and operators under Directive 2003/87/EC (EU ETS), the energy data reported pursuant to Article 4 of, and Annex B to, Regulation (EC) No 1099/2008 and the data reported pursuant to Article 19 of F-gas regulation No. 517/2014;

-) LEGMC quality manager and MEPRD performed cross-checking information for all sectors to verify that no mistakes occurred during input/import process. Completeness and consistency were checked using CRF Reporter functions. As a result of the CRF completeness check, the list of gaps in the CRF Reporter was summarized. After detailed re-checking in the CRF Reporter it was concluded that all findings are related to the CRF bugs (for example orange light in completeness check for categories that are obviously complete). Also incompleteness is caused by partially filled F-gas categories. As in the current CRF Reporter version v6.0.8 it is not possible to enter notation keys for F-gases which are not occurring in Latvia directly in grey and green cells. Cells related to F-gases which are not occurring were left blank untill it will be possible to fill in the CRF without adding unnecessary child nodes;

-) LEGMC quality manager summarizes the QA/QC activities performed by the experts and summary submittion to MEPRD;

-) Quality assurance meetings between sectoral experts were held in order to discuss problems and possible improvements in GHG inventory as well as to ensure consistency between activity data used by experts in emission estimation for different sectors;

-) Detailed QA/QC procedures were done by institutions involved in the GHG inventory preparation (MoA, MoT, MoE, MEPRD, CSB). Meetings between sectoral experts and involved institutions were held according to comments received and improvements needed in the NIR;

-) Sectorial experts participate in capacity building webinars of ESD review 2021 & LULUCF trial review 2021.

Main activity data provider for Latvia's GHG inventory – CSB – has established Quality Guidelines[6] that is an informative document describing the main aspects of the CSB activity: stages, methods and organizational principles of producing the national statistics, policy of data protection and dissemination. The purpose of the Guidelines is to ensure higher quality to a maximum extent from both ethical and professional aspect, national statistics similarly to the Community statistics must follow the principles of impartiality, reliability, relevance, cost-effectiveness, statistical confidentiality and transparency.

As a general rule, the statistics are revised according to a fixed, coherent and published plan, called a revision cycle. This plan determines when the individual statistics are revised and the periods that are subject to revision:

- CSB Revision Policy is available in the CSB website;
- Database of Macroeconomic statistics data revision analysis established.

Detailed source specific QC descriptions are included under each sub sector relevant chapter.

Quality control of EU Member States submissions` are performed in web-based tool hosted by the European Environmental Agency (EEA) to facilitate quality checks and reviews of national emission inventories reported by EU Member States under the EU MMR. The tool is used in the annual review process under the ESD.

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[6] *CSB Quality Guidelines. Available: https://www.csb.gov.lv/en/documents/official-statistics-system/quality-framework*

1.2.3.2 Quality Assurance procedures

Quality Assurance activities include a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process. According to Regulation No. 737 MEPRD is responsible for ensuring QA procedures for GHG inventory.

The QA reviews are performed after the implementation of QC procedures to the finalised inventory. The inventory QA system comprises reviews to assess the quality of the inventory.

A basic review of the draft GHG emission and removal estimates, and the draft report takes place before the final submissions to the EU and UNFCCC (January to March) by the involved institutions in the GHG inventory preparation process.

Improvements for GHG inventory are compiled based on the findings of the UNFCCC, EC, internal reviews and recommendations from third party experts (periodically all sectors are revised by third party experts).

The UNFCCC inventory review teams coordinated by the UNFCCC Secretariat carry out international reviews of the GHG inventory. The expert review teams produce an independent review reports on GHG inventory. Last UNFCCC review for Latvia was held in 2020.

Annually technical reviews by a Technical Expert Review Team (TERT) to verify the annual emissions under the ESD have been conducted under the EU MMR also for the inventory submissions.

1.2.3.3 Documentation and Archiving

As part of general QC procedures, it is a good practice to document and archive all information that is used for emission estimates. Documentation has a significant role in the inventory quality management.

All institutions involved in GHG inventory preparation process are responsible for archiving the collected data and estimated emissions.

<u>Documentation system in CSB include:</u>

- Survey and calculations documentation system;
- Quality indicators documentation system;
- Thesaurus;
- 2 sub-systems – internal & external.

CSB a Document Storage System (ADS):

- In 2008, ADS was developed in the CSB;
- Each year, since 2009, all the fundamental processes performed for each statistical survey as well as for calculations have to be described in detail;
- In addition, all quality indicators have to be described;
- ADS provides also a technical possibility to attach a number of supporting documents;
- ADS is made accessible for external users on the CSB website.

Revisions of data are defined as any changes to statistics that have already been published.

CSB uses integrated statistical data management system (ISDMS) for data processing. It is a metadata driven system based on metadata and standardisation of data processing, which in essence does not require individual programming. This system is used for processing surveys of business (mainly) and social statistics. Data collected by means of questionnaires which are not included in the ISDMS are processed by the CSB using other especially developed data processing applications. Detailed information is given in the Annex 5.

The expert organizations have archives located in their own facilities. Experts keep all the information (all disaggregated emission factors, activity data, and documentation about how these factors and data have been generated and aggregated for the preparation of the inventory) on the individual expert's computers.

Every annual inventory (CRF tables, XML, NIR and Registry information) is archived.

Latvia has a centralized archiving system at LEGMC where all the information (including corresponding letters, internal documentation on QA/QC procedures, external and internal reviews, documentation on annual key categories and key category identification, planned inventory improvements) used for inventory compilation are collected on the special server (FTP folder) and the backup of data are made periodically.

1.2.3.4 Verification activities

Verification activities that have been undertaken are described in the category-specific chapters.

Annually the greenhouse gas inventory data is compared with the data reported under the EU ETS, energy statistics and under the CLRTAP.

The CSB verifies data in two processing stages: on raw data level (processing of individual information) and on aggregated data level (verifying prepared aggregates).

CSB uses several methods for data verification at the raw data level:

- arithmetical connections;
- logical connections;
- comparison with data of previous periods;
- mutual coherence verification with other statistical questionnaires;
- statistical registers and administrative data.

Aggregates are made and different groupings are formed from the raw data produced. CSB uses similar methods for verification of aggregates to ones applied in the verification of raw data.

1.2.3.5 Treatment of confidentiality issues

For Latvia's GHG Inventory confidentiality is mainly related to activity data provided to LEGMC by CSB. The data then is used for emission estimation and cannot be reported further. If the data that could be considered as confidential is provided to LEGMC by production plan or other enterprise then the data is not considered as a confidential and can be reported within GHG Inventory.

Data of CSB

Legal, technical and administrative measures:

Legal:

"Statistics Law"

"Law on State Information Systems"

"Personal Data Protection Law"

"Information Publicity Law".

Technical:

Physical Security (environmental (temperature fluctuations, etc.), technical (voltage reduction, etc.) and human factors (theft, deliberate or unintentional damages, etc.).

Logical Security (security measures provided by IT: user names and passwords, antivirus, firewalls etc.).

Administrative:

Information Security Management Coordination Council (ISMCC) ensure and implement the principles of granting access rights in the CSB security policy, security means and principles of data storage, information classification and confidentiality.

Information Security Policy developed (2008).

CSB ensures confidentiality and protection of information supplied by the respondents, as well individual information received from other sources pursuant to the requirements of National legislation in force.

The CSB takes the necessary organisational, administrative and technical measures to ensure confidentiality.

Technical: described in internal regulations and procedures on security and use of Information Systems.

Organisational and administrative:

- "Confidentiality Statement" signed by every employee, laying down the personal data non-disclosure obligation;
- Confidentiality Council established to ensure that individual information possessed by the CSB is used for scientific and research purposes according to the provisions of the Official Statistics Law and legal acts, as well to deal with legally unregulated confidentiality issues;
- Handbook of statistical confidentiality developed in 2009 that provides explanations of the methods used by the CSB for ensuring data confidentiality.

It is strictly determined in Law of Statistics what information could be provided to other institutions even though the information is needed in emission estimation and reporting under international conventions. CSB cannot give the information of amount of production if one or two companies produce up to 95% from total market production in particular sector. Due to small market of Latvia almost all industrial production data is classified as confidential with some exceptions in food and drink sector. LEGMC has interdepartmental agreement with CSB to receive confidential information for the emission estimation but these activity data has to be reported as "C" in CRF Tables and in NIR.

Data of the EU ETS

Some of the Latvia's industrial processes sector's companies are participating in the EU ETS, and accordingly the data from these companies can be obtained from their annual GHG reports within compliance obligations under EU ETS.

ETR documentation

As no significant changes were made in Latvia's ETR, ITL Initialization documentation wasn't changed either.

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

Changes in national inventory arrangements since the previous annual inventory are described in Chapter 13.

1.3 *INVENTORY PREPARATION, DATA COLLECTION, PROCESSING AND STORAGE*

1.3.1 GHG inventory and KP-LULUCF inventory

Each sector has assigned one or more sectoral experts, responsible for conformity with the relevant reporting guidelines, selection of appropriate methods and data sources and activity data collection, processing and updating of data.

For the Energy (excluding Transport), IPPU and Waste sectors data collection and emission estimation is performed by LEGMC experts from Air and Climate Division, Chemicals and Hazardous Waste Division and Inland Waters Division.

For Transport sector activity data is collected and emissions are calculated by experts from IPE.

For Agriculture sector, data collection and emission estimations are made by LULST.

Land-use, land use change and forestry and KP-LULUCF sector data are collected and emissions/removals are calculated in LSFRI "Silava".

All the experts responsible for data collection and processing in a particular sector are preparing their data (activity data, emission factors) to import into the CRF Reporter software.

1.4 *BRIEF GENERAL DESCRIPTION OF METHODOLOGIES AND DATA SOURCES USED*

1.4.1 GHG inventory

Latvia's GHG emissions inventory is based on:

- 2006 IPCC Guidelines;
- 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (IPCC Wetlands Supplement);

- 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (2013 IPCC Kyoto Protocol Supplement);
- EMEP/CORINAIR Guidebook 2007 and EMEP/EEA 2009;
- EMEP/EEA air pollutant emission inventory guidebook 2016;
- EMEP/EEA air pollutant emission inventory guidebook 2019.

The main sources for emission factors are guidelines mentioned above as well as national studies for country specific parameters and emission factors (e.g. CO_2 emission factors, aspects influencing SO_2 emission factors, distribution of animal waste management systems, average N excretion and etc.).

For 2022 submission (NIR and CRF tables) compilation of the CRF Reporter version v6.0.8 was used. To calculate GHG emissions, supplemental locally developed database in Excel format was applied for all sectors except for Road Transport where COPERT 5 was used.

In cases where data of bottom – up method were available and plants had reported estimated data using plant specific emission factors and estimation methodologies for Energy sector, these data were used in the submission. If these data were not available, Tier 1 method from the 2006 IPCC Guidelines was used to estimate emissions. Emissions for the whole country fuel consumption were estimated by adding up fuel consumption of individual sectors multiplied by appropriate emission factors.

Emissions from Road Transport sector were estimated by using COPERT 5 model for 1990–2020 (Tier 2 method for CO_2 and Tier 3 method for CH_4 and N_2O). Emissions for the other transport sub-sectors were estimated according to IPCC Tier 1 and Tier 2 methodologies (Tier 2 method for diesel oil CO_2 emission calculation in railway and navigation and Tier 2 method for jet kerosene emission calculation in aviation (civil and international). The rest of the emissions have been calculated using Tier 1 method).

Emissions from Industrial Processes and Product Use were estimated according to the 2006 IPCC Guidelines, EMEP/CORINAIR 2007 Guidebook, EMEP/EEA 2009, EMEP/EEA air pollutant emission inventory guidebooks 2019 as well as using expert research and judgment about activity data and emission factors.

Emissions from Agriculture sector were estimated according to methodologies from the 2006 IPCC Guidelines, the IPCC Wetlands Supplement as well as using expert research and judgment about activity data and emission factors.

The 2006 IPCC Guidelines, the 2013 IPCC Kyoto Protocol Supplement and the IPCC Wetlands Supplement for CO_2, CH_4 and N_2O emissions from drained and rewetted soils were used to estimate emissions from LULUCF and KP-LULUCF sector.

The 2006 IPCC Guidelines were used to estimate emissions from Waste sector.

Table 1.3 presents the main data sources used for activity data as well as information on actual calculations.

Table 1.3 Main data sources for activity data and emission values

Sector	Data Sources for Activity Data	Emission Calculation
Energy	*Central Statistical Bureau Energy Balance;* *IEA/ OECD – EUROSTAT – UNECE Annual questionnaires;* *National database"2-Air";* *Research of experts,* *Natural gas enterprises*	*LEGMC Air and Climate division,* *plant operators*
Transport	*CSB Energy Balance;* *IEA/AIE – EUROSTAT – UNECE Annual questionnaires;* *Data of Road Traffic safety Directorate;* *Research of experts.*	*IPE*
IPPU	*National production and sales statistics;* *Direct information from enterprises operating with pollutants;* *Central Statistical Bureau;* *National Chemicals Database;* *Assumptions by experts;* *State Agency of Medicines;* *Research by experts;* *GHG report under EU ETS* *National database"2-Air".*	*LEGMC Air and Climate division,* *plant operators*
Agriculture	*National agricultural statistics obtained from CSB;* *National studies.*	*LULST in collaboration with Ministry of Agriculture*
LULUCF; LULUCF KP	*NFI* *SFS* *Ministry of Agriculture of Republic of Latvia* *Central Statistical Bureau* *SFRS* *National studies and expert judgment*	*LSFRI "Silava" in collaboration with Ministry of Agriculture and LULST*
Waste	*Latvian Environment, Geology and Meteorology Centre "3-Waste" and "2-Water" databases;* *Methane recovery installations;* *CSB.*	*LEGMC Chemicals and Hazardous Waste division,* *LEGMC Inland Waters Division*

1.4.2 KP-LULUCF inventory

The NFI is the main data provider for the GHG reporting in LULUCF sector and activities listed in Kyoto protocol Article 3, paragraph 3 and paragraph 4 (Article 3.3 and 3.4).

The land use matrix is based on the results of land use changes to and from forest land derived from four cycles of the NFI (2004-2008, 2009-2013 and 2014-2018 and 2019-2020, the first two years of 4th cycle). Land use changes are determined according to the methodology elaborated by Krumsteds et al. (2019)[7]. Methodology for estimation of earlier land use changes (including deforestation activities) is developed in the LSFRI Silava as a part of the NFI.

Historical figures of deforestation were estimated using remote sensing methods. LANDSAT satellite image series from 1990, 1995 and 2000 were geographically referenced to fit to the actual location of sample plots before satellite image analysis and non-guided classification of vegetation types. The information is updated in the study by Krumsteds et al. (2019).

[7] *Krumsteds, L. L., Ivanovs, J., Jansons, J., & Lazdiņš, A. (2019). Development of Latvian land use and land use change matrix using geospatial data of National forest inventory. Agronomy Research, 17. https://doi.org/10.15159/AR.19.195.*

Forest soil properties (carbon stock in litter and mineral soil) in forest lands were determined in permanent 16 x 16 km grid of 95 sample plots of the 1st level forest monitoring programme. No soil carbon stock changes are considered in afforested lands, according to research data demonstrating insignificant carbon stock differences in forest land and grassland.

Methods for estimating carbon stock changes in forests for Article 3.3 afforestation, reforestation, deforestation and Article 3.4 forest management are the same as those used for the LULUCF inventory reported under the UNFCCC. Estimations of carbon stock changes in living biomass on Forest Land Remaining Forest Land in the 1st cycle of the NFI are based on measurements of radial increment of growing trees and calculation of actual gross increment of timber volume of all living trees; in the second, third and fourth, "floating", periods increment is calculated as stock difference of living trees; mortality is accounted as the stock of trees changing status (destiny) from living trees to dead and left in the stand; harvesting stock is accounted as stock of trees changing status (destiny) to dead and extracted. The NFI data are harmonized with the SFS data provided information by application of linear factor to the whole accounting period.

Since research data are available, historical figures (before 2004) on mortality are recalculated and provided in the inventory considering 20 years decay period for dead biomass, respectively; calculations are made for the period 1970-2020. Removals of CO_2 in living biomass on afforested areas are calculated on the base of the NFI data on growth rate and mortality in afforested lands.

No harvesting takes place in lands converted to forests; therefore no removals and emissions are reported in HWP in this category. However, if by some reason (for instance, thinning) harvesting took place on afforested area it is also reported in national statistics and included in Forest management related carbon stock changes.

Losses in living biomass due to deforestation are reported based on average growing stock in deforested land during the corresponding NFI cycle. All biomass, including stem, branches and below-ground biomass is considered instantly oxidized and extracted from HWP as proportion of harvest rate.

Carbon stock changes in dead wood, litter and soils are reported under deforestation assuming that average carbon stock on forest lands remaining forest in dead biomass pools is instantly oxidizing during conversion. Carbon stock change (CSC) in mineral soils are estimated using Equation 2.25 of the 2006 IPCC Guidelines assuming that carbon accumulated in upper 30 cm (82.6 tonnes C ha^{-1} according to the forest soil monitoring project BioSoil) partially turns into emissions within 20 years.

1.4.3 European Union Emission Trading System (EU ETS) data

The EU emissions trading system (EU ETS) is a cornerstone of the EU's policy to combat climate change and it is its key tool for reducing greenhouse gas emissions cost-effectively.

Set up in 2005, the EU ETS is the world's first international emissions trading system, and is now the second largest one, accounting for about one-quarter of international carbon trading.

Phase 1 (2005-2007)

This was a 3-year pilot of 'learning by doing' to prepare for phase 2, when the EU ETS would need to function effectively to help the EU meet its Kyoto targets.

Phase 2 (2008-2012)

Phase 2 coincided with the first commitment period of the Kyoto Protocol, where the countries in the EU ETS had concrete emissions reduction targets to meet.

Phase 3 (2013-2020)

Similarly to phase 2, phase 3 coincided with the second commitment period of the Kyoto Protocol, where the countries in the EU ETS had concrete emissions reduction targets to meet.

Phase 4 (2021-2030)

The EU ETS is currently in it's fourth phase, with an EU-wide GHG emission reduction target of 43% by 2030 for the sectors covered by the EU ETS, compared to 2005 levels. In it's fourth phase the EU ETS has more targeted free-allocation as well as more robust and fair rules to address the risk of carbon leakage.

Latvia has fully implemented the Directive 2003/87/EC[8] of the European Parliament and of the Council establishing a scheme for GHG emission allowance trading within the Community, as well as any related legal acts that have amended this Directive.

Latvia implemented the EU ETS and set all the requirements in 2003 and 2004 when amendments in Law On Pollution were made and all the necessary Cabinet of Ministers regulations were approved for the stationary installations – monitoring, reporting, verification and compliance obligations, and creating the possibility of voluntary participation for the installations not exceeding thermal input of 20 MW. Since then a total of 93 installations have received GHG permits. Operation of EU ETS in Latvia is ensured mainly by the MEPRD and institutions under the supervision of MEPRD – namely the State Environmental Service that is responsible for approval of monitoring plans, issuance of permits, and approval of annual emission reports for stationary installations and LEGMC, which is Latvia's National Administrator of ETR (Union Registry since 2012).

Since 2008 (Kyoto Protocol's 1st period) the EU ETS was linked to the international emissions trading under the Kyoto Protocol. The scope of the EU ETS was expanded but in Latvia no new installation was included in EU ETS due to enlarged scope.

Since 2012 the aviation activities have also been included in the EU ETS regarding all aircraft operators that perform flights to/from EU. However, in 2013 exemptions were created applied to the flights to/from countries outside European Economic Area (EEA) so in 2013-2017 only internal flights to/from EEA countries as well as to/from aerodromes in the outermost region are included in the EU ETS scope. The current derogation from the EU ETS obligations for flights to and from third countries is extended until 31 December 2023, subject to review, to allow the experience necessary for the implementation of the International Civil Aviation Organization scheme (global market-based measure) to be gathered.

[8] *Directive 2003/87/ec of the European Parliament and of the Council. Available: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02003L0087-20140430&from=EN*

The Civil Aviation Agency (institution under the purview of the Ministry of Transport) is the main competent authority responsible for approval of monitoring plans and approval of annual emission reports for aircraft operators while MEPRD is fully responsible regarding the implementation of the requirements for the aviation activities in EU ETS.

The Latvian National Accreditation Bureau, an institution under the supervision of the Ministry of Economy, is responsible for accreditation and monitoring of verifiers.

Starting in 2013 in EU ETS Phase 3 the scope was again extended and three new installations of Latvia started operations in the EU ETS. Starting in phase 3, the emission allowances are mainly auctioned. European Commission developed new harmonized requirements for the calculation and allocation of the EU allowances in 2011, and in 2012 harmonized requirements for monitoring, reporting, accreditation and verification were developed. Harmonized templates for monitoring plan, emission report (and tonnkilometer reports for aircraft operators), verification report as well as templates for emission allocation calculation and reporting were developed by the European Commission. Latvia uses these developed harmonized templates. Since 2013 the MEPRD monitors, controls, and recalculates the annual free allocation amounts, based on activity level data.

For phase 4, the EU ETS scope was not revised, but other revisions took place to ensure better functioning of the EU ETS. The linear reduction factor was raised from 1.74% to 2.2% to increase the pace of emissions cuts. The carbon leakage rules were also revised, to ensure better targeted allocation of free allowances. In sectors that are not considered at risk of carbon leakage, allowances allocated free of charge would be capped at 30 % of predicted allowance need of the operator.

In January 2020, the linking agreement between the EU ETS and the Swiss ETS came into force, allowing for allowances to be used between both registries. Additionally, this also means that the EU ETS now covers flights from the EEA to Switzerland. In 2005 Latvia's Emission Trading Registry was developed and launched. Unified emission trading registry system was developed and launched in 2012 so all EU Member States use the same registry for EU ETS compliance activities.

The EU ETS data obtained from annual emission reports submitted by operators to the competent authority is used as source of activity and emission data for the GHG inventory, particularly in Energy and Industrial Processes and Product use sectors. All emission reports are available on the web page of the competent authority and are fully available for the GHG inventory.

In 2020, there were 61 stationary installations in Latvia and 1 aircraft operator of EU ETS was set as administered by Latvia. Latvia`s verified ETS emissions in 2020 were 2021.99 kt CO_2 eq.

1.5 *BRIEF DESCRIPTION OF KEY CATEGORIES, INCLUDING FOR KP-LULUCF*

1.5.1 GHG inventory

This section provides an overview of key categories (Table 1.4).

For 2022 submission, Approach 1 and Approach 2 according to the 2006 IPCC Guidelines are used to identify key categories for period of time 1990-2020. The identification was divided in two parts, key categories excluding LULUCF and key categories including LULUCF source categories. The starting point for the choice of source categories with LULUCF is the list presented in the 2006 IPCC Guidelines, Chapter 4 Methodological Choice and Identification of Key Categories (Table 4.1). In Latvia`s case list of IPCC categories is modified to reflect particular national circumstances, for example, types of fuels in transport, more disaggregated agricultural categories (by animal species) and more disaggregated LULUCF categories (by taking into account soil type etc.) Such modifications have been made to clarify the key categories. Key category analysis is an important element for planning and prioritization of necessary inventory improvements.

The base year for CO_2, CH_4, and N_2O greenhouse gas emissions is 1990.

Indircet CO_2 emissions are not included in the key category analysis.

Summary of key categories is shown in Table 1.4.

Table 1.4 Key categories in 2022 submission[9]

IPCC category	Gas	Identification criteria	with LULUCF	without LULUCF
1.A.1.a Public Electricity and Heat Production - Biomass Fuels	*N_2O*	*L1,L2,T1,T2*		*X*
1.A.1.a Public Electricity and Heat Production - Biomass Fuels	*CH_4*	*T2*		*X*
1.A.1.a Public Electricity and Heat Production - Gaseous Fuels	*CO_2*	*L1,L2,T1,T2*	*X*	*X*
1.A.1.a Public Electricity and Heat Production - Liquid Fuels	*CO_2*	*T1,T2*	*X*	*X*
1.A.1.a Public Electricity and Heat Production - Peat	*CO_2*	*T1,T2*	*X*	*X*
1.A.1.a Public Electricity and Heat Production - Solid Fuels	*CO_2*	*T1*	*X*	*X*
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels	*CO_2*	*L1*		*X*
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Peat	*CO_2*	*T1*		*X*
1.A.2.a Iron and Steel - Gaseous Fuels	*CO_2*	*T1,T2*	*X*	*X*
1.A.2.a Iron and Steel - Liquid Fuels	*CO_2*	*T1*	*X*	*X*
1.A.2.a Iron and Steel - Other fossil fuels	*CO_2*	*T1,T2*		*X*
1.A.2.c Chemicals - Liquid Fuels	*CO_2*	*T1,T2*	*X*	*X*
1.A.2.d. Pulp, Paper and Print - Gaseous Fuels	*CO_2*	*T1*	*X*	*X*
1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels	*CO_2*	*L1,T1*	*X*	*X*
1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels	*CO_2*	*T1,T2*	*X*	*X*
1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels	*CO_2*	*T1*	*X*	*X*
1.A.2.f Non-metallic Minerals - Gaseous Fuels	*CO_2*	*L1,T1*	*X*	*X*
1.A.2.f Non-metallic Minerals - Liquid Fuels	*CO_2*	*T1,T2*	*X*	*X*
1.A.2.f Non-metallic Minerals - Other Fossil Fuels	*CO_2*	*L1*	*X*	*X*
1.A.2.f Non-metallic Minerals - Solid Fuels	*CO_2*	*L1,T1*	*X*	*X*
1.A.2.g Other - Biomass Fuels	*N_2O*	*T2*		*X*
1.A.2.g Other - Biomass Fuels	*CH_4*	*T2*		*X*

[9] *Table 1.4 since NIR 2018 was slightly modified by combining columns A and B of Table 4.4 of the 2006 IPCC Guidelines, which does not change the information reported, and also columns "with LULUCF" and "without LULUCF" were added to show the conditions in which a category is selected as a key one*

IPCC category	Gas	Identification criteria	with LULUCF	without LULUCF
1.A.2.g Other - Gaseous Fuels	CO_2	L1,T1,T2	X	X
1.A.2.g Other - Liquid Fuels	CO_2	L1,T1,L2,T2	X	X
1.A.3.b Road Transportation - Diesel Oil	CO_2	L1,L2,T1,T2	X	X
1.A.3.b Road Transportation - Diesel Oil	N_2O	L1,L2,T1,T2		X
1.A.3.b Road Transportation - Gasoline	CO_2	L1,L2,T1,T2	X	X
1.A.3.b Road Transportation - LPG	CO_2	L1,T1,T2	X	X
1.A.3.c Railways - Liquid Fuels	CO_2	L1,T1	X	X
1.A.3.c Railways - Liquid Fuels	N_2O	T2		X
1.A.4.a Commercial/Institutional - Gaseous Fuels	CO_2	L1,L2,T1,T2	X	X
1.A.4.a Commercial/Institutional - Liquid Fuels	CO_2	L1,L2,T1,T2	X	X
1.A.4.a Commercial/Institutional - Peat	CO_2	T1		X
1.A.4.a Commercial/Institutional - Solid Fuels	CO_2	T1,T2	X	X
1.A.4.a Commercial/Institutional - Liquid Fuels	N_2O	T2	X	X
1.A.4.b Residential - Biomass Fuels	CH_4	L1,L2,T1,T2	X	X
1.A.4.b Residential - Gaseous Fuels	CO_2	L1,L2,T1,T2	X	X
1.A.4.b Residential - Liquid Fuels	CO_2	L1,L2,T1	X	X
1.A.4.b Residential - Solid Fuels	CO_2	T1,T2	X	X
1.A.4.b Residential - Solid Fuels	CH_4	T2		X
1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels	CO_2	L1,T1,T2	X	X
1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels	CO_2	L1,L2,T1,T2	X	X
1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels	N_2O	L1,L2,T1,T2		X
1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels	CO_2	T1	X	X
1.B.2.b Natural Gas	CH_4	L1,L2,T1,T2	X	X
2.A.1. Cement Production	CO_2	L1,L2,T1,T2	X	X
2.A.2. Lime Production	CO_2	T1,T2	X	X
2.A.4. Other process uses of carbonates	CO_2	T1		X
2.C.1 Iron and Steel Production	CO_2	T1		X
2.D.3. Solvent Use	CO_2	L1,T2		X
2.F.1. Refrigeration and air conditioning	HFCs	L1,L2	X	X
3.A.1 Enteric Fermentation - Cattle	CH_4	L1,L2,T1,T2	X	X
3.B.1.1 Manure Management - Cattle	CH_4	L1,L2,T1,T2	X	X
3.B.2.1 Manure Management - Cattle	N_2O	L1,L2,T1,T2		X
3.B.2.3 Manure Management - Swine	N_2O	T2		X
3.B.5 Indirect N_2O emissions from Manure Management	N_2O	L1,L2,T2	X	X
3.D.1. Direct N2O emissions from managed soils	N_2O	L1,L2,T1,T2	X	X
3.D.2 Indirect N_2O Emissions from managed soils	N_2O	L1,L2,T1,T2	X	X
3.G. Liming	CO_2	L1,L2,T1,T2	X	X
4.A.1 Forest Land Remaining Forest Land – Carbon stock change, dead wood	CO_2	L1,L2,T1,T2	X	
4.A.1 Forest Land Remaining Forest Land – Carbon stock change, living biomass	CO_2	L1,L2,T1,T2	X	
4.A.1 Forest Land Remaining Forest Land – Carbon stock change, organic soil	CO_2	L1,L2,T1,T2	X	
4.A. Forest land – 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils, total organic soils	CO_2	L1,L2	X	

IPCC category	Gas	Identification criteria	with LULUCF	without LULUCF
4.A. Forest land – 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils, total organic soils	N_2O	L1,L2,T1,T2	X	
4.A. Forest land – 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils, total organic soils	CH_4	L1,L2,T1,T2	X	
4.A.2 Land Converted to Forest Land – Carbon stock change, living biomass	CO_2	L1,T1	X	
4.B. Cropland 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	L1,L2,T2	X	
4.B.1 Cropland remaining Cropland – Carbon stock change, organic soil	CO_2	L1,L2,T1,T2	X	
4.B.1 Land converted to Cropland – Carbon stock change, forest land converted to cropland, dead organic matter	CO_2	L1	X	
4.B.1 Cropland remaining Cropland – Carbon stock change, living biomass	CO_2	L1,L2	X	
4.B.2 Land converted to Cropland – Carbon stock change, organic soil	CO_2	L1,L2,T1,T2	X	
4.C. Grassland – 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	L1,L2,T2	X	
4.C.1 Grassland remaining Grassland – Carbon stock change, organic soil	CO_2	L1,L2,T1,T2	X	
4.C.1 Grassland remaining Grassland – Carbon stock change, living biomass	CO_2	L2,L2,T1,T2	X	
4.C.2 Land converted to Grassland – Carbon stock change, organic soil	CO_2	L1,L2,T1,T2	X	
4.C.2 Land converted to Grassland – Carbon stock change, forest land converted to grassland, living biomass	CO_2	L1	X	
4.C.2 Land converted to Grassland – Carbon stock change, forest land converted to grassland, dead organic matter	CO_2	L1,L2	X	
4.D. Wetlands 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils, Peat extraction from lands, rewetted organic soils	CO_2	L2,T2	X	
4.D. Wetlands 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils, Peat extraction from lands, rewetted organic soils	CH_4	L1,L2,T2	X	
4.D. Wetlands 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils, Peat extraction from lands, drained organic soils	CO_2	L1,L2,T1	X	
4.D.1 Wetlands remaining Wetlands – Carbon stock change, dead organic matter	CO_2	L1,T1	X	
4.D.1 Wetlands remaining Wetlands – Carbon stock change, living biomass	CO_2	T1,T2	X	
4.D.1 Wetlands remaining Wetlands – Carbon stock change, organic soils	CO_2	L1,L2	X	
4.D.2 Land Converted to Wetland - Carbon stock change, organic soils	CO_2	L2,T2	X	
4.E.1 Settlements remaining Settlements – Carbon stock change, living biomass	CO_2	L1,L2,T1,T2	X	
4.E.2 Land converted to Settlements – Carbon stock change, dead organic matter	CO_2	L1	X	

IPCC category	Gas	Identification criteria	with LULUCF	without LULUCF
4.E.2 Land converted to Settlements – Carbon stock change, living biomass	CO_2	L1,L2,T2	X	
4.E.2 Land converted to Settlements – Carbon stock change, mineral soils	CO_2	L1	X	
4.E.2 Land converted to Settlements – Carbon stock change, organic soils	CO_2	L1,L2,T1,T2	X	
4.E.2 Lands converted to settlements – Direct nitrous oxide (N_2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils	N_2O	L1,L2,T1,T2	X	
4.G. Harvested Wood Products	CO_2	L1,L2,T1,T2	X	
5.A.1. Managed Waste Disposal on Land	CH_4	L1,L2	X	X
5.A.2. Unmanaged Waste Disposal Sites	CH_4	L1,L2,T1,T2	X	X
5.B.1. Composting	CH_4	L1,L2,T1,T2		X
5.B.1. Composting	N_2O	L2,T2		X
5.B.2. Anaerobic digestion at biogas facilities	CH_4	L2		X
5.D.1 Domestic Wastewater	CH_4	L1,L2,T1,T2	X	X
5.D.1 Domestic Wastewater	N_2O	L1		X
5.D.2 Industrial Wastewater	CH_4	T1,T2	X	X

Key categories identified in Latvia`s GHG inventory slightly differs from the CRF Reporter Table 7 because key categories in the GHG inventory is a combination of categories from both Approaches 1 and 2, whereas in the CRF Reporter key categories are calculated only by using Approach 1.

Results of the key category analysis are important because they guide decisions for the methodological choice (together with uncertainty analysis, see Section 1.6). The goal is to find IPCC categories that are the most important in terms of the emissions level and the trend. This list (Table 1.4) forms the basis of discussions with the sectoral experts on the quality of the estimates and possible need for improvement. The key categories are also subject to more detailed documentation and quality control.

1.5.2 KP-LULUCF inventory

There were several key categories in KP-LULUCF. The most significant key categories of emissions and removals in KP-LULUCF in 2020 were:

- CSC in living biomass;
- Dead organic matter and organic soils under Forest Management;
- Deforestation and Afforestation/Reforestation;
- CSC in HWP.

Other key categories are CO_2, N_2O and CH_4 emissions from drainage and rewetting of organic soils under Forest Management and N_2O emissions from N mineralization/immobilization associated with loss of soil organic matter under Deforestation.

1.6 *GENERAL UNCERTAINTY EVALUATION*

1.6.1 GHG inventory

This section provides an overview of the approach to uncertainty analysis for Latvia's inventory.

The uncertainty estimates of the 2022 submission have been made according to Approach 1 method presented in the 2006 IPCC Guidelines. The Approach 1 is based on emission estimates and uncertainty coefficients for activity data and emission factors. The mandatory, detailed reporting tables of the uncertainty analysis (Table 3.3 of volume 1 of the 2006 IPCC Guidelines with and without LULUCF) are provided in Annex 2 of this submission.

The uncertainty analysis was prepared for all the sectors: Energy, Industrial Processes and Product Use, Agriculture, Waste and LULUCF. Uncertainties are estimated for direct GHG, e.g. CO_2, CH_4, N_2O and F-gases only.

The results of the uncertainty analysis are used to prioritise inventory improvements in association with the key category analysis.

Results of uncertainties analysis

In 2022, submission total uncertainties are reflected in the Table 1.5.

Table 1.5 Uncertainties of 2022 submission

	Uncertainty in total inventory %	Trend uncertainty %
With LULUCF	*23%*	*14%*
Without LULUCF	*6%*	*2%*

Uncertainties of <u>activity data</u> are taken from:

- CSB (generally 2% uncertainty is used according to received information from CSB);
- GHG reports from enterprises operating within EU ETS;
- Information by companies;
- NFI.

In some cases uncertainty of activity data is calculated using trend line and measured data (Waste sector).

Uncertainties of <u>emission factors</u> are taken from:

- 2006 IPCC Guidelines;
- IPCC Wetlands Supplement;
- Expert judgments;
- NFI;
- Specific research results.

All sources of uncertainties are documented and referenced.

The uncertainty calculation is based on Excel file, that is annually sent to sectoral experts for updating. Responsible experts are requested to go through uncertainties and make an updates if necessary. When the information is received from experts, the inventory compiler summarizes all the uncertainties and makes the uncertainty analysis. For each source, the combined uncertainty for activity data and emission factors were estimated and given in percent.

In the annual meeting at the beginning of the inventory cycle the experts are advised to go through the uncertainty ranges of activity data and emissions factors in order to prioritize inventory improvements.

Within the project of EEA Financial Mechanism 2009-2014 Programme "National Climate Policy" the Monte Carlo model has been developed inside of the integrated database that covers climate change and air quality data. Work on the implementation of the database is still ongoing. Hence it is planned to use Monte Carlo model in uncertainty evaluation when integrated database will be fully tested.

Detailed information about uncertainty assessment is described under each subsector.

Base year (1990) uncertainties

Annex I Parties shall quantitatively estimate the uncertainty of the data used for all source and sink categories using at least approach 1, as provided in the 2006 IPCC Guidelines, and report uncertainties for the base year. Latvia has included an overview of uncertainties in the base year in Annex 2.

The improvement of uncertainties in the base year is still ongoing in order to obtain the most accurate uncertainties for 1990.

Table 1.6 shows the uncertainties in the base year (Approach 1).

Table 1.6 Assessment of uncertainties in 1990 emissions

	Uncertainty for 1990 %
With LULUCF	*25%*
Without LULUCF	*4%*

1.6.2 KP-LULUCF inventory

Tier 1 was implemented for estimating uncertainty rates related to activity data and emission factors employed in the estimates under Article 3.3. and 3.4. activities. More information available under the Part II of this submission in Chapter 11.3.1.5 Uncertainty estimates.

1.7 *GENERAL ASSESSMENT OF COMPLETENESS*

1.7.1 GHG inventory

Latvia has provided estimates for all significant IPCC source and sink categories according to the detailed CRF classification. Estimates are provided for the following gases: CO_2, N_2O, CH_4, F-gases (HFC, PFC, SF_6 and NF_3), NMVOC, NO_x, CO and SO_2. No additional sources and sinks have been identified.

In accordance with the IPCC Guidelines, international aviation and marine bunker fuel emissions are not included in national totals.

The notation keys presented below are used to fill in the blanks in all the tables in the CRF. Notation keys used in the NIR are consistent with those reported in the CRF.

NE (not estimated):

"NE" is used for existing emissions by sources and removals by sinks of GHG that have not been estimated.

IE (included elsewhere):

"IE" is used for emissions by sources and removals by sinks of GHG that have been estimated but included elsewhere in the inventory instead of the expected source/sink category.

NA (not applicable):

"NA" is used for activities in a given source/sink category that do not produce emissions or emissions are negligible.

C (confidential):

"C" is used for emissions that could lead to the disclosure of confidential information classified in the National legislation if reported at the most disaggregated level. In this case a minimum of aggregation is required to protect business information.

Table 1.7 represents categories reported as "not estimated" (NE) in 2022 submission. Emissions/removals are not estimated mainly due to lack of available IPCC methodologies and/or lack of activity data as well as gases and categories considered insignificant.

Table 1.7 Sources and sinks not estimated ("NE") in 2022 submission

Sources and sinks not estimated ("NE")			
GHG	Sector	Source/sink category	Explanation
CH_4	Agriculture	*3.D Agricultural Soils*	*Emissions are neglible (explanation is provided in NIR)*
CH_4	Waste	*5.C Incineration and Open Burning of Waste/5.C.1 Waste Incineration/5.C.1.2 Non-biogenic/5.C.1.2.b Other (please specify)*	*Emissions are negligible (explanation is provided in NIR chapter 7.4.1.1.)*
CH_4	Waste	*5.C Incineration and Open Burning of Waste/5.C.2 Open Burning of Waste/5.C.2.1 Biogenic/5.C.2.1.a Municipal Solid Waste*	*Emissions are neglible (explanation is provided in NIR)*
CH_4	Waste	*5.C Incineration and Open Burning of Waste/5.C.2 Open Burning of Waste/5.C.2.2 Non-biogenic/5.C.2.2.a Municipal Solid Waste*	*Emissions are neglible (explanation is provided in NIR)*
CH_4	Waste	*5.C Incineration and Open Burning of Waste/5.C.2 Open Burning of Waste/5.C.2.2 Non-biogenic/5.C.2.2.b Other (please specify)*	*Emissions are neglible (explanation is provided in NIR)*
CO_2	Agriculture	*3.I Other Carbon-containing Fertilizers*	*The amount of emissions is negligible.*
CO_2	Waste	*5.C Incineration and Open Burning of Waste/5.C.2 Open Burning of Waste/5.C.2.1 Biogenic/5.C.2.1.a Municipal Solid Waste*	*Emissions are neglible (explanation is provided in NIR)*
CO_2	Waste	*5.C Incineration and Open Burning of Waste/5.C.2 Open Burning of Waste/5.C.2.2 Non-biogenic/5.C.2.2.a Municipal Solid Waste*	*Emissions are neglible (explanation is provided in NIR)*

Sources and sinks not estimated ("NE")			
GHG	Sector	Source/sink category	Explanation
CO_2	Waste	*5.C Incineration and Open Burning of Waste/5.C.2 Open Burning of Waste/5.C.2.2 Non-biogenic/5.C.2.2.b Other (please specify)*	*Emissions are neglible (explanation is provided in NIR)*
N_2O	Waste	*5.C Incineration and Open Burning of Waste/5.C.2 Open Burning of Waste/5.C.2.1 Biogenic/5.C.2.1.a Municipal Solid Waste*	*Emissions are neglible (explanation is provided in NIR)*
N_2O	Waste	*5.C Incineration and Open Burning of Waste/5.C.2 Open Burning of Waste/5.C.2.2 Non-biogenic/5.C.2.2.a Municipal Solid Waste*	*Emissions are neglible (explanation is provided in NIR)*
N_2O	Waste	*5.C Incineration and Open Burning of Waste/5.C.2 Open Burning of Waste/5.C.2.2 Non-biogenic/5.C.2.2.b Other (please specify)*	*Emissions are neglible (explanation is provided in NIR)*

1.7.2 Completeness by geographical coverage

All statistical data sources covers the whole territory of Latvia, therefore, the GHG inventory represents the whole country.

1.7.3 Completeness by timely coverage

A complete set of CRF tables are provided for all years and the estimates are calculated in a consistent manner.

2 TRENDS IN GREENHOUSE GAS EMISSIONS

Detailed information on emission trends is provided in the description of IPCC sectors in chapters 3-7 and in the CRF trend tables.

2.1 *DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS FOR AGGREGATED GREENHOUSE GAS EMISSIONS*

As illustrated in Figure 2.1, since 1990 Latvia's GHG emissions have considerably decreased by 59.6% (excluding LULUCF, with indirect CO_2) and by 18.4% including LULUCF, with indirect CO_2. This decrease has influenced the economic situation in the country. In Latvia the transition period to market economy started after 1991. This process caused essential changes in all sectors of national economy and resulted in decrease of GHG emissions after 1990.

In 2020, the GHG emissions excluding LULUCF, including indirect CO_2 in Latvia constituted 10459.72 kt CO_2 eq. The main GHG emission source in Latvia is Energy sector (64.8%) followed by Agriculture (21.5%), IPPU (8.3%) and Waste (5.2%).

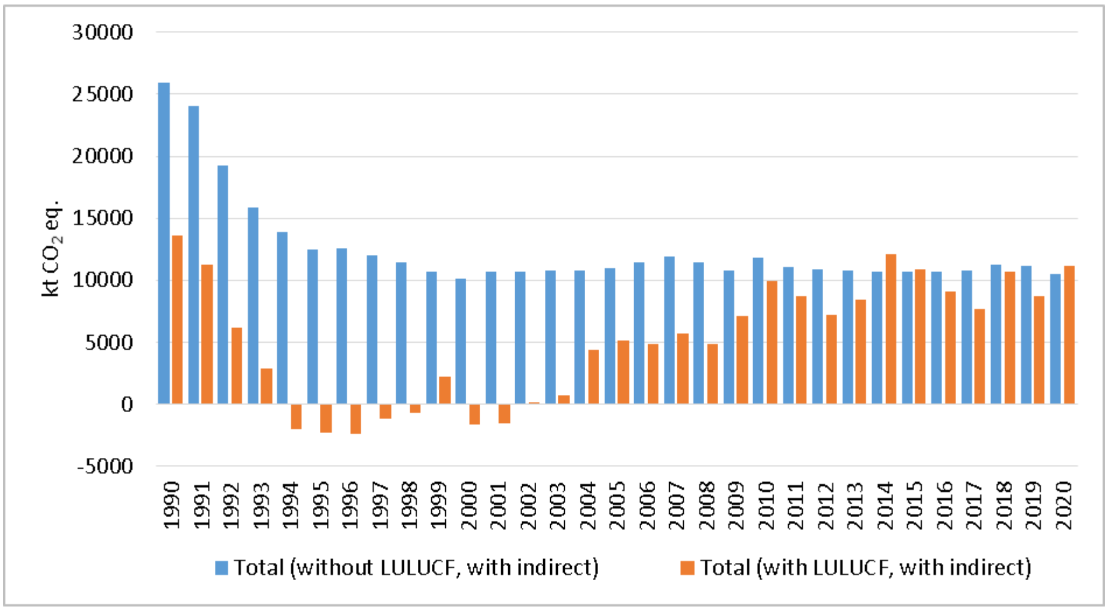

Figure 2.1 Latvia`s aggregated GHG emissions in 1990-2020 (kt CO_2 eq.)

In contrast, GHG emissions from the LULUCF sector since 1990 has fluctuated. These changes are driven mostly by reduction of CO_2 removals in living biomass due to increase of harvest rate and ageing of forests, increasing of mortality in mature forests. If compared to 1990, both figures are significantly increased since 1990; respectively, average mortality rate (stem volume) in forest in 1990 was 1.29 m^3 ha^{-1} annually, now (in 2020) it is 1.86 m^3 ha^{-1} annually, but felling rate in 1990 was 6.3 mill. m^3 annually, now it is 17.7 mill. m^3 (in 2020, excluding deforestation). LULUCF sector is also heavily affected by land use changes – in 1990s considerable area of afforested lands was converted back to agricultural production, however, in recent decade another trend is growing – conversion of forest land to settlements to build roads, industrial centers and other infrastructure.

2.2 *DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS BY GAS*

Carbon dioxide (CO_2) is the main GHG causing climate change. In 2020, CO_2 emissions constituted 67.0% of Latvia's total GHG emissions (without indirect CO_2 emissions) (Figure 2.2). In 2020, total CO_2 eq. emissions without LULUCF and indirect CO_2 emissions decreased by 64.4% compared to 1990.

The most important source of CO_2 emissions (kt) in 2020 was fossil fuel combustion – 90.4%, including Energy Industries – 19.0%, Manufacturing Industries and Construction – 8.7%; Transport – 43.9% and Other sectors (Agriculture, Forestry, etc.) – 18.6%.

Other anthropogenic emission sources of CO_2 are Industrial Processes and Product Use – 8.6%, Agriculture 1.0% and Waste 0.0006%.

Main sources of CH_4 emissions in Latvia are Enteric Fermentation of Livestock, Solid Waste Disposal Sites and Energy sector. Other important sources of CH_4 emissions are leakage from natural gas pipeline systems and combustion of biomass. CH_4 emissions in 2020 contributed to 16.4% of total GHG emissions (excluding LULUCF, excluding indirect CO_2). Methane emissions (kt) decreased 52.6% in 2020 since 1990.

Agricultural soils are the main source of N_2O emissions in Latvia generating 83.8% of all N_2O emissions (kt) in 2020. Other N_2O emission sources are from Transport sector and, biomass, liquid and other solid fuel combustion in other Energy sectors, also IPPU and Waste sectors. Since 1990 total N_2O emissions had decreased by 43.0% in 2020, mainly due to decrease in the emissions from agriculture.

Emissions from HFCs and sulphur hexafluoride (SF_6) consumption are reported for the period of 1995-2020. Total HFCs emissions decreased by 2.4% in 2020 compared to 2019. Since 1995 HFC emissions have increased significantly due to substitution of ozone depleting substances in refrigeration and air conditioning as well as due to increase of cars, trucks and buses equipped with mobile air conditioners. SF_6 emissions from electrical equipment contributed to 11.94 kt CO_2 eq. in 2020. Emissions of the PFCs and NF_3 does not occur (NO) in Latvia for all time series.

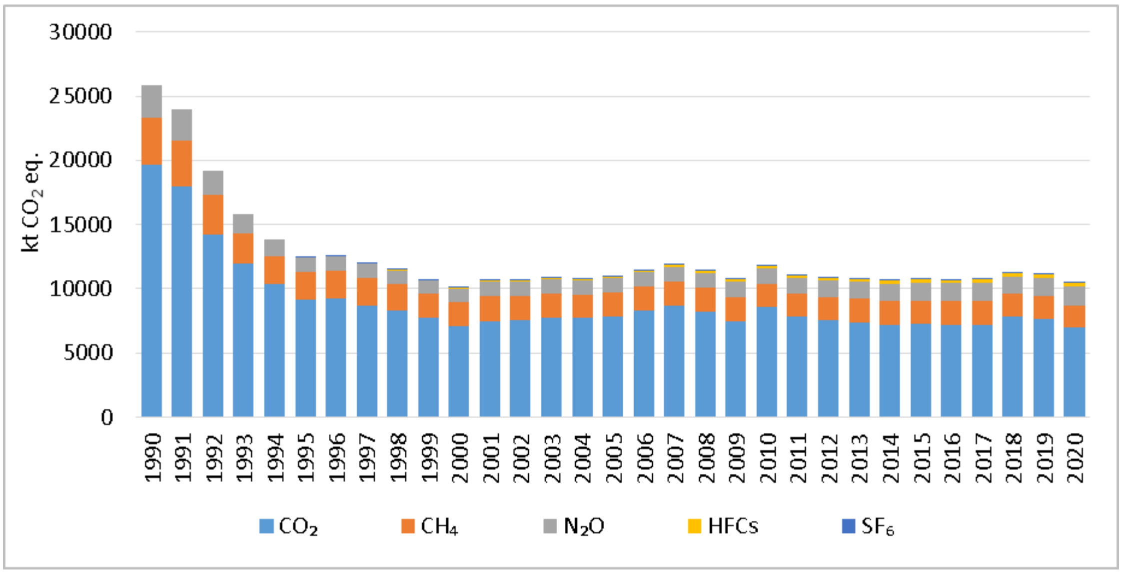

Figure 2.2 Trend in GHG emissions by gases (kt CO_2 eq.)

Emissions by sources are illustrated in Figure 2.3.

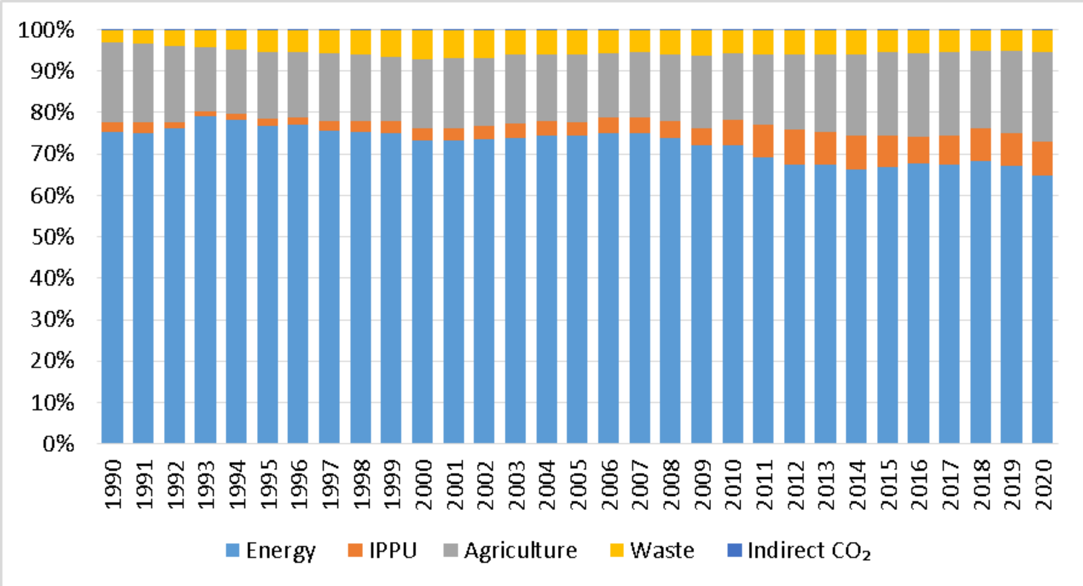

Figure 2.3 Latvia`s GHGs emissions by source 1990-2020 excluding LULUCF, including indirect CO_2

2.3 *DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS BY SECTOR*

2.3.1 Trends in ENERGY

Energy sector share of GHG emissions in 2020 is 64.8% or 6780.35 kt CO_2 eq. that makes it the largest emitter in Latvia. Emissions since 1990 in the Energy sector have decreased by 65.2%.

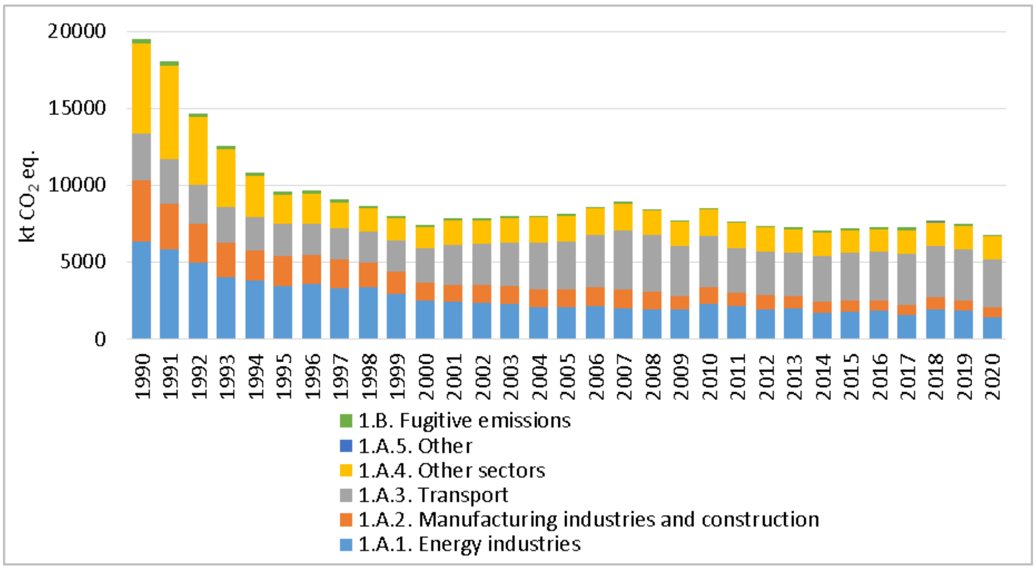

Figure 2.4 Trend in GHG emissions from Energy sector in 1990-2020 (kt CO_2 eq.)

Figure 2.4 shows GHG emission trends in Energy sector from 1990 to 2020. The most of the Energy sector emissions in 1990 were produced in the Energy Industries (32.4%) and the Other Sectors (Commercial/Institutional; Residential; Agriculture/Forestry/Fishing) (30.4%). In 2020 situation has changed and the largest GHG emitter is Transport sector with 45.8% from total GHG emissions emitted in Energy sector.

In 2020, emissions have decreased in Energy Industries by 78.3%, Manufacturing Industries and Construction by 83.4% and Other Sectors (Commercial /Institutional; Residential; Agriculture/Forestry/Fishing) by 74.2% since 1990. Only in Transport sector GHG emissions have increased (2.2%) in comparison with 1990. In CRF 1.B. sector Fugitive emissions from fuels sector the decrease in GHG emissions is 59.4%. One of the reasons for these changes, is fuel switching from coal and liquid fossil fuels that is used for combustion to biomass and natural gas, as well as amount of fuel consumed in sectors have changed. Use of biomass has increased more than 2 times and use of fossil fuels have significantly decreased - liquid fuel (-59.5%), solid fuel (-96.3%), peat (-98.44%) and natural gas (-62.1%) since 1990. The share of biomass has increased from 8.6% in 1990 to 38.2% in 2020. Biofuels (biodiesel and bioethanol) constitutes 4.2% of the total fuel consumption in the Transport sector in 2020.

Emissions in Energy sector in 2020 have decreased by 9.1% in comparison with previous year. Energy Industries have decreased by 25.0%, Manufacturing Industries and Construction by 2.4%, Transport sector by 6.7% and Other by 37.9% , but increase in emissions can be seen in sector Other Sectors (Commercial/institutional; Residential; Agriculture/forestry/fishing) by 1.5% and Fugitive emissions (oil and natural gas) by 2.6%.

After the decrease in the period 1990-1999, total GHG emissions from Transport sector had the rapid growth in the period 2000 – 2007 (Figure 2.5). Peak of GHG emissions in Transport sector has been recognized in 2007 when emissions exceeded 1990 level by 27.4%. The main reason for this increase of emissions was a sharp growth of economy and income of population, that resulted in an increase in the number of cars (mainly passenger cars).

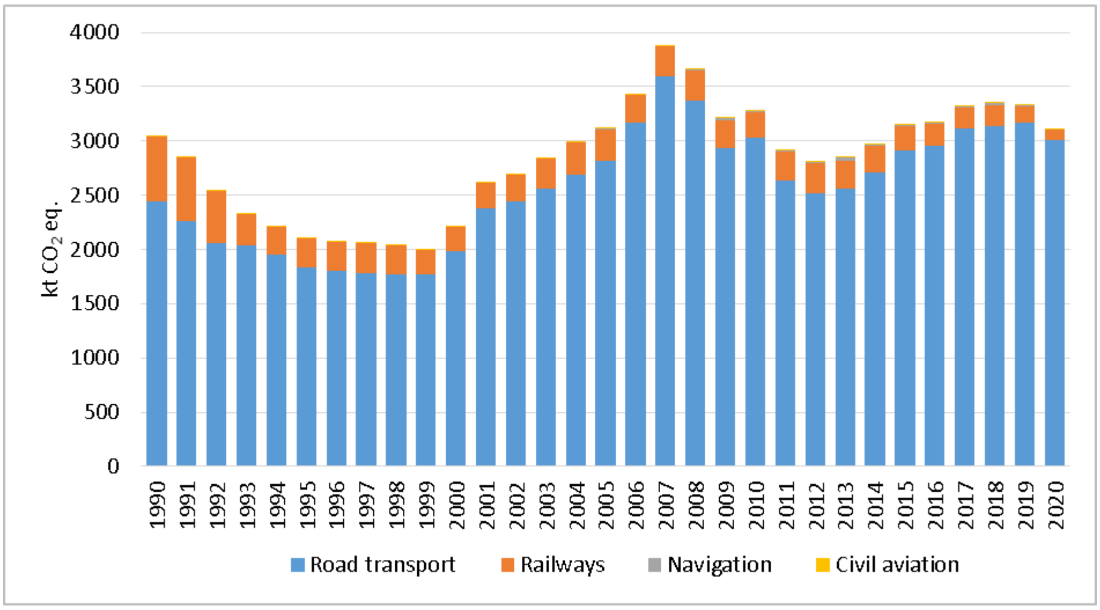

Figure 2.5 Trend in GHG emissions from Transport sector in 1990-2020 (kt CO_2 eq.)

Recession of the national economy was the major reason for decreasing of transport activities – decrease of mobitity parameters (passenger km by passenger cars and ton km by freight transport) - and corresponding GHG emission decreasing in the time period 2008–2009. GHG emissions have increased for time period 2013-2018 but from 2019 emissions have decreased.

In 2020, total GHG emissions in the Transport sector compared to 1990 have increased by 2.2% but decreased by 6.7% compared to 2019.

The decrease of emissions in 2020 in the Transport sector was caused mainly by the decreasing of road transport and railways emissions.

2.3.2 Trends in INDUSTRIAL PROCESSES AND PRODUCT USE

In 2020, IPPU sector contributed 8.3% of the total GHG emissions in Latvia or 868.15 kt CO_2 eq. Emissions from IPPU have increased by 32.3% since 1990 with significant fluctuations afterwards (Figure 2.6). Compared to 2019 emissions from IPPU sector in 2020 have decreased by 2.6%.

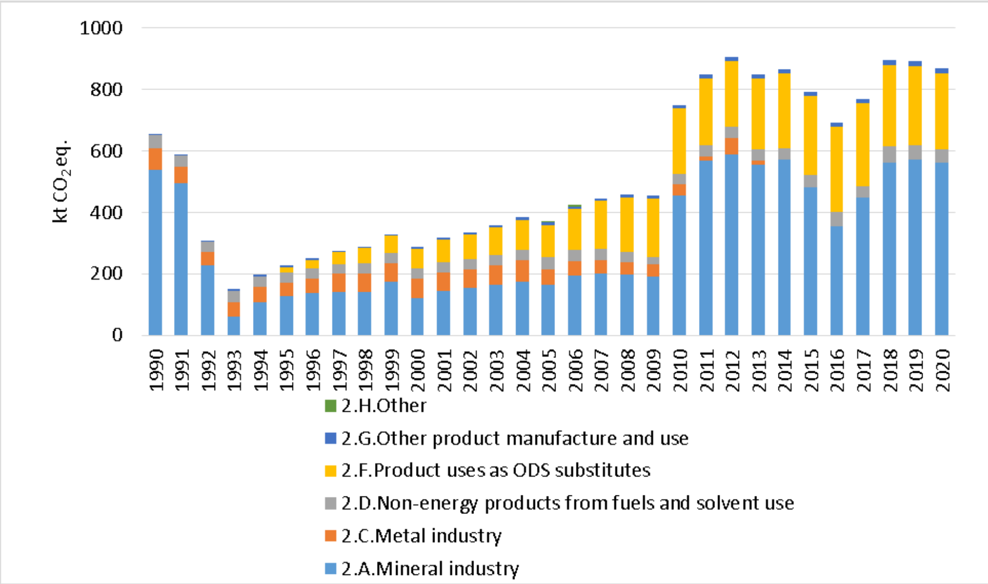

Figure 2.6 Trend in GHG emissions from IPPU sector in 1990-2020 (kt CO_2 eq.)

The largest part of GHG emissions in IPPU sector constitutes CO_2 emissions from 2.A Mineral industry (64.6% of total GHG emissions from IPPU sector and 5.4% from total CO_2 emissions without LULUCF, with indirect CO_2 in 2020). The second largest source is 2.F Product Uses as ODS Substitutes causing 28.7% from all the IPPU emissions and 2.4% from total GHG emissions without LULUCF, with indirect CO_2 in 2020. Considerably smaller are the rest of the IPPU emission sources – 2.G Other Product manufacture and use and 2.D Non energy products from fuels and solvents use, together constituting 6.7% from the entire IPPU emissions in 2020. 2.C Metal industry emissions are not occurring in Latvia since 2016, due to interruption of production in the only metal producing plant.

Data on emissions in IPPU sector are linked with the economic situation of the country as well as availability of statistical data. The largest decrease of emissions occurred between 1990 and 1993 when industry was affected by an economic crisis. In addition, at the beginning of 1990s during the countrywide changes of governmental system and national economy, statistics was not well kept. Therefore extrapolation is made for activity data in some subsectors.

GHG emissions from IPPU sector have increased from 286.55 kt CO_2 eq. in 2000 to 905.11 kt CO_2 eq. in 2012. It can be explained with sharp development of Latvian industry when construction activities increased and industrial production of building materials also increased.

Due to Latvia's economic features since 2007–2008 the industry development was slowing down as the financing and real estate sectors started to dominate the national economy. In 2010 compared to 2009 IPPU emissions increased by 64.4% mainly due to sharp increase of mineral industry emissions because the cement production plant changed their production technology and installations, increasing capacity by approximately 2.4 times.

1995 is the base year for F-gases under the Kyoto Protocol. The total F-gas emissions increased significantly since that time. The main reason that caused emission growth was substitution of ozone depleting substances (ODS) with F-gases in refrigeration and air conditioning appliances. The usage of products that substitute ODSs in Latvia mainly depends on import. The imported amounts could be associated with the economic situation in the country that consequently led to F-gases emission growth, especially in the latest years.

CO_2 emissions from Solvent Use sector have been constantly increasing during the later period 2009 till 2020. However, in 2020 CO_2 emissions of Solvent sector have decreased by 5.0% compared to 2019.

2.3.3 Trends in AGRICULTURE

In 2020, Agriculture sector contributed 21.5% of the total GHG emissions in Latvia or 2250.88 kt CO_2 eq. GHG emissions increased by 2.2% in 2020 compared to 2019 due to the increase of livestock and fertilizer use for crops. The trend of emissions in CO_2 eq. by category is presented in Figure 2.7. The annual emissions have reduced approximately by 54.9% since 1990 due to decrease in agricultural production, including livestock population, crop production and amounts of mineral fertilizer consumption.

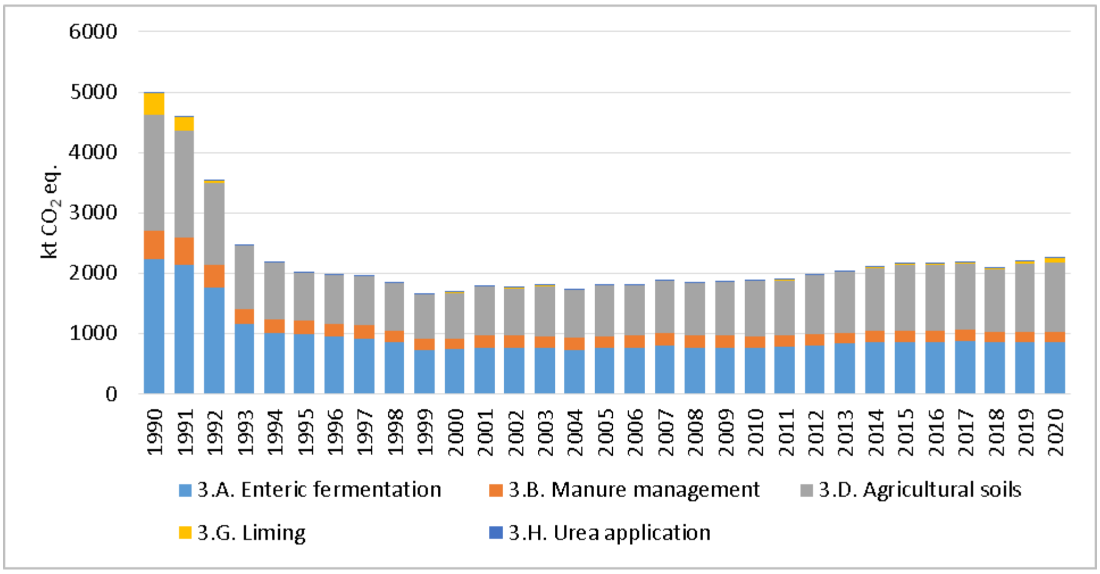

Figure 2.7 Trend in GHG emissions from Agriculture sector in 1990-2020 (kt CO_2 eq.)

Agricultural GHG emissions in Latvia consist of CH_4 emissions from enteric fermentation of domestic livestock, CH_4 and N_2O emissions from manure management, N_2O emissions from agricultural soils and CO_2 emissions from liming and urea application.

Emissions from agricultural soils contributed major share of the total emissions from the sector – 51.6%, enteric fermentation emissions was second largest source from the sector – 38.0%.

The share of manure management emissions was evaluated as 7.2% of total emissions in the sector, remaining 3.2% of emissions refer to liming and urea application.

2.3.4 Trends in LULUCF

In 2020, total emissions of aggregated GHGs in the LULUCF sector were 646.57 kt CO_2 eq. Aggregated net removals of the GHG were reduced by 105% in 2020 in comparison to 1990 mostly due to increase of harvest rate in mature forests, however considerable role in the increase of the GHG emissions has conversion of forest land to settlements, as well as conversion of naturally afforested lands to cropland and grassland. The land use conversion to cropland is associated mostly to removal of woody vegetation from naturally afforested farmlands abandoned in 1980s and 1990s. Although the increment of living biomass in forest land remaining forest land and afforested land is still larger than the carbon losses due to commercial felling and natural mortality, the gap between gains and losses is decreasing, causing reduction of the net removals of CO_2 in forest land. Hence, the total growing stock of living biomass is still increasing in forest lands. Summary of the net emissions including HWP is shown in Figure 2.8. Fluctuations in total GHG emissions during the last years (e.g. peak in 2014) mostly are associated with the annual changes in CO_2 removals in living biomass in forest land caused by changes in forest characteristics and related management (gross annual increment of living biomass, natural mortality, harvesting rate, etc.). The most important impact factor is harvesting rate (e.g. peaks in 1999 and 2014) that is also the main cause of net emission fluctuation between the last years.

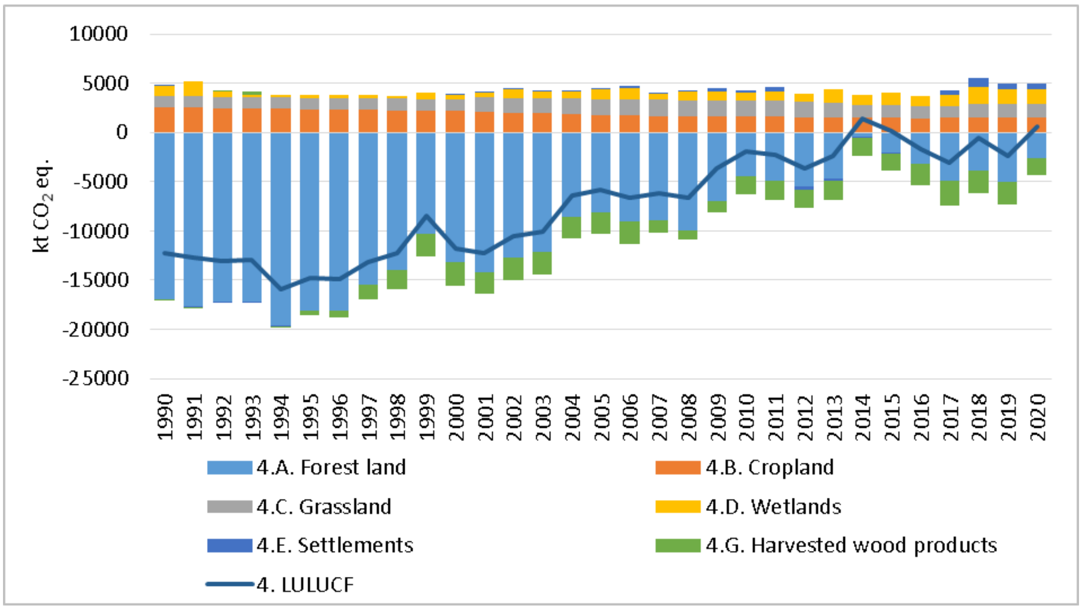

Figure 2.8 Trend in net emissions from LULUCF sector in 1990-2020 (kt CO_2 eq.)

Absolute increase of the net annual GHG emissions in LULUCF sector in 2020 if compared to 1990 is 12947.4 kt CO_2 eq., mostly because of reduction of the net CO_2 removals in living biomass in forest lands (by 14852.1 kt CO_2 eq. between 1990 and 2020). Emissions increased also in settlements (by 569.5 kt CO_2 eq.), wetlands (by 451.2 kt CO_2 eq.) and grassland (by 225.7 kt CO_2 eq.) between 1990 and 2020. In cropland emissions decreased by 1042.8 kt CO_2 eq. between 1990 and 2020. Reduction of emissions in cropland is caused by mineralization of organic soils in cropland and by conversion of cropland to grassland.

2.3.5 Trends in WASTE

In 2020, emissions have decreased by 25.2% compared to 1990. In 2020, emissions from the Waste sector were 547.25 kt CO_2 eq., contributing 5.2% of the total GHG emissions (excluding LULUCF, including indirect CO_2).

GHG emissions from Waste sector have fluctuated from 1990-2000. Fluctuations in total GHG emissions in Waste sector could be explained with changes of economic situation, data availability and data collection (Figure 2.9).

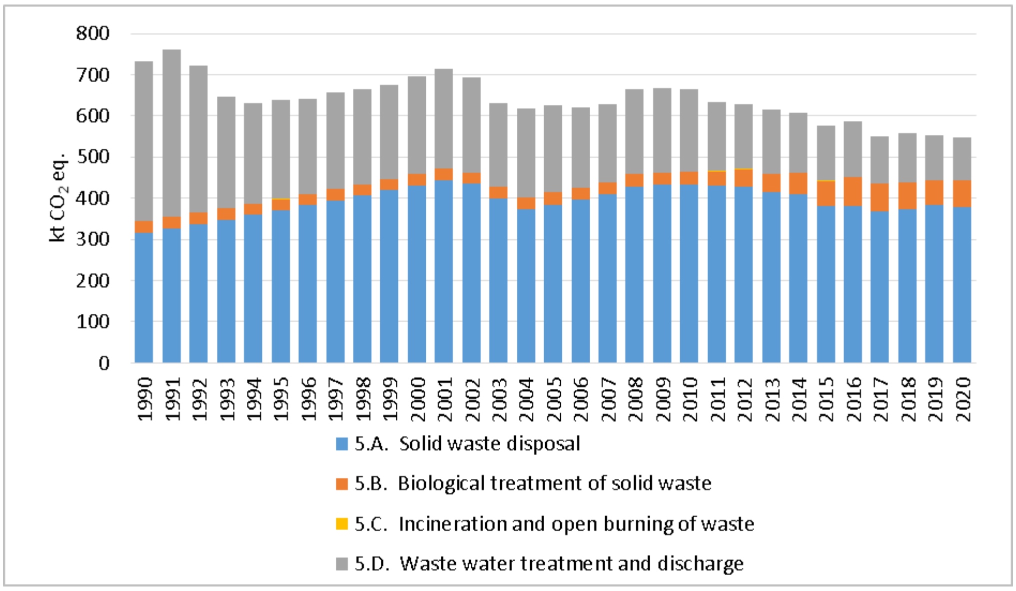

Figure 2.9 Trend in GHG emissions from Waste sector in 1990-2020 (kt CO_2 eq.)

Some industry sectors were almost closed in the middle of 1990s. The main sources of GHG emissions from waste sector are Solid waste disposal (5A) and Wastewater handling (5D). Emissions from Biological treatment of solid waste (5B) and Incineration and open burning of waste (5C) are small in comparison to main sources.

Fluctuations in Wastewater handling sector are the main reason for GHG emission changes for period of 1990-2000. Solid waste disposal (SWD) emissions are calculated according to First order decay method and disposed waste amount is estimated as equal rise between years 1975-2002, that gives equal growth of emissions in times series untill year 2002. Starting of methane recovery landfills causes SWD emissions decrease in years 2002–2004.

Emissions in 2020 have decreased by 0.9% compared to 2019 in Latvia.

2.4 *DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS OF PRECURSORS AND SULPHUR DIOXIDE*

The emissions trends of the precursors and sulphur dioxide emissions are presented in Figure 2.10.

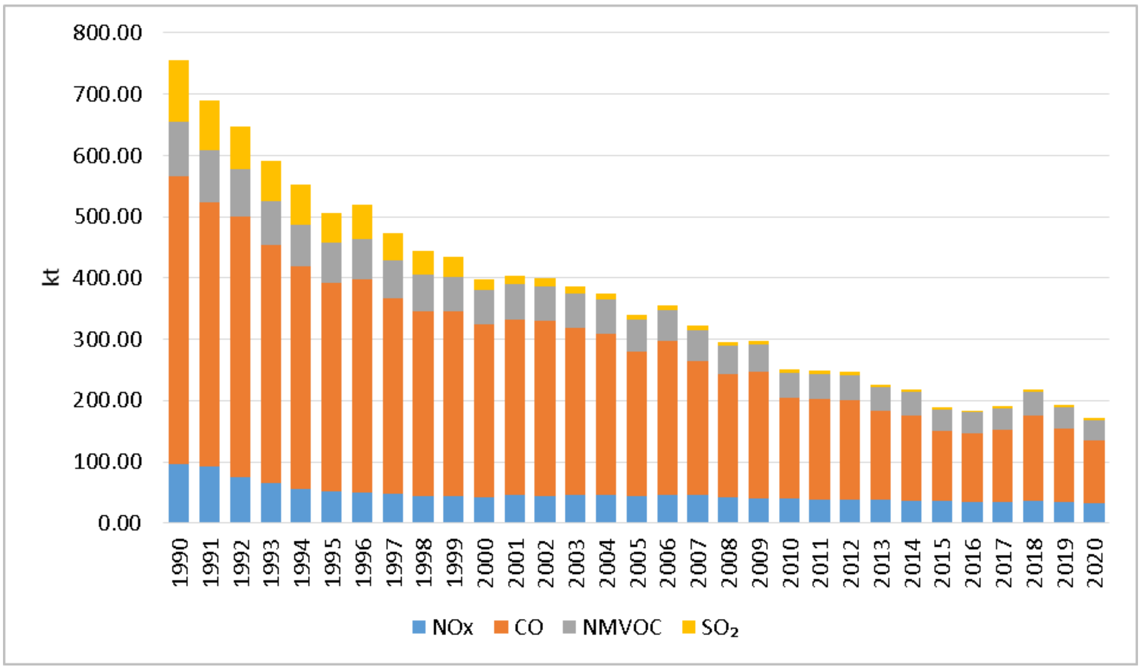

Figure 2.10 Total precursors trend 1990-2020 (kt)

In 2020, the **sulphur dioxide emissions** were 3.51 kt from which 94.2% originated in the Energy sector and 5.7% from the IPPU. Since 1990 to 2020 the total SO_2 emissions have decreased by 96.5%. The reduction is mainly due to use of fuels with lower content of sulphur as well as fuel switching from solid and liquid types of fuel to natural gas and biomass.

Emissions from nitrogen oxides were 31.95 kt in 2020. 79.4% of NO_x emissions generated in the Energy sector, 14.1% in Agriculture and 6.1% in IPPU. Transport sector was responsible for 37.5% of the total NO_x emissions. The total NO_x emissions have decreased by 66.7% from 1990 to 2020. Generally the reduction is due to decrease of total fuel consumption that was caused by transformation of national economy as well as the energy efficiency and control measures and also solid fuels and heavy liquid fuels replacement with natural gas and biomass fuels.

Carbon monoxide emissions were 102.71 kt, being produced generally in the Energy sector (91.5%). Other Sectors (include heating of buildings, other fuel use in agriculture, forestry, fisheries) generate the biggest part of the total CO emissions – 72.9%. The CO emission trend shows the decrease of the emissions for period 1990–2020 by 78.1%.

Total emissions of **non-methane volatile organic compounds** were 33.56 kt from which 39.8% are generated in Energy sector (mainly residential stationary combustion plants) and 37.0% comes from IPPU (mainly from Non-energy products from fuels and solvent use which constitute 33.0% from total NMVOC emissions in 2020). Also 22.5% from NMVOC emissions come from Agriculture mainly from manure management. The NMVOC emission trend shows a decrease of emissions for period 1990–2020 by 62.4%.

Emission consistency with the data used to prepare inventories of air pollutants under the EU Directive 2016/2284/EU and CLRTAP are verified.

2.5 *DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS FOR KP-LULUCF ACTIVITIES*

Coverage of reporting of carbon pools and emission sources with regard to activities under the Article 3.3 afforestation (A), reforestation (R) and deforestation (D) and under the Article 3.4 forest management (FM) are presented in Table 2.1.

Table 2.1 Information table relating to Article 3.3 and elected activities under Article 3.4

Activity		Change in carbon pool reported						Greenhouse gas sources reported							
		Above-ground biomass	Below-ground biomass	Litter	Dead wood	Soil		Fertili-zation	Drained, rewetted and other soils		Nitrogen minerali-zation in mineral soils	Indirect N_2O emissions from managed soils	Biomass burning		
						Mineral	Organic	N_2O	CH_4	N_2O	N_2O	N_2O	CO_2	CH_4	N_2O
A 3.3	**A/R**	*R*	*R*	*R*	*R*	*NO*	*R*	*NO*	*R*	*R*	*NO*	*NO*	*NO*	*NO*	*NO*
	D	*R*	*R*	*R*	*R*	*R*	*R*	*IE*	*R*	*R*	*R*	*R*	*NO*	*NO*	*NO*
A 3.4	**FM**	*R*	*R*	*R*	*R*	*NO*	*R*	*NO*	*R*	*R*	*NO*	*NO*	*R*	*R*	*R*
	CM	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*		*NA*		*NA*	*NA*	*NA*
	GM	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*		*NA*		*NA*	*NA*	*NA*
	RV	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

R (reported), NR (not reported), IE (included elsewhere), NO (not occurring), NA (not applicable)

The net emissions due to deforestation increases during the recent years due to active economic growth (building of roads and other infrastructure, recovery of abandoned farmlands) in Latvia. Afforestation rate has decreased during recent years, however, accumulation of carbon in afforested areas continues to grow due to higher increment rates in older previously afforested stands. The net CO_2 removals due to forest management decreased considerably during recent years (especially in 2014) mostly due to increase of harvesting stock (by about 10% in 2014-2016 in comparison to 2010-2013). Despite the fact that relative changes between these years seem significant, in most cases they are within the uncertainty range. The changes in mortality and increment are mainly associated with ageing of forests. Considering predominance of mature forests declining of increment and increase of the natural mortality is predicted also in the following decades.

Net emissions from ARD in 2020 were 857.42 kt CO_2 eq. and net removals from FM 1558.75 kt CO_2 eq. (Table 2.2). Area reported under AR in 2020 is 120.63 kha, under D 103.25 kha and under FM 3120.88 kha.

Table 2.2 Emissions and removals resulting from activities under Article 3.3 and 3.4 of the Kyoto Protocol in 2020

	Net CO_2 emissions/ removals, kt	CH_4, kt	N_2O, kt	Net CO_2 eq. emissions/ removals, kt CO_2 eq.
A. Article 3.3 activities				*857.42*
A.1. Afforestation and reforestation	*-301.45*	*0.19*	*0.01*	*-293.25*
A.2. Deforestation	*1017.35*	*1.01*	*0.36*	*1150.67*
B. Article 3.4 activities				*-1558.75*
B.1. Forest management	*-2434.00*	*15.11*	*1.67*	*-1558.75*

	Net CO_2 emissions/ removals, kt	CH_4, kt	N_2O, kt	Net CO_2 eq. emissions/ removals, kt CO_2 eq.
B.2. Cropland management (if elected)	*NA*	*NA*	*NA*	*NA*
B.3. Grazing land management (if elected)	*NA*	*NA*	*NA*	*NA*
B.4. Revegetation (if elected)	*NO,NA*	*NO,NA*	*NO,NA*	*NO,NA*
B.5. Wetland drainage and rewetting (if elected)	*NA*	*NA*	*NA*	*NA*

3 ENERGY (CRF 1)

3.1 *OVERVIEW OF SECTOR*

3.1.1 Quantitative overview

Energy sector is the main emission source in Latvia`s GHG inventory in 2020 (Figure 3.1). In total, Energy sector forms 64.8% of all GHG emissions (including indirect CO_2, excluding LULUCF), and largest part of it contributes to Transport sector (45.8% of Energy GHG emissions). As Latvia is located on temperate climate zone, heat production is an essential part of Latvia's energy production, thus having an impact on GHG and air pollutant emissions.

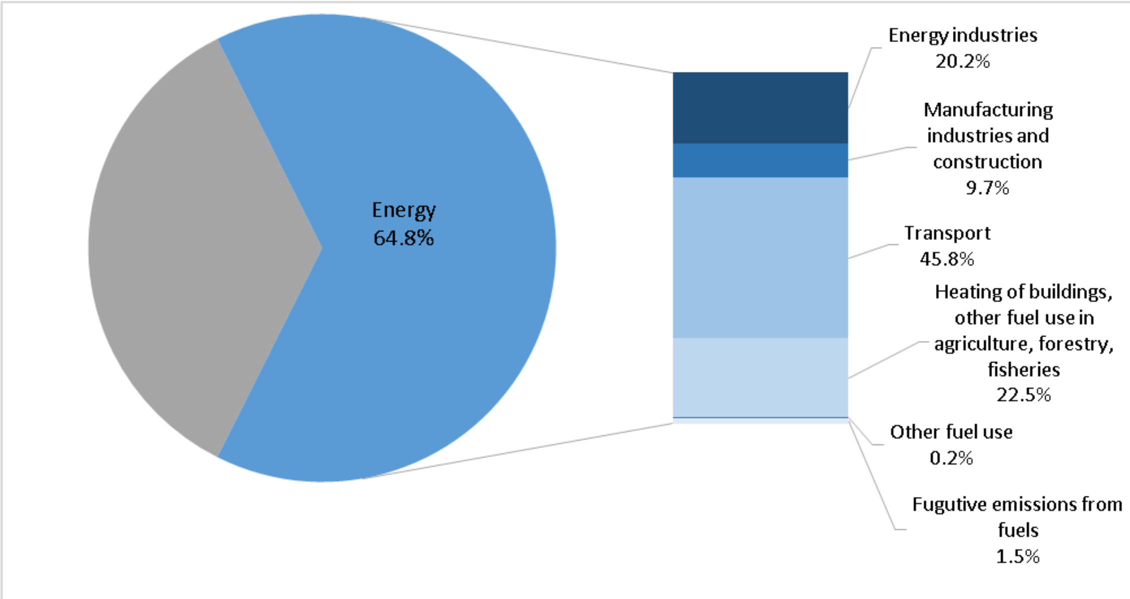

Figure 3.1 Emissions from the Energy sector (CRF 1) compared with the total emissions in 2020

Energy sector consists of two subsectors – fuel combustion (contributing 98.5%) including stationary combustion and transport emissions, and fugitive emissions (1.5%), where emissions from non-combustion processes of fuels are reported, e.g., leakages from natural gas and diffuse emissions from gasoline.

In fuel combustion (CRF 1.A), the largest part of GHG emissions contributes Transport sector (CRF 1.A.3; 45.8%). Energy Industries (CRF 1.A.1) produces 20.2%, Other Sectors (CRF 1.A.4) where heating of buildings (small combustion installations in institutions and households) and fuel use in agriculture, forestry and fisheries generates 22.5% and 9.7% are produced by Manufacturing Industries and Construction (CRF 1.A.2). Emissions from off-road vehicles from other sources are reported under Other (CRF 1.A.5; in the figure above depicted as Other fuel use). These emissions contribute to 0.2% from all Energy emissions.

In the following sections of Energy sector chapter both emissions from fuel combustion and fugitive emissions are described.

As can be seen in Figure 3.2, the GHG emissions share of subsectors in the Energy sector has changed, especially 1.A.3 Transport, 1.A.4 Other Sectors and 1.A.1. Energy Industries sector.

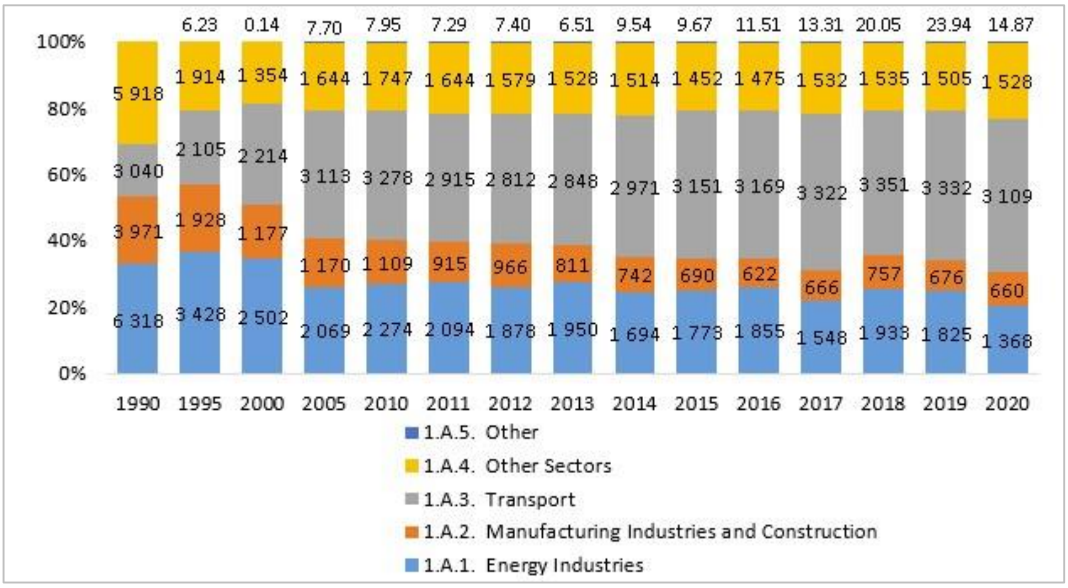

Figure 3.2 Share of emissions in the Energy sector (CRF 1.A) in 1990-2020 (kt CO_2 eq.)

In 1990, the largest share of GHG emissions from combustion was generated by Energy Industries with 32.8% as well as Other Sectors with 30.7% from emissions produced in Energy sector except Fugitive emissions. 20.6% of emissions occurred in Manufacturing Industries and Construction sector, and the smallest share of emissions was in the Transport sector with only 15.8%. Emissions in Other (CRF 1.A.5) were not estimated until 1995.

The share of Transport emissions have grown since 1990 reaching 34.0% in 2001. Since then, Transport sector has been the largest emissions' producer in Energy sector, that can be generally explained with the increase of population's income and growth of the economy. In 2020 Transport sector is responsible for 46.5% of Energy sector GHG emissions.

In 2020, the second largest subsector with 22.9% share is 1.A.4 Other Sectors (Commercial/Institutional (5.9%), Residential (7.5%) and Agricultural/Forestry/Fishing (7.3%)), and the third largest subsector with 20.5% share is Energy Industries. Emissions from Other (CRF 1.A.5) contribute 0.2% share from Energy emissions.

Table 3.1 GHG emissions from Energy sector (CRF 1) in 1990–2020 (kt)

Year	A Fuel combustion			B Fugitive emissions from fuels		Aggregate GHGs
	CO_2	CH_4	N_2O	CO_2	CH_4	CO_2, CH_4, N_2O
	kt			kt		kt CO_2 eq.
1990	*18644.90*	*11.92*	*1.02*	*0.0115*	*9.90*	*19494.38*
1991	*17105.64*	*13.16*	*1.19*	*0.0111*	*9.54*	*18026.42*
1992	*13853.25*	*11.88*	*0.90*	*0.0101*	*8.70*	*14634.96*
1993	*11772.02*	*12.59*	*0.79*	*0.0097*	*8.32*	*12528.91*
1994	*10174.61*	*12.51*	*0.49*	*0.0094*	*8.13*	*10835.39*
1995	*8925.94*	*12.98*	*0.44*	*0.0092*	*7.92*	*9578.59*
1996	*8993.25*	*13.30*	*0.44*	*0.0089*	*7.63*	*9647.87*
1997	*8446.39*	*12.65*	*0.44*	*0.0083*	*7.12*	*9071.94*
1998	*8066.17*	*11.81*	*0.41*	*0.0079*	*6.83*	*8654.98*
1999	*7445.41*	*11.58*	*0.40*	*0.0076*	*6.51*	*8017.89*
2000	*6857.55*	*10.87*	*0.40*	*0.0070*	*6.03*	*7397.85*

Year	A Fuel combustion			B Fugitive emissions from fuels		Aggregate GHGs
	CO_2	CH_4	N_2O	CO_2	CH_4	CO_2, CH_4, N_2O
	kt			kt		kt CO_2 eq.
2001	*7253.73*	*12.03*	*0.43*	*0.0073*	*5.84*	*7827.63*
2002	*7252.80*	*11.74*	*0.43*	*0.0074*	*6.10*	*7827.23*
2003	*7438.02*	*12.16*	*0.46*	*0.0055*	*4.76*	*7998.19*
2004	*7449.17*	*12.47*	*0.49*	*0.0055*	*4.71*	*8024.71*
2005	*7549.04*	*12.37*	*0.49*	*0.0062*	*5.33*	*8137.43*
2006	*8022.77*	*12.00*	*0.51*	*0.0044*	*3.82*	*8571.57*
2007	*8347.18*	*11.89*	*0.55*	*0.0046*	*3.92*	*8905.96*
2008	*7921.88*	*10.88*	*0.50*	*0.0047*	*4.03*	*8444.76*
2009	*7191.77*	*11.75*	*0.51*	*0.0044*	*3.81*	*7733.32*
2010	*8024.13*	*9.50*	*0.52*	*0.0043*	*3.66*	*8508.00*
2011	*7179.38*	*9.47*	*0.53*	*0.0054*	*2.52*	*7638.44*
2012	*6826.69*	*9.89*	*0.57*	*0.0049*	*3.18*	*7322.10*
2013	*6744.53*	*9.04*	*0.58*	*0.0080*	*4.04*	*7244.12*
2014	*6541.07*	*8.58*	*0.59*	*0.0138*	*5.41*	*7066.82*
2015	*6713.65*	*7.38*	*0.59*	*0.0129*	*4.11*	*7178.05*
2016	*6777.81*	*7.38*	*0.57*	*0.0119*	*4.66*	*7249.80*
2017	*6694.97*	*8.19*	*0.61*	*0.0157*	*6.11*	*7234.47*
2018	*7198.58*	*8.25*	*0.64*	*0.0093*	*3.64*	*7686.97*
2019	*6975.17*	*7.93*	*0.63*	*0.0102*	*3.92*	*7458.18*
2020	*6319.41*	*7.08*	*0.62*	*0.0111*	*4.02*	*6780.35*
2020 vs 2019	*-9.4*	*-10.8*	*-1.8*	*9.0*	*2.6*	*-9.1*
2020 vs 1990	*-66.1*	*-40.6*	*-39.6*	*-3.5*	*-59.4*	*-65.2*

Emissions decreased during 1990s are due to the changes in economic and social situation in Latvia. Overall emissions from Energy sector have decreased from 1990 to 2020.

GHG emissions from the Energy sector in latest years (since 2000) are fluctuating with a peak point in 2007 (Figure 3.3). In the second half of 2008, a recession of the national economy started, caused by the global economic crisis. Decrease in economic output is one of the reasons why all GHG emissions in Energy sector decreased by 13.2% in 2007-2009. But in 2010, total GHG emissions increased by 10.0%, compared to 2009, as economy started to recover from crisis, also number of heating degree days increased, compared to 2009.

In 2020, emissions in Energy sector are 9.1% lower than in 2019, emissions have decreased in almost all sectors with significant decrease in CRF 1.A.1 Energy Industries (25.0%) due to the significant decrease of natural gas use in the sector.

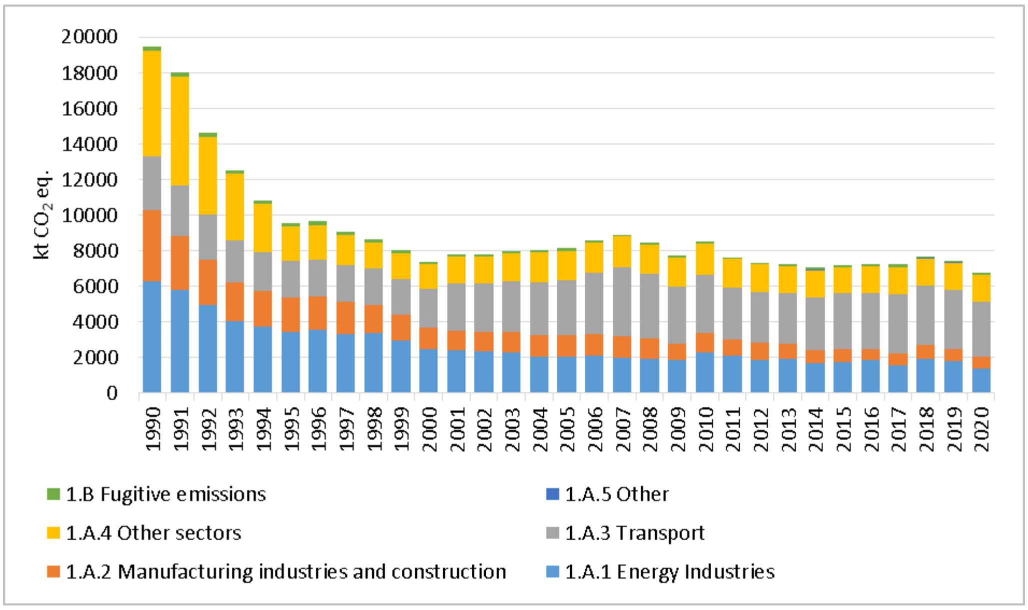

Figure 3.3 GHG emissions from Energy sector (CRF 1) 1990–2020 (kt CO_2 eq.)

In CRF 1.A.1 Energy Industries sector GHG emission decrease in 2008-2009 can be explained with the recession in national economy caused by the global financial crisis, also winter in 2009 was quite warm, therefore in 2009 GHG emissions in CRF 1.A.1 decreased by 2.6% compared to 2008. In 2009-2010 an increase of emissions by 20.4% in Energy Industries was observed, mostly because global economic crisis was ending. As 2011 was warmer than previous year, the fuel consumption decreased and emissions decreased by 7.9% if compared to 2010. Similar fluctuations in emissions in Energy sector can be observed through later years as well. Emission decrease can also be contributed to the increase of energy efficiency in buildings that reduces use of heat and power in them. EU ETS policy promotes use of renewable energy resources, therefore decrease of fossil fuels and increase use of biomass can be observed in the sector. In 2020 emissions decreases by 25.0% compared to 2019 due to significant decrease of natural gas and all the other fuel use in the sector.

The decrease of industrial production (CRF 1.A.2) was influenced by economic situation when national economy in financial and real estate sectors were undergoing development and the import dominated over export. Therefore, GHG emissions from CRF 1.A.2 sector decreased by 19.8% in 2008-2009. In 2011, emissions decreased by 17.5% which can be explained with great reconstructions in the steel and iron enterprise under CRF 1.A.2.a sector where the fuel consumption decreased significantly (-76.5%). In 2012 compared to 2011 the GHG emissions increased by 5.5% mainly due to intensified steel melting as emissions in CRF 1.A.2.a sector increased by 44.1%. In 2013, largest metallurgy company went bankrupt. In 2020, emissions decreased by 2.4% compared to 2019.

For the Transport sector (CRF 1.A.3) emissions decreased from 2008 to 2009 by 12.4%, that was influenced mainly by recession of the national economy and decrease of transport activities – decrease of passenger km by passenger cars and ton km by freight transport. In 2020 compared to 2019 6.7% decrease can be observed due to emission decrease in all the subsectors.

Emissions in CRF 1.A.4 Other Sectors are constantly decreasing since 1990, with some fluctuations from year to year. Similar as Energy Industries fluctuations can be explained with average outdoor temperature during heating season and increase of energy efficiency in the buildings. In 2020, emissions have increased by 1.5% compared to 2019.

In 2020, emissions in 1.A.5 Other have decreased by 37.9% compared to 2019.

Decrease of fugitive emissions since 1990 can be explained with a constant improvement of natural gas supply infrastructure.

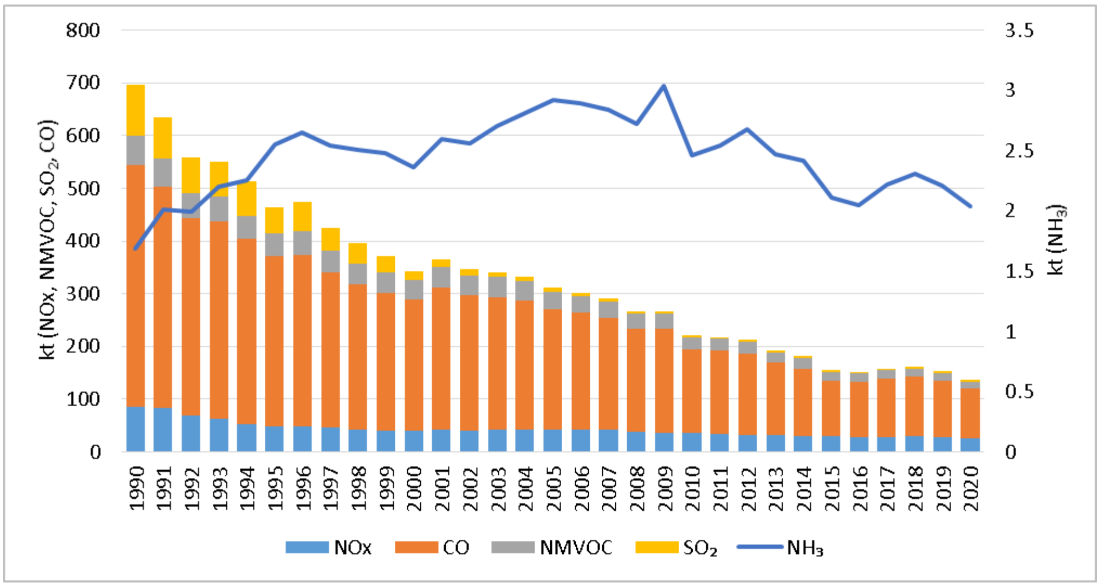

Figure 3.4 Total precursors and NH_3 emissions from Energy sector (CRF 1) in 1990–2020 (kt)

In 2020, the largest part of precursors contributes CO, then NOx and NMVOC emissions (Figure 3.4). Most of CO and NMVOC emissions come from wood combustion in the Residential sector, while the largest share of NO_x emissions comes from Transport sector.

The biggest decrease is observed in SO_2 emissions where emissions decreased from 96.88 kt in 1990 to 3.31 kt in 2020. It can be explained with switching towards fuels with less sulphur content due to the implementation of National legislations for sulphur content in liquid fuels used for transport. One of the largest decreases can be observed in Energy Industries and it can be explained with change of used fuel. It was popular to use liquid or solid fuel for heating, but in latest years it was switched to biomass or gaseous fuels with lower sulphur content.

Precursors are lower in 2020 compared to 2019: NOx emissions have decreased by 7.0%, CO emissions by 11.7%, NMVOC emissions by 10.0%, and SO_2 emissions by 7.1%.

There are also ammonia emissions calculated and reported in Energy sector. In 1990-2020, NH_3 emissions have increased by 20.9% that can be explained with increased amounts of biomass burned in Energy Industries, Manufacturing Industries, as well as in Other Sectors (Commercial/Institutional, Residential, Agriculture/Forestry/Fisheries).

3.1.2 Description

Activity data

Both the imported (natural gas, liquid gas, oil and oil products, coal) and local energy resources (wood, peat, hydro and wind resources) are used in the Energy sector in Latvia (Table 3.2). Mainly the imported fuels (natural gas, coal) are used in cogeneration and heat generation. Smaller boiler houses burn local fuel (wood) and coal as well.

Table 3.2 Consumption of energy resources in Latvia (TJ)

Fuel type	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
Energy consumption	***318550***	***176154***	***143517***	***178624***	***185680***	***175920***	***180674***	***182085***	***185933***	***192504***	***171339***
Liquid fuels, total	*161188*	*81668*	*53511*	*68002*	*72016*	*68606*	*72012*	*73181*	*64811*	*75231*	*65230*
Shale Oil	NO	78	2440	157	39	NO	7	1	8	9	1
LPG	3691	1548	2095	2552	2103	4103	4174	4226	3892	3432	3256
Gasoline	26752	18130	14833	15131	12666	8922	8752	8363	8031	7638	7322
Jet Kerosene	3068	1172	1142	2525	4929	4530	5170	5924	6497	6688	2468
Other Kerosene	647	432	43	NO	NO	NO	6	4	4	1	NO
Diesel Oil	48023	18273	20907	36712	41923	45521	47458	49400	46098	55572	51849
RFO	76326	41290	9462	10231	8661	5467	6258	5154	207	1822	202
Petroleum Coke	NO	NO	NO	429	627	NO	124	44	5	NO	60
Other Oil Products	2680	745	2590	264	1068	62	63	66	68	69	71
Solid fuels, total	*26249*	*7225*	*2785*	*3199*	*4378*	*1950*	*1678*	*1689*	*1894*	*1644*	*966*
Anthracite	NO	NO	NO	NO	NO	NO	27	7	NO	NO	NO
Coal	25984	7172	2759	3145	4378	1950	1651	1679	1893	1643	966
Coke	237	53	26	54	NO	NO	NO	3	1	1	NO
Oil Shale	28	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Peat products, total	*3217*	*3837*	*2392*	*80*	*46*	*11*	*34*	*40*	*135*	*72*	*51*
Peat	2350	3436	2361	80	40	10	34	29	119	54	34
Peat Briquettes	867	401	31	NO	6	1	NO	11	16	18	17
Natural gas	*99517*	*41304*	*44962*	*56685*	*61044*	*45758*	*46751*	*41193*	*48494*	*45680*	*37754*
Biomass, total	*27501*	*42120*	*39774*	*49681*	*47655*	*58314*	*59278*	*64810*	*68948*	*68398*	*65633*
Wood	27501	42102	39695	49124	45375	52231	53905	59118	61890	61617	58221
Charcoal	NO	NO	NO	60	60	60	65	66	68	87	90
Straws	NO	NO	NO	NO	60	135	161	223	414	457	426
Biofuel	NO	NO	NO	101	1116	1013	495	450	1600	1488	1988
Landfill Gas	NO	NO	NO	251	331	420	409	422	405	365	364
Sludge Gas	NO	18	41	95	137	85	107	101	83	90	76
Other Biogas	NO	NO	NO	NO	66	3239	3328	3463	3242	2970	2961
Municipal Wastes	NO	NO	37	49	510	1131	808	968	1247	1324	1506
Other fuels, total	*879*	*NO*	*94*	*977*	*540*	*1281*	*921*	*1172*	*1651*	*1480*	*1705*
Municipal Waste	NO	NO	NO	NO	320	934	736	962	1215	1086	1270
Industrial Waste	NO	NO	94	125	84	284	155	180	338	320	351
Other Fossil Fuels	NO	NO	NO	6	42	33	5	3	65	61	72
Waste Oil	879	NO	NO	847	95	29	25	27	33	13	12

Liquid fossil fuels have an important place as energy resource. Its share was about 38.1% in 2020. The essential decrease of RFO share in Energy Balance is explained with increasing fuel costs because of implementation of the EU Directive 1999/32/EC prescribing that sulphur content of heavy oil should not exceed 1%. The major part of the liquid fuel consumption contributes to diesel oil with approximately 79.5% from total liquid fuel consumption in 2020; diesel oil is mostly used in Transport sector. The total consumption of liquid fuels in 2020 has decreased by 59.5% since 1990. The reason for such a drastic decrease can be explained with the changes in technology (with the exception of Transport sector and Other (CRF 1.A.5)), since the technology that uses liquid fuel is replaced with one that uses natural gas and biomass.

Total share of *solid fossil fuels* in national market is low – approximately 0.6% in 2020. The solid fuel consumption in recent years is stable. The total consumption of solid fuels in 2020 has decreased by 96.3% since 1990. A decrease (19.3%) in solid fuel consumption can be seen in 2008-2009 due to the global economic crisis. Decrease of solid fuel consumption can be explained with the technology change, when solid fuel combustion was replaced with natural gas and biomass for heat and energy production.

Peat and *peat briquettes* are local fuels that were used in Latvia in 1990 with 1.0% of total energy consumption. However, nowadays amounts of peat products used for stationary burning have decreased by 98.4% compared to 1990 and has 0.03% of total share in 2020. Peat was widely used in heat production, but now mostly biomass and gaseous fuels are used for both heat and electricity production.

The largest consumers of *natural gas* are combined heat and power plants, and heat generation enterprises as well as industrial enterprises. Natural gas has a stable place in total fuel consumption where its share was 31.2% in 1990 and 22.0% in 2020. Natural gas consumption has decreased by 62.1% in 1990-2020. Decrease in natural gas use could be explained with fuel switching from natural gas to biomass as well as increased energy efficiency in buildings.

Biomass fuels are wood and wood products, straw, charcoal, liquid biofuels (bioethanol and biodiesel), biogas (landfill gas, sludge gas, other biogas). In the total fuel consumption, the share of firewood and other wood products is substantial – 38.3% of total energy consumption in 2020, while in 1990 all biomass fuels in total made up only 8.6% from total energy consumption. Such fuels as straws have an increasing trend in the past few years.

Industrial and *municipal waste*[10] was also consumed and in 2020 reached 1.0% share from the total energy consumption. In 2020 consumption increased by 14.6% in comparison to 2019. Waste oils are reported as other fuels.

Hydroelectric power plants (HPP) and combined heat and power plants (CHP) produce part of the electrical power, while also partly is imported (Table 3.3, Table 3.4). Volume of electricity generation in HPP directly depends on the through-flow of the river Daugava. Also, the import and export of electricity from other countries has a significant role in the internal electricity market in Latvia.

Table 3.3 Heat production and consumption in Latvia (TJ)

Year	Production	Own use and losses	Final consumption		
			CRF 1.A.2	CRF 1.A.4	TOTAL
1990	*99439*	*15171*	*32929*	*51339*	*84268*
1995	*46112*	*7156*	*1969*	*36987*	*38956*
2000	*31867*	*6815*	*659*	*24393*	*25052*
2001	*33937*	*7038*	*641*	*26258*	*26899*
2002	*33048*	*6541*	*630*	*25877*	*26507*
2003	*33516*	*6409*	*626*	*26481*	*27107*

[10] *For reporting purposes municipal waste has been divided into fossil and non-fossil fractions, but in the particular paragraph it is described as whole.*

Year	Production	Own use and losses	Final consumption		
			CRF 1.A.2	CRF 1.A.4	TOTAL
2004	*31093*	*6174*	*608*	*24311*	*24919*
2005	*31144*	*5886*	*684*	*24574*	*25258*
2006	*30056*	*5454*	*634*	*23968*	*24602*
2007	*28685*	*4911*	*554*	*23220*	*23774*
2008	*26402*	*4010*	*356*	*22036*	*22392*
2009	*26308*	*4099*	*298*	*21911*	*22209*
2010	*28662*	*4590*	*387*	*23685*	*24072*
2011	*25000*	*4104*	*268*	*20628*	*20896*
2012	*26857*	*4464*	*259*	*22134*	*22393*
2013	*26249*	*4551*	*479*	*21219*	*21698*
2014	*25747*	*4608*	*890*	*20249*	*21139*
2015	*25459*	*4358*	*1450*	*19651*	*21101*
2016	*28967*	*4635*	*2506*	*21826*	*24332*
2017	*29989*	*4668*	*3291*	*22030*	*25321*
2018	*29688*	*4494*	*3781*	*21413*	*25194*
2019	*28612*	*4288*	*3324*	*21000*	*24324*
2020	*27010*	*3782*	*2932*	*20296*	*23228*

Table 3.4 Electricity production and consumption in Latvia (TJ)

Year	Production	Own use and losses	Import	Export	Final consumption			
					CRF 1.A.2	CRF 1.A.3	CRF 1.A.4	TOTAL
1990	*23933*	*6883*	*25700*	*12798*	*11484*	*918*	*17550*	*29952*
1991	*20318*	*6681*	*15217*	*7*	*10807*	*785*	*17255*	*28847*
1992	*13803*	*5646*	*14688*	*7*	*8316*	*745*	*13777*	*22838*
1993	*14126*	*6101*	*9619*	*612*	*5440*	*688*	*10904*	*17032*
1994	*15984*	*6681*	*9533*	*2988*	*5076*	*670*	*10102*	*15848*
1995	*14324*	*6371*	*9529*	*1408*	*5130*	*677*	*10267*	*16074*
1996	*11254*	*7989*	*12377*	*760*	*4975*	*641*	*9266*	*14882*
1997	*16218*	*7692*	*6566*	*4*	*5519*	*634*	*8935*	*15088*
1998	*20869*	*6559*	*3290*	*1382*	*5296*	*612*	*10310*	*16218*
1999	*14796*	*5775*	*9349*	*2311*	*5130*	*554*	*10375*	*16059*
2000	*14890*	*5203*	*7589*	*1159*	*5159*	*547*	*10411*	*16117*
2001	*15408*	*5688*	*8424*	*1645*	*5562*	*623*	*10314*	*16499*
2002	*14310*	*5188*	*10217*	*1764*	*5494*	*518*	*11563*	*17575*
2003	*14310*	*5065*	*9616*	*137*	*5778*	*490*	*12456*	*18724*
2004	*16881*	*4976*	*9839*	*2290*	*5882*	*500*	*13072*	*19454*
2005	*17658*	*4766*	*10278*	*2545*	*6120*	*533*	*13972*	*20625*
2006	*17607*	*4522*	*10116*	*1087*	*6332*	*540*	*15242*	*22114*
2007	*17176*	*4194*	*17870*	*7070*	*6538*	*504*	*16740*	*23782*
2008	*18987*	*4198*	*16715*	*7643*	*6066*	*497*	*17298*	*23861*
2009	*20048*	*4032*	*15333*	*9378*	*5421*	*436*	*16114*	*21971*
2010	*23857*	*4626*	*14303*	*11160*	*5724*	*453*	*16197*	*22374*
2011	*21938*	*4133*	*14432*	*9950*	*6012*	*446*	*15829*	*22287*
2012	*22202*	*3636*	*17766*	*11678*	*7175*	*464*	*17015*	*24654*
2013	*22352*	*3556*	*18018*	*13140*	*6509*	*446*	*16719*	*23674*
2014	*18500*	*3138*	*19221*	*10883*	*6003*	*421*	*17276*	*23700*
2015	*19921*	*3215*	*18888*	*12330*	*6130*	*384*	*16750*	*23264*
2016	*23129*	*3513*	*17382*	*13662*	*6005*	*378*	*16953*	*23336*
2017	*27111*	*3535*	*14662*	*14893*	*6345*	*377*	*16623*	*23345*
2018	*24210*	*3498*	*18625*	*15353*	*6630*	*374*	*16980*	*23984*
2019	*23178*	*3312*	*16599*	*12574*	*6646*	*363*	*16882*	*23891*

Year	Production	Own use and losses	Import	Export	Final consumption			
					CRF 1.A.2	CRF 1.A.3	CRF 1.A.4	TOTAL
2020	*20609*	*2976*	*15024*	*9172*	*6709*	*339*	*16437*	*23485*

Types of fuels used for combustion in Latvia:

Liquid fuels are mainly imported from Latvia's neighbouring countries (Lithuania, Belarus, Russian Federation), Scandinavian countries and others:

- shale oil;
- liquefied petroleum gas (LPG);
- motor gasoline and aviation gasoline;
- kerosene type jet fuel;
- other kerosene;
- gasoline type jet fuel;
- motor diesel oil and heating gas oil;
- residual fuel oil (RFO);
- other liquids;
- petroleum coke.

Solid fuels - coal and coke are mainly imported from Russian Federation, Kazakhstan and Ukraine;

Peat products - peat and peat briquettes are mainly domestic;

Gaseous fuels (natural gas) are imported from Russian Federation and Lithuania;

Biomass fuels:

- solid biomass – wood and other wood products, charcoal, straw - are mainly domestic,
- biogas that is produced domestically – landfill gas, used since 2002 when the first landfill started to collect and combust biogas with the energy recovery; sludge gas that is combusted with the energy recovery since 1993 largest sewage purification plant; and other biogases produced from agriculture crops, animal slurries, breweries and other agro-food industries from anaerobic fermentation,
- liquid biofuels – biogasoline and biodiesel, are mainly imported from Latvia's neighbouring countries.

Other fuels are municipal waste and industrial waste – used tires, different types of industrial fuel collected by and combusted in cement production plant in Latvia, as well as waste oils.

Methodological issues

Table 3.5 Methods and emission factors used in Energy sector

CATEGORIES	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
1. Energy	*T1, T2, T3*	*CS, D, PS*	*T1, T2, T3*	*CR, CS, D, M*	*T1, T2*	*CR, D, M*
A. Fuel combustion	*T1, T2*	*CS, D, PS*	*T1, T2*	*CR, CS, D, M*	*T1, T2*	*CR, D, M*
1. Energy industries	*T1, T2*	*CS, D*	*T1*	*D*	*T1*	*D*
2. Manufacturing industries and construction	*T1, T2*	*CS, D, PS*	*T1*	*D*	*T1*	*D*
3. Transport	*T1, T2*	*CS, D*	*T1, T2*	*CR, D, M*	*T1, T2*	*CR, D, M*
4. Other sectors	*T1, T2*	*CS, D*	*T1, T2*	*CS, D*	*T1*	*D*
5. Other	*T1*	*D*	*T1*	*D*	*T1*	*D*
B. Fugitive emissions from fuels	*T3*	*CS*	*T3*	*CS*	*NA*	*NA*
1. Solid fuels	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
2. Oil and natural gas	*T3*	*CS*	*T3*	*CS*	*NA*	*NA*
C. CO_2 transport and storage	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

The main methods and emission factors (EF) are displayed on the Table 3.5. In fuel combustion for CO_2 emission calculations methods from Tier 1 to Tier 3 used, generally Tier 2, while for CH_4 and N_2O Tier 1 and Tier 2 are used, generally Tier 1. In stationary combustion, CO_2 EFs are country-specific (CS), but for CH_4 and N_2O – default values (D) from the 2006 IPCC Guidelines, while in Transport country-specific, default, Corinair (CR) and model (M) values are used. For fugitive emissions, Tier 3 method and country-specific EFs are used. As from solid fuels there are only particulate matter emissions, a notation key "NA" has been used. There are no operations for CO_2 transport and storage therefore also a notation key "NA" is used.

Key categories

Key categories of Energy sector are presented in Table 3.6. They are estimated using Approach 1 and Approach 2 both by level and trend with and without taking LULUCF sector into account.

Table 3.6 Key categories in Energy sector in 2022 submission

Category	Gas	Identification criteria	with LULUCF	without LULUCF
1.A.1.a Public Electricity and Heat Production - Biomass Fuels	*N_2O*	*L1,L2,T1,T2*		*X*
1.A.1.a Public Electricity and Heat Production - Biomass Fuels	*CH_4*	*T2*		*X*
1.A.1.a Public Electricity and Heat Production - Gaseous Fuels	*CO_2*	*L1,L2,T1,T2*	*X*	*X*
1.A.1.a Public Electricity and Heat Production - Liquid Fuels	*CO_2*	*T1,T2*	*X*	*X*
1.A.1.a Public Electricity and Heat Production - Peat	*CO_2*	*T1,T2*	*X*	*X*
1.A.1.a Public Electricity and Heat Production - Solid Fuels	*CO_2*	*T1*	*X*	*X*
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries - Gaseous Fuels	*CO_2*	*L1*		*X*

Category	Gas	Identification criteria	with LULUCF	without LULUCF
1.A.1.c Manufacture of Solid Fuels and Other Energy Industries – Peat	CO_2	T1		X
1.A.2.a Iron and Steel - Gaseous Fuels	CO_2	T1,T2	X	X
1.A.2.a Iron and Steel - Liquid Fuels	CO_2	T1	X	X
1.A.2.a Iron and Steel - Other fossil fuels	CO_2	T1,T2		X
1.A.2.c Chemicals - Liquid Fuels	CO_2	T1,T2	X	X
1.A.2.d. Pulp, Paper and Print - Gaseous Fuels	CO_2	T1	X	X
1.A.2.e Food Processing, Beverages and Tobacco - Gaseous Fuels	CO_2	L1,T1	X	X
1.A.2.e Food Processing, Beverages and Tobacco - Liquid Fuels	CO_2	T1,T2	X	X
1.A.2.e Food Processing, Beverages and Tobacco - Solid Fuels	CO_2	T1	X	X
1.A.2.f Non-metallic Minerals - Gaseous Fuels	CO_2	L1,T1	X	X
1.A.2.f Non-metallic Minerals - Liquid Fuels	CO_2	T1,T2	X	X
1.A.2.f Non-metallic Minerals - Other Fossil Fuels	CO_2	L1	X	X
1.A.2.f Non-metallic Minerals - Solid Fuels	CO_2	L1,T1	X	X
1.A.2.g Other - Biomass Fuels	N_2O	T2		X
1.A.2.g Other - Biomass Fuels	CH_4	T2		X
1.A.2.g Other - Gaseous Fuels	CO_2	L1,T1,T2	X	X
1.A.2.g Other - Liquid Fuels	CO_2	L1,T1,L2,T2	X	X
1.A.3.b Road Transportation - Diesel Oil	CO_2	L1,L2,T1,T2	X	X
1.A.3.b Road Transportation - Diesel Oil	N_2O	L1,L2,T1,T2		X
1.A.3.b Road Transportation - Gasoline	CO_2	L1,L2,T1,T2	X	X
1.A.3.b Road Transportation - LPG	CO_2	L1,T1,T2	X	X
1.A.3.c Railways - Liquid Fuels	CO_2	L1,T1	X	X
1.A.3.c Railways - Liquid Fuels	N_2O	T2		X
1.A.4.a Commercial/Institutional - Gaseous Fuels	CO_2	L1,L2,T1,T2	X	X
1.A.4.a Commercial/Institutional - Liquid Fuels	CO_2	L1,L2,T1,T2	X	X
1.A.4.a Commercial/Institutional - Peat	CO_2	T1		X
1.A.4.a Commercial/Institutional - Solid Fuels	CO_2	T1,T2	X	X
1.A.4.a Commercial/Institutional - Liquid Fuels	N_2O	T2		X
1.A.4.b Residential - Biomass Fuels	CH_4	L1,L2,T1,T2	X	X
1.A.4.b Residential - Gaseous Fuels	CO_2	L1,L2,T1,T2	X	X
1.A.4.b Residential - Liquid Fuels	CO_2	L1,L2,T1	X	X
1.A.4.b Residential - Solid Fuels	CO_2	T1,T2	X	X
1.A.4.b Residential - Solid Fuels	CH_4	T2		X
1.A.4.c Agriculture/Forestry/Fisheries - Gaseous Fuels	CO_2	L1,T1,T2	X	X
1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels	CO_2	L1,L2,T1,T2	X	X
1.A.4.c Agriculture/Forestry/Fisheries - Liquid Fuels	N_2O	L1,L2,T1,T2		X
1.A.4.c Agriculture/Forestry/Fisheries - Solid Fuels	CO_2	T1	X	X
1.B.2.b Natural Gas	CH_4	L1,L2,T1,T2	X	X

3.2 *FUEL COMBUSTION (CRF 1.A)*

Emissions from fuel combustion comprise all in-country fuel combustion, including point sources, transport and other fuel combustion. Emissions from fuel combustion in the Energy sector are divided into following subcategories:

- 1.A.1 Energy Industries;
- 1.A.2 Manufacturing Industries and Construction;
- 1.A.3 Transport – Road transport, Civil aviation, Railways and Domestic navigation;
- 1.A.4 Other Sectors (Commercial/Institutional, Residential, Agriculture/Forestry/Fisheries);
- 1.A.5 Other (Not elsewhere specified).

Reported emissions are listed in Table 3.7.

Table 3.7 Reported emissions from fuel combustion in Latvia in 2020

Source	Fuel Type	Emissions						
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
1.A.1 Energy Industries								
a. Public Electricity and Heat Production								
	Liquid Fuels	√	√	√	√	√	√	√
	Solid Fuels	√	√	√	√	√	√	√
	Peat	√	√	√	√	√	√	√
	Gaseous Fuels	√	√	√	√	√	√	√
	Biomass	√	√	√	√	√	√	√
	Other Fuels	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
b. Petroleum Refining								
	Liquid Fuels	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
	Solid Fuels	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
	Peat	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
	Gaseous Fuels	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
	Biomass	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
	Other Fuels	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
c. Manufacture of Solid Fuels and Other Energy Industries								
	Liquid Fuels	√	√	√	√	√	√	√
	Solid Fuels	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
	Peat	√	√	√	√	√	√	√
	Gaseous Fuels	√	√	√	√	√	√	√
	Biomass	√	√	√	√	√	√	√
	Other Fuels	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
1.A.2 Manufacturing Industries and Construction								
a. Iron and Steel								
	Liquid Fuels	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
	Solid Fuels	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
	Peat	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
	Gaseous Fuels	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
	Biomass	√	√	√	√	√	√	√
	Other Fuels	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
b. Non-Ferrous Metals								
	Liquid Fuels	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*

Source	Fuel Type	Emissions						
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	Solid Fuels	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
	Peat	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
	Gaseous Fuels	√	√	√	√	√	√	√
	Biomass	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
	Other Fuels	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
c. Chemicals								
	Liquid Fuels	√	√	√	√	√	√	√
	Solid Fuels	√	√	√	√	√	√	√
	Peat	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
	Gaseous Fuels	√	√	√	√	√	√	√
	Biomass	√	√	√	√	√	√	√
	Other Fuels	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
d. Pulp, Paper and Print								
	Liquid Fuels	√	√	√	√	√	√	√
	Solid Fuels	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
	Peat	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
	Gaseous Fuels	√	√	√	√	√	√	√
	Biomass	√	√	√	√	√	√	√
	Other Fuels	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
e. Food Processing, Beverages and Tobacco								
	Liquid Fuels	√	√	√	√	√	√	√
	Solid Fuels	√	√	√	√	√	√	√
	Peat	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
	Gaseous Fuels	√	√	√	√	√	√	√
	Biomass	√	√	√	√	√	√	√
	Other Fuels	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
f. Non-metallic minerals								
	Liquid Fuels	√	√	√	√	√	√	√
	Solid Fuels	√	√	√	√	√	√	√
	Peat	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
	Gaseous Fuels	√	√	√	√	√	√	√
	Biomass	√	√	√	√	√	√	√
	Other Fuels	√	√	√	*NO*	*NO*	*NO*	*NO*
g. Other								
	Liquid Fuels	√	√	√	√	√	√	√
	Solid Fuels	√	√	√	√	√	√	√
	Peat	√	√	√	√	√	√	√
	Gaseous Fuels	√	√	√	√	√	√	√
	Biomass	√	√	√	√	√	√	√
	Other Fuels	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
1.A.3 Transport								
a. Civil Aviation								
	Aviation Gasoline	√	√	√	√	√	√	√
	Jet Kerosene	√	√	√	√	√	√	√
	Biomass	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
b. Road Transportation								
	Gasoline	√	√	√	√	√	√	√
	Diesel Oil	√	√	√	√	√	√	√
	LPG	√	√	√	√	√	√	√
	Other Liquid Fuels	√	√	√	*NA*	*NA*	*NA*	*NA*
	Gaseous Fuels	√	√	√	√	√	√	*NA*

Source	Fuel Type	Emissions						
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	Biomass	√	√	√	NO	NO	NO	NO
	Other Fuels	√	NA	NA	NA	NA	NA	NA
c. Railways								
	Liquid Fuels	√	√	√	√	√	√	√
	Solid Fuels	NO	NO	NO	NO	NO	NO	NO
	Gaseous Fuels	NO	NO	NO	NO	NO	NO	NO
	Biomass	√	√	√	NO	NO	NO	NO
	Other Fuels	NA	NA	NA	NA	NA	NA	NA
d. Navigation								
	Residual Oil (Residual Fuel Oil)	NO	NO	NO	NO	NO	NO	NO
	Gas/Diesel Oil	√	√	√	√	√	√	√
	Gasoline	√	√	√	√	√	√	√
	Other Liquid Fuels	NO	NO	NO	NO	NO	NO	NO
	Gaseous Fuels	NO	NO	NO	NO	NO	NO	NO
	Biomass	NO	NO	NO	NO	NO	NO	NO
	Other Fuels	NO	NO	NO	NO	NO	NO	NO
e. Other Transportation								
	Liquid Fuels	NO	NO	NO	NO	NO	NO	NO
	Solid Fuels	NO	NO	NO	NO	NO	NO	NO
	Gaseous Fuels	NO	NO	NO	NO	NO	NO	NO
	Biomass	NO	NO	NO	NO	NO	NO	NO
	Other Fuels	NO	NO	NO	NO	NO	NO	NO
1.A.4 Other Sectors								
a. Commercial/Institutional								
	Liquid Fuels	√	√	√	√	√	√	√
	Solid Fuels	√	√	√	√	√	√	√
	Peat	√	√	√	√	√	√	√
	Gaseous Fuels	√	√	√	√	√	√	√
	Biomass	√	√	√	√	√	√	√
	Other Fuels	√	√	√	√	√	√	√
b. Residential								
	Liquid Fuels	√	√	√	√	√	√	√
	Solid Fuels	√	√	√	√	√	√	√
	Peat	NO	NO	NO	NO	NO	NO	NO
	Gaseous Fuels	√	√	√	√	√	√	√
	Biomass	√	√	√	√	√	√	√
	Other Fuels	NO	NO	NO	NO	NO	NO	NO
c. Agriculture/Forestry/Fisheries								
	Liquid Fuels	√	√	√	√	√	√	√
	Solid Fuels	NO	NO	NO	NO	NO	NO	NO
	Peat	NO	NO	NO	NO	NO	NO	NO
	Gaseous Fuels	√	√	√	√	√	√	√
	Biomass	√	√	√	√	√	√	√
	Other Fuels	√	√	√	√	√	√	√
1.A.5 Other								
a. Stationary								
	Liquid Fuels	NO	NO	NO	NO	NO	NO	NO
	Solid Fuels	NO	NO	NO	NO	NO	NO	NO
	Peat	NO	NO	NO	NO	NO	NO	NO
	Gaseous Fuels	NO	NO	NO	NO	NO	NO	NO

Source	Fuel Type	Emissions						
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	Biomass	NO	NO	NO	NO	NO	NO	NO
	Other Fuels	NO	NO	NO	NO	NO	NO	NO
b. Mobile – Military navigation and aircrafts								
	Liquid Fuels	√	√	√	√	√	√	√
	Solid Fuels	NO	NO	NO	NO	NO	NO	NO
	Peat	NO	NO	NO	NO	NO	NO	NO
	Gaseous Fuels	NO	NO	NO	NO	NO	NO	NO
	Biomass	NO	NO	NO	NO	NO	NO	NO
	Other Fuels	NO	NO	NO	NO	NO	NO	NO

CO_2 emissions from fuel combustion were 6319.41 kt (including Transport sector) in 2020 and accounted for 90.2% of the total CO_2 emissions. The biggest CO_2 emissions contributor is Transport sector with 3068.59 kt CO_2 (43.8% of total CO_2 emissions).

CH_4 emissions from fuel combustion were 7.08 kt (including Transport sector) in 2020 and accounted for 10.3% of total CH_4 emissions. The biggest part of CH_4 emissions contribute Other sectors (CRF 1.A.4) – 5.74 kt.

N_2O emissions from fuel combustion were 0.62 kt (including Transport sector) and accounted 12.3% of the total N_2O emissions in 2020.

3.2.1 Comparison of the sectoral approach with the reference approach

Reference approach (RA) is carried out using import, export, production and stock change data as well as data of fuel consumption in international aviation and navigation reported as bunkering from CSB Energy Balance.

Difference between fuel consumption estimated with RA and Sectorial Approach (SA) liquid fuels is from 3.59% in 1995 to -19.61% in 2010 (Table 3.8). Difference for solid fuels is smaller from 0.62% in 2008 to -1.65% in 2005. Difference for gaseous fuels fluctuates from 3.10% in 1993 to 0.14% in 1990. For other fuels the fluctuations are from -7.72% in 2010 to 0% in 1999-2003. For peat the fluctuations are more significant – from 130.43% in 2010 to 0% in 2002, 2011, 2012, 2014, 2015, 2017, 2018, 2019 and 2020.

Table 3.8 Difference (%) between Sectoral and Reference approach data (PJ) and CO_2 emissions (kt)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Fuel consumption - Liquid fuels										
SA	138.369	123.918	103.899	96.848	91.071	74.327	80.205	68.889	67.747	63.128
RA	139.734	123.055	104.093	96.509	93.067	76.997	79.642	67.346	66.368	55.122
Diff., %	1.0	-0.7	0.2	-0.4	2.2	3.6	-0.7	-2.2	-2.0	-12.7
CO_2 emissions - Liquid fuels										
SA	10352.834	9256.469	7760.806	7233.550	6831.235	5563.597	6022.154	5149.124	5056.573	4702.819
RA	10431.750	9162.884	7749.850	7179.873	6954.013	5736.053	5880.222	5018.691	4936.963	4118.943
Diff., %	0.8	-1.0	-0.1	-0.7	1.8	3.1	-2.4	-2.5	-2.4	-12.4
Fuel consumption - Solid fuels										
SA	26.249	22.512	18.756	17.092	12.173	7.225	6.853	5.630	4.178	3.636
RA	26.126	22.626	18.869	17.048	12.095	7.171	6.802	5.578	4.155	3.586
Diff., %	-0.5	0.5	0.6	-0.3	-0.6	-0.7	-0.7	-0.9	-0.5	-1.4
CO_2 emissions - Solid fuels										
SA	2408.525	2062.188	1718.079	1567.332	1116.310	662.616	628.572	516.510	383.096	333.912
RA	2426.354	2085.292	1743.791	1585.324	1136.974	679.933	646.108	545.150	411.924	362.550
Diff., %	0.7	1.1	1.5	1.1	1.9	2.6	2.8	5.5	7.5	8.6

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Fuel consumption - Gaseous fuels										
SA	99.517	98.844	70.753	46.150	33.623	41.304	35.224	43.116	42.217	40.442
RA	99.652	100.467	72.234	47.582	34.624	42.279	36.224	44.146	43.249	41.440
Diff., %	0.1	1.6	2.1	3.1	3.0	2.4	2.8	2.4	2.4	2.5
CO_2 emissions - Gaseous fuels										
SA	5485.517	5448.372	3972.205	2591.664	1872.620	2296.458	1975.738	2416.352	2368.888	2263.348
RA	5496.735	5541.689	4058.320	2674.041	1929.737	2352.323	2033.249	2475.848	2428.487	2320.858
Diff., %	0.2	1.7	2.2	3.2	3.1	2.4	2.9	2.5	2.5	2.5
Fuel consumption - Peat										
SA	3.217	3.243	3.854	3.624	3.370	3.837	3.495	3.465	2.448	1.356
RA	4.154	3.931	4.623	4.120	3.681	4.242	3.931	3.809	2.629	1.459
Diff., %	29.1	21.2	20.0	13.7	9.2	10.6	12.5	9.9	7.4	7.6
CO_2 emissions - Peat										
SA	333.589	338.607	402.160	379.478	354.448	403.264	366.786	364.406	257.611	143.237
RA	433.180	411.771	483.970	432.345	387.635	446.469	413.220	401.074	276.780	153.537
Diff., %	29.9	21.6	20.3	13.9	9.4	10.7	12.7	10.1	7.4	7.2
Fuel consumption - Other fuels										
SA	0.879	NO	NO	NO	NO	NO	NO	NO	NO	0.026
RA	0.879	NO	NO	NO	NO	NO	NO	NO	NO	0.026
Diff., %	0.0	NO	NO	NO	NO	NO	NO	NO	NO	0.0
CO_2 emissions - Other fuels										
SA	64.431	NO	NO	NO	NO	NO	NO	NO	NO	2.090
RA	64.498	NO	NO	NO	NO	NO	NO	NO	NO	2.092
Diff., %	0.1	NO	NO	NO	NO	NO	NO	NO	NO	0.1

Continuation of Table 3.8

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Fuel consumption - Liquid fuels										
SA	52.047	52.268	51.981	53.897	55.166	54.650	59.946	65.001	60.075	54.860
RA	44.980	47.994	43.843	47.871	49.774	49.303	53.583	59.404	55.768	46.911
Diff., %	-13.6	-8.2	-15.7	-11.2	-9.8	-9.8	-10.6	-8.6	-7.2	-14.5
CO_2 emissions - Liquid fuels										
SA	3838.443	3842.920	3825.622	3977.980	4071.505	4017.693	4406.591	4770.153	4406.256	4033.129
RA	3299.690	3512.441	3217.213	3582.312	3274.634	3025.879	3948.982	4332.194	4054.504	3427.792
Diff., %	-14.0	-8.6	-15.9	-9.9	-19.6	-24.7	-10.4	-9.2	-8.0	-15.0
Fuel consumption - Solid fuels										
SA	2.785	3.638	2.928	2.674	2.596	3.199	3.439	4.248	4.222	3.409
RA	2.761	3.614	2.903	2.648	2.570	3.146	3.408	4.248	4.248	3.409
Diff., %	-0.9	-0.7	-0.9	-1.0	-1.0	-1.6	-0.9	0.0	0.6	0.0
CO_2 emissions - Solid fuels										
SA	255.542	333.638	268.664	251.898	244.561	301.617	323.932	399.626	397.159	320.696
RA	284.141	362.333	294.802	266.525	262.073	316.286	338.073	411.371	414.262	335.277
Diff., %	11.2	8.6	9.7	5.8	7.2	4.9	4.4	2.9	4.3	4.5
Fuel consumption - Gaseous fuels										
SA	44.962	52.255	53.501	55.666	55.247	56.685	58.627	56.588	55.478	50.742
RA	45.736	53.162	54.072	56.408	55.785	56.852	58.893	56.922	55.814	51.381
Diff., %	1.7	1.7	1.1	1.3	1.0	0.3	0.5	0.6	0.6	1.3
CO_2 emissions - Gaseous fuels										
SA	2502.885	2903.725	2974.757	3090.325	3070.325	3148.814	3258.515	3145.255	3081.689	2822.652
RA	2547.784	2956.227	3008.596	3133.695	3102.374	3160.288	3275.619	3166.036	3102.511	2860.177
Diff., %	1.8	1.8	1.1	1.4	1.0	0.4	0.5	0.7	0.7	1.3
Fuel consumption - Peat										
SA	2.392	1.245	1.005	0.673	0.080	0.080	0.070	0.090	0.051	0.026
RA	2.483	1.261	1.005	0.914	0.091	0.081	0.071	0.091	0.091	0.036
Diff., %	3.8	1.3	0.0	35.8	13.8	1.1	1.1	0.8	78.1	38.5

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2 emissions - Peat										
SA	253.219	131.852	106.516	71.334	8.479	8.489	7.440	9.557	5.407	2.705
RA	263.090	133.623	106.590	96.939	9.651	8.591	7.530	9.649	9.634	3.804
Diff., %	3.9	1.3	0.1	35.9	13.8	1.2	1.2	1.0	78.2	40.7
Fuel consumption - Other fuels										
SA	0.094	0.553	1.034	0.617	0.722	0.977	0.351	0.303	0.406	0.164
RA	0.094	0.553	1.034	0.617	0.721	0.973	0.348	0.299	0.401	0.161
Diff., %	0.0	0.0	0.0	0.0	-0.1	-0.5	-0.9	-1.2	-1.1	-2.1
CO_2 emissions - Other fuels										
SA	7.463	41.595	77.245	46.479	54.301	72.429	26.294	22.586	31.370	12.583
RA	7.468	41.634	77.320	46.522	54.278	72.147	26.092	22.324	31.075	12.335
Diff., %	0.1	0.1	0.1	0.1	0.0	-0.4	-0.8	-1.2	-0.9	-2.0

Continuation of Table 3.8

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Fuel consumption - Liquid fuels											
SA	56.585	50.493	49.308	49.702	51.186	53.446	53.694	56.428	56.791	56.369	54.118
RA	45.491	43.816	47.424	47.140	51.131	49.343	49.304	55.094	55.982	54.383	53.198
Diff., %	-19.6	-13.2	-3.8	-5.2	-0.1	-7.7	-8.2	-2.4	-1.4	-3.5	-1.7
CO_2 emissions - Liquid fuels											
SA	4174.550	3704.465	3611.370	3635.947	3742.656	3913.669	3934.664	4137.953	4169.643	4144.796	3981.270
RA	3375.078	3190.002	3456.613	3431.099	3722.307	3594.144	3604.246	4031.051	4099.274	3986.171	3905.990
Diff., %	-19.2	-13.9	-4.3	-5.6	-0.5	-8.2	-8.4	-2.6	-1.7	-3.8	-1.9
Fuel consumption - Solid fuels											
SA	4.378	4.509	3.645	2.905	2.473	1.950	1.678	1.689	1.894	1.644	0.966
RA	4.378	4.509	3.645	2.906	2.473	1.950	1.678	1.686	1.893	1.643	0.966
Diff., %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-0.1	-0.1	0.0
CO_2 emissions - Solid fuels											
SA	411.877	424.180	343.257	280.510	238.754	188.262	162.050	163.107	182.865	158.729	93.262
RA	420.718	433.051	360.724	286.365	238.920	188.392	162.159	163.219	183.374	158.840	93.327
Diff.,%	2.15	2.09	5.09	2.09	0.07	0.07	0.07	0.07	0.28	0.07	0.07
Fuel consumption - Gaseous fuels											
SA	61.044	53.528	50.301	49.994	44.798	45.758	46.751	41.193	48.494	45.680	37.754
RA	61.313	54.034	50.806	50.544	45.386	46.096	47.209	41.670	49.024	46.304	38.207
Diff., %	0.4	0.9	1.0	1.1	1.3	0.7	1.0	1.2	1.1	1.4	1.2
CO_2 emissions - Gaseous fuels											
SA	3388.966	2971.035	2786.684	2724.612	2443.643	2499.750	2599.260	2289.890	2693.622	2538.140	2093.922
RA	3406.262	3001.201	2816.613	2756.498	2477.435	2519.962	2626.545	2318.013	2724.951	2574.600	2120.523
Diff., %	0.5	1.0	1.1	1.2	1.4	0.8	1.0	1.2	1.2	1.4	1.3
Fuel consumption - Peat											
SA	0.046	0.043	0.034	0.064	0.035	0.011	0.034	0.040	0.135	0.072	0.051
RA	0.106	0.043	0.034	0.084	0.035	0.011	0.035	0.040	0.135	0.072	0.051
Diff., %	130.4	0.0	0.0	31.3	0.0	0.0	2.9	0.0	0.0	0.0	0.0
CO_2 emissions - Peat											
SA	4.824	4.532	3.570	6.749	3.667	1.157	3.604	4.146	14.172	7.478	5.261
RA	11.211	4.553	3.602	8.892	3.669	1.135	3.712	4.187	14.065	7.361	5.215
Diff., %	132.4	0.5	0.9	31.7	0.1	-1.9	3.0	1.0	-0.8	-1.6	-0.9
Fuel consumption - Other fuels											
SA	0.540	0.784	0.905	1.143	1.314	1.281	0.921	1.172	1.651	1.480	1.705
RA	0.499	0.752	0.877	1.115	1.279	1.248	0.917	1.169	1.586	1.418	1.633
Diff., %	-7.7	-4.2	-3.1	-2.4	-2.7	-2.6	-0.5	-0.3	-3.9	-4.1	-4.2
CO_2 emissions - Other fuels											
SA	43.915	75.165	81.810	96.712	112.355	110.809	78.234	99.873	138.275	126.025	145.699
RA	40.803	72.754	79.766	94.697	109.769	108.331	77.933	99.709	133.461	121.500	140.393
Diff., %	-7.1	-3.2	-2.5	-2.1	-2.3	-2.2	-0.4	-0.2	-3.5	-3.6	-3.6

The biomass consumption in comparison is not included as this type of fuel is assumed as CO_2 neutral.

The amount of used tires combusted in cement production plant is reported as Other fuels as well as municipal waste combusted in the same cement production plant. According to 2006 IPCC Guidelines, used oils are also reported under the Other fuels.

3.2.1.1 Explanation of the difference

Energy Balance

In the Annual questionnaires, as well as in CSB online database statistical differences, distribution losses and interproduct transfer are reported for certain fuels, whereas in the RA table only stock changes are possible to insert. These data are not taken into account and are not put in stock changes' cells of the CRF Reporter RA tables. Therefore the difference in liquid fuels and peat have been quite significant for many years. For example, distribution losses for peat are quite visible, in comparison to total consumption, especially in 2010. To improve the transparency of reporting, the statistical differences, losses, as well as an interproduct transfers for the whole time series are presented in Annex A.3.1 "Energy losses, statistical differences, transfers and secondary production of products in Energy sector, TJ" of this report.

CSB estimates total consumption data by taking production, import, export, international bunkering and stock changes data into account. Final consumption data is estimated by taking into account sectoral consumption data reported by fuel consumers, excluding reported distribution losses data. Transformation of Energy sectors are not included in final consumption data. For several fuel types difference between these two estimation approaches is reported as a statistical difference that is quite significant for some fuel types – diesel oil, gasoline, residual fuel oil. For peat amount of distribution losses is also quite significant but this amount is not taken into account in RA reporting.

CSB also reports the amount of fuel that is used in interproduct transfer, but it is not reported in RA tables. Therefore the consumption of fuel in RA tables is reported even though the fuel was not consumed in Latvia, for example, for other kerosene in 2004-2008.

The changes larger than 5% between fuel consumption in RA and Sectorial Approach (SA) are explained below for each fuel type.

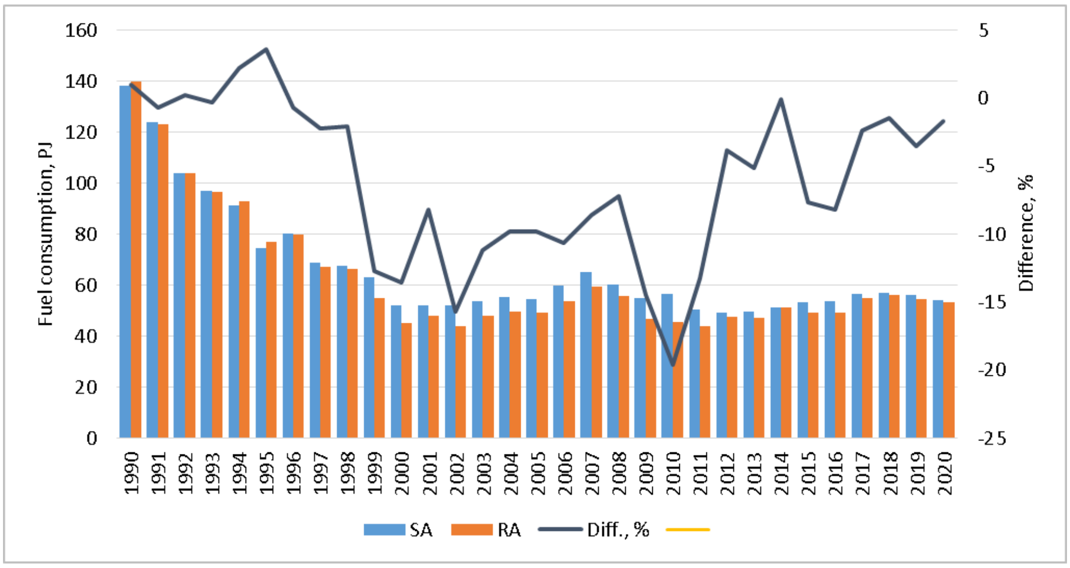

Figure 3.5 Difference in fuel consumption of Liquid fuels between Reference and Sectoral Approach (PJ;%)

The difference in Liquid fuels consumption between different types of fuels varies from -2% to 4% until 1998, and with up to -19.6% difference in 2010 (Table 3.5). The differences after 1998 can be generally explained with statistical differences in diesel oil energy balance that are not taken into account when calculating RA, and also with interproduct transfers of RFO, shale oil, jet fuel and kerosene. For transparency purposes of reporting, the statistical differences and losses for the whole time series are presented in Annex A.3.1 of this report.

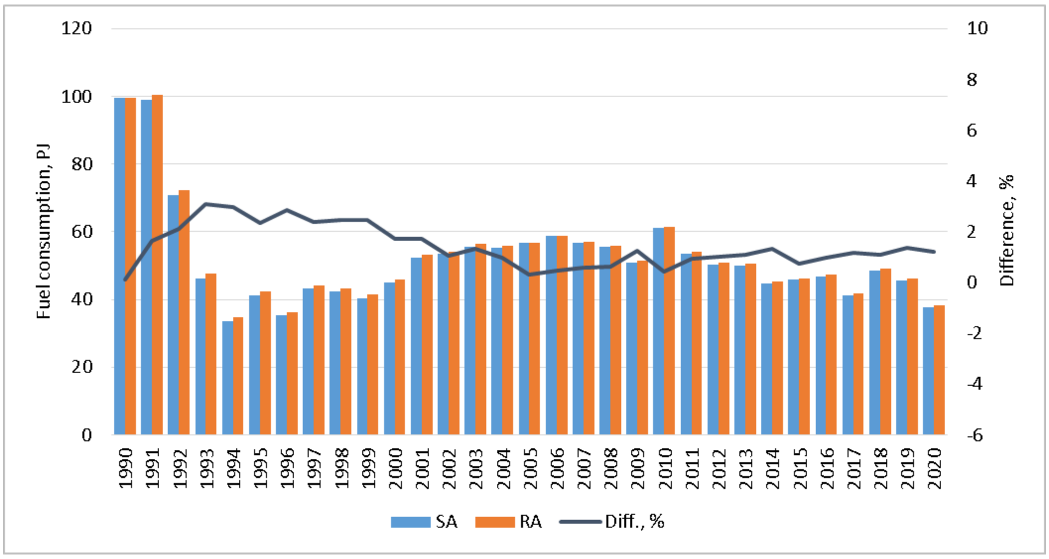

Figure 3.6 Difference in fuel consumption of Gaseous fuels between Reference and Sectoral Approach (PJ;%)

The differences in Natural gas consumption between Sectoral and Reference approaches are mainly due to losses that occur every year (Figure 3.6). For transparency purposes of reporting, the statistical differences and losses for the whole time series are presented in Annex A.3.1 of this report.

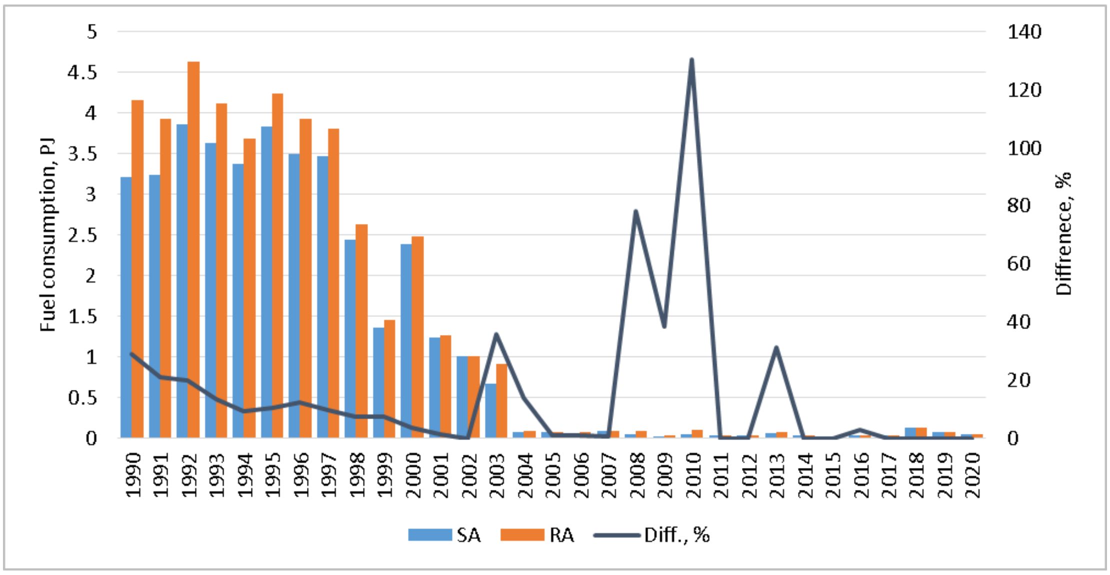

Figure 3.7 Difference in fuel consumption of Peat (including Peat briquettes) between Reference and Sectoral Approach (PJ;%)

Among the all fuel types, for peat and peat briquettes the differences are the most significant (Figure 3.7). It is because there are significant losses of peat reported by CSB, for example, in 2003, there were 241 TJ reported by CSB as peat losses, and it can be clearly seen in difference of RA and SA - while the total consumption according to RA is 914 TJ, within SA only 673 TJ were reported. The same applies to years 2008-2011 and 2013, where losses of peat are around 10-60 TJ. With a small total peat consumption these losses immensely affect the difference between SA and RA. For transparency purposes of reporting, losses for the whole time series are presented in Annex A.3.1 of this report.

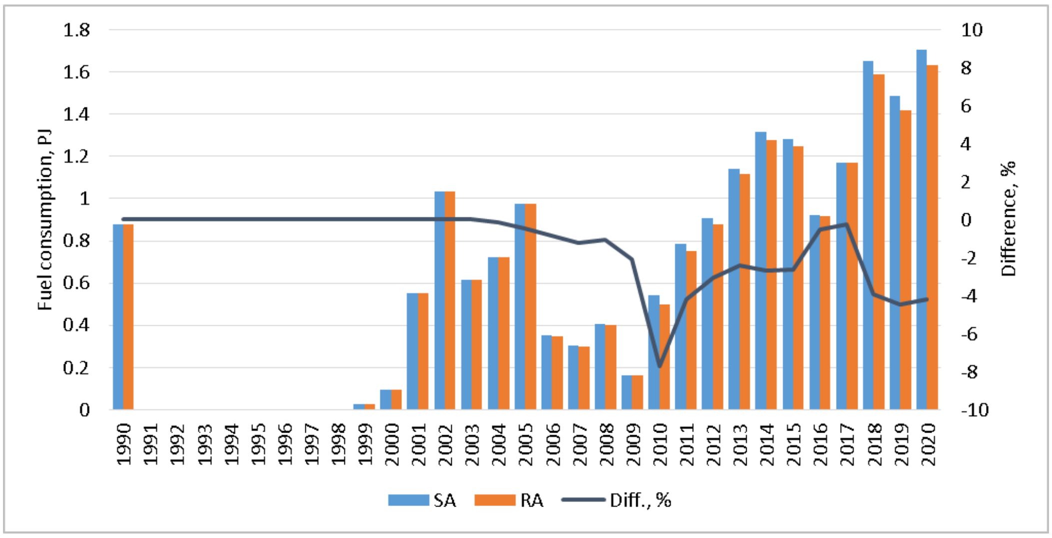

Figure 3.8 Difference in consumption of Other fuels between Reference and Sectoral Approach (PJ;%)

The differences for Other fuels are not more than ±5% (Figure 3.8), therefore they are not analysed.

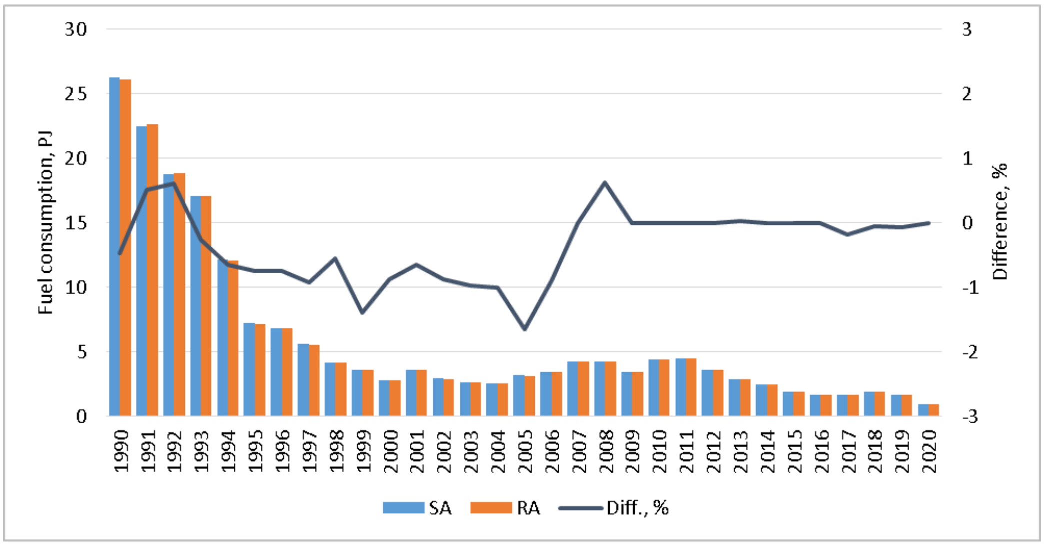

Figure 3.9 Difference in consumption of Solid fuels between Reference and Sectoral Approach (PJ;%)

Also the differences for solid fuels are no more than ±5% (Figure 3.9), therefore they are not analysed.

3.2.1.2 Explanation of the fluctuations

Fluctuations of emissions estimated with SA and RA are more or less equal. All fuels had decreased in 1990-1995 due to continual changes of structure of the economy, inflation and collapse of the former Soviet Union industry. Still in 1995-1996 the government adopted strict rules to cut back the inflation and downward of industry, so the fuel consumption since 1995-1996 also was restructured. Since 1996 the natural gas consumption was increasing, while the other fuel consumption was increasing only after 2000, due to the development of national economy that was prepared for joining the European Union. In addition, in recent years there can be seen the influence of the global economic crisis in 2007-2009 and a recovery after that in 2010-2014 with a decreasing trend of emissions. In 2014-2018 overall use of fuels has increased that can be explained with the economic growth and increased household purchasing power (increase in average salary), largest fuel consumption can be seen in Road transportation (CRF 1.A.3.b).

3.2.1.3 Methodological issues

The 2006 IPCC Guidelines RA for the CO_2 emission estimations and comparison of CO_2 emissions were used. CRF Reporter software was used to report emission data. Annual import, export, production, international bunkers and stock changes data divided by fuel types are put in the RA tables of CRF Reporter as well as carbon EF and coefficient of fraction of carbon oxidized.

Generally emissions are calculated by multiplying fuel consumption with country specific, plant specific or IPCC default carbon EF taking into account fraction of carbon oxidized.

Carbon EFs were estimated by taking into account net calorific values (NCV) and the molecular weight ratio of the carbon and CO_2. NCV of the fuels are taken from CSB Energy Balance. The consumption of fuels is taken from CSB on-line database due to more precise data (smaller units) as in Annual Questionnaires, therefore, in order to improve transparency of the reporting, it was decided to use data from CSB Energy Balance instead of Annual Questionnaires.

For coal, peat, gasoline, diesel oil, RFO, shale oil, jet fuel, kerosene, wood, used oils and natural gas carbon EF is assumed as country specific. For several fuels NCV changes once in whole time series, but for natural gas and municipal waste NCV and also carbon EF changes for every year in whole time series. NCV and carbon emission factor (C_{EF}) of other liquid fuels changes in every year in time series are explained with the fluctuation of other oil fuel structure (biogasoline, biodiesel, other liquid biofuels – bioethanol). Municipal waste structure also influenced C_{EF} change in 2008-2020.

Table 3.9 Carbon emission factors (t/TJ)

Fuel type	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
Peat	*28.93*	*28.93*	*28.93*	*28.93*	*28.93*	*28.93*	*28.93*	*28.93*	*28.93*	*28.93*	*28.93*
Gasoline	*18.89*	*18.89*	*18.89*	*18.91*	*18.91*	*18.91*	*18.91*	*18.91*	*18.91*	*18.91*	*18.91*
Diesel oil	*20.40*	*20.40*	*20.40*	*20.40*	*20.40*	*20.40*	*20.40*	*20.40*	*20.40*	*20.40*	*20.40*
RFO	*21.11*	*21.11*	*21.11*	*21.11*	*21.11*	*21.11*	*21.11*	*21.11*	*21.11*	*21.11*	*21.11*
Shale oil	*21.05*	*21.05*	*21.05*	*21.05*	*21.05*	*21.05*	*21.05*	*21.05*	*21.05*	*21.05*	*21.05*
LPG	*17.13*	*17.13*	*17.13*	*17.13*	*17.13*	*17.13*	*17.13*	*17.13*	*17.13*	*17.13*	*17.13*
Jet fuel	*19.72*	*19.72*	*19.72*	*19.71*	*19.71*	*19.71*	*19.71*	*19.71*	*19.71*	*19.71*	*19.71*
Kerosene	*19.72*	*19.72*	*19.72*	*19.72*	*19.72*	*19.72*	*19.72*	*19.72*	*19.72*	*19.72*	*19.72*
Wood	*30.01*	*30.01*	*30.01*	*30.01*	*30.01*	*30.01*	*30.01*	*28.86*	*28.86*	*28.86*	*28.86*
Used oils	*20.01*	*20.01*	*20.01*	*20.01*	*20.01*	*20.01*	*20.01*	*20.01*	*20.01*	*20.01*	*20.01*
Natural gas	*15.04*	*15.17*	*15.19*	*15.16*	*15.15*	*14.91*	*15.17*	*15.17*	*15.16*	*15.16*	*15.14*
Landfill gas, sludge gas, other biogas	*NO*	*14.90*	*14.90*	*14.90*	*14.90*	*14.90*	*14.90*	*14.90*	*14.90*	*14.90*	*14.90*
Municipal waste (biomass)	*NO*	*NO*	*6.14*	*6.14*	*23.77*	*12.14*	*11.27*	*10.99*	*10.31*	*12.14*	*11.68*
Industrial waste	*NO*	*NO*	*21.68*	*21.68*	*23.97*	*22.17*	*23.48*	*23.46*	*21.88*	*23.15*	*23.49*
Municipal waste (non-biomass)	*NO*	*NO*	*NO*	*NO*	*22.57*	*24.25*	*23.23*	*23.32*	*23.32*	*23.46*	*23.46*
Petroleum coke	*26.60*	*26.60*	*26.60*	*26.60*	*26.60*	*26.60*	*26.60*	*26.60*	*26.60*	*26.60*	*26.60*
Anthracite	*26.80*	*26.80*	*26.80*	*26.80*	*26.80*	*26.80*	*26.80*	*26.80*	*26.80*	*26.80*	*NO*
Peat briquettes	*26.60*	*26.60*	*26.60*	*26.60*	*26.60*	*26.60*	*26.60*	*26.60*	*26.60*	*26.60*	*26.60*
Waste oils	*20.00*	*20.00*	*20.00*	*20.00*	*20.00*	*20.00*	*20.00*	*20.00*	*20.00*	*20.00*	*20.00*
Straws	*27.30*	*27.30*	*27.30*	*27.30*	*27.30*	*27.30*	*27.30*	*27.30*	*27.30*	*27.30*	*27.30*
Charcoal	*30.50*	*30.50*	*30.50*	*30.50*	*30.50*	*30.50*	*30.50*	*30.50*	*30.50*	*30.50*	*30.50*
Oil shale	*29.10*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
Coal	*25.00*	*25.00*	*25.00*	*25.68*	*25.68*	*26.35*	*26.35*	*26.35*	*26.35*	*26.35*	*26.35*
Coke	*29.20*	*29.20*	*29.20*	*29.20*	*29.20*	*29.20*	*29.20*	*29.20*	*29.20*	*29.20*	*19.30*
Biogasoline, biodiesels	*NO*	*NO*	*NO*	*19.30*	*19.30*	*19.30*	*19.30*	*19.30*	*19.30*	*19.30*	*19.30*

C_{EF} for landfill gas, sludge gas, other biogas, petroleum coke, anthracite, peat briquettes, waste oils, straws, charcoal, oil shale, coke, biogasoline, biodiesels and other liquid biofuels taken from the 2006 IPCC Guidelines were used (Table 3.9). C_{EF} for industrial and municipal waste was estimated based on CO_2 EF reported by a cement production plant within EU ETS.

3.2.1.4 Time-series consistency

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

3.2.1.5 Category-specific QA/QC and verification

The best way to check RA data is to compare them with SA data that is done already in CRF Reporter. The difference between these two emission estimation and reporting methodologies has to be double-checked and explained.

Activity data are checked:

- Energy sector data is taken from the CSB Energy Balance, and it has the internal QA/QC procedures based on mathematical model and analysis to avoid logic mistakes.
- Data of RA are verified by CSB within the National Inventory System Quality assurance process and in case of inconsistency of data reported in NIR and CRF with the data in CSB Energy Balance and data reported to EUROSTAT by CSB, all the information of data mismatch is reported to LEGMC. After that, the Energy sector's sectoral expert checks the reported data and incorporates the necessary changes in the CRF and NIR. If the sectoral expert doesn't agree with the reported data mismatch and considers that no changes are necessary, the information is sent to CSB with the detailed explanation.

Estimated CO_2 emissions are checked:

- By comparing the emissions estimated with RA and SA. All significant differences (more than 5%) are double-checked. Difference has to be explained and agreed with CSB. This verification step is done for total fuel combustion sector.
- By comparing used carbon emission factor with CO_2 EFs used in SA.

3.2.2 International bunker fuels

International bunkers cover international aviation and navigation according to the 2006 IPCC Guidelines. Emissions from international aviation and navigation are not included in national total emissions. Taking into consideration that ports in Latvia are focused on transit cargo transport, navigation activities have big fluctuations and depend on neighbouring countries' economical and international trading activities and competitiveness of Latvian ports' with other neighbouring ports in Baltic Sea. At the same time emissions from aviation are more stable, and recent trend depicts a persistent increase. In 2020, total GHG emissions of International Bunkering (see Figure 3.10), compared to 2019, have decreased by 39.7%. GHG emissions reductions in international aviation were more rapid than in navigation. If emissions in international aviation decreased by 63.0%, in international navigation by 28.6%.

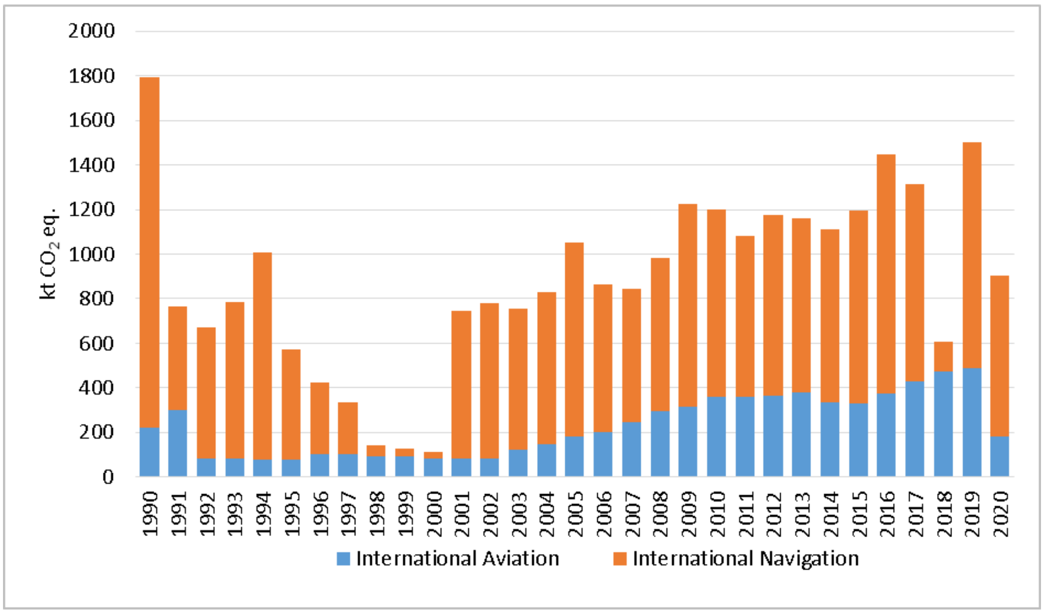

Figure 3.10 Emissions from International Bunkers (kt CO_2 eq.)

Data about international bunker fuel consumption is provided by CSB (Table 3.10). CSB split of fuel for national and international navigation/aviation is based on EUROSTAT and IEA guidelines on data collection. Defined approach concerning energy consumption allocation for international and national navigation/aviation is fully in line with the defined criteria in IPCC GPG 2000 (for more details see "Energy Statistics Manual", IEA, EUROSTAT (2005)). In Latvia there are no situations where international marine/aviation transport departs from one port and stops in other port of Latvia for passengers or freight and then departs to final destination in other country. Therefore, implemented data collections of fuel consumption in international and national navigation/aviation fully ensure a correct allocation between national and international mode.

To provide consistent allocation of fuel consumption between domestic and international mode in the navigation and aviation, CSB each month collects and summarizes the information that is submitted by every enterprise performing fuel bunkering. For this purpose, the particular statistical report format is elaborated where the enterprises must fill in the data regarding amount of fuel sold respectively in domestic and international navigation and aviation.

Table 3.10 Energy consumption in international transport (TJ)

Year	Aviation	Navigation	
	Jet Kerosene	Diesel Oil	Residual Fuel oil
1990	*3067*	*5014*	*14738*
1995	*1080*	*1105*	*5156*
2000	*1123*	*340*	*NO*
2001	*1123*	*4249*	*3938*
2002	*1166*	*3612*	*4994*
2003	*1685*	*3102*	*4750*
2004	*2031*	*3187*	*5278*
2005	*2463*	*3824*	*7064*
2006	*2765*	*2762*	*5481*
2007	*3371*	*2507*	*4953*

Year	Aviation	Navigation	
	Jet Kerosene	Diesel Oil	Residual Fuel oil
2008	*4051*	*1912*	*6699*
2009	*4278*	*2592*	*8851*
2010	*4907*	*2932*	*7592*
2011	*4921*	*3187*	*5800*
2012	*4984*	*3697*	*6374*
2013	*5142*	*3148*	*6658*
2014	*4580*	*2932*	*6780*
2015	*4494*	*5226*	*5440*
2016	*5116*	*6976*	*6226*
2017	*5858*	*5779*	*5116*
2018	*6417*	*1531*	*72*
2019	*6612*	*10523*	*1727*
2020	*2443*	*8541*	*128*

New sulphur regulations entered into force in 1 January 2015 for marine fuels used on board ships operating in the Emission Control Areas comprising the Baltic Sea and the North Sea. That resulted in the change of fuel type used on board ships. The maximum sulphur content in marine fuels was reduced from 1.00% to 0.10% by mass. To fulfil this requirement, the consumption of diesel oil substantially increased in 2015 (Table 3.10).

In 2020, GHG emissions from international aviation, compared to 2019, have decreased by 63% (Figure 3.10) due to decrease of arriving and departing flights affected by the Covid-19 pandemic. In 2020, the number of arriving and departing international flights have decreased by around 59%, compared to 2019.

CO_2 emissions from the international navigation are affected by fuel consumption depending on several factors:

- On the one hand it is affected by the port activity indicators (loaded, unloaded cargo). As shown in Figure 3.11, the total loaded and unloaded cargo volume in 2020 has decreased by nearly 28% compared to 2019. At the same time the structure of the cargo loaded in the time span 2002 - 2020 has changed (see Figure 3.12). The main changes have affected the oil transshipment, whose share in handeled cargo volume has decreased from 18.7% to 0.2%. At the same time, the cargo in containers share in the total handled cargo volume has increased from 1% to 8.5%.
- On the other hand, important reason for these fluctuation of fuel consumption in international navigation has been the variation in bunker fuel prices. Vessels can refuel in one or other country depending on fuel prices. This was the main factor for a sharp decrease in fuel consumption in 2018 and increase in 2019.

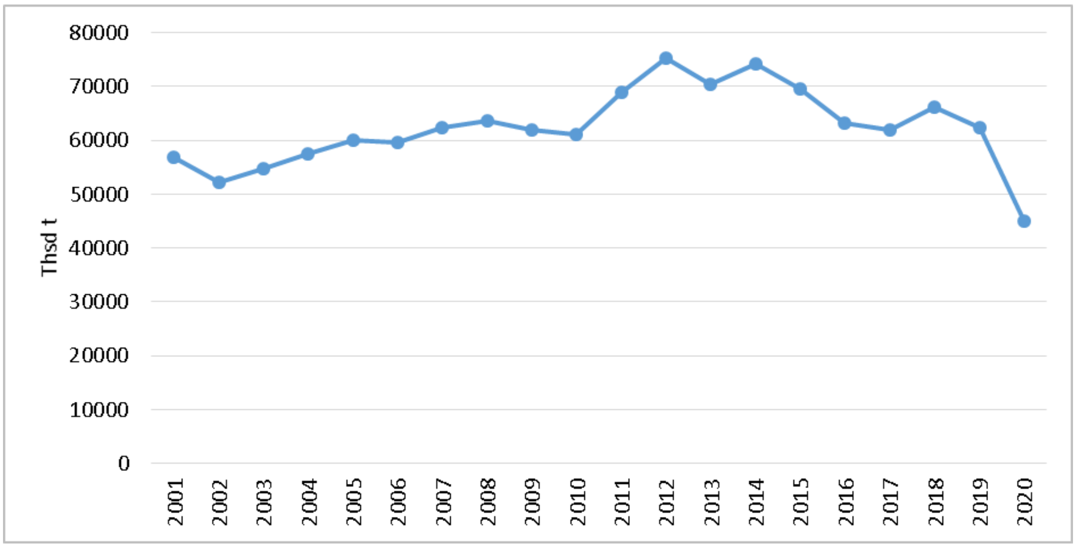

Figure 3.11 Loaded, unloaded cargo at ports in Latvia (thsd t)

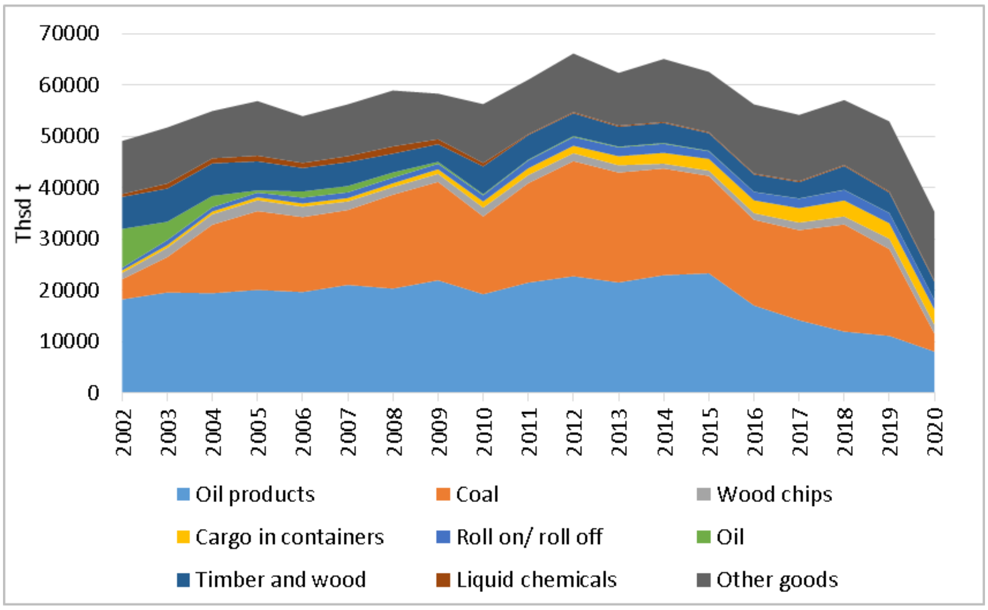

Figure 3.12 Structure of loaded goods at ports in Latvia (thsd t)

The implemented EFs for emission calculation from international navigation are displayed in Table 3.11.

Table 3.11 Emission factors used in the calculation of emissions from International Bunkering

Fuel	CO_2 kt/PJ	CH_4 kt /PJ	N_2O kt /PJ	NO_x kt /PJ	CO kt /PJ	NMVOC kt /PJ
Diesel oil	*74.75*	*0.004*	*0.03*	*1.8475*	*0.1742*	*0.0659*
RFO	*77.4*	*0.005*	*0.002*	*1.9532*	*0.1822*	*0.0665*

The methodology used for calculation of emissions from international aviation corresponds to the 2006 IPCC Guidelines Tier 2 where the amount of LTO/cruises (landing and take-off) is crucial. The calculated average specific fuel consumption of LTO have been compared and verified with Eurocontrol's emission data for time span 2008-2019. Emissions from international navigation are calculated in pursuance with the 2006 IPCC Guidelines Tier 1.

The relevant EFs are used from different sources. All of the international aviation and navigation EFs (CO_2, CH_4 and N_2O) derived from the 2006 IPCC Guidelines, while the remaining factors – from EMEP/EEA 2019 (for determination of SO_2 EF country-specific sulphur content is applicable) (see Table 3.12 and Table 3.13).

Table 3.12 SO_2 Emission factors used for diesel oil in the SO_2 calculation of emissions International Bunkering

Diesel oil	Content in fuel, %	NCV, GJ/t	EF (Gg/PJ)
1990-2002	*0.2*	*42.49*	*0.094*
2003-2004	*0.05*	*42.49*	*0.024*
2004-2007	*0.2*	*42.49*	*0.094*
2008-2020	*0.1*	*42.49*	*0.047*

Table 3.13 SO_2 Emission factors used for RFO in the SO_2 calculation of emissions International Bunkering

RFO	Content in fuel, %	NCV, GJ/t	EF (Gg/PJ)
1990-1999	*3.5*	*40.6*	*1.689*
2000-2009	*1.5*	*40.6*	*0.724*
2010-2014	*1.0*	*40.6*	*0.483*
2015-2020	*0.1*	*40.6*	*0.048*

3.2.3 Feedstocks and non-energy use of fuels (CRF 1.AD)

3.2.3.1 Category description

Under this category consumption of different types of fuels used as feedstock is reported. Emissions from these fuels are reported as "CO_2 not emitted" because it is assumed that in CO_2 emissions are captured and not emitted to the air.

Consumption of Bitumen, Lubricants, Coke, White spirits and Paraffin wax is reported in 1.AD tables for all years in time series 1990–2020.

3.2.3.2 Methodological issues

C_{EF} used in the 2006 IPCC Guidelines were used for calculation:

- Bitumen - 22 t/TJ;
- Lubricants - 20 t/TJ;
- Coke - 29.2 t/TJ;
- White spirits - 20 t/TJ;
- Paraffin waxes - 20 t/TJ.

Carbon excluded from fuel combustion emissions is calculated using IPCC 2006 Volume 2 Energy equation 6.4

$$\boldsymbol{Excluded\ Carbon_{fuel} = Activity\ Data_{fuel} * CC_{fuel} * 10^{-3}} \quad (3.1)$$

where:
Excluded carbon – carbon excluded from fuel combustion emissions (kt C)
Activity Data – activity data (TJ)
CC – carbon content (tonne C/TJ)

Activity data was prepared by CSB and available on CSB on-line database (Table 3.14).

Table 3.14 Activity data for Feedstocks and Non-energy use of fuels in 1990–2020 (TJ)

Year	Bitumen	Lubricants[11]			Coke	Other Oil[12]		
		Total consumption from Energy balance	Amount in Transport sector from combustion	Fuel quantity[13]		White spirits	Paraffin waxes	Fuel quantity[14;15]
1990	*1633*	*1633*	*43.2*	*1589.8*	*290*	*84*	*NO*	*84*
1991	*544*	*1047*	*39.8*	*1007.2*	*105*	*84*	*NO*	*84*
1992	*84*	*921*	*37.0*	*884.0*	*132*	*84*	*NO*	*84*
1993	*167*	*1088*	*36.2*	*1051.8*	*211*	*84*	*NO*	*84*
1994	*544*	*1005*	*34.7*	*970.3*	*264*	*84*	*NO*	*84*
1995	*712*	*963*	*32.8*	*930.2*	*211*	*84*	*NO*	*84*
1996	*879*	*963*	*32.1*	*930.9*	*211*	*84*	*NO*	*84*
1997	*1633*	*879*	*32.0*	*847.0*	*316*	*84*	*NO*	*84*
1998	*2051*	*1005*	*32.4*	*972.6*	*290*	*126*	*NO*	*126*
1999	*2344*	*879*	*32.9*	*846.1*	*316*	*84*	*126*	*210*
2000	*2009*	*879*	*36.9*	*842.1*	*290*	*126*	*126*	*252*
2001	*1507*	*837*	*44.0*	*793.0*	*290*	*126*	*167*	*293*
2002	*2093*	*837*	*45.7*	*791.3*	*268*	*84*	*167*	*251*
2003	*2177*	*921*	*48.2*	*872.8*	*161*	*84*	*167*	*251*
2004	*2009*	*1005*	*51.3*	*953.7*	*188*	*126*	*251*	*377*
2005	*2512*	*1088*	*54.3*	*1033.7*	*188*	*126*	*335*	*461*
2006	*3098*	*1088*	*61.1*	*1026.9*	*161*	*126*	*251*	*377*
2007	*3349*	*1088*	*69.2*	*1018.8*	*107*	*84*	*251*	*335*
2008	*3600*	*1047*	*66.0*	*981.0*	*134*	*84*	*209*	*293*
2009	*2218*	*628*	*59.0*	*569.0*	*134*	*42*	*293*	*335*
2010	*1967*	*586*	*62.7*	*523.3*	*80*	*40*	*461*	*501*
2011	*2930*	*795*	*54.1*	*740.9*	*80*	*42*	*293*	*335*
2012	*2888*	*922*	*52.1*	*869.9*	*161*	*42*	*251*	*293*
2013	*3181*	*880*	*54.2*	*825.8*	*52*	*42*	*377*	*419*
2014	*2930*	*632*	*58.1*	*573.9*	*NO*	*42*	*335*	*377*
2015	*3349*	*1022*	*62.4*	*959.6*	*NO*	*42*	*335*	*377*
2016	*2244*	*1398*	*62.9*	*1335.1*	*NO*	*47*	*316*	*363*
2017	*2398*	*872*	*65.8*	*806.2*	*3*	*42*	*249*	*291*
2018	*2649*	*1122*	*67.9*	*1054.1*	*1*	*45*	*396*	*441*
2019	*2205*	*1118*	*69.3*	*1048.7*	*1*	*47*	*368*	*415*
2020	*2739*	*905*	*66.4*	*838.6*	*NO*	*56*	*345*	*401*

Bitumen is used for Asphalt roofing and Road paving. CO_2 emissions are reported under Non-energy Products. Additional information about CO_2 calculations can be found in CRF 2.D.3 Asphalt roofing and Road paving (4.5.3 Road paving with asphalt (2.D.3.b) and Asphalt roofing (2.D.3.c)).

[11] *Lubricants used in Transport sector are subtracted from total consumption.*
[12] *Paraffin waxes and White spirits are included in "Other Oil" – IPCC 2006, Volume 2 Energy, Chapter 6: Reference Approach Table 6.2 Activity data for excluded carbon flows.*
[13] *Activity data entered in the CRF Table 1.A(d) Feedstock, reductants, and other non-energy use of fuels*
[14] *Activity data entered in the CRF Table 1.A(d) Feedstock, reductants, and other non-energy use of fuels*
[15] *In the CRF Table 1.A(b) Reference Approach Other oil is sum of White spirit (non-energy use), Paraffin waxes (non-energy use) and Other oil products (combustion)*

Lubricants are used in Transport sector (3.2.6.1.2 Road transport (CRF 1.A.3.b)) and IPPU (4.5.1 Lubricant Use (CRF 2.D.1)). Excluded CO_2 emissions from RA are reported under Lubricant use.

Coke is used as ingredient in metallurgy to produce higher quality steel. CO_2 emissions are reported under Iron and Steel Production (4.4.1 Iron and Steel Production (CRF 2.C.1)). Iron and steel production includes not only coke, but all emissions from Iron and Steel production process, therefore notation key "IE" is used.

Other oils (Paraffin waxes and White spirits) mainly are used in chemical industry and wood processing. CO_2 emissions are reported under Paraffin Wax Use, Solvent Use (4.5.2 Paraffin Wax Use (CRF 2.D.2) and 4.5.3 Other (CRF 2.D.3)). Solvent use includes not only white spirits, but also a variety of substances therefore it is not possible to determine the exact amount of CO_2 from white spirits exclusively, Paraffin wax emissions are calculated separately, therefore notation key "IE" is used.

3.2.4 Energy Industries (CRF 1.A.1)

3.2.4.1 Category description

CRF 1.A.1 Energy Industries sector includes emissions from fuel combustion in point sources in energy and heat production. According to the 2006 IPCC Guidelines, emissions from autoproducers (undertakings which generate electricity/heat wholly or partly for their own use, as an activity that supports their primary activity) are assigned to the sector where they were generated and not under CRF 1.A.1.

Emissions from combustion installations with NACE 2 codes 35.11 and 35.30 are reported in CRF 1.A.1.a sector. There are no petroleum refineries in Latvia therefore in CRF 1.A.1.b notation key „NO" is used. CRF 1.A.1 sector also includes the emissions from on-site use of fuel in the energy production facilities and emissions from manufacturing of solid fuels (peat briquettes and charcoal production plants) – these emissions are reported under 1.A.1.c Manufacture of solid fuels and other energy industries sector.

The GHG emissions were reported under following sectors:

- 1. A.1. Energy industries:
- 1.A.1.a. Public electricity and heat production:
    - 1.A.1.a.i Electricity generation;
    - 1.A.1.a.ii Combined heat and power generation;
    - 1.A.1.a.iii Heat plants;
- 1.A.1.c. Manufacture of solid fuels and other energy industries:
    - 1.A.1.c.i Manufacture of solid fuels.

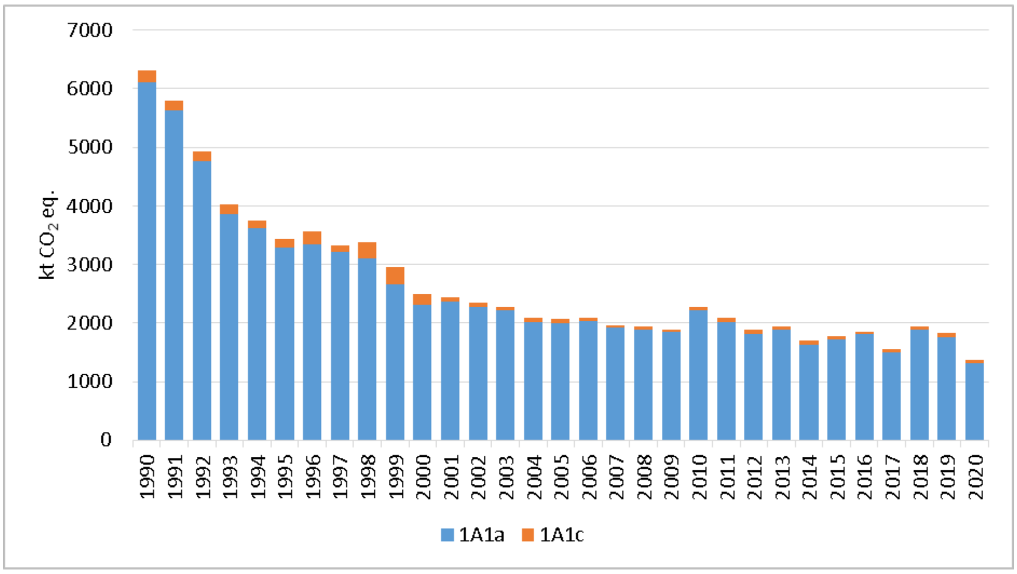

Figure 3.13 GHG emissions in CRF 1.A.1. Energy Industries by subsectors (kt CO_2 eq.)

In Figure 3.13 there can be seen a distribution of GHG emissions in CRF 1.A.1. sector. The largest part of emissions consists of CRF 1.A.1.a Public electricity and heat production (96.4% in 2020), while CRF 1.A.1.c Manufacture of solid fuels and Other energy industries contributes only 3.6% of Energy Industry emissions. As mentioned above, there are no emissions in CRF 1.A.1.b Petroleum refining, therefore notation key "NO" is used.

Table 3.15 Emissions from Energy industries (CRF 1.A.1) in 1990–2020 (kt)

Year	CO_2	CH_4	N_2O	GHGs (CO_2 eq)	NO_x	CO	NMVOC	SO_2
	kt			kt CO_2 eq.	kt			
1990	6301.72	0.19	0.038	6317.71	10.64	2.65	0.22	36.39
1991	5790.01	0.17	0.034	5804.33	9.74	2.60	0.21	29.52
1992	4924.64	0.15	0.031	4937.60	8.39	2.11	0.17	26.86
1993	4019.95	0.14	0.030	4032.26	7.16	1.52	0.14	28.30
1994	3743.31	0.15	0.032	3756.53	6.92	1.28	0.13	32.20
1995	3417.27	0.12	0.026	3428.11	6.25	1.39	0.12	22.83
1996	3542.01	0.15	0.030	3554.82	6.54	1.32	0.13	28.61
1997	3301.80	0.19	0.032	3316.07	6.10	1.70	0.14	19.66
1998	3363.37	0.21	0.035	3379.27	6.11	1.75	0.15	20.84
1999	2940.28	0.19	0.030	2954.01	5.24	1.61	0.13	16.02
2000	2491.00	0.15	0.024	2502.07	4.40	1.56	0.12	7.64
2001	2435.86	0.17	0.025	2447.43	4.37	1.75	0.13	5.51
2002	2331.21	0.18	0.026	2343.39	4.23	1.75	0.13	5.22
2003	2259.75	0.20	0.028	2273.09	4.15	1.86	0.14	3.89
2004	2068.30	0.20	0.026	2081.12	3.78	1.78	0.13	2.28
2005	2058.13	0.17	0.023	2069.22	3.61	1.66	0.12	1.61
2006	2084.68	0.19	0.025	2096.80	3.43	1.57	0.12	0.92
2007	1954.74	0.19	0.024	1966.67	3.17	1.42	0.11	1.06
2008	1927.07	0.18	0.024	1938.69	3.01	1.31	0.11	0.67
2009	1877.07	0.18	0.024	1888.79	2.94	1.26	0.11	0.78
2010	2260.90	0.20	0.027	2273.92	3.38	1.42	0.13	0.68
2011	2081.80	0.19	0.025	2093.86	3.06	1.25	0.11	0.63
2012	1864.41	0.22	0.029	1878.35	3.17	1.47	0.12	0.63

Year	CO_2	CH_4	N_2O	GHGs (CO_2 eq)	NO_x	CO	NMVOC	SO_2
	kt			kt CO_2 eq.	kt			
2013	*1929.18*	*0.32*	*0.043*	*1949.91*	*3.45*	*1.73*	*0.15*	*0.65*
2014	*1670.10*	*0.38*	*0.050*	*1694.50*	*3.29*	*1.84*	*0.15*	*0.60*
2015	*1746.42*	*0.41*	*0.054*	*1772.97*	*3.43*	*1.93*	*0.17*	*0.63*
2016	*1821.90*	*0.52*	*0.068*	*1855.07*	*3.75*	*2.23*	*0.19*	*0.80*
2017	*1510.68*	*0.59*	*0.078*	*1548.49*	*3.69*	*2.43*	*0.20*	*0.91*
2018	*1893.32*	*0.61*	*0.081*	*1932.70*	*3.97*	*2.44*	*0.21*	*0.98*
2019	*1783.09*	*0.64*	*0.085*	*1824.57*	*3.85*	*2.45*	*0.22*	*1.00*
2020	*1328.81*	*0.61*	*0.081*	*1368.15*	*3.89*	*2.75*	*0.21*	*0.93*
Share of Energy total, 2020	*21.0%*	*5.5%*	*13.1%*	*20.2%*	*15.0%*	*2.9%*	*1.6%*	*28.0%*
2020 vs 2019	*-25.5%*	*-5.2%*	*-5.1%*	*-25.0%*	*0.9%*	*12.4%*	*-3.1%*	*-7.1%*
2020 vs 1990	*-78.9%*	*221.6%*	*114.0%*	*-78.3%*	*-63.5%*	*3.8%*	*-5.0%*	*-97.5%*

CO_2 emissions from CRF 1.A.1 sector have a decreasing trend with a few fluctuations (Table 3.15). Since 1990 CO_2 emissions have decreased by 78.9%. In the beginning of the 90's the decrease of CO_2 emissions is explained with economic crisis caused by changes of political and social situation in country when national economy was completely reorganized. Decrease of emissions can be explained with higher standards of physical specification of fuels and switching to fuels with lower costs and emissions – natural gas and biomass. In recent years, fluctuation of CO_2 emissions can be explained with colder/warmer winter changes and therefore changes in length of the heating season - it is related with the amounts of fuel used for heat and electricity production. Emission fluctuations in later years can be contributed to changes of hydro power production, increase of energy efficiency in buildings as well as policies that promotes use of renewable energy resource, therefore significant decrease of fossil fuels and increase use of biomass can be observed in the sector. In 2020, CO_2 emissions have had significant decrease compared to 2019 – 25.5% and it is mainly due to the decrease use of natural gas (25.1%).

CH_4 and N_2O emissions increased in recent years, starting from 2011, due to increased use of biomass. Since 2011 up to 2019 CH_4 and N_2O emissions increased by 242.4% and 245.1%, respectively. If compared with CO_2 emissions, the increase in CH_4 and N_2O emissions is due to the biomass use – as it is considered as CO_2 neutral, it does not take place in CO_2 balance (CO_2 emissions from biomass is not included in national total), however, from biomass combustion CH_4 and N_2O emissions are counted. In 2020 CH_4 and N_2O emissions have decreased in comparison with 2019 by 5.2% and 5.1% because the use of biomass has decreased.

Precursors from CRF 1.A.1 Energy Industries were estimated as well. SO_2 had the biggest decrease by 97.5% in 1990–2020. It can be explained with fuel switching from coal, peat and heavy fuel oils to natural gas and biomass from what sulphur dioxide emissions are emitted in considerably smaller amounts. Also a strict National legislation was approved to improve the quality of used liquid fuels in country. NOx emissions have also decreased by 63.5% in 1990-2020, NMVOC emissions – by 5.0%, and CO emissions by 3.8%. These changes can be explained with fuel switch from liquid and solid fuels to natural gas and biomass, which have lower EFs.

3.2.4.2 Methodological issues

The 2006 IPCC Guidelines' Tier 2 method was used to estimate CO_2 emissions from fuel combustion as country specific parameters were used to estimate CO_2 EF. However, for some fuels country-specific EFs is not available, therefore the 2006 IPCC Tier 1 method using default EFs was used. The 2006 IPCC Guidelines' Tier 1 method was used to calculate CH_4 and N_2O emissions from the CRF 1.A.1 sector.

For calculation of all emissions from fuel combustion is used Excel databases developed by the experts from LEGMC. The general method for emission data calculation:

$$\boldsymbol{Em = EF * B_q} \tag{3.2}$$

where:
Em – total emissions (kt)
EF – estimated or default emission factor (t/TJ)
B_q – amount of fuel in thermal units (TJ)

SO_2 emission data are taken from the national database "2-Air" where enterprises that do any pollution activity and have A, B or C category pollution permits report their emissions and information about sulphur content in fuel used. Other precursors (NO_x, CO, NMVOC) are calculated using Tier 1 and Tier 2 method.

Emission factors and other parameters

The main sources for EFs are:

- National studies for country specific parameters and EFs;
- Data from natural gas provider company - natural gas physical characteristics;
- 2006 IPCC Guidelines;
- EMEP/EEA 2019.

Country specific EFs were used to calculate carbon dioxide and sulphur dioxide emissions.

CO_2 emission factors

In 2004, a research by a local expert was made regarding CO_2 EFs for Latvia. National expert assessed influences on CO_2 EF and calculated CO_2 EF in "Methodological instructions for CO_2 emissions determination" study. This research was made considering the UNFCCC IPCC guidelines and physical characterizations of types of fuels used in Latvia.

In 2017, research "Determination of Carbon Content and Calculation of Carbon Dioxide Emission Factors"[16] was carried out. In this research CO_2 EF for coal and wood was updated.

<u>Solid and liquid fuels and solid biomass</u>

For calculating CO_2 EFs for liquid and solid fuels following equation was used:

$$\boldsymbol{EF_{CO_2} = \frac{C^d * M_{CO_2} * 1000}{Q_d^z * M_c * 100}} \tag{3.3}$$

where:
EF_{CO2} – emission factor for CO_2 (kg CO_2/MJ)

[16] *Determination of Carbon Content and Calculation of Carbon Dioxide Emission Factors. Available: https://drive.google.com/file/d/1sbh7tna1pZfohvL_P-EVlJvzJqCvAyBR/view*

Q_z^d – net calorific value of fuel (MJ/kg (m^3))
C^d – carbon content in fuel (%)
M_{CO2} – molecule weight for CO_2 – 44. 0098 (g/mcl)
M_C – molecule weight for C – 12.011 (g/mcl)

NCV value was obtained from fuel consumers that must report the data about amount of fuel used and other relavant information to CSB within the annual reporting process (Table 3.16).

Table 3.16 Characteristics of liquid solid and solid biomass fuels and estimated CO_2 emission factors

Fuel type	Carbon content in working mass of fuel, (C^d) %	NCV, GJ/t	Oxidation factor	Emission factor (EF CO_2), t/TJ
Peat W_d=40%	*29.07*	*10.05*	*1*	*105.99*
Motor gasoline (for off-roads)	*83.13*	*44 (1990-2002)*	*1*	*69.23*
		43.97 (2003-)		*69.27*
Diesel oil	*86.68*	*42.49*	*1*	*74.75*
RFO	*85.72*	*40.6*	*1*	*77.36*
Shale oil	*82.82*	*39.35*	*1*	*77.12*
LPG	*77.99*	*45.54*	*1*	*62.75*
Jet fuel	*85.18*	*43.2 (1990-2002)*	*1*	*72.25*
		43.21 (2003-)		*72.23*
Other kerosene	*85.17*	*43.2 (1990-2000)*	*1*	*72.24*
		43.21 (2004)		*72.22*
		43.2 (2005-)		*72.24*
Other Oil Products	*83.77*	*41.86*	*1*	*73.33*
Wood W_d = 55%	*20.11*	*6.7*[17] *(1990-2016)*	*1*	*109.98*
Firewood W_d=51%	*22.88*	*7.7*[18]*(2017-)*	*1*	*108.45*
Wood waste W_d=57.2%	*20.3*	*2.69*[19]*(2017-)*	*1*	*117.32*
Wood chips W_d=44.7%	*23.92*	*3.26*[20]*(2017-)*	*1*	*98.70*
Wood briquettes W_d=9.65%	*48.1*	*16.78(2017-)*	*1*	*105.03*
Pellete wood W_d=7.38%	*49.83*	*17.54(2017-)*	*1*	*104.01*
Coal	*67.32*	*28.46 (1990-2002)*	*1*	*94.08*
	71.15	*26.22 (2003-2012)*		*91.60*
	63.50	*24.1 (2013-)*		*96.54*

For fuels mentioned bellow default CO_2 EFs from the 2006 IPCC Guidelines, Volume 2, Chapter 2 Stationary combustion, Table 2.2, were taken due to unavailability of country specific data:

- coke – 107 kt/PJ;
- peat briquettes – 97.5 kt/PJ;
- landfill gas – 54.6 kt/PJ;
- sludge gas – 54.6 kt/PJ;
- other biogas – 54.6 kt/PJ;
- biodiesel – 70.8 kt/PJ;
- straws – 100 kt/PJ;
- waste oils – 73.3 kt/PJ.

[17] Wood NCV – GJ/ tight m^3
[18] Firewood NCV – GJ/tight m^3
[19] Wood waste NCV – GJ/bulk m^3
[20] Wood chips NCV – GJ/bulk m^3

Natural gas

For calculating CO_2 EF for natural gas following equation was used:

$$EF_{CO_2} = \frac{C^d * M_{CO_2}}{M_c * 100} * p \tag{3.4}$$

where:
EF_{CO2} – emission factor for CO_2 (t/1000m^3)
C^d – carbon content in fuel (%)
M_{CO2} – molecule weight for CO_2 – 44.0098 (g/mcl)
Mc – molecule weight for C – 12.011 (g/mcl)
ρ – natural gas density – for transition from density to mass units (t/1000m^3)

Data of carbon content and natural gas density for 1990-2016 were obtained from only natural gas supplier JSC "Latvijas Gāze" that collected/measured these data by themselves (Table 3.17). In 2017 and after that information about natural gas density and carbon content was received from JSC "Conexus Baltic Grid". After liberalization of the Latvian gas market JSC "Conexus Baltic Grid" was handed over the natural gas infrastructure (main transmission system and underground gas storage). NCV values to calculate data further in energy units were taken from CSB.

Table 3.17 Characteristics of natural gas and estimated CO_2 emission factors

Year	Carbon content in working mass of fuel, (C_d)	Natural gas density, (ρ)	Oxidation factor	Emission factor, (EF CO_2)	Net calorific value, (NCV)
	%	t/1000m^3		t/1000m^3	GJ/1000 m^3
1990	*74.33*	*0.687*	*1*	*1.8703*	*33.93*
1991	*74.33*	*0.687*	*1*	*1.8703*	*33.93*
1992	*74.36*	*0.692*	*1*	*1.8863*	*33.60*
1993	*74.15*	*0.697*	*1*	*1.8924*	*33.70*
1994	*74.04*	*0.691*	*1*	*1.8757*	*33.68*
1995	*74.26*	*0.689*	*1*	*1.8745*	*33.71*
1996	*74.30*	*0.686*	*1*	*1.8673*	*33.29*
1997	*74.39*	*0.685*	*1*	*1.8658*	*33.29*
1998	*74.35*	*0.686*	*1*	*1.8680*	*33.29*
1999	*74.31*	*0.684*	*1*	*1.8627*	*33.28*
2000	*74.32*	*0.688*	*1*	*1.8733*	*33.65*
2001	*74.36*	*0.688*	*1*	*1.8735*	*33.71*
2002	*74.36*	*0.686*	*1*	*1.8686*	*33.61*
2003	*74.38*	*0.685*	*1*	*1.8672*	*33.63*
2004	*74.39*	*0.684*	*1*	*1.8641*	*33.54*
2005	*74.40*	*0.684*	*1*	*1.8633*	*33.54*
2006	*74.39*	*0.684*	*1*	*1.8639*	*33.53*
2007	*74.38*	*0.683*	*1*	*1.8609*	*33.48*
2008	*74.38*	*0.683*	*1*	*1.8622*	*33.53*
2009	*74.41*	*0.686*	*1*	*1.8704*	*33.62*
2010	*74.42*	*0.686*	*1*	*1.8692*	*33.67*
2011	*74.43*	*0.686*	*1*	*1.8698*	*33.69*
2012	*74.31*	*0.686*	*1*	*1.8665*	*33.69*
2013	*74.34*	*0.688*	*1*	*1.8751*	*34.41*
2014	*74.36*	*0.692*	*1*	*1.8857*	*34.57*
2015	*74.41*	*0.697*	*1*	*1.9009*	*34.80*

Year	Carbon content in working mass of fuel, (C_d)	Natural gas density, (ρ)	Oxidation factor	Emission factor, (EF CO_2)	Net calorific value, (NCV)
	%	t/1000m^3		t/1000m^3	GJ/1000 m^3
2016	*74.40*	*0.698*	*1*	*1.9020*	*34.21*
2017	*74.42*	*0.697*	*1*	*1.9012*	*34.20*
2018	*74.44*	*0.697*	*1*	*1.9022*	*34.25*
2019	*74.45*	*0.697*	*1*	*1.9008*	*34.21*
2020	*74.51*	*0.697*	*1*	*1.9024*	*34.30*

Fluctuation in the natural gas EF is due to changes of the natural gas composition. NCV and carbon content fluctuations are related to quality of the natural gas received.

SO_2 emission factors

SO_2 EFs were calculated by equation taken from EMEP/EEA 2019 by national expert considering physical characterizations of types of fuels used in Latvia and national and international legislation. Percentage amount of sulphur content in used fuels is taken from the national database "2-Air" where polluters report the sulphur content data for certain types of fuels (Annex A.3.1 "Sulphur content and SO_2 EFs by fuel type in Energy sector (excluding Transport)").

EFs for SO_2 are calculated by using following equation:

$$\boldsymbol{EF_{SO_2} = 2 * \left(\frac{s}{100}\right) * \frac{1}{Q} * 10^6 * \left(\frac{100-r}{100}\right) * \left(\frac{100-n}{100}\right)} \quad (3.5)$$

where:
EF – emission Factor (kg/TJ)
2 – SO_2 / S (kg/kg)
s – sulphur content in fuel (%)
r – retention of sulphur in ash (%)
Q – net calorific value (TJ/kt)
10^6 – (unit) conversion factor
n – efficiency of abatement technology and/or reduction efficiency (%)

Other emission factors

The default CH_4 and N_2O EFs used in estimation of emissions were taken from the 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.2.

EFs for NOx, NMVOC and CO were taken from EMEP/EEA 2019, 1.A.1 Energy Industries, Table 3-2 (coal, coke), Table 3-3 (peat, peat briquettes), Table 3-4 (LPG, biogas), Table 3-5 (RFO), Table 3-6 (liquid fuels, including biodiesel), Table 3-7 (biomass), Table 3-12 and Table 3-17 (natural gas). EFs used in 2022 submission are listed in Table 3.18.

Table 3.18 CH_4, N_2O, NO_x, CO, NMVOC emission factors used in CRF 1.A.1. Energy Industries (kt/PJ)

Fuel type	CH_4	N_2O	NO_x	NMVOC	CO
Diesel oil	*0.003*	*0.0006*	*0.065*	*0.0008*	*0.0162*
RFO	*0.003*	*0.0006*	*0.142*	*0.0023*	*0.0151*
LPG	*0.001*	*0.0001*	*0.089*	*0.0026*	*0.039*
Jet fuel	*0.003*	*0.0006*	*0.065*	*0.0008*	*0.0162*
Other kerosene	*0.003*	*0.0006*	*0.065*	*0.0008*	*0.0162*
Other liquid	*0.003*	*0.0006*	*0.065*	*0.0008*	*0.0162*
Shale oil	*0.003*	*0.0006*	*0.065*	*0.0008*	*0.0162*
Coal	*0.001*	*0.0015*	*0.209*	*0.0010*	*0.0087*
Coke	*0.001*	*0.0015*	*0.209*	*0.0010*	*0.0087*
Peat briquettes	*0.001*	*0.0015*	*0.247*	*0.0014*	*0.0087*
Peat	*0.001*	*0.0015*	*0.247*	*0.0014*	*0.0087*
Natural gas	*0.001*	*0.0001*	*0.089*	*0.0026*	*0.0390*
			0.048	*0.0016*	*0.0048*
Wood	*0.030*	*0.0040*	*0.081*	*0.00731*	*0.0900*
Sludge gas	*0.001*	*0.0001*	*0.089*	*0.0026*	*0.0390*
Landfill gas	*0.001*	*0.0001*	*0.089*	*0.0026*	*0.0390*
Other biogas	*0.001*	*0.0001*	*0.089*	*0.0026*	*0.0390*
Biodiesel	*0.003*	*0.0006*	*0.065*	*0.0008*	*0.0162*
Straws	*0.030*	*0.0040*	*0.081*	*0.00731*	*0.0900*
Waste oils	*0.030*	*0.0040*	*0.065*	*0.0008*	*0.0162*

Activity data

Emissions from fuel combustion are mainly calculated using fuel consumption data from the CSB Energy Balance. Data on fuel consumption in CRF 1.A.1 sector is presented in Annex A.3.1 "1.A.1 Energy Industries".

The CSB data collection system is based on detailed compulsory survey 2-EK (annual). Form 2-EK "Survey on acquisition and consumption of energy resources" is collected from about 6000 enterprises and organizations (with all kinds of economic activity) included in the lists of suppliers of statistical information.

Approximately 6000 respondents were surveyed - all enterprises of the local and public administration employing 10 or more persons, other enterprises employing 80 and more persons, as well as enterprises with largest statistical units with turnover of 50% of total industry, and other enterprises that CSB considers to be significant enough to include in the CSB Energy Balance, for example, with large imports of coal and oil products as well as wooden briquettes and chip pellets manufacturers. Enterprises and organizations that are not included in the above mentioned selection were surveyed by random sampling and the acquired results were extrapolated afterwards. Survey 2–EK represents the basic tool for creating energy balances at a country level. The amount of methane from combusted landfill gas is described in Chapter 7.2 Solid waste disposal and is consistent with numbers of recovered amounts of landfill gas in Waste sector (CRF 5.A). The amount of methane from combusted sludge gas is given by only Sludge gas combustion enterprise and is consistent with numbers of gas, recovered from Wastewater handling sector (CRF 5.D).

Fuel consumption by fuel types in 1990-2020 in Energy Industries sector can be seen in Figure 3.14. Gaseous fuels are mostly used in Energy Industries in this time period. Liquid fuels were mostly used in the beginning of 1990-ties and in the beginning of 2000 the use of them notably decreased. The amounts of biomass consumed is constantly increasing, while the consumption of solid fossil fuels and peat have decreased.

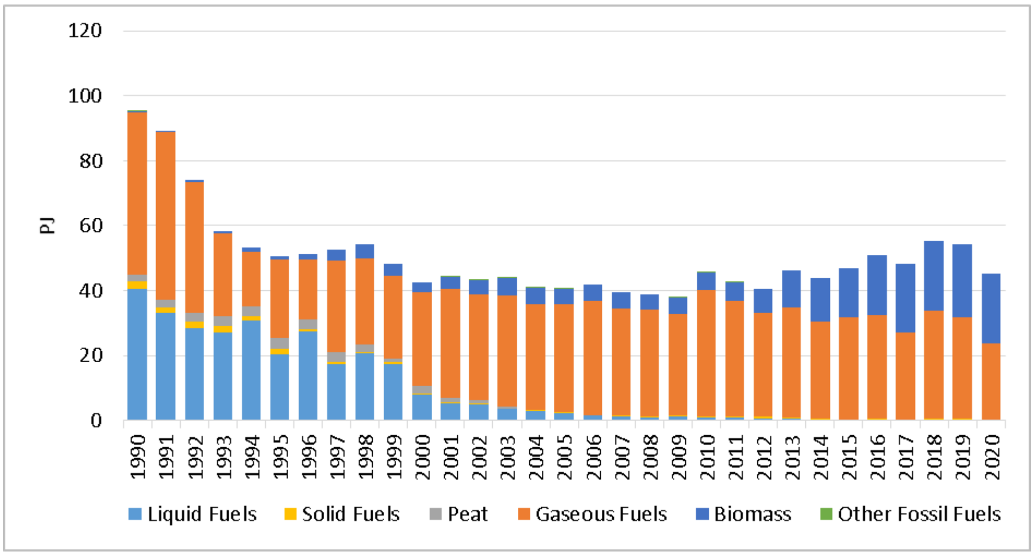

Figure 3.14 Fuel consumption in Energy Industries (CRF 1.A.1) for 1990-2020 (PJ)

The largest decrease in 1990–2020 for the two sub-sectors of 1.A.1 Energy Industries sector was for liquid fuel (by 99.2%). It can be explained with fuel switching when liquid fuels were switched to cheaper fuels. Also, a stronger legislation contributed fuel switch to the type of fuels with lower level of emissions. It also explains why consumption of solid fuels have decreased (by 98.5%). Use of peat decreased by 98.9% and gaseous fuels by 53.2% in comparison with 1990. In 2020-2019 fuel consumption decreased for all fuel types - liquid fuels (26.7%), solid fuels (66.3%), peat (34.3%) and gaseous fuels (25.1%). Consumption of biomass fuel has significantly increased in 1990–2020 for more than 50 times. Solid biomass is a local fuel and has lower costs therefore liquid and solid fuels were replaced. And due to biomass CO_2 neutrality, enterprises switched from fossil fuels to biomass. In 2020, biomass consumption has decreased by 3.8% compared to 2019.

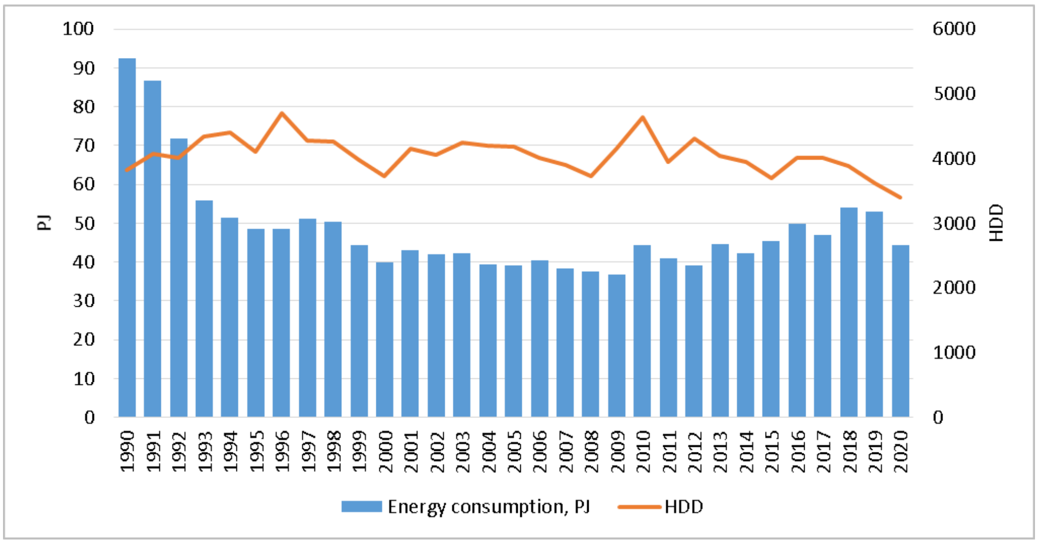

Figure 3.15 Fuel consumption in Main activity electricity and heat production (CRF 1.A.1.a) and heating degree days in Latvia (PJ;HDD)

As can be seen in Figure 3.15 the fuel consumption in 1.A.1.a sector can be related with the heating degree days (HDD) with an an exception of the beginning of 1990s when Soviet Union collapsed and reorganizations took place in Latvia. From 1997 to 2002 in years where energy consumption reduced, the HDD were also reduced. In 2006-2008 average temperature had quite high therefore the fuel consumption of combined heat plants and heat plants for heat production decreased as there was limited need for heat production. In 2009-2010 the average temperature was lower and the use of fuel consumption increased. However, in 2011 the fuel consumption decreased because of a relatively warm winter, and in 2012 the consumption of fuel continued to decrease despite the fall of average temperature (hence the decrease in HDDs), that could be explained with the better heat insulation installed in houses and therefore less heat needed.

3.2.4.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty of activity data for fuel combustion in CRF 1.A.1 is ±2% in 2020. CSB gives approximately 2% statistical sample error for statistical data. According to CSB, since data is obtained using information given by respondents, this number is a variation coefficient which characterizes selection of respondents. Total variation coefficient for energy balance is within 2-3%. In Latvia all fossil fuels (oil, natural gas and coal) are imported and import and export statistics are fairly accurate.

Uncertainty of activity data for solid biomass was assigned 1% as biomass activity data was collected by CSB with questionnaires sent by enterprises consuming biomass. Uncertainty activity data for peat combustion was assigned 2%. Uncertainty of landfill gas stationary combusted in enterprises covered by CRF 1.A.1 Energy Industries was assumed rather low – 2% because the combusted fuel amount is obtained directly from landfill plant that has precise measurement equipment for accounting of combusted fuel.

CO_2 EF was estimated according to the physical characterization of used fuels in country based on average NCV reported by fuel consumers and carbon content, hence the uncertainty for liquid fuels was assigned as quite low – about 10%. As EFs for other fossil fuels were taken from the 2006 IPCC Guidelines, the uncertainty was assumed 20%. EF uncertainty for peat and peat briquettes was assumed 10% because peat EF is country specific. CO_2 EF for natural gas was assumed rather low – as 5% because annual plant specific fuel data is used to estimate EF. Uncertainty for coal is assumed 3% provided in 2017 national research "Determination of Carbon Content and Calculation of Carbon Dioxide Emission Factors".

CH_4 and N_2O EFs used in estimation of emissions were taken from the 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.12, that provides the range of default values for uncertainties. The uncertainty of both CH_4 and N_2O EFs of 50% was assigned similarly as in previous submissions – 50%.

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

3.2.4.4 Category-specific QA/QC and verification

All the documentation and information received for inventory purposes are archived in FTP folder (maintained by LEGMC).

Activity data verification

All sources of energy data are presented in the corresponding NIR chapter (3.2.4.2 Methodological issues), as well as the disaggregated data at the finest level possible are presented in the corresponding Annex A.3.1. Data completeness has been explained in the previous subchapter.

Activity data has been verified with the data provider – CSB, that has its own internal QA/QC procedures based on mathematic model and analysis to avoid logic mistakes. When activity data is received, the sectoral expert responsible for the emission estimation and reporting is comparing all the changes of the data with the previous inventory, and all changes are explained in the corresponding subchapter. All fluctuations or changes in NCVs are double checked and agreed with CSB.

Activity data used in SA are also compared with activity data used in RA estimations. All significant differences (±5%) are explained in the corresponding subchapter. Apparent consumption reported in GHG inventory has been compared with activity data form AQ in Annex A.3.3.

Emission factor verification

For country-specific CO_2 EFs, the sources of the calorific values, carbon content and oxidation factors, as well as these values are provided in 3.2.4.2 Methodological issues.

Country specific CO_2 values for year are compared with default ones available in the 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.2. Whether country specific CO_2 EF is or is not in the confidence interval can be seen in Table 3.19.

Table 3.19 Comparison of country specific and the 2006 IPCC Guidelines default CO_2 emission factor values (kt/PJ)

Fuel type	Lower	CS	Upper
Gasoline	*67.50*	*71.18*	*73.00*
Diesel oil	*72.60*	*74.74*	*74.80*
RFO	*75.50*	*77.36*	*78.80*
LPG	*61.60*	*62.75*	*65.60*
Jet fuel	*69.70*	*72.23*	*74.40*
Other kerosene	*70.80*	*72.24*	*73.70*
Other liquid	*72.20*	*72.59*	*74.40*
Shale oil	*67.80*	*77.12*	*79.20*
Peat	*100.00*	*105.99*	*108.00*
Natural gas	*54.30*	*54.63*	*58.30*
Wood	*95.00*	*109.98*	*132.00*
Firewood	*95.00*	*108.45*	*132.00*
Wood waste	*95.00*	*117.32*	*132.00*
Wood chips	*95.00*	*98.70*	*132.00*
Wood briquettes	*95.00*	*105.03*	*132.00*
Pellete wood	*95.00*	*104.01*	*132.00*

Fuel type	Lower	CS	Upper
Coal	*89.50*	*94.08 (1990-2002)*	*99.70*
		91.60 (2003-2013)	
		96.54 (2013-)	

All country specific values incorporate in the 2006 IPCC Guidelines default CO_2 EF value range.

Emission verification:

To verify the CO_2 emissions, logical mistakes are checked on the time series of the activity data, EFs and emissions consistency to display all significant and illogical changes in the activity data and emissions. The emissions of precursors in the database are cross-checked with emissions reported within CLRTAP for verification purposes.

CO_2 emissions are compared with emissions in RA estimations, and all significant differences (±5%) are explained in the corresponding subchapter.

3.2.4.5 Category-specific recalculations

Recalculations made in 2022 submission are provided in Table 3.20.

Table 3.20 Recalculations in CRF 1.A.1 Energy Industries

Sub-category	Recalculation	Improvements
1.A.1.a.ii Combined Heat and Power Generation	*Corrected Sludge gas consumption values 2004-2019*	*Sludge gas consumption values corrected to match CSB Energy Balance consumption of Sludge gas. In 2019 CO_2 eq. emissions from Sludge gas have decreased by 7.7%.*

3.2.4.6 Category-specific planned improvements

No improvements are planned for this sector.

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

3.2.5.1 Category description

CRF 1.A.2 Manufacturing industries and construction sector includes emissions from fuel combustion in combustion installations for industrial production including emissions from off–road. CRF 1.A.2 sector also includes the emissions from on-site use of fuel in the industrial production facilities (autoproducers) – these emissions are reported under particular sub-sectors of CRF 1.A.2 according to the 2006 IPCC Guidelines.

According to the 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.1., emissions arising from off-road and and other mobile machinery in industry should be taken out as a separate subcategory. These emissions are calculated together from gasoline and diesel oil use in particular subsectors within CRF 1.A.2. It also ensures the consistency between CLRTAP and UNFCCC data.

CRF 1.A.2 Manufacturing industries are split into subsectors that are in line with the 2006 IPCC Guidelines/CRF Reporter structure:

- 1.A.2.a Iron and steel;
- 1.A.2.b Non-ferrous metals;
- 1.A.2.c Chemicals;
- 1.A.2.d Pulp, paper and print;
- 1.A.2.e Food processing, beverages and tobacco;
- 1.A.2.f Non-metallic minerals;
- 1.A.2.g Other:
  - 1.A.2.g.i Manufacturing of machinery;
  - 1.A.2.g.ii Manufacturing of transport equipment;
  - 1.A.2.g.iii Mining (excluding fuels) and quarrying;
  - 1.A.2.g.iv Wood and wood products;
  - 1.A.2.g.v Construction;
  - 1.A.2.g.vi Textile and leather;
  - 1.A.2.g.vii Off-road vehicles and other machinery;
  - 1.A.2.g.viii Other.

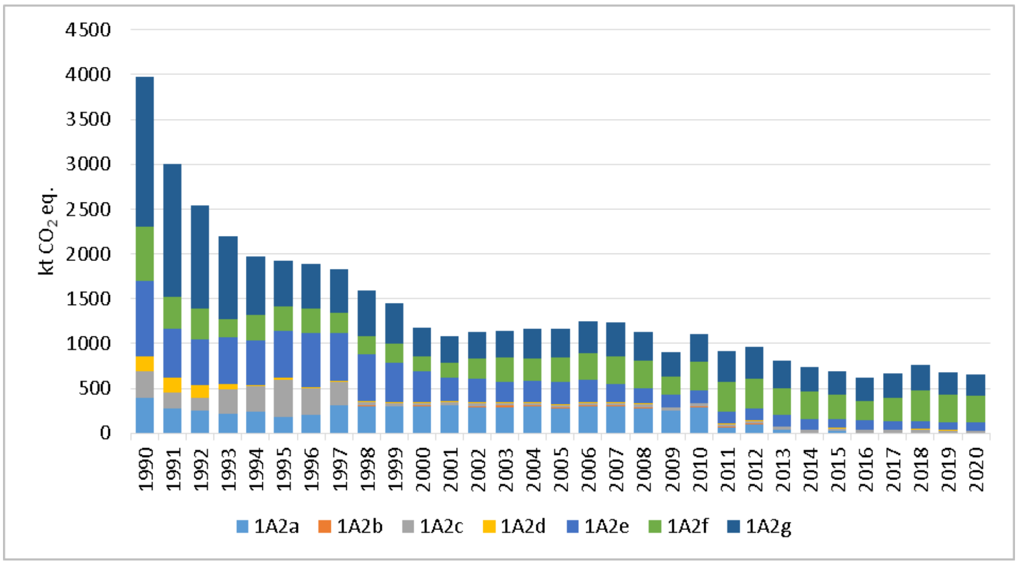

Figure 3.16 GHG emissions in CRF 1.A.2. Manufacturing industries and Construction by subsectors (kt CO_2 eq.)

In Figure 3.16 can be seen the distribution of GHG emissions in CRF 1.A.2 sector. The largest part of emissions are contributed by CRF 1.A.2.f Non-metallic minerals (45.3% in 2020) and CRF 1.A.2.g Other (36.6% in 2020), where emissions from Machinery, Transport equipment, Mining and quarrying, Wood processing, Construction, Textiles, Offroads and Other products are produced. In CRF 1.A.2.e Food processing, beverages and tobacco 13.5% of CRF 1.A.2 GHG emissions are produced in 2020. Such sectors as CRF 1.A.2.a Iron and Steel, 1.A.2.b Non-ferrous metals, 1.A.2.c Chemicals. 1.A.2.d Pulp, Paper and Print contributes to 0.06%, 0.1%, 3.6% and 0.7% from total CRF 1.A.2 GHG emissions in 2020, accordingly.

Table 3.21 Emissions from Manufacturing industries and construction (CRF 1.A.2) in 1990–2020 (kt)

Year	CO_2	CH_4	N_2O	GHGs (CO_2 eq)	NO_x	CO	NMVOC	SO_2
	kt			kt CO_2 eq.	Kt			
1990	*3909.78*	*0.24*	*0.184*	*3970.69*	*18.73*	*22.82*	*3.92*	*24.33*
1991	*2944.09*	*0.13*	*0.175*	*2999.45*	*13.62*	*9.26*	*2.28*	*15.12*

Year	CO_2	CH_4	N_2O	GHGs (CO_2 eq)	NO_x	CO	NMVOC	SO_2
	kt			kt CO_2 eq.	Kt			
1992	*2493.86*	*0.12*	*0.129*	*2535.23*	*11.55*	*8.32*	*1.95*	*13.96*
1993	*2159.66*	*0.15*	*0.127*	*2201.31*	*11.20*	*9.20*	*2.20*	*14.44*
1994	*1951.22*	*0.15*	*0.066*	*1974.65*	*10.09*	*6.75*	*1.78*	*15.67*
1995	*1905.58*	*0.14*	*0.063*	*1927.99*	*10.11*	*4.65*	*1.65*	*15.08*
1996	*1862.21*	*0.15*	*0.059*	*1883.72*	*9.82*	*6.12*	*1.83*	*14.68*
1997	*1802.86*	*0.15*	*0.071*	*1827.76*	*9.84*	*5.39*	*1.81*	*14.25*
1998	*1572.09*	*0.16*	*0.068*	*1596.37*	*8.34*	*5.36*	*1.85*	*11.02*
1999	*1422.61*	*0.15*	*0.064*	*1445.37*	*7.47*	*4.44*	*1.71*	*9.10*
2000	*1156.55*	*0.12*	*0.058*	*1177.03*	*5.47*	*3.72*	*1.46*	*4.70*
2001	*1055.20*	*0.16*	*0.060*	*1077.15*	*4.29*	*4.20*	*1.77*	*2.55*
2002	*1104.56*	*0.16*	*0.056*	*1125.30*	*4.04*	*4.31*	*1.68*	*2.07*
2003	*1123.71*	*0.15*	*0.053*	*1143.31*	*4.05*	*3.83*	*1.58*	*1.86*
2004	*1137.17*	*0.19*	*0.063*	*1160.93*	*4.10*	*5.36*	*2.09*	*1.42*
2005	*1143.59*	*0.23*	*0.069*	*1170.08*	*4.30*	*5.29*	*1.14*	*1.56*
2006	*1214.75*	*0.25*	*0.075*	*1243.47*	*4.83*	*5.93*	*1.13*	*1.79*
2007	*1209.45*	*0.22*	*0.085*	*1240.30*	*4.58*	*6.16*	*1.12*	*1.72*
2008	*1102.38*	*0.24*	*0.077*	*1131.33*	*4.12*	*6.09*	*0.99*	*1.37*
2009	*875.57*	*0.30*	*0.083*	*907.67*	*4.18*	*5.56*	*0.90*	*1.25*
2010	*1073.71*	*0.37*	*0.087*	*1108.80*	*4.23*	*4.92*	*0.78*	*0.99*
2011	*872.49*	*0.44*	*0.108*	*915.45*	*3.77*	*5.38*	*0.84*	*0.81*
2012	*917.06*	*0.49*	*0.121*	*965.54*	*4.24*	*5.87*	*0.84*	*0.94*
2013	*761.63*	*0.51*	*0.123*	*810.98*	*4.00*	*5.51*	*0.72*	*0.83*
2014	*691.29*	*0.57*	*0.123*	*742.24*	*3.94*	*5.74*	*0.71*	*0.90*
2015	*640.34*	*0.56*	*0.118*	*689.59*	*3.76*	*5.52*	*0.61*	*0.84*
2016	*576.87*	*0.50*	*0.110*	*622.13*	*3.49*	*5.05*	*0.59*	*0.79*
2017	*619.25*	*0.51*	*0.114*	*666.13*	*3.40*	*4.92*	*0.59*	*0.76*
2018	*704.21*	*0.60*	*0.127*	*757.04*	*3.78*	*5.73*	*0.70*	*0.88*
2019	*625.85*	*0.58*	*0.120*	*676.31*	*3.62*	*5.83*	*0.71*	*0.86*
2020	*607.88*	*0.61*	*0.125*	*660.34*	*3.73*	*5.47*	*0.72*	*0.87*
Share of Energy total, 2020	*9.6%*	*5.5%*	*20.3%*	*9.7%*	*14.4%*	*5.8%*	*5.4%*	*26.4%*
2020 vs 2019	*-2.9%*	*3.7%*	*4.1%*	*-2.4%*	*3.2%*	*-6.2%*	*1.6%*	*1.4%*
2020 vs 1990	*-84.5%*	*153.3%*	*-32.1%*	*-83.4%*	*-80.1%*	*-76.0%*	*-81.5%*	*-96.4%*

Emissions from CRF 1.A.2 significantly decreased in 1990 to 2001, which can be explained with collapse of Soviet Union and following reformations and reorganizations within Latvia after that. Since 2001 the emissions started to increase until 2006, because of development in national economy and industry, as well as growing demand of industrial production (Table 3.21). Growth in GHG emissions in the given time period were caused by increased amounts of coal and natural gas consumed. Crisis in national economy in the 2008 caused a decrease in total emissions. The increasing amounts of solid biomass consumption caused a drop in CO_2 emissions. The national economy was affected by the global financial crisis in 2008-2009 influencing significantly the decrease of GHG emissions by 19.8%. The development of EU ETS influenced biomass consumption for 2008-2009 in CRF 1.A.2 sector that was growing, while amounts of almost all the other fuels decreased. In 2010-2013 emissions were fluctuating mainly due to reconstruction of the largest steel producer company (from 2011 to 2012). As it replaced its furnace to electric one, the emissions decreased, however, in 2013 due to several reasons it initiated bankruptcy, therefore the amounts of production decreased significantly afterwards. From 2012-2016 CO_2 emissions have constantly decreased. Currently, CRF 1.A.2 produces only 9.6% of total GHG emissions in Energy sector, thus emissions in this sector have decreased by 84.5% in comparison to 1990. In comaparison to 2019 CRF 1.A.2 emissions decreased by 2.9% in 2020.

Due to increase of biomass consumption CH_4 emissions have increased more than two times in 1990-2020. N_2O emissions have decreased by 32.1% since 1990 due to decease of the fossil fuel used in sector.

Also precursors from CRF 1.A.2 sector were estimated. In this sector almost all precursors have decreased: NOx emissions have decreased by 80.1%, CO emissions – by 76.0%, NMVOC by 81.5% and SO_2 emissions have a decrease by 96.4% in 1990–2020. The decrease in emissions is explained with fuel switching to natural gas and biomass, and there are less NOx and CO emissions from these fuels comparing with solid and liquid fuels.

3.2.5.2 Methodological issues

Methods

The 2006 IPCC Guidelines' Tier 2 method was used to estimate CO_2 emissions from fuel combustion as country specific parameters were used to estimate CO_2 EFr. However, for some fuels there are no country-specific EFs, therefore the 2006 IPCC Tier 1 method using default EFs was used. To calculate CO_2 emissions from Industrial and Municipal waste plant specific values was applied. The 2006 IPCC Guidelines' Tier 1 method was used to calculate CH_4 and N_2O emissions from the CRF 1.A.2 sector.

Calculation of all emissions from fuel combustion were made with Excel databases developed by the experts from LEGMC.

The general method for emission data preparation was used:

$$\boldsymbol{Em = EF * B_q} \tag{3.6}$$

where:
Em – total emissions (kt)
EF – estimated or default emission factor (t/TJ)
B_q – amount of fuel in thermal units (TJ)

Emission factors and other parameters

The main sources for EFs are:

- National studies for country specific parameters and EFs;
- Data from only natural gas supplier company of natural gas physical characteristics;
- EU ETS reports (for used tires and municipal waste);
- IPCC 2006 Guidelines;
- EMEP/EEA 2019.

Country specific EFs were used to calculate CO_2 and SO_2 emissions.

CO_2 emission factors

CO_2 EFs for CRF 1.A.2 Manufacturing Industries and Construction sector are estimated with the same equations and using the same method as for CRF 1.A.1 Energy industries sector with the exception for industrial waste and municipal waste that are not combusted in CRF 1.A.1 sector.

For some fuels default CO_2 EFs from the 2006 IPCC Guidelines, Volume 2, Chapter 2 Stationary combustion, Table 2.3, were taken due to unavailability of country specific data:

- other liquid fuels – 73.3 kt/PJ;
- coke – 107 kt/PJ;
- anthracite – 98.3 kt/PJ;
- oil shale – 107 kt/PJ;
- petroleum coke – 97.5 kt/PJ
- peat briquettes – 97.5 kt/PJ;
- other biogas – 54.6 kt/PJ;
- biodiesel – 70.8 kt/PJ;
- straws – 100 kt/PJ;
- waste oils – 73.3 kt/PJ.

Municipal waste

CO_2 EFs of municipal waste combusted in the cement production plant are taken from plant's annual GHG report within EU ETS for 2008-2020. This CO_2 EFs are estimated by using plant specific data about combustion installation as well as net calorific value and carbon content measured and obtained in the plant laboratory. The 2006 IPCC Guidelines state separate non-biomass and biomass parts of the municipal waste. It has been done in submission 2022 as follows: CO_2 emissions to be reported to EU ETS have been taken from 2008-2020 for non-biomass part. EFs given in the reports are for whole emissions and it is possible to calculate the EF for non-biomass fraction. EFs for total CO_2 emissions and for non-biomass fraction are provided in Table 3.22.

Table 3.22 CO_2 emission factors, carbon content and NCV for municipal waste by waste types

Municipal waste type	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	Total CO_2 EF, kt/PJ												
Ecofuel 1	*85.19*	*82.81*	*82.69*	*113.22*	*95.24*								
Ecofuel 2		*120.95*				*85.98*	*86.41*	*88.85*	*85.13*	*85.44*	*85.45*	*85.97*	*85.97*
	Fossil CO_2 EF, kt/PJ												
Ecofuel 1	*44.16*	*43.03*	*35.11*	*27.99*	*32.42*								
Ecofuel 2		*49.95*				*38.69*	*38.52*	*42.31*	*42.62*	*45.76*	*46.72*	*46.18*	*46.10*
	C content, %												
Ecofuel 1	*23.25*	*22.60*	*22.57*	*30.90*	*25.99*								
Ecofuel 2		*33.01*				*23.46*	*23.58*	*24.25*	*23.23*	*23.32*	*23.32*	*23.46*	*23.46*
	NCV, TJ/kt												
Ecofuel 1	*22.78*	*23.51*	*19.59*	*18.23*	*16.85*								
Ecofuel 2		*17.42*				*17.61*	*19.35*	*20.21*	*20.84*	*21.36*	*21.54*	*20.77*	*21.54*
	Biomass content, %												
Ecofuel 1	*48.2%*	*48.0%*	*57.5%*	*75.3%*	*66.0%*								
Ecofuel 2		*58.7%*				*55.0%*	*55.4%*	*52.4%*	*49.9%*	*46.4%*	*45.3%*	*46.3%*	*46.2%*

For estimating biomass emissions the following equation was used:

$$E_{biomass} = E_{total} - E_{non-biomass} \quad (3.7)$$

where:

$E_{biomass}$ – CO_2 emissions from biomass fraction (kt)

E_{total} – total CO_2 emissions (kt)

$E_{non\text{-}biomass}$ - CO_2 emissions from biomass fraction (kt)

The calculated results for total CO_2 emissions from municipal waste, as well as from biomass and non-biomass fraction can be found in Table 3.23.

Table 3.23 CO_2 emissions from municipal waste non-biomass and biomass fractions by waste types

Municipal waste type	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	Fossil CO_2 emissions, t												
Ecofuel 1	6856	2285	26440	37606	54948								
Ecofuel 2		214				60808	77069	83051	62691	82173	103849	93342	109179
	Biomass CO_2 emissions, t												
Ecofuel 1	6370	2112	35835	114499	106458								
Ecofuel 2		305				74321	95804	91323	62540	71245	86106	80421	94422
	Total CO_2 emissions, t												
Ecofuel 1	13226	4397	62275	152105	161406								
Ecofuel 2		519				135129	172873	174374	125231	153418	189955	173763	203602

Industrial waste

EFs for CO_2 emission estimation for industrial waste – used tires, neutralised polluted soil, waste wood, fluffy tyre, wood processing residues and shredded rubber – combusted in CRF 1.A.2.f Non-metallic minerals (cement production) for years 1999–2020 are used from GHG emission reports that plant submitted under EU ETS (Table 3.24). These CO_2 EFs are estimated at the plant by using plant specific data about combustion installation as well as NCV and carbon content measured and obtained in the plant laboratory. Also for this fuel type biomass and non-biomass emissions have been calculated, as this fuel contains biomass.

Table 3.24 CO_2 emission factors, carbon content and NCV for industrial waste

Industrial waste	1999	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	Total CO_2 EF, kt/PJ													
Used tyres	79.44	79.44	79.44	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00
Fluffy tyres					81.13	81.13	87.01	88.52	88.22	85.21	85.84	87.40	84.29	85.53
NPS						79.43	80.60	85.03	72.90	91.93	89.01	69.60	87.51	91.68
Shredded rubber							81.13							
Wood processing residues					135.3	130.35								
Waste wood				117.6										
	Fossil CO_2 EF, kt/PJ													
Used tyres	56.93	56.93	56.93	60.91	60.91	60.91	60.91	60.91	60.91	60.91	60.91	60.91	60.91	60.95
Fluffy tyres					27.01	17.93	30.45	44.97	45.23	47.72	57.51	55.40	44.29	34.00
NPS						66.31	56.42	60.03	59.70	51.46	31.11	30.35	10.61	28.08
Shredded rubber							41.21							
Wood processing residues					37.58	41.47								
Waste wood				15.88										
	C content, %													
Used tyres	21.68	21.68	21.68	23.20	23.20	23.20	23.20	23.20	23.20	23.20	23.20	23.20	23.20	23.20
Fluffy tyres					22.14	22.14	23.75	24.16	24.08	23.26	23.43	23.85	23.88	25.02
NPS						21.68	22.00	23.21	19.90	25.09	24.29	18.99	23.00	23.34
Shredded rubber							22.14							

Industrial waste	1999	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	Total CO_2 EF, kt/PJ													
Wood processing residues					36.93	35.57								
Waste wood				32.09										
	NCV (TJ/kt)													
Used tyres	26.21	26.21	26.21	26.21	26.21	26.21	26.21	26.21	26.21	26.21	26.21	26.21	26.21	26.21
Fluffy tyres					28.50	42.94	28.96	31.46	31.34	30.23	31.93	32.09	31.48	31.28
NPS						14.30	15.00	16.23	17.46	15.10	13.28	16.73	15.54	15.11
Shredded rubber							31.06							
Wood processing residues					12.57	12.11								
Waste wood				13.18										
	Biomass content, %													
Used tyres	28.3%	28.3%	28.3%	28.3%	28.3%	28.3%	28.3%	28.3%	28.3%	28.3%	28.3%	28.3%	28.3%	28.3%
Fluffy tyres					66.7%	77.9%	65.0%	49.2%	48.7%	44.0%	33.0%	36.6%	47.5%	60.3%
NPS						16.5%	30.0%	29.4%	18.1%	44.0%	65.1%	56.4%	87.9%	69.4%
Shredded rubber							49.2%							
Wood processing residues					72.2%	68.2%								
Waste wood				86.5%										

For estimating biomass emissions, the above mentioned equation for municipal waste is used.

Since 2005 the cement production plant is participating in EU ETS therefore estimated CO_2 EF is verified by accredited verifiers and approved by the State Environmental Service.

SO_2 emission factors

SO_2 EFs for all fuels, except industrial and municipal waste, in CRF 1.A.2 Manufacturing Industries and Construction sector are estimated with the same equations and using the same method as for CRF 1.A.1 Energy industries sector.

For industrial and municipal waste SO_2 EFs are taken from EMEP/EEA 2019, Chapter 5.C.1.b, Table 3-1 (0.047 kg/Mg) and Chapter 5.C.1.a, Table 3-1 (0.087 kg/Mg).

Other emission factors

List of other EFs can be seen in Table 3.25.

The default CH_4 and N_2O EFs are taken from the 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.3. Gasoline EFs are used for CH_4 and N_2O emission estimation from off-roads (2006 IPCC Guidelines, Volume 2, Chapter 3 *Mobile combustion*, Table 3.3.1.). As there is no information on distribution between 2-stroke and 4-stroke engines, it was assumed that 25% of consumed gasoline is combusted in 2-stroke engines, while 75% - in 4-stroke engines. Such an assumption has been made, based on Danish data presented in EMEP/EEA 2019 for air pollutants' calculations.

NOx, CO and NMVOC EFs used in estimation of emission from stationary combustion were taken from EMEP/EEA 2019, Chapter 1.A.21, Tables 3-13, EMEP/EEA 2019, Chapter 1.A.2, Tables 3-2 to 3-5 and EMEP/EEA 2019, Chapter 1.A.4 Small combustion, Table 3-26, Table 3-27, Table 3-45 and Table 3-46. For industrial waste and municipal waste NOx, CO and NMVOC EFs are taken from EMEP/EEA 2019, Chapter 5.C.1.b, Table 3-1 and Chapter 5.C.1.a, Table 3-1. For

CRF 1.A.2.g.v.ii Off-road vehicles and other machinery NOx, CO and NMVOC EFs are taken from EMEP/EEA 2019 1.A.2.g vii Non-road mobile sources and machinery Table 3.2.

Table 3.25 CH_4, N_2O, NO_x, NMVOC, CO emission factors (kt/PJ[21])

Fuel type		CH_4	N_2O	NO_x	NMVOC	CO
Gasoline	2-stroke	*0.130*	*0.0004*	*2.58*[22]	*116.72*[22]	*695.13*[22]
	4-stroke	*0.050*	*0.002*	*6.48*[22]	*15.71*[22]	*800.36*[22]
Diesel oil (off-road)		*0.00415*	*0.0286*	*12.40*[22]	*1.15*[22]	*6.81*[22]
Diesel oil		*0.003*	*0.0006*	*0.513*	*0.025*	*0.066*
RFO		*0.003*	*0.0006*	*0.513*	*0.025*	*0.066*
LPG		*0.001*	*0.0001*	*0.074*	*0.023*	*0.029*
Jet fuel		*0.003*	*0.0006*	*0.513*	*0.025*	*0.066*
Other kerosene		*0.003*	*0.0006*	*0.513*	*0.025*	*0.066*
Other liquid		*0.003*	*0.0006*	*0.513*	*0.025*	*0.066*
Petroleum coke		*0.003*	*0.0006*	*0.513*	*0.025*	*0.066*
Other oil products		*0.003*	*0.0006*	*0.513*	*0.025*	*0.066*
Shale oil		*0.003*	*0.0006*	*0.513*	*0.025*	*0.066*
Coal		*0.01*	*0.0015*	*0.173*	*0.0888*	*0.931*
Coke		*0.01*	*0.0015*	*0.173*	*0.0888*	*0.931*
Anthracite		*0.01*	*0.0015*	*0.173*	*0.0888*	*0.931*
Oil shale		*0.01*	*0.0015*	*0.173*	*0.0888*	*0.931*
Peat briquettes		*0.01*	*0.0015*	*0.173*	*0.0888*	*0.931*
Peat		*0.002*	*0.0015*	*0.173*	*0.0888*	*0.931*
Natural gas		*0.001*	*0.0001*	*0.074*	*0.023*	*0.029*
				0.073[23]	*0.000360*[23]	*0.024*[23]
				0.04[23]	*0.03*[23]	*0.002*[23]
Wood		*0.03*	*0.004*	*0.091*	*0.3*	*0.57*
				0.181[24]	*0.016*[24]	*0.265*[24]
Other biogas		*0.001*	*0.0001*	*0.074*	*0.023*	*0.029*
Biodiesel		*0.003*	*0.0006*	*0.513*	*0.025*	*0.066*
Industrial waste (used tires)		*0.03*	*0.004*	*0.87*	*7.4*	*0.07*
Municipal waste		*0.03*	*0.004*	*1.071*	*0.0059*	*0.041*
Waste oils		*0.03*	*0.004*	*0.513*	*0.025*	*0.066*

There is a different approach regarding CRF 1.A.2.f *Non-metallic minerals* subsector and corresponding subsector under IPPU (CRF 2.A.1 *Cement production*). Until 2010 emissions of precursors under CRF 2.A.1 sector were calculated using EMEP/CORINAIR 2007 and EMEP/EEA 2019 methodology, but afterwards these emissions were automatically detected at plant site, and measurements were taken from the main chimney. However, as these values are measured directly from the chimney, there is no way to allocate emissions under the Energy and IPPU sectors separately (there are both emissions from fuel combustion and technological processes). Regarding calculation of precursors, to avoid double counting, the following fuel types (used tyres, petroleum coke, wood, coal, natural gas consumed in "SCHWENK") are subtracted from Energy part (from CRF 1.A.2.f subsector) and their emissions can be considered as included elsewhere (CRF 2.A.1 sector under IPPU) in case of "SCHWENK". However, as "SCHWENK" is not the only company under CRF 1.A.2.f subsector, fuel consumption and

[21] For precursors for gasoline, industrial and municipal waste – kg/Mg

[22] IEF for year 2020 – kg/t. Calculations made using Tier 2 method from EMEP/EEA 2019 1.A.2.g vii Non-road mobile sources and machinery Table 3-2, Table 3-3 and Table 3-4.

[23] Tier 2 EF for emission calculations from Natural gas use in sector CRF 1.A.2.g – kt/PJ.

[24] Tier 2 IEF for emission calculation from Wood combustion in 2020 sector CRF 1.A.2.g – kt/PJ

emissions appear from the other enterprises. As for GHGs, these emissions are taken from EU ETS reports (CO_2) reported by "SCHWENK" or calculated (CH_4, N_2O), therefore can be allocated under the appropriate sectors.

Activity data

Mainly emissions from fuel combustion are calculated using fuel consumption data from the CSB Energy Balance. The data collection system for CRF 1.A.2 sector is the same as for CRF 1.A.1 sector. Data on fuel consumption in 1.A.2 sector is presented in Annex A.3.1 "1.A.2 Manufacturing Industries and Construction".

Autoproducers data prepared by CSB is taken into account calculating emissions from CRF 1.A.2 sector according to the 2006 IPCC Guidelines.

Gasoline combustion is reported as off-roads in CRF 1.A.2 sector. Also, total diesel oil combustion is reported as off-road in CRF 1.A.2 sector, with exception for sectors: CRF 1.A.2.a (stationary combusted 35% from total diesel oil combustion), CRF 1.A.2.g.i (stationary combusted 1% from total diesel oil combustion) and CRF 1.A.2.g.v (stationary combusted 1% form total diesel oil combustion).

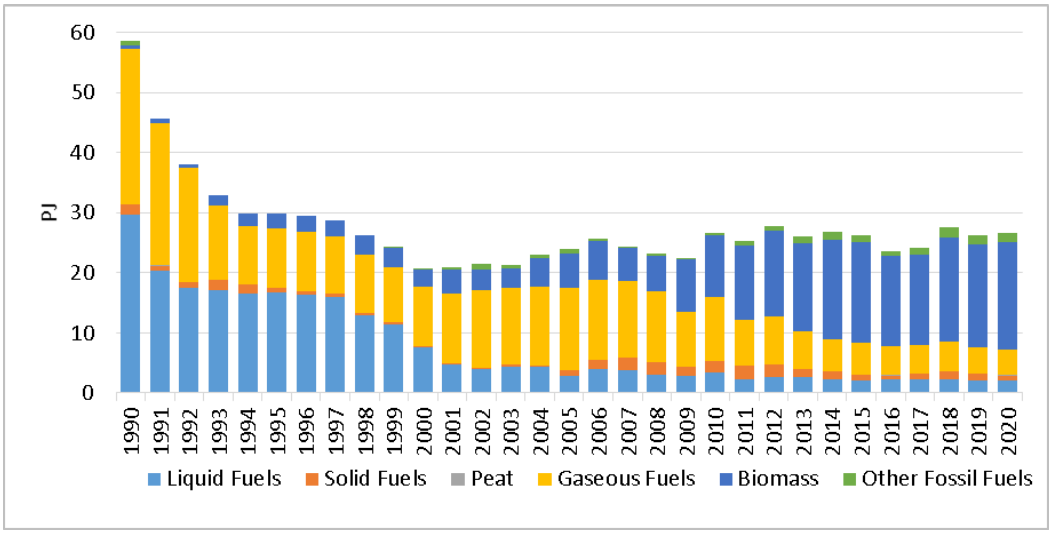

Figure 3.17 Fuel consumption in Manufacturing Industries and Construction (CRF 1.A.2) for 1990-2020 (PJ)

The most of the fuel types with an exception of biomass and other fossil fuels have decreased in 1990-2020 (Figure 3.17). Liquid fuels have the biggest decrease 92.8%. It is explained with fuel switching processes when liquid fuels were replaced with other cheaper fuels. Also stronger legislation contributed fuel replacement to the type of fuels with lower level of emissions. Decrease of natural gas (-83.7%) reflects the total decrease of industrial production if compared with 1990.

Since 1990 solid fuel consumption have decreased by 47.7%, as in 2020 consumption have decreased by 33.4% mainly due to decreased fuel consumption in CRF 1.A.2.f Non-metallic mineral sector.

During the 1990s natural gas consumption started decreasing steadily with some minor exceptions due to fuel replacement processes and development of national economy or due to the changes in demand. In 1990-2020 natural gas consumption have decreased by 83.7% and in 2019-2020 consumption have decreased by 0.9%.

Consumption of biomass have increased significantly, approximately 29 times bigger than it was in 1990. Large availability of the fuel in-country as well as development of EU ETS were reasons for liquid and solid fuels' replacement with biomass and natural gas.

Consumption of used tires and municipal waste in Mineral production (information about waste burnt in cement production company taken from „SCHWENK", the only company which combusts used tires and municipal waste for energy purposes) reported as other fossil fuels have increased approximately 50 times since 1999. The increase was influenced by intensified cement production caused by increased demand of construction materials and sharp development of construction sector. In the category other fossil fuels waste oils are also reported, and the amount of this fuel is fluctuating over the years with a decreasing trend in recent years. In 2019-2020 consumption increased by 15.2%.

3.2.5.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty for activity data of fuel combustion in CRF 1.A.2 sector is ±2% in 2020. CSB gives approximately 2% statistical sample error for statistical data. According to CSB, as data is obtained using information given by respondents, this number is a variation coefficient which characterizes selection of respondents. Total variation coefficient for energy balance is within 2-3%. In Latvia all fossil fuels (oil, natural gas and coal) are imported and import and export statistics are fairly accurate.

Uncertainty of activity data for solid biomass was assigned 1% as biomass activity data was collected by CSB (with questionnaires sent by enterprises consumed biomass). Uncertainty for peat combustion activity data was assigned 2%.

Uncertainty of other fuels consumption – municipal and industrial waste used in mineral production is assumed also low as 2% as the activity data is obtained from only one producer within EU ETS therefore the data is verified by accredited verifier and Regional Environmental Board.

CO_2 EF was estimated according physical characterization of used fuels in country based on average NCV reported by fuel consumers and carbon content so uncertainty for liquid fuels was assigned as quite low - about 10%. The same uncertainty level was assigned for peat. However, for combustion of solid fuels and other fossil fuels (waste oils) the uncertainty of CO_2 EF was assigned higher - to 20% because CO_2 EF of anthracite and coke was taken from the 2006 IPCC Guidelines. CO_2 EF for natural gas was assumed rather low - as 5%, because plant specific fuel data is used to estimate EF. Uncertainty for coal is assumed 3% provided in 2017 research "Determination of Carbon Content and Calculation of Carbon Dioxide Emission Factors".

CO_2 EFs for industrial and municipal waste are assumed as 2% as were determined in accredited laboratory of cement production company.

CH_4 and N_2O EF used in estimation of emissions was taken according to the 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.12., which provides the range of default values for uncertainties. The uncertainty both for CH_4 and N_2O EFs was assigned as uncertainties used in previous submissions – 50%.

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

3.2.5.4 Category-specific QA/QC and verification

All documentation and information received for inventory purposes are archived in FTP folder (maintained by LEGMC).

Activity data verification

All sources of energy data are presented in the corresponding NIR chapter Methodological issues.

In addition, disaggregated data at the finest level possible are presented in the corresponding Annex A.3.1. Data completeness has been explained in the previous subchapter.

Activity data has been checked at the data provider – CSB, that has its own internal QA/QC procedures based on mathematic model and analysis to avoid logic mistakes. When activity data is received, the sectoral expert responsible for the emission estimation and reporting is comparing all data changes with the previous inventory, and all the changes are explained in the corresponding subchapter. All fluctuations or changes in NCVs are double checked and agreed with CSB.

All activity data used in SA are also compared with activity data used in RA estimations. All significant differences (±5%) are explained in the corresponding subchapter. Apparent consumption reported in GHG inventory has been compared with activity data form AQ in Annex A.3.3.

Emission factor verification

For country-specific CO_2 EFs, the sources of the calorific values, carbon content and oxidation factors, as well as these values are provided in corresponding NIR chapter Methodological issues.

Country specific CO_2 values for year are compared with default ones available in the 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.2. Information on the country specific CO_2 EF, can be seen in Table 3.26.

Table 3.26 Comparison of country specific and the 2006 IPCC Guidelines default CO_2 emission factor values (kt/PJ)

Fuel type	Lower	CS	Upper
Gasoline	*67.50*	*71.18*	*73.00*
Diesel oil	*72.60*	*74.74*	*74.80*
RFO	*75.50*	*77.36*	*78.80*
LPG	*61.60*	*62.75*	*65.60*
Jet fuel	*69.70*	*72.23*	*74.40*
Other kerosene	*70.80*	*72.24*	*73.70*
Other liquid	*72.20*	*72.59*	*74.40*
Shale oil	*67.80*	*77.12*	*79.20*
Peat	*100.00*	*105.99*	*108.00*
Natural gas	*54.30*	*54.63*	*58.30*

<table>
<tr><th>Fuel type</th><th>Lower</th><th>CS</th><th>Upper</th></tr>
<tr><td>Wood</td><td>95.00</td><td>109.98</td><td>132.00</td></tr>
<tr><td>Firewood</td><td>95.00</td><td>108.45</td><td>132.00</td></tr>
<tr><td>Wood waste</td><td>95.00</td><td>117.32</td><td>132.00</td></tr>
<tr><td>Wood chips</td><td>95.00</td><td>98.70</td><td>132.00</td></tr>
<tr><td>Wood briquettes</td><td>95.00</td><td>105.03</td><td>132.00</td></tr>
<tr><td>Pellete wood</td><td>95.00</td><td>104.01</td><td>132.00</td></tr>
<tr><td rowspan="3">Coal</td><td rowspan="3">89.50</td><td>94.08 (1990-2002)</td><td rowspan="3">99.70</td></tr>
<tr><td>91.60 (2003-2013)</td></tr>
<tr><td>96.54 (2013-)</td></tr>
</table>

All country specific values incorporate in the 2006 IPCC Guidelines default CO_2 EF value range.

Emission verification:

To verify the CO_2 emissions, logical mistakes are checked. It is done by checking the time series of the activity data, EFs and emissions consistency to display all significant and illogical changes in the activity data and emissions. The emissions of precursors GHGs in the database are cross-checked with emissions reported within CLRTAP for verification purposes.

CO_2 emissions are compared with emissions in RA estimations, and all significant differences (±5%) are explained in the corresponding subchapter.

3.2.5.5 Category-specific recalculations

Recalculations made in 2022 submission are provided in Table 3.27.

Table 3.27 Recalculations in CRF 1.A.2 Manufacturing Industries and Constructions

Sub-category	Recalculation	Improvements
1.A.2.a Iron and Steel	*Corrected consumption of Natural gas in 2019*	*Corrected Natural gas consumption and emissions in 2019 increased by 0.33 kt CO_2 eq.*

3.2.5.6 Category-specific planned improvements

No improvements are planned for this sector.

3.2.6 Transport (CRF 1.A.3)

3.2.6.1 Category description

This section describes GHG emissions resulting from transport fuel combustion. In 2020, this source category was responsible for around 29.7% of total GHG emissions in Latvia, reaching 3108.60 kt CO_2 eq. (see Figure 3.18).

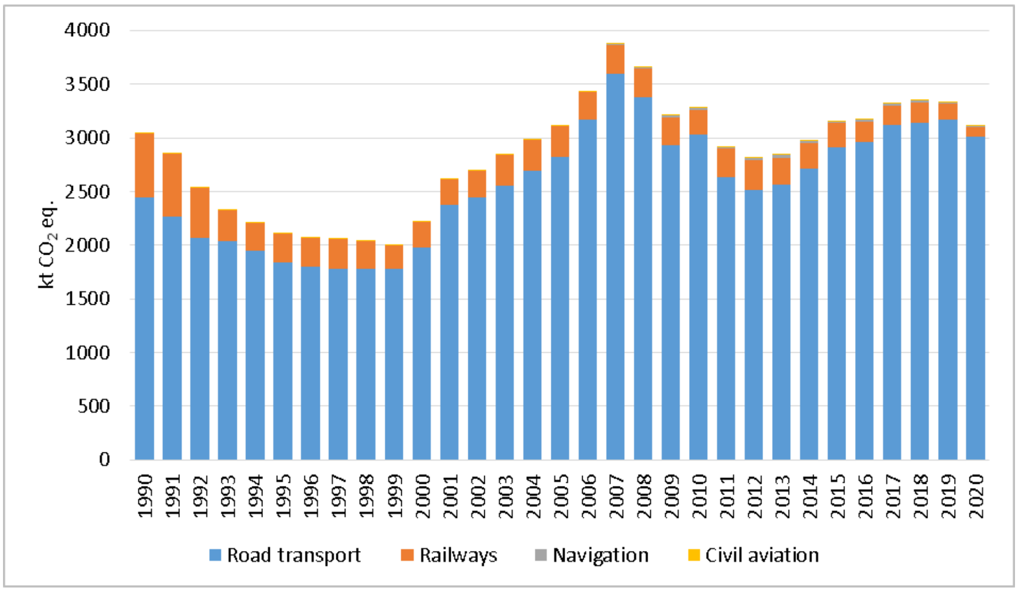

Figure 3.18 GHG emissions development in Transport 1990–2020 (kt CO_2 eq.)

Emissions from Transport (CRF 1.A.3) include all domestic transport sectors: Civil aviation, Road Transport, Railways and Domestic navigation.

In 2020, total GHG emissions in the Transport sector, compared to 1990, have increased by 2.2%. GHG emissions in 2020, compared to 2019, were by 6.7% lower.

Peak of GHG emissions in Transport sector has been recognized in 2007 when emissions exceeded 1990 level by 27.4%.

Road transport constitutes a convincing majority of the total GHG emissions in the Transport sector. In 2020, it gave around 96.8% of total emissions but the next largest emission source was railway – 2.9% (see Figure 3.19).

CO_2 emissions constitute nearly 98.3% of the total GHG emissions in the Transport sector and they are key categories in Road transport and Railway as well (see Figure 3.20).

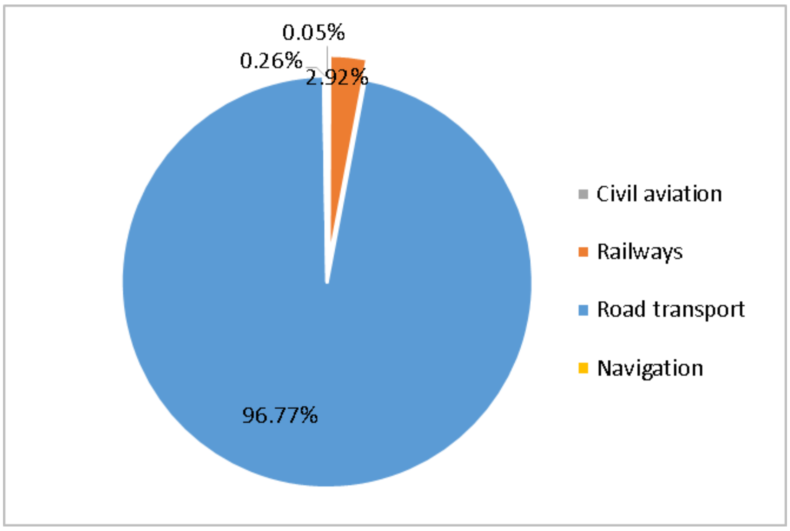

Figure 3.19 GHG emissions in Transport sector by sub-sectors in 2020 (%)

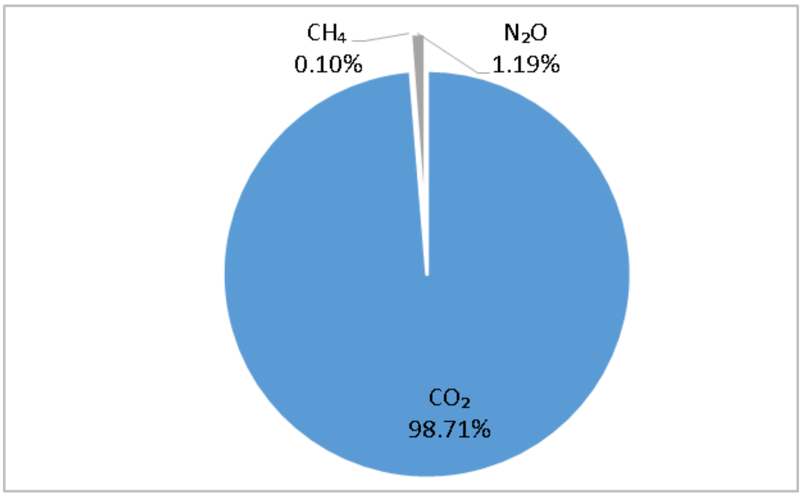

Figure 3.20 GHG emissions in Transport sector by gases in 2020 (%)

One of the critical factors influencing CO_2 emission is the amount and type of the consumed fuel. In 2020, total fossil fuel consumption (excluding consumption of lubricants) in the transport sector, compared to 2019, has decreased by 6.6%. In different subsectors various changes have taken place in 2020. The main impact to changes in total fuel consumption related to decreasing of fuel consumption is in Railways where the fuel consumption has decreased by around 40.5%. It has to be emphasised that the additional impact on CO_2 emission changes in transport sector is caused also due to the increase of the share of diesel fuel in the total consumption.

In total (excluding electricity and lubricants), road transport consumes around 97.3%, railway – about 2.6% and domestic civil aviation and domestic navigation – the remaining share of fuel.

Diesel oil is the major fuel type in the transport sector in Latvia,and it constitutes 75.1%, and is followed by gasoline – 16.2%, but LPG constitutes 4.2% and biofuels (biodiesel and bioethanol) 4.4% of the total fuel consumption in transport sector (see Figure 3.21). Biofuel includes biodiesel and bioethanol and it is mainly used in road transport, but small portion is consumed in railway as well. In 2020 there was no growth of LPG consumption compared to trend of time period between 2010-2015.

In 2020, compared to 2019, LPG consumption declined more rapidly than other fossil fuels (9.6%).

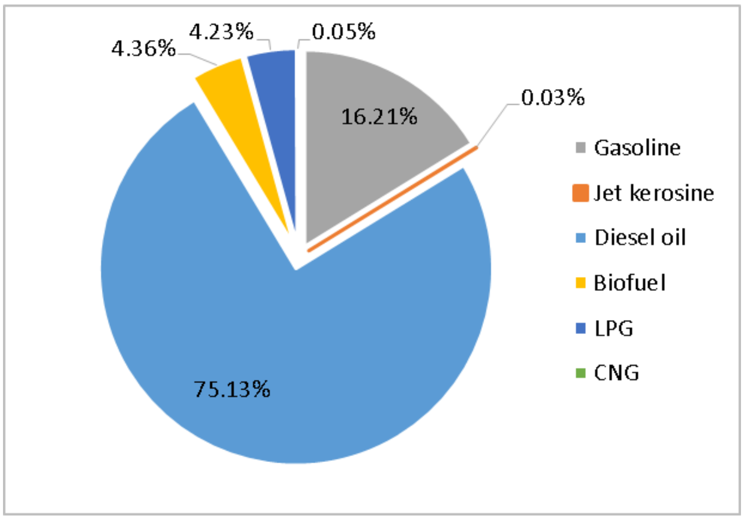

Figure 3.21 Fuel consumption in transport by fuel type in 2020 (%)

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

In Latvia, civil aviation, excluding international flights, has really a small impact to development of GHG emissions in transport sector. Therefore the fuel consumption and thus also the volume of GHG emissions is comparably insignificant, constituting mere 0.05% of GHG emissions from the transport sector in 2020. In aviation emissions are calculated for aviation gasoline and jet kerosene. The aviation gasoline is mainly used by small-sized propeller planes but jet kerosene is used by airplanes with turbofan and turbo props engines.

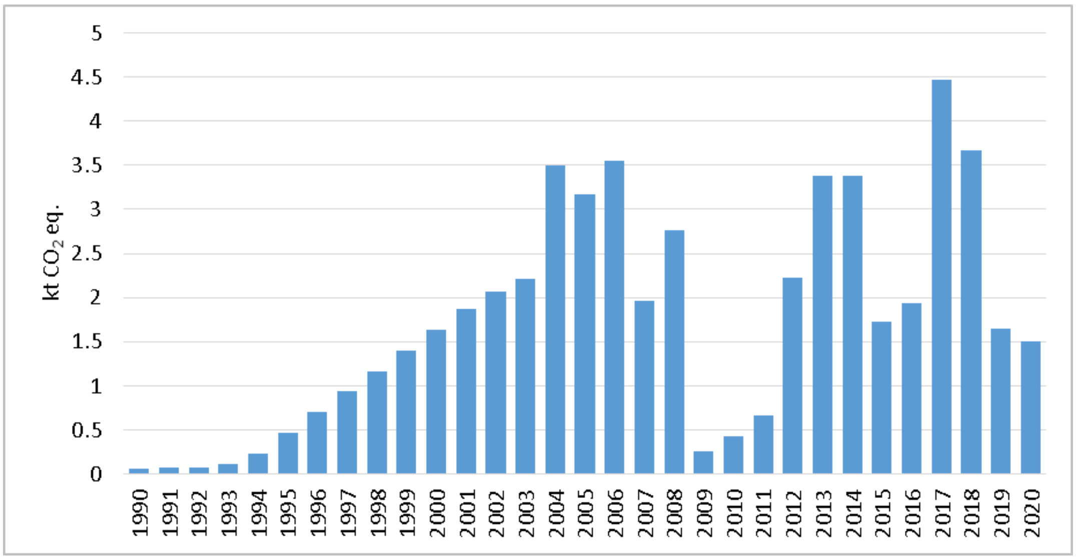

Figure 3.22 GHG emissions in civil aviation (kt CO_2 eq.)

In Latvia, there are two airports for commercial aviation, of which the largest is the Riga International Airport. Considering that local commercial flights are very dependent on the strategy of local state owned airline company; the number of flights, fuel consumption and emission amount are quite unsteady over the years. As it can be seen, after the state owned (80.05% of shares) national airline company (Air Baltic Corporation) had aborted domestic commercial flights in 2009, fuel consumption had decreased dramatically in 2009. The main activities in civil aviation are related to private flights. Economic recovery that started in 2011 has fostered activity and fuel consumption in civil aviation in Latvia. The results from additional analyses indicate no evidence of any certain trend in gasoline and jet fuel consumption. In 2017, Air Baltic Corporation restarted the commercial domestic flights. Thus the consumption of jet kerosine in 2017 increased by 2.8 times, compared to 2016. Due to this change, the total GHG emissions in civil aviation in 2017 increased by 2.3 times compared to 2016 as well. In 2020, GHG emissions in civil aviation, compared to 2019, have decreased by 6.7%.

Methods

When calculating emissions from civil aviation, two approaches have been applied. The 2006 IPCC Guidelines Tier 1 method has been applied when estimating emissions from aviation gasoline for all gases. When calculating emissions from jet kerosene Latvia uses Tier 1 to estimate emissions of CO_2 and SO_2, and Tier 2 to estimate CH_4, N_2O and all other gases. Using Tier 2 approach, emissions for LTO (landing/take off) and cruise are calculated individually. Separate EFs are provided for LTO and Cruise activities. Prior to the emission calculation, representative aircraft type was selected, for which the fuel consumption and emission data exist in the EMEP database (EMEP/EEA 2019).

1. Total Emissions = LTO Emissions + Cruise Emissions

*2. LTO Emissions = Number of LTOs * Emission Factor of LTOs*

*3. LTO Fuel Consumption = Number of LTOs * Fuel Consumption per LTO*

*4. Cruise Emissions = (Total Fuel Consumption – LTO Fuel Consumption) * EF Cruise*

The summary of the latest key category assessment, methods and EFs used is presented in Table 3.28.

Table 3.28 Summary of source category description (CRF 1.A.3.a)

CRF	Gas	Method	EF	All sources estimated
1.A.3.a	CO_2	*T1*	*D*	*Yes*
	CH_4	*T1,T2*	*D*	*Yes*
	N_2O	*T1, T2*	*D*	*Yes*

T1 Tier 1; T2 Tier 2; D Default.

Activity data

The data about fuel consumption (see Table 3.29) in aviation is derived from the CSB. CSB has started to separate fuel consumption for domestic flights from total fuel consumption data in aviation as of year 2006. For the time period 1990 – 2005 the data for fuel consumption is used from the study ("Evaluation of fuel consumption for domestic aviation and navigation", IPE, 2004). For 2004 onwards, the air flight statistics is provided by the Riga and Liepaja airports.

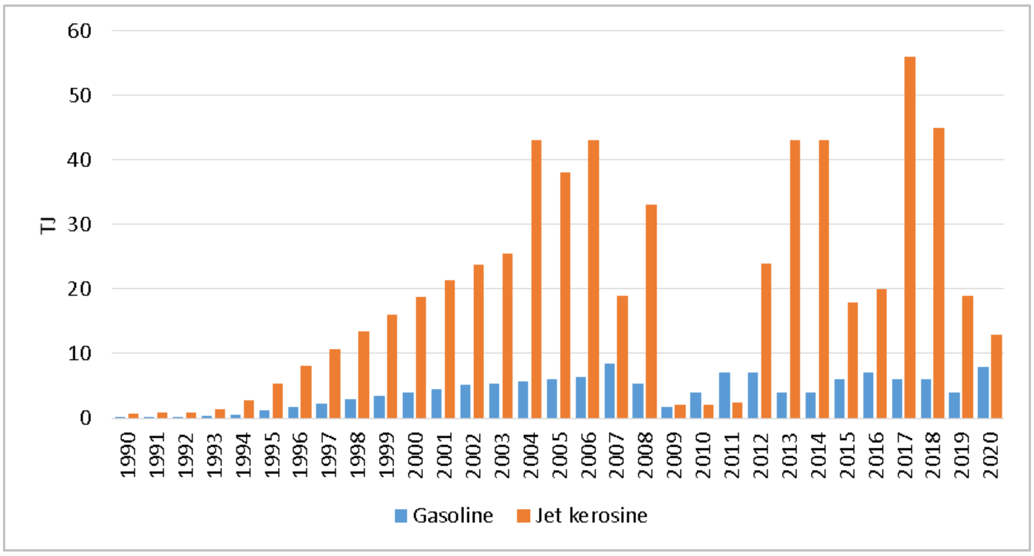

Figure 3.23 Fuel consumption in domestic civil aviation (TJ)

Table 3.29 Fuel consumption in domestic civil aviation (TJ)

Year	Jet kerosene	Gasoline
1990	*0.8*	*0.2*
1995	*5.4*	*1.1*
2000	*18.8*	*4.0*
2001	*21.4*	*4.6*
2002	*23.7*	*5.1*
2003	*25.5*	*5.4*
2004	*43.0*	*5.7*
2005	*38.0*	*6.0*
2006	*43.0*	*6.4*
2007	*19.0*	*8.4*
2008	*33.0*	*5.4*
2009	*2.0*	*1.7*
2010	*2.0*	*4.0*
2011	*2.0*	*7.0*
2012	*24.0*	*7.0*
2013	*43.0*	*4.0*
2014	*43.0*	*4.0*
2015	*18.0*	*6.0*
2016	*20.0*	*7.0*
2017	*56.0*	*6.0*
2018	*45.0*	*6.0*
2019	*19.0*	*4.0*
2020	*13.0*	*8.0*

Emission factors

Default EFs of LTO and cruise (jet kerosene) for civil aviation is used (2006 IPCC Guidelines and EMEP/EEA 2019).

Table 3.30 Emission factors used in the calculation of emissions from civil aviation

Fuel type	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	kt/PJ	kt/PJ	kt/PJ	kt/PJ	kt/PJ	kt/PJ	kt/PJ
Aviation gasoline	*70.0*	*0.0005*	*0.002*	*0.25*	*0.1*	*0.05*	*0.023*

3.2.6.1.2 Road transport (CRF 1.A.3.b)

The road transport constituted around 96.8% of GHG emissions in the Transport sector in 2020. After the rapid growth in the period 2000 – 2007 (see Figure 3.24), emissions in 2009 have sharply decreased. The main reason was a sharp decrease of fuel consumption in the Road transport in 2009. It decreased by 12.8%, compared to 2008. The major reason for this tendency was recession of the national economy and decrease of transport activities – decrease of passenger km by passenger cars and ton km by freight transport. Due to the Covid-19 pandemic, GHG emissions in 2020 are by 5.0% less than in 2019. Emissions decreased slightly more from passenger cars, but less from trucks and light commercial vehicles.

The road transport is widely used for the local transportation and also for providing cross-border transportation. The freight road transport approximately constitutes 63.2% (2020) of the total freight in the country (traffic of goods in ton-km). The share has increased by around 13.3% point, compared with 2019. In the freight road transport (traffic of goods in ton), the inland freight constitutes approximately 80% of gross in time span 2010-2020 – timber products, food products, household goods and building materials are dominant. Fuel consumption in road transport has decreased by around 4.0% in 2020 compared to 2019. In different fuels various changes have taken place in 2020 compared to 2019. Gasoline consumption has decreased by 4.0%, diesel fuel consumption has decreased by 5.0% and LPG consumption by 9.6% whereas biofuel consumption has increased by 31.2% (see Figure 3.28).

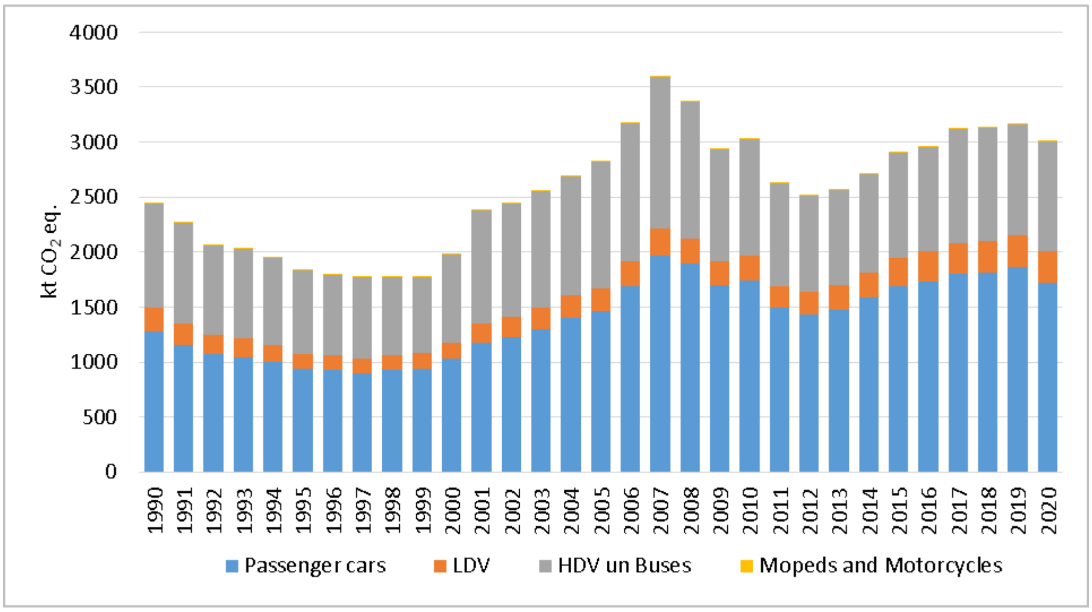

Figure 3.24 GHG emissions in road transport (kt CO_2 eq.)

Road transport includes five vehicle categories: Passenger cars, Buses, Heavy duty-vehicles (HDV), Light duty-vehicles (LDV) and Mopeds & Motorcycles. In 1990–2020, essential changes have taken place in structure of GHG emissions created by the road transport (see Table 3.31). Gasoline has been the most common fuel used for road transport up to 2000, but in 2020 the amount of diesel used for road traffic is 4.5 times more as gasoline and the emissions of CO_2 from diesel surpassed the emissions of CO_2 from gasoline as from 2001.

In 2020, emissions from gasoline consumption created by passenger cars were less than that of 1990 level, while emissions created by diesel oil consumption in passenger cars have increased several times. Emissions of LDV and HDV gasoline consumption have decreased, but the emissions of diesel oil fuel consumption have essentially increased at this time span.

Table 3.31 GHG emissions in road transport by vehicle types (kt CO_2 eq.)

Year	Passenger Cars		LDV		HDV	
	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel
1990	*1242*	*33*	*148*	*38*	*358*	*560*
1995	*903*	*29*	*101*	*34*	*297*	*458*
2000	*860*	*128*	*57*	*73*	*135*	*665*
2001	*933*	*200*	*56*	*107*	*118*	*895*
2002	*937*	*245*	*48*	*122*	*99*	*928*
2003	*950*	*303*	*43*	*136*	*91*	*965*
2004	*982*	*366*	*38*	*149*	*69*	*1010*
2005	*971*	*428*	*35*	*165*	*60*	*1080*
2006	*1089*	*535*	*32*	*181*	*58*	*1186*
2007	*1207*	*694*	*30*	*209*	*51*	*1319*
2008	*1109*	*727*	*24*	*201*	*39*	*1202*
2009	*928*	*717*	*18*	*191*	*28*	*987*
2010	*845*	*832*	*16*	*205*	*23*	*1034*
2011	*783*	*637*	*15*	*175*	*22*	*918*
2012	*662*	*659*	*14*	*182*	*19*	*853*
2013	*601*	*724*	*11*	*207*	*17*	*844*
2014	*588*	*837*	*11*	*204*	*17*	*878*
2015	*584*	*945*	*12*	*232*	*16*	*937*
2016	*571*	*999*	*11*	*254*	*14*	*934*
2017	*549*	*1104*	*10*	*263*	*13*	*1015*
2018	*526*	*1149*	*10*	*267*	*11*	*1016*
2019	*499*	*1236*	*9*	*268*	*10*	*1000*
2020	*479*	*1130*	*9*	*264*	*9*	*987*
Trend 2020 vs 1990 (%)	*-61.4*	*3325.7*	*-94.1*	*590.5*	*-97.6*	*76.3*
Trend 2020 vs 2019 (%)	*-4.0*	*-8.6*	*-7.6*	*-1.5*	*-9.0*	*-1.3*

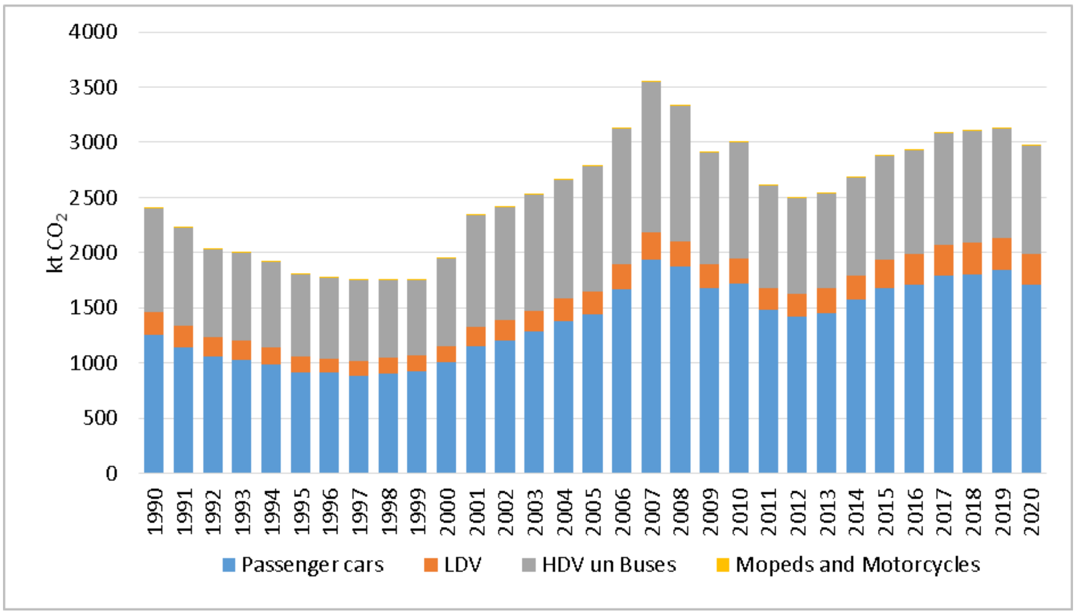

Figure 3.25 CO_2 emissions in road transport by vehicle types (kt)

CO_2 emissions are directly fuel-use dependent and, in this way, the development in the emissions reflects a trend in the fuel consumption. As shown in Figure 3.25, the most important emission source for the road transport is passenger cars and HDV vehicles followed by LDV, buses and motorcycles. Share of CO_2 emissions from passenger cars was 57.4%, HDV and buses 33.1 % and LDV 9.4% in 2020. In 2020, CO_2 emissions in road transport, compared to 2019, have decreased by 4.9%.

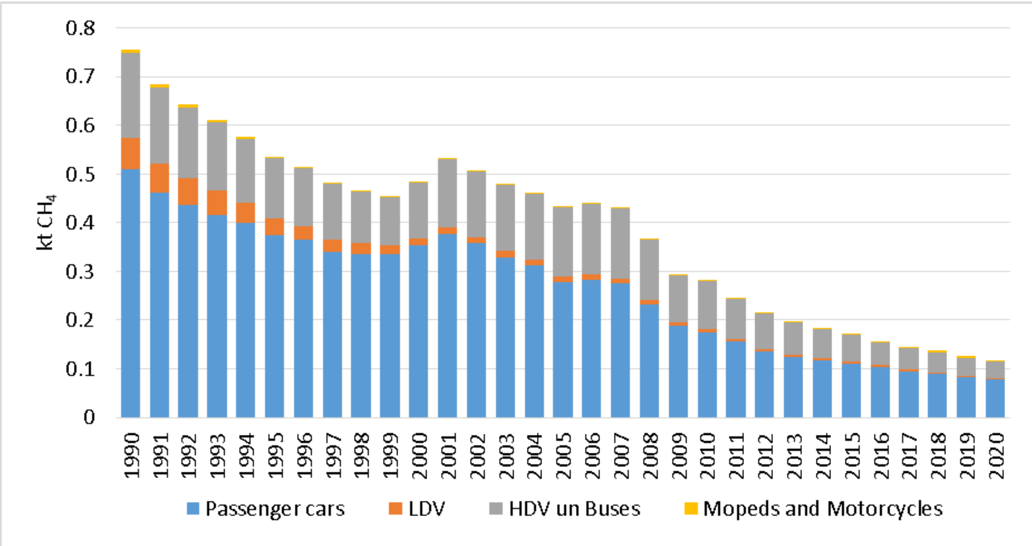

Figure 3.26 CH_4 emissions in road transport by vehicle types (kt)

CH_4 emissions present consistent decrease trend within the whole period (see Figure 3.26). In 2020, CH_4 emissions in road transport, compared to 2019, have decreased by 6.0%. The majority of CH_4 emissions from the road transport come from passenger cars (65.7%). The substantial emission drop from 2001 onwards is explained by the sharp penetration of EURO4, EURO5 and EURO6 passenger cars into Latvia`s fleet and additionally in years 2009 - 2020 with decrease of gasoline consumption by passenger cars. Share of CH_4 emissions of HDV and buses was 29.2% and mopeds and motorcycles 2.9% in 2020.

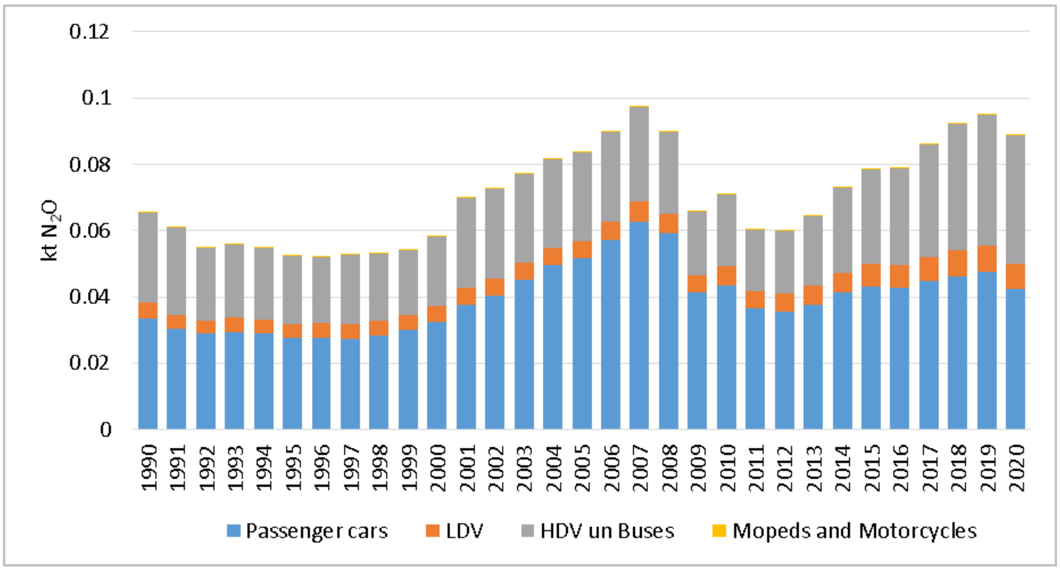

Figure 3.27 N_2O emissions in road transport by vehicle types (kt)

In 2020, N_2O emissions in road transport, compared to 2019, have decreased by 6.3%. Taking into account that N_2O emission rates are largely dependent from implemented combustion and emission control technologies, different factor interaction characterises the trend of N_2O changes.

To analyze the trend of N_2O emission at first the significance of different emission sources should be clearly identified. The passenger cars (Figure 3.27) contribute 47.9%, LDV 8.4% and HDV and busses 43.6% of total N_2O emission in Latvia's road transport (2020). Thus the N_2O emission trend is mainly determined by the change in the technologies and fuel used by passenger cars and HDV.

Regarding total N_2O emission created by the fleet of Latvia passenger cars, gasoline fuelled passenger cars contribute slightly above 12.4%, the rest is mainly emitted by diesel fuelled passenger cars (74%). Important, in the period after year 2005 the average N_2O EF (t/TJ) for gasoline fuelled passenger cars has tendency to decrease due to change in the relative share of EURO3, EURO4 cars and EURO5 and EURO6 cars. The N_2O EF (g/km) of gasoline fuelled passenger cars of the EURO1 and EURO2 classes is more than twice higher compared to the EF of gasoline fuelled passenger cars of the EURO3 and EURO4 classes. The mileage shares in 2020, calculated by summing the shares of EURO3 and EURO4 and EURO5 and EURO6 gasoline passenger cars, has increased at least five times – from 15% to 78.9% of the total gasoline passenger cars mileage, compared to 2005.

At the same time, one can see the opposite trend in the group of diesel passenger cars. The N_2O EF (g/km) of EURO3 and EURO4 and EURO5 diesel passenger cars is per about 60% higher than the EF for EURO1 and EURO2 diesel passenger cars. Thus, due to the significant rise of the mileage share of EURO3, EURO4, EURO5 and EURO6 cars – from 24% (year 2005) up to 85% (year 2020) of the total diesel passenger cars mileage, the average N_2O EF (t/TJ) for diesel passenger cars has also slightly increased.

Methods

For Road transport, the detailed methodology is used to make annual estimates of the Latvian emissions, as described in the 2006 IPCC Guidelines and EMEP/EEA 2019. The actual calculation is made with a COPERT 5 model[25]. COPERT 5 provides factors for fuel consumption and for all exhaust emission components which are included in the national inventory. For several reasons, COPERT 5 is regarded as the most appropriate source of road traffic fuel consumption and EFs. First of all, very few Latvia's emission measurements exist, so data are too scarce to support emission calculations on a national level. Secondly, the COPERT model is regularly updated with new experimental findings from European research programmes and, apart from updated fuel-use and EFs, the use of COPERT 5 by many European countries ensures a large degree of cross-national consistency in reported emission results.

In COPERT 5, fuel consumption and emission simulation can be made for operationally hot engines, taking into account gradually tighten emission standards and emission degradation due to catalyst wear. Furthermore, the emission effects of cold-start and evaporation are simulated. Estimation of evaporative emissions of hydrocarbons and the inclusion of cold start emission effects are dealt with in the Latvian inventory by using LEGMC meteorological input data for ambient temperature variations during months; the distribution of evaporate emissions in the driving modes are used default by COPERT 5 model.

Corresponding to the COPERT 5 fleet classification, all vehicles in the Latvia's fleet are grouped into vehicle classes, subclasses and layers. The layer classification is a further division of vehicle sub-classes into groups of vehicles with the same average fuel consumption and emission behaviour, according to EU emission legislation levels.

Trip-speed dependent basis factors for fuel consumption and emissions are implemented. The fuel consumption and EFs used in the Latvia`s inventory are taken from the COPERT 5 model. The summary of the methods and EFs used is presented in Table 3.32.

Table 3.32 Summary of source category description (CRF 1.A.3.b)

CRF	Gas	Method	EF	All sources estimated
1.A.3.b Gasoline, diesel, LPG, CNG	*CO_2*	*T2*	*CS*	*Yes*
	CH_4	*T3*	*D (COPERT 5 model)*	*Yes*
	N_2O	*T3*	*D (COPERT 5 model)*	*Yes*
1.A.3.b Biofuel, lubricants, biodiesel (FAME) fuel that are of fossil origin	*CO_2*	*T1*	*D*	*Yes*
1.A.3.b Biofuel, lubricants	*CH_4*	*T1*	*D*	*Yes*
	N_2O	*T1*	*D*	*Yes*

T2 Tier 2; T3 Tier 3; CS Country Specific; D Default.

Reported CO_2 emissions from lubricant consumption in road transport have been calculated based on kilometres travelled. Lubricant consumption have been calculated for an each of road

[25] *COPERT model. Available: www.emisia.com*

transport groups (passenger cars, HDV, LDV, busses and motorcycles) including 2-stroke motorcycles whom petrol engine should be lubricated by a mixture of lubricating oil and petrol.

To calculate CO_2 emissions from lubrication oil using in car's engines in road transport is calculated amount of oil, which the oil film developed on the inner cylinder walls. This oil film further is exposed to combustion and burned along with the fuel. A calculation of lubricant oil consumption for engine operation has been performed using a typical oil consumption factors for different vehicle types, fuel used and vehicle age (see Table 3-30 EMEP/EEA 2019). Based on this calculated lubricant oil consumption and using default EF (2006 IPCC Guidelines) CO_2 emissions for lubricant oil burning for engine operation has been calculated.

Further from the total quantity of lubricants consumed in road transport, the above mentioned amount of lubricants for which CO_2 emissions in road transport from combustion have been calculated and reported, is deducted.

Total consumption of lubricants (road transport) = lubricants consumption of engines (burned along with the fuel) + other consumption of lubricants

where:

- Lubricant consumption burned along with the fuel is calculated and CO_2 emissions reported under category road transport;
- Other consumption of lubricants is reported under IPPU sector (CRF 2.D).

For estimating CO_2 emissions from use of urea-based additives in catalytic converters (non-combustive emissions), it is used equation from the 2006 IPCC Guidelines:

$$\boldsymbol{Emission = Activity * \frac{12}{60} * Purity * \frac{44}{12}} \tag{3.8}$$

where:
Emissions - CO_2 Emissions from urea-based additive in catalytic converters (Gg CO_2);
Activity - amount of urea-based additive consumed for use in catalytic converters (Gg);
Purity - the mass fraction (= percentage divided by 100) of urea in the urea-based additive;
12/60 - conversion from urea to carbon;
44/12 - conversion from carbon to CO_2.

In calculations, it is assumed that 75% of the HDV (starting with Euro IV class and later) the urea-based additives are used in catalytic converters. The activity level is 3 percent of diesel consumption by the HDV. Thirty-two and half percent is taken as default purity. Estimated CO_2 emissions are reported in the IPPU sector (CRF 2).

Bioshares of transport fuels

Due to the activity data (statistics) of biofuels consumption in road transport sector are not split for blended and pure biofuels, it is assumed that all biofuel is consumed as the mix to fossil fuel in the volume defined by Cabinet of Minister's Regulation. To ensure efficient growth of the share of RES in the transport sector, the mandatory 4.5-5% volume of bioethanol mix for the gasoline of "95" trademark and mandatory 4.5-5% volume of biodiesel mix for the diesel fuel were introduced as from October 1, 2009 according to Regulations of the Cabinet of Ministers No.648 (Art.8.1[26] and 9.1). From 01.01.2020 the mandatory mix share for biofuels have been

[26] *including diesels of A-F categories, utilised in moderate climate conditions, exemption is made for artic diesels of 0-4 classes.*

increased - at least 9.5% (volume) of bioethanol mix for the gasoline of "95" trademark and mandatory 6.5% (volume) of biodiesel mix for the diesel fuel.

At the first step the calculations of emissions in COPERT 5 model are performed using total fuel consumption data, including biofuels. Afterwards it is calculated separately the average share of bioethanol and biodiesel in the gasoline and diesel mix respectively and, assuming that each of the road vehicle groups (passenger cars, HDV, LDV and busses) consume this calculated average biofuel share, the fossil fuel consumption is calculated for each of noted vehicle groups. In preparing the inventory, CO_2 emission data for each of vehicle groups include only emissions related to fossil fuels consumption; thus CO_2 EFs are defined to include the fossil share of total fuel mix.

Table 3.33 Amount of biocomponent in liquid fuels and avoided fossil CO_2 in road transport (TJ)

Year	Gasoline, TJ	Diesel oil, TJ	Avoided fossil CO_2, kt
2005	*NO*	*107*	*8*
2006	*43*	*57*	*7.4*
2007	*NO*	*71*	*5.3*
2008	*1*	*81*	*6*
2009	*108*	*65*	*12.5*
2010	*350*	*752*	*81.1*
2011	*318*	*526*	*62*
2012	*279*	*463*	*54.5*
2013	*264*	*473*	*54.2*
2014	*257*	*583*	*61.9*
2015	*322*	*558*	*64.6*
2016	*343*	*22*	*26.1*
2017	*331*	*28*	*25.7*
2018	*354*	*1151*	*111.2*
2019	*306*	*1101*	*104.1*
2020	*534*	*1312*	*136.1*

In Latvia the following biofuels are used to replace fossil diesel and gasoline: 1) biodiesel (FAME) and 2) bioethanol. According to the 2006 IPCC Guidelines (volume 2, chapter 3, section 'CO_2 emissions from biofuels' in page 3.17): "it is important to assess the biofuel origin so as to identify and separate fossil from biogenic feedstocks". It means that a part of the carbon of biofuels (and the associated CO_2 emissions) may have a fossil origin. To evaluate both fossil and biogenic CO_2 emissions associated to FAME the proposed method (2006 IPCC Guidelines and Note on fossil carbon content in biofuels presents in WG1) has been implemented. Calculated CO_2 emissions from biodiesel (FAME) fuel that are of fossil origin in 2020 is 5.24 kt (emissions have been reported in CRF under category road transport other fossil fuels).

Activity data

As a basis for model input information CSB and LR Road Traffic Safety Directorate (RTSD) data is used. CSB data have been used considering the fuel consumption, RTSD collected and published data have been used considering stock of road transport in Latvia. Total mileage data for passenger cars, light commercial trucks, heavy duty trucks and buses produced by the RTSD is used for the years 1996-2020. The summary of the data sources used in emission calculation for road transport are presented in Table 3.34.

Table 3.34 Activity data and sources used for emission calculation in road transport

Activity data	Source of activity data	Remarks
Fuel consumption	*National statictics (CSB)*	*It is assumed that all liquid biofuel is consumed as blended with fossil fuel*
Number of cars	*Road Traffic Safety Directorate*	*For calculation it is used number of cars with permission to participate in traffic*
Number of cars by fuel and vehicle type	*Road Traffic Safety Directorate and expert calculation*	*Based on available data cars are grouped by fuel type, engine power, age and vehicle categories according to emission control system*
Distance travelled by cars by fuel and vehicle type	*Road Traffic Safety Directorate and expert calculation*	*Based on an average data by cars classes it is modelled by fuel type, engine power, age and vehicle categories*
Emission factors	*National specific for CO_2 emissions, COPERT emission factors for CH_4 and N_2O*	*CO_2 emission factors are based on carbon content in fuel.* *1990 – onwards EF for gasoline is 71.18 kt/PJ;* *1990 – onwards EF diesel oil 74.75 kt/PJ.*

General information about activity data is presented in Figure 3.29-Figure 3.35 (number of cars and their split by sub-classes and layers). Before emission calculation COPERT 5 model was calibrated to be consistent with actual fuel consumption (energy statistics see Table 3.35).

Table 3.35 Fuel consumption in road transport (TJ)

Year	Gasoline, TJ	Diesel oil, TJ	LPG, TJ	Natural gas, TJ	Biofuel (biodiesel and bioethanol), TJ
1990	*24200*	*8328*	*592*	*305*	*NO*
1995	*17996*	*6883*	*91*	*33*	*NO*
2000	*14520*	*11472*	*865*	*68*	*NO*
2001	*15268*	*15934*	*865*	*101*	*NO*
2002	*14960*	*17166*	*865*	*68*	*NO*
2003	*14950*	*18611*	*956*	*68*	*NO*
2004	*15038*	*20225*	*1047*	*68*	*NO*
2005	*14730*	*22180*	*1093*	*68*	*107*
2006	*16313*	*25235*	*1184*	*68*	*100*
2007	*17852*	*29488*	*1093*	*67*	*71*
2008	*16269*	*28256*	*956*	*33*	*82*
2009	*13586*	*25154*	*865*	*4*	*173*
2010	*12308*	*27449*	*989*	*1*	*1102*
2011	*11432*	*22945*	*1184*	*NO*	*844*
2012	*9697*	*22465*	*1858*	*NO*	*742*
2013	*8794*	*23539*	*2368*	*NO*	*737*
2014	*8617*	*25409*	*2646*	*NO*	*840*
2015	*8576*	*28001*	*2687*	*NO*	*880*
2016	*8363*	*28992*	*2591*	*NO*	*365*
2017	*8030*	*31570*	*2440*	*NO*	*359*
2018	*7700*	*32158*	*2312*	*2*	*1505*
2019	*7307*	*33123*	*2028*	*8*	*1407*
2020	*7015*	*31475*	*1833*	*22*	*1846*

As mentioned above reported CO_2 emissions from lubricant consumption in Road transport have been calculated based on kilometres travelled. Lubricant consumption have been calculated for an each of road transport groups (passenger cars, HDV, LDV, busses and motorcycles) including 2-stroke motorcycles whom petrol engine should be lubricated by a mixture of lubricating oil and petrol. The quantity of lubricants in Road transport for which emissions are calculated is shown in Table 3.36.

Table 3.36 Calculated lubricant consumption in road transport for CO_2 emission reporting (TJ)

Year	Lubricants, TJ
1990	*43.18*
1995	*32.77*
2000	*36.93*
2005	*54.25*
2010	*62.66*
2015	*62.39*
2016	*62.91*
2017	*65.78*
2018	*67.90*
2019	*69.31*
2020	*66.36*

As it can be seen in Figure 3.28 the fuel consumption has essentially changed in the time period 1990 – 2020. The gasoline consumption from the highest consumption in 1990 has decreased untill 1999, reaching the lowest consumption and after six year stabilization the increase was observed in 2006 and 2007. Consumption of gasoline had decreased in 2020 by 4.0% compared to 2019. Whereas diesel fuel consumption starting from 1997 has increased gradually untill 2007, however, it decreased in 2008 and 2009, mainly due to economic recession. Diesel fuel consumption has decreased in 2020 by 5% compared to 2019. Substantial LPG consumption increasing in road transport was observed starting from 2011, slightly decreasing in 2016-2020.

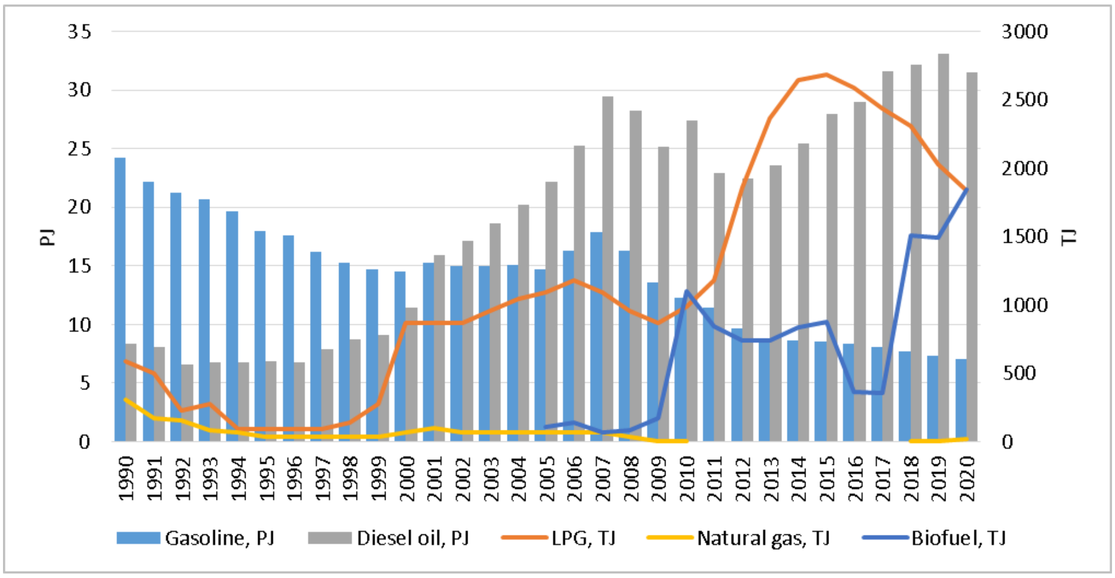

Figure 3.28 Development of Fuel consumption in road transport (PJ;TJ)[27]

[27] *LPG, natural gas and biofuel on secondary axes*

The vehicle numbers per passenger cars sub-class and layers are shown in Figure 3.29.

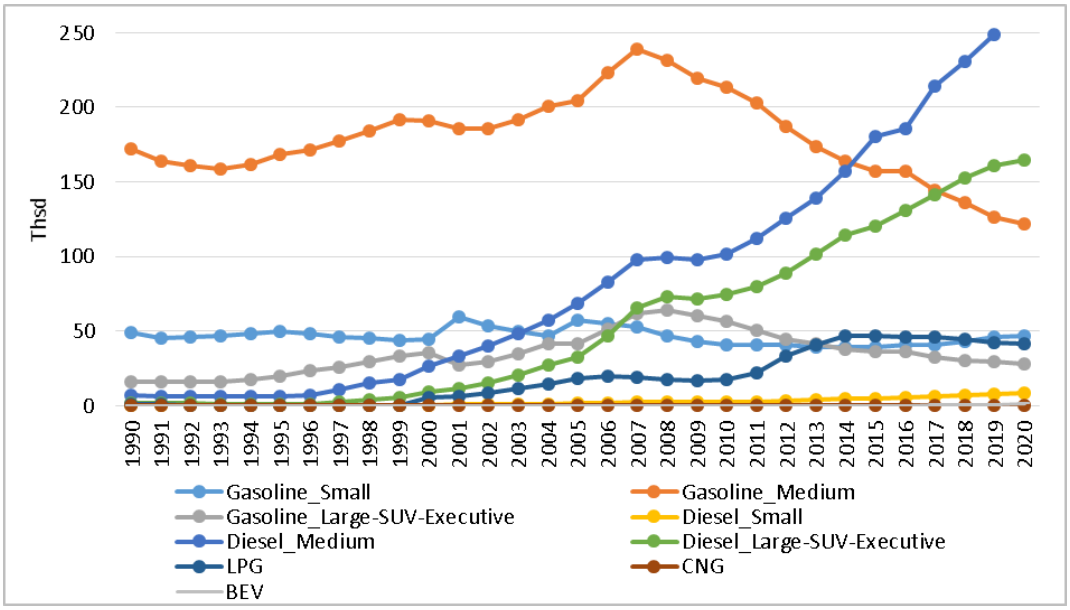

Figure 3.29 Distribution of passenger cars fleet by sub-classes (thsd)

Analyzing the development of the passenger car fleet in the period of time from 1990 – 2020 (Figure 3.30, Figure 3.31), following features can be noted:

- Cars with a diesel engine of a capacity 1.4l - 2.0l (Medium) constitute the major part (39%) but the second leading group (24.3%) are cars with a diesel engine of a capacity > 2.0l (Large-SUV-Executive); cars with a gasoline engine of a capacity 1.4l - 2.0l (Medium) -18%;
- Cars with a gasoline engine of a capacity <1.4l during the whole period have small changes and constitute approximately 7% in year 2020 from total passenger cars;
- Cars with a gasoline engine of a capacity >2.0l starting from 2010 have a small decreasing in their share of total passenger cars and they constitutes around 4.1% in 2020;
- As of 2000, the number of cars with diesel engines, both, <2.0l and >2.0l, grow rapidly and their share is 64.7% from the total number of passenger cars in 2020;
- As of 2005, in the car fleet with a gasoline engine, the number of EURO4, EURO5 and EURO6 cars grows gradually. In 2020 a share of EURO4 and EURO5 and EURO6 cars constitutes 48.7%;
- As of 2005, in the car fleet with a diesel engine, the number of EURO 4 and EURO 5 cars grows gradually. In 2020 a share of EURO4, EURO5 and EURO6 cars constitute 45.4%.

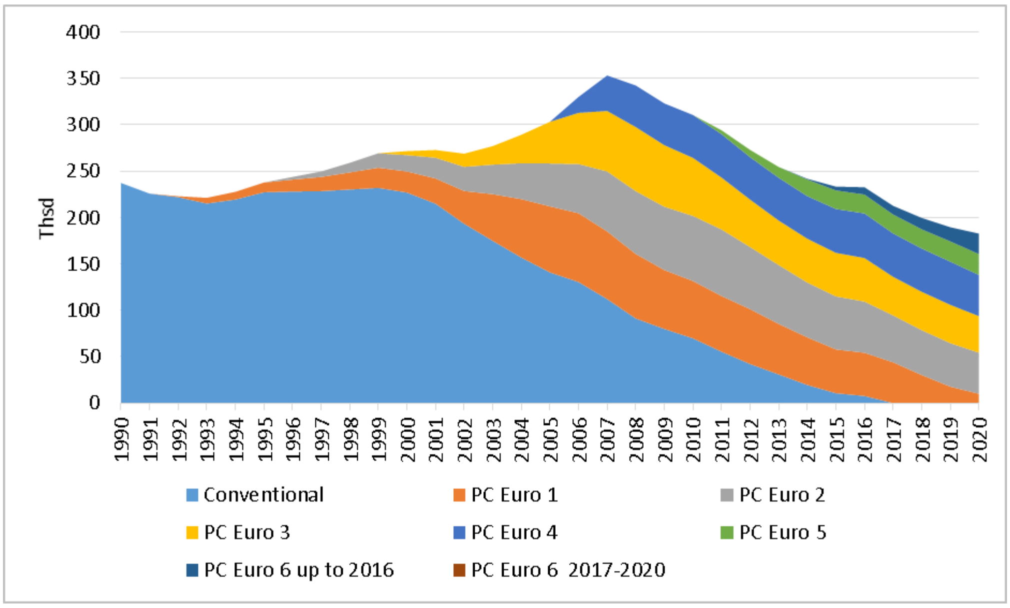

Figure 3.30 Distribution of gasoline passenger cars fleet by layers (thsd)

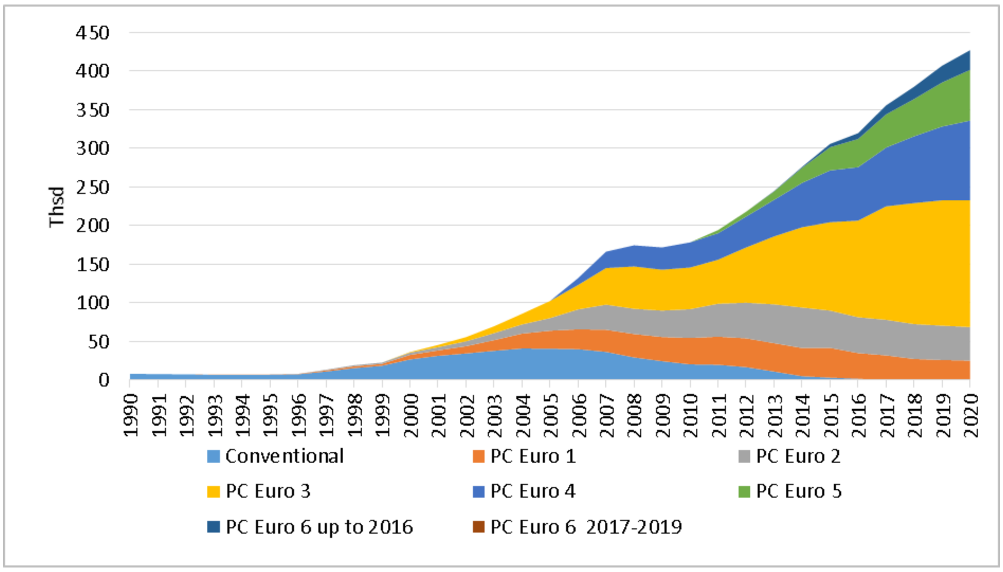

Figure 3.31 Distribution of diesel oil passenger cars fleet by layers (thsd)

Analyzing the development of LDV fleet (Figure 3.32, Figure 3.33) in the period of time 1990-2020 major features can be noted as follows:

- As of 1996, the number of cars with a gasoline engines have decreased;
- As of 2000, the number of cars with a diesel engine rapidly increases. In 2020 the share of diesel cars is 94.7%;
- As of 2005, the number of EURO4 and EURO5 and EURO6 cars have increased. In 2020 the share of EURO4, EURO5 and EURO6 cars constitute 68.4%.

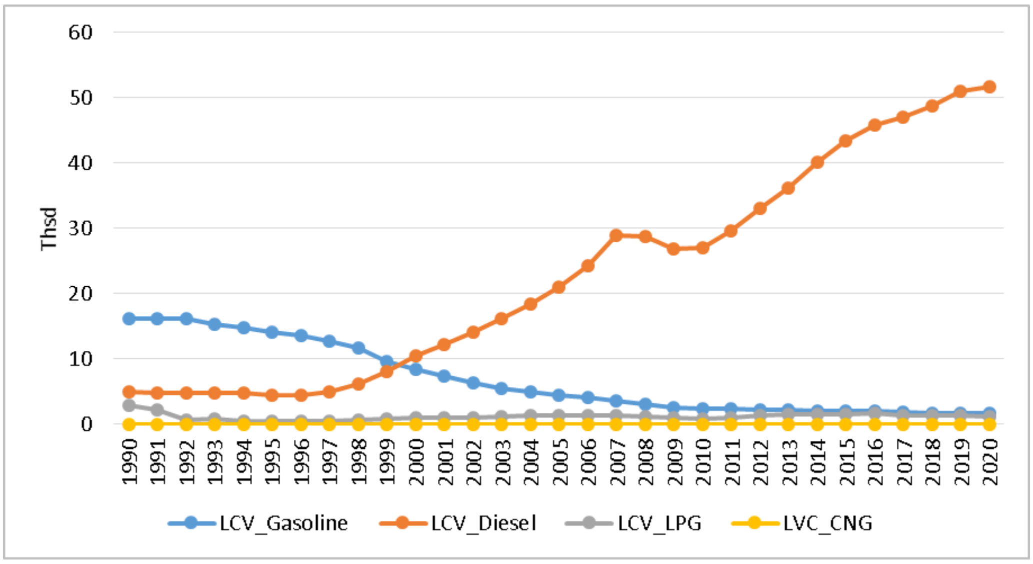

Figure 3.32 Distribution of light commercial vehicles fleet by sub-classes (thsd)

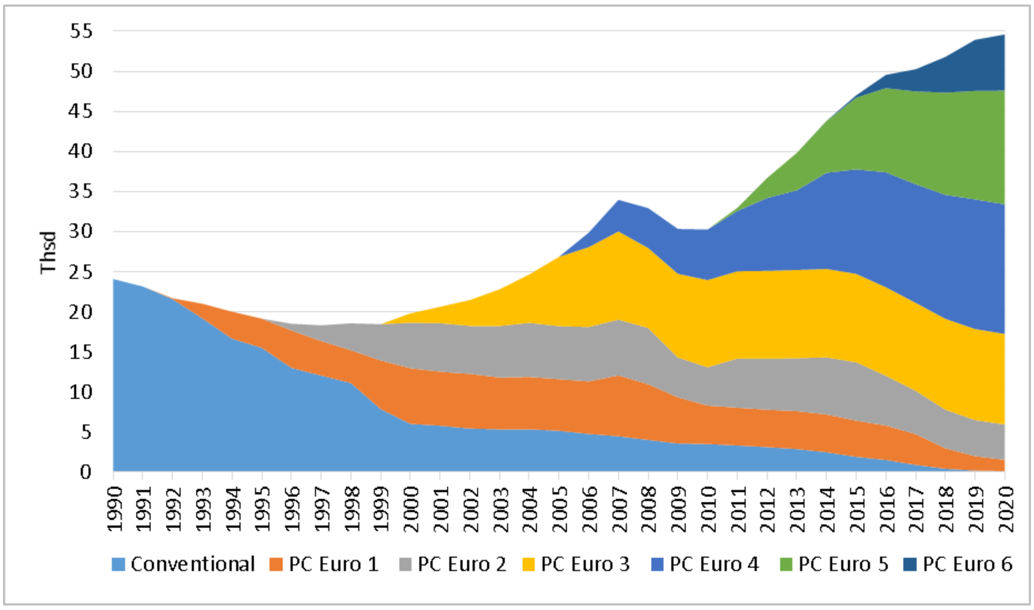

Figure 3.33 Distribution of light duty vehicles fleet by layers (thsd)

The vehicle numbers per HDV sub-classes and layers are presented in Figure 3.34 and Figure 3.35. Analyzing the development of HDV fleet in the following time period, major features can be noted as follows:

- Since 2000 the number of cars with a gasoline engines have rapidly decreased. The share of gasoline cars has decreased from 28% to 2.1% corresponding years 2000 and 2020;
- Since 2000 the number HDV cars with tonnage 14-34 t and a diesel engine starts to increase;
- As of 2000, average age reduction of cars takes place gradually. In 2020, the share of EURO IV, EURO V and EURO VI cars constituted 64.9%.

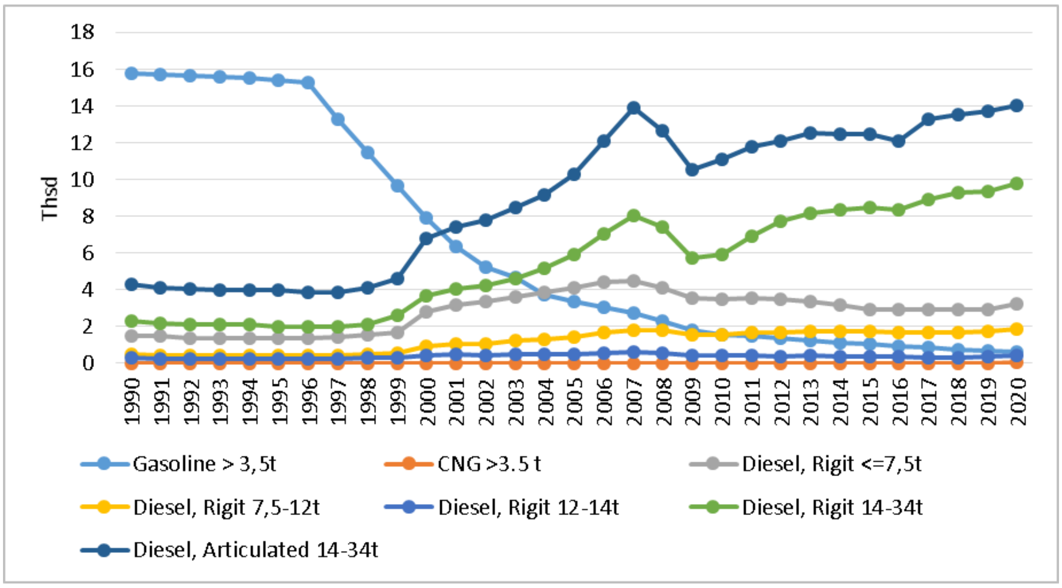

Figure 3.34 Distribution of heavy duty vehicles fleet by sub-classes (thsd)

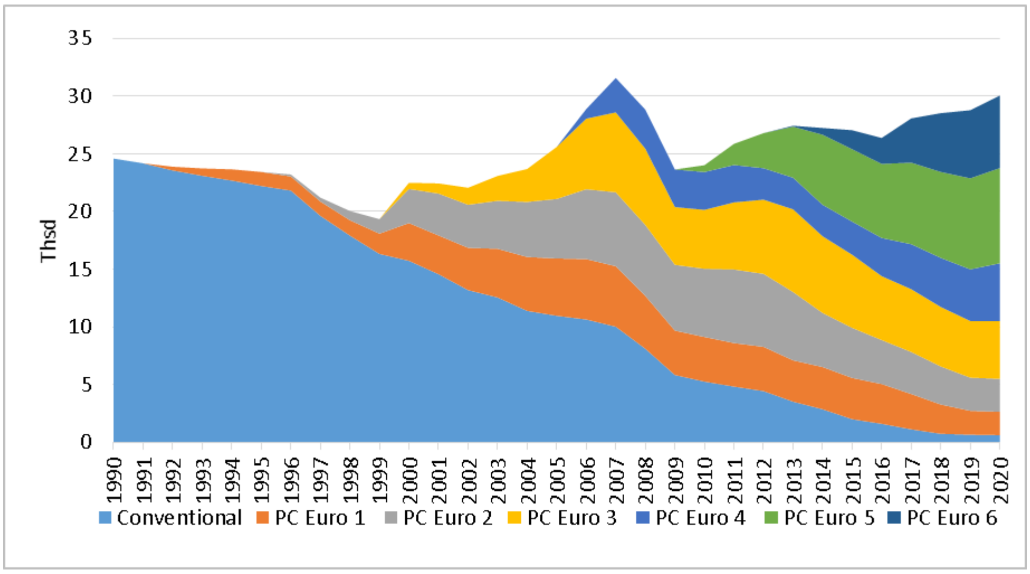

Figure 3.35 Distribution of heavy duty vehicles fleet by layers (thsd)

Emission factors

CO_2 emissions in COPERT 5 model were calculated using country-specific CO_2 EF that are calculated based on the information available on the C and H content in fuel. Country specific EF for CO_2 emission calculation (gasoline, diesel oil) in road transport is used:

- 1990 – 2020 EF diesel oil 74.75 kg/GJ;
- 1990 – 2020 EF for unleaded gasoline is 71.18 kg/GJ.

In 2012, MEPRD funded research "Research on carbon content in transport fuels". The research on C content in fuels carried out in 2012 quantified C and H content in gasoline. For gasoline the C content is 84.7%, further it is calculated NCV for gasoline (43.97 MJ/kg) and estimated CO_2 EF is in accordance with requirements from the 2006 IPCC Guidelines. For diesel oil the C content is 86.7%, further it is calculated NCV for diesel oil (42.49 MJ/kg) and estimated CO_2 EF is in accordance with requirements from the 2006 IPCC Guidelines. Based on the results of this research, CO_2 EF of gasoline has been calculated - 71.18 kg/GJ and diesel oil 74.75 kg/GJ (oxidation factor is 1). Although quantification of C and H content in gasoline and diesel oil has been performed for fuel with a requirement for gasoline quality which is in force since January 1, 2009, the updated CO_2 EF is implemented for emissions calculation 1990-2008 as well to ensure consistent time series. Rest of EFs (CH_4 and N_2O) comes from the COPERT 5 model.

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

In 2020, the fuel consumption in railway constituted 2.9% of GHG emissions from the total GHG emissions in Freight transport and had a dominant role in railway. The railway transport accomplishes around 37% (2020) of the total freight transport in Latvia (measured in tonne-kilometres) and the transit transport traffic to ports is dominant. Since 2012 the transported freight along the railway (measured in tonne-kilometres) have decreased by around 63.5% due to dependence on transit transport of goods from Russian Federation and other neighboring countries. Fuel consumption has decreased by approximately 67.1% in 2020 compared to 2012.

The very sharp decline in fuel consumption came in exactly 2020, compared to 2019 (40.5%).

It results in decreased GHG emissions by 40.9% in 2020 compared to 2019. Emission calculation in railway transport includes railway transport operated by diesel locomotives.

Railway related fuel consumption is key categories for CO_2 emissions. In 2020, total GHG emissions in railway, compared to 1990, have decreased by 84.8% (see Figure 3.36).

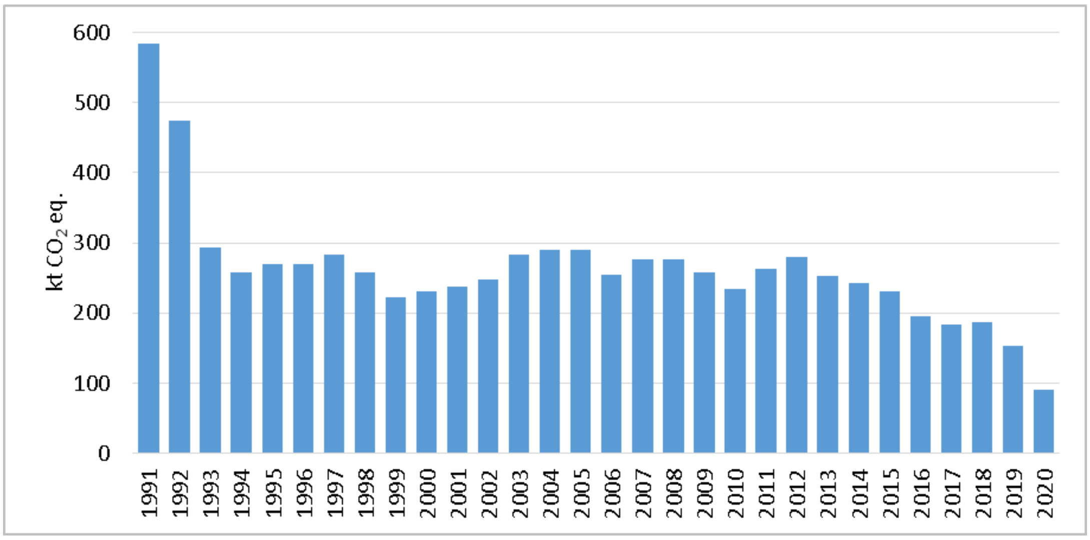

Figure 3.36 Development of GHG emissions in railway (kt CO_2 eq.)

Methodological issues

Methods

When calculating emissions from railway, the 2006 IPCC Guidelines Tier 1 and Tier 2 methods have been applied. The summary of the latest key category assessment, methods and EFs used is presented in Table 3.37.

Table 3.37 Summary of source category description (CRF 1.A.3.c)

CRF	Gas	Method	EF	All sources estimated
1.A.3.c	*CO_2*	*T2*	*CS*	*Yes*
	CH_4	*T1*	*D*	*Yes*
	N_2O	*T1*	*D*	*Yes*

T1 Tier 1; T2 Tier 2; CS Country Specific; D Default.

Activity data

The data on diesel oil consumption in railway derived from the CSB. Development of diesel oil consumption is presented in Figure 3.37 and Table 3.38. As can be seen, starting from 2010 only small portion of biodiesel is used in railway.

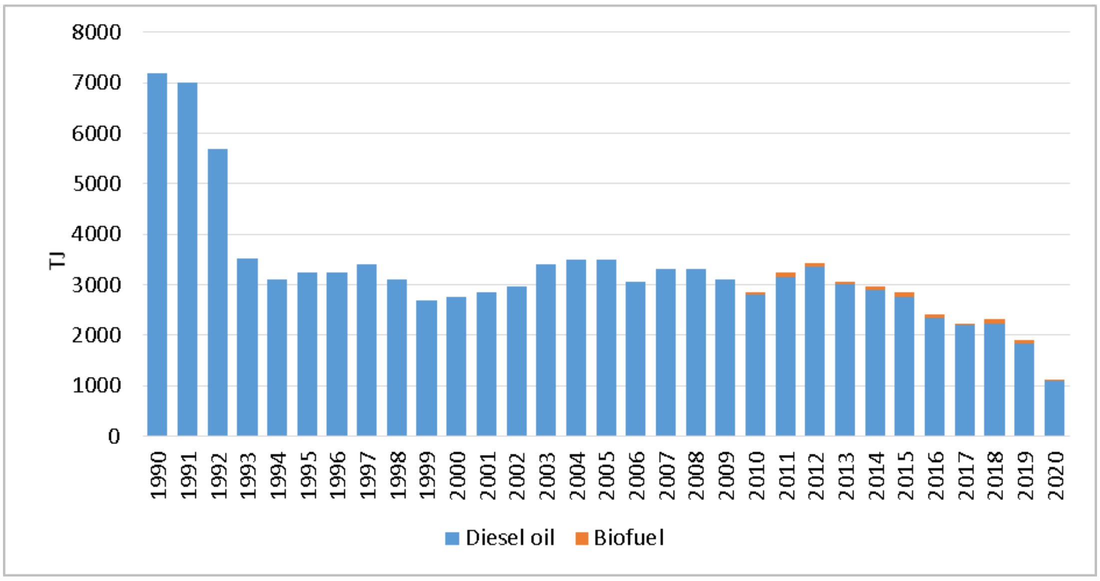

Figure 3.37 Development of fuel consumption in railway (TJ)

Table 3.38 Fuel consumption in railway (TJ)

Year	Diesel oil	Biodiesel
1990	*7181*	*NO*
1995	*3229*	*NO*
2000	*2762*	*NO*
2001	*2847*	*NO*
2002	*2974*	*NO*
2003	*3399*	*NO*
2004	*3484*	*NO*
2005	*3484*	*NO*
2006	*3059*	*NO*

Year	Diesel oil	Biodiesel
2007	*3314*	*NO*
2008	*3314*	*NO*
2009	*3102*	*NO*
2010	*2804*	*35*
2011	*3144*	*91*
2012	*3357*	*63*
2013	*3017*	*48*
2014	*2889*	*83*
2015	*2765*	*74*
2016	*2335*	*67*
2017	*2193*	*29*
2018	*2235*	*78*
2019	*1836*	*55*
2020	*1083*	*42*

Emission factors

Country specific EF for CO_2 emissions is used ("Guidance Manual for CO_2 emission estimations" (2004)). Rest of EFs comes from the 2006 IPCC Guidelines and EMEP/EEA 2019 (see Table 3.39).

Table 3.39 Emission factors used in the calculation of emissions from railway

Fuel type	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	kt/PJ	kt/PJ	kt/PJ	kt/PJ	kt/PJ	kt/PJ	kt/PJ
Diesel oil	*74.75*	*0.00415*	*0.0286*	*1.2332*	*0.251823*	*0.10943*	*0.02353 (2003-2004) 0,09414 (1990-2007) 0.04707 (2008-2014) 0.005 (2015 -2020)*

3.2.6.1.4 Domestic Navigation (CRF 1.A.3.d)

In 2020, fuel consumption in navigation was responsible for around 0.3% of GHG emissions from total GHG emissions in transport.

Although Latvia has several ports, domestic navigation providing transport of freight or passengers among local ports is not developed. Major activities in ports deal with international freight transport. In domestic navigation, the emissions are calculated for miscellaneous vessels (tugs, barges, towboats, and icebreakers), recreational crafts and personal boats (Figure 3.38).

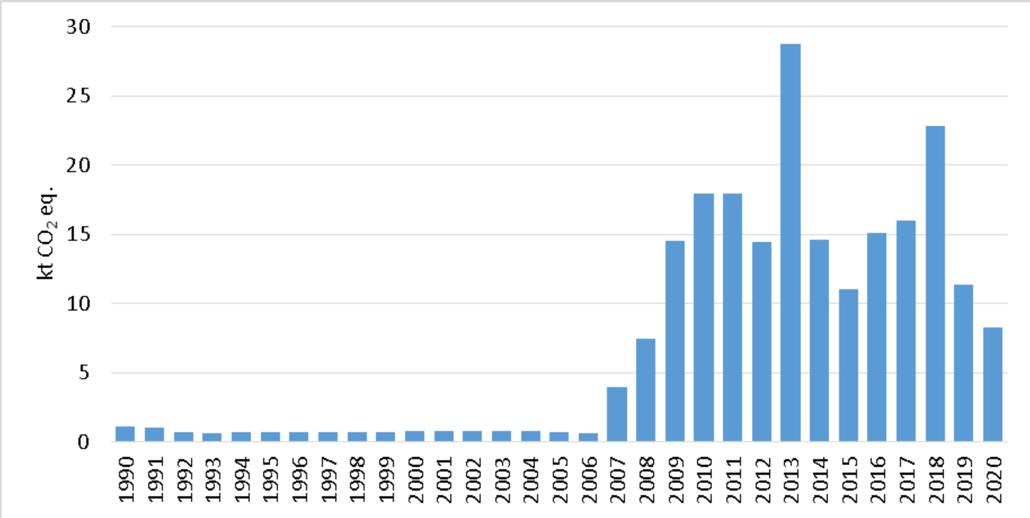

Figure 3.38 GHG emission development in domestic navigation (kt CO_2 eq.)

Fuel consumption and CO_2 emissions trend in domestic navigation mainly depends from international (import, export) cargo activities in ports (cargo turnover and number of vessels served in ports). Variation in domestic navigation's fuel consumption in 2006-2020 indicates that this consumption is highly dependent on the harbour services' activities and weather conditions. The amount of cargo handled at ports decreased by around 28% in 2020 compared to 2019.

Before the GHG emission calculation is performed CSB is asked to check and further confirm fuel consumption in sector if fluctuation is more than 20% points compare to the previous year.

Methodological issues

Methods

When calculating emissions from navigation, Tier 1 and Tier 2 methods from the 2006 IPCC Guidelines have been applied. Country specific CO_2 EFs are used for emission calculation from diesel fuel consumption. The summary of the latest key category assessment, methods and EFs used are presented in Table 3.40.

Table 3.40 Summary of source category description (CRF 1.A.3.d)

CRF	Gas	Method	EF	All sources estimated
1.A.3.d	*CO_2*	*T1,T2*	*CS (diesel); D (gasoline)*	*Yes*
	CH_4	*T1*	*D*	*Yes*
	N_2O	*T1*	*D*	*Yes*

T1 Tier 1; T2 Tier 2; CS Country Specific; D Default.

Activity data

The data about diesel oil consumption and gasoline consumption in domestic navigation are obtained from the CSB. CSB have started to collect data about diesel oil consumption and gasoline consumption in domestic navigation from 2006. For the period of time 1990 – 2005 the data for fuel consumption is used from the study "Evaluation of fuel consumption for domestic aviation and navigation" (Institute pf Physical Energetics, 2004). Development of fuel consumption in domestic navigation is presented in Figure 3.39 and in Table 3.41.

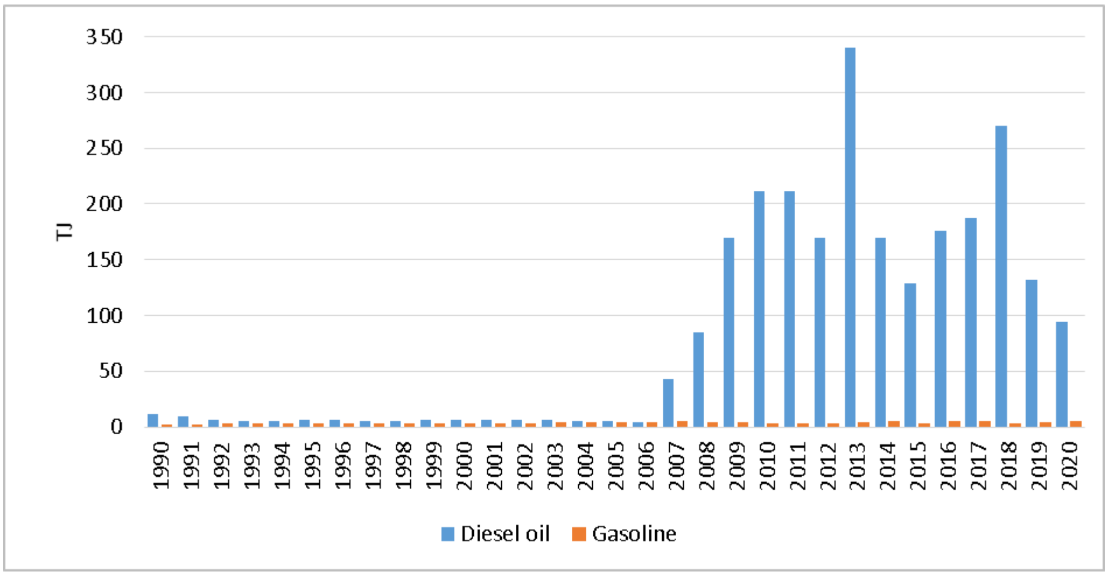

Figure 3.39 Development of gasoline and diesel oil fuel consumption in domestic navigation (TJ)

Variation in domestic navigation's fuel consumption in 2012-2020 indicates that this consumption is highly dependent on the harbour services' activities. In 2013 there had harbour deepening project of large scale resulting also in significant increase in fuel consumption. After the realization of this project, the fuel consumption in 2014 and 2015 come back to roughly 2012 level. Also in 2018 the main reason of fuel consumption increase was performing of mentioned harbour service' activities. Due to the rapid decline in cargo volumes in 2020, this was a key factor in the reduction in diesel consumption in domestic navigation.

An additional factor that have an impact on fuel consumption in domestic navigation is weather conditions. This can be observed in 2010 and 2011 when air temperature was low and sea was covered by ice. An ice breaker operated many months to ensure operation of ports in 2010 and 2011. This factor had an impact on fuel consumption in 2010 and 2011.

In the last 5 years, diesel consumption has only been affected by the first of these factors.

Table 3.41 Fuel consumption in domestic navigation (TJ)

Year	Diesel oil	Gasoline
1990	*11*	*2*
1995	*6*	*3*
2000	*6*	*3*
2001	*6*	*3*
2002	*6*	*4*
2003	*6*	*4*
2004	*6*	*4*
2005	*5*	*4*
2006	*4*	*4*
2007	*43*	*5*
2008	*85*	*5*
2009	*170*	*4*

Year	Diesel oil	Gasoline
2010	*212*	*3*
2011	*212*	*3*
2012	*170*	*3*
2013	*340*	*4*
2014	*170*	*5*
2015	*129*	*3*
2016	*176*	*5*
2017	*187*	*5*
2018	*270*	*3*
2019	*132*	*4*
2020	*94*	*5*

Emission factors

Default EFs for navigation are used (2006 IPCC Guidelines and EMEP/EEA 2019,Table 3.42).

Table 3.42 Emission factors used in the calculation of emissions from navigation (t/TJ)

Fuel type	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
Gasoline	*69.3*	*0.0473*	*0.000296*	*0.2*	*13.1*	*4.1*
Diesel oil	*74.75*	*0.004*	*0.003*	*1.8*	*0.2*	*0.1*

3.2.6.1 Uncertainties and time series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6. Activity data about fuel consumption in transport sector is mainly available from 1990 and they are provided by CSB. Considering that CSB gives approximately 2% statistical sample error for statistical data uncertainty in activity data of fuel consumption in transport is ±2% in 2020. Before GHG emission calculation is performed CSB is asked to check and further confirm fuel consumption in sector if fluctuation is more than 10% compare to the previous year.

As mentioned above, for certain categories (domestic aviation and domestic navigation), fuel consumption in the base year (1990) has been determined using a calculation model and an extrapolation method ("Evaluation of fuel consumption for domestic aviation and navigation" (IPE, 2004)). Consequently, the uncertainty over fuel consumption is relatively high and 20% assumed.

CO_2 EF was estimated according to physical characterization of used fuels in country based on average NCV reported by fuel consumers and carbon content so uncertainty was assigned as quite low about 2%. If default CO_2 EF is used uncertainty was assigned about 5-10%. Default CH_4 and N_2O EFs used in estimation of emissions were taken from the 2006 IPCC Guidelines, so uncertainty was assigned 30 -70%.

In order to maintain consistency with the time-series the estimation procedures have been developed as described above (Section 1.6.). However, due to the fact that some of the estimations are not based on activity data but on other factors as LTO cycles in civil aviation sector, a certain degree of uncertainty exists. In road transport one important basic parameter for the COPERT 5 model is vehicle-km, which is calculated through another model. This second model is based on the mileage driven by the vehicle noted at time of TA (annual inspection/testing of the vehicle) at Road Traffic Safety Directorate. In case if there is in place sharp changes of some external factors impacting the fuel consumption, for example economy recession, or fuel price or energy tax, it will not be shown as clearly in the development of vehicle mileage as in statistics on fuel consumption.

To ensure time series consistency any recalculations related with model version updating are done for all time period. Linear interpolation has been implemented only for cases when activity data fluctuation does not take place.

3.2.6.2 Source-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's greenhouse gas inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the transport sector in order to achieve these quality objectives. Meetings dedicated for quality ensure and improvement are held annually among inventory and external experts.

All Tier 1 general inventory level QC procedures listed in chapter 1.2. applicable to this sector are used. These measures are implemented every year during the transport sector inventory. In addition, the consumption of every type of fuel in the last year is checked and compared with previous years. If large variations are discovered for certain fuels, responsible CSB staff is contacted for an explanation.

The country specific CO_2 EFs used to calculate transport sector CO_2 emissions are compared with IPCC default (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, Chapter 3, Mobile combustion) to see if they compare reasonably well.

In making this comparison, it can be concluded that all the country specific CO_2 EFs used are within the interval specified in the 2006 IPCC Guidelines, this is between the lowest and the highest values. The assessment is carried out taking into account the values represent 100 percent oxidation of fuel carbon content.

Estimated emission verification:

- All estimations of the emissions made for a transport sector are examined on the logical mistakes by checking the time series of the activity data, EFs and emission consistency to display the significant and illogic changes in the activity data and emissions.
- Emissions are checked using time series consistency check for the IEF estimated in CRF Reporter and all IEF changes in time series are double-checked and reasonable explanation for IEF changes has to be found under the each subsector source category description. The calculated air transport emissions have been compared and verified with Eurocontrol's emission data for 2008-2020. The calculated activity data for fuel consumption of LTO and cruise mode and emissions were comparable and very close to those estimated by Eurocontrol.
- For the road transport examination is made on less aggregated level than CRF reporter. Non CO_2 EF changes that are higher than 5% in time series are double-checked and reasonable explanation for IEF changes has to be found.

The QC form has been filled in for each category taking into account criteria given in QA/QC plan approved in National legislation. All information on activity data and emission calculations are stored and archived in the common FTP folder.

Additional QA/QC checks for Tier2 methodology

For emission calculation in road transport additional QA/QC check approach has to be implemented. QC activities are realized with emission data and activity data QC.

It is assessed that implemented default EF from COPERT 5 model are applicable to national circumstances because model comprises all the necessary technologies. Country specific EFs for CO_2 are calculated based on the 2006 IPCC Guidelines methodology. Activity data (fuel consumption, total number of vehicles) provider CSB has the internal QA/QC procedures based on mathematical model and analysis to avoid logic mistakes. To ensure QA procedure expert from Road Traffic Safety Directorate is asked to make peer review about the main assumption implemented in emission calculation.

3.2.6.3 Category-specific recalculations

The following recalculations and improvements in 2022 submission have been made in the transport sector since the 2021 submission (Table 3.43).

Table 3.43 Recalculations in CRF 1.A.3 Transport

Sub-category	Recalculation	Improvements
Road transport (CRF 1.A.3.b)	*All GHG emissions for time series 1990 – 2019 have been recalculated*	*Recalculations have been done due to the switch from COPERT 5.3 model version to COPERT 5.5 model version (corrected EF for EU standards (Convention, Euro 1-3). In addition, GHG emissions from buses have been recalculated for 2015-2019, as the distribution of buses by group (Urban Buses Midi <=15 t, Urban Buses Standard 15 - 18 t, Urban Buses Articulated >18 t) has been clarified.* *Compared to the 2021 submission, GHG emissions ranged from -0.4% to +0.3%.*

3.2.6.4 Source specific planned improvements

The applicability of implied EFs for international aviation calculated by Eurocontrol will be studied.

3.2.7 Other Sectors (CRF 1.A.4)

3.2.7.1 Category description

CRF 1.A.4 Other Sectors include emissions from the small combustion of fuels in Commercial/Institutional, Residential sectors and Agriculture/Forestry/Fisheries. In addition, emissions from mobile machinery used in Commercial, Residential and Agriculture and Forestry sectors are included here as off-road. Also emissions from the autoproducers are included in relevant sectors of CRF 1.A.4 – according to the 2006 IPCC Guidelines these emissions have to be reported in sectors producing them.

The CRF subsector 1.A.4. Other Sectors were split into subsectors which are in line with the 2006 IPCC Guidelines/CRF Reporter structure:

- 1.A.4.a Commercial/Institutional:
  - 1.A.4.a.i Stationary combustion;
  - 1.A.4.a.ii Off-road vehicles and other machinery;
- 1.A.4.b Residential:
  - 1.A.4.b.i Stationary combustion;
  - 1.A.4.b.ii Off-road vehicles and other machinery;
- 1.A.4.c Agriculture/Forestry/Fishing:
  - 1.A.4.c.i Stationary combustion;
  - 1.A.4.c.ii Off-road vehicles and other machinery;
  - 1.A.4.c.iii Fishing.

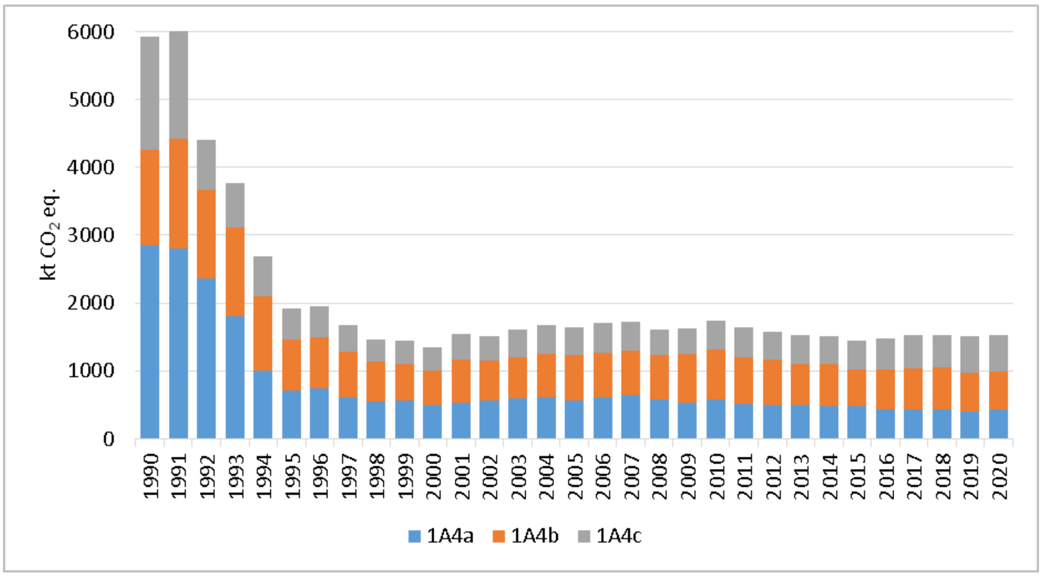

Figure 3.40 GHG emissions in CRF 1.A.4. Other Sectors by subsectors (kt CO_2 eq.)

In Figure 3.40, there can be seen the distribution of GHG emissions in CRF 1.A.4 sector. The largest part of emissions contribute CRF 1.A.4.b Residential subsector (36.1% in 2020). CRF 1.A.4.a Commercial/Institutional contributes 28.5% from 1.A.4 emissions, while CRF 1.A.4.c Agriculture/Forestry/Fisheries, where also offroad emissions from Fisheries contributes 35.4% of emissions.

Table 3.44 Emissions from Other Sectors (CRF 1.A.4) in 1990–2020 (kt)

Year	CO_2	CH_4	N_2O	GHGs (CO_2 eq)	NO_x	CO	NMVOC	SO_2
	kt			kt CO_2 eq.	kt			
1990	*5493.45*	*10.70*	*0.53*	*5917.99*	*24.36*	*170.20*	*22.03*	*35.12*
1991	*5617.39*	*12.14*	*0.72*	*6134.23*	*29.61*	*165.28*	*22.58*	*32.73*
1992	*3977.91*	*10.95*	*0.52*	*4406.27*	*22.58*	*145.15*	*20.42*	*26.62*
1993	*3326.77*	*11.68*	*0.47*	*3759.43*	*20.59*	*151.92*	*21.17*	*22.14*
1994	*2330.50*	*11.62*	*0.24*	*2693.92*	*13.99*	*146.75*	*20.15*	*17.44*
1995	*1549.14*	*12.16*	*0.20*	*1913.65*	*11.09*	*141.72*	*21.22*	*9.95*

Year	CO_2	CH_4	N_2O	GHGs (CO_2 eq)	NO_x	CO	NMVOC	SO_2
	kt			kt CO_2 eq.	kt			
1996	*1572.32*	*12.46*	*0.21*	*1945.60*	*11.35*	*149.33*	*22.07*	*10.73*
1997	*1323.72*	*11.81*	*0.19*	*1674.86*	*9.19*	*140.22*	*20.84*	*8.33*
1998	*1146.40*	*10.96*	*0.17*	*1469.94*	*7.80*	*133.65*	*19.93*	*6.30*
1999	*1123.97*	*10.78*	*0.18*	*1446.46*	*8.94*	*129.52*	*19.61*	*5.10*
2000	*1049.47*	*10.10*	*0.18*	*1354.29*	*8.78*	*126.24*	*18.88*	*3.93*
2001	*1206.44*	*11.15*	*0.19*	*1542.02*	*9.71*	*138.92*	*20.37*	*4.49*
2002	*1175.99*	*10.88*	*0.19*	*1504.78*	*8.96*	*134.17*	*19.83*	*3.80*
2003	*1268.86*	*11.31*	*0.20*	*1612.55*	*10.08*	*141.17*	*20.75*	*3.76*
2004	*1312.49*	*11.60*	*0.22*	*1667.52*	*10.02*	*142.34*	*20.99*	*3.64*
2005	*1292.67*	*11.52*	*0.21*	*1644.37*	*9.87*	*142.91*	*19.42*	*3.66*
2006	*1351.78*	*11.10*	*0.24*	*1699.92*	*9.79*	*138.66*	*18.75*	*3.41*
2007	*1375.00*	*11.04*	*0.25*	*1724.12*	*9.30*	*135.71*	*18.25*	*3.05*
2008	*1295.32*	*10.08*	*0.22*	*1611.58*	*7.98*	*132.09*	*17.48*	*2.44*
2009	*1282.68*	*10.96*	*0.25*	*1629.96*	*8.37*	*145.62*	*19.23*	*2.57*
2010	*1458.02*	*8.63*	*0.25*	*1747.47*	*8.37*	*112.16*	*14.51*	*2.27*
2011	*1356.71*	*8.59*	*0.24*	*1643.69*	*8.10*	*117.50*	*14.98*	*2.23*
2012	*1280.01*	*8.95*	*0.25*	*1579.01*	*7.89*	*117.29*	*15.07*	*2.16*
2013	*1252.77*	*8.00*	*0.25*	*1527.52*	*7.49*	*104.26*	*13.31*	*2.01*
2014	*1252.47*	*7.44*	*0.25*	*1513.85*	*7.33*	*96.88*	*12.34*	*1.97*
2015	*1220.09*	*6.22*	*0.26*	*1452.38*	*6.79*	*77.61*	*9.91*	*1.79*
2016	*1247.99*	*6.20*	*0.24*	*1475.16*	*6.57*	*78.08*	*9.91*	*1.70*
2017	*1279.94*	*6.93*	*0.26*	*1531.75*	*6.82*	*86.46*	*11.19*	*1.79*
2018	*1283.23*	*6.89*	*0.27*	*1534.80*	*6.61*	*89.18*	*11.52*	*1.81*
2019	*1260.20*	*6.57*	*0.27*	*1504.55*	*6.23*	*84.63*	*11.06*	*1.66*
2020	*1299.41*	*5.74*	*0.29*	*1527.84*	*5.96*	*74.88*	*9.82*	*1.48*
Share of Energy total, 2020	*20.6%*	*51.7%*	*46.4%*	*22.5%*	*23.0%*	*79.3%*	*73.5%*	*44.6%*
2020 vs 2019	*3.1%*	*-12.7%*	*6.5%*	*1.5%*	*-4.4%*	*-11.5%*	*-11.2%*	*-11.1%*
2020 vs 1990	*-76.3%*	*-46.4%*	*-45.8%*	*-74.2%*	*-75.5%*	*-56.0%*	*-55.4%*	*-95.8%*

CO_2 emissions in CRF 1.A.4 sector have decreased by 80.9% in 1990-2000 due to the transition and reorganizations in the country after the collapse of Soviet Union, as mentioned in previous chapters (Table 3.44). Since 2000 CO_2 emissions started to grow due to development of the national economy, and increased by 31.0% in 2007. During economic crisis in 2008-2009 emissions decreased. In later years emissions fluctuated form year to year. In 2020, CO_2 emissions from Other Sectors make up 20.6% from total CO_2 emission produced in Energy sector. In comparison with 2019 emissions have increased by 3.1%, but in comparison with 1990 decreased by 76.3%.

CH_4 and N_2O emissions in 2020 since 1990 have decreased by 46.4% and 45.8% accordingly. It can be explained with fuel switch from dominating fossil fuels in sector to biomass. In 2020 CH_4 emissions have decreased by 12.7% and N_2O increased by 6.5% in comparison with 2019. They make up 52.7% and 46.4% from total emissions produced in Energy sector accordingly.

Emissions of precursors from CRF 1.A.4 Other Sectors were estimated as well. SO_2 had the biggest decrease by 95.8% in 1990–2020. It can be explained with fuel switching from coal, peat and heavy fuel oils to natural gas and biomass. Also a strict National legislation was approved to improve the quality of used liquid fuels in country. NOx emissions have also decreased by 75.5% in 1990-2020, NMVOC emissions – by 55.4%, and CO emissions – by 56.0%. The decrease can also be explained with fuel switch from solid to natural gas and biomass, which have lower EFs.

3.2.7.2 Methodological issues

Methods

The 2006 IPCC Guidelines' Tier 2 method was used to estimate CO_2 emissions from fuel combustion as country specific parameters were used to estimate CO_2 EF. However, for some fuels there are no country specific EFs, therefore the 2006 IPCC Guidelines Tier 1 method using default EFs was used. The 2006 IPCC Guidelines' Tier 1 method was used to calculate CH_4 and N_2O emissions from the CRF 1.A.4 Sector.

Calculation of all emissions from fuel combustion is done with Excel databases developed by the experts from LEGMC.

The general method for emission data preparation used:

$$\boldsymbol{Em = EF * B_q} \quad (3.9)$$

where:
Em – total emissions (kt)
EF – estimated or default emission factor (t/TJ)
B_q – amount of fuel in thermal units (TJ)

Emission factors and other parameters

The main sources for EFs are:

- National studies for country specific parameters and EFs;
- Data from only natural gas supplier company of natural gas physical characteristics;
- IPCC 2006 Guidelines;
- EMEP/EEA 2019.

Country specific EFs were used to calculate CO_2 and SO_2 emissions.

CO_2 emission factors

CO_2 EFs for CRF 1.A.4 Other Sectors are estimated with the same equations and using same methods as for CRF 1.A.1 Energy Industries sector, including calculation methods and assumptions for landfill gas and other biogas as in CRF 1.A.1 sector.

For some fuels default CO_2 EFs from the 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion,* Table 2.4, were taken due to unavailability of country specific data:

- anthracite – 98.3 kt/PJ;
- other liquid fuels – 73.3 kt/PJ;
- landfill gas – 54.6 kt/PJ;
- other biogas – 54.6 kt/PJ;
- biodiesel – 70.8 kt/PJ;
- straws – 100 kt/PJ;
- charcoal – 112 kt/PJ;
- waste oils – 73.3 kt/PJ.

For CRF 1.A.4.c.iii Fishing default EFs were taken from the 2006 IPCC Guidelines, Volume 2, Chapter 3 *Mobile combustion*, Table 3.5.2:

- diesel oil – 74.1 kt/PJ;
- residual fuel oil – 77.4 kt/PJ.

SO_2 emissions factors

SO_x EFs for CRF 1.A.4 Other Sectors are estimated with the same equations and using the same method as for CRF 1.A.1 and CRF 1.A.2 sectors.

Other emission factors

The default CH_4 and N_2O EFs are taken from the 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.3 (CRF 1.A.4.a, 1.A.4.c). For estimating CH_4 emissions from wood in CRF 1.A.4.b.i sector, Tier 2 approach with country specific EFs was used. N_2O EFs for wood products are taken from the 2006 IPCC Guidelines, Chapter 2 *Stationary combustion*, Table 2.3. It has to be noted that for wood and charcoal the lowest N_2O EFs were taken from the given range.

NOx, CO and NMVOC EFs used in estimation of emission were taken from EMEP/EEA 2019, Chapter 1.A.4 Small combustion, Tables 3-12 to 3-25 (CRF 1.A.4.b.i), Tables 3-7 to 3-10 (CRF 1.A.4.a.i, 1.A.4.c.i) and Tables 3-26 to 3-27.

List of other EFs can be seen in Table 3.45, Table 3.46 and Table 3.47.

Table 3.45 CH_4, N_2O, NO_x, NMVOC, CO emission factors in CRF 1.A.4.a (kt/PJ)

Fuel type	CH_4	N_2O	NO_x	NMVOC	CO
Shale oil	*0.01*	*0.0006*	*0.3033*	*0.0129*	*0.0403*
LPG	*0.005*	*0.0001*	*0.074*	*0.023*	*0.029*
Other kerosene	*0.01*	*0.0006*	*0.3033*	*0.0129*	*0.0403*
Diesel oil	*0.01*	*0.0006*	*0.3033*	*0.0129*	*0.0403*
RFO	*0.01*	*0.0006*	*0.3033*	*0.0129*	*0.0403*
Other liquid	*0.01*	*0.0006*	*0.3033*	*0.0129*	*0.0403*
Anthracite	*0.01*	*0.0015*	*0.173*	*0.0888*	*0.0931*
Coal	*0.01*	*0.0015*	*0.173*	*0.0888*	*0.931*
Peat	*0.01*	*0.0014*	*0.173*	*0.0888*	*0.931*
Peat briquettes	*0.01*	*0.0015*	*0.173*	*0.0888*	*0.931*
Natural gas	*0.005*	*0.0001*	*0.073*	*0.00036*	*0.024*
			0.04	*0.002*	*0.03*
Wood	*0.3*	*0.004*	*0.091*	*0.3*	*0.57*
			0.162[28]	*0.0696*[28]	*0.354*[28]
Straws	*0.3*	*0.004*	*0.091*	*0.3*	*0.57*
Biodiesel	*0.01*	*0.0006*	*0.3033*	*0.0129*	*0.0403*
Landfill gas	*0.005*	*0.0001*	*0.074*	*0.023*	*0.029*
Other biogas	*0.005*	*0.0001*	*0.074*	*0.023*	*0.029*
Waste oils	*0.3*	*0.004*	*0.3033*	*0.0129*	*0.0403*

[28] *Tier 2 IEF for emission calculation from Wood combustion in 2020 – kt/PJ*

Table 3.46 CH_4, N_2O, NOx, NMVOC, CO emission factors in CRF 1.A.4.c (kt/PJ)

Fuel type	CH_4	N_2O	NO_x	NMVOC	CO
LPG	*0.005*	*0.0001*	*0.074*	*0.023*	*0.029*
Other kerosene	*0.01*	*0.0006*	*0.3033*	*0.0129*	*0.0403*
Diesel oil	*0.01*	*0.0006*	*0.3033*	*0.0129*	*0.0403*
RFO	*0.01*	*0.0006*	*0.3033*	*0.0129*	*0.0403*
Other liquid	*0.01*	*0.0006*	*0.3033*	*0.0129*	*0.0403*
Coal	*0.3*	*0.0015*	*0.173*	*0.0888*	*0.931*
Peat	*0.3*	*0.0014*	*0.173*	*0.0888*	*0.931*
Peat briquettes	*0.3*	*0.0015*	*0.173*	*0.0888*	*0.931*
Natural gas	*0.005*	*0.0001*	*0.074*	*0.023*	*0.029*
Wood	*0.3*	*0.004*	*0.091*	*0.3*	*0.57*
Straws	*0.3*	*0.004*	*0.091*	*0.3*	*0.57*
Biodiesel	*0.01*	*0.0006*	*0.3033*	*0.0129*	*0.0403*
Other biogas	*0.005*	*0.0001*	*0.074*	*0.023*	*0.029*
Waste oils	*0.3*	*0.004*	*0.3033*	*0.0129*	*0.0403*

Table 3.47 CH_4, N_2O, NO_x, NMVOC, CO emission factors in CRF 1.A.4.b (kt/PJ)

Fuel type	CH_4	N_2O	NO_x	NMVOC	CO
LPG	*0.005*	*0.0001*	*0.042*	*0.0018*	*0.022*
Other kerosene	*0.01*	*0.0006*	*0.069*	*0.00017*	*0.0037*
Diesel oil	*0.01*	*0.0006*	*0.069*	*0.00017*	*0.0037*
RFO	*0.01*	*0.0006*	*0.069*	*0.00017*	*0.0037*
Coal	*0.3*	*0.0015*	*0.158*	*0.174*	*4.787*
Peat	*0.3*	*0.0014*	*0.158*	*0.174*	*4.787*
Peat briquettes	*0.3*	*0.0015*	*0.158*	*0.174*	*4.787*
Natural gas	*0.005*	*0.0001*	*0.042*	*0.0018*	*0.022*
Wood[29]	*0.232*	*0.0015*	*0.0646*	*0.4469*	*3.498*
Charcoal	*0.2*	*0.0003*	*0.05*	*0.6*	*4*
Straws	*0.3*	*0.004*	*0.05*	*0.6*	*4*

Gasoline EFs are used for CH_4 and N_2O emission estimation from off-roads (2006 IPCC Guidelines, Volume 2, Chapter 3 *Mobile combustion*, Table 3.3.1.). As there is no information about distribution between 2-stroke and 4-stroke engines, it was assumed that 25% of consumed gasoline is combusted in 2-stroke engines, while 75% in 4-stroke engines. Such an assumption has been made, based on Danish data that were presented in EMEP/EEA 2019 for air pollutants' calculations. NOx, CO and NMVOC EFs used in estimation of emission were taken from EMEP/EEA 2019, Chapter 1.A.4 Non-road mobile sources and machinery, Table 3-1 and Table 3-2. Default diesel oil EFs are used for CH_4 and N_2O emission estimation from off-roads (2006 IPCC Guidelines, Volume 2, Chapter 3 Mobile combustion, Table 3.3.1.) and EFs for precursors were taken from EMEP/EEA 2019 Chapter 1.A.4. Non-road mobile sources and machinery. NOx, CO and NMVOC EFs used in estimation of emission were taken from EMEP/EEA 2019, Chapter 1.A.4 Non-road mobile sources and machinery, Table 3-1 and Table 3-2. It was assumed that not all diesel oil in sector CRF 1.A.4.a combusts in off-roads (99% form total diesel oil combustion in sector), but 1% is used in stationary combustion. For sector CRF 1.A.4.b it is assumed that all diesel oil used is used in off-roads.

[29] *IEF for 2020 – kt/PJ. Calculations for CH_4, NOx, NMVOC and CO emissions done using Tier 2 methodology and country specific residential combustion plant distribution.*

Also, diesel oil and residual fuel oil consumed in Fisheries sector was assumed as consumed by fishing ships and EFs were taken from the 2006 IPCC Guidelines, Volume 2, Chapter 3 *Mobile combustion,* Table 3.5.2 and Table 3.5.3. EFs for precursors are taken from EMEP/EEA 2019, Chapter 1.A.3.d., Table 3-1. It was assumed that not all diesel oil combusts in off-roads, but 99% of amount that is produced in 1.A.4.c. CSB confirmed that 1% of diesel oil is used in stationary combustion.

EFs for gasoline and diesel oil consumed in off-roads and diesel oil and residual fuel oil consumed in Fisheries are presented in Table 3.48.

Table 3.48 CH_4, N_2O, NO_x, NMVOC, CO emission factors for gasoline, diesel and RFO (kg/t[30])[31]

Category		Gasoline		Diesel oil	Diesel oil		RFO
		2-stroke	4-stroke		Agriculture	Forestry	
1.A.4.a.ii	CH_4	*0.18*	*0.12*	*0.00415*	*NO*	*NO*	*NO*
	N_2O	*0.0004*	*0.002*	*0.0286*	*NO*	*NO*	*NO*
	NOx	*2.5*	*6.68*	*13.87*	*NO*	*NO*	*NO*
	NMVOC	*113.16*	*16.13*	*1.27*	*NO*	*NO*	*NO*
	CO	*695.24*	*804.16*	*6.93*	*NO*	*NO*	*NO*
1.A.b.ii	CH_4	*0.18*	*0.12*	*0.00415*	*NO*	*NO*	*NO*
	N_2O	*0.0004*	*0.002*	*0.0286*	*NO*	*NO*	*NO*
	NOx	*2.765*	*7.117*	*32.629*	*NO*	*NO*	*NO*
	NMVOC	*227.289*	*18.893*	*3.377*	*NO*	*NO*	*NO*
	CO	*620.793*	*770.368*	*10.774*	*NO*	*NO*	*NO*
1.A.4.c.ii	CH_4	*0.17*	*0.08*	*NO*	*0.00415*	*0.00415*	*NO*
	N_2O	*0.0004*	*0.002*	*NO*	*0.286*	*0.286*	*NO*
	NOx	*2.5*	*6.68*	*NO*	*15.42*	*10.53*	*NO*
	NMVOC	*113.16*	*16.13*	*NO*	*1.43*	*1.1*	*NO*
	CO	*695.24*	*804.16*	*NO*	*6.89*	*6.94*	*NO*
1.A.4.c.iii	CH_4	*NO*	*NO*	*0.007*	*NO*	*NO*	*0.007*
	N_2O	*NO*	*NO*	*0.002*	*NO*	*NO*	*0.002*
	NOx	*NO*	*NO*	*78.3*	*NO*	*NO*	*79.3*
	NMVOC	*NO*	*NO*	*2.8*	*NO*	*NO*	*2.7*
	CO	*NO*	*NO*	*7.4*	*NO*	*NO*	*7.4*

Activity data

Mainly emissions from fuel combustion are calculated using fuel consumption data from the CSB Energy Balance. The data collection system for CRF 1.A.4 sector is the same as for CRF 1.A.1 and CRF 1.A.2 sectors. Data on fuel consumption in 1.A.4 sector are presented in Annex A.3.1 "1.A.4 Other Sectors".

Autoproducers data prepared by CSB are taken into account into the calculation of the emissions from CRF 1.A.4 sector according to the 2006 IPCC Guidelines.

Gasoline and diesel oil combustion is reported as off-roads in CRF 1.A.4 sector. Only 1% of diesel oil is combusted stationary in CRF 1.A.4.a and CRF 1.A.4.c.

[30] *For CH_4 and N_2O – kt/PJ*

[31] *For sectors CRF 1.A.4.a.ii and CRF 1.A.4.c.ii NOx, NMVOC and CO IEF are shown in the table. For these sectors calculations are made using Tier 2 method from EMEP/EEA 2019 1.A.4i Non-road mobile sources and machinery Table 3-2, Table 3-3 and Table 3-4.*

In CRF 1.A.4.c.iii Fishing it is assumed, that diesel oil and residual fuel oil is consumed by fishing vessels.

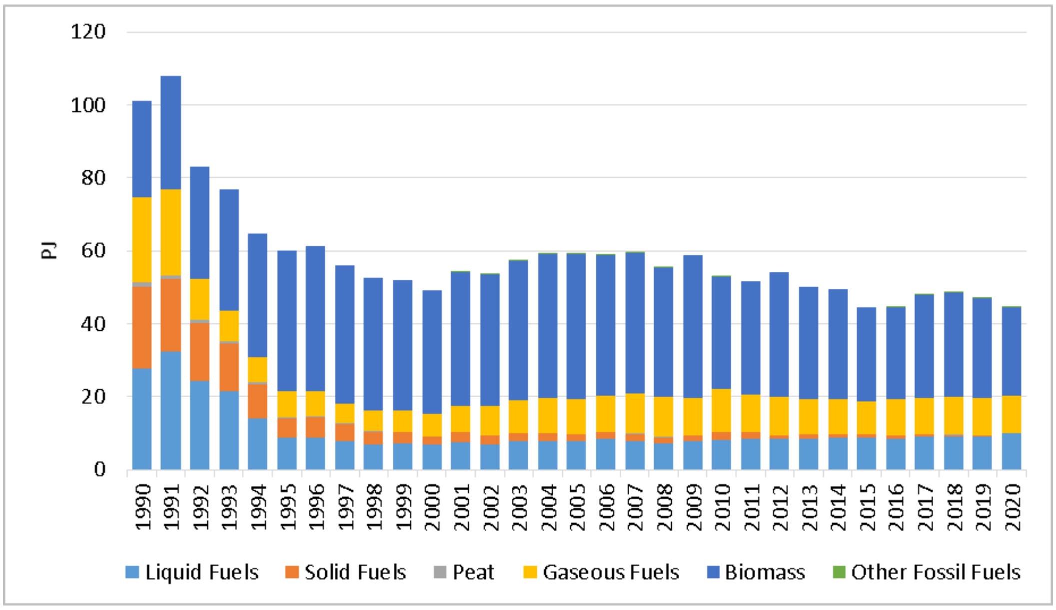

Figure 3.41 Fuel consumption in Other Sectors (CRF 1.A.4) for 1990-2020 (PJ)

The major decrease in 1990-2020 was for solid fuel consumption – 99.5%, liquid fuels consumption – 64.5% (Figure 3.41) and gaseous fuels by 56.6%. It is explained with fuel switching processes when solid and liquid fuels were replaced with cheaper fuels. Also stronger legislation contributed fuel switching to the type of fuels with a lower level of emissions.

Since 1990 biomass dominates as a fuel in CRF 1.A.4 sector. The biggest part of solid biomass consumption goes to Residential sector where biomass is the main fuel in small capacity burning installations. Consumption of biomass fuel has increased by 3.5% in 1990–2019 in Other Sector but, compared to 2020, consumption have decreased by 8.0%. It can be seen that the amount of biomass has been fluctuating over the recent years which can be partly explained with temperature fluctuations during winter. In 2020, biomass combustion decreased by 11.1% compared to 2019.

Since 1997 gaseous fuel consumption was constantly increasing until 2007, due to lower costs and the fact that liquid and solid fuels were replaced with natural gas. The increase in fuel consumption in CRF 1.A.4 Other Sectors is linked to decrease in fuel consumption in CRF 1.A.1 Energy Industries when central heating supply consumers switched to individual heating supply. In the recent years a decreased consumption in natural gas is observed, which was influenced by increasing costs of particular fuel.

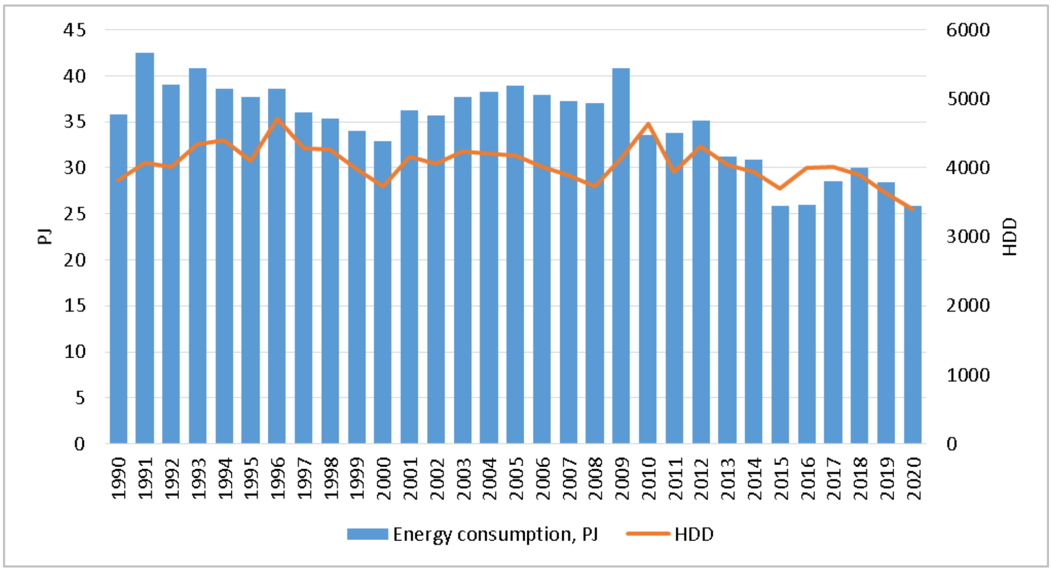

Figure 3.42 Fuel consumption in Residential sector (CRF 1.A.4.b) for stationary combustion and heating degree days in Latvia

As it can be seen in Figure 3.42, fuel consumption in 1.A.4.b sector is related with changes in temperature – in years where HDD are more, the amounts of consumed fuel are also larger, especially it can be seen in 1994-2003. In 2009-2010 the correlation between HDDs and consumption is less visible because of impact of global crisis, which clearly affected the Residential sector. Difference in trend between fuel used and HDD could be explained with changes in heating devices that impact the amount of fuel used (more energy efficient). Higher efficiently boiler will use less fuel to produce the same amount of heat. Also, energy efficiency was increasing due to building new and renovating residential buildings to be more energy efficient.

3.2.7.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty for activity data of fuel combustion in CRF 1.A.4 sector is ±2% in 2020. CSB gives approximately 2% statistical sample error for statistical data. According to CSB, as data is obtained using information given by respondents, this number is a variation coefficient which characterizes selection of respondents. Total variation coefficient for energy balance is within 2-3%. In Latvia all fossil fuels (oil, natural gas and coal) are imported and import and export statistics are fairly accurate.

Uncertainty of activity data for solid biomass was assigned 1% as biomass activity data was collected by CSB with questionnaires sent by enterprises consumed biomass. Uncertainty for peat combustion activity data was assigned 2%. Uncertainty of landfill gas stationary combusted in enterprises covered by CRF 1.A.4 Other Sectors was assumed rather low – 2% because the combusted fuel amount is obtained directly from landfill plant that has precise measurement equipment for accounting of combusted fuel.

CO_2 EF was estimated according physical characterization of used fuels in country based on average NCV reported by fuel consumers and carbon content, hence the uncertainty for liquid fuels was assigned as quite low – about 10%. The same level of uncertainty was assigned for solid fuels. CO_2 EF for natural gas was assumed rather low – as 5% because annual plant specific fuel data is used to estimate EF. Uncertainty for coal is assumed 3% provided in 2017 research "Determination of Carbon Content and Calculation of Carbon Dioxide Emission Factors".

CH_4 and N_2O EFs used in estimation of emissions were taken according to the 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.12., which provides the range of default values for uncertainties. The uncertainty both for CH_4 and N_2O EFs was assigned as uncertainties used in previous submissions – 50%.

Time series of the estimated emissions are consistent and complete because the same methodology, EFs and data sources are used for sectors for all years in time series. Emissions from all sectors 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 verification

All documentation and information received for inventory purposes are archived in FTP folder.

Activity data verification

All sources of energy data are presented in the corresponding NIR chapter as well as disaggregated data at the finest level possible are presented in the corresponding Annex A.3.1. Data completeness has been explained in the previous subchapter.

Activity data has been checked at the data provider – CSB, which has its own internal QA/QC procedures based on mathematic model and analysis to avoid logic mistakes. When activity data is received, the sectoral expert responsible for the emission estimation and reporting is comparing all data changes with the previous inventory, and all changes are explained in the corresponding subchapter. All fluctuations or changes in NCVs are double checked and agreed with CSB.

All activity data used in SA are also compared with activity data used in RA estimations. All significant differences (±5%) are explained in the corresponding subchapter. Apparent consumption reported in GHG inventory has been compared with activity data form AQ in Annex A.3.3.

Emission factor verification

For country-specific CO_2 EFs, the sources of the calorific values and carbon content, as well as these values are provided in 3.2.7.2 Methodological issues.

Country specific CO_2 values for year are compared with default ones available in the 2006 IPCC Guidelines, Volume 2, Chapter 2 *Stationary combustion*, Table 2.2. Whether country specific CO_2 EF is or is not in the confidence interval, can be seen in Table 3.49.

Table 3.49 Comparison of country specific and the 2006 IPCC Guidelines default CO_2 emission factor values (kt/PJ)

Fuel type	Lower	CS	Upper
Gasoline	*67.50*	*71.18*	*73.00*

Fuel type	Lower	CS	Upper
Diesel oil	*72.60*	*74.74*	*74.80*
RFO	*75.50*	*77.36*	*78.80*
LPG	*61.60*	*62.75*	*65.60*
Jet fuel	*69.70*	*72.23*	*74.40*
Other kerosene	*70.80*	*72.24*	*73.70*
Other liquid	*72.20*	*72.59*	*74.40*
Shale oil	*67.80*	*77.12*	*79.20*
Peat	*100.00*	*105.99*	*108.00*
Natural gas	*54.30*	*54.63*	*58.30*
Wood	*95.00*	*109.98*	*132.00*
Firewood	*95.00*	*108.45*	*132.00*
Wood waste	*95.00*	*117.32*	*132.00*
Wood chips	*95.00*	*98.70*	*132.00*
Wood briquettes	*95.00*	*105.03*	*132.00*
Pellete wood	*95.00*	*104.01*	*132.00*
Coal	*89.50*	*94.08 (1990-2002)* *91.60 (2003-2013)* *96.54 (2013-)*	*99.70*

All country specific values incorporate in the 2006 IPCC Guidelines default CO_2 EF value range.

Emission verification:

To verify CO_2 emissions, logical mistakes are examined by checking the time series of the activity data, EFs and emissions consistency to display all significant and illogical changes in the activity data and emissions. Emissions of precursors in the database are cross-checked with emissions reported within CLRTAP for verification purposes.

CO_2 emissions are compared with emissions in RA estimations, and all significant differences (±5%) are explained in the corresponding subchapter.

3.2.7.5 Category-specific recalculations

Recalculations made in 2022 submission are provided in Table 3.50.

Table 3.50 Recalculations in CRF 1.A.4 Other Sector

Sub-category	Recalculation	Improvements
1.A.4.c.i Stationary	*Corrected due to Biodiesel consumption in 2019*	*Corrected Biodiesel consumption in 2019, emissions increased by 0.00086 kt CO_2 eq.*

3.2.7.6 Category-specific planned improvements

No improvements are planned for this sector.

3.2.8 Other (CRF 1.A.5)

3.2.8.1 Category description

Under the CRF 1.A.5.b Other Mobile sources emissions from liquid fuels – aviation gasoline, diesel oil and jet kerosene, used in aircrafts and ships are reported. These emissions appear since 1995 (Table 3.51).

Table 3.51 Emissions from Other sources (CRF 1.A.5) in 1990–2020 (kt)

Year	CO_2	CH_4	N_2O	Aggregate GHGs	NO_x	CO	NMVOC	SO_2
	kt			kt CO_2 eq.	kt			
1990	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*
1991	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*
1992	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*
1993	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*
1994	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*	*NO,NE*
1995	*6.18*	*4.32E-05*	*0.00017*	*6.23*	*0.008*	*2.40*	*0.038*	*0.004*
1996	*3.28*	*2.30E-05*	*0.00009*	*3.31*	*0.004*	*1.27*	*0.020*	*0.002*
1997	*12.45*	*8.71E-05*	*0.00035*	*12.56*	*0.016*	*4.84*	*0.077*	*0.008*
1998	*3.28*	*2.30E-05*	*0.00009*	*3.31*	*0.004*	*1.27*	*0.020*	*0.002*
1999	*9.42*	*6.59E-05*	*0.00026*	*9.50*	*0.012*	*3.66*	*0.058*	*0.006*
2000	*0.14*	*9.67E-07*	*3.87E-06*	*0.14*	*0.0002*	*0.05*	*0.001*	*0.000*
2001	*0.17*	*1.19E-06*	*4.75E-06*	*0.17*	*0.0002*	*0.06*	*0.001*	*0.000*
2002	*6.78*	*5.31E-04*	*0.00018*	*6.84*	*0.14*	*0.50*	*0.013*	*0.008*
2003	*6.35*	*4.63E-04*	*0.00017*	*6.41*	*0.12*	*0.62*	*0.014*	*0.007*
2004	*11.51*	*8.00E-04*	*0.00031*	*11.62*	*0.21*	*1.30*	*0.028*	*0.012*
2005	*7.62*	*5.53E-04*	*0.00021*	*7.70*	*0.14*	*0.75*	*0.017*	*0.008*
2006	*8.91*	*5.36E-04*	*0.00024*	*8.99*	*0.14*	*1.37*	*0.026*	*0.009*
2007	*2.84*	*1.12E-04*	*0.00008*	*2.87*	*0.03*	*0.70*	*0.012*	*0.002*
2008	*3.41*	*1.58E-04*	*0.00009*	*3.44*	*0.04*	*0.73*	*0.013*	*0.002*
2009	*5.34*	*3.55E-04*	*0.00015*	*5.39*	*0.09*	*0.67*	*0.014*	*0.003*
2010	*7.87*	*6.17E-04*	*0.00021*	*7.95*	*0.16*	*0.58*	*0.015*	*0.005*
2011	*7.22*	*5.71E-04*	*0.00020*	*7.29*	*0.15*	*0.51*	*0.013*	*0.005*
2012	*7.33*	*5.61E-04*	*0.00020*	*7.40*	*0.15*	*0.60*	*0.014*	*0.005*
2013	*6.45*	*4.56E-04*	*0.00018*	*6.51*	*0.12*	*0.69*	*0.015*	*0.004*
2014	*9.44*	*7.50E-04*	*0.00026*	*9.54*	*0.20*	*0.65*	*0.017*	*0.006*
2015	*9.57*	*7.90E-04*	*0.00026*	*9.67*	*0.21*	*0.52*	*0.015*	*0.006*
2016	*11.39*	*8.67E-04*	*0.00031*	*11.51*	*0.23*	*0.95*	*0.023*	*0.007*
2017	*13.17*	*1.18E-03*	*0.00036*	*13.31*	*0.31*	*0.31*	*0.015*	*0.008*
2018	*19.85*	*1.65E-03*	*0.00054*	*20.05*	*0.43*	*1.05*	*0.031*	*0.013*
2019	*23.70*	*1.88E-03*	*0.00064*	*23.94*	*0.49*	*1.66*	*0.043*	*0.015*
2020	*14.72*	*1.31E-03*	*0.00040*	*14.87*	*0.35*	*0.39*	*0.018*	*0.009*
Share of Energy total, 2020	*0.2%*	*0.0%*	*0.1%*	*0.2%*	*1.3%*	*0.4%*	*0.1%*	*0.3%*
2020 vs 2019	*-37.9%*	*-30.2%*	*-38.1%*	*-37.9%*	*-30.0%*	*-76.3%*	*-58.1%*	*-38.1%*
2020 vs 1995	*238.3%*	*3032.0%*	*230.5%*	*238.8%*	*4314.8%*	*16.4%*	*47.3%*	*232.8%*

Emissions from this sector are not influenced by the changes in national economy or in the economy of Latvia's trade partners. In the recent years there has been an increase of fuel consumption and therefore increase in emissions. CO_2 emissions 2019-2020 have decreased by 37.9%, CH_4 by 30.2% and N_2O by 38.1%.

3.2.8.2 Methodological issues

Methods

The 2006 IPCC Guidelines' Tier 1 method was used to calculate GHG emissions from the 1.A.5.b Other Mobile source sector.

Calculations of all emissions from fuel combustion are done with Excel databases developed by experts from LEGMC.

The general method for preparing inventory data was used:

$$\boldsymbol{Em = EF * B_q} \tag{3.10}$$

where:
Em – total emissions (kt)
EF – estimated or default emission factor (t/TJ)
B_q – amount of fuel in thermal units (TJ)

Emission factors and other parameters

Default EFs for direct GHGs from aircrafts are taken from the 2006 IPCC Guidelines, Volume 2, Chapter 3 *Mobile combustion*, Table 3.5.2 and Table 3.6.4 (Table 3.52).

Precursors EFs were taken from EMEP/EEA 2019. Country specific EFs were used to calculate SO_2 emissions.

Table 3.52 CO_2, CH_4, N_2O, NO_x, NMVOC, CO emission factors[32]

Fuel type	CO_2	CH_4	N_2O	NO_x	NMVOC	CO
Aviation gasoline	*70.0*	*0.0005*	*0.002*	*4*	*19*	*1200*
Diesel oil	*74.1*	*0.007*	*0.002*	*78.5*	*2.8*	*7.4*
Jet fuel	*71.5*	*0.0005*	*0.002*	*4*	*19*	*1200*

3.2.8.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty for activity data of fuel combustion in sectors CRF 1.A.5.b is 2±% in 2020 because official statistical information from CSB is used.

EFs used for emission estimation were taken from the 2006 IPCC Guidelines. For diesel oil the uncertainty for CO_2 EF, according to these Guidelines, Volume 2, Chapter 3 *Mobile combustion*, Section 3.5.1.7, is 2%, but for CH_4 and N_2O it is much higher - about 50%. For aviation gasoline and jet fuel, the uncertainty for CO_2 EF, according to the 2006 IPCC Guidelines, Volume 2, Chapter 3 *Mobile combustion*, Section 3.6.1.7, is 5%, but for CH_4 and N_2O it is assumed that the uncertainty is 100%.

[32] *Units for GHGs are in kt/PJ, for precursors GHGs in kg/Mg.*

Time series of the estimated emissions are consistent and complete because the same methodology, EFs and data sources are used for sectors for all years in time series.

3.2.8.4 Category-specific QA/QC and verification

All the documentation and information received for inventory purposes is archived in FTP folder (maintained by LEGMC).

Activity data verification

All sources of energy data are presented in the corresponding NIR chapter (3.2.8.2 Methodological issues) as well as disaggregated data at the finest level possible are presented in the corresponding Annex A.3.1 "1.A.5 Other". Data completeness has been explained in the previous subchapter.

Activity data has been checked at the data provider – CSB, that has its own internal QA/QC procedures based on mathematic model and analysis to avoid logic mistakes. When activity data is received, the sectoral expert responsible for the emission estimation and reporting is comparing all data changes with the previous inventory, and all changes are explained in the corresponding subchapter. All fluctuations or changes in NCVs are double checked and agreed with CSB.

All activity data used in SA are also compared with activity data used in RA estimations. All significant differences (±5%) are explained in the corresponding subchapter.

Emission factor verification

As all EFs are taken from the 2006 IPCC Guidelines, no additional verification procedures have been performed.

Emission verification

To verify CO_2 emissions, logical mistakes are checked by checking the time series of the activity data, EFs and emissions consistency to display all significant and illogical changes in the activity data and emissions. The emissions of precursors GHGs in the database are cross-checked with emissions reported within CLRTAP for verification purposes.

CO_2 emissions are compared with emissions in RA estimations, and all significant differences (±5%) are explained in the corresponding subchapter. Apparent consumption reported in GHG inventory has been compared with activity data form AQ in Annex A.3.3.

3.2.8.5 Category-specific recalculations

No recalculations were done for this sector.

3.2.8.6 Category-specific planned improvements

No improvements are planned for this sector.

3.3 *FUGITIVE EMISSIONS FROM SOLID FUELS AND OIL AND NATURAL GAS (CRF 1.B)*

Under the 1.B Fugitive emissions category CO_2, CH_4 and NMVOC emissions from operations with natural gas and light liquid fuels are reported (Table 3.53).

Table 3.53 Reported fugitive CO_2, CH_4, NMVOC emissions in Latvia in 1990-2020 (kt)

Year	CO_2	CH_4	Aggregate GHGs	NMVOC
	kt		kt CO_2 eq.	kt
1990	*0.0115*	*9.90*	*247.59*	*4.18*
1991	*0.0111*	*9.54*	*238.49*	*3.88*
1992	*0.0101*	*8.70*	*217.43*	*3.59*
1993	*0.0097*	*8.32*	*207.94*	*3.45*
1994	*0.0094*	*8.13*	*203.20*	*3.35*
1995	*0.0092*	*7.92*	*197.89*	*3.19*
1996	*0.0089*	*7.63*	*190.68*	*3.10*
1997	*0.0083*	*7.12*	*177.96*	*2.88*
1998	*0.0079*	*6.83*	*170.75*	*2.75*
1999	*0.0076*	*6.51*	*162.79*	*2.63*
2000	*0.0070*	*6.03*	*150.64*	*2.48*
2001	*0.0073*	*5.84*	*146.09*	*2.47*
2002	*0.0074*	*6.10*	*152.57*	*2.52*
2003	*0.0055*	*4.76*	*119.08*	*2.12*
2004	*0.0055*	*4.71*	*117.87*	*2.11*
2005	*0.0062*	*5.33*	*133.19*	*2.28*
2006	*0.0044*	*3.82*	*95.53*	*1.91*
2007	*0.0046*	*3.92*	*98.07*	*2.72*
2008	*0.0047*	*4.03*	*100.70*	*2.50*
2009	*0.0044*	*3.81*	*95.13*	*2.44*
2010	*0.0043*	*3.66*	*91.61*	*2.35*
2011	*0.0054*	*2.52*	*63.03*	*1.40*
2012	*0.0049*	*3.18*	*79.61*	*1.44*
2013	*0.0080*	*4.04*	*101.01*	*1.71*
2014	*0.0138*	*5.41*	*135.33*	*2.34*
2015	*0.0129*	*4.11*	*102.81*	*2.40*
2016	*0.0119*	*4.66*	*116.59*	*2.06*
2017	*0.0157*	*6.11*	*152.70*	*0.91*
2018	*0.0093*	*3.64*	*91.07*	*0.65*
2019	*0.0102*	*3.92*	*97.97*	*0.71*
2020	*0.0111*	*4.02*	*100.54*	*0.78*
Share of Energy total, 2020	*0.0002%*	*36.2%*	*1.5%*	*5.8%*
2020 vs 2019	*9.0%*	*2.6%*	*2.6%*	*9.6%*
2020 vs 1990	*96.5%*	*40.6%*	*40.6%*	*18.6%*

It is assumed that no GHG emissions are generated during hard coal transportation via railways. Only particulate matter emissions are estimated from coal transportation in Latvia.

There are lasting peat extraction and manufacturing traditions in Latvia. As stated in the 2006 IPCC Guidelines, Volume 4 *Agriculture, Forestry and Other Land Use*, Chapter 1 *Introduction*, with current state of scientific knowledge, it is possible to provide methods for estimating CO_2 and N_2O emissions associated with management of peatlands, and CO_2 from conversion to wetlands by flooding. However, according to the 2006 IPCC Guidelines, Volume 4, Chapter 7 *Wetlands*, all on-site sources of GHG emissions should be reported under AFOLU *Wetlands* category regardless of the end-use of peat.

There are no coal mines in Latvia and therefore no fugitive emissions from mining processes occur.

3.3.1 Fugitive emission from oil (CRF 1.B.2.a)

3.3.1.1 Category description

CRF sector 1.B.2.a Oil includes NMVOC emissions from refined oil products storage and distribution. There are no oil refineries in Latvia; therefore NMVOC emissions from gasoline distribution only were calculated for 1990–2020.

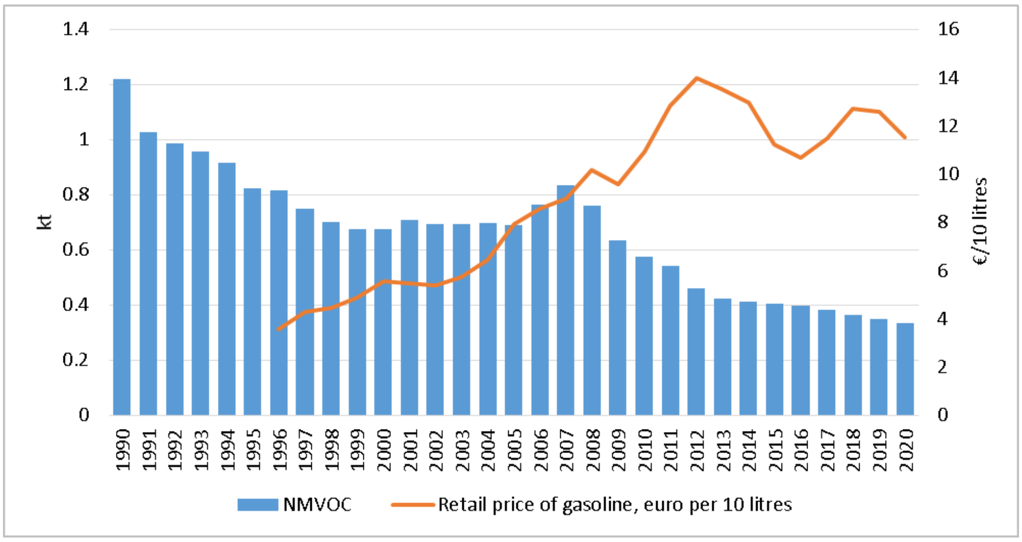

Figure 3.43 Fugitive NMVOC emissions from oil products in 1990–2020 (kt)

NMVOC emissions trend can partly be explained with fluctuating costs of gasoline as well as changes in technology, that impact gasoline consumption in Energy sector. In 2005-2007 there are rise in emissions that can be explained with the economic growth, however, in 2008 due to global crisis, the use of gasoline, as well as NMVOC emissions decreased, and continued to decline after that (Figure 3.43). Since 1990 up 2020 NMVOC emissions have decreased by 72.7%. In 2020, NMVOC emissions have decreased by 4.3% compared to 2019.

3.3.1.2 Methodological issues

Methods

EMEP/EEA 2019 Tier 1 methodology is used to estimate fugitive NMVOC emissions from operations with gasoline in 1990–2020. It uses the general equation, where emissions are obtained by multiplying the total amount of gasoline sold with the EF.

Emission factors

NMVOC EF – 2 kg/Mg oil – for emission from gasoline distribution was taken from EMEP/EEA 2019, Chapter 1.B.2.a.v Distribution of oil products, Table 3-1.

Activity data

Activity data for NMVOC emission calculation was taken from CSB Energy Balance (Table 3.54).

Table 3.54 Gasoline consumption in Latvia in 1990–2020 (TJ)

Year	Gasoline consumption (TJ)
1990	*26796*
1991	*22616*
1992	*21692*
1993	*21032*
1994	*20108*
1995	*18128*
1996	*17908*
1997	*16456*
1998	*15400*
1999	*14872*
2000	*14831*
2001	*15535*
2002	*15228*
2003	*15214*
2004	*15346*
2005	*15126*
2006	*16753*
2007	*18299*
2008	*16672*
2009	*13941*
2010	*12667*
2011	*11926*
2012	*10146*
2013	*9282*
2014	*9018*
2015	*8922*
2016	*8751*
2017	*8362*
2018	*8030*
2019	*7637*
2020	*7317*

3.3.1.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Activity data for fugitive emissions from operations with gasoline were taken from CSB and uncertainty was assumed as low as 2% statistical frame mistake. Uncertainty for EF is assumed as 100%, according to the 2006 IPCC Guidelines, Volume 2, Chapter 4 *Fugitive emissions*, Table 4.2 (refined product distribution).

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

3.3.1.4 Category-specific QA/QC and verification

All documentation and information received for inventory purposes are archived in FTP folder.

Activity data verification

All sources of energy data are presented in the corresponding NIR chapter (3.3.1.2 Methodological issues) as well as disaggregated data at the finest level possible are presented in the corresponding Annex A.3.1. Data completeness has been explained in the previous subchapter.

Activity data has been checked at the data provider – CSB, which has its own internal QA/QC procedures based on mathematic model and analysis to avoid logic mistakes. When activity data is received, the sectoral expert responsible for the emission estimation and reporting is comparing all data changes with the previous inventory, and all changes are explained in the corresponding subchapter. All fluctuations or changes in NCVs are double checked and agreed with CSB.

Emission factor verification

As all EFs are taken from EMEP/EEA 2019, no additional verification procedures have been performed.

Emission verification

To verify NMVOC emissions, logical mistakes are examined by checking the time series of the activity data, EFs and emissions consistency to display all significant and illogical changes in the activity data and emissions. Emissions are also cross-checked with emissions reported within CLRTAP for verification purposes.

3.3.1.5 Category-specific recalculations

No recalculations were done for this sector.

3.3.1.6 Category-specific planned improvements

No improvements are planned for this sector.

3.3.2 Fugitive emissions from natural gas (CRF 1.B.2.b, CRF 1.B.2.c, CRF 1.B.2.d)

3.3.2.1 Category description

CO_2, CH_4 and NMVOC emissions from operations with natural gas are reported in the following sub-sectors CRF 1.B.2.b Natural gas sector:

- 1.B.2.b.i Venting;
- 1.B.2.b.iii All other:
    - 1.B.2.b.iii 4 Transmission and storage;
    - 1.B.2.b.iii 5 Distribution;
    - 1.B.2.b.iii 6 Other (includes leakage at industrial plants and power stations and leakage at residential and commercial sectors)

Table 3.55 Fugitive CH_4, CO_2 and NMVOC emissions from natural gas 1990-2020 (kt)

Year	CO_2	CH_4	Aggregate GHGs	NMVOC
	kt		kt CO_2 eq.	kt
1990	*0.0115*	*9.90*	*247.59*	*2.97*
1991	*0.0111*	*9.54*	*238.49*	*2.86*

Year	CO_2	CH_4	Aggregate GHGs	NMVOC
	kt		kt CO_2 eq.	kt
1992	*0.0101*	*8.70*	*217.43*	*2.60*
1993	*0.0097*	*8.32*	*207.94*	*2.49*
1994	*0.0094*	*8.13*	*203.20*	*2.43*
1995	*0.0092*	*7.92*	*197.89*	*2.37*
1996	*0.0089*	*7.63*	*190.68*	*2.28*
1997	*0.0083*	*7.12*	*177.96*	*2.13*
1998	*0.0079*	*6.83*	*170.75*	*2.05*
1999	*0.0076*	*6.51*	*162.79*	*1.95*
2000	*0.0070*	*6.03*	*150.64*	*1.80*
2001	*0.0073*	*5.84*	*146.09*	*1.76*
2002	*0.0074*	*6.10*	*152.57*	*1.83*
2003	*0.0055*	*4.76*	*119.08*	*1.43*
2004	*0.0055*	*4.71*	*117.87*	*1.41*
2005	*0.0062*	*5.33*	*133.19*	*1.60*
2006	*0.0044*	*3.82*	*95.53*	*1.14*
2007	*0.0046*	*3.92*	*98.07*	*1.89*
2008	*0.0047*	*4.03*	*100.70*	*1.74*
2009	*0.0044*	*3.81*	*95.13*	*1.81*
2010	*0.0043*	*3.66*	*91.61*	*1.77*
2011	*0.0054*	*2.52*	*63.03*	*0.86*
2012	*0.0049*	*3.18*	*79.61*	*0.98*
2013	*0.0080*	*4.04*	*101.01*	*1.28*
2014	*0.0138*	*5.41*	*135.33*	*1.93*
2015	*0.0129*	*4.11*	*102.81*	*2.00*
2016	*0.0119*	*4.66*	*116.59*	*1.66*
2017	*0.0157*	*6.11*	*152.70*	*0.53*
2018	*0.0093*	*3.64*	*91.07*	*0.28*
2019	*0.0102*	*3.92*	*97.97*	*0.36*
2020	*0.0111*	*4.02*	*100.54*	*0.45*
Share of Energy total, 2020	*0.0002%*	*36.2%*	*1.5%*	*3.3%*
2020 vs 2019	*9.0%*	*2.6%*	*2.6%*	*22.8%*
2020 vs 1990	*-3.5%*	*-59.4%*	*-59.4%*	*-84.9%*

GHG emissions have decreased in 1990-2020 by 59.4%. There are few years where the emissions increased, and in all cases the increase is related with repair works and modernisation of existing pipeline system. Compared to 2019 emissions have increased by 2.6% in 2020.

Table 3.56 Pipeline length 1990-2020 (km)

Year	Transport (main) gas pipeline system lenght, km	Distribution pipeline lenght, km
1990	*1109*	-
1991	*1109*	-
1992	*1112*	-
1993	*1124*	-
1994	*1213*	-

Year	Transport (main) gas pipeline system lenght, km	Distribution pipeline lenght, km
1995	*1213*	-
1996	*1213*	-
1997	*1213*	*2882*
1998	*1213*	*2921*
1999	*1213*	*2999*
2000	*1213*	*3085*
2001	*1234*	*3234*
2002	*1234*	*3509*
2003	*1234*	*3675*
2004	*1234*	*3906*
2005	*1281*	*4339*
2006	*1281*	*4418*
2007	*1242*	*4586*
2008	*1238*	*4757*
2009	*1240*	*4771*
2010	*1240*	*4825*
2011	*1240*	*4857*
2012	*1240*	*4898*
2013	*1240*	*4934*
2014	*1240*	*4967*
2015	*1191*	*5040*
2016	*1191*	*5124*
2017	*1188*	*5212*
2018	*1188*	*5243*
2019	*1188*	*5272*
2020	*1188*	*5337*

Information about gas pipeline length was received from JSC "Latvijas Gāze" (1990-2016) and can be seen in Table 3.56. In 2017 after liberalization of the Latvian gas market "Latvijas Gāze" was split up and JSC "Conexus Baltic Grid" was handed over the natural gas infrastructure (main transmission system and underground gas storage) and JSC "Gaso" natural gas distribution. Pipeline length differs from year to year due to construction of new pipelines and closing old ones.

In the distribution part of pipeline system operated by AS "Gaso" gas pressure ranges from 20mbar to 16bar. Gas pressure in the transmission part of pipeline system operated by JSC "Conexus Baltic Grid" is around of 35bar. Pipline materials are range from steel pipes with bitumen insulation (USSR) and with triple polyethylene insulation after separation from the USSR; polyethylene pipes.

3.3.2.2 Methodological issues

<u>Methods</u>

LEGMC received data about CH_4 emissions from the natural gas holding company JSC "Latvijas Gāze" for the time period 1990–2016. Consequently JSC "Latvijas Gāze" calculates emissions itself, using data of natural gas density and other physical parameters and measures the content of methane and other chemical compounds in natural gas, therefore it is assumed as Tier 3 method, using country-specific data and calculations. In 2017, after liberalization of the

Latvian gas market JSC "Conexus Baltic Grid" was handed over the natural gas infrastructure (main transmission system and underground gas storage) and JSC "Gaso" natural gas distribution. Therefore information about fugitive emissions form natural gas starting 2017 is received from new companies. JSC "Conexus Baltic Grid" calculates emissions from main transmission system and underground gas storage for venting (CRF1.B.2.c.1.ii) , transmission and storage (CRF 1.B.2.b.iii 4) and JSC "Gaso" from distribution system for venting (CRF 1.B.2.c.1.ii), distribution (CRF 1.B.2.b.iii 5) and other (CRF 1.B.2.b.iii 6).

Methodology used for emission calculations by natural gas companies was submitted to inventory compailers.

Activity data

CH_4 emissions are obtained from the holding company JSC "Latvijas Gāze" (1990-2016), JSC "Conexus Baltic Grid" (2017-), JSC "Gaso" (2017-) and the activity data (millions m^3) are provided in Table 3.57.

Table 3.57 Amounts of natural gas leaked in 1990-2020 (10^6 m^3)

Year	1.B.2.c.1.ii Venting	1.B.2.b.iii 4 Transmission and storage	1.B.2.b.iii 5 Distribution	1.B.2.b.iii 6 Other	Total
1990	*5.61*	*0.13*	*0.69*	*12.44*	*18.87*
1991	*5.38*	*0.13*	*0.69*	*11.98*	*18.17*
1992	*4.83*	*0.13*	*0.59*	*10.92*	*16.47*
1993	*4.58*	*0.13*	*0.69*	*10.44*	*15.85*
1994	*4.46*	*0.13*	*0.69*	*10.21*	*15.48*
1995	*4.32*	*0.13*	*0.69*	*9.94*	*15.08*
1996	*4.13*	*0.13*	*0.69*	*9.58*	*14.53*
1997	*3.80*	*0.13*	*0.69*	*8.94*	*13.56*
1998	*3.63*	*0.11*	*0.69*	*8.58*	*13.01*
1999	*3.42*	*0.11*	*0.69*	*8.18*	*12.40*
2000	*3.11*	*0.11*	*0.69*	*7.57*	*11.48*
2001	*0.30*	*0.10*	*0.69*	*10.03*	*11.14*
2002	*0.98*	*0.10*	*0.69*	*9.86*	*11.63*
2003	*1.09*	*0.10*	*0.69*	*7.20*	*9.07*
2004	*1.56*	*0.09*	*0.69*	*6.63*	*8.98*
2005	*3.25*	*0.09*	*0.69*	*6.12*	*10.15*
2006	*1.80*	*0.08*	*0.69*	*4.71*	*7.28*
2007	*1.76*	*0.07*	*0.69*	*4.95*	*7.47*
2008	*2.44*	*0.07*	*0.69*	*4.48*	*7.67*
2009	*1.78*	*0.06*	*0.69*	*4.71*	*7.25*
2010	*1.64*	*0.06*	*0.69*	*4.59*	*6.98*
2011	*1.77*	*0.05*	*0.69*	*1.70*	*4.21*
2012	*1.34*	*0.05*	*0.69*	*3.35*	*5.43*
2013	*1.09*	*0.04*	*0.69*	*4.06*	*5.89*
2014	*1.53*	*0.04*	*0.66*	*5.69*	*7.93*
2015	*0.95*	*0.04*	*0.71*	*4.35*	*6.06*
2016	*0.93*	*0.04*	*0.67*	*5.18*	*6.83*
2017	*0.83*	*0.01*	*0.73*	*7.82*	*9.39*
2018	*0.41*	*0.01*	*0.73*	*4.42*	*5.57*
2019	*0.84*	*0.01*	*0.74*	*4.40*	*6.00*
2020	*1.04*	*0.01*	*0.76*	*4.32*	*6.13*

In Table 3.57 information received from natural gas company and represents natural gas companies' calculations about amount of natural gas leaked 1990-2020.

Table 3.58 Amounts of natural gas in 1990-2020 (10^6 m^3)

Year	Import	Export	Stock change	Apparent consumption
1990	*3310*	*150*	*223*	*2937*
1991	*2961*	*NO*	*NO*	*2961*
1992	*2660*	*NO*	*510*	*2150*
1993	*943*	*NO*	*-469*	*1412*
1994	*1010*	*NO*	*-18*	*1028*
1995	*1241*	*NO*	*-13*	*1254*
1996	*1089*	*NO*	*1*	*1088*
1997	*1318*	*NO*	*-8*	*1326*
1998	*1382*	*NO*	*83*	*1299*
1999	*1290*	*NO*	*45*	*1245*
2000	*1385*	*NO*	*26*	*1359*
2001	*1350*	*NO*	*-227*	*1577*
2002	*1425*	*NO*	*-184*	*1609*
2003	*1750*	*NO*	*73*	*1677*
2004	*2170*	*NO*	*507*	*1663*
2005	*1790*	*NO*	*95*	*1695*
2006	*1910*	*NO*	*154*	*1756*
2007	*1645*	*NO*	*-55*	*1700*
2008	*1368*	*NO*	*-297*	*1665*
2009	*1743*	*NO*	*215*	*1528*
2010	*1125*	*NO*	*-696*	*1821*
2011	*1755*	*NO*	*151*	*1604*
2012	*1716*	*NO*	*208*	*1508*
2013	*1698*	*NO*	*229*	*1469*
2014	*947*	*NO*	*-366*	*1313*
2015	*1306*	*NO*	*-19*	*1325*
2016	*1132*	*NO*	*-248*	*1380*
2017	*1243*	*NO*	*24*	*1219*
2018	*1415*	*NO*	*-17*	*1432*
2019	*1354*	*NO*	*NO*	*1354*
2020	*1115*	*NO*	*1*	*1114*

In Table 3.58 information about natural gas net supply is provided.

3.3.2.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

The level of uncertainty was determined by natural gas distributing company JSC „Latvijas Gāze", JSC "Conexus Baltic Grid" and JSC "Gaso". The uncertainty both for activity data (gas amounts) and CH_4, CO_2 and NMVOC emissions from gas venting and natural gas leakages in gas distribution and transmission systems, as well as in gas storage facility is assigned as quite low – 10%, as these were estimated by the enterprise operated with natural gas by methodology developed for enterprise. However, for other leakage (CRF 1.B.2.b.iii 6) the uncertainty for the emissions is assumed as 35%.

Emissions from all sectors are estimated or reported as not occurring / not applicable therefore there are no "not estimated" sectors.

3.3.2.4 Category-specific QA/QC and verification

JSC "Latvijas Gāze", JSC "Conexus Baltic Grid" and JSC "Gaso" report fugitive CH_4 emissions from the operations with natural gas, estimates CH_4 and CO_2 emissions according to methodology prepared especially for the organization that is internationally verified and approved by the Environment State Bureau. Underground storage "Inčukalns" also has an ISO standard and all the information obtaining procedures are controlled and verified.

Emissions are compared with calculations made using Tier 1 methodology from IPCC 2006 Chapter 4: Fugative Emissions emission factors from Table 4.2.4 "Tier 1 emission factors for fugitive emissions (including venting and flaring) from oil and gas operations in developed countries". Calculations are available to ERT after request.

All documentation and information received for inventory purposes are archived in FTP folder.

3.3.2.5 Category-specific recalculations

No recalculations were done for this sector.

3.3.2.6 Category-specific planned improvements

No improvements are planned for this sector.

3.4 *CO_2 TRANSPORT AND STORAGE (CRF 1.C)*

There is no CO_2 captured and further storaged in Latvia. There is a research done to find the potential sites for CO_2 geological storage in Latvia within international project "Assessing European Capacity for Geological Storage of Carbon Dioxide" (EU GeoCapacity)[33,34]. Latvia has a storage potential in local structures in the Cambrian water-saturated sandstone. In one of such geological structures, an underground storage of natural gas was established already in 1968 – the Inčukalns natural gas storage. For modelling the potential costs, the largest CO_2 source in Latvia in 2005 from EU ETS was taken, and as potential storages were selected the two largest ones. The modelling results demonstrated that the efficiency of the establishment of CO_2 storages there is too low. The unsatisfactory results are associated with the inefficient injection of small volumes of CO_2 in the storages, and the cost of the establishment of infrastructure is quite high, and the expenditure is unfounded with the low level of CO_2 injection.

[33] *Assessing European capacity for geological storage of carbon dioxide–the EU GeoCapacity project. Available: https://www.sciencedirect.com/science/article/pii/S1876610209006778*

[34] *Potential sites for CO_2 geologicalstorage. Available: http://meteo.lv/fs/CKFinderJava/userfiles/files/Geologija/Potential%20sites.pdf*

4 INDUSTRIAL PROCESSES AND PRODUCT USE (CRF 2)

4.1 *OVERVIEW OF SECTOR*

Greenhouse gas emissions from Industrial Processes and Product Use contributed 8.3% to the total anthropogenic GHG emissions excluding LULUCF, including indirect CO_2 totalling 868.15 kt CO_2 eq. in 2020 (Figure 4.1).

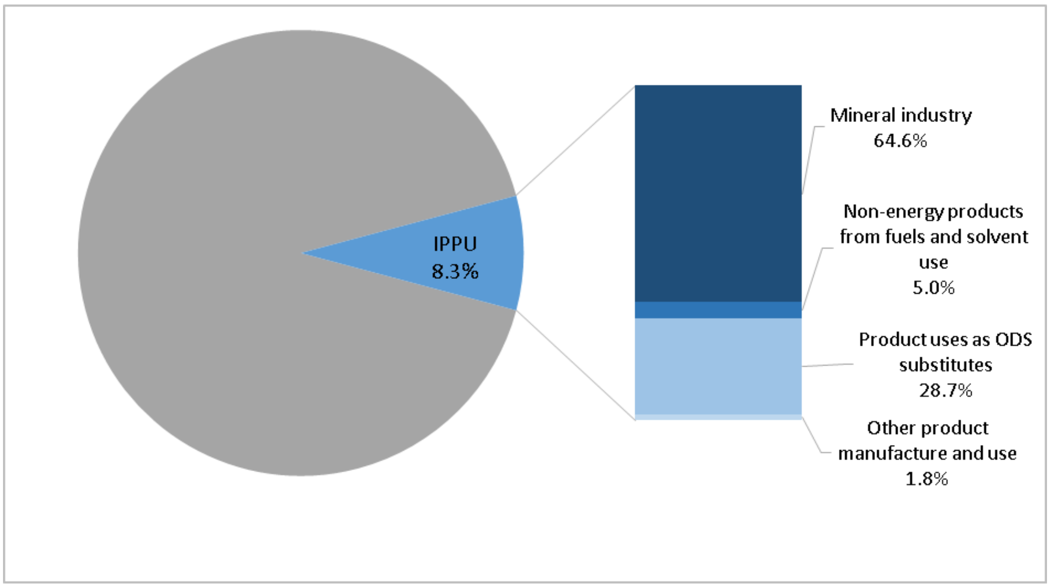

Figure 4.1 Emissions from the Industrial processes and product use sector compared with the total emissions in 2020

The majority (64.6%) of IPPU emissions originate in 2.A Mineral industry (emissions from Cement production (63.5%), Other process uses of carbonates (1.0%) and Glass production (0.1%)). The second largest emission category under IPPU sector is 2.F Product uses as substitutes for ODS constituting 28.7% from IPPU emissions and 2.4% from total GHG emissions in Latvia (excluding LULUCF, including indirect CO_2). Almost all 2.F. emissions comes from 2.F.1 Refrigeration and air conditioning appliances (97.4%). Remaining sectors generating emissions in IPPU are 2.D Non-energy products from fuels and solvent use (5.0%) and 2.G Other product manufacture and use constituting 1.8% from total IPPU emissions in 2020.
Sources of emissions from IPPU sector reported in Latvia`s GHG inventory are as follows:

- Mineral Industry (CRF 2.A)
    - Cement Production (CRF 2.A.1)
        - CO_2 from cement production
        - SO_2, NO_x, CO, NMVOCs from cement production
    - Lime Production (CRF 2.A.2)
        - CO_2 from limestone and dolomite use in lime production and quicklime production in iron & steel industry
    - Glass Production (CRF 2.A.3)
        - CO_2 from raw material use in glass production
        - NMVOCs from glass fibre production
    - Other Process Uses of Carbonates (CRF 2.A.4)
        - CO_2 from Ceramics (Bricks and tiles production) (CRF 2.A.4.a)

    - CO_2 from Other uses of Soda Ash (waste water neutralization in glass fibre production plant) (CRF 2.A.4.b)
    - Other (NO_x and CO emissions from cement production, NMVOCs from cement and glass fibre production) (CRF 2.A.4.d)
- Metal Industry (CRF 2.C)
  - Iron and Steel Production (CRF 2.C.1)
    - CO_2 emissions from crude iron use as raw material
    - CH_4, NO_x, SO_2, CO, NMVOC emissions from total iron and steel production
    - CO_2 emissions from limestone, dolomite, coke and carbon electrodes use in steel production
- Non-energy products from fuels and solvent use (CRF 2.D)
  - CO_2 from lubricant use (CRF 2.D.1)
  - CO_2 from paraffin wax use (CRF 2.D.2)
  - Other (CRF 2.D.3)
    - CO_2 and NMVOCs from Solvent use
    - CO_2 and NMVOCs from road paving with asphalt
    - CO_2, CO and NMVOCs from asphalt roofing
    - CO_2 from urea use
- Product uses as Substitutes for ODS (CRF 2.F)
  - HFCs from Refrigeration and Air Conditioning (CRF 2.F.1)
    - 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)
    - Stationary Air-Conditioning (CRF 2.F.1.f)
  - HFCs from Foam Blowing Agents (CRF 2.F.2)
    - Closed Cells (CRF 2.F.2.a)
    - Open Cells (CRF 2.F.2.b)
  - HFCs from Fire Protection (CRF 2.F.3)
  - HFCs from Aerosols (CRF 2.F.4)
    - Metered Dose Inhalers (CRF 2.F.4.a)
- Other product manufacture and use (CRF 2.G)
  - SF_6 from Electrical Equipment (CRF 2.G.1)
  - N_2O From Product Uses (CRF 2.G.3)
- Other Production (CRF 2.H)
    - SO_2 emissions from Pulp and Paper production for 1990–1996 (2.H.1).
    - NMVOC emissions from food and beverages production (2.H.2)
    - CO_2 emissions from limestone use in sugar production for 2005-2006 (2.H.2)

Emissions from the Chemical Industry (CRF 2.B), Electronics Industry (CRF 2.E) are not occurring (NO) in Latvia for all timeseries. Since 2016 emissions from 2.A.2 Lime production and 2.C Metal Production are not occurring due to interruption of lime and iron & steel production in the country.

Emissions from IPPU have been increased by 32.3% since 1990 and decreased by 2.6% in 2020 compared to 2019 (Figure 4.2, Table 4.1).

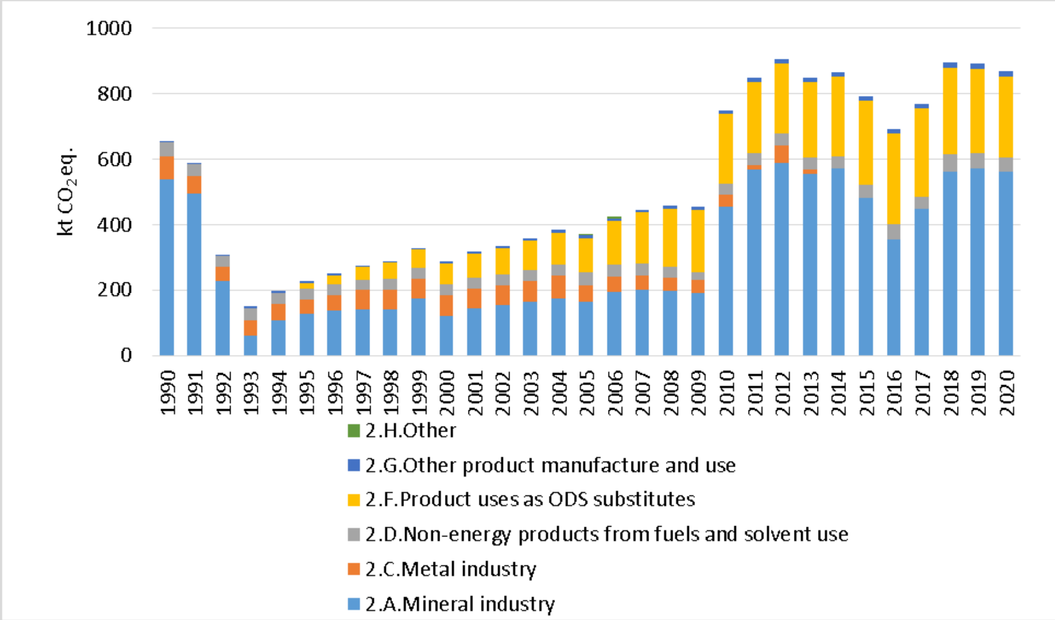

Figure 4.2 GHG emissions from Industrial processes and product use in 1990–2020 (kt CO_2 eq.)

Emission fluctuations through the years are mainly linked to the economic situation in country. The largest decrease in emissions occurred between 1991 and 1993, when industry was affected by a crisis. It has to be noted that at the beginning of 1990s during the countrywide changes in the governmental system the national economy statistics was not well developed. Therefore there are a lack of statistical data regarding industry during this period of time or statistical data are vague. The data extrapolation was carried out for the sectors where it was possible.

A key drivers for IPPU emission growth starting from 1994 are overall increase of activity in industrial production processes (cement and lime production). Since that time sharp development of construction activities has been observed and industrial production of building materials also increased. Changes in export of products from Latvia to Commonwealth of Independent States (CIS) countries has also caused emission fluctuations 1998-2000.

F-gas emissions have been increasing significantly since 1995. This growth is reflected in IPPU emission curve. The sharp increase of F-gas emissions is related to growing demand for refrigeration and air conditioning equipment along with improved economic situation in Latvia. There is no manufacturing of F-gases containing products in the country thus emissions mainly depend on consumption of imported products.

In 2010, compared to 2009 rapid emission growth could be observed in Mineral industry (by 137.2%) where CO_2 emission increase was a result of setting up of a new dry process technological plant in cement production.

In 2014, the CO_2 and CH_4 emissions from metal industry have decreased by 100% compared to 1990 due to insolvency of the only metal production plant in Latvia however in 2015 the metal production company begun to produce steel again therefore emissions again appeared, but in

2016 again metal production was stopped and facility was not reporting GHG emissions from metal production processes anymore (NO).

Table 4.1 Greenhouse gas emission trend in 1990–2020 (kt CO_2 eq.)

Year	Total	2.A Mineral Industry	2.C Metal Industry	2.D Non-Energy Products from Fuels and Solvent	2.F Product Uses as Substitutes for ODS	2.G Other Product Manufacture and Use	2.H. Other
1990	*655.98*	*537.24*	*69.62*	*44.28*	*NE,NO*	*4.84*	*NA,NO*
1991	*588.36*	*493.54*	*54.34*	*35.66*	*NE,NO*	*4.82*	*NA,NO*
1992	*308.08*	*226.26*	*43.29*	*33.73*	*NE,NO*	*4.79*	*NA,NO*
1993	*149.62*	*61.17*	*48.01*	*35.75*	*NE,NO*	*4.69*	*NA,NO*
1994	*196.95*	*108.06*	*50.08*	*34.21*	*NE,NO*	*4.61*	*NA,NO*
1995	*227.13*	*126.57*	*45.41*	*33.30*	*17.13*	*4.71*	*NA,NO*
1996	*250.18*	*138.83*	*44.19*	*33.08*	*29.43*	*4.65*	*NA,NO*
1997	*275.14*	*139.53*	*60.20*	*31.66*	*38.94*	*4.80*	*NA,NO*
1998	*288.23*	*139.70*	*62.72*	*33.31*	*47.59*	*4.91*	*NA,NO*
1999	*329.24*	*173.67*	*61.43*	*33.15*	*55.93*	*5.06*	*NA,NO*
2000	*286.55*	*122.68*	*61.16*	*32.91*	*64.60*	*5.19*	*NA,NO*
2001	*316.63*	*145.16*	*60.34*	*32.61*	*72.86*	*5.65*	*NA,NO*
2002	*335.17*	*154.93*	*60.39*	*32.33*	*80.68*	*6.83*	*NA,NO*
2003	*356.84*	*163.39*	*64.70*	*33.37*	*88.46*	*6.93*	*NA,NO*
2004	*383.02*	*174.50*	*68.59*	*35.85*	*96.69*	*7.38*	*NA,NO*
2005	*371.16*	*165.38*	*50.05*	*37.84*	*105.20*	*7.86*	*4.85*
2006	*423.70*	*193.11*	*48.43*	*36.53*	*132.80*	*8.11*	*4.73*
2007	*445.50*	*199.63*	*44.48*	*38.35*	*154.49*	*8.56*	*NA,NO*
2008	*457.00*	*198.81*	*37.80*	*33.04*	*178.32*	*9.03*	*NA,NO*
2009	*455.93*	*190.97*	*39.07*	*25.58*	*188.60*	*11.72*	*NA,NO*
2010	*749.44*	*452.96*	*38.71*	*32.04*	*214.05*	*11.67*	*NA,NO*
2011	*846.92*	*569.00*	*13.73*	*36.13*	*215.86*	*12.20*	*NA,NO*
2012	*905.11*	*586.96*	*53.44*	*36.40*	*216.01*	*12.30*	*NA,NO*
2013	*848.75*	*553.79*	*13.90*	*38.48*	*229.53*	*13.05*	*NA,NO*
2014	*863.37*	*571.51*	*0.01*	*35.13*	*243.65*	*13.06*	*NA,NO*
2015	*791.23*	*479.57*	*0.81*	*41.73*	*254.52*	*14.60*	*NA,NO*
2016	*690.99*	*356.11*	*NO*	*45.69*	*275.02*	*14.17*	*NA,NO*
2017	*768.38*	*447.25*	*NO*	*38.52*	*267.87*	*14.74*	*NA,NO*
2018	*893.97*	*561.62*	*NO*	*54.27*	*263.09*	*14.99*	*NA,NO*
2019	*891.77*	*570.83*	*NO*	*47.77*	*255.11*	*18.07*	*NA,NO*
2020	*868.15*	*560.56*	*NO*	*43.11*	*248.91*	*15.56*	*NA,NO*
Share of total % in 2020	-	*64.6%*	-	*5.0%*	*28.7%*	*1.8%*	-
2020 versus 2019	*-2.6%*	*-1.8%*	*-100.0%*	*-9.7%*	*-2.4%*	*-13.9%*	-
2020 versus 1990	*32.3%*	*4.3%*	*-100.0%*	*-2.6%*	*1353.3%*	*221.6%*	-

Key categories under IPPU sector are listed in Table 4.2. Information regarding approaches used for key category analysis available in Chapter 1.5 and Annex 1.

Table 4.2 Key categories in IPPU sector in 2022 submission

Category	Gas	Identification criteria	with LULUCF	without LULUCF
2.A.1. Cement Production	*CO_2*	*L1,L2,T1,T2*	*X*	*X*
2.A.2. Lime Production	*CO_2*	*T1,T2*	*X*	*X*
2.A.4. Other process uses of carbonates	*CO_2*	*T1*		*X*
2.C.1 Iron and Steel Production	*CO_2*	*T1*		*X*
2.D.3. Solvent Use	*CO_2*	*L1,T2*		*X*
2.F.1. Refrigeration and air conditioning	*HFCs*	*L1,L2*	*X*	*X*

To achieve better time-series consistency planned improvements within the programme "European Economic Area Financial Mechanism 2009-2014 – National Climate Policy" are implemented. The use of the integrated database has enabled to identify some errors in previous calculations, leading to some improvements in time-series consistency.

4.2 *MINERAL INDUSTRY (CRF 2.A)*

4.2.1 Category description

2.A Mineral industry sector is the main emission source under IPPU sector. Sources of non-energy CO_2 emissions under 2.A sector is a cement production (98.3%), glass production (0.1%), ceramics (1.6%) and other use of soda ash (0.03%). Mineral industry sector GHG emissions amounts to 560.56 kt CO_2 eq. (5.4%) of total GHG emissions without LULUCF, with indirect CO_2 and 64.6% from total IPPU emissions in Latvia in 2020. The only lime production plant stopped lime production in 2016 therefore since 2016 emissions are not occurring (NO) in 2.A.2 sector.

In 2020, emissions from Mineral industry have increased by 4.3% since 1990 and decreased by 1.8% compared to 2019 (Figure 4.3 and Table 4.3).

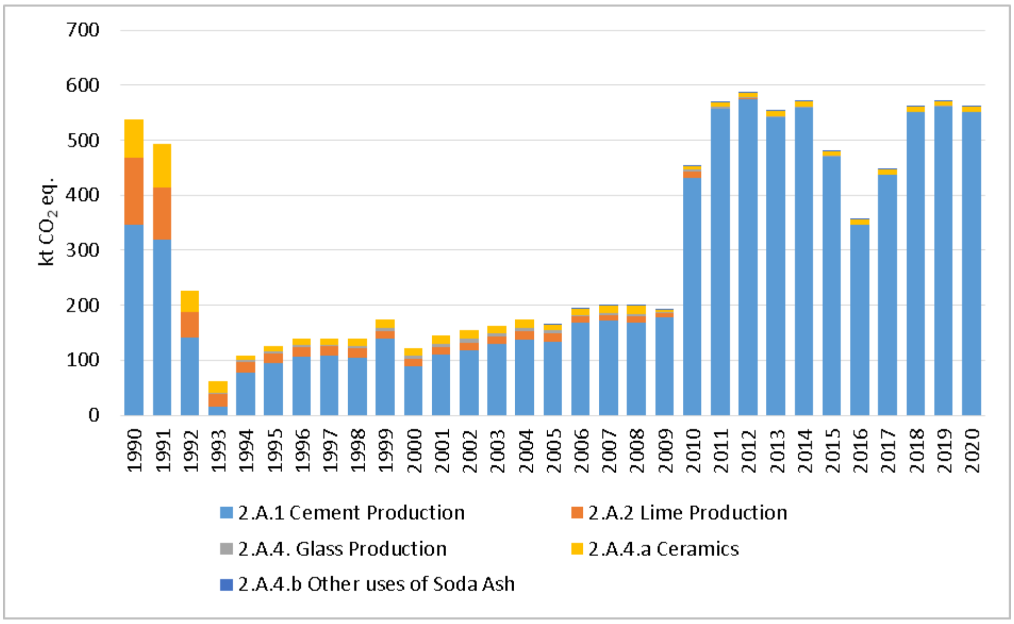

Figure 4.3 Emissions from Mineral industry in 1990–2020 (kt CO_2 eq.)

CO_2 emissions are strongly influenced by economic situation in the country. Emission curve reflects economic crisis in the period of time 1991–1993 after transition of national economy due to collapse of former Soviet Union market when significant amount of industrial producers stopped their activity (Table 4.3). Since 1993 Latvia`s economy started to revover and GDP started to increase hence industrial production and IPPU emissions increased untill 2007.

Due to Latvia's economic downturn in 2007–2008 the industry development was slowing down as the financing and real estate sectors started to dominate in national economy. In 2009-2010 emissions from 2.A.1 Cement production have been significantly growing due to setting up a new technology and installations increasing it`s capacity approximately 2.4 times. Cement industry reached it`s emissions peak in 2012. Afterwards emissions started to fluctuate and since 2014 the decrease in emissions from cement production can be observed. In 2016 compared to 2015 the amount of clinker production has decreased by 26.2% due to decrease of export amounts and reduced activity in building sector which caused lower demand for cement but then until 2020 there is an increase in emissions due to a growth in demand. So in 2020 the amount of clinker has decreased by 0.6% compared to 2019.

Table 4.3 Emissions from 2.A Mineral Industry in 1990–2020 (kt)

Year	CO_2						NO_x	CO	NMVOC	SO_2
	2.A	2.A.1	2.A.2	2.A.3	2.A.4.a	2.A.4.b				
1990	*537.24*	*345.78*	*121.91*	*0.36*	*69.18*	*NO*	*0.90*	*NO,NA,NE*	*0.16*	*3.41*
1995	*126.57*	*94.32*	*17.85*	*3.40*	*11.00*	*NO*	*0.24*	*NO,NA,NE*	*0.04*	*0.90*
2000	*122.68*	*88.37*	*13.97*	*5.93*	*14.41*	*NO*	*0.23*	*NO,NA,NE*	*0.04*	*0.85*
2005	*165.38*	*134.38*	*14.12*	*5.71*	*10.97*	*0.20*	*0.46*	*0.01*	*0.07*	*1.39*
2006	*193.11*	*169.24*	*9.74*	*2.68*	*11.21*	*0.22*	*0.54*	*0.01*	*0.08*	*1.72*
2007	*199.63*	*171.49*	*10.69*	*4.45*	*12.78*	*0.22*	*0.58*	*0.03*	*0.10*	*1.77*
2008	*198.81*	*167.70*	*11.97*	*4.04*	*14.91*	*0.20*	*0.57*	*0.03*	*0.09*	*1.75*
2009	*190.97*	*178.06*	*6.80*	*2.62*	*3.38*	*0.11*	*0.63*	*0.02*	*0.05*	*1.77*
2010	*452.96*	*430.57*	*12.31*	*4.49*	*5.49*	*0.10*	*0.59*	*0.85*	*0.03*	*0.12*

Year	CO_2						NO_x	CO	NMVOC	SO_2
	2.A	2.A.1	2.A.2	2.A.3	2.A.4.a	2.A.4.b				
2011	*569.00*	*556.96*	*0.09*	*4.34*	*7.51*	*0.10*	*1.11*	*1.78*	*0.03*	*0.41*
2012	*586.96*	*575.09*	*0.28*	*3.77*	*7.58*	*0.24*	*1.60*	*3.56*	*0.01*	*0.44*
2013	*553.79*	*540.50*	*0.25*	*3.30*	*9.12*	*0.62*	*1.64*	*2.62*	*0.01*	*0.23*
2014	*571.51*	*558.63*	*0.42*	*0.95*	*10.88*	*0.63*	*1.90*	*2.27*	*0.02*	*0.21*
2015	*479.57*	*470.31*	*0.46*	*0.48*	*7.64*	*0.67*	*1.97*	*1.68*	*0.02*	*0.25*
2016	*356.11*	*346.34*	*NO*	*0.62*	*8.82*	*0.34*	*1.41*	*0.71*	*0.02*	*0.10*
2017	*447.25*	*437.08*	*NO*	*0.73*	*9.27*	*0.18*	*1.75*	*1.28*	*0.01*	*0.08*
2018	*561.62*	*550.93*	*NO*	*0.75*	*9.78*	*0.16*	*2.13*	*1.48*	*0.02*	*0.11*
2019	*570.83*	*561.46*	*NO*	*0.57*	*8.67*	*0.12*	*2.09*	*2.42*	*0.02*	*0.10*
2020	*560.56*	*550.83*	*NO*	*0.68*	*8.86*	*0.19*	*1.95*	*2.60*	*0.02*	*0.20*
Share of IPPU total in 2020, %	*64.6%*	*63.5%*	*0.0%*	*0.1%*	*1.0%*	*0.0%*				
2020 versus 2019	*-1.8%*	*-1.9%*	*-100%*	*19.0%*	*2.1%*	*57.3%*	*-6.6%*	*7.4%*	*-0.5%*	*93.4%*
2020 versus 1990	*4.3%*	*59.3%*	*-100%*	*92.5%*	*-87.2%*	*-3.4%*	*116.2%*	*21722%*	*-88.9%*	*-94.1%*

Beside GHG emissions also SO_2, NO_x, NMVOC and CO emissions from cement production and NMVOC emissions from glass fibre production are reported under 2.A Mineral industry. NO_x, CO and NMVOC emissions from glass and cement production and SO_2 from glass production are reported in 2.A.4.d Other sector because it is not technically possible to enter data under relevant sectors in CRF Reporter.

Reported emissions and calculation methods for the 2.A Mineral Industry in Latvia`s GHG inventory are summarized in Table 4.4.

Table 4.4 GHG emission categories, methods and gases reported from 2.A Mineral Industry

Category	Method used	Gases reported
2.A Mineral Industry		
1. Cement Production	*Tier2*	*CO_2, CO, NMVOC, SO_2, NO_x*
2. Lime Production	*Tier2*	*CO_2*
3. Glass Production	*Tier3*	*CO_2, CO, NMVOC, SO_2, NO_x*
4. Other Process Uses of Carbonates		
4.a Ceramics		
Production of bricks	*Tier2*	*CO_2*
Production of tiles	*Tier1,2*	*CO_2*
4.b Other uses of soda ash	*Tier1*	*CO_2*

4.2.2 Cement Production (CRF 2.A.1)

4.2.2.1 Category description

In 2020, GHG emissions from Cement production were 550.83 kt CO_2 eq. (5.3%) of Latvia`s total CO_2 eq. emissions including indirect CO_2, without LULUCF and 63.5% from total IPPU sector emissions. Compared to 2019 emissions have decreased by 1.9%, but compared to 1990 emissions have increased by 59.3% (Table 4.3 and Figure 4.4).

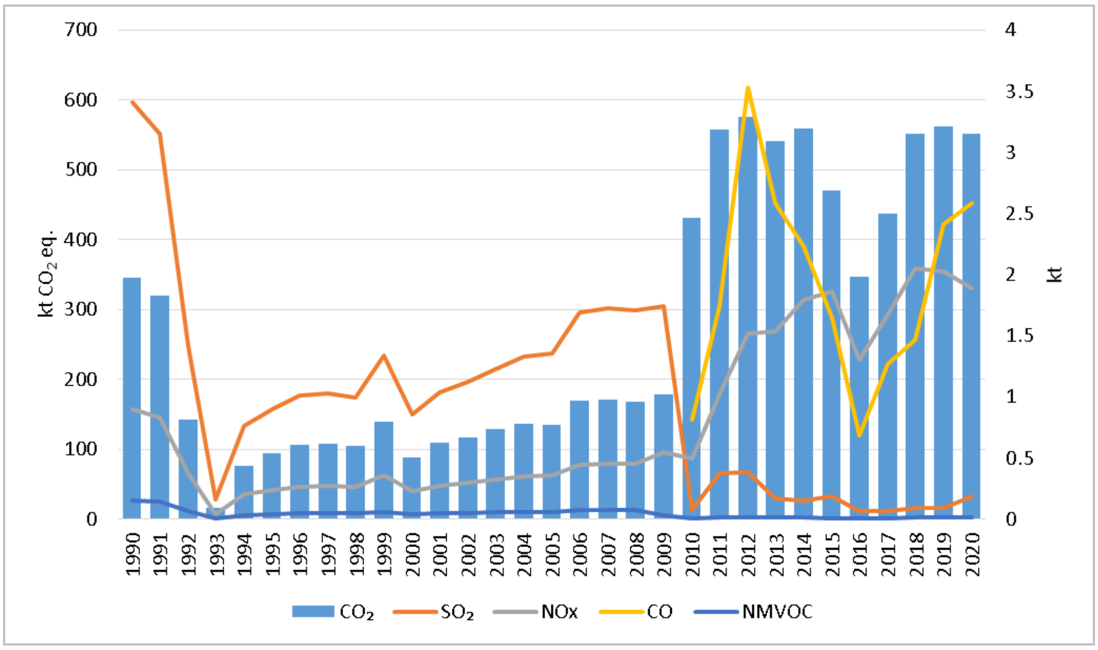

Figure 4.4 Emissions from Cement production in 1990–2020 (SO_2, NO_x, NMVOC and CO emissions on secondary axis) (kt CO_2 eq.; kt)

The emission curve represents the situation in national economy where the big decrease occurred in the beginning of the 1990s due to changes in national economy, domestic market and production demand. CO_2 emissions from Cement Production had decreased by 95.4% in 1990-1993. Increase of emissions in period 2000-2007 by 94.1% represents the development of building sector and development of external market. In the middle of 2009 new production plant with dry process kiln production technology was built instead of the old one where the wet process kiln technology was used. Consequently the cement kiln dust recovery was stopped and further cement kiln dust was collected and transported to landfill for storage. Therefore the amount of cement kiln dust and CKD/clinker ratio increased affecting CO_2 emissions.

NMVOC emissions have decreased in 2009-2010 by 72.0% due to adjustment of EF for new dry production process that is lower than for the old production plant's wet kiln process technology. SO_2, NO_x and CO emissions are automatically measured at plant site.

Starting from 2010 fully dry process kiln is used in cement production in Latvia. For 2009 both kiln processes - dry and wet was used in cement production. Previously (1990 – 2009 partly) only wet process kiln was used in cement production. Due to increasing activity for cement clinker production in 2010, decrease of SO_x emissions can be observed. Tyres and lube oil consisting of sulphur compounds were used as raw materials.

For 2010 SO_x, NO_x and CO data are not representative as new technology began to operate with full capacity only in July on 2nd half of year 2010 and fully in 2011. Emissions rapidly increased in 2010 due to capacity building in cement production comparing with previous years. Clinker production is depending on the demand in internal and external market. In 2016 amount of clinker production has decreased by about 26.1%, compared to 2015, due to decrease of exported amounts and decrease of building activities in Latvia. From 2017 to 2019 the amount of clinker has grown. But in 2020 the amount of clinker has decreased by 0.6% compared to 2019.

4.2.2.2 Methodological issues

Activity data

Data on the clinker production and cement kiln dust (CKD) are used as activity data for CO_2 emission calculation from 2.A.1 sector. As the only cement producer in Latvia participates in European Union Emission Trading Scheme (EU ETS), the activity data are available annually from the installation's annual GHG report[35] under the EU ETS. In 2019, the company changed its name from "Cemex" to "SCHWENK Latvija", but without changing its operations.

The clinker production is estimated from final produced amount of cement clinker because clinker production is not weighted directly in the cement production plant due to non-stop production process. As plant produces many types of cement, clinker activity data are estimated taking into account different cement types multiplying with cement/clinker ratio and also mass balance of cement, clinker and used additives in cement production. Based on the information from the cement producer, clinker production is estimated from cement production data and all incoming and outgoing volumes of material are weighed on calibrated car and rail scales.

Producer does the mass balance approach calculation at plant site. Final clinker data are calculated using plant mass balance approach in two steps:

1) Clinker production = ((cement export – cement stock changes) * clinker/cement ratio)) - clinker export – clinker stock changes ;
2) Clinker production = used clinker + clinker export – clinker import + clinker stock change.

The official CKD data for 1990-1994 are not available therefore the default CKD correction factor 1.02 according to the 2006 IPCC Guidelines is used. Since 1995 CKD data are available from cement plant. The CKD is weighted before the transportation outside the company for the storage. CKD ratio fluctuates from year to year depending on clinker production and CKD (Table 4.5).

Table 4.5 Clinker production and CKD/clinker ratio

Year	Clinker production (kt)	Produced cement kiln dust (kt)	CKD / clinker ratio (%)
1990	*668.50*	*NA*	*NA*
1995	*175.69*	*15.00*	*8.54*
2000	*167.18*	*10.00*	*5.98*
2005	*265.40*	*1.53*	*0.58*
2006	*330.65*	*2.89*	*0.87*
2007	*338.31*	*3.35*	*0.99*
2008	*334.46*	*0.99*	*0.30*
2009	*340.99*	*8.08*	*2.37*
2010	*834.94*	*7.02*	*0.84*
2011	*1095.23*	*10.87*	*0.99*
2012	*1129.11*	*13.29*	*1.18*
2013	*1054.95*	*12.43*	*1.18*
2014	*1093.04*	*12.92*	*1.18*

[35]*Polluting activity permit. Available: https://registri.vvd.gov.lv/izsniegtas-atlaujas-un-licences/atlauju-un-licencu-mekletajs/?company_name=schwenk&company_code=&s=1*

Year	Clinker production (kt)	Produced cement kiln dust (kt)	CKD / clinker ratio (%)
2015	*918.41*	*12.96*	*1.41*
2016	*678.27*	*9.02*	*1.33*
2017	*853.97*	*10.59*	*1.24*
2018	*1072.87*	*15.13*	*1.41*
2019	*1091.08*	*11.69*	*1.07*
2020	*1084.22*	*12.88*	*1.19*

Emission factors and calculations

CaO and MgO content in clinker production is measured in the cement plant therefore are plant specific.

Tier 2 method from the 2006 IPCC Guidelines is used for CO_2 EF and emission estimation. CO_2 emissions from clinker production are estimated using the 2006 IPCC Guidelines.

$$\boldsymbol{CO_2 Emissions = M_{cl} * EF_{cl} * CF_{ckd}} \quad (4.1)$$

where:

CO_2 Emissions - emissions of CO_2 from cement production (tonnes)
M_{cl} – weight (mass) of clinker production (tonnes)
EF_{cl} – emission factor for clinker, tonnes CO_2 /tonne clinker. This clinker emission factor (EF_{cl}) is not corrected for CKD
CF_{ckd} – emissions correction factor for CKD (dimensionless)

CO_2 EF is calculated using 2006 IPCC Guidelines for all time series according to the plant specific CaO content in used limestone and CKD correction factor.

$$\boldsymbol{EF_{clc} = (0.785 * CaO_{content}) * CKD_{correction}} \quad (4.2)$$

where:

EF_{clc} – clinker production EF (kt/kt)
0.785 – molecular weight ration of CO_2 to CaO in the raw material ($CaCO_3$)
CaO – CaO content (weight fraction) in clinker production (%)
$CKD_{correction}$ – correction factor for cement kiln dust

CKD correction factor is calculated using the 2006 IPCC Guidelines taking into account cement/clinker ratio, plant specific fraction of original carbonate in the CKD (Cd), fraction calcination of the original carbonate in the CKD (Fd), EFc from the 2006 IPCC Guidelines (0.43971 tCO_2/t carbonate) and clinker production EF without CKD correction (calculated by multiplying CaO content in clinker production with molecular weight ratio of CO_2 to CaO in the raw material (0.785 t/t)) (Table 4.6).

$$\boldsymbol{CF_{ckd} = 1 + \left(\frac{M_d}{M_{cl}}\right) * C_d * F_d * \left(\frac{EF_c}{EF_{cl}}\right)} \quad (4.3)$$

where:

CF_{ck} - emissions correction factor for CKD (dimensionless)
M_d - weight of CKD not recycled to the kiln (tonnes)
M_{cl} - weight of clinker production (tonnes)
C_d - fraction of original carbonate in the CKD (i.e., before calcination) (fraction)
F_d – fraction calcination of the original carbonate in the CKD (fraction)
EF_c – emission factor for the carbonate (tonnes CO_2 /tonne carbonate)

EF_{cl} - emission factor for clinker uncorrected for CKD (tonnes CO_2/ tonne clinker)

Table 4.6 Parametrs for EF_{clc} and CF_{CKD} emission factor calculation and emission factors 1990–2020

Year	CaO content (%)	MgO content (%)	Cd (%)	Fd (Fraction)	Clinker production EF without CKD correction factor	CKD correction factor	Clinker production EF with CKD correction factor
1990	*64.60*	*3.56*	*1.16*	*0.77*	*0.51*	*1.02*	*0.52*
1995	*64.06*	*3.76*	*1.17*	*0.78*	*0.50*	*1.07*	*0.54*
2000	*64.29*	*3.65*	*1.17*	*0.78*	*0.50*	*1.05*	*0.53*
2005	*64.21*	*3.79*	*1.16*	*0.78*	*0.50*	*1.00*	*0.51*
2006	*64.75*	*3.31*	*1.19*	*0.78*	*0.51*	*1.01*	*0.51*
2007	*64.06*	*4.01*	*1.18*	*0.78*	*0.50*	*1.01*	*0.51*
2008	*63.72*	*3.36*	*1.17*	*0.78*	*0.50*	*1.00*	*0.50*
2009	*65.27*	*2.95*	*1.21*	*0.78*	*0.51*	*1.02*	*0.52*
2010	*65.24*	*3.61*	*1.19*	*0.81*	*0.51*	*1.01*	*0.52*
2011	*64.34*	*3.61*	*1.13*	*0.70*	*0.51*	*1.01*	*0.51*
2012	*64.30*	*3.59*	*1.14*	*0.78*	*0.50*	*1.01*	*0.51*
2013	*64.65*	*3.51*	*1.14*	*0.82*	*0.51*	*1.01*	*0.51*
2014	*64.50*	*3.81*	*1.13*	*0.81*	*0.51*	*1.01*	*0.51*
2015	*64.52*	*3.85*	*1.11*	*0.81*	*0.51*	*1.01*	*0.51*
2016	*64.41*	*3.79*	*1.17*	*0.73*	*0.51*	*1.01*	*0.51*
2017	*64.57*	*3.64*	*1.12*	*0.81*	*0.51*	*1.01*	*0.51*
2018	*64.76*	*3.62*	*1.14*	*0.72*	*0.51*	*1.01*	*0.51*
2019	*65.21*	*3.40*	*1.10*	*0.52*	*0.51*	*1.01*	*0.51*
2020	*64.35*	*3.55*	*1.12*	*0.50*	*0.51*	*1.01*	*0.51*

Until 2009 Tier 2 approach from EMEP/EEA 2019 was used to calculate NO_x, NMVOC, SO_2 emissions from cement production taking into account of clinker production in wet and dry process kiln. EFs for NO_x, NMVOC and SO_2 are not available in EMEP/EEA 2019[36] therefore the EFs from EMEP/CORINAIR 2007[37] were used. Since 2010 NO_x, CO and SO_2 emissions are automatically measured in cement plant in dry process production therefore are plant-specific (data publicly available in the national database "2-Air"). The cement production plant "SCHWENK Latvija" has indicated in it`s "2-Air" report that emissions of precursors arise from technological processes which include also heat generation to maintain certain temperatures during particular process.

Regarding calculation of precursors since 2010, to avoid double counting fuel types used in cement production process in "SCHWENK Latvija" are subtracted from Energy part and their emissions can be considered as included elsewhere "IE" (2.A.1 sector under IPPU) in case of cement producer "SCHWENK Latvija".

For both technologies only NMVOC emissions are estimated using EFs provided in EMEP/CORINAIR 2007 for all timeseries (Table 4.7).

[36] EMEP/EEA air pollutant emission inventory guidebook 2019 2.A.1 Cement production. Available: https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/2-industrial-processes/2-a-mineral-products/2-a-1-cement-production/view
[37] EMEP/CORINAIR Emission Inventory Guidebook – 2007. Available: https://www.eea.europa.eu/publications/EMEPCORINAIR5/page013.html

Table 4.7 EFs for cement clinker production emission estimation (kt/kt)

Technology	NO_x	NMVOC	SO_2
Wet process kiln	*0.00135*	*0.00023*	*0.0051*
Dry process kiln	*0.00175*	*0.00001*	*0.0051*

4.2.2.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty of cement production data is taken from Cement production installation's annual GHG report under the EU ETS (2.5% uncertainty for activity data of clinker production and 7.5% uncertainty for activity data of CKD).

The total uncertainty U_{total} is being calculated, using following formula of combined uncertainty:

$$\boldsymbol{U_{total}} = \sqrt{(\boldsymbol{U_1^2} + \boldsymbol{U_2^2} + \cdots + \boldsymbol{U_n^2})} \quad (4.4)$$

where:

U_{total} - the percentage uncertainty in the product of the quantities
U_i - the percentage uncertainties associated with each of the quantities

Combined activity data uncertainty is calculated as 8%.

CO_2 EF for 2.A.1 sector is estimated based on plant specific data of used limestone characterizations so average uncertainty of 4.5% is assumed according to the 2006 IPCC Guidelines.

Time series of the estimated emissions are consistent and complete because the same methodology, EFs and data sources are used for sectors for all years. GHG emissions from the sector are estimated or reported excepting 2.A.4.c sector for wich NO is reported.

All industrial production historical data used in emission estimation from 2.A Mineral Products sector till 2005 are obtained from mineral producers, but since 2005 data are taken from annual GHG reports that industrial producers submit within the EU ETS. According to the EU ETS legislation all GHG reports have to be verified by an ISO accredited verifiers checks whether all reported information – activity data, CO_2 EFs, estimated emissions as well as estimation methodology, is correct and corresponds to certain requirements from the legislation. Cement and lime production facilities certify that all additional information for CO_2 emission estimation is verified. State Environmental Service also checks the annual GHG reports and compares the data in the reports with the data reported by the enterprise to the national database "2-Air" and to CSB.

Consistency of time series was checked by verifying IEF, AD and emission changes. Fluctuations in time series are explained in NIR.

4.2.2.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the IPPU sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

Emissions are checked using time series consistency check for the IEF estimated in CRF Reporter and all IEF changes - in time series are double-checked and reasonable explanation for IEF changes has to be found under each subsector source category description.

Quality control check list is filled for each category taking into account criteria given in QA/QC plan approved in National legislation. All corrections are archived.

In September 2020, there was a conversation with a representative from cement production plant, who confirmed the amount of produced clinker, and that all materials in the plant are weighed on calibrated scales thus strengthening the institutional, legal and procedural arrangements for national systems where data collection and evaluation are carried out by other organizations.

Data comparison between EU ETS data and GHG inventory emissions was made. Results of checks are represented in Table 4.8.

Table 4.8 Differences between 2.A.1 CO_2 emissions calculated in GHG inventory and EU ETS in 2020

2.A.1 Cement Production (kt CO_2 eq.)			Difference (%)
Year	IPCC methodology 2006 IPCC Guidelines Volume 3 Chapter 2 equation 2.2	EU Monitoring and Reporting Regulation[38] Art.30 and 31.	
2020	*550.83*	*575.98*	*4.6*

Differences between CO_2 emissions under EU ETS and GHG inventory are caused by use of different emission calculation methodologies from cement production under UNFCCC reporting (2006 IPCC Guidelines) and European Union Monitoring Reporting Regulation (EU MRR). There is only one cement plant in Latvia which uses Tier 1 method under EU ETS reporting. In Tier 1 default EFs are taken for CO_2 emission calculation as it is not possible to obtain all necessary laboratory measurements in plant laboratory to apply higher Tier method under EU ETS as this laboratory is not accredited.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

4.2.2.5 Category-specific recalculations

No recalculations were done for this sector.

4.2.2.6 Category-specific planned improvements

No improvements are planned for this sector.

[38] *COMMISSION REGULATION (EU) No 601/2012. Available : http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012R0601&from=EN*

4.2.3 Lime Production (CRF 2.A.2)

4.2.3.1 Category description

In Latvia CO_2 emissions of 2.A.2 Lime production occur from calcination of dolomite ("Saulkalne S" - 1990-2015 except 2011) and limestone ("Būvmateriāli AN" - 2007-2015). In 2016, "Saulkalne S" ceased lime production therefore since 2016 CO_2 emissions from lime production are not occurring (NO). In 2020, CO_2 emissions from 2.A.2 sector have decreased by 100% compared to 1990 and 2015 (Figure 4.5). In 2011, dolomite was not used in lime production and production was stopped due to exhausted limestone career and preparation of implementing the highest best available technology (BAT) according to information by lime production plant but emissions from Lime production, but in 2011 emissions from Lime production occurred from limestone use ("Būvmateriāli AN").

CO_2 emissions from non-marketed lime (quicklime) produced in iron & steel industry are also accounted under 2.A.2 sector according to the 2006 IPCC Guidelines. These emissions are added since 2018 submission for the time period 1990-2010.

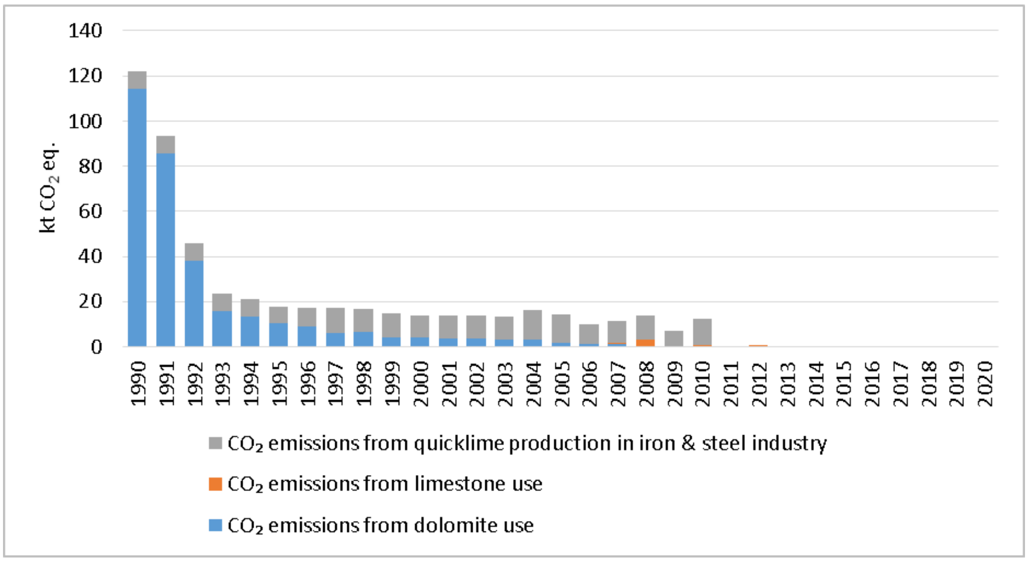

Figure 4.5 CO_2 emissions from lime production 1990–2020 (kt CO_2 eq.)

CO_2 emissions from dolomite use in lime production are continuously decreasing since the beginning of 1990s due to recession of overall national economy. Economic crisis also affected lime production in 2008-2009. After 2009 emissions from lime production remained very small and fluctuated due to economic situation and changes in industrial activities in the country but in 2016 the lime production has been fully stopped.

4.2.3.2 Methodological issues

Activity data

Data on total produced lime from dolomite and limestone was used as activity data for emission calculation from 2.A.2 sector. It means that different types of lime were used as activity data. As both lime producers in Latvia were participants of EU ETS, the activity data were available annually from the installation's annual GHG reports under EU ETS[39, 40]. Activity data before 2005 were available from the installation's applications for the GHG permit to operate within the EU ETS.

Limestone in lime production were used 2007-2012. Since 2013 limestone is not used anymore, but dolomite was still used in lime production in one plant till 2015 (Table 4.9).

Limestone is also used for non-marketed lime (quicklime) production in iron and steel industry. Amounts of limestone for the production of quicklime are used to determine activity data and CO_2 emissions within the iron and steel industry. The quantities were obtained directly from the iron and steel production company and for the period 2005-2010 from the installation's annual GHG reports under the EU ETS[39,40].

Activity data are summarized in Table 4.9.

Table 4.9 Lime and quicklime production AD and amount of produced lime 1990–2020 (kt)

Year	Total produced lime from lime	Total produced lime from dolomite	Limestone used in quicklime production (iron & steel industry)
		Kt	
1990	*NO*	*214.23*	*10.45*
1995	*NO*	*19.21*	*10.45*
2000	*NO*	*7.89*	*13.42*
2005	*NO*	*3.16*	*17.10*
2006	*NO*	*2.23*	*11.76*
2007	*0.60*	*1.90*	*12.94*
2008	*2.05*	*0.48*	*14.84*
2009	*0.13*	*0.58*	*8.85*
2010	*0.20*	*0.66*	*16.32*
2011	*0.20*	*NO*	*NO*
2012	*0.18*	*0.37*	*NO*
2013	*NO*	*0.47*	*NO*
2014	*NO*	*0.79*	*NO*
2015	*NO*	*0.87*	*NO*
2016	*NO*	*NO*	*NO*
2017	*NO*	*NO*	*NO*
2018	*NO*	*NO*	*NO*
2019	*NO*	*NO*	*NO*
2020	*NO*	*NO*	*NO*

Activity data fluctuates in whole time series. The largest decrease could be observed at the beginning of 1990s when enonomic situation in the country was unstable due to change from a centrally planned economy to a market economy. In latest years there is an overall decrease of activity in sector 2.A.2 due to reduced industrial activity.

[39] GHG reports for period till 2012. Available: http://www.meteo.lv/lapas/uznemumi-kuriem-izsniegtas-siltumnicefekta-gazu-emisijas-atlaujas-2-pe?id=1253&nid=575

[40] GHG reports for period since 2013. Available: https://registri.vvd.gov.lv/izsniegtas-atlaujas-un-licences/atlauju-un-licencu-mekletajs/?company_name=saulkalne&company_code=&s=1

Emission factors and calculations

CO_2 emissions from limestone and dolomite use in lime production and non-marketed quicklime production in iron & steel industry were estimated using Tier 2 method from the 2006 IPCC Guidelines Volume 3, Chapter 2, pp. 2.23:

$$\boldsymbol{CO_{2\ Emissions}} = (\boldsymbol{EF_{lime,i}} * \boldsymbol{M_l} * \boldsymbol{CF_{lkd}} * \boldsymbol{C_h}) \quad (4.5)$$

where:

CO_2 Emissions - emissions of CO_2 from lime production (tonnes)
EF lime,i - emission factor for lime type i, tonnes CO_2/tonne lime (estimated according Equation 2.9)
Ml,i - lime production of type i (tonnes)
CF lkd,i - correction factor for LKD for lime of type (dimensionless) (default 1.02 according to the 2006 IPCC Guidelines, Volume 3, Chapter 2, pp. 2.24 is used)
Ch,i - correction factor for hydrated lime of the type i of lime (dimensionless) (default 0.97 according to the 2006 IPCC Guidelines, Volume 3, Chapter 2, pp. 2.24 is used only in case of quicklime emission estimation)
i –each f specific lime types (dolomite, hydraulic and quicklime)

According to the 2006 IPCC Guidelines the CO_2 EF from dolomite use in lime production were calculated taken into account Tier 2 equation 2.9 and derived plant specific CaO*MgO content.

$$\boldsymbol{EF_{lime}} = \boldsymbol{SR_{CaO*MgO}} * \boldsymbol{CaO} * \boldsymbol{MgO\ Content} \quad (4.6)$$

where:
EF $_{lime}$ - emission factor for dolomite lime (tonnes CO_2/tonne lime)
*SR $_{CaO*MgO}$ – stoichiometric ratio of CO_2 and CaO*MgO (tonnes CO_2/tonne CaO*MgO)*
*CaO*MgO content – derived CaO*MgO content (tonnes CaO*MgO/tonne lime)*

CO_2 EF from limestone use in lime production were calculated taken into account Tier 2 equation 2.9 and derived plant specific CaO content.

$$\boldsymbol{EF_{lime}} = \boldsymbol{SR_{CaO*MgO}} * \boldsymbol{CaO\ Content} \quad (4.7)$$

where:
EF lime - emission factor for hydraulic lime (tonnes CO_2/tonne lime)
SR CaO – stoichiometric ratio of CO_2 and CaO (tonnes CO_2/tonne CaO)
CaO content – derived CaO content (tonnes CaO /tonne lime)

CO_2 EF for quicklime is also calculated according to equation:

$$\boldsymbol{EF_{lime}} = \boldsymbol{SR_{CaO}} * \boldsymbol{CaO_{Content}} \quad (4.8)$$

where:

$EF_{lime\ a}$ - emission factor for quicklime (high-calcium lime) (tonnes CO_2/tonne lime)
SR_{CaO} - stoichiometric ratio of CO_2 and CaO (0.785 according to Table 2.4 of the 2006 IPCC Guidelines, Volume 3, Chapter 2, pp.2.22) (tonnes CO_2/tonne CaO)
CaO $_{Content}$ - derived CaO content (tonnes CaO/tonne lime)

Table 4.10 CO_2 emission factors for lime production (t CO_2/t raw material)

	1990–2020
Dolomite use in lime production	*0.523155*
Limestone use in lime production	*0.439600*
Quicklime production	*0.749675*

According to the plant`s laboratory data:

- average content of water in dolomite is 5.24%;
- average content of water in produced lime is 0%;
- average content of dolomite (dry) is 94.76%.

Average moisture content in dolomite (5.24%) is taken into account when activity data of used dolomite is estimated for the inventory. The amount of used dolomite (wet) are multiplied with moisture content coefficient k=0.9476. As a result amount of dry dolomite is obtained. CO_2 emissions are calculated by multiplying dry dolomite amount with derived EF and default CF_{lkd} correction factor for LKD for lime (1.02).

4.2.3.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty of lime production activity data is taken from Lime production installation's GHG report under EU ETS (7.5 % uncertainty for activity data of lime production).

CO_2 EF for 2.A.2 sector is estimated based on plant specific data of used dolomite characterizations so average uncertainty of 2% is assumed according to the 2006 IPCC Guidelines.

Time series of the estimated emissions are consistent and complete because the same methodology, EFs and data sources are used for sectors for all years in time series. All other GHG emissions except CO_2 emissions could not be reported in CRF Reporter.

Consistency of time series was checked by verifying IEF, AD and emission changes and attention was paid to increase/decrease that are explained in NIR.

4.2.3.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the IPPU sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

Activity data are taken from the annual GHG reports that lime production plant submits within EU ETS. According to EU ETS legislation all GHG reports have to be verified by an ISO accredited verifier that checks that all reported information is correct and corresponds to certain requirements from the legislation. State Environmental Service also checks the annual GHG reports and approves the report if everything reported is correct.

Emissions are checked using time series consistency check for the IEF estimated in CRF Reporter and all IEF changes in time series are double-checked and reasonable explanation for IEF changes has to be found under each subsector source category description.

The QC form has been filled in for each category taking into account criteria given in QA/QC plan approved in National legislation.

Data comparison between EU ETS data and GHG inventory emissions was made. Differences in 2013-2015 ocuured due to methodological inconsistencies between IPCC and EU ETS methodology. Under EU ETS lime producer using dolomite (one company in Latvia) used EU MRR methodology and calculated EF differently from the 2006 IPCC Guidelines by taking into account CO_2 content 16.99% in lime.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

4.2.3.5 Category-specific recalculations

No recalculations were done for this sector.

4.2.4 Glass production (CRF 2.A.3)

4.2.4.1 Category description

Glass production sector constitutes 0.68 kt CO_2 eq. which is less than 0.1% of total IPPU emissions in Latvia in 2020.

CO_2 emissions from 2.A.3 sector have increased by 92.5% since 1990 and by 19.0% compared to 2019 (Figure 4.6 and Table 4.3).

Emissions are calculated using the use of carbonates as activity data. Emissions from raw materials used in glass production are reflected in Figure 4.6.

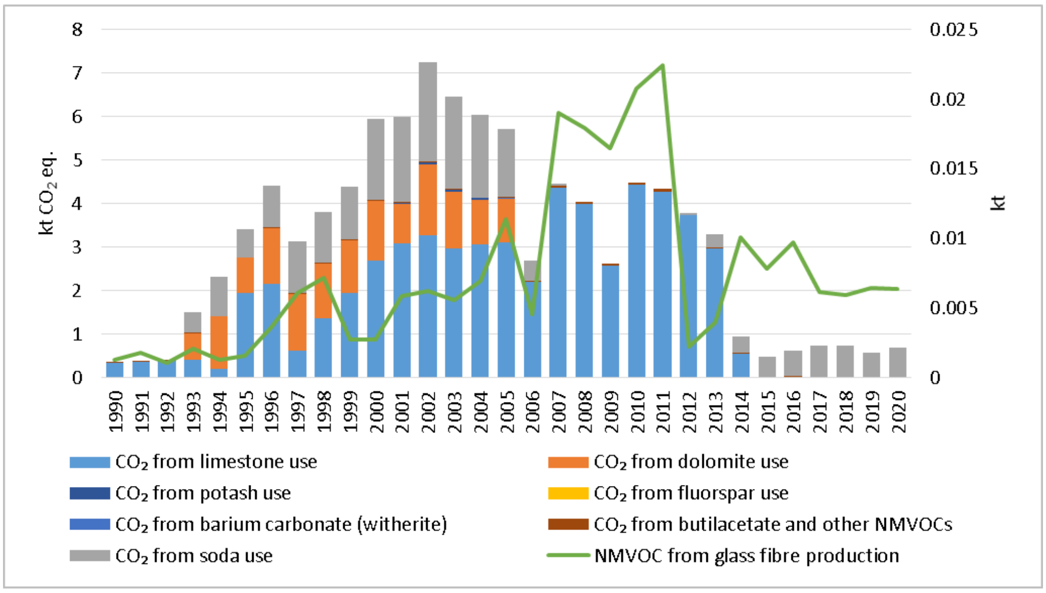

Figure 4.6 Emissions from raw materials used in glass production 1990-2020 (NMVOC emissions on secondary axis) (kt CO_2 eq.; kt)

Limestone, dolomite, fluorspar, potash, witherite (barium carbonate), butilacetate and soda ash are typically used as raw materials in the production of glass in Latvia from which CO_2 emissions are calculated. Additionally NMVOC emissions from glass production and glass fibre production were reported by production facilities. CO_2 emissions from glass fibre production processes are estimated from NMVOC emissions due to lack of CO_2 EFs and activity data to CO_2

emissions directly. NMVOC emissions are fluctuating in whole timeseries because use of raw materials depends on market demand.

4.2.4.2 Methodological issues

Activity data

Activity data of used carbonates are collected from individual glass and glass fibre producing company`s annual GHG reports under EU ETS[41] as well as installations applications for the GHG permit to operate within the EU ETS system before 2005.

Amount of raw materials used in glass production is quite small and fluctuates in whole time series. Potash was used in two glass production facilities from 2001-2007. Use of witherite occured in 2005-2007 and 2016, but emissions from fluorspar have been estimated in 1993-2012.

NMVOC emissions for 1997-2020 were taken from the national database "2-Air" where the only glass fiber producer reported it`s emissions divided by NMVOC sub-type. For time period 1990-1996 only butylacetate data was available from the installation's application for the GHG permit to operate within to EU ETS (Table 4.11).

Table 4.11 Activity data for raw materials use in glass production 1990-2020 (kt)

Year	Use of potash	Use of fluorspar	Use of barium carbonate (whiterite)	Use of butylacetate and other NMVOCs	Use of dolomite	Use of limestone	Soda ash use
1990	*NO*	*NO*	*NO*	*0.001*	*NO*	*0.80*	*NO*
1995	*NO*	*0.12*	*NO*	*0.002*	*1.70*	*4.43*	*1.55*
2000	*NO*	*0.08*	*NO*	*0.003*	*2.88*	*6.13*	*4.48*
2005	*0.04*	*0.27*	*0.01*	*0.011*	*2.09*	*7.07*	*3.74*
2006	*0.02*	*0.22*	*0.02*	*0.005*	*NO*	*4.99*	*1.12*
2007	*0.01*	*0.20*	*0.01*	*0.019*	*NO*	*9.90*	*0.09*
2008	*NO*	*0.26*	*NO*	*0.018*	*NO*	*9.07*	*NO*
2009	*NO*	*0.41*	*NO*	*0.016*	*NO*	*5.85*	*NO*
2010	*NO*	*0.62*	*NO*	*0.021*	*NO*	*10.07*	*NO*
2011	*NO*	*0.59*	*NO*	*0.022*	*NO*	*9.73*	*NO*
2012	*NO*	*0.64*	*NO*	*0.002*	*NO*	*8.47*	*0.09*
2013	*NO*	*NO*	*NO*	*0.004*	*NO*	*6.77*	*0.74*
2014	*NO*	*NO*	*NO*	*0.010*	*NO*	*1.26*	*0.88*
2015	*NO*	*NO*	*NO*	*0.008*	*NO*	*NO*	*1.10*
2016	*NO*	*NO*	*0.02*	*0.010*	*NO*	*NO*	*1.40*
2017	*NO*	*NO*	*NO*	*0.006*	*NO*	*NO*	*1.72*
2018	*NO*	*NO*	*NO*	*0.006*	*NO*	*NO*	*1.76*
2019	*NO*	*NO*	*NO*	*0.006*	*NO*	*NO*	*1.34*
2020	*NO*	*NO*	*NO*	*0.006*	*NO*	*NO*	*1.60*

[41] *Polluting activity permit. Available: https://registri.vvd.gov.lv/izsniegtas-atlaujas-un-licences/atlauju-un-licencu-mekletajs/?company_name=stikla+%C5%A1%C4%B7iedra&company_code=&s=1*

Dolomite was used in two glass production plants from 1993 till 2005, but limestone - in two plants from 1990 till 2014. In 2016 soda ash and barium carbonate are used as raw materials in glass production but from 2017 onwards only soda ash is used as raw materials.

Emission factors and calculations

Emissions are calculated using Tier 3 method (Equation 2.12 from the 2006 IPCC Guidelines), as various types of carbonates consumed for glass production have been collected from annual GHG reports by glass producers under EU ETS.

$$CO_{2\,Emissions} = (M_i * EF_i * F_i) \tag{4.9}$$

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 - weight or mass of the carbonate i consumed (tonnes)
F_i - fraction calcination achieved for the carbonate I (fraction)

According to the 2006 IPCC Gudelines it was assumed that the fraction calcination is equal to 1.00.

CO_2 EFs used to estimate emissions from use of raw materials in glass production are taken from the 2006 IPCC Guidelines (Volume 3, Chapter 2, pp. 2.7, Table 2.1) and plants annual GHG reports within EU ETS (Table 4.12). NMVOC emissions for time period 1997-2020 are taken from the national database "2-Air" where both glass production and glass fibre production companies report their emissions.

Table 4.12 Emission factors for materials use in glass production (t emissions / t product or raw material)

Used material	1990 – 2020
Fluorspar	*0.0017*
Potash	*0.32*
Barium carbonate (witherite)	*0.223*
Butylacetate (NMVOC)[42]	*1.0*
Limestone	*0.440*
Dolomite	*0.477*
Soda ash	*0.415*

Emissions of precursors from glass fibre production processes were estimated according to the 2006 IPCC Guidelines. CO_2 EF is not provided in methodology and it is not possible to obtain activity data for direct CO_2 emission estimation.

NMVOC emissions were taken as activity data for CO_2 calculation and CO_2 emissions were estimated using carbon conversion factor.

$$E_{CO_2} = EF_{CO_2} * NMVOC \tag{4.10}$$

where:

E_{CO2} – CO_2 emissions (kt)
EF_{CO2} – estimated CO_2 emission factor
NMVOC – NMVOC emissions (kt)

[42] *For emission estimation only for year 1990-1996, since 1997 the plant reported data from the national database "2-Air" is used*

For CO_2 emission from glass fibre production estimation 80% of carbon content conversion factor was used. According to the 2006 IPCC Guidelines[43], indirect emissions of CO_2 from amospheric oxidation of emitted NMVOC are calculated and reported in the inventory. The average amount of carbon in NMVOC is assumed to be 80%[44].

The CO_2 EF from the 2006 IPCC Guidelines was estimated using following equation:

$$\boldsymbol{EF_{CO_2} = 80\% * \frac{44.0098}{12.011}} \qquad (4.11)$$

where:

EF_{CO2} – CO_2 emission factor (kt/kt)
80% – the average amount of carbon in NMVOC
44.0098 / 12.011 – carbon dioxide and carbon molmass ratio

This leads to an EF for indirect CO_2 release of 2.931299642 kg CO_2/kg NMVOC.

4.2.4.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty of glass production activity data is taken from Glass production installations' GHG report under EU ETS (2.5% uncertainty for activity data of glass production). The uncertainty is quite low as plant specific reported data is used. Accredited verifiers verify and State Environmental Service approves the activity data reported in production plant's annual GHG reports within EU ETS so the activity data is adequately verified.

As default EFs for limestone, dolomite and soda ash use are used the uncertainty is assumed quite high. Other CO_2 EFs for this sector are taken from glass production plant. As the default Tier 1 methodology is used for emission calculation from glass production sector, the default EF uncertainty 2% from the 2006 IPCC Guidelines is used.

Time series of the estimated emissions are consistent and complete because the same methodology, EFs and data sources are used for sectors for all years in time series. All emissions with exception of CO_2 emissions for use of fluorspar and potash as well as NMVOC emissions for glass fibre production are not estimated due to lack of estimation methodology.

Consistency of time series was checked by verifying IEF, AD and emission changes and attention was paid to important increase/decrease that are explained in NIR.

4.2.4.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the IPPU sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

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[43] 2006 IPCC Guidelines, Vol.1 Ch.7. Available : http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_7_Ch7_Precursors_Indirect.pdf (page 7.6)
[44] Basing of the most often used average carbon conversion factor

Activity data, CO_2 EFs and estimated emissions from glass production plants are taken from the annual GHG reports that installations submit within the EU ETS. All GHG reports are verified by an ISO accredited verifier that checks that all reported information is correct and corresponds to certain requirements from the legislation. State Environmental Service also checks the annual GHG reports and approves the report if everything reported is correct.

Data comparison between EU ETS data and GHG inventory emissions was made. Small differences are represented in Table 4.13.

Table 4.13 Differences between 2.A.3 CO_2 emissions calculated in GHG inventory and EU ETS in 2020

2.A.3 Glass production			Difference
kt CO_2 eq.			%
Year	2006 IPCC Tier 3 method	EU MRR[45] Annex IV section 11	
2020	*0.68*	*0.67*	*-2.7*

Difference is caused because under EU ETS soda use in wastewater neutralization is reported under 2.A.3 Glass production, but in GHG inventory soda use in wastewater neutralization in glass fibre production company is reported in separate subsector 2.A.4.b Other uses of soda ash.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

4.2.4.5 Category-specific recalculations

No recalculations were done for this sector.

4.2.4.6 Category-specific planned improvements

No improvements are planned for this sector.

4.2.5 Ceramics (2.A.4.a)

4.2.5.1 Category description

Under Ceramics sector CO_2 emissions from bricks and tiles production are reported. Ceramics sector emissions constituted 8.86 kt (1.0%) of total IPPU emissions in Latvia in 2020. CO_2 emissions from 2.A.4.a sector decreased by 87.2% since 1990 and increased by 2.1% compared to 2019 (Figure 4.7).

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[45] *COMMISSION REGULATION (EU) No 601/2012. Available: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012R0601&from=EN*

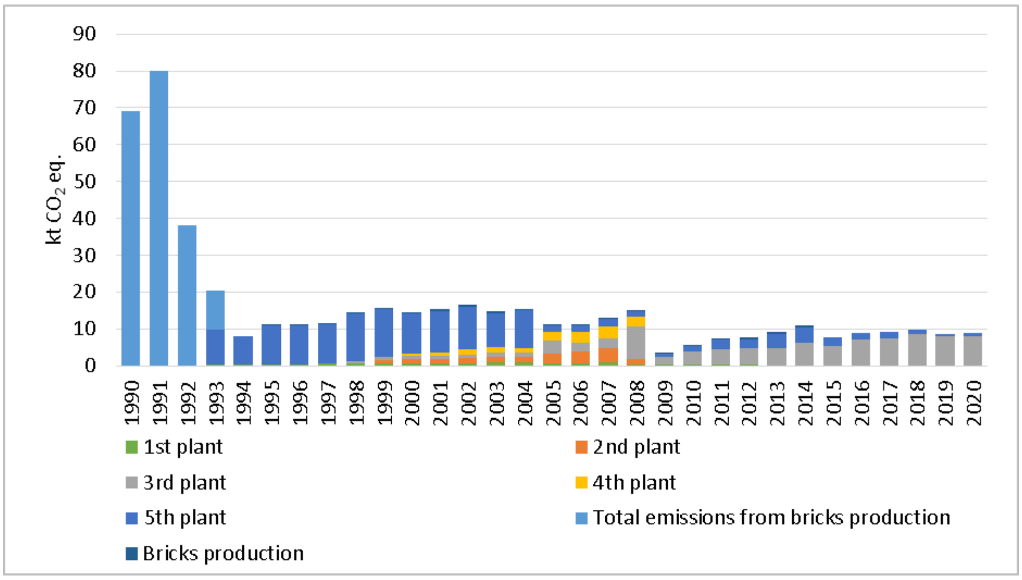

Figure 4.7 CO_2 emissions from bricks and tiles production 1990-2020 (kt)

Bricks production has strong traditions in Latvia as production plants operate many decades, for example in bricks production plant "Lode" the brick production was started in 1964. Still from 5 now operating bricks production plants only two were operating up to 1990. There is no information if the other companies were working for time period 1990-1993 what is not covered by GHG permit application requirements.

In 1990-1993, CO_2 emissions were estimated only using total produced bricks amount due to lack of data for raw materials used in bricks production companies No 1 and No 5. After 1993 it was possible to estimate CO_2 emissions for each plant separately.

There is only one tiles production plant in Latvia and CO_2 emissions from use of clay in tile production process in 1995-2014 are reported in 2.A.4.a sector. The tiles production plant and all bricks production plants are covered by the EU ETS so the data from the installation annual GHG reports are available for GHG inventory.

CO_2 emissions from Ceramics are decreasing 1990-1994 due to recession of overall national economy. 1995-2008 emission trend is quite stable, but in 2009 CO_2 emissions decreased approximately 4 times as a result of economic crisis because the building and construction sector became inactive. In later years emissions slightly increased depending on demand for construction materials (Figure 4.7).

4.2.5.2 Methodological issues

For 1990-1993 no plant specific data is available from bricks production plants therefore CO_2 emission estimation for these 3 years is done based on final produced bricks amount taking into account average weight of one brick. Average weight of one brick is 3.9 kg. According to plant data average produced bricks/used clay ratio is 1.25.

If final amount of produced bricks is known, it is possible to estimate approximate clay consumption (Table 4.14). In CO_2 emission estimation EF 0.047 tCO_2/t used clay is applied.

Table 4.14 Data and assumptions used for CO_2 emission estimation for 1990-1993

	1990	1991	1992	1993
produced bricks (thousand pieces)	*471800*	*546423*	*259918*	*722020*
average weight of one brick (kg)	*3.9*	*3.9*	*3.9*	*3.9*
produced bricks (tonnes)	*1840020*	*2131049.7*	*1013680.2*	*281587.8*
average produced bricks / used clay ratio	*1.25*	*1.25*	*1.25*	*1.25*
used clay (kt)	*1472.016*	*1704.84*	*810.9442*	*225.2702*
CO_2 emission factor of used clay tCO_2/t used clay	*0.047*	*0.047*	*0.047*	*0.047*
CO_2 emissions (kt)	*69.1848*	*80.1275*	*38.1144*	*10.5877*

Since 1994 CO_2 emissions are estimated differently in five Latvia's brick production plants because it was possible to use higher tier of emission estimation due to availability of necessary activity data and laboratory measurements of used raw materials.

1st bricks production plant

According to 1st bricks installations application for a GHG permit and annual GHG reports for 2005-2009 under the EU ETS the plant has changed CO_2 emission estimation methodology 3 times:

1. CO_2 emission for time period 1993-2004 was estimated by using used clay as an activity data and CO_2 EF for used clay – 0.047 t CO_2/t used clay. The particular EF is determined for total used clay data when clay characterizations are not known. CO_2 emissions are determined by ignition loses of clay: in 1000 °C – 4.7% of instant CO_2 is emitted).
2. For 2005-2007 the plant is using calculation method B – alkali earth oxides, from the from EU Monitoring Reporting Guidelines (MRG)[46] when calculation is based on the content of the CaO, MgO and other (earth) alkali.
3. For years 2008-2012 plant is using the calculation method "A" – carbon input, from the MRG when calculation is based on the carbon input on each of the relevant raw materials. Tier 1 EFs from the MRG corresponding particular method are used when conservative value of 0.2 tonnes $CaCO_3$ (0.08794 tonnes of CO_2) per tonne of dry clay is applied for the calculation of the EF instead of results of analyses.

Activity data

As MgO and CaO content data was not available for years 1993-2004 therefore the data reported in bricks production plant's GHG report for 2005 was used: MgO content – 4.9%, CaO content – 11.6%.

As for years 2008-2009 different emission estimation methodology is used and MgO and CaO data is not available content data of 2006-2007 was used also to estimate emissions for 2008-2012: MgO content – 2.9%, CaO content – 10.26%.

[46] *EU Monitoring Reporting Guidelines. Available: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:LV:PDF*

Table 4.15 Data and assumptions used for CO_2 emission estimation from 1st bricks production plant

Year	Use of clay (kt)	MgO content (%)	CaO content (%)	MgO amount (kt)	CaO amount (kt	MgO CO_2 EF (tCO_2/t oxide)	CaO CO_2 EF (tCO_2/t oxide)	CO_2 emissions (kt)	Average CO_2 EF (tCO_2/t oxides)
1990	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
1995	*2.700*	*4.90%*	*11.60%*	*0.132*	*0.313*	*1.092*	*0.785*	*0.390*	*0.876*
2000	*4.800*	*4.90%*	*11.60%*	*0.235*	*0.557*	*1.092*	*0.785*	*0.694*	*0.876*
2005	*5.257*	*4.90%*	*11.60%*	*0.258*	*0.610*	*1.092*	*0.785*	*0.760*	*0.876*
2006	*6.245*	*2.90%*	*10.26%*	*0.181*	*0.641*	*1.092*	*0.785*	*0.701*	*0.853*
2007	*7.745*	*2.90%*	*10.26%*	*0.225*	*0.795*	*1.092*	*0.785*	*0.869*	*0.853*
2008	*3.880*	*2.90%*	*10.26%*	*0.113*	*0.398*	*1.092*	*0.785*	*0.435*	*0.853*
2009	*2.268*	*2.90%*	*10.26%*	*0.066*	*0.233*	*1.092*	*0.785*	*0.254*	*0.853*
2010	*1.922*	*2.90%*	*10.26%*	*0.056*	*0.197*	*1.092*	*0.785*	*0.216*	*0.853*
2011	*1.698*	*2.90%*	*10.26%*	*0.049*	*0.174*	*1.092*	*0.785*	*0.191*	*0.853*
2012	*1.670*	*2.90%*	*10.26%*	*0.048*	*0.171*	*1.092*	*0.785*	*0.187*	*0.853*

Since 2013 1st bricks production plant is not operating anymore.

Emission factors and calculations

CO_2 emissions in whole timeseries was calculated by using calculation method B – alkali earth oxides, from the MRG[47] when calculation is based on the content of the CaO, MgO and other (earth) alkali.

According to bricks production plant's information the following equation for CO_2 emission estimation was used:

$$\boldsymbol{CO_2} = \sum((\boldsymbol{AD_{raw}} * \boldsymbol{AD_{CaO,MgO}}) * \boldsymbol{EF} * \boldsymbol{CF}) \tag{4.12}$$

where:

CO_2 – total CO_2 emissions from bricks production (kt)
AD_{raw} – activity data of used raw materials – clay (kt)
$AD_{CaO,MgO}$ – CaO and MgO content in used raw materials (%)
EF – CO_2 emission factor of CaO and MgO (kt/kt)
CF – conversion factor

CO_2 EFs for CaO and MgO – 0.785 and 1.092 for tonne CO_2 per tonne of oxide respectively, were taken from MRG[48] (Table 4.15).

2nd bricks production plant

For 1999-2008 the plant is using the same emission estimation methodology but for 2008 average default EF from MRG is used.

The plant was closed at the end of 2008 and was not operated in 2009 due to company's reorganization when production plant using old obsolete installations were closed and all production was transferred to other modern production facilities.

[47] EU Monitoring Reporting Guidelines. Available: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF (page 80)
[48] EU Monitoring Reporting Guidelines. Available: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF (page 81)

Activity data

The content of $CaCO_3$ and $MgCO_3$ are determined in plant laboratories or stated in mineral deposits passport.

Activity data carbonate is $CaCO_3$, $MgCO_3$ or other alkali earth or alkali carbonates amount that is used during the reporting period input (clay). Carbonate mass is estimated using clay consumption amount and results of clay content measurement with maximal allowable process uncertainty of ± 2.5% (Table 4.16).

Table 4.16 Data and assumptions used for CO_2 emission estimation from 2nd bricks production plant

	1990	1995	2000	2005	2006	2007	2008
Use of clay (kt)	*NO*	*NO*	*16.37*	*22.983*	*28.559*	*37.203*	*13.975*
$MgCO_3$ content (%)	*NO*	*NO*	*5.00%*	*10.98%*	*9.56%*	*9.52%*	*9.50%*
$CaCO_3$ content (%)	*NO*	*NO*	*9.00%*	*13.06%*	*13.15%*	*13.10%*	*13.10%*
$MgCO_3$ amount (kt)	*NO*	*NO*	*0.819*	*2.523*	*2.729*	*3.542*	*1.328*
$CaCO_3$ amount (kt)	*NO*	*NO*	*1.473*	*3.002*	*3.756*	*4.874*	*1.831*
$MgCO_3$ CO_2 EF (tCO_2/t oxide)	*NO*	*NO*	*0.522*	*0.522*	*0.522*	*0.522*	*0.522*
$CaCO_3$ CO_2 EF (tCO_2/t oxide)	*NO*	*NO*	*0.440*	*0.440*	*0.440*	*0.440*	*0.440*
CO_2 emissions (kt)	*NO*	*NO*	*1.076*	*2.638*	*3.077*	*3.993*	*1.500*
Average CO_2 EF (tCO_2/t oxides)	*NO*	*NO*	*0.469*	*0.477*	*0.475*	*0.475*	*0.474*

Since 2009 2nd bricks production plant is not operating anymore.

Emission factors and calculations

Calculation method A – carbon input, from the MRG[49] is used in plant's emission estimation for its application for GHG permit as well for reporting of annual CO_2 emission:

$$\boldsymbol{CO_2} = \left(\boldsymbol{AD_{raw}} * \boldsymbol{AD_{CaCO_3}} * \boldsymbol{EF_{CaCO_3}}\right) + \left(\boldsymbol{AD_{raw}} * \boldsymbol{AD_{MgCO_3}} * \boldsymbol{EF_{MgCO_3}}\right) \quad (4.13)$$

where:

CO_2 – CO_2 emissions from 2nd bricks production plant (kt)
AD_{raw} – activity data of used clay (kt)
AD_{CaCO3} – $CaCO_3$ content in used clay (%)
EF_{CaCO3} – $CaCO_3$ emission factor (kt/kt)
AD_{MgCO3} – $MgCO_3$ content in used clay (%)
EF_{MgCO3} – $MgCO_3$ emission factor (kt/kt)

Default CO_2 EFs from the MRG for the $CaCO_3$ and $MgCO_3$ are used. CO_2 EF for $CaCO_3$ is 0.44 tCO_2/t $CaCO_3$ and CO_2 EF for $MgCO_3$ is 0.522 tCO_2/t $MgCO_3$.

3rd bricks production plant

CO_2 emissions from 3rd plant is estimated for 1998-2020. In 2005 the methodology was changed from one approach – alkali earth oxides, to other approach – carbon input because the carbon input laboratory measurement data became available since 2005. As both methodologies are

[49] *EU Monitoring Reporting Guidelines. Available: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF (page 79)*

appropriate and both are assumed as Tier 2 therefore the methodology change was considered as acceptable.

For years 2008-2009 lower Tier EF from MRG[50] – a conservative value of 0.2 tonnes $CaCO_3$ (corresponding to 0.08794 tonnes of CO_2) per tonne of dry clay, was used to estimate CO_2 emissions. The plant indicated that the lower Tier use is acceptable within the EU ETS as the installation is low emission producer.

Activity data

For 1998-2004 emission estimation MgO and CaO content is used. According to mineral passport of State Geology Service's quarry "Progress" alkali earth oxides – MgO and CaO, contents are 8.03% and 3.02% respectively.

For years 2005-2007 emission estimation the contents of $CaCO_3$ and $MgCO_3$ are determined in plant laboratories or stated in mineral deposits passport and are 12.79% and 10.75% respectively. As for year 2008-2009 the carbonates input percentage amount is not known the data of 2005-2007 was used (Table 4.17, Table 4.18).

According to production plant's application for the GHG permit and annual GHG reports activity data of used raw materials are estimated using following equation:

$$\boldsymbol{AD_{raw} = AD_{clay} * (1 - M)} \quad (4.14)$$

where:

AD_{raw} – activity data of used raw materials – dray clay (kt)
AD_{clay} – amount of used clay (kt)
M – moisture content of clay in bricks pressing process (%)

For year 2005-2020 the activity data was estimated by using following equation from bricks production plant's GHG report:

$$\boldsymbol{AD_{raw} = \sum(AD_{bulk} * M_{av})} \quad (4.15)$$

where:

AD_{raw} – activity data of used raw materials – clay (kt)
AD_{bulk} – amount of dried bulk materials (pieces)
M_{av} – average mass with 0% moisture content (kt)

The activity data was estimated by plant randomly taking 10 examples of production from drying tunnels dried after that till 0% moisture content and weighted. After that average mass of production is estimated. Therefore for 2005-2020 the used clay is reported already with 0% moisture content.

The used raw materials – used clay, were estimated by taking into account the moisture content of the clay.

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[50] EU Monitoring Reporting Guidelines. Available: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF (page 80)

Table 4.17 Data and assumptions used for CO_2 emission estimation from 3rd bricks production plant

	1990	1995	2000
use of clay (kt)	*NO*	*NO*	*10.25*
moisture content (%)	*NO*	*NO*	*17.00%*
used raw materials – dry clay (kt)	*NO*	*NO*	*8.51*
MgO content (%)	*NO*	*NO*	*8.03%*
CaO content (%)	*NO*	*NO*	*3.02%*
MgO amount (kt)	*NO*	*NO*	*0.683*
CaO amount (kt)	*NO*	*NO*	*0.257*
MgO CO_2 EF (tCO_2/t oxide)	*NO*	*NO*	*1.092*
CaO CO_2 EF (tCO_2/t oxide)	*NO*	*NO*	*0.785*
CO_2 emissions (kt)	*NO*	*NO*	*0.95*
Average CO_2 EF (tCO_2/t oxides)	*NO*	*NO*	*1.008*

Table 4.18 Data and assumptions used for CO_2 emission estimation from 3rd bricks production plant (continuation)

Year	Use of clay (kt)	$MgCO_3$ content (%)	$CaCO_3$ content (%)	$MgCO_3$ amount (kt)	$CaCO_3$ amount (kt)	$MgCO_3$ CO_2 EF (tCO_2/t oxide)	$CaCO_3$ CO_2 EF (tCO_2/t oxide)	CO_2 emissions (kt)	Average CO_2 EF (tCO_2/t oxides)
2005	*29.891*	*10.75%*	*12.79%*	*3.213*	*3.823*	*0.522*	*0.440*	*3.359*	*0.477*
2006	*22.316*	*10.75%*	*12.79%*	*2.399*	*2.854*	*0.522*	*0.440*	*2.508*	*0.477*
2007	*23.854*	*10.75%*	*12.79%*	*2.564*	*3.051*	*0.522*	*0.440*	*2.681*	*0.477*
2008	*77.687*	*10.75%*	*12.79%*	*8.351*	*9.936*	*0.522*	*0.440*	*8.730*	*0.477*
2009	*19.814*	*10.75%*	*12.79%*	*2.13*	*2.534*	*0.522*	*0.440*	*2.230*	*0.477*
2010	*32.513*	*10.75%*	*12.79%*	*3.495*	*4.158*	*0.522*	*0.440*	*3.650*	*0.477*
2011	*38.914*	*10.75%*	*12.79%*	*4.183*	*4.977*	*0.522*	*0.440*	*4.370*	*0.477*
2012	*40.698*	*10.75%*	*12.79%*	*4.375*	*5.205*	*0.522*	*0.440*	*4.570*	*0.477*
2013	*49.705*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*4.772*	*0.096*
2014	*63.733*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*6.145*	*0.096*
2015	*54.317*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*5.237*	*0.096*
2016	*74.917*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*7.223*	*0.096*
2017	*76.487*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*7.375*	*0.096*
2018	*89.084*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*8.589*	*0.096*
2019	*81.635*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*7.871*	*0.096*
2020	*81.609*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*7.869*	*0.096*

According to the data from plant GHG annual report average CO_2 EF=0.09642 tCO_2/t oxides already include $CaCO_3$ and $MgCO_2$ EFs.

Emission factors and calculations

According to the installation's application for a GHG permit under the EU ETS, for 1998-2004 the plant is using calculation method B – alkali earth oxides, from the MRG when calculation is based on the content of the CaO, MgO and other (earth) alkali.

According to bricks production installations reported information the following equation to estimate CO_2 emissions was used:

$$\boldsymbol{CO_2} = \sum((\boldsymbol{AD_{raw}} * \boldsymbol{AD_{CaO,MgO}}) * \boldsymbol{EF} * \boldsymbol{CF}) \quad (4.16)$$

where:

CO_2 – total CO_2 emissions from bricks production (kt)
AD_{raw} – activity data of used raw materials – clay (kt)
$AD_{CaO,MgO}$ – CaO and MgO content in used raw materials (%)
EF – CO_2 emission factor of CaO and MgO (kt/kt)
CF – conversion factor

The plant for time period 2005-2007 is using the calculation method A – carbon input, from the MRG when calculation is based on the carbon input on each of the relevant raw materials. As it was mentioned above the plant in using different methodology again for 2008-2009 therefore the data was recalculated using the emission estimation method as for 2005-2007. Following equation from MRG is used to estimate emissions for 2005-2012:

$$\boldsymbol{CO_2} = (\boldsymbol{AD_{raw}} * \boldsymbol{AD_{CaCO_3}} * \boldsymbol{EF_{CaCO_3}}) + (\boldsymbol{AD_{raw}} * \boldsymbol{AD_{MgCO_3}} * \boldsymbol{EF_{MgCO_3}}) \quad (4.17)$$

where:

CO_2 – CO_2 emissions from 3rd bricks production plant (kt)
AD_{raw} – activity data of used clay (kt)
AD_{CaCO3} – $CaCO_3$ content in used clay (%)
EF_{CaCO3} – $CaCO_3$ emission factor (kt/kt)
AD_{MgCO3} – $MgCO_3$ content in used clay (%)
EF_{MgCO3} – $MgCO_3$ emission factor (kt/kt)

CO_2 EFs for CaO and MgO – 0.785 and 1.092 for tonne CO_2 per tonne of oxide respectively, were taken from MRG[51] (Table 4.17).

CO_2 EFs for $CaCO_3$ and $MgCO_3$ – 0.44 and 0.522 for tonne CO_2 per tonne of carbonates respectively, were taken from MRG[52] to recalculate the emissions (Table 4.17, Table 4.18).

4th bricks production plant

The estimation of CO_2 emissions from 4th bricks production plant is rather complicated due to allowed approach in Latvia that Latvia's ETS operator can use different methodology for every year to estimate their CO_2 emissions.

According to 4th bricks production plant's application for GHG permit and the plant's annual GHG reports in 2005-2008 the plant's used methodology for CO_2 emission estimation is changed four times:

1. CO_2 emission for time period 2000-2004 was estimated by using used clay (with moisture content 23%) as an activity data and CO_2 EF for used clay – 0.0658 t CO_2/t used clay. Then CO_2 EF for dry clay is estimated by reducing it by 23% that gives EF – 0.050666 tCO_2/t used clay.

[51] EU Monitoring Reporting Guidelines. Available: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF (page 81)
[52] EU Monitoring Reporting Guidelines. Available: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF (page 79)

2. The plant for year 2005 is using the calculation method "A" – carbon input, from the MRG when calculation is based on the carbon input on each of the relevant raw materials. The content of $CaCO_3$ and $MgCO_3$ are determined in plant laboratories or stated in mineral deposits passport. Default CO_2 emission EFs
3. For 2006 and 2007 the plant is using calculation method B – alkali earth oxides, from the MRG when calculation is based on the content of the CaO, MgO and other (earth) alkali.
4. For 2008 plant is using the same calculation method A as for year 2005– carbon input, from the MRG when calculation is based on the carbon input on each of the relevant raw materials. Still Tier 1 EFs from the MRG corresponding particular method are used when conservative value of 0.2 tonnes $CaCO_3$ (0.08794 tonnes of CO_2) per tonne of dry clay is applied for the calculation of the EF instead of results of analysis.

To make emission estimation more consistent:

1. For years 2000-2004 emissions were calculated by using the $CaCO_3$ and $MgCO_3$ content data reported by plant in its application for a GHG permit when the EU ETS was created in Latvia – $CaCO_3$ – 11.48%, and $MgCO_3$ – 1.8%, and using EFs from MRG.
2. For year 2006-2007 the $CaCO_3$ and $MgCO_3$ content data were estimated from MgO and CaO content data corresponding molar mass of MgO, CaO and CO_2.
3. For year 2008 the same $CaCO_3$ and $MgCO_3$ content data as for 2007 was used in emission estimation as other information was not available (Table 4.19).

Activity data

The plant reported that amount of carbonates ($CaCO_3$ and $MgCO_3$) in used clay is estimated according to chemical content of clay that was determined in Institute of Silicate Materials. For 2005 the $CaCO_3$ and $MgCO_3$ content is taken from production plant's annual GHG report. For 2006-2007 $CaCO_3$ and $MgCO_3$ data was estimated by taking into account used clay content data and its estimation parameters available from bricks production plant. For 2008 that particular data was no available therefore the percentage amount of carbonates of year 2007 was used (Table 4.19).

According to production plant's application for GHG permit and annual GHG reports activity data of used raw materials is estimated using following equation:

$$\boldsymbol{AD_{raw}} = \sum \left(\boldsymbol{AD_{bulk}} * \boldsymbol{M_{av}} - \boldsymbol{M_{bulk}} * \frac{\boldsymbol{moisture}}{\boldsymbol{100}} \right) - \boldsymbol{M_{chippings}} - \boldsymbol{M_{tenisite}} \quad (4.18)$$

where:

AD_{raw} – activity data of used raw materials – clay (kt)
AD_{bulk} – amount of dried bulk materials (pieces)
M_{av} – average mass (kt)
M_{bulk} – mass of dried bulk materials loaded in furnace
moisture/100 – average moisture content of clay (%)
$M_{chippings}$ – mass of dried scobs (kt)
$M_{tenisite}$ – mass of tenisite (granulated burnt defectives of ceramics) (kt)

Mass of chippings wasn't taken into account as it is biomass and is assumed as CO_2 neutral. Mass of tenisite – granulated burnt defectives of previously made ceramics that is folded into mass of clay to improve lasting of final production, is not taken into account as it is secondary process and during repeated burning the CO_2 emissions are not emitted.

Table 4.19 Data and assumptions used for CO_2 emission estimation from 4th bricks production plant

	1990	1995	2000	2005	2006	2007	2008
Use of clay (kt)	*NO*	*NO*	*9.000*	*25.246*	*29.826*	*34.166*	*27.329*
$MgCO_3$ content (%)	*NO*	*NO*	*1.80%*	*6.47%*	*6.47%*	*6.67%*	*6.67%*
$CaCO_3$ content (%)	*NO*	*NO*	*11.48%*	*14.62%*	*14.62%*	*13.71%*	*13.71%*
$MgCO_3$ amount (kt)	*NO*	*NO*	*0.162*	*1.634*	*1.929*	*2.28*	*1.824*
$CaCO_3$ amount (kt)	*NO*	*NO*	*1.033*	*3.691*	*4.361*	*4.684*	*3.747*
$MgCO_3$ CO_2 EF (tCO_2/t oxide)	*NO*	*NO*	*0.522*	*0.522*	*0.522*	*0.522*	*0.522*
$CaCO_3$ CO_2 EF (tCO_2/t oxide)	*NO*	*NO*	*0.440*	*0.440*	*0.440*	*0.440*	*0.440*
CO_2 emissions (kt)	*NO*	*NO*	*0.539*	*2.477*	*2.926*	*3.251*	*2.601*
Average CO_2 EF (tCO_2/t oxides)	*NO*	*NO*	*0.451*	*0.465*	*0.465*	*0.467*	*0.467*

In 2009, the bricks production plant is not operating due to economic crisis that affected construction sector in Latvia when demand for the production sharply decreased. Still the non-operation of particular plant is assumed only temporary and it is prospective that plant will be operating again.

Emission factors and calculations

As 4th bricks production plant is changing used methodology to estimate their annual CO_2 emissions within the EU ETS requirements from year to year, the emissions were calculated using the most appropriate approach. As the $CaCO_3$ and $MgCO_3$ content data was available for 2000-2004 and then for 2005 but MgO and CaO content data was available for 2006-2007 CO_2 emissions were calculated using Calculation A method – carbon input from MRG[53].

The following equation was used to estimate CO_2 emissions from 4th bricks production plant:

$$\boldsymbol{CO_2} = \left(\boldsymbol{AD_{clay}} * \boldsymbol{AD_{CaCO_3}} * \boldsymbol{EF_{CaCO_3}}\right) + \left(\boldsymbol{AD_{clay}} * \boldsymbol{AD_{MgCO_3}} * \boldsymbol{EF_{MgCO_3}}\right) \qquad (4.19)$$

where:

CO_2 – CO_2 emissions from 4th bricks production plant (kt)
AD_{clay} – activity data of used clay (kt)
$ADCaCO_3$ – $CaCO_3$ content in used clay (%)
$EFCaCO_3$ – $CaCO_3$ emission factor (kt/kt)
$ADMgCO_3$ – $MgCO_3$ content in used clay (%)
$EFMgCO_3$ – $MgCO_3$ emission factor (kt/kt)

CO_2 EFs for $CaCO_3$ and $MgCO_3$ – 0.44 and 0.522 for tonne CO_2 per tonne of carbonates were taken from MRG[54].

5th bricks production plant

According to 5th bricks plant's application for GHG permit and annual GHG reports activity data of used raw materials is estimated using following equation:

[53] *EU Monitoring Reporting Guidelines. Available: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF (pages 78,79)*
[54] *EU Monitoring Reporting Guidelines. Available: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF (page 79)*

$$AD_{raw} = \sum(AD_{bulk} * M_{av} - M_{bulk} * moisture/100) \quad (4.20)$$

where:

AD_{raw} – activity data of used raw materials – clay (kt)
AD_{bulk} – amount of dried bulk materials (pieces)
M_{av} – average mass (kt)
M_{bulk} – mass of dried bulk materials
moisture/100 – content of moisture (%)

Content of CaO and MgO in used clay is determined in independent certified laboratory taking analysis of used clay. Used additives – $CaCO_3$ (limestone flour) is weighted in production plant before addition to clay.

For 1993-2004 the CaO and MgO content was unknown as such laboratory measurements were not done before the EU ETS monitoring requirements. The CaO and MgO content data was determined only in the end of 2003. This particular amount was then used for all years in time period 1993-2004 as other data was not available.

Emission factors and calculations

The particular bricks production plant is using Calculation method B – alkali earth oxides, from MRG[55]. According to the MRG calcination of CO_2 is calculated based on the amounts of ceramics produced and the CaO, MgO and other (earth) alkali oxide contents of the ceramics.

Following equation from bricks production installation's annual GHG reports within the EU ETS was used to estimate CO_2 emissions.

$$CO_2 = \sum(\left(AD_{raw} * \frac{AD_{CaO,MgO}}{100}\right) * EF * CF) \quad (4.21)$$

where:

CO_2 – total CO_2 emissions from bricks production (kt)
AD_{raw} – activity data of used raw materials – clay (kt)
$AD_{CaO,MgO}$% / 100 – CaO and/or MgO content in used raw materials (%)
EF – CO_2 emission factor of CaO and/or MgO (kt/kt)
CF – conversion factor

For some years in bricks production also $CaCO_3$ was used as additive to clay for yellow bricks production. Following equation from plant's annual GHG reported was used to estimate CO_2 emissions from $CaCO_3$ use:

$$CO_2 = \sum(\left(AD_{raw} * \frac{AD_{additive}}{100}\right) * 1.785 * EF * CF) \quad (4.22)$$

where:

CO_2 – total CO_2 emissions from additive use (kt)
AD_{raw} – activity data of used raw materials – clay (kt)
$AD_{additive}$% / 100 – CaO content in used raw materials (%)
1.785 – factor to estimate CaO from used $CaCO_3$ data
EF – CO_2 emission factor of CaO (kt/kt)
CF – conversion factor

[55] EU Monitoring Reporting Guidelines. Available: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF (page 80)

In latest years 2008-2013 the CO_2 emissions were estimated for different bulks of used clay therefore CaO and MgO content data for these bulks differs. Therefore the CO_2 emissions were estimated separately. In 2020, EF=0.013 (tCO_2/t oxides) which already includes CO_2 EFs from MgO and CaO is used (Table 4.20).

Table 4.20 Data and assumptions used for CO_2 emission estimation from 5th bricks production plant

Year	Use of clay (kt)	MgO content (%)	CaO content (%)	MgO amount (kt)	CaO amount (kt)	MgO CO_2 EF (tCO_2/t oxide)	CaO CO_2 EF (tCO_2/t oxide)	$CaCO_3$ (additive) (kt)	CO_2 emissions (kt)	Average CO_2 EF (tCO_2/t oxides)
1990	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
1995	*107.38*	*1.43%*	*10.39%*	*1.536*	*11.152*	*1.092*	*0.785*	*0.000*	*10.431*	*0.822*
2000	*112.50*	*1.43%*	*10.39%*	*1.609*	*11.683*	*1.092*	*0.785*	*0.000*	*10.928*	*0.822*
2005	*88.29*	*0.39%*	*1.75%*	*0.344*	*1.545*	*1.092*	*0.785*	*0.000*	*1.589*	*0.841*
2006	*94.44*	*0.39%*	*1.75%*	*0.368*	*1.653*	*1.092*	*0.785*	*0.342*	*1.849*	*0.841*
2007	*80.90*	*0.36%*	*1.47%*	*0.291*	*1.189*	*1.092*	*0.785*	*1.218*	*1.787*	*0.845*
2008	*26.32*	*1.23%*	*0.32%*	*0.324*	*0.084*	*1.092*	*0.785*	*0.000*	*1.594*	*1.029*
	28.33	*1.35%*	*0.41%*	*0.382*	*0.116*	*1.092*	*0.785*			*1.020*
	28.82	*1.26%*	*0.38%*	*0.363*	*0.110*	*1.092*	*0.785*			*1.021*
	13.21	*1.09%*	*0.25%*	*0.144*	*0.033*	*1.092*	*0.785*			*1.035*
2009	*1.05*	*1.09%*	*0.25%*	*0.011*	*0.003*	*1.092*	*0.785*	*0.000*	*0.647*	*1.035*
	21.02	*1.07%*	*0.27%*	*0.225*	*0.057*	*1.092*	*0.785*			*1.030*
	22.05	*1.16%*	*0.27%*	*0.256*	*0.060*	*1.092*	*0.785*			*1.034*
	1.19	*1.12%*	*0.23%*	*0.013*	*0.003*	*1.092*	*0.785*			*1.040*
2010	*0.82*	*1.12%*	*0.23%*	*0.009*	*0.002*	*1.092*	*0.785*	*1.019*	*1.396*	*1.040*
	21.05	*1.23%*	*0.26%*	*0.259*	*0.055*	*1.092*	*0.785*			*1.038*
	21.15	*1.13%*	*0.24%*	*0.239*	*0.051*	*1.092*	*0.785*			*1.038*
	20.80	*1.16%*	*0.28%*	*0.241*	*0.058*	*1.092*	*0.785*			*1.032*
2011	*17.72*	*1.12%*	*0.23%*	*0.198*	*0.041*	*1.092*	*0.785*	*2.875*	*2.638*	*1.040*
	26.51	*1.23%*	*0.26%*	*0.326*	*0.069*	*1.092*	*0.785*			*1.038*
	25.05	*1.13%*	*0.24%*	*0.283*	*0.060*	*1.092*	*0.785*			*1.038*
	24.07	*1.16%*	*0.28%*	*0.279*	*0.067*	*1.092*	*0.785*			*1.032*
2012	*21.17*	*1.12%*	*0.23%*	*0.237*	*0.049*	*1.092*	*0.785*	*2.465*	*2.287*	*1.040*
	20.83	*1.23%*	*0.26%*	*0.256*	*0.054*	*1.092*	*0.785*			*1.038*
	18.59	*1.13%*	*0.24%*	*0.210*	*0.045*	*1.092*	*0.785*			*1.038*
	21.41	*1.16%*	*0.28%*	*0.248*	*0.060*	*1.092*	*0.785*			*1.032*
2013	*20.75*	*1.02%*	*0.25%*	*0.212*	*0.052*	*1.092*	*0.785*	*5.863*	*3.744*	*1.032*
	20.28	*1.22%*	*0.39%*	*0.247*	*0.079*	*1.092*	*0.785*			*1.018*
	18.48	*1.20%*	*0.30%*	*0.222*	*0.055*	*1.092*	*0.785*			*1.031*
	20.60	*1.20%*	*0.03%*	*0.247*	*0.006*	*1.092*	*0.785*			*1.085*
2014	*76.93*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*6.932*	*4.163*	*0.0145*
2015	*64.53*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*3.265*	*2.403*	*0.0150*
2016	*82.46*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*0.830*	*1.599*	*0.0150*
2017	*83.23*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*1.619*	*1.892*	*0.0142*
2018	*72.04*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*0.398*	*1.191*	*0.0141*
2019	*59.98*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*0.000*	*0.802*	*0.0134*

Year	Use of clay (kt)	MgO content (%)	CaO content (%)	MgO amount (kt)	CaO amount (kt)	MgO CO_2 EF (tCO_2/t oxide)	CaO CO_2 EF (tCO_2/t oxide)	$CaCO_3$ (additive) (kt)	CO_2 emissions (kt)	Average CO_2 EF (tCO_2/t oxides)
2020	*72.15*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*0.000*	*0.989*	*0.0134*

CO_2 EFs for CaO and MgO – 0.785 and 1.092 for tonne CO_2 per tonne of oxide respectively, were taken from MRG[56]. EF for 1993-2004 was calculated using MRG.

Production of tiles

There is only one tiles production plant in Latvia and CO_2 emissions from use of clay in tile production process in 1995-2014 are reported in 2.A.4 sector. The tiles production plant is a participant of the EU ETS therefore the data from plant's annual GHG reports is available for inventory. In 2015 tiles production was ceased due to financial complications and decrease of demand. Therefore plant were not using clay and emissions from tiles production are not occurring since 2015 (Table 4.21).

Table 4.21 Activity data for tiles production (kt) and reported CO_2 emissions (kt)

Year	Use of clay in tiles production	CO_2 emissions
	kt	
1990	*NO*	*NO*
1995	*2.034*	*0.18*
2005	*1.685*	*0.15*
2006	*1.748*	*0.15*
2007	*2.242*	*0.20*
2008	*0.525*	*0.05*
2009	*2.861*	*0.25*
2010	*2.497*	*0.22*
2011	*3.484*	*0.31*
2012	*6.033*	*0.53*
2013	*6.684*	*0.59*
2014	*6.556*	*0.58*
2015	*NO*	*NO*
2016	*NO*	*NO*
2017	*NO*	*NO*
2018	*NO*	*NO*
2019	*NO*	*NO*
2020	*NO*	*NO*

Default methodology was used to estimate emissions by multiplying activity data with EF. CO_2 EF – 0.08794 (t CO_2/t dry clay) which is used to estimate emissions from clay use in tiles production is taken from EU MRG[57].

[56] *EU Monitoring Reporting Guidelines. Available: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF (page 81)*
[57] *EU Monitoring Reporting Guidelines. Available: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:LV:PDF (page 80)*

4.2.5.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

The uncertainty of activity data for this sector is assumed as 7.5%. The activity data reported in bricks production plant's annual GHG reports within the EU ETS is verified by accredited verifiers and approved by the State Environmental Service so the activity data is adequately verified.

CO_2 EFs used in emission calculation from bricks and tiles production are the default ones from Monitoring and Reporting Regulation within the EU ETS[58] so the uncertainty of EFs is assumed as 3%.

Only CO_2 emissions from tiles and bricks production are estimated. Other emissions are not estimated due to lack of methodology and EFs.

For years 1990-1992 and 1993-2008 two different emission estimation methodologies are used still the time series is assumed as consistent as for 1990-1992 default Tier1 methodology is used but for 1993-2008 already plant specific emission estimation methodology assumed as Tier2 is used.

For time period 1993-2008 two different methodologies are used for 3rd bricks production plant so that could lead to inconsistent time series although it is assumed that these are plant specific data and there is no need to recalculate them with using default EFs or average carbonates content data.

Consistency of time series was checked by verifying IEF, AD and emission changes and attention was paid to important increase/decrease that are explained in NIR.

4.2.5.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the IPPU sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

Activity data, CO_2 EF and estimated emissions are taken from the annual GHG reports that tiles production plant submit within EU ETS.

CO_2 EFs for tiles production are taken from MRG[59] and are the default ones therefore there is no need to re-check correctness of EFs.

Quality control check list is filled for each category taking into account criteria given in QA/QC plan approved in National legislation. All findings were documented and introduced in GHG inventory. All corrections are archived.

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[58] *EU Monitoring Reporting Guidelines. Available: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF*

[59] *EU Monitoring Reporting Guidelines. Available: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF*

All estimations of the emissions done in the LEGMC also are checked on the logical mistakes by checking the time series of the activity data, EFs and emissions consistency to display all significant and illogic changes in the activity data and emissions.

Data comparison between the EU ETS data and GHG inventory emissions was made.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

4.2.5.5 Category-specific recalculations

No recalculations were done for this sector.

4.2.5.6 Category-specific planned improvements

No improvements are planned for this sector.

4.2.6 Other uses of Soda Ash (2.A.4.b)

4.2.6.1 Category description

Under this category CO_2 emissions from waste water neutralization using soda ash have been estimated 2005-2020. Till 2005 soda ash was not used in waste water neutralization.

In 2020, CO_2 emissions constitute 0.19 kt CO_2 eq. which are 57.3% higher than in 2019. Compared to 2005 emissions have decreased by 3.4% (Figure 4.8).

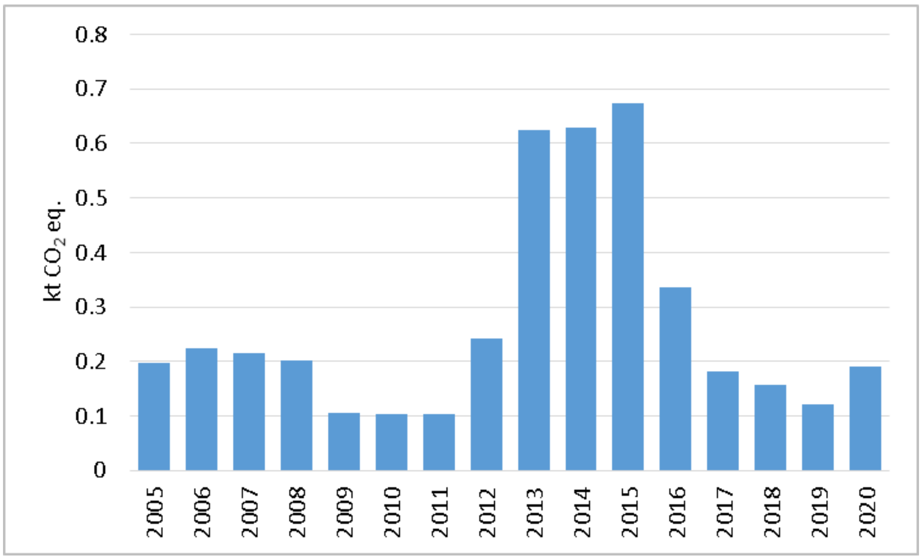

Figure 4.8 CO_2 emissions from other uses of soda ash 2005-2020 (kt CO_2 eq.)

4.2.6.2 Methodological issues

Activity data

Glass fibre production company annually reports amounts of used soda ash in waste water neutralization within the the EU ETS since 2005. This data is available in annual GHG reports under the EU ETS[60] (Table 4.22).

Table 4.22 Amount of used Soda for waste water nautralization (kt)

Year	Soda use for waste water nautralization (kt)
1990	*NO*
1995	*NO*
2000	*NO*
2005	*0.48*
2006	*0.54*
2007	*0.52*
2008	*0.49*
2009	*0.26*
2010	*0.25*
2011	*0.25*
2012	*0.58*
2013	*1.50*
2014	*1.51*
2015	*1.62*
2016	*0.81*
2017	*0.44*
2018	*0.38*
2019	*0.29*
2020	*0.46*

Emission factors and calculations

Emissions are calculated according to the 2006 IPCC Guidelines default methodology by multiplying amount of soda used with appropriate EF for soda ash taken from EU MRR (0.415 tCO_2/t).

4.2.6.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Activity data for emission calculation from other uses of soda ash is taken from glass production plant`s annual GHG report under the EU ETS. According to that the 7.5% uncertainty for activity data could be applied.

As the EF for CO_2 emission calculation is default from EU MRR (0.415 tCO_2/t) the uncertainty of EF is assumed 3%.

[60] *Polluting activity permit. Available: https://registri.vvd.gov.lv/izsniegtas-atlaujas-un-licences/atlauju-un-licencu-mekletajs/?company_name=stikla+%C5%A1%C4%B7iedra&company_code=&s=1*

4.2.6.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the IPPU sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

Quality control check list is filled for each category taking into account criteria given in QA/QC plan approved in National legislation. All corrections are archived.

All estimations of the emissions done in the LEGMC also are checked on the logical mistakes by checking the time series of the activity data, EFs and emissions consistency to display all significant and illogic changes in the activity data and emissions.

Data comparison between the EU ETS data and GHG inventory emissions was made.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

4.2.6.5 Category-specific recalculations

No recalculations were done for this sector.

4.2.6.6 Category-specific planned improvements

No improvements are planned in this sector.

4.2.7 Other Process Uses of Carbonates (2.A.4.d)

Under sector 2.A.4.d Other emissions of SO_2 emissions from glass production and NOx, CO and NMVOC emissions from cement production and glass production are reported as it is not technically possible to report these emissions under 2.A.1 Cement production sector and 2.A.3 Glass production sector in CRF Reporter directly under relevant categories.

4.3 *CHEMICAL INDUSTRY (CRF 2.B)*

4.3.1 Category description

There are no chemical industry production processes listed in the 2006 IPCC Guidelines or EMEP/EEA 2019 generating GHG emissions.

The biggest part of chemical industry is medicine production and then small part of paints and varnishes production.

There are no F-gases emissions under sectors 2.B.9.a By-Product Emissions and 2.B.9.2 Fugitive emissions so there are no child nodes added under these categories in CRF Reporter. Corresponding CRF tables are left blank due to CRF internal issue which does not allow to directly enter NO in green and grey cells without adding child nodes. It was confirmed by CRF help desk that this issue will be improved in the future releases of the software. Some F-gases data in the parent categories (green and grey cells) in corresponding CRF tables are missing due to this reason.

4.4 *METAL INDUSTRY (CRF 2.C)*

CO_2, CH_4 and precursors (NO_x, CO, NMVOC, SO_2) from 2.C.1 Iron and Steel production are reported under 2.C Metal Industry. There are no GHG emissions under rest of the sectors under 2.C. therefore these categories are NO in CRF Reporter.

There are no F-gases emissions under sectors 2.C.3. Aluminium production, 2.C.4. Magnesium production in Latvia therefore in CRF Reporter the corresponding CRF tables are left blank due to CRF internal issue which does not allow to directly enter NO in green and grey cells without adding child nodes. Some F-gases data in the parent categories (green and grey cells) in corresponding CRF tables are missing due to this reason.

4.4.1 Iron and Steel Production (CRF 2.C.1)

4.4.1.1 Category category description

In Latvia only one company produced steel 1990-2015 which used open-heart furnaces (OHF) from 1990 till 2010 and electric arc furnaces (EAF) from 1990 till 2015 in their steel production process. In 2016 steel production in Latvia was stopped as the only metal producing plant ceased to produce steel. According to information by plant, activity which still occurs in the plant is rolling of armature. This process cannot be accounted under 2.C.1 sector emissions. Emissions from combustion of fuels for provision of this process is accounted under 1.A.2.a sector.

Since 1990 and compared to 2015 both CO_2 and CH_4 emissions from 2.C.1 sector have decreased by 100% because metal production was stopped and facility is not reporting GHG emissions from metal production processes anymore (NO) (Figure 4.9).

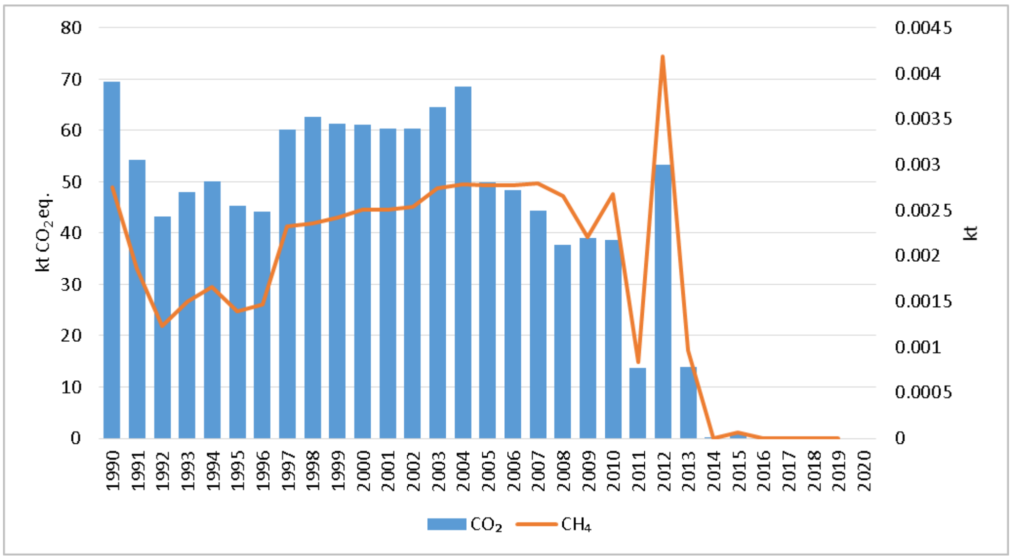

Figure 4.9 CO_2 and CH_4 emissions from Metal industry 1990-2020 (CH_4 emissions on secondary axis) (kt CO_2 eq.; kt)

CO_2 emissions from crude iron as input material in iron and steel production in OHF and crude iron used in EAF are included in the inventory according to the 2006 IPCC Guidelines. Emissions of precursors are also estimated from iron and steel production (Table 4.23).

Table 4.23 Emissions from 2.C Metal Production in 1990–2020 (kt)

Year	CO_2	CH_4	NO_x	CO	NMVOC	SO_2
	Kt					
1990	*69.56*	*0.003*	*0.004*	*0.012*	*0.011*	*0.087*
1995	*45.38*	*0.001*	*0.002*	*0.006*	*0.006*	*0.044*
2000	*61.10*	*0.003*	*0.003*	*0.007*	*0.010*	*0.080*
2005	*49.98*	*0.003*	*0.004*	*0.011*	*0.011*	*0.088*
2006	*48.36*	*0.003*	*0.004*	*0.011*	*0.011*	*0.088*
2007	*44.41*	*0.003*	*0.003*	*0.003*	*0.011*	*0.089*
2008	*37.73*	*0.003*	*0.003*	*0.006*	*0.011*	*0.085*
2009	*39.01*	*0.002*	*0.002*	*0.001*	*0.009*	*0.070*
2010	*38.64*	*0.003*	*0.003*	*0.002*	*0.011*	*0.086*
2011	*13.71*	*0.001*	*0.022*	*0.285*	*0.008*	*0.010*
2012	*53.34*	*0.004*	*0.109*	*1.422*	*0.038*	*0.050*
2013	*13.88*	*0.001*	*0.025*	*0.328*	*0.009*	*0.012*
2014	*0.01*	*4.6255E-07*	*1.20263E-05*	*0.0002*	*4.25546E-06*	*5.5506E-06*
2015	*0.81*	*6.23796E-05*	*0.002*	*0.021*	*0.001*	*0.001*
2016	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
2017	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
2018	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
2019	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
2020	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
2020 versus 2019	-	-	-	-	-	-
2020 versus 1990	*-100%*	*-100%*	*-100%*	*-100%*	*-100%*	*-100%*

Considerable emission decrease can be observed in 1990–1992 due to changes in Latvia's national economy (Figure 4.9). Decrease of CO_2 emissions in 1990–1996 also occurred due to decrease of used crude iron in OHF as CO_2 emissions are estimated only from crude iron use excluding used scrap metal part. It can explained with modification of production process when majority of primary and final steel products was produced by smelting of scrap metal.

CO_2 emissions increased almost twice in 2002–2004 when amount of used crude iron increased but the amount of used scrap metal remained at the same level. In 2005 emissions decrease by 27% compared to 2004 due to decline of used raw materials as well as decresed amount of produced steel. Afterwards till 2010 the emission level was quite stable with small fluctuations. In 2011 sharp decrease of emissions can be observed due to closing of OHF (installations were dismantled). In 2011 the metal production plant was working only 4 months. Since 2011 entire amount of crude steel was produced only in EAF and plant worked only 5-7 months in a year. The highest emission peak was reached in 2012, but after that emissions decreased. In 2014 only 0.09 kt crude steel were produced from scrap metal that caused 0.01 kt CO_2 emissions and was the lowest result since the plant exists. In 2015, the metal production company resumed to produce steel therefore small emissions appeared again, but in 2016 the iron & steel production was stopped at all.

4.4.1.2 Methodological issues

Reported gases and calculation methods for the 2.C Metal Industry are summarized in Table 4.24.

Table 4.24 GHG emission categories, methods and gases reported from 2.C

Category	Method used	Gases reported
C. Metal Industry		
1. Iron and Steel Production	*Tier1,2*	*CO_2, CH_4, NO_X, CO, NMVOC, SO_2*

Activity data

Activity data used for 2.C.1 emission calculations were:

- Amount of raw materials used in steel production in OHF and EAF (1990-2004 data was available from the installation's application for a GHG permit to operate within the EU ETS system. Since 2005 data is available annually from the installation's annual GHG report under the EU ETS[61] and directly from metal plant);
- Carbon electrodes consumption (data received directly from metal plant);
- Mass of steel produced in OHF and EAF (data received directly from metal plant);
- Used scrap metal in steel production in OHF and EAF (data received directly from metal plant);
- Carbon content in crude iron and Carbon content in crude steel (data received directly from metal plant);

Raw materials - coke, coke fine and carburizators - are used in crude steel production process as reducing agents to decrease the carbon content in final produced crude steel. Also lime, limestone and dolomite is used for steel smelting in OHF.

Since large amount of scrap metals is used in crude steel production it was necessary to exclude this amount from total crude steel amount and to estimate only amount of crude steel in what production crude iron where involved in both technologies. It was estimated by using crude iron/scrap metal ratio since amounts of used scrap metal in OHF and EAF as well as used crude iron in the furnaces were known. Then the iron/scrap metal ratio was multiplied with amount of steel produced in OHF or EAF to estimate amount of crude steel produced directly from crude iron.

But coke was used only as raw material in crude steel production and metallurgical coke was not produced in Latvia during the period 1990-2015.

The amount of direct limestone used in iron and steel production facility and the amount of limestone used for quicklime production were different. Since activity data were taken from the only metal producer`s annual GHG report under the EU ETS then metal producer clearly distinguished limestone stream which was used in iron and steel production from the amount of non-marketed lime (quicklime) produced during iron and steel making process. Therefore there are two limestone streams and is not double counting.

Activity data and parametrs for emission calculation from iron and steel production as well as emissions (kt CO_2 eq.) are reflected in Table 4.25.

[61] *Polluting activity permit. Available: https://registri.vvd.gov.lv/izsniegtas-atlaujas-un-licences/atlauju-un-licencu-mekletajs/?company_name=liep%C4%81jas+metalurgs&company_code=&s=1*

Table 4.25 Activity data and emissions from 2.C.1 Metal production

Year	Crude steel production, t	Mass of steel produced in OHF, t	Mass of steel produced in EAF, t	Crude iron used in OHF, t	Crude iron used in EAF, t	Used coke, t	Used Limestone, t	Used Dolomite, t	Carbon electrodes consumption kg/t steel	Used scrap metal in steel production in OHF, t	Used scrap metal in steel production in EAF, t	Crude iron/scrap metal ratio	Amount of crude steel in what production crude iron where involved (in OHF), t	Amount of crude steel in what production crude iron where involved (in EAF), t	Carbon content in crude iron	Carbon content in crude steel	Total emissions from Iron and Steel (kt CO_2 eq)
1990	*550000*	*543074*	*6926*	*107732*	*1160.79*	*11362.49*	*14300*	*33000*	*1.5*	*537227*	*5788.52*	*0.20*	*108905*	*1389*	*3.5%*	*0.25%*	*69.62*
1995	*279326*	*275747*	*3579*	*37086*	*412.71*	*6207.00*	*14300*	*33000*	*1.5*	*285015*	*3171.79*	*0.13*	*35880*	*466*	*3.5%*	*0.25%*	*45.41*
2000	*500292*	*496434*	*3858*	*70637*	*475.83*	*10061.00*	*14300*	*33000*	*1.5*	*503123*	*3389.18*	*0.14*	*69698*	*542*	*3.5%*	*0.25%*	*61.16*
2005	*554345*	*548472*	*5873*	*104010*	*969.77*	*6757.14*	*6325.85*	*29706.56*	*1.5*	*527950*	*4922.49*	*0.20*	*108053*	*1157*	*3.5%*	*0.25%*	*50.05*
2006	*554546*	*548419*	*6127*	*105769*	*1021.06*	*5206.69*	*12024.72*	*30491*	*1.5*	*531026*	*5126.36*	*0.20*	*109233*	*1220*	*3.5%*	*0.25%*	*48.43*
2007	*558156*	*556814*	*1342*	*109248*	*256.97*	*3731.08*	*9016.919*	*30404.8*	*1.5*	*463940*	*1091.28*	*0.24*	*131118*	*316*	*4%*	*0.30%*	*44.48*
2008	*530462*	*526964*	*3498*	*88319*	*532.78*	*4575.17*	*5378.374*	*26245*	*18*	*492450*	*2970.71*	*0.18*	*94509*	*627*	*3%*	*0.30%*	*37.80*
2009	*440458*	*440016*	*442*	*68783.57*	*63.33*	*4950.34*	*8472.2*	*22392.65*	*6.4*	*413058*	*380.32*	*0.17*	*73273*	*74*	*4%*	*0.20%*	*39.07*
2010	*535301*	*534168*	*1133*	*81340*	*165.73*	*3985.92*	*4146.5*	*28114.65*	*6.4*	*476868*	*971.63*	*0.17*	*91114*	*193*	*4%*	*0.20%*	*38.71*
2011	*167624*	*NO*	*167624*	*NO*	*3389.46*	*3948.52*	*1.728*	*245.86*	*1.8*	*NO*	*187103*	*0.02*	*NO*	*3037*	*4%*	*0.20%*	*13.73*
2012	*535301*	*NO*	*836431*	*NO*	*13387.21*	*3985.92*	*541.354*	*28114.65*	*1.4*	*NO*	*900803*	*0.01*	*NO*	*12431*	*4%*	*0.20%*	*53.44*
2013	*193190*	*NO*	*193190*	*NO*	*3185.32*	*3710.19*	*NO*	*NO*	*3.0*	*NO*	*227834*	*0.01*	*NO*	*2701*	*4%*	*0.20%*	*13.90*
2014	*92.51*	*NO*	*92.51*	*NO*	*NO*	*2.97*	*NO*	*NO*	*NO*	*NO*	*120.50*	*NO*	*NO*	*NO*	*4%*	*0.20%*	*0.01*
2015	*12475.91*	*NO*	*12475.91*	*NO*	*4.54*	*239.31*	*NO*	*NO*	*1.8*	*NO*	*14180.69*	*0.0003*	*NO*	*4*	*4%*	*0.20%*	*0.81*
2016	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
2017	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
2018	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
2019	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*
2020	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*

Emission factors and calculations

The 2006 IPCC Guidelines, EMEP/CORINAIR 2009 and EMEP/EEA 2019 were used to calculate GHG emissions and precursors from the 2.C.1 sector.

For CO_2 emission calculation Tier 2 method from the 2006 IPCC Guidelines is used. It is based on estimation of carbon losses through the production processes when remaining carbon is emitted to air.

CO_2 emissions were estimated only from crude iron used. In steel production steel is produced mostly by melting scrap metal that does not produce CO_2 emissions by leaking carbon therefore only amount of crude steel in what production crude iron where involved in OHF and EAF was used as activity data.

Equation 4.9 from the 2006 IPCC Guidelines is used to calculate CO_2 emissions from steel production:

$$\boldsymbol{E_{CO2,non-energy} = [PC * C_{PC} + L * C_L + D * C_D + CE * C_{CE} + O_b * C_b + S_{in} * C_{in} - S_{out} * C_{out}] * 44/12} \quad (4.23)$$

where:

PC-quantity of coke consumed in iron and steel production (not including sinter production) (tonnes)
C_{PC}–carbon content in coke (tC/tonne)
L-quantity of limestone consumed in iron and steel production (tonnes)
C_L–carbon content in limestone (tC/tonne)
D- quantity of dolomite consumed in iron and steel production (tonnes)
C_D–carbon content in dolomite (tC/tonne)
CE-quantity of carbon electrodes consumed in EAFs (tonnes)
C_{CE}–carbon contents in carbon electrodes (tC/tonne)
O_b–quantity of other carbonaceous and process material (tonnes)
C_b–carbon content of other carbonaceous material (tC/tonne)
S_{in}–amount of used metal in steel production process as input material (crude iron) (tonnes)
C_{in} - carbon content in input material (crude iron) (tC/tonne)
S_{out} – amount of produced metal material as output material (crude steel) (tonnes)
C_{out} – carbon content in output material (crude steel) (tC/tonne)

Carbon contents for raw materials are taken from the 2006 IPCC Guidelines[62] and are reflected in Table 4.26.

Table 4.26 Carbon contents of raw materials used in iron & steel production

Process material	Carbon content (kg C/kg)
Limestone	*0.12*
Dolomite	*0.13*
Coke	*0.83*

Carbon emissions from consumed electrodes in EAF are estimated by multiplying emission mass of steel produced in electric arc furnaces with carbon electrodes consumption EF.

EFs of CH_4 and precursors are taken from EMEP/CORINAIR 2007 and EMEP/EEA 2019 for estimations of emissions from processes in OHFs, where 95% of total steel production is produced till 2010 and for EAF starting from year 2011 (Table 4.27).

[62] *IPCC 2006 Guidelines, Vol.3, Ch.4. Available: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol3.html*

Table 4.27 Emission factors of metal production (t/t)

	CH_4	NO_x	CO	NMVOC	SO_2
OHF	*0.000005*	*0.0051*	*0.000001*	*0.00002*	*0.00016*
EAF	*0.000005*	*0.00013*	*0.0017*	*0.000046*	*0.00006*

CH_4, NMVOC, CO, NO_x and SO_2 emissions are estimated from total produced crude steel data but for CO_2 emission estimation only crude steel produced from crude iron is taken into account.

4.4.1.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

The uncertainty of activity data for this sector is assumed as 5%. The activity data reported in iron and steel production plant's annual GHG report within EU ETS is verified by accredited verifiers and approved by the State Environmental Service so the activity data is adequately verified.

As the material-specific default carbon contents for process materials are used from the 2006 IPCC Gudelines, the 10% EF uncertainty could be applied.

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

Time series consistency was checked by verifying IEF, AD and emission changes and attention was paid to important increase/decrease that are explained in NIR.

4.4.1.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the IPPU sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

All estimations of the emissions done in the LEGMC also are checked on the logical mistakes by checking the time series of the activity data, EFs and emissions consistency to display all significant and illogic changes in the activity data and emissions.

Quality control check list is filled for each category taking into account criteria given in QA/QC plan approved in National legislation. All findings were documented and introduced in GHG inventory. All corrections are archived.

Data comparison between the EU ETS data and GHG inventory emissions was made. Differences in 2013-2015 were caused by different emission calculation methodologies that are used under UNFCCC reporting (2006 IPCC Guidelines) and EU ETS monitoring and reporting. According to the 2006 IPCC Guidelines the CO_2 emissions from 2.C.1 were estimated taking into account only particular part of used raw materials that generate CO_2 emissions in production process. As mostly scrap metals are used in production of crude steel in Latvia, only amount of used crude iron as input material in crude steel production is taken into account. During remelting of scrap metal the CO_2 emissions are not generated. The crude iron/scrap metal ratio is used in emission calculation.

Under the EU ETS CO_2 emissions by plant are calculated by multiplying AD (used raw materials) with EF without any division into used technologies that gives very approximately calculated CO_2 emissions that differ from emissions reported in GHG inventory.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

4.4.1.5 Category-specific recalculations

No recalculations were done for this sector.

4.4.1.6 Category-specific planned improvements

No improvements are planned for this sector.

4.5 *NON-ENERGY PRODUCTS FROM FUELS AND SOLVENT USE (CRF 2.D)*

Under 2.D Non-energy Products from Fuels and Solvent Use sector emissions from Paraffin wax, Lubricant use and Other (including Solvent use, Asphalt roofing and Road paving with asphalt, urea use) are reported.

Non-energy products from fuels and solvent use sector GHG emissions were 43.09 kt which is 5.0% from total IPPU emissions and 0.4% of total CO_2 eq. emissions including indirect CO_2, without LULUCF in Latvia in 2020. CO_2 emissions from 2.D sector have decreased by 2.6% since 1990 and by 9.7% compared to 2019 due to decreased amount of solvents (Figure 4.10). The main part of this sector emissions constitute 2.D.3 Other subsector with 25.74 kt (59.7%) from total 2.D sector emissions. 2.D.3 Other subsector includes emissions from Solvent use, Asphalt roofing, Road paving with asphalt and Urea use. Solvent use sector constitutes 94.6% of 2.D.3 Other sector. Remaining part of emissions (5.4%) from 2.D.3 Other constitute Asphalt roofing, Road paving with asphalt and Urea Use.

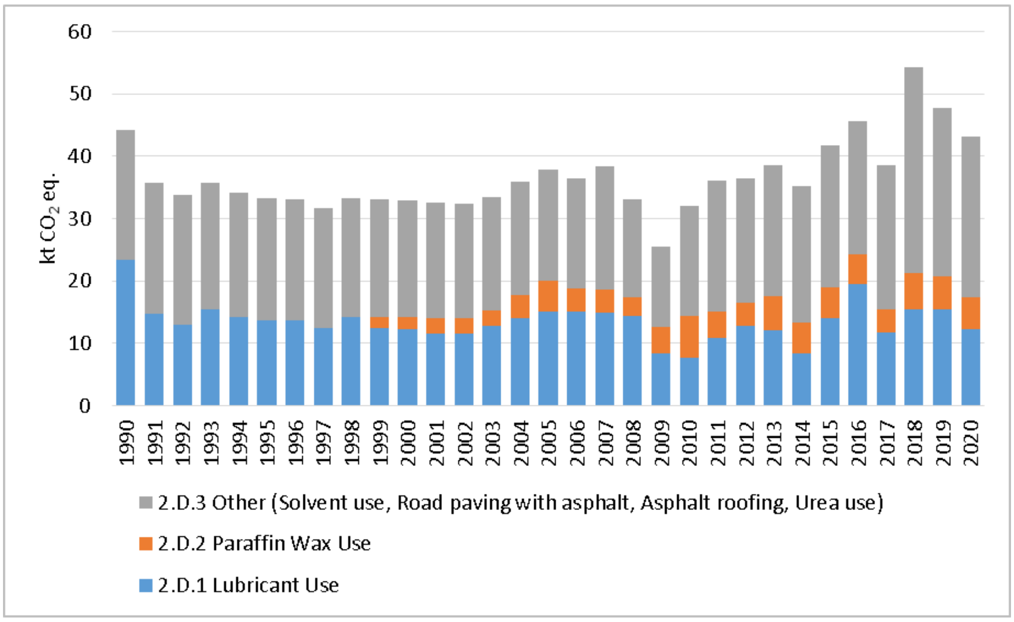

Figure 4.10 Emissions from Non-energy Products from Fuels and Solvent Use sector 1990-2020 (kt CO_2 eq.)

Reported emissions and calculation methods for the 2.D Non-energy Products from Fuels and Solvent Use in the Latvian inventory are summarized in Table 4.28.

Table 4.28 GHG emission categories, methods and gases reported from 2.D

Category	Method used	Gases reported
D. Non-energy Products from Fuels and Solvent Use		
1.Lubricant Use	*Tier1*	*CO_2*
2. Paraffin Wax Use	*Tier1*	*CO_2*
3. Other		
Solvent Use	*Tier1,2, CS,D*	*CO_2, NMVOC, CO, SO_2, NOx*
Road paving with asphalt	*Tier1*	*CO_2, NMVOC*
Asphalt roofing	*Tier1*	*CO_2, NMVOC, CO*
Urea use	*Tier1*	*CO_2*

4.5.1 Lubricant Use (CRF 2.D.1)

4.5.1.1 Category description

Lubricant use sector emissions amounts 12.29 kt (28.5%) of total Non-energy sector products emissions in Latvia in 2020. CO_2 emissions from 2.D.1 sector decreased by 47.2% since 1990 and decreased by 20.0% compared to 2019 due to decreased lubricant consumption (Figure 4.11 and Table 4.29).

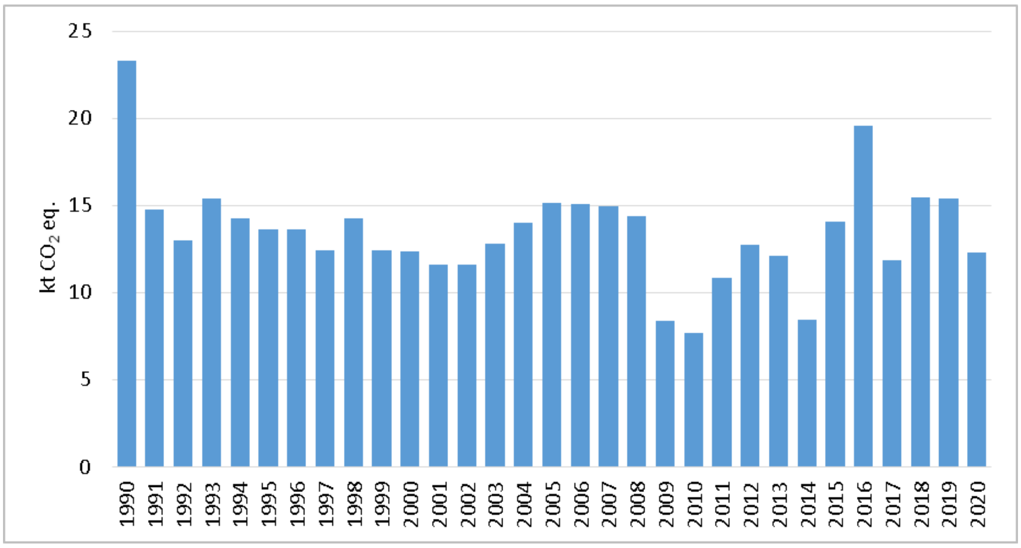

Figure 4.11 CO_2 emissions from Lubricant use 1990-2020 (kt)

Under this category lubricant consumption are reported as feedstocks in Latvia. Emissions from lubricants use are reported as „CO_2 not emitted" because it is assumed that CO_2 emissions are captured and not emitted into air.

Consumption and emissions from lubricants are reported in sector 2.D.1 for all years in time series 1990-2020 (Table 4.29).

Table 4.29 CO_2 emissions from lubricant use 1990-2020 (kt)

Year	CO_2 emissions (kt)
1990	*23.30*
1995	*13.63*
2000	*12.34*
2005	*15.15*
2006	*15.05*
2007	*14.93*
2008	*14.38*
2009	*8.34*
2010	*7.67*
2011	*10.86*
2012	*12.75*
2013	*12.10*
2014	*8.41*
2015	*14.06*

Year	CO_2 emissions (kt)
2016	*19.57*
2017	*11.82*
2018	*15.45*
2019	*15.37*
2020	*12.29*
Share in IPPU total in 2020	*1.42%*
2020 versus 2019	*-20.03%*
2020 versus 1990	*-47.25%*

4.5.1.2 Methodological issues

Activity data

Lubricant consumption data from CSB Energy Balance[63] was used as activity data for emission calculation.

Lubricants are mainly used in transport sector. The amount of oil from which the oil film has been formed on the inner cylinder walls is calculated. This oil film further is exposed to combustion and burned along with the fuel.

Share of used lubricants in transport sector is calculated according to kilometres travelled. It includes used lubricants for each of the subgroups of road transport separately, including 2 -stroke motocycles for which petrol engine should be lubricated by a mixture of lubricating oil and petrol.

CO_2 emissions from the lubricants consumed in transport are estimated and reported under transport sector and constitute 7.3% of total lubricants amount in 2020. The rest of the lubricants are used as feedstocks and CO_2 emissions from them are calculated and reported under 2.D.1 sector.

Table 4.30 Activity data for lubricant use 1990-2020

Year	Total consumption of lubricants	Consumption of lubricants in 1.A.3.b	Consumption of lubricants in Lubricants Use 2.D.1. sector	Share of total lubricants used in 1.A.3.b sector
		TJ		**%**
1990	*1633*	*43.18*	*1589.82*	*2.6*
1995	*963*	*32.77*	*930.23*	*3.4*
2000	*879*	*36.93*	*842.07*	*4.2*
2005	*1088*	*54.25*	*1033.75*	*5.0*
2006	*1088*	*61.09*	*1026.91*	*5.6*
2007	*1088*	*69.24*	*1018.76*	*6.4*
2008	*1047*	*66.03*	*980.97*	*6.3*
2009	*628*	*58.97*	*569.03*	*9.4*
2010	*586*	*62.66*	*523.34*	*10.7%*
2011	*795*	*54.11*	*740.89*	*6.8%*
2012	*922*	*52.08*	*869.92*	*5.6%*
2013	*880*	*54.16*	*825.84*	*6.2%*

[63] *Energy balance. Available: https://data.stat.gov.lv/pxweb/lv/OSP_PUB/START__NOZ__EN__ENB/ENB060/*

Year	Total consumption of lubricants	Consumption of lubricants in 1.A.3.b	Consumption of lubricants in Lubricants Use 2.D.1. sector	Share of total lubricants used in 1.A.3.b sector
		TJ		%
2014	*632*	*58.06*	*573.94*	*9.2%*
2015	*1022*	*62.39*	*959.61*	*6.1%*
2016	*1398*	*62.91*	*1335.09*	*6.1%*
2017	*872*	*65.78*	*806.22*	*7.5%*
2018	*1122*	*67.90*	*1054.10*	*6.1%*
2019	*1118*	*69.31*	*1048.69*	*6.2%*
2020	*905*	*66.36*	*838.64*	*7.3%*

Emission factors and calculations

CO_2 emissions are calculated according to Tier 1 method and EFs as well as default carbon content are taken from the 2006 IPCC Guidelines. Carbon content for lubricant is 20.0 kg/GJ according to the 2006 IPCC Guidelines Volume 3 Chapter 5 Table 5.2.

NCV for lubricants is 40.20 TJ/10^3 t and it is taken from CSB Energy Balance[64].

CO_2 emissions are calculated using the 2006 IPCC Guidelines:

$$\boldsymbol{CO_2Emissions = LC * CC_{Lubricant} * ODU_{Lubricant} * 44/12} \qquad (4.24)$$

where:

CO_2 emissions - CO_2 Emissions from lubricants (tonne CO_2)
LC - total lubricant consumption (TJ)
$CC_{Lubricant}$ - carbon content of lubricants (default) (tonneC/TJ(=kg/ C/TJ)
$ODU_{Lubricant}$ –ODU (Oxidised during use) factor (based on default composition of oil and grease) fraction
44/12 - mass ratio of CO_2/C

4.5.1.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Activity data are taken from CSB of Latvia and uncertainty are assumed as 2%.

As the default ODU factor is used, the uncertainty (50%) from the 2006 IPCC Guidelines is applied for ODU EF.

The carbon content coefficients is taken from the 2006 IPCC Guidelines and are based on two studies of the carbon content and heating value of lubricants, from which an uncertainty range is about 3%.

The total EF uncertainty U_{total} is being calculated, using following formula of combined uncertainty:

$$\boldsymbol{U_{total}} = \sqrt{(\boldsymbol{U_1^2 + U_2^2 + \cdots + U_n^2})} \qquad (4.25)$$

[64] *Energy balance. Available: https://data.stat.gov.lv/pxweb/lv/OSP_PUB/START__NOZ__EN__ENB/ENB060/*

where:

U_{total} - the percentage uncertainty in the product of the quantities
U_i - the percentage uncertainties associated with each of the quantities

Combined EF uncertainty is calculated as 50%.

4.5.1.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the IPPU sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

QA/QC check is performed according to the 2006 IPCC Guidelines. There are compared the amounts discarded, recovered and combusted in Transport sector with total consumption figures in the calculation to check the internal consistency data and ODU factors if they are used in the calculation of different source categories across sectors.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

4.5.1.5 Category-specific recalculations

Recalculation was done due to precised activity data for 2010-2019 (Table 4.31).

Table 4.31 Results of recalculations in 2.D.1 Lubricant use sector (2010-2019)

Year	CO_2 emissions before recalculation	CO_2 emissions after recalculation	Absolute difference	Relative difference
		kt CO_2 eq.		%
2010	*7.67*	*7.67*	*0.00*	*0.00*
2011	*10.86*	*10.86*	*0.00*	*0.00*
2012	*12.75*	*12.75*	*0.00*	*-0.01*
2013	*12.11*	*12.10*	*0.00*	*-0.03*
2014	*8.42*	*8.41*	*0.00*	*-0.04*
2015	*14.06*	*14.06*	*0.00*	*0.01*
2016	*19.56*	*19.57*	*0.00*	*0.02*
2017	*11.81*	*11.82*	*0.01*	*0.05*
2018	*15.44*	*15.45*	*0.01*	*0.04*
2019	*15.37*	*15.37*	*0.00*	*-0.01*

4.5.1.6 Category-specific planned improvements

No improvements are planned for this sector.

4.5.2 Paraffin Wax Use (CRF 2.D.2)

4.5.2.1 Category description

Paraffin wax use subsector emissions constitute 5.06 kt (11.7%) of total Non-energy sector emissions in Latvia in 2020. CO_2 emissions from 2.D.2 sector have been increased by 173.1% since 1999 and decreased by 6.3% compared to 2019 (Figure 4.12 and Table 4.32).

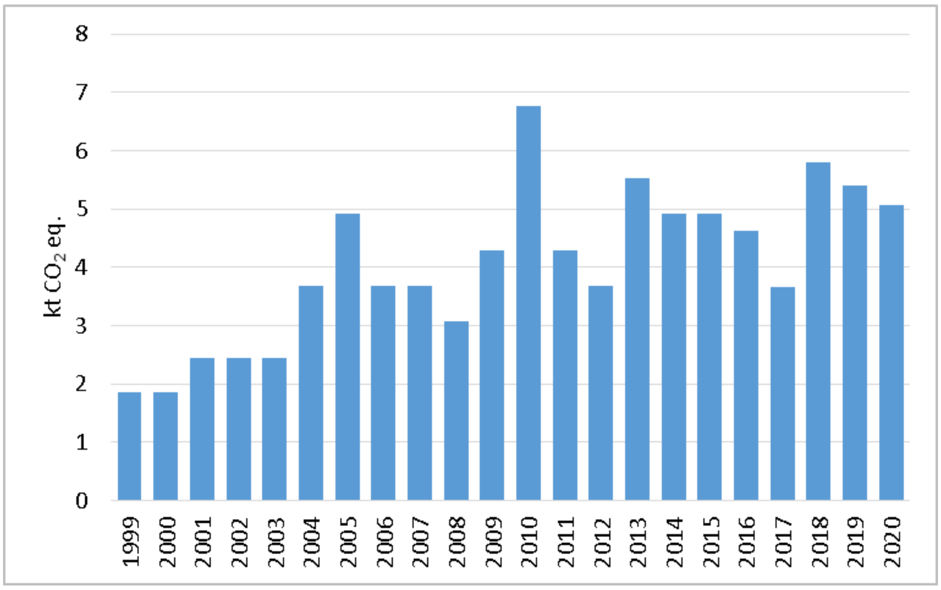

Figure 4.12 CO_2 emissions from Paraffin wax use 1999-2020 (kt CO_2 eq.)

Under this category paraffin wax consumption is reported as feedstocks in Latvia. Paraffin wax mainly is used in chemical substance in chemical production as well as plastic, rubber and furniture production. Emissions from paraffin wax are reported as „CO_2 not emitted" because it is assumed that CO_2 emissions are captured and not emitted into the air.

Consumption and emissions of paraffin wax are reported in sector 2.D.2 for time series 1990-2020 (Table 4.32).

Table 4.32 Activity data and CO_2 emissions from paraffin wax use 1990-2020

Year	Consumption of paraffin wax (TJ)	CO_2 emissions (kt)
1990	*NO*	*NO*
1995	*NO*	*NO*
2000	*126*	*1.85*
2005	*335*	*4.91*
2006	*251*	*3.68*
2007	*251*	*3.68*
2008	*209*	*3.06*
2009	*293*	*4.29*
2010	*461*	*6.76*
2011	*293*	*4.29*
2012	*251*	*3.68*
2013	*377*	*5.53*
2014	*335*	*4.91*
2015	*335*	*4.91*

Year	Consumption of paraffin wax (TJ)	CO_2 emissions (kt)
2016	*316*	*4.63*
2017	*249*	*3.65*
2018	*396*	*5.80*
2019	*368*	*5.39*
2020	*345*	*5.06*
Share in IPPU total in 2020	–	*0.58%*

4.5.2.2 Methodological issues

Activity data

Paraffin wax consumption data from CSB Energy Balance was used as activity data for emission calculation. Data from CSB about paraffin wax consumption are available only from 1999.

Emission factors and calculations

CO_2 emissions are calculated according to Tier1 method and EFs as well as default carbon content are taken from the 2006 IPCC Guidelines. Carbon content for paraffin wax is 20.0 kg/GJ as default one taken from the 2006 IPCC Guidelines Volume 3 Chapter 5 p.p 5.12.

NCV for paraffin wax is 40.20 TJ/10^3 t and it is taken from CSB Energy Balance[65].

CO_2 emissions are calculated using the 2006 IPCC Guidelines equation 5.4:

$$\boldsymbol{CO_2Emissions = PW * CC_{Wax} * ODU_{Wax} * 44/12} \quad (4.26)$$

where:

CO_2 emissions - CO_2 Emissions from waxes (tonne CO_2)
LC - total wax consumption (TJ)
CC_{Wax} - carbon content of paraffin wax (default) (tonneC/TJ =kg/ C/TJ)
ODU_{Wax} - Oxidised during use (ODU) factor for paraffin wax (fraction)
44/12 - mass ratio of CO_2/C

4.5.2.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Activity data are taken from CSB of Latvia and uncertainty is assumed 2%.

The default ODU factor for paraffin wax is taken from the 2006 IPCC Guidelines. Due to lack of information regarding application of paraffin wax in the country, the uncertainty of ODU factor is assumed 100%.

The carbon content coefficient is taken from the 2006 IPCC Guidelines and uncertainty is 5%.

The total EF uncertainty U_{total} is being calculated, using following formula of combined uncertainty:

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[65] *Energy balance. Available: https://data.stat.gov.lv/pxweb/lv/OSP_PUB/START__NOZ__EN__ENB/ENB060/*

$$U_{total} = \sqrt{(U_1^2 + U_2^2 + \cdots + U_n^2)} \quad (4.27)$$

where:

U_{total} - the percentage uncertainty in the product of the quantities
U_i - the percentage uncertainties associated with each of the quantities

Combined EF data uncertainty is calculated as 100%.

4.5.2.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the IPPU sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

QA/QC check is performed according to the 2006 IPCC Guidelines. There are compared the amounts discarded, recovered and combusted with total consumption figures in the calculation to check the internal consistency data and ODU factors if they are used in the calculation of different source categories across sectors.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

4.5.2.5 Category-specific recalculations

No recalculations were done.

4.5.2.6 Category-specific planned improvements

No improvements are planned for this sector.

4.5.3 Other (CRF 2.D.3)

4.5.3.1 Category description

This chapter describes emissions from Solvent Use, Road paving with asphalt and Asphalt roofing sector under Other (CRF 2.D.3).

Solvent Use

The use of solvents and products containing solvents results in emissions of non-methane volatile organic compounds (NMVOC). NMVOC emissions are regarded as an indirect GHG as it over a period of time will oxidize into CO_2 when emitted to the atmosphere.

According to the 2006 IPCC Guidelines and EMEP/EEA 2019 Solvent Use sector covers emissions from the four SNAP (Selected Nomenclature for Air Pollution) subcategories:

- SNAP 0601: Paint application (Including such activities as paints and varnishes from decorative, industrial and other coating applications);
- SNAP 0602: Degreasing, Dry cleaning (Degreasing includes cleaning products from water-insoluble substances such as grease, fats, oils waxes and tars. Dry cleaning refers to any process to remove contamination from furs, leather, down leathers, textiles or other objects made of fibres using organic solvents);

- SNAP 0603: Chemical products manufacturing or processing (Including the processing of polyester, PVC, foams and rubber, manufacture of paints, inks, glues and adhesives and finishing of textile);
- SNAP 0604: Other use of solvents and related activities (Including such activities as "enduction" (i.e. coating) of glass wool and mineral, printing industry, fat and oil extraction, uses of glues and adhesives, wood preservation, domestic use (other than paint application) and vehicle underseal treatment and vehicle dewaxing);
- SNAP 060602: Other product use (e.g. tobacco, fireworks).

Latvia`s reported NMVOC and indirect CO_2 emissions from NMVOC under Solvent Use sector in 2020 are shown in Table 4.33.

Table 4.33 Reported emissions from Solvent Use in Latvia in 2020

CATEGORY		SUBCATEGORY TITLE	EMISSIONS
SNAP	NRF		
0601	2D3d	*Paint application*	*NMVOC, indirect CO_2*
0602	2D3e	*Degreasing*	*NMVOC, indirect CO_2*
0602	2D3f	*Dry cleaning*	*NMVOC, indirect CO_2*
0603	2D3g	*Chemical products*	*NMVOC, indirect CO_2*
0604	2D3h	*Printing industry*	*NMVOC, indirect CO_2*
0604	2D3a	*Domestic solvent use (other than paint application)*	*NMVOC, indirect CO_2*
0604	2D3i	*Other solvent use*	*NMVOC, indirect CO_2*
0606	2G	*Other product use (e.g. tobacco, fireworks)*	*NMVOC, indirect CO_2*

Solvent Use sector is significant pollution source of NMVOC emissions in Latvia in 2020 and it covered over 33.0% (11.09 kt) from the total Latvia's NMVOC emissions. From Solvent use sector the main share of total NMVOC emissions contributed Paint application – 33.8% or 3.75 kt and Other solvent use – 31.7% or 3.51 kt (Figure 4.13).

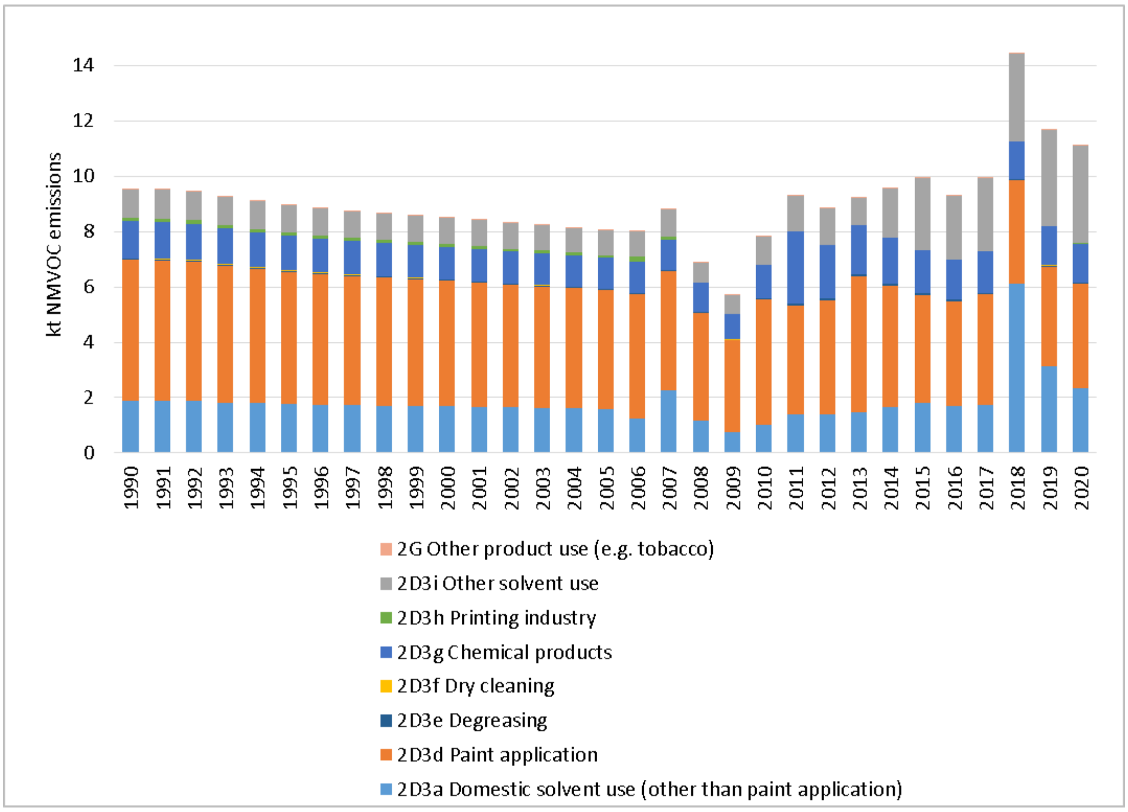

Figure 4.13 Total NMVOC emissions from Solvent Use for the period 1990-2020 (kt)

Since 1990 NMVOC emissions have increased in the Solvent use sector by 16.3%. Categories where an increase in NMVOC emissions has occurred in recent years include Domestic solvent use (other than paint application) (2D3a) and Other solvent use (2D3i). The fluctuation of NMVOC emissions in the period 1990-2020 has mostly occurred due to the welfare of the economic state of the country. The slightly decrease in emissions occurred between years 1990 and 2006. From 2006 the economy began to grow until 2008, when the world was struck by the economic crisis which also affected the Solvent Use sector in Latvia. As a result, by the year 2009, NMVOC emissions decrease by 35.1% in comparison with 2007. As shown there is increase of NMVOC emissions during the later period of 2010 till 2020. In 2020 NMVOC emissions increased by 37.9% in comparison with 2005. However, in 2020 NMVOC emissions of Solvent sector have decreased by 5.0% in comparison with 2019 (Table 4.34). This is due to the fact that in 2020 emissions of Domestic solvent use including fungicides (2D3a) have decreased. Since 2022 submission emissions from use of tobacco combustion is calculated for time period 1990 – 2020.

Table 4.34 NMVOC and indirect CO_2 emissions from Solvent Use for the period 1990-2020 (kt)

Year	NMVOC	Indirect CO_2 emissions
	kt	
1990	*9.54*	*20.97*
1995	*8.94*	*19.66*
2000	*8.50*	*18.69*
2005	*8.04*	*17.68*
2010	*7.80*	*17.16*

Year	NMVOC	Indirect CO_2 emissions
	kt	
2011	9.30	20.45
2012	8.83	19.42
2013	9.20	20.23
2014	9.56	21.03
2015	9.92	21.81
2016	9.31	20.47
2017	9.95	21.87
2018	14.43	31.72
2019	11.67	25.65
2020	11.09	24.38

It is assumed that the NMVOC containing products imported in the country in a particular year are utilized in the same year as the data of the actual use is not available or is confidential. At the same time enterprises tend to provide a stockpiles taking into account economic situation. This in turn affects amount of CO_2 emission, causing fluctuations of time series.

Road paving with asphalt (2.D.3.b) and Asphalt roofing (2.D.3.c)

In this sector emissions from road paving activities are reported.

Table 4.35 Activity data for Road paving and Asphalt roofing 1990-2020

Year	Amount of bitumen mixtures used (kt)	% of asphalt used for Road Paving	% of asphalt used for Asphalt roofing	Road Paving with asphalt (kt)	Asphalt roofing (kt)
1990	39	80%	20%	31	8
1995	117	80%	20%	94	23
2000	424	90%	10%	381	42
2005	1165	90%	10%	1049	117
2006	1117	90%	10%	1005	112
2007	1493	90%	10%	1343	149
2008	1537	90%	10%	1383	154
2009	838	90%	10%	755	84
2010	937	90%	10%	843	94
2011	1481	90%	10%	1333	148
2012	1585	90%	10%	1426	158
2013	1255	90%	10%	1130	126
2014	1290	90%	10%	1161	129
2015	1724	90%	10%	1552	172
2016	1681	90%	10%	1513	168
2017	1317	90%	10%	1185	132
2018	1263	90%	10%	1137	126
2019	1255	90%	10%	1129	125
2020	1418	90%	10%	1276	142

According to CSB data the biggest share of NMVOC and CO_2 emissions are originating during road paving with asphalt. Just small part of all bitumen mixtures is used in asphalt roofing sector (Table 4.35).

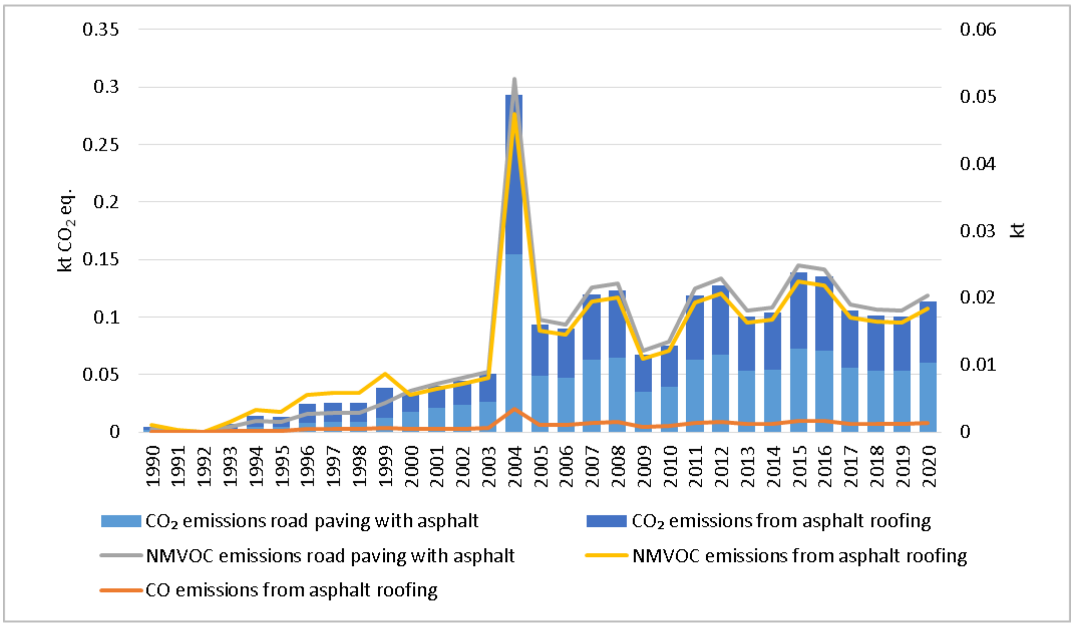

Figure 4.14 Emissions from asphalt roofing and road paving in 1990–2020 (NMVOC and CO emissions on secondary axis) (kt CO_2 eq.; kt)

The emissions from these two particular sectors are constantly increasing since the beginning of 1990s. Slight emission decrease in 1999-2000 could be explained with the change of percentage that is used to divide activity data used in roofing and road paving. The sharp emission increase in 2003-2004 could be explained with Latvia's joining the EU in the May of 2004 before and after when the road paving works were very active and there were built VIA Baltic that connects all Baltic States. In 2011 and 2012 activity in road paving and asphalt roofing rised by 58.1% and 7.0% respectively. In 2013 overall activity of bitumen use in industrial processes had decreased by about 20.8% and was related to financial resources that were assigned directly to this sector for road paving or asphalt roofing. In 2015 emission increase has been observed because according to Latvia`s State Road Network Statistics the length of renewed and constructed bituminous pavements (km) increased compared with 2014. In 2020, CO_2 emissions from road paving with asphalt and asphalt roofing increased by 13.0% compared to 2019 (Figure 4.14).

Urea use

Urea are used as catalyst in fuel consumption and calculated under 1.A.3 Transport sector but emissions are reported under 2.D Non-energy Products from Fuels and Solvent Use (Table 4.36).

Table 4.36 Urea use activity data and CO_2 emissions 2006-2020

Year	Urea consumption (t)	CO_2 emissions (kt)
1990	*NO*	*NO*
1995	*NO*	*NO*
2000	*NO*	*NO*
2005	*NO*	*NO*
2006	*369*	*0.09*

Year	Urea consumption (t)	CO_2 emissions (kt)
2007	*1298*	*0.31*
2008	*1415*	*0.34*
2009	*1322*	*0.32*
2010	*1605*	*0.38*
2011	*1739*	*0.41*
2012	*1812*	*0.43*
2013	*2178*	*0.52*
2014	*2868*	*0.68*
2015	*3423*	*0.82*
2016	*3732*	*0.89*
2017	*4533*	*1.08*
2018	*5034*	*1.20*
2019	*5250*	*1.25*
2020	*5316*	*1.27*

4.5.3.2 Methodological issues

Solvent Use

The NMVOC inventory is carried out to fulfil the obligations of the UNECE CLRTAP.

Activity data

From the 1990ties till 2005 statistics for Domestic solvent use including fungicides (2D3a), Paint application (2D3d) and Other solvent use (2D3i) were not well kept due to the country-wide changes in the governmental system and national economy. For 2006-2020 activity data for these subcategories was obtained from National Chemicals Database at LEGMC. In the National Chemicals Database data of imported and produced amount of chemical products containing NMVOCs is collected together with the percentage of a particular NMVOC in imported or produced products. It is assumed that the NMVOC containing products imported in the country in a particular year are utilized in the same year as the data of the actual use is not available or is confidential. In the National Chemicals Database information on a particular year, amount of produced and imported chemicals (ton), product group (intended use), trade name, chemical name, CAS number and concentration (from … till … %) is provided.

Tobacco activity data on imports and exports are obtained from the CSB.

In 2018, first time estimation of exported NMVOC containing products from the country for the period 2006-2017 was carried out. Activity data on export of solvent products for the years 2006-2017 was provided by CSB. The results of estimation of exported NMVOC containing products are presented in Table 4.37. As shown NMVOC emission has decreased for all time series between 14.6% in 2013 and 30.7% in 2005.

Share of export as percentage, calculated on NMVOC emissions for the year 2020 were extrapolated taking into account GDP in 2017-2020 taken from CSB database.

Table 4.37 Share of export as percentage, calculated on NMVOC emissions

Year	Share of export as percentage, calculated on NMVOC emissions, %
2006	*23.86*
2007	*21.31*
2008	*28.44*
2009	*26.89*
2010	*19.17*
2011	*13.77*
2012	*14.65*
2013	*14.60*
2014	*15.19*
2015	*15.77*
2016	*18.03*
2017	*19.61*
2018	*21.19*
2019	*22.27*
2020	*21.45*

To obtain a comparable data in time series for 1990-2005 where statistics on imported, produced and exported NMVOC containing products was not well kept NMVOC emissions were extrapolated taking into account number of inhabitants taken from CSB database in Table 4.38.

Activity data from Degreasing (2D3e), Dry cleaning (2D3f), Chemical products (2D3g) and Printing (2D3h) subsectors is not available as that data is not required to be reported under National legislation and could be assumed as confidential.

Emission factors

The main database of EFs is the EMEP/EEA 2019.

Methods

NMVOC emissions from Domestic solvent use including fungicides (2D3a), Coating applications (2D3d) and Other solvent use (2D3i) were estimated according to EMEP/EEA 2019 methodology based on Tier 1 or Tier 2 approach (Table 4.28). NMVOC emissions (kt) from these subcategories of Solvent Use sector were calculated for the time series 2006-2020 using the equation below:

$$\boldsymbol{E_{NMVOC} = EF_{NMVOC} * AD} \qquad (4.28)$$

where:

E_{NMVOC} – non-methane volatile organic compounds emissions from solvents and other production use (kt);
EF_{NMVOC} – emission factor from EMEP/EEA 2019;
AD – activity data from the National Chemicals Database (kt).

NMVOC emissions data from Degreasing (2D3e), Dry cleaning (2D3f), Chemical products (2D3g) and Printing (2D3h) subsectors was obtained directly from the national database "2-Air" for 2006-2020. From the 1990ties till 2001 statistics for NMVOC emissions data was not kept. The

"2-Air" is a database where enterprises (that do any pollution activity and have category A, B, or C polluting activity) report their emissions data. There are 240 licences currently in force in Latvia (Category A – 10 licences, category B – 230 licences). From these enterprises data is used only from the enterprises that produced NMVOC emissions according to the EMEP/EEA 2019. The enterprises have been reporting their produced NMVOC emissions dividing in a particular NMVOC.

To obtain a comparable data in time series for 1990-2001 where statistics was not kept NMVOC emissions were extrapolated taking into account number of inhabitants taken from CSB database (Table 4.38).

Table 4.38 The number of population used as activity data under Other solvent and product use for years 1990-2005

Year	Number of inhabitants
1990	*2668140*
1991	*2658161*
1992	*2643000*
1993	*2585675*
1994	*2540904*
1995	*2500580*
1996	*2469531*
1997	*2444912*
1998	*2420789*
1999	*2399248*
2000	*2381715*
2001	*2353384*
2002	*2320956*
2003	*2299390*
2004	*2276520*
2005	*2249724*

Indirect CO_2 emissions from Solvent Use sector was estimated using methodology from the 2006 IPCC Guidelines:

$$\boldsymbol{Emissions_{CO_2} = Emissions_{NMVOC} * Percent\ carbon\ in\ NMVOCs\ by\ mass * 44.0098/12.011} \quad (4.29)$$

It was assumed that the average carbon content of NMVOC is 60% by mass for all categories under the sector of Solvent Use in accordance with the 2006 IPCC Guidelines.

This leads to an EF for indirect CO_2 release of 2.198474731 kg CO_2/kg NMVOC.

Road paving with asphalt (2.D.3.b) and Asphalt roofing (2.D.3.c)

EMEP/EEA 2019 Tier 1 method was used to estimate NMVOC emissions from the 2.D.3.b Road paving with asphalt and 2.D.3.c Asphalt roofing. According to CSB data the biggest part of bitumen mixtures amount is used for road paving (90%). Only small part is used for roofing activities (10%) (Table 4.39).

NMVOC emissions are estimated using simpler default methodology:

$$\boldsymbol{E_{NMVOC} = AD_{bitumen} * EF_{NMVOC}} \quad (4.30)$$

where:

E_{NMVOC} – NMVOC emissions (kt)
$AD_{bitumen}$ – bitumen and bitumen mixtures used in CRF 2.D.3.b and 2.D.3.c activities (kt)
EF_{NMVOC} –NMVOC emission factor (kt/kt)

Indirect CO_2 emissions from asphalt roofing and road paving with asphalt activities were estimated according to the 2006 IPCC Guidelines and explanation of indirect CO_2 emission estimation basing on carbon conversion factor and average default carbon content amount.

For the CO_2 emission estimation NMVOC emissions were taken as activity data and CO_2 emissions were estimated using carbon conversion factor:

$$E_{CO_2} = EF_{CO_2} * NMVOC \qquad (4.31)$$

where:

E_{CO2} – CO_2 emissions (kt)
EF_{CO2} – estimated CO_2 emission factor
NMVOC – NMVOC emissions (kt)

Emission factors

For CO_2 emission estimation 80% of carbon content conversion factor is used. According to the 2006 IPCC Guidelines[66] indirect emissions of CO_2 from atmospheric oxidation of emitted NMVOC are included in the national emission inventory. The average amount of carbon in NMVOC is assumed as 80%[67].

Therefore the CO_2 EF from the 2006 IPCC Guidelines was estimated using following equation:

$$EF_{CO_2} = 80\% * 44.0098/12.011 \qquad (4.32)$$

where:

EF_{CO2} – CO_2 emission factor (kt/kt)
80% – the average amount of carbon in NMVOC
44.0098 / 12.011 – carbon dioxide and carbon molmass ratio

This leads to an EF for indirect CO_2 release of 2.931299642 kg CO_2/kg NMVOC.

Default CO and NMVOC EFs are taken from EMEP/EEA 2019[68,69]. Due to lack of the technology use information Tier1 EFs were used (Table 4.39).

Table 4.39 Emission factors for asphalt roofing and Road paving in 1990–2020

Category	CO_2 (t CO_2/t NMVOC)	CO (kt/kt)	NMVOC (kt/kt)
Asphalt Roofing	*2.93*	*0.0000095*	*0.00013*
Road Paving with Asphalt	*2.93*	*NE*	*0.000016*

[66] IPCC 2006 Guidelines, Vol.1 Ch.7. Available :http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_7_Ch7_Precursors_Indirect.pdf (page 7.6)
[67] Based of the most often used average carbon conversion factor
[68] EMEP/EEA air pollutant emission inventory guidebook 2019, 2.D.3.b Road paving with atsphalt. Available: https://www.eea.europa.eu/publications/emep-eea-guidebook-2019 (page 8)
[69] EMEP/EEA air pollutant emission inventory guidebook 2019, 2.D.3.c Asphalt roofing. Available: https://www.eea.europa.eu/publications/emep-eea-guidebook-2019 (page 9)

Urea use

Description of methodology to calculate CO_2 emissions from Urea use is reported under sector 1.A.3 Transport.

4.5.3.3 Uncertainties and time series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Solvent use

Latvia has developed a detailed inventory for the Solvent Use sector thereby the uncertainty of activity data for Domestic solvent use including fungicides (2D3a), Paint application (2D3d) and Other solvent use (2D3i) is estimated to be the default value of 25% according to the IPCC 2006 Guidelines. However the uncertainty of activity data for Degreasing (2D3e), Dry cleaning (2D3f), Chemical products (2D3g) and Printing (2D3h) subsectors cannot be determined as that activity data is not required to be reported under national legislation and could be assumed as confidential. Uncertainties of indirect CO_2 emissions from Solvent Use sector were estimated on the basis on uncertainties of respective NMVOC emissions. Uncertainty of EF is assumed to be default value of 10%. According to the IPCC 2006 Guidelines the uncertainty of EF took into account the fact that the default fossil carbon content fraction of NMVOC is 60% by mass, and can vary between 50-70%.

Road paving with asphalt (2.D.3.b) and Asphalt roofing (2.D.3.c)

Uncertainty of activity data for estimations of CO_2 emissions from 2.D.3.c Asphalt roofing sector and 2.D.3.b Road paving with asphalt sector is assumed rather low as CSB data of used bitumen mixtures are used and the percentage of the 2006 IPCC Guidelines is used to divide bitumen use for roofing and paving activities. Still as it is not clearly known how much of the total bitumen is used for asphalt paving and for asphalt roofing (bitumen use in construction sector) the uncertainty is assumed at least 20%.

CO_2 EFs for 2.D.3.b and 2.D.3.c sectors are assumed as high as 50% because default EFs are used and CO_2 emissions are estimated from NMVOC emissions. The uncertainty of precursors factors for these two sectors taken from EMEP/EEA 2019 as Tier 1 EFs is assumed as high as 50% as the default EFs are used.

Time series of the estimated emissions are consistent and complete because the same methodology, EFs and data sources are used for sectors for all years in time series. NO_x, CO and SO_2 emissions are not estimated due to lack of estimation methodology and official EFs.

Time series consistency was checked by verifying IEF, AD and emission changes and attention was paid to important increase/decrease that are explained in NIR.

4.5.3.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the IPPU sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

Solvent use

All estimations of emissions done in the LEGMC are checked on the logical mistakes by checking the time series of the activity data, EFs and emissions consistency to display all significant and illogic changes in the activity data and emissions.

Quality control check list is filled for each category taking into account criteria given in QA/QC plan approved in the National legislation. All corrections are archived in centralized archiving system.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

Road paving with asphalt (2.D.3.b) and Asphalt roofing (2.D.3.c).

Activity data used in NMVOC and CO_2 emissions from asphalt roofing and road paving with asphalt was reported by CSB in Annual Questionnaire tables. Bitumen data used in emission estimation and reported in NIR are verified by CSB. Data also is compared to the data reported in 1A(d) sector.

CSB has the internal QA/QC procedures based on mathematical model and analysis to avoid logic mistakes.

The activity data used in estimations is repeatedly verified by CSB energy experts by checking the data input in data estimation database and reported in the NIR.

All estimations of emissions done in the LEGMC also are checked on the logical mistakes by checking the time series of the activity data, EFs and emissions consistency to display all significant and illogic changes in the activity data and emissions.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

4.5.3.5 Category-specific recalculations

Solvent use

In order to obtain more precise emission data each year activity data for latest submitted year (in this case year 2019) was reviewed and recalculated if it is necessary (Table 4.40).

Table 4.40 Recalculated NMVOC emissions by subcategories for 2019 (kt)

Sector	Emissions before recalculation	Emissions after recalculation	Relative difference
	kt NMVOC		%
2D3a	*2.64*	*3.12*	*18.25*
2D3d	*3.28*	*3.60*	*9.88*
2D3e	*0.04*	*0.04*	*-7.14*
2D3f	*0.00*	*0.00*	*765.56*
2D3g	*1.39*	*1.40*	*-0.50*
2D3h	*0.01*	*0.01*	*27.51*
2D3i	*3.90*	*3.47*	*-11.10*

Sector	Emissions before recalculation	Emissions after recalculation	Relative difference
	kt NMVOC		%
2G	*NO*	*0.02*	*-*
Total	*11.26*	*11.67*	*3.50*

Table 4.41 Results of recalculations in NMVOC emissions 1990-2019 (kt)

Year	NMVOC emissions before recalculation (before use of tobacco calculation)	NMVOC emissions after recalculation (including use of tobacco)	Absolute difference	Relative difference
	kt NMVOC			%
1990	*9.53*	*9.54*	*0.01*	*0.12*
1995	*8.93*	*8.94*	*0.01*	*0.12*
2000	*8.49*	*8.50*	*0.01*	*0.12*
2005	*8.03*	*8.04*	*0.01*	*0.10*
2006	*8.01*	*8.01*	*0.00*	*0.01*
2007	*8.78*	*8.79*	*0.00*	*0.00*
2008	*6.87*	*6.89*	*0.01*	*0.17*
2009	*5.71*	*5.72*	*0.01*	*0.17*
2010	*7.80*	*7.80*	*0.01*	*0.11*
2011	*9.29*	*9.30*	*0.01*	*0.08*
2012	*8.82*	*8.83*	*0.01*	*0.10*
2013	*9.19*	*9.20*	*0.01*	*0.08*
2014	*9.56*	*9.56*	*0.01*	*0.09*
2015	*9.91*	*9.92*	*0.01*	*0.08*
2016	*9.30*	*9.31*	*0.01*	*0.09*
2017	*9.94*	*9.95*	*0.01*	*0.09*
2018	*14.41*	*14.43*	*0.01*	*0.08*
2019	*11.26*	*11.67*	*0.02*	*3.62*

Urea use

Recalculation was done for CO_2 emissions in 2.D.3 Urea use due to precised activity data.

Table 4.42 Results of recalculations in 2.D.3 Urea use sector 2012-2019

Year	CO_2 emissions from urea use before recalculation	CO_2 emissions from urea use after recalculation	Absolute difference	Relative difference
		kt CO_2 eq.		%
2012	*0.43*	*0.43*	*0.00*	*-0.3*
2013	*0.53*	*0.52*	*-0.01*	*-1.5*
2014	*0.69*	*0.68*	*-0.01*	*-1.4*
2015	*0.84*	*0.82*	*-0.02*	*-2.4*
2016	*0.90*	*0.89*	*-0.01*	*-1.4*
2017	*1.09*	*1.08*	*-0.01*	*-0.9*
2018	*1.21*	*1.20*	*-0.01*	*-0.5*
2019	*1.31*	*1.25*	*-0.06*	*-4.7*

4.5.3.6 Category-specific planned improvements

Solvent use

No improvements are planned for this sector.

Urea use

No improvements are planned for this sector.

Road paving with asphalt (2.D.3.b) and Asphalt roofing (2.D.3.c)

No improvements are planned for this sector.

4.6 *ELECTRONICS INDUSTRY (CRF 2.E)*

HFC, PFC, SF_6 and NF_3 emissions from manufacturing of integrated circuit of semiconductors, TFT flat panel displays, photovoltaics and heat transfer fluids are not occurring in Latvia.

There is one company in Latvia which manufactures liquid crystal displays (LCDs) and 3D products for industrial, professional, medical and defence applications. Directly contacting with the company they confirmed that NF_3 is not used in technology as well as company has no plans to use it in the future.

Other types of equipment listed in the 2006 IPCC Guidelines, Volume 3, Chapter 6 under this sector are not manufactured in Latvia. Currently using CRF Reporter software version v6.0.8 it is not possible to enter NO in green and grey cells although CRF Reporter User manual says that if disaggregated data is not available for certain categories, the CRF Reporter allows users to report information in the parent category. This can be done by directly entering data in the green cells (i.e. overwriting formulas).

Under Electronics industry subcategories Latvia doesn`t report emissions so child nodes (gases) are not added according to CRF User manual however it is not currently possible to enter data in green cells so some information in the parent category (green cells) in corresponding CRF tables are missing. It was confirmed by CRF Reporter help desk that this is an CRF internal issue which will be improved in the future releases of the software. But for the moment it was suggested to leave cells blank.

4.7 *PRODUCT USES AS SUBSTITUTES FOR OZONE DEPLETING SUBSTANCES (CRF 2.F)*

Under 2.F Latvia reports emissions from usage of hydrofluorocarbons (HFCs) occurring in following sectors:

- Refrigeration and air-conditioning equipment (CRF 2.F.1);
- Foam blowing products (CRF 2.F.2);
- Fire Protection (CRF 2.F.3);
- Aerosols (CRF 2.F.4).

In 2020, GHG emissions from Product uses as substitutes for ODS substances amounted 248.91 kt CO_2 eq. (2.4%) from Latvia`s total CO_2 eq. emissions with indirect CO_2, without LULUCF. Compared to 2019, 2.F category emissions have decreased by 2.4%, but compared to 1995 emissions have increased by even 1353.3%.

There is no production of HFCs in Latvia. Emissions of the perfluorocarbons (PFCs) and nitrogen trifluoride (NF_3) do not occur in Latvia for all time series. HFC and PFC emissions from Solvents (CRF 2.F.5) and Other Applications (CRF 2.F.6) are not occurring in Latvia (reported as "NO" in CRF Reporter). Currently using CRF Reporter software version v6.0.8 it is not possible to enter NO in green and grey cells therefore some information in the parent category (green cells) in corresponding CRF tables are missing.

The calculation of emissions under 2.F was carried out for following gases:

- HFC–23
- HFC–32
- HFC–125
- HFC–134a
- HFC–143a
- HFC–152a
- HFC-245fa
- HFC-365mfc
- HFC–227ea

The biggest part of 2.F emissions constitutes 2.F.1 Refrigeration and Air Conditioning (97.4%) which is also a key category of Latvia`s GHG inventory. Additionally, 2.4% from 2.F emissions comes from 2.F.4. Aerosols (metered dose inhalers), but 0.1% comes from 2.F.2 Foam blowing agents. About 0.001% comes from 2.F.3 Fire protection in 2020 (Figure 4.15).

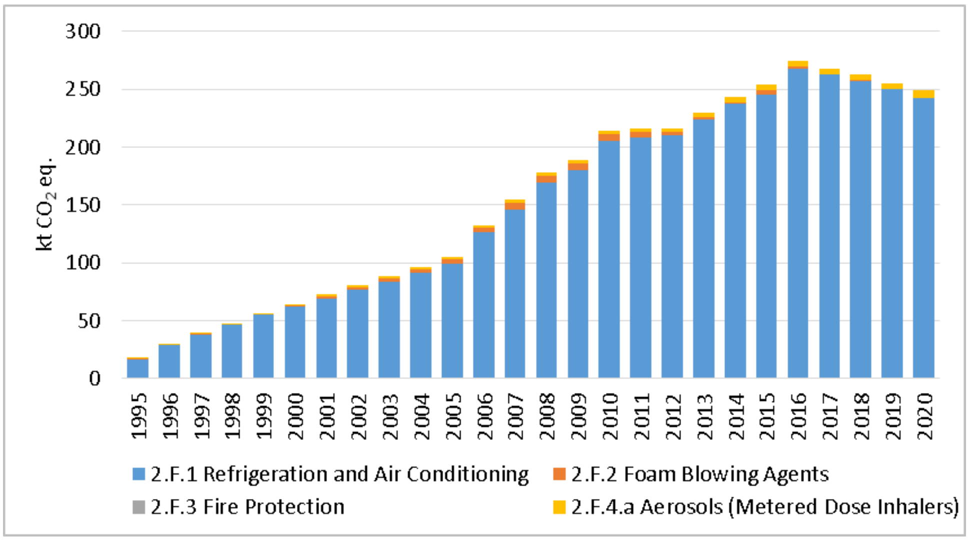

Figure 4.15 HFC emissions from 2.F Product Uses as ODS Substitutes 1995-2020 (kt CO_2 eq.)

The total emissions from 2.F have increased significantly since 1995 to 2016 but after 2016 the amount of emissions is decreased (see Table 4.43 and Figure 4.15). The main reason which caused emission growth was substitution of ODS with alternatives commonly named F-gases in refrigeration and air conditioning appliances. However, F-gases are powerful GHG, with a global warming effect up to 23000 times greater than CO_2, hence their emissions were growing rapidly[70]. The usage of products which substitute ODSs in Latvia mainly depends on import. The imported amounts could be associated with economic situation in the country consequently this led to F-gases emission growth. As the significant part of total 2.F.1.e emissions (40.1% in 2020) results from the increase of car population under this subsector.

[70] *Fluorinated GHG. Available: https://ec.europa.eu/clima/policies/f-gas_en*

Table 4.43 HFC emissions from 2.F Product Uses as Substitutes for ODS, 1995-2020 (kt CO_2 eq.)

Year	2.F Product Uses as Substitutes for ODS	2.F.1 Refrigeration and Air Conditioning	2.F.2 Foam blowing agents	2.F.3 Fire Protection	2.F.4 Aerosols
1995	*17.13*	*16.67*	*0.40*	*NO*	*0.06*
1996	*29.43*	*28.77*	*0.42*	*NO*	*0.23*
1997	*38.94*	*38.04*	*0.45*	*NO*	*0.46*
1998	*47.59*	*46.63*	*0.50*	*NO*	*0.46*
1999	*55.93*	*55.00*	*0.23*	*NO*	*0.70*
2000	*64.60*	*62.59*	*0.78*	*NO*	*1.24*
2001	*72.86*	*69.60*	*1.52*	*0.016*	*1.73*
2002	*80.68*	*76.66*	*1.97*	*0.016*	*2.03*
2003	*88.46*	*84.12*	*2.38*	*0.039*	*1.93*
2004	*96.69*	*91.49*	*3.21*	*0.079*	*1.91*
2005	*105.20*	*99.38*	*3.64*	*0.051*	*2.13*
2006	*132.80*	*126.17*	*4.22*	*0.018*	*2.39*
2007	*154.49*	*146.53*	*5.18*	*0.015*	*2.77*
2008	*178.32*	*169.50*	*5.81*	*0.012*	*3.00*
2009	*188.60*	*180.36*	*5.41*	*0.009*	*2.82*
2010	*214.05*	*205.13*	*6.19*	*0.016*	*2.72*
2011	*215.86*	*208.62*	*4.51*	*0.017*	*2.71*
2012	*216.01*	*210.77*	*2.63*	*0.062*	*2.55*
2013	*215.86*	*224.11*	*1.84*	*0.062*	*3.52*
2014	*243.65*	*237.97*	*0.96*	*0.028*	*4.70*
2015	*254.52*	*245.33*	*4.39*	*0.003*	*4.80*
2016	*275.02*	*267.73*	*2.46*	*0.003*	*4.83*
2017	*267.87*	*262.67*	*0.15*	*0.003*	*5.05*
2018	*263.09*	*257.47*	*0.69*	*0.003*	*4.93*
2019	*255.11*	*249.82*	*0.75*	*0.003*	*4.54*
2020	*248.91*	*242.55*	*0.28*	*0.003*	*6.07*
Share of total IPPU emissions in 2020 (%)	*28.7%*	*27.9%*	*0.1%*	*0.0003%*	*0.7%*
2020 versus 2019	*-2.4%*	*-2.9%*	*-62.2%*	*0.0%*	*33.8%*
2020 versus 1995	*1353.3%*	*1355.4%*	*-28.8%*	*-81.9%*	*1227.8%*

In 2004, the first research of F-gases sources and emissions in Latvia was carried out. Within the project "SF_6, HFC and PFC emission inventory in Latvia 1995-2003"[71] (hereinafter F-gases research (2004)) the areas and users of F-gases in Latvia were identified for the first time. The result of this project was initial activity and consumption data for F-gases emission estimation (in accordance with IPCC 1996 methodology). Activity data and assumptions derived during this project and shortly after were used for F-gases emission calculations. Obtained data from the research did not provide completeness, therefore extrapolation is used for historical data.

In 2015-2016 the F-gases research within the EEA Financial Mechanism 2009-2014 Programme "National Climate Policy (hereinafter F-gases research (2016)) was carried out. The aim of this research was to improve activity data obtaining process and EFs in 2.F.1 Refrigeration and Air

[71] *Project report "SF_6, HFC and PFC emission inventory in Latvia 1995-2003", Riga 2004*

conditioning sector as well as to split the activity data for years 2004-2014 between the 2.F.1 subcategories according to the 2006 IPCC Guidelines.

F-gases research (2016) has been bottom-up orientated. F-gases importers, suppliers, users and service companies were asked to supplement the information reported under F-gas Regulation No. 517/2014[72] and national Regulation No.563[73] with the information regarding the sector and purpose of the substances they import, use or refill in equipment in the country. As a result F-gas data was divided by categories relevant to the 2006 IPCC Gudelines 2.F.1 sector. EFs and assumptions were discussed and confirmed by Latvian Association of Refrigeration Engineers which is the responsible institution in certification of F-gases operators in Latvia.

In 2016-2017 the split of 2.F.1 subcategories were revised during evaluation study on F-gases in stocks (amount of refrigerants in new and operating systems as well as number of companies per F-gas sectors). The results revealed that within the F-gas research (2016) emissions from commercial and industrial refrigeration were overestimated and emissions from stationary air conditioning and transport refrigeration were underestimated (Table 4.44). Results are included in this report under relevant categories. This F-gas split evualation has calculated since submission 2017.

Table 4.44 Proportions by 2.F.1 sub applications in LV inventory and EU

Proportion of F-gas emissions 2.F.1	Commercial refrigeration	Domestic refrigeration	Industrial Refrigeration	Transport refrigeration	Mobile air conditioning	Stationary air conditioning
EU average*	*34%*	*1%*	*16%*	*5%*	*26%*	*18%*
F-gases research (2016)	*41%*	*0.3%*	*15%*	*2%*	*33%*	*9%*
F-gas split evaluation (since Submission 2017)	*28%*	*0.3%*	*7%*	*5%*	*36%*	*24%*

**14 MS, weighted shares*

4.7.1 Refrigeration and Air Conditioning (CRF 2.F.1)

4.7.1.1 Category description

The calculation of actual emissions from Refrigeration and Air Conditioning is done according to the 2006 IPCC Guidelines, Chapter 7 (Emissions of Fluorinated Substitutes for Ozone Depleting Substances).

Refrigeration and Air Conditioning Systems are responsible for about 97.4% of the 2.F Product uses as substitutes for ozone depleting substances sector in 2020. Under 2.F.1 sector HFC emissions are reported covering 6 subcategories according to the 2006 IPCC Gudelines:

[72] *F-gas regulation No. 517/2014 of The European Parliament and the Council of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006*

[73] *Regulation No.563 of the Cabinet of Ministers of Latvia on "Provisions concerning specific restrictions and prohibitions on activities with ozone-depleting substances and fluorinated greenhouse gases"*

- Commercial Refrigeration (refrigerators for supermarkets, shops etc.);
- Domestic Refrigeration (fridges and freezers in households);
- Industrial Refrigeration (refrigeration units in food and chemical industries);
- Transport Refrigeration (refrigerated vehicles);
- Mobile Air Conditioning (air conditioning systems in passenger cars, light and heavy duty vehicles and buses);
- Stationary Air Conditioning (room air-conditioning systems and heat pumps).

In 2020, HFC emissions from 2.F.1 Refrigeration and Air Conditioning totalled 242.55 kt CO_2 eq. Compared to 2019 the emissions were decreased by 2.9%. In 2020, the majority of F-gases emissions under 2.F.1 originates from 2.F.1.e Mobile air conditioning (41.2%), 2.F.1.f Stationary Air Conditioning (36.2%) and 2.F.1.a Commercial Refrigeration (17.0%). Other less significant sources are 2.F.1.c Industrial Refrigeration (3.4%) and 2.F.1.d Transport Refrigeration (2.0%) as well as 2.F.1.b Domestic Refrigeration (0.2%) (Figure 4.16).

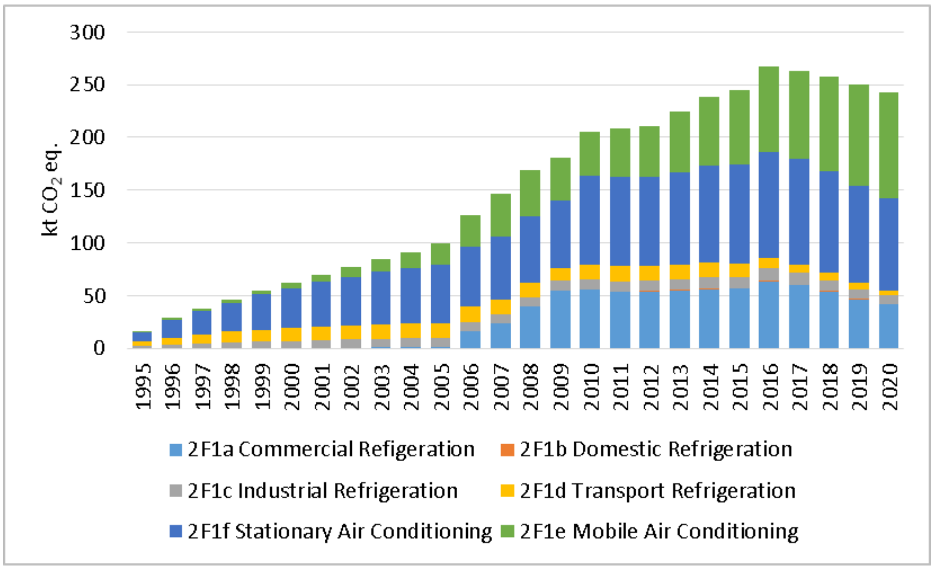

Figure 4.16 F-gases emissions from 2.F.1. Refrigeration and Air Conditioning equipment 1990-2020 (kt CO_2 eq.)

4.7.1.2 Methodological issues

An overview of the methods used and gases reported under 2.F.1 sector is presented in Table 4.45.

Table 4.45 Summary of emission calculation methods and gases in CFR 2.F.1

CRF Category/subcategory	Method used	Gases reported
2.F.1.a Commercial Refrigeration	*Tier 2a*	*HFC-134a* *HFC-32* *HFC-125* *HFC-143a* *HFC-152a* *HFC-23*
2.F.1.b Domestic Refrigeration	*Tier 2a*	*HFC-134a*
2.F.1.c Industrial Refrigeration	*Tier 2a*	*HFC-134a* *HFC-32* *HFC-125*

CRF Category/subcategory	Method used	Gases reported
		HFC-143a
2.F.1.d Transport Refrigeration	*Tier 2a*	*HFC-134a* *HFC-32* *HFC-125* *HFC-143a* *HFC-23*
2.F.1.e Mobile Air Conditioning	*Tier 2a*	*HFC-134a*
2.F.1.f Stationary Air Conditioning	*Tier 2a*	*HFC-134a* *HFC-32* *HFC-125* *HFC-143a* *HFC-152a*

Emissions are calculated by the IPCC Tier 2a EF approach of the 2006 IPCC Guidelines (Vol. 3, Chapter 7, Equation 7.10, p. 7.49). However, Tier 2 method is written in the CRF tables because it is not possible to enter Tier 2a.

Based on the 2006 IPCC Guidelines one part of Vol. 3, Chapter 7, Equation 7.10 is emissions from refrigerant management of containers. Applying default EF and according to information represented by F-gas database emissions of refrigerant management of containers are below the 0.05% (0.01-0.04% for time period 2013-2018) of the national total GHG emissions and could be characterized as emissions below the threshold of significance in Latvia. Therefore for Latvia emissions are considered as negligible.

- *Commercial Refrigeration (CRF 2.F.1.a)*

Activity data

Activity data for emission calculation is taken from annual reports by F-gases operators according to F-gas Regulation No.517/2014 and national Regulation No.563[74] "Requirements for activities with ozone depleting substances and fluorinated greenhouse gases". According to these regulations operators (merchants and other institutions) which perform activities with ozone depleting substances or F-gases annually shall report to LEGMC the following information:

– Name of the substance;
– Amount of substance at the beginning of the year;
– Imported amount;
– Exported amount;
– Charged amount in freezing equipment units;
– Recycled amount;
– Regenerated amount;
– Disposed amount;
– Amount of substance at the end of the year.

From 1995 to 1997 the amount of filled in new manufactured products is extrapolated based on IPCC 2006 Guidelines Volume 1 Chapter 5 about extrapolation. For 1998-2003 activity data

[74] Regulation No.563 of the Cabinet of Ministers of Latvia on "Provisions concerning specific restrictions and prohibitions on activities with ozone-depleting substances and fluorinated greenhouse gases"

were obtained from questionnaires within first F-gases research. For 2004-2005 activity data were obtained from enterprises that responded on data request letters sent by LEGMC. For 2006-2016 data were obtained from reporting within national Regulation No.563 or extrapolated. In 2017 the share of F-gases filled into new commercial refrigeration units were reduced due to F-gas evaluation study. During this study for 2010-2015 the F-gas data reported by operators within national Regulation No.563 were reevaluated. As a result it was concluded that share of F-gases filled into new commercial refrigeration units is lower than estimated in F-gas research (2016). According to study results commercial refrigeration constitutes 28% from all 2.F.1 emissions and not 41% as previously thought (Table 4.44). Share of F-gases filled in new appliances in 2016 was based on evaluation study results.

Emission factors and calculations

Tier 2a – emission-factor approach from the 2006 IPCC Guidelines was used to estimate emissions from commercial refrigeration. Emissions result from charging, lifetime and end-of-life of equipment and are calculated for each type of HFC separately.

According to the methodology, refrigerant emissions at a reporting year can be calculated separately for each stage of life of the equipment. These emissions come from:

- $E_{charge,\ t}$ – emissions related to the refrigerant charge: connection and disconnection of the refrigerant container and the new equipment to be charged;
- $E_{lifetime,t}$ – annual emissions from the banks of refrigerants during operation (fugitive emissions and ruptures) and servicing;
- $E_{end\text{-}of\text{-}life,}t$ – emissions at system disposal.

Equation 7.10 from the 2006 IPCC Guidelines was used to sum up all the emissions occurring during the lifetime of the equipment:

$$\boldsymbol{E_{total,t} = E_{Charge,t} + E_{Lifetime,t} + E_{End-of-life,t}} \qquad (4.33)$$

There are no HFC-containing equipment manufacturing companies in Latvia and all appliances used in commercial refrigeration are imported.

EFs and assumptions used in emission calculation from commercial refrigeration are as follows:

- HFCs mainly charged in Commercial Refrigeration are HFC-134a, HFC-404a, HFC-422d, HFC-407c, HFC-507a and HFC-410a;
- Average EF during charging of equipment is 1.8%[75];
- Average EF during operation of equipment is 18%[76];
- Average life time of commercial applications assumed 15 years;
- Residual charge of HFC in equipment being disposed 80%[77];
- Recovery efficiency at disposal 70%[78].

[75] *2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9 – Average value applied for commercial applications.*
[76] *2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9 – Average value applied for commercial applications.*
[77] *2006 IPCC Guidelines, Vol. 3, Ch. 7, Table 7.9*
[78] *2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9*

Equation from the 2006 IPCC Guidelines for charging emissions estimation:

$$\boldsymbol{E_{Charged,t} = M_t * k/100} \qquad (4.34)$$

where:

$E_{charged}$ – emissions during system manufacture/assembly in year (kg)
Mt – amount of HFC charged into a new equipment in year (kg)
k – charging losses (%)

Equation from the 2006 IPCC Guidelines for emission estimation stocks:

$$\boldsymbol{E_{lifetime,t} = B_t * x/100} \qquad (4.35)$$

where:

$E_{lifetime}$ – amount of emissions during equipment operation (t)
Bt – amount of HFC held in stocks in year t
x – losses during operation period (%)

Equation from the 2006 IPCC Guidelines for emission estimation from disposal:

$$\boldsymbol{E_{end-of-life,t} = M_{t-d} * \frac{p}{100} * (1 - \eta_{rec,d}/100)} \qquad (4.36)$$

where:

$E_{lend-of-life}$– amount of HFC emitted at system disposal in year (t)
Mt-d – residual charge of HFC in equipment being disposed of expressed in percentage of full charge (%)
ηrec, d – recovery efficiency at disposal, which is the ration of recovered HFC reffered to the HFC contained in the system (%)

There are no HFC-134a emissions for 1990-1994 therefore notation key – NO – is used. Started from 1995 emissions are calculated for HFC-134a. HFC-32, HFC-125, HFC-143a are not used before 2004, so for 1900-2003 the notation key – NO – are used. HFC-152a is not used before 2006, so for 1900-2005 the notation key – NO is used. HFC-23 is not used before 2008, so for 1900-2007 the notation key – NO – is used.

The total amount of HFC charged into commercial refrigeration equipment in 2020 amounts to 4.66 t constituting 0.08 t manufacturing emissions. HFC in stocks amounts to 61.23 t constituting 36.34 t operating emissions.

As the HFC-134a amount filled into refrigeration equipment is available since 1995, disposal emissions according to 15 years lifetime are estimated from 2010. Before 2010 notation key – NO – is used. HFC-32, HFC-125 and HFC-143a amount that has been filled in new manufactured products and amounts in operating systems has been since 2004, therefore disposal emissions are estimated from 2019. Before 2019 notation key - NO – is used. HFC-152a amount that has been filled in new manufactured products and amounts in operating systems has been since 2006, disposal emissions are not yet occurred, so notation key - NO – is used. HFC-23 amount that has been filled in new manufactured products and amounts in operating systems has been since 2008. Based on the 2006 IPCC guidelines according that lifetime of equipment is 15 years, disposal emissions are not yet occurred, so notation key - NO – is used.

In 2020, the amount of HFCs remained in decommission is amount of refrigerant initially charged into the systems in 2005 (1.30 t) which constitutes 0.31 t disposal emissions.

- *Domestic Refrigeration (CRF 2.F.1.b)*

Activity data

This category includes all refrigeration units (fridges and freezers) for domestic use. As there is no production of such equipment in Latvia, emissions could be estimated taking into account data on imported units which are charged and used within the country. Prior to 1990 most refrigeration appliances used CFC-12. Since 1993 there was a shift to HFC-134a. Many countries have subsequently moved to systems using hydrocarbon HFC-600a which is now the predominant refrigerant for new domestic refrigeration appliances.

From domestic refrigeration HFC-134a emissions are estimated.

The activity data for HFC-134a emission estimation from domestic refrigerators and freezers are:

- number of inhabitants in Latvia – data taken from CSB database „Resident population at the beginning of the year"[79];
- number of households in Latvia – data taken from CSB database „Total number of households and the average size of a household"[80];
- number of new imported fridges and freezers – data taken from CSB database "Imports by countries 1995-2020"[81];
- share of annually sold new equipment filled with HFC-134a – taken from Finland according to Finnish research[82];
- share (%) of households using refrigerators and freezers – for 1996, 2001, 2006, 2010, 2015 years data taken from CSB database „Number of electrical appliances used in dwellings and average age of appliances"[83];
- share (%) of refrigerators and freezers charged with HFC-134a from 1995 till 2005 were determined during first F-gases research in 2004. As from 2006 the F-gases regulation entered into force it was assumed that the share of HFC-134a containing domestic refrigerators (stocks) started to decrease since that time. All European manufacturers of household appliances have changed their production from HFC-134a to R600a some time ago and appliances containing HFC-134a have only been imported from outside the EU to a small extent in recent years. No new equipment entered the stock from 2011 onwards. It was confirmed by Latvian Association of Refrigeration Engineers that the share of HCF-134a in domestic refrigeration stock is 15%.

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[79] *Population in regions and cities by age and gender at the beginning of the year. Available: https://stat.gov.lv/lv/statistikas-temas/iedzivotaji/iedzivotaju-skaits/tabulas/ird040-iedzivotaji-pec-dzimuma-un-vecuma*

[80] *Total number and average size of private households in regions, cities, municipalities, urban and rural areas at the beginning of the year. Available: https://stat.gov.lv/lv/statistikas-temas/iedzivotaji/privato-majsaimniecibu-skaits/tabulas/mvs010-privato-majsaimniecibu*

[81] *Exports and imports by countries. Available: https://data.stat.gov.lv/pxweb/lv/OSP_PUB/START__TIR__AT__ATD/ATD020*

[82] *Share of annually sold new equipment filled with HFC-134. Available: a http://www.vtt.fi/inf/pdf/tiedotteet/2001/T2099.pdf*

[83] *Number of electrical appliances used in dwellings and average age of appliances. Available: https://data.stat.gov.lv/pxweb/lv/OSP_OD/OSP_OD__apsekojumi__energ_pat/EPM210.px/*

Emission factors and calculations

HFC-134a emissions from domestic refrigerators and freezers are estimated by using the 2006 IPCC Guidelines Tier 2a – Emission-factor approach.

EFs and assumptions used in emission calculation from domestic refrigeration are as follows:

- Country specific average refrigerant charge per unit: 150 g HFC-134a;
- Default manufacturing EF 0.6%[84];
- Default operating EF 0.3%[85];
- Default disposal EF 80%[86];
- Recovery efficiency at disposal 70%[87].

There are no manufacturing companies in Latvia and all domestic refrigerators and freezers are imported.

That gives approximate annual amount of HFC-134a charged that is estimated with equation from the 2006 IPCC Guidelines:

$$\boldsymbol{HFC_{Charged,t} = R * n/f} \quad (4.37)$$

where:

$HFC_{charged}$ – amount of HFC-134a charged in year t (tonnes)
R – amount of refrigerators and freezers charged with HFC-134a (units)
n – average equipment lifetime (years)
f – amount of HFC-134a charged once in lifetime of equipment

Equation from the 2006 IPCC Guidelines was used for charging emissions estimation:

$$\boldsymbol{E_{Charged,t} = Mt * k/100} \quad (4.38)$$

where:

$E_{charged}$ – emissions during system manufacture/assembly in year (kg)
Mt – amount of HFC-134a charged into a new equipment in year (kg)
k – charging losses (%)

Amount of HFC-134a in stocks is estimated according to data from CSB. Approximate amount of HFC-134a stored in domestic refrigerators and freezers was estimated based on CSB data on number of households and share of households using refrigerators and freezers as well as assumption of share (%) of refrigerators and freezers filled with with HFC-134a.

Equation from the 2006 IPCC Guidelines for emission estimation from equipment lifetime:

$$\boldsymbol{E_{lifetime,t} = B_t * x/100} \quad (4.39)$$

where:

$E_{lifetime}$ – amount of HFC emitted during system operation in year (kg)
Bt – amount of HFC banked in existing systems in year (kg)

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[84] *2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9, average value applied for domestic refrigeration*
[85] *2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9, average value applied for domestic refrigeration*
[86] *2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9, value applied for domestic refrigeration*
[87] *2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9*

x – annual emission rate (%)

According to 15 years lifetime it is assumed that first disposal emissions from domestic refrigerators and freezers appear in 2010. Equation from the 2006 IPCC Guidelines for emission estimation from disposal:

$$\boldsymbol{E_{end-of-life,t} = M_{t-d} * \frac{p}{100} * (1 - \eta_{rec,d}/100)} \quad (4.40)$$

where:

$E_{lend\text{-}of\text{-}life}$– amount of HFC emitted at system disposal in year t (kg)
Mt-d – residusl charge of HFC in equipment being disposed of expressed in percentage of full charge, (%)
ηrec, d – recovery efficiency at disposal, which is the ration of recovered HFC reffered to the HFC contained in the system (%)

HFC-134a emissions were not occurring for 1990-1994. So there is used notation key – NO. Since 1995 HFC-134a emissions are calculated.

In 2020, the total HFC emissions from HFC-134a used in domestic refrigeration amounts to 0.40 t or 0.57 kt CO_2 eq. There is increase (13.6%) in 2020 compared to 2019 because in the calculation are not only used inhabitants and households of Latvia but also is used HFC-134a that were charged into new refrigerators and freezers 15 years ago. And in this case the increase is because in 2005 HFC-134a, that were charged into refrigerators and freezers, were higher that it was charged in 2004. The majority of HFC emissions from domestic refrigerators occur at end-of-life from 2010 onwards. There are no charging emissions since 2011 and stock emissions are comparably low since HFC-134a is replaced with HFC-600a in domestic refrigerators and freezers.

- *Industrial Refrigeration (CRF 2.F.1.c)*

Activity data

Activity data for emission calculation from Industrial Refrigeration is taken from annual reports by F-gases operators according to F-gas Regulation No.517/2014 and national Regulation No.563[88]. For historical years the amount of filled in new manufactured products is extrapolated based on IPCC 2006 Guidelines Volume 1 Chapter 5 about extrapolation. For 2004-2015 data were obtained from reporting within national Regulation No.563 or extrapolated. In 2016 the share of F-gases filled into new industrial refrigeration units were reduced due to F-gas evaluation study. During this study for 2010-2015 the F-gas reports reported by operators within national Regulation No.563 were reevaluated. As a result it was concluded that share of F-gases filled into new industrial refrigeration units is lower than estimated in F-gas research (2016). According to study results industrial refrigeration constitutes 7% from all 2.F.1 emissions and not 15% as previously thought (Table 4.44). This could be explained with better control measures of industrial appliances done by State Environmental Service. Share of F-gases filled in new appliances in 2016 was based on evaluation study results.

[88] Regulation No.563 of the Cabinet of Ministers of Latvia on "Provisions concerning specific restrictions and prohibitions on activities with ozone-depleting substances and fluorinated greenhouse gases"

Emission factors and calculations

Tier 2a – emission-factor approach from the 2006 IPCC Guidelines was used to estimate emissions from industrial refrigeration. Emissions result from charging, lifetime and end-of-life of equipment and are calculated for each type of HFC separately.

According to the methodology, refrigerant emissions at a reporting year can be calculated separately for each stage of life of the equipment. These emissions come from:

- $E_{charge,\ t}$ – emissions related to the refrigerant charge: connection and disconnection of the refrigerant container and the new equipment to be charged;
- $E_{lifetime,t}$ – annual emissions from the banks of refrigerants during operation (fugitive emissions and ruptures) and servicing;
- $E_{end\text{-}of\text{-}life,}t$ – emissions at system disposal.

Equation 7.10 from the 2006 IPCC Guidelines was used to sum up all the emissions occurring during the lifetime of the equipment:

$$\boldsymbol{E_{total,t} = E_{Charge,t} + E_{Lifetime,t} + E_{End-of-life,t}} \quad (4.41)$$

There are no HFC-containing equipment manufacturing companies in Latvia and all appliances used in industrial refrigeration are imported.

EFs and assumptions used in emission calculation from industrial refrigeration are as follows:

- HFCs mainly charged in Industrial Refrigeration are HFC-134a, HFC-404a, HFC-422d, HFC-407c, HFC-507a and HFC-410a;
- Average EF during charging of equipment is 1.8%[89];
- Average EF during operation of equipment is 16%[90];
- Average life time of industrial applications 15 years[91];
- Residual charge of HFC in equipment being disposed 80%[92];
- Recovery efficiency at disposal 90%[93].

Equation from the 2006 IPCC Guidelines for charging emissions estimation:

$$\boldsymbol{E_{Charged,t} = M_t * k/100} \quad (4.42)$$

where:

$E_{charged}$ – emissions during system manufacture/assembly in year (kg)
Mt – amount of HFC-134a charged into a new equipment in year (kg)
k – charging losses (%)

Equation from the 2006 IPCC Guidelines for emission estimation stocks:

$$\boldsymbol{E_{lifetime,t} = B_t * x/100} \quad (4.43)$$

[89] *2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9 – Average value applied for industrial applications.*
[90] *2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9 – Average value applied for industrial applications.*
[91] *Assumed in accordance with similarities to Estonia and Lithuania*
[92] *2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9*
[93] *2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9*

where:

$E_{lifetime}$ – amount of emissions during equipment operation (t)
Bt – amount of F-gases held in stocks in year t (tonnes)
x – losses during operation period (%)

Equation from the 2006 IPCC Guidelines for emission estimation from disposal:

$$\boldsymbol{E_{end-of-life,t} = M_{t-d} * \frac{p}{100} * (1 - \eta_{rec,d}/100)} \tag{4.44}$$

where:

$E_{lend-of-life}$– amount of HFC emitted at system disposal in year t (kg)
Mt-d – residusl charge of HFC in equipment being disposed of expressed in percentage of full charge, (%)
ηrec, d – recovery efficiency at disposal, which is the ration of recovered HFC reffered to the HFC contained in the system (%)

There are no emissions for 1990-1994 therefore the notation key – NO – are used. Started from 1995 emissions are calculated.

The total amount of HFC filled into industrial refrigeration equipment in 2020 amounts to 1.16 t constituting 0.02 t manufacturing emissions. HFC in stocks amounts to 16.42 t constituting 2.63 t operating emissions.

As the HFC amounts filled into refrigeration equipment are available since 1995, the disposal emissions according to 15 years lifetime are estimated from 2010. Before 2010 notation key – NO – is used.

In 2020, the amount of HFCs remained in decommission is amount of refrigerant initially charged into the systems in 2005 (2.89 t) which constitutes 0.23 t disposal emissions.

- *Transport Refrigeration (CRF 2.F.1.d)*

Activity data

According to F-gases research (2004), only negligible amount of HFCs was used in railways and water transport. Small amount of HFC-23 was filled into refrigerating equipment in ships. HFC-134a and HFC-125 was filled into mobile refrigerators used in road transport. For 1995-1997 HFC-134a amount of filled in new manufactured products is extrapolated based on IPCC 2006 Guidelines Volume 1 Chapter 5 about extrapolation. For 1998-2003 activity data for HFC-134a emission calculation were taken from responses to questionnaires during first F-gases research (2004). For 1995-2003 HFC-32, HFC-125 and HFC-143a amount of filled in new manufactured products is extrapolated based on IPCC 2006 Guidelines Volume 1 Chapter 5 about extrapolation.

For 2004-2020 activity data for emission calculation from Transport Refrigeration is taken from National Regulation No.563 or extrapolated. In 2018 during evaluation study the substances and their share in transport refrigeration were reevaluated. It was concluded that only HFC-134a is being filled in new manufactured products hence only HFC-134a manufacturing emissions are reported under this category. For the rest of previously filled gases (HFC-125, HFC-32 and HFC-143a) only operation emissions are estimated. According to study results transport refrigeration constitutes 5% from all 2.F.1 emissions and not 2% as it was previously thought (Table 4.44). Share of F-gases filled in new appliances in 2016 was based on evaluation study results.

Emission factors and calculations

Tier 2a – emission-factor approach from the 2006 IPCC Guidelines was used to estimate emissions from transport refrigeration. Emissions result from charging, lifetime and end-of-life of equipment and are calculated for each type of HFC separately.

According to the methodology, refrigerant emissions at a reporting year can be calculated separately for each stage of life of the equipment. These emissions come from:

- $E_{charge,\ t}$ – emissions related to the refrigerant charge: connection and disconnection of the refrigerant container and the new equipment to be charged;
- $E_{lifetime,t}$ – annual emissions from the banks of refrigerants during operation (fugitive emissions and ruptures) and servicing;
- $E_{end\text{-}of\text{-}life,}t$ – emissions at system disposal.

Equation 7.10 from the 2006 IPCC Guidelines was used to sum up all the emissions occurring during the lifetime of the equipment:

$$\boldsymbol{E_{total,t} = E_{Charge,t} + E_{Lifetime,t} + E_{End-of-life,t}} \quad (4.45)$$

There are no HFC-containing equipment manufacturing companies in Latvia and all appliances used in transport refrigeration are imported therefore HFC emissions are estimated from stocks and from disposal.

EFs and assumptions used in emission calculation from transport refrigeration are as follows:

- HFCs mainly charged in Transport Refrigeration are HFC-134a and HFC-404a;
- Average EF during charging of equipment is 0.6%[94];
- Country specific EF during operation of equipment is 30%[95];
- Average life time of transport applications 8 years[96];
- Residual charge of HFC in equipment being disposed 50%[97];
- Recovery efficiency at disposal 90%[98].

Equation from the 2006 IPCC Guidelines for charging emissions estimation:

$$\boldsymbol{E_{Charged,t} = M_t * k/100} \quad (4.46)$$

where:

$E_{charged}$ – emissions during system manufacture/assembly in year (kg)
Mt – amount of HFC-134a charged into a new equipment in year (kg)
k – charging losses (%)

Equation from the 2006 IPCC Guidelines for emission estimation stocks:

$$\boldsymbol{E_{lifetime,t} = B_t * x/100} \quad (4.47)$$

[94] *2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9 – Average value applied for transport applications.*
[95] *Confirmed by Latvian Association of Refrigeration Engineers*
[96] *2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9 – Average value applied for transport applications*
[97] *2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9*
[98] *2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9*

where:

$E_{lifetime}$ – amount of emissions during equipment operation (t)
Bt – amount of F-gases held in stocks in year t (tonnes)
x – losses during operation period (%)

Equation from the 2006 IPCC Guidelines for emission estimation from disposal:

$$\boldsymbol{E_{end-of-life,t} = M_{t-d} * \frac{p}{100} * (1 - \eta_{rec,d}/100)} \qquad (4.48)$$

where:

$E_{lend-of-life}$– amount of HFC emitted at system disposal in year t (kg)
Mt-d – residusl charge of HFC in equipment being disposed of expressed in percentage of full charge, (%);
ηrec, d – recovery efficiency at disposal, which is the ration of recovered HFC reffered to the HFC contained in the system (%)

There are no HFC-134a, HFC-125, HFC-143a and HFC-32 emissions for 1990-1994 therefore the notation key – NO – are used. Started from 1995 emissions are calculated. Also there are no HFC-23 emissions for all time series therefore the notation key – NO – are used.

The total amount of HFC filled into transport refrigeration equipment in 2020 amounts to 1.86 t constituting 0.01 t manufacturing emissions. HFC in stocks amounts to 9.43 t constituting 2.83 t operating emissions.

As the HFC amounts filled into refrigeration equipment are available since 1995, disposal emissions according to 8 years lifetime are estimated starting from 2003. Before 2003 notation key - NO – is used.

In 2020, the amount of HFCs remained in decommission is amount of refrigerant initially charged into the systems in 2012 (6.75 t) which constitutes 0.34 t disposal emissions.

- *Mobile Air Conditioning (CRF 2.F.1.e)*

Activity data

Under 2.F.1.e HFC-134a emissions are estimated for the following road vehicle types which were assessed according to emission control system (EURO classes):

- Passenger cars
- Light Duty Vehicles <3,5t
- Heavy duty vehicles 3,5 -12 t
- Heavy duty vehicles >=12 t
- Buses <=18 t
- Buses >18 t

Number of road vehicles in technical order by types above was used as activity data for emission estimation in this sector. This data is receved annually by IPE and are also used for CO_2 emission calculation from road transport (1.A.3.b sector). EU MAC Directive[99] prohibits the use of F-gases with GWP of more than 150 in all new cars and vans produced from 2017 and refrigerant R-1234yf is used as a replacement for R134a in mobile air conditioning systems. It is assumed, that air conditioning systems of vehicles produced from 2017 are filled with refrigerant R-1234yf, so these vehicles are not included in the total number of cars. R-1234yf emissions from

[99] *EU MAC Directive. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32006L0040*

mobile air conditioning are about 0.01 kt CO_2 eq. Taking into account that these emissions are insignificant and are not subject to reporting obligations, emissions are neither reported in the CRF tables or included in the national total emissions.

Average share (%) of vehicles equipped with mobile air conditioning (MAC) systems according to technology used in each vehicle type was estimated taking into account the information from Lithuanian NIR 2021[100] according to vehicle suppliers assuming similar conditions with Lithuania`s vehicle fleet (Table 4.46).

Table 4.46 Average share (%) of vehicles equipped with MAC systems by vehicle type and technology

Technology	Passenger cars	Light Duty Vehicles <3,5t	Heavy duty vehicles 3,5 -12 t	Heavy duty vehicles >=12 t	Buses <=18 t	Buses >18 t
Convential 1990-1993	*0*	*0*	*3*	*0*	*0*	*0*
EURO 1 1993-1997	*16*	*3*	*12*	*4*	*4*	*16*
EURO 2 1997-2001	*41*	*22*	*24*	*22*	*22*	*41*
EURO 3 2001-2006	*66*	*33*	*47*	*38*	*38*	*66*
EURO 4 2006-2011	*80*	*47*	*73*	*55*	*55*	*80*
EURO 5 2011-2014	*89*	*50*	*89*	*60*	*60*	*89*
EURO 6 Since 2014	*94*	*50*	*94*	*60*	*60*	*94*

Average amounts of HFC-134a in each vehicle type are summarized in Table 4.47.

Table 4.47 HFC-134a average amount by vehicle type

Vehicle type	Average refrigerant amount (kg)
Passenger cars	*0.7*
Light Duty Vehicles <3,5t	*0.7*
Heavy duty vehicles 3,5 -12 t	*1.2*
Heavy duty vehicles >=12 t	*1.2*
Buses <=18 t	*8*
Buses >18 t	*13*

Emission factors and calculations

Tier 2a – emission-factor approach from the 2006 IPCC Guidelines for each vehicle type was used to estimate emissions from MACs. As most part of vehicle fleet in Latvia are second hand there are no data available on the original factory charge. HFC emissions from MACs are estimated from stocks and disposal. According to the methodology, refrigerant emissions at a reporting year can be calculated separately for each stage of life of the equipment. HFC-134a emissions from MACs are estimate from following stages:

- $E_{lifetime,t}$ – annual emissions from the banks of refrigerants during operation (fugitive emissions and ruptures) and servicing;
- $E_{end\text{-}of\text{-}life,}t$ – emissions at system disposal.

[100] *National Inventory Report of Lithuania. Available: https://unfccc.int/ghg-inventories-annex-i-parties/2021*

Equation 7.10 from the 2006 IPCC Guidelines was used to sum up all the emissions occurring during the lifetime of the equipment:

$$\boldsymbol{E_{total,t} = E_{Lifetime,t} + E_{End-of-life,t}} \tag{4.49}$$

EFs and assumptions used in emission calculation from MACs are as follows:

- HFC used in mobile air conditioning is HFC-134a ;
- Average EF during operation of equipment is 15%[101];
- 8% of total MACs are disposed every year[102];
- Average life time of transport applications 13 years[103];
- Residual charge of HFC in equipment being disposed 100%[104];
- $\eta_{rec,\ d}$ = 0[105]

Equation from the 2006 IPCC Guidelines for emission estimation stocks:

$$\boldsymbol{E_{lifetime,t} = B_t * x/100} \tag{4.50}$$

where:

$E_{lifetime}$ – amount of emissions during equipment operation (t)
Bt – amount of F-gases held in stocks in year t (tonnes)
x – losses during operation period (%)

The amount of F-gases remained in MACs after the disposal every year is estimated by multiplying amount of MACs disposed with the approximate amount of F-gases remained in one appliance. It is assumed that 100% of F-gases remained in MACs after their lifetime.

Equation from the 2006 IPCC Guidelines for emission estimation from disposal of MACs:

$$\boldsymbol{E_{end-of-time,t} = M_{t-d} * \frac{p}{100} * (1 - \eta_{rec,d}/100)} \tag{4.51}$$

where:

$E_{end-of-life,t}$– amount of emissions from system disposal (t)
Mt-d– amount of HFC initially charged into new systems installed in year (t-n) (tonnes)
p – residual charge of HFC in equipment being disposed of expressed in percentage of full charge (%)
ηrec,d – recovery efficiency at disposal (%)

There are no HFC-134a emissions for 1990-1994 therefore the notation key – NO – is used. Started from 1995 emissions are calculated.

In 2020, the total HFC-134a stock in all road vehicle types in Latvia amounts to 383.51 t. The HFC-134a emissions from stocks are 57.53 t. In 2020, the amount of HFC in disposed MACs was 12.27 t which according to assumption of 100% emission of disposal resulted in 12.27 t of HFC-134a. Expressed in CO_2 eq. total emissions from mobile air conditioniers constituted 99.81 kt

[101] *2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9 – Average value applied for mobile air conditioners*
[102] *Confirmed by Latvian Association of Refrigeration Engineers*
[103] *2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9 – Average value applied for mobile air conditioners*
[104] *Confirmed by Latvian Association of Refrigeration Engineers*
[105] *Confirmed by Latvian Association of Refrigeration Engineers*

CO_2 eq. and hence was the major F-gas emission source in 2.F.1 category in 2020. The increase in emissions in 2020 compared to 2019 can be explained by the increase in the number of vehicles.

- *Stationary Air Conditioning (CRF 2.F.1.f)*

Activity data

Activity data for emission calculation from stationary air conditioning is taken from annual reports by F-gases operators according to F-gas Regulation No.517/2014 and national Regulation No.563[106]. For historical yers amount of filled in new manufactured products is extrapolated based on IPCC 2006 Guidelines Volume 1 Chapter 5 about extrapolation. Activity data for this category is initially derived during F-gases research (2016) when the proportion of HFCs used in stationary air conditioning were obtained directly contacting with operators who report the F-gases amounts within national Regulation No.563.

In 2017, based on F-gases research the share of F-gases filled in stationary air conditioning systems for time period 2010-2015 were reevaluated. It was concluded that emissions from this category previously have been underestimated therefore recalculations were done taking into account study results which show that stationary air conditioning constitutes 24% from all 2.F.1 emissions and not 9% as previously thought (Table 4.44). Recalculation affects all timeseries because years prior to 2010 are extrapolated taking into account 2010-2015 data. Share of F-gases filled in new appliances in 2016 was based on evaluation study results.

Emission factors and calculations

Tier 2a – emission-factor approach from the 2006 IPCC Guidelines was used to estimate emissions from stationary air conditioning. Emissions result from charging, lifetime and end-of-life of equipment and are calculated for each type of HFC separately.

According to the methodology, refrigerant emissions at a reporting year can be calculated separately for each stage of life of the equipment. These emissions come from:

- $E_{charge,\,t}$ – emissions related to the refrigerant charge: connection and disconnection of the refrigerant container and the new equipment to be charged;
- $E_{lifetime,t}$ – annual emissions from the banks of refrigerants during operation (fugitive emissions and ruptures) and servicing;
- $E_{end\text{-}of\text{-}life,t}$ – emissions at system disposal.

Equation 7.10 from the 2006 IPCC Guidelines was used to sum up all the emissions occurring during the lifetime of the equipment:

$$\boldsymbol{E_{total,t} = E_{Charge,t} + E_{Lifetime,t} + E_{End-of-life,t}} \qquad (4.52)$$

There are no HFC-containing equipment manufacturing companies in Latvia and all appliances used in stationary air conditioning are imported.

EFs and assumptions used in emission calculation from stationary air conditioners are as follows:

[106] *Regulation No.563 of the Cabinet of Ministers of Latvia on "Provisions concerning specific restrictions and prohibitions on activities with ozone-depleting substances and fluorinated greenhouse gases"*

- HFCs mainly charged in Industrial Refrigeration are HFC-407c, HFC-410a, HFC-404a, HFC-134a, HFC-422d and HFC-417a;
- Average EF during charging of equipment is 0.6%[107];
- Average EF during operation of equipment is 8%[108];
- Average life time of stationary air conditioning applications 15 years[109];
- Residual charge of HFC in equipment being disposed 80%[110];
- Recovery efficiency at disposal 80%[111].

Equation from the 2006 IPCC Guidelines for charging emissions estimation:

$$\boldsymbol{E_{Charged,t} = M_t * k/100} \tag{4.53}$$

where:
$E_{charged}$ – emissions during system manufacture/assembly in year (kg)
Mt – amount of HFC-134a charged into a new equipment in year (kg)
k – charging losses (%)

Equation from the 2006 IPCC Guidelines for emission estimation stocks:

$$\boldsymbol{E_{lifetime,t} = B_t * x/100} \tag{4.54}$$

where:
$E_{lifetime}$ – amount of emissions during equipment operation (t)
Bt – amount of F-gases held in stocks in year t (tonnes)
x – losses during operation period (%)

There are no emissions for 1990-1994 therefore notation key – NO – are used for HFC-125, HFC-134a, HFC-143a and HFC-32. Started from 1995 emissions are calculated. HFC-152a is not used before 2011, so for 1900-2010 the notation key – NO – is used.

The total amount of HFC filled into stationary air conditioners in 2020 amounts to 12.94 t constituting 0.08 t manufacturing emissions. HFC in stocks amounts to 321.11 t constituting 25.69 t operating emissions.

As the HFC-125, HFC-134a, HFC-143a and HFC- amounts filled into refrigeration equipment are available since 1995, disposal emissions according to 15 years lifetime are estimated starting from 2010. Before 2010 notation key – NO – is used. HFC-152a amount that has been filled in new manufactured products and amounts in operating systems are available since 2011, therefore disposal emissions are not yet occurred, so notation key - NO – is used.

In 2020, the amount of HFCs remained in decommission is amount of refrigerant initially charged into the systems in 2005 (28.07 t) which constitutes 4.49 t disposal emissions.

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[107] 2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9 – Average value applied for residental and commercial air conditioners including heat pumps
[108] 2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9 – Average value applied for residental and commercial air conditioners including heat pumps
[109] Confirmed by Latvian Association of Refrigeration Engineers
[110] 2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9
[111] 2006 IPCC Guidelines, Vol.3, Ch.7, Table 7.9

4.7.1.3 Uncertainties and time series-consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty for Refrigeration and air conditioning sector activity data is assumed 30% according to expert judgment. It has been reduced in 2017 according to F-gas evaluation study during which the procentual shares of F-gases used in each 2.F.1 subsector were revised.

Uncertainty of EFs is based on EF ranges from Table 7.8 (2006 IPCC Guidelines, Volume 3, Chapter 7, pp.7.52) that highlight the uncertainty associated with this sector. The total uncertainty U_{total} is being calculated, using following formula of combined uncertainty:

$$\boldsymbol{U_{total}} = \sqrt{(\boldsymbol{U_1^2} + \boldsymbol{U_2^2} + \cdots + \boldsymbol{U_n^2})} \quad (4.55)$$

where:

U_{total} *- the percentage uncertainty in the product of the quantities*
U_i *- the percentage uncertainties associated with each of the quantities*

Combined EF uncertainty is 40.91%.

Time series of the estimated emissions are consistent because the same methodology, EFs and data sources are used for sectors for all years in time series.

4.7.1.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the 2.F. sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

All information on activity data and emission calculations are stored and archived in the common FTP folder. All findings are documented using check-lists which are archived and documented in centralized archiving system (common FTP folder).

All estimations of the emissions done in the LEGMC are checked on the logical mistakes by checking the time series of the activity data, EFs and emissions consistency to display all significant and illogic changes in the activity data and emissions.

Quality control check list is filled for each category taking into account criteria given in QA/QC plan approved in National legislation.

Quality manager from LEGMC has checked the data between CRF and NIR to ensure the consistency as well as QC actions were done in CRF in purpose to double check if all sub-applications are covered.

Currently using CRF Reporter software version v6.0.8 it is not possible to enter NO in green and grey cells for those F-gases where emissions are not occurring in Latvia although CRF Reporter User manual says that if disaggregated data is not available for certain categories, the CRF Reporter allows users to report information in the parent category. This can be done by directly entering data in the green cells (i.e. overwriting formulas).

Under 2.F.1 Refrigeration and Air Conditioning only F-gases which are source of emissions are reported. Remaining F-gases are not added as child nodes according to CRF User manual however it is not currently possible to enter data in green cells for these F-gases therefore some information in the parent category (green cells) in corresponding CRF tables are missing. It was confirmed by CRF Reporter help desk that this is an CRF internal issue which will be improved in the future releases of the software. But for the moment it was suggested to leave cells blank. Due to this reason completeness check in CRF Reporter shows incompleteness (orange light) which could be solved when CRF Reporter will allow to enter notation keys for F-gases directly in green and grey cells.

QA/QC procedures within CRF Reporter were carried out in order to ensure completeness and consistency of reported data.

4.7.1.5 Category-specific recalculations

For subsectors – 2.F.1.a Commercial Refrigeration, 2.F.1.c Industrial Refrigeration, 2.F.1.d Transport Refrigeration and 2.F.1.f Stationary Air Conditioning - recalculations were done from 2017 to 2019 due to updated activity data from F-gases database. Total results of recalculations are shown in Table 4.48.

Table 4.48 Results of recalculations in 2.F.1. Refrigeration and Air Conditioning (2017-2019)

Year	HFC emissions before recalculation	HFC emissions after recalculation	Absolute difference	Relative difference
		kt CO_2 eq.		%
2017	*262.66*	*262.67*	*0.01*	*0.00003*
2018	*257.45*	*257.47*	*0.01*	*0.00005*
2019	*249.75*	*249.82*	*0.06*	*0.00026*

4.7.1.6 Category-specific planned improvements

No improvements are planned for this sector.

4.7.2 Foam Blowing Agents (CRF 2.F.2)

4.7.2.1 Category description

The category covers HFC emissions from open and closed-cell foams. HFCs from foams are emitted only from the use of imported foams containing F-gases as there is no production of foams in Latvia. Emissions from foaming of polyether for shoe soles are not occurring anymore due to prohibitions described in F-gas Regulation No.517/2014.

The calculation of emissions under 2.F.2 was carried out for following gases:

- HFC-134a
- HFC-227ea
- HFC-245fa
- HFC-152a
- HFC-365mfc

In 2020, emissions from foam blowing agents totalled 0.28 kt CO_2 eq. and this is 62.2% lower than in 2019 (Figure 4.17). Fluctuations in 2.F.2 emissions could be observed from year to year because data very depends on information provided by merchants which is available in National Chemicals Database.

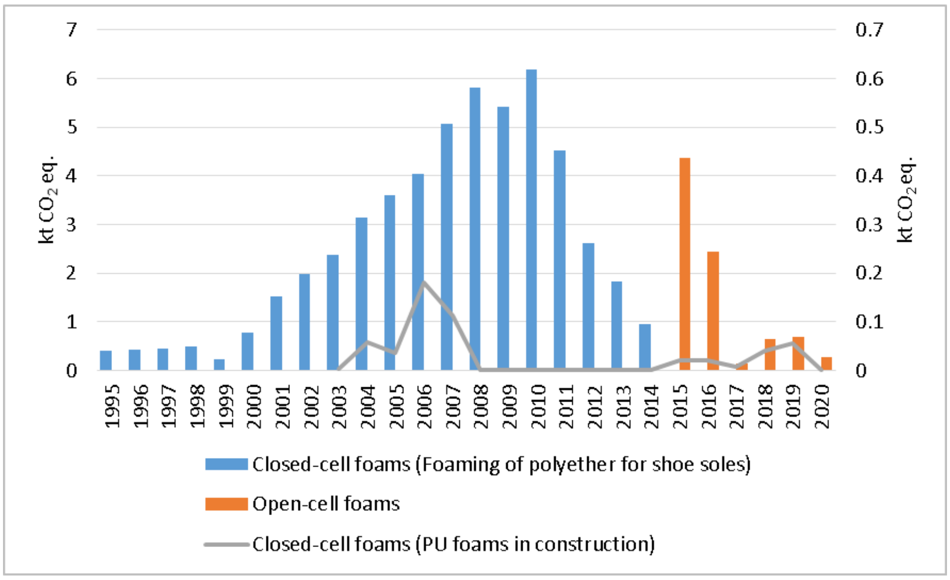

Figure 4.17 HFC emissions from 2.F.2 (Closed cell foams on secondary axis) (kt CO_2 eq.)

HFC-134a emissions were not occurring for 1990-1994, so notation key – NO - is used. Manufacturing of shoes (shoe soles) containing HFC-134a occurred in 1995-2002 when comparatively smaller amounts of HFC were emitted. After 2002 emissions from stocks and disposal were estimated and emissions started to increase reaching peak level in 2010. According to F-gas regulation No.517/2014 which repeals Regulation (EC) No.842/2006 from 4 July 2006 it is prohibited to place on the EU market footwear containing F-gases. According to prohibitions described in EU regulations it was assumed that amount of shoes containing HFC-134a started to decrease since 2007 however emissions from disposal were still at previous level.

Emissions from closed-cell PU foams used in construction are estimated starting from 2003 when data from National Chemicals Database become available. Since then emissions have been increased very rapidly due to economic development and increased activity in building sector reaching the highest level in 2006. Afterwards emissions started to decrease and since 2008 rather small amounts are emitted. HFC-152a emissions from Closed cells were not occurring for 1995-2005 and for 2008-2014, therefore notation key – NO - is used, HFC-227ea and HFC-245fa emissions were not occurring for 1995-2003 and after 2004, therefore notation key – NO - is used. HFC-365mfc emissions were not occurring for 1995-2007 and for 2015-2018 and in 2020, therefore notation key – NO - is used.

Emissions from open-cell foams are estimated starting from 2015.

4.7.2.2 Methodological issues

An overview of the methods used and gases reported under 2.F.2 sector is presented in Table 4.49.

Table 4.49 Summary of emission calculation methods and gases in CFR 2.F.2

CRF Category/subcategory	Method used	Gases reported
2.F.1 Foam Blowing agents		
2.F.2.a Closed Cells	*Tier 1a*	*HFC-134a* *HFC-227ea* *HFC-245fa* *HFC-152a* *HFC-365mfc*
2.F.2.b Open Cells	*Tier 1a*	*HFC-227ea* *HFC-245fa* *HFC-365mfc* *HFC-134a*

- *Closed-cell PU foams*

Activity data

The imported amount of PU construction foams is obtained from National Chemicals Database. No export and production data is reported to the National Chemicals Database therefore only imported amount can be obtained. So only emissions from use of PU foams (stocks) are calculated.

Although the activity in building sector in previous years has radically increased, emission estimations for PU foams can be done starting from 2003 due to the lack of activity data of imported and used building foams or foams used in windows manufacturing as well as lack of data on foams containing F-gases. It is assumed that all the construction foams imported are closed cells foams (used in insulation applications) according to NACE classification. The data on foams imported as well as the average share (%) of F-gases in foams were obtained from National Chemicals Database.

Emission factors and calculations

HFC emissions are calculated from foams in stocks. Emission calculations were done according to the 2006 IPCC Guidelines Tier 1a method using activity data on imported foams and default EF – annual losses 4.5% of the original HFC charge/year[112].

Equation from the 2006 IPCC Guidelines for emissions from closed-cell foam in year was used:

$$\boldsymbol{Emissions_t = Bank_t * EF_{AL}} \tag{4.56}$$

where:

Emissions $_t$ - emissions from closed-cell foam in year t (tonnes)
Bank $_t$ - HFC charge blown into closed-cell foam manufacturing between year t and year t-n (tonnes)
EF $_{AL}$ - annual loss emission factor (fraction)
t - current year

The product lifetime of foam is 20 years. As in that time Latvia was part of Soviet Union the specific data was not collected as well as it is believable that the foam blowing did not occur in country. Therefore decommissioning losses from foams are not occurring.

[112] 2006 IPCC Guidelines, Vol.3, Ch.7, p.7.35

- *Closed-cell foams from foaming of polyether for shoe soles*

Activity data

Activity data for emission estimation from foaming of polyether for shoe soles is taken from CSB databases about produced imported and exported amount of shoes[113]. Assumptions and default leakage factors are taken from Danish project "The Greenhouse gases: HFCs, PFCs and SF_6" [114].

The manufacturing of shoe soles containing HFC-134a occurred in Latvia in 1995-2002. The amount of produced shoes (shoe soles) is obtained by CSB. According to Danish project[103] it was assumed that 5% of all shoes with plastic, rubber and leather soles contain polyether containing 8 g of HFC-134a per shoe.

Emission factors and calculations

Total amount of HFC-134a used for manufacturing of shoe soles can be estimated by using equation:

$$\boldsymbol{HFC_{filled} = Sh_{produced} * d_{HFC} * HFC_{sh}} \tag{4.57}$$

where:

HFC_{filled} – total amount of HFC-134a used in manufacturing of shoes (t)
$Sh_{produced}$ – amount of produced shoes (pieces)
d_{HFC} – amount of shoes containing HFC-134a (%)
HFC_{sh} – amount of HFC-134a filled in one shoe sole (t)

Danish default leakage EF for HFC-134a emitted during manufacturing is 15%.

The HFC-134a emissions from manufacturing of shoe soles can be estimated by using equation:

$$\boldsymbol{E_{production} = HFC_{filled} * k} \tag{4.58}$$

where:

$E_{production}$ – HFC-134a emissions from shoe manufacturing (t)
HFC_{filled} – total amount of HFC used in manufacturing of shoes (t)
k – leakage from shoes production (%)

The amount of imported, exported and produced shoes (shoe soles) is obtained by CSB. According to Danish project[114] it was assumed that 5% of all shoes with plastic, rubber and leather soles contain polyether containing 8 g of HFC-134a per shoe.

Total amount of HFC-134a held in stocks in shoe soles can be estimated by using equation:

$$\boldsymbol{HFC_{stocks} = HFC_{filled} + HFC_{imported} - HFC_{exported}} \tag{4.59}$$

where:

HFC_{stocks} – total amount of HFC-134 held in stocks in shoe soles and used in country in particular year (t)
HFC_{filled} – total amount of HFC-134a filled in shoes during manufacture of shoes (t)
$HFC_{imported}$ – total amount of HFC-134a imported in shoes (t)
$HFC_{exported}$ – total amount of HFC-134a exported in shoes (t)

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[113]Exports and imports by countries. Available: https://data.stat.gov.lv/pxweb/lv/OSP_PUB/START__TIR__AT__ATD/ATD020
[114]Danish consumption and emission of F-gases. Available: https://www2.mst.dk/Udgiv/publications/2016/03/978-87-93435-48-3.pdf

Danish default leakage EF for HFC-134a emitted during lifetime is 4.5% (lifetime is 3 years) or 1.5% annually.

The HFC-134a emissions from stocks held in shoe soles can be estimated by using equation:

$$\boldsymbol{E_{stocks} = HFC_{stocks} * x} \tag{4.60}$$

where:

E_{stocks} – HFC-134a emissions from shoe lifetime (t)
HFC_{stocks} – total amount of HFC-134 held in stocks in shoe soles and used in country in particular year (t)
x – leakage from using of shoes during its lifetime (%)

According to above mentioned Danish project average lifetime of shoes is 3 years. It means that for HFC-134a emission estimation the amount of HFC-134a remained in shoe soles after their lifetime in year^{-3} has to be known. As CSB doesn't have so old data the approximate amount back to year 1992 is extrapolated taken into account the amount curve in 1995-2000.

Total amount of HFC-134a left in shoe soles after their lifetime ends can be estimated by using equation:

$$\boldsymbol{HFC_{remained} = HFC_{stocks} * (1 - x)} \tag{4.61}$$

where:

$HFC_{remained}$ – total amount of HFC-134a remained in shoes after their lifetime in year^{-3} (t)
(1-x) – percentage amount of HFC left in shoes (%)

For the emission estimation from disposal default Danish EF 71.5% is used as some part of shoes are destroyed in incineration and thereby not released as emissions.

The HFC-134a emissions from disposal of shoe soles can be estimated by using equation:

$$\boldsymbol{E_{disposal} = HFC_{remained} * Q} \tag{4.62}$$

where:
$E_{disposal}$ – total amount of HFC-134a emissions from disposal
$HFC_{remained}$ – total amount of HFC-134a remained in shoes after their lifetime in year^{-3} (t)
Q – leakage from disposal (%)

- *Open-cell foams*

Activity data

The imported amount of open-cell foams used in furniture and seating is obtained from National Chemicals Database. No export and production data is reported to National Chemicals Database therefore only imported amount well as the average percentage of F-gases in foams can be obtained.

According to the 2006 IPCC Guidelines open-cell foam upon foaming the blowing agent is released almost completely within one year hence the manufacturing EF is assumed as 100%. All the amounts are emitted during manufacturing therefore emissions from stocks are not calculated.

Emission factors and calculations

HFC emissions are calculated from foams in manufacturing. The emission calculations were done according to the 2006 IPCC Guidelines Tier 1a method using activity data on imported foams and default EF – first year loss factor 100% of the original HFC charge/year.

Equation 7.8 from the 2006 IPCC Guidelines for emissions from ope-cell foam in year was used:

$$\boldsymbol{Emissions_t = M_t} \quad (4.63)$$

where:

Emissions$_t$ - emissions from open-cell foam in year t (tonnes)
M$_t$ - total HFC used in manufacturing new open-cell foam in year t (tonnes)

The product lifetime according to the 2006 IPCC Guidelines is 12 years. Therefore decommissioning losses from open-cell foams are not occurring yet.

4.7.2.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty for Foam Blowing sector could arise to 50% according to assumptions. Also uncertainty of EFs for HFCs is assumed as 50%.

Time series of the estimated emissions are consistent because the same methodology, EFs and data sources are used for sectors for all years in time series.

4.7.2.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the 2.F. sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

More detailed description can be found under chapter 4.7.1.4.

Currently using CRF Reporter software version v6.0.8 it is not possible to enter NO in green and grey cells for those F-gases where emissions are not occurring in Latvia although CRF Reporter User manual says that if disaggregated data is not available for certain categories, the CRF Reporter allows users to report information in the parent category. This can be done by directly entering data in the green cells (i.e. overwriting formulas).

It is not currently possible to enter notation keys NO in green cells for these F-gases which are not occurring under this sector therefore some information in the parent category (green cells) in corresponding CRF tables are missing. It was confirmed by CRF Reporter help desk that this is an CRF internal issue which will be improved in the future releases of the software. But for the moment it was suggested to leave cells blank. Due to this reason completeness check in CRF Reporter shows incompleteness (orange light) which could be solved when CRF Reporter will allow to enter notation keys for F-gases directly in green and grey cells.

QA/QC procedures within CRF Reporter were carried out in order to ensure completeness and consistency of reported data.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

4.7.2.5 Category-specific recalculations

No recalculations were done for this sector.

4.7.2.6 Category-specific planned improvements

No improvements are planned for this sector.

4.7.3 Fire Protection (CRF 2.F.3)

4.7.3.1 Category description

The category covers HFC emissions from use of fire protecting equipment. In 2020, emissions totalled 0.003 kt CO_2 eq. giving about 0.001% from total HFC emissions in 2.F (Figure 4.18). As the emissions from fire suppression systems occur when the system is discharged in case of fire or accidentally, emissions are estimated only from for operating of fire protection systems using HFC-227ea and HFC-23.

HFC-227ea emissions were not occurring for time period 1990-2000 so notation key – NO - is used. But HFC-23 emissions were not occurring for time period 1990-2009 therefore notation key – NO - is used.

Emission time series started in 2001 when the first data regarding use of fire protection systems containing HFCs was received during the first F-gases research (2004). Since then strong emission fluctuations have been observed. In 2020, the emissions from this category remained at the same level as in 2019.

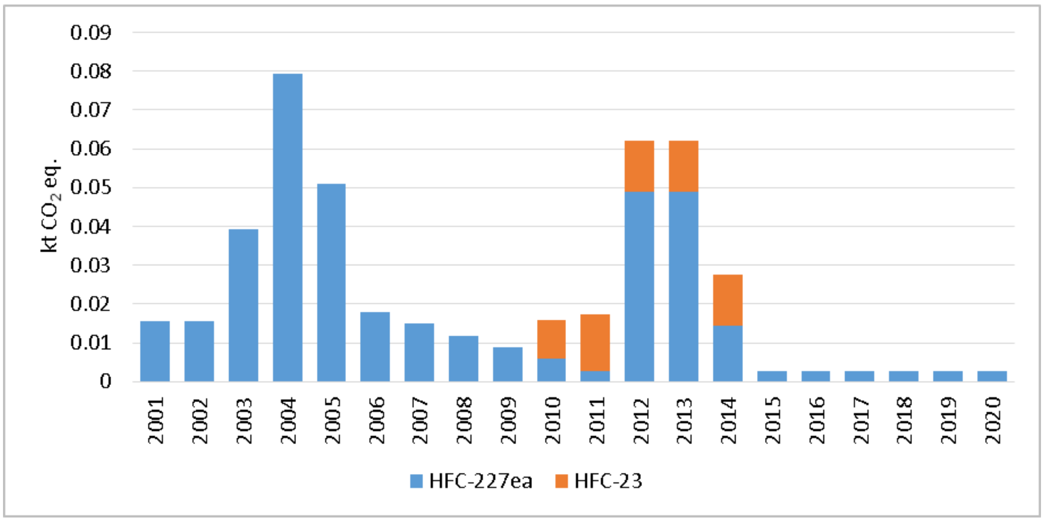

Figure 4.18 HFC emissions from 2.F.3 (kt CO_2 eq.)

Emissions from fire extinguishing are problematic to estimate due to the fact that there is only statistical information of the registered fires (incidents) where different extinguishing materials were used. Type of materials (substances) used in equipment is not registered.

According to the national Regulation No.563 of the Cabinet of Ministers of Latvia companies who use F-gases in stationary fire protection equipment shall report amounts used to responsible institution (LEGMC) each year till 31st of March. Information from LEGMC database on ozone depleting substances and F-gases available since 2010. Till then historical data from basic F-gases research (2004) was used and extrapolation was done.

4.7.3.2 Methodological issues

An overview of the methods used and gases reported under 2.F.3 sector is presented in Table 4.50.

Table 4.50 Summary of emission calculation methods in CFR 2.F.3

CRF Category/subcategory	Method used	Gases reported
2.F.3 Fire Protection	*Tier 2a*	*HFC-227ea, HFC-23*

Emissions are calculated based on the Tier 2a method of the 2006 IPCC guidelines, however, Tier 2 method is written in the CRF tables because it is not possible to enter Tier 2a.

Activity data

During the F-gases research (2004) it was found out that there is no manufacturing of fire extinguishers containing F-gases. 19 enterprises were questioned including only manufacturer of fire extinguishers. According to responses received a little amount of fire extinguishers are filled with F-gases. Only 2 enterprises reported the amount of HFC-227ea in their installed equipment in particular year and amount of HFC-227ea held in stocks (containers) of fire extinguishing equipment. It was reported that no charging was done for the installed equipment. Fire extinguishers were installed already filled with F-gases and there weren't any necessity to recharge them. Therefore only emissions from stocks were calculated.

Amount of F-gases in annually installed equipment and amount held in containers is used as activity data for emission estimations from stocks. Activity data for historical years (2001-2006) is taken from the first F gases research done in 2004. Since 2010 data is taken from annual F-gases reports, where operators annually report F-gases amounts used in their equipment.

Emission factors and calculations

It is assumed that 2% from total stocks is emitted during equipment operations annually according to the 2006 IPCC Guidelines [115].

Equation from the 2006 IPCC Guidelines for emission estimation from stocks:

$$\boldsymbol{E_{Lifetime,t} = B_t * x/100} \tag{4.64}$$

where:

$E_{lifetime}$ – amount of emissions during equipment operation (t)
Bt – amount of F-gases held in stocks in year t (tonnes)
x – losses during operation period (%)

The lifetime of the equipment is 20 years therefore emissions at system disposal were not estimated.

[115] *2006 IPCC Guidelines, Vol.3, Ch.7, p.7.63*

4.7.3.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty for Fire Protection sector could arise to 50% according to expert judgement. Also uncertainty of EFs for HFCs is assumed as 50%.

Time series of the estimated emissions are consistent because the same methodology, EFs and data sources are used for sectors for all years in time series.

4.7.3.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the 2.F. sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

More detailed description can be found under chapter 4.7.1.4.

Currently using CRF Reporter software version v6.0.8 it is not possible to enter NO in green and grey cells for those F-gases where emissions are not occurring in Latvia although CRF Reporter User manual says that if disaggregated data is not available for certain categories, the CRF Reporter allows users to report information in the parent category. This can be done by directly entering data in the green cells (i.e. overwriting formulas).

Under 2.F.3 Fire Protection only F-gases which are source of emissions are reported. Remaining F-gases are not occurring and are not added as child nodes according to CRF User manual however it is not currently possible to enter data in green cells for these F-gases therefore some information in the parent category (green cells) in corresponding CRF tables are missing. It was confirmed by CRF Reporter help desk that this is an CRF internal issue which will be improved in the future releases of the software. But for the moment it was suggested to leave cells blank. Due to this reason completeness check in CRF Reporter shows incompleteness (orange light) which could be solved when CRF Reporter will allow to enter notation keys for F-gases directly in green and grey cells.

QA/QC procedures within CRF Reporter were carried out in order to ensure completeness and consistency of reported data.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

4.7.3.5 Category-specific recalculations

No recalculations were done for this sector.

4.7.3.6 Category-specific planned improvements

No improvements are planned for this sector.

4.7.4 Aerosols (Metered Dose Inhalers CRF 2.F.4.a)

4.7.4.1 Category description

This category covers HFC-134a emissions from metered dose inhalers. There are no other HFC containing aerosol types used in Latvia.

There are no emissions for 1990-1994 therefore notation key – NO – is used. After 1995 HFC-134a emissions are calculated.

In 2020, emissions totalled 6.07 kt CO_2 eq. giving 2.4% from total HFC emissions in 2.F (Figure 4.19). In 2020, emissions increased by 33.8% compared to 2019 due to the increased amount of imported HFC-134a in products. Emissions have increased compared to the base year. The fluctuation in the time series is due to observed changes in consumption of HFC containing metered dose inhalers.

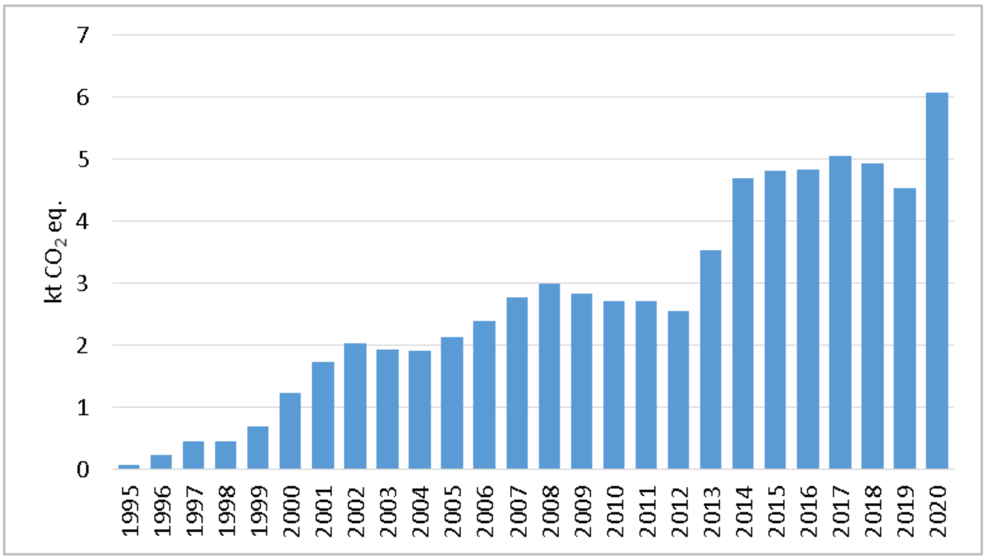

Figure 4.19 HFC emissions from 2.F.4.a (kt CO_2 eq.)

During the first F-gases research (2004) it was found out that there is no production of F-gases containing aerosols in Latvia. All aerosols used in Latvia are imported. It is very difficult to collect the data of imported aerosols as it is necessary to separate HFCs containing aerosols from others. It is almost impossible to get the information from all households and importers of industrial aerosols in Latvia as Central Custom Service registers only all imported aerosols with one custom code not dividing them by type or by substances containing. Also since Latvia is in Schengen zone only imported amount from Third Countries is registered.

Only the aerosols used in medicine for asthmatics are estimated and reported under this category. During the first F-gases research number of inhalers containing HFC–134a was obtained as well as average amount of HFC-134a filled in one inhaler divided by the type of medicine. All the inhalers are imported as no inhalers for asthmatics are produced in Latvia.

4.7.4.2 Methodological issues

An overview of the methods used and gases reported under 2.F.4 sector is presented in Table 4.51.

Table 4.51 Summary of emission calculation methods in CFR 2.F.4

CRF Category/subcategory	Method used	Gases reported
2.F.4 Aerosols	*Tier 1a*	*HFC-134a*

Activity data

From 1995 to 1997 the amount of metered dose inhalers is extrapolated based on IPCC 2006 Guidelines Volume 1 Chapter 5 about extrapolation. For 1998-2006 data of imported inhalers reported by importers of medical preparations was used as activity data for emission calculations. From 2007 till 2020 data for emission estimations annually is reported by State Agency of Medicines of Latvia. All users of the medical preparations shall report the sold amount of medicines so these data are very precise.

Total amount of HFC-134a used in metered dose inhalers in particular year can be estimated as the amount of inhalers containing HFC-134a and an average amount of HFC-134a filled in each type of inhalers is known.

Emission factoirs and calculations

Equation for total amount HFC-134a used as medical preparation:

$$\boldsymbol{HFC_{sold} = \sum MDI_{sold} * HFC_{filled}} \tag{4.65}$$

where:

HFC_{sold} – total amount of HFC sold in country (t)
MDI_{sold} – amount of sold particular type of metered dose inhalers containing F-gases (pieces)
HFC_{filled} – amount of HFCs filled in particular type of inhaler (t)

According to the 2006 IPCC Guidelines 50%[116] leakage from metered dose inhalers sold in particular year and 50% from inhalers sold in year before particular year is assumed.

Equation from the 2006 IPCC Guidelines for metered dose inhalers emissions:

$$\boldsymbol{Emissions_t = S_t * EF + S_{t-1} * (1 - EF)} \tag{4.66}$$

where:

$Emissions_t$ - emissions in year t (tonnes)
St – quantity of HFC and PFC contained in aerosol products sold in year t (tonnes)
S_{t-1} – quantity of HFC and PFC contained in aerosol products sold in year t-1 (tonnes)
EF - emission factor (=fraction of chemical emitted during the first year) (fraction)

4.7.4.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty for Aerosol sector could arise to 50% according to expert judgement. Also uncertainty of EFs for HFCs is assumed as 50%.

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[116] 2006 IPCC Guidelines Vol.3, Ch.7, p.7.29

Time series of the estimated emissions are consistent because the same methodology, EFs and data sources are used for sectors for all years in time series.

4.7.4.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the 2.F. sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

More detailed description can be found under chapter 4.7.1.4.

Currently using CRF Reporter software version v6.0.8 it is not possible to enter NO in green and grey cells for those F-gases where emissions are not occurring in Latvia although CRF Reporter User manual says that if disaggregated data is not available for certain categories, the CRF Reporter allows users to report information in the parent category. This can be done by directly entering data in the green cells (i.e. overwriting formulas). Entering data in green cells is only possible when the parent node to which the grid with green cells belongs does not have any child nodes.

Under 2.F.4 Aerosols only F-gases which are source of emissions are reported. Remaining F-gases are not occurring and are not added as child nodes according to CRF User manual however it is not currently possible to enter data in green cells for these F-gases therefore some information in the parent category (green cells) in corresponding CRF tables are missing. It was confirmed by CRF Reporter help desk that this is an CRF internal issue which will be improved in the future releases of the software. But for the moment it was suggested to leave cells blank. Due to this reason completeness check in CRF Reporter shows incompleteness (orange light) which could be solved when CRF Reporter will allow to enter notation keys for F-gases directly in green and grey cells.

QA/QC procedures within CRF Reporter were carried out in order to ensure completeness and consistency of reported data.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

4.7.4.5 Category-specific recalculations

No recalculations were done for this sector.

4.7.4.6 Category-specific planned improvements

No improvements are planned for this sector.

4.8 *OTHER PRODUCT MANUFACTURE AND USE (2.G)*

Under 2.G Latvia reports emissions from SF_6 and N_2O, occurring in following sectors:

- Electrical equipment (CRF 2.G.1);
- N_2O from product uses (CRF 2.G.3);

SF_6 and PFCs emissions from Other product use (2.G.2) and Other (2.G.4) are not occurring in Latvia. Under 2.G only F-gases which are source of emissions are reported. Remaining F-gases are not occurring and are not added as child nodes in CRF Reporter software version v6.0.8 according to CRF User manual (25.03.2018) however it is not currently possible to enter data in green cells for these F-gases therefore some information in the parent category (green cells) in corresponding CRF tables are missing.

In 2020, GHG emissions from other product manufacture and use amounted 15.56 kt CO_2 eq. (0.1%) from Latvia`s total CO_2 eq. emissions without LULUCF. In 2020 compared to 2019 emissions have decreased by 13.9%, but compared to 1990 emissions have increased by 221.6% (Figure 4.20 and Table 4.53).

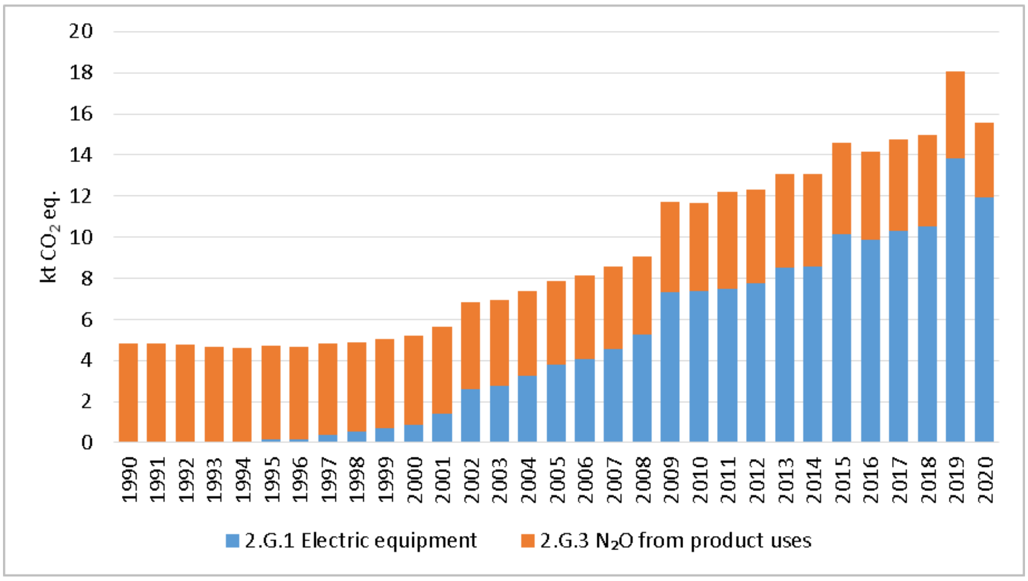

Figure 4.20 Emissions from 2.G Other product manufacture and use (kt CO_2 eq.)

Emission trend could mainly associated with increase in activity data received from companies. Emission fluctuations in the N_2O From Product Uses sector are linked with the economic situation of the country.

Reported emissions and calculation methods for the 2.G Other Product Manufacture and Use in the Latvian inventory are summarized in Table 4.52.

Table 4.52 GHG emission categories, methods and gases reported from 2.G Other Product Manufacture and Use

Category	Method used	Gases reported
G. Other Product Manufacture and Use		
2.G.1 Electrical Equipment	*Tier1*	*SF_6*
2.G.3 N_2O from Product Uses (Medical Applications and Propellant for pressure and aerosol products)	*CS*	*N_2O*

Table 4.53 Total emissions from 2.G Other Product Manufacture and Use, 1990-2020 (kt CO_2 eq.)

Year	2.G Other Product manufacture and Use	2.G.1 Electrical Equipment	2.G.3 N_2O from Product Uses
1990	*4.84*	*NO*	*4.84*
1995	*4.71*	*0.17*	*4.53*
2000	*5.19*	*0.88*	*4.31*
2005	*7.86*	*3.78*	*4.08*
2006	*8.11*	*4.07*	*4.04*
2007	*8.56*	*4.55*	*4.01*
2008	*9.03*	*5.23*	*3.80*
2009	*11.72*	*7.33*	*4.39*
2010	*11.67*	*7.35*	*4.32*
2011	*12.20*	*7.47*	*4.73*
2012	*12.30*	*7.78*	*4.53*
2013	*13.05*	*8.50*	*4.54*
2014	*13.06*	*8.58*	*4.48*
2015	*14.60*	*10.12*	*4.48*
2016	*14.17*	*9.89*	*4.27*
2017	*14.74*	*10.32*	*4.42*
2018	*14.99*	*10.54*	*4.44*
2019	*18.07*	*13.82*	*4.25*
2020	*15.56*	*11.94*	*3.62*
Share of total IPPU % in 2020	*1.8%*	*1.4%*	*0.4%*
2020 versus 2019	*-13.9%*	*-13.6%*	*-14.6%*
2020 versus 1990	*221.6%*	*6786.0%*	*-25.1%*

4.8.1 Electrical Equipment (CRF 2.G.1)

4.8.1.1 Category description

This category covers emissions of sulphur hexafluoride from electrical equipment used in high and medium voltage commutation and control installations. Equipment is not manufactured in Latvia. SF_6 emissions are estimated from charging and lifetime. There is only 3 enterprises where SF_6 is filled. Installations are not produced in Latvia and the old equipment without fill of the SF_6 was dismantled at the beginning of 1990s. Only starting from 1992 new equipment was gradually installed. Since 1992 it uses small amount of SF_6 in electrical equipment, but since 1995 used amount is increasing.

In 2020, SF_6 emissions from Electrical Equipment constituted 11.94 kt CO_2 eq. (76.7% from total 2.G emissions). Emissions have grown since 1995 by 6786.0% due to replacement of the old equipment and installation of the new equipment where, until then, SF_6 was not used. But in 2020 SF_6 emissions from electrical equipment decrease by 13.6% compared to 2019 due to lower amount of emergency leakage (Figure 4.21 and Table 4.54).

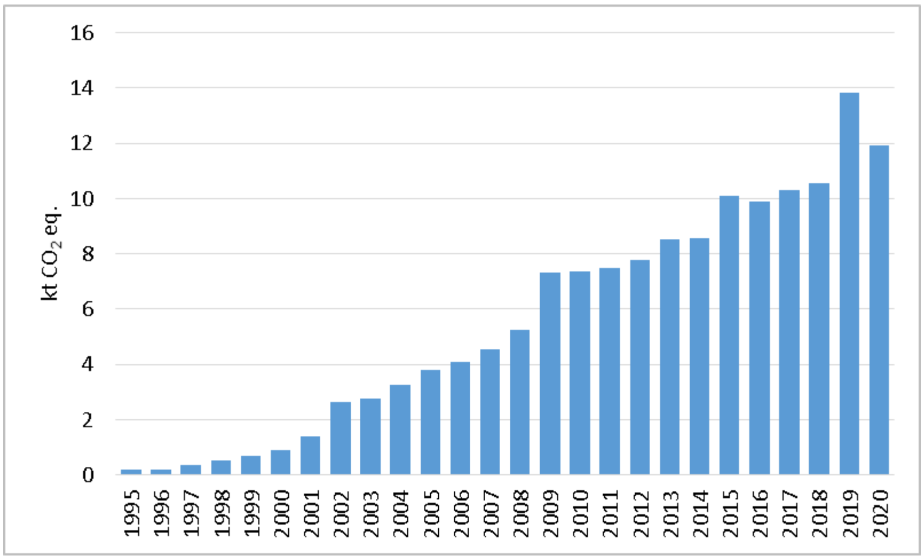

Figure 4.21 SF_6 emissons from 2.G.1 (kt CO_2 eq.)

Table 4.54 SF_6 emissions from 2.G.1 Electrical Equipment, 1995-2020 (kt CO_2 eq.)

	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
SF_6 from electrical equipment	*0.17*	*0.88*	*3.78*	*7.35*	*7.47*	*7.78*	*8.50*	*8.58*	*10.12*	*9.89*	*10.32*	*10.54*	*13.82*	*11.94*

4.8.1.2 Methodological issues

An overview of the methods used and gases reported under 2.G.1 sector is presented in Table 4.55.

Table 4.55 Summary of emission calculation methods and gases in CFR 2.G.1

CRF Category/subcategory	Method used	Gases reported
2.G.1 Electrical Equipment	*Tier1*	*SF_6*

Activity data

Enterprises imports equipment already filled with SF_6. There is no manufacturing of the electric equipment containing SF_6 in Latvia, therefore only emissions from charging and operating were estimated using amount of SF_6 in newly installed equipment as activity data reported by the company. For 2003-2020 enterprises report the emergency leakage from electrical equipment which are also reported as operating emissions.

Emission factors and calculations

For emission estimations the Tier 1 default EF method from the 2006 IPCC Guidelines was used. Emissions are estimated by multiplying default regional EF (for Europe) by amount of SF_6 used in equipment in enterprises according the 2006 IPCC Guidlines. The emissions are estimated by splitting data into the sealed pressure electrical equipment (MV switchgear) and closed pressure electrical equipment (HV switchgear) containing the SF_6 due to the different EFs for each of these installations in the 2006 IPCC Guidelines. For HV switchgears 2.6%, but for MV switchgears 0.2% EF was used.

Equation from the 2006 IPCC Guidelines for emission estimation from charging:

$$E_{charged,t} = M_t * k/100 \quad (4.67)$$

where:

$E_{charged}$ – emissions during system manufacture/assembly in year (kg)
M_t – amount of HFC-134a charged into a new equipment in year (kg)
k – charging losses (%)

Equation from the 2006 IPCC Guidelines for emission estimation from stocks:

$$E_{lifetime,t} = B_t * x/100 \quad (4.68)$$

where:

$E_{lifetime}$ – amount of emissions during equipment operation (t)
B_t – amount of F-gases held in stocks in year t (tonnes)
x – losses during operation period (%)

Lifetime of used equipment is 30 years and no equipment was dismantled yet therefore emissions from disposal are marked "NO" in CRF Reporter.

4.8.1.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

As there are three facilities in the country which uses SF_6 in their technology and report the data on SF_6 usage directly to LEGMC, it is assumed that data used for emission estimation under this subcategory is more precise. Uncertainty of activity data for SF_6 from electrical equipment is assumed as ±2% for AD, but EF uncertainty is 30% according to the 2006 IPCC Guidelines.

Time series of the estimated emissions are consistent because the same methodology, EFs and data sources are used for sectors for all years in time series.

4.8.1.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the 2.G. sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

More detailed description can be found under chapter 4.7.1.4.

Currently using CRF Reporter software version v6.0.8 it is not possible to enter NO in green and grey cells for those F-gases where emissions are not occurring in Latvia although CRF Reporter User manual says that if disaggregated data is not available for certain categories, the CRF Reporter allows users to report information in the parent category. This can be done by directly entering data in the green cells (i.e. overwriting formulas).

Under 2.G.1 Electrical equipment only F-gases which are source of emissions are reported. Remaining F-gases are not occurring and are not added as child nodes according to CRF User manual however it is not currently possible to enter data in green cells for these F-gases therefore some information in the parent category (green cells) in corresponding CRF tables are missing. It was confirmed by CRF Reporter help desk that this is an CRF internal issue which will be improved in the future releases of the software. But for the moment it was suggested to leave cells blank. Due to this reason completeness check in CRF Reporter v6.0.8 shows incompleteness (orange light) which could be solved when CRF Reporter will allow to enter notation keys for F-gases directly in green and grey cells.

QA/QC procedures within CRF Reporter were carried out in order to ensure completeness and consistency of reported data.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

4.8.1.5 Category-specific recalculations

No recalculations were done for this sector.

4.8.1.6 Category-specific planned improvements

No improvements are planned for this sector.

4.8.2 N_2O From Product Uses (CRF 2.G.3)

4.8.2.1 Category description

This chapter describes emissions from the use of N_2O for anesthesia and N_2O emissions from aerosol cans. N_2O emissions from this sector formed a negligible part of total GHG emissions in Latvia. In 2020, these emissions were 3.62 kt CO_2 eq.

4.8.2.2 Methodological issues

N_2O emissions from anesthesia were estimated taking into account the amount of N_2O sold. According to the 2006 IPCC Guidelines, it was assumed that 100% of N_2O sold for anaesthesia was emitted to the air, therefore activity data is equal to estimated emissions. The data on N_2O sales was available since 2007. Activity data was provided by the State Agency of Medicines of Latvia. The estimation of emissions is based on the assumption that all used N_2O is emitted to the atmosphere in the same year when it is produced or imported in Latvia. To obtain a comparable data in time series for years 1990-2006 assume that base year for N_2O emissions is year 2007, N_2O emissions for years 1990-2006 were calculated proportionally, taking into account the number of inhabitants provided by CSB.

At the moment there is no data on N_2O emissions from aerosol cans in Latvia. However, in order to estimate these N_2O emissions from aerosol cans in Latvia, Belgium approach[117] was used.

N_2O emissions from anesthesia and from aerosol cans are shown in Table 4.56.

Table 4.56 Estimated N_2O emissions from anesthesia and from aerosol cans

Year	N_2O emissions from anesthesia, kt CO_2 eq.	N_2O emissions from aerosol cans, kt CO_2 eq.	Total emissions from N_2O from product Use, kt CO_2 eq.
1990	*1.30*	*3.54*	*4.84*
1991	*1.30*	*3.52*	*4.82*

[117] *Belgium's greenhouse gas inventory (1990-2019) 2G3b Other (propellant for pressure and aerosol product 184p. Available: https://unfccc.int/documents/271642*

Year	N_2O emissions from anesthesia, kt CO_2 eq.	N_2O emissions from aerosol cans, kt CO_2 eq.	Total emissions from N_2O from product Use, kt CO_2 eq.
1992	*1.29*	*3.50*	*4.79*
1993	*1.26*	*3.43*	*4.69*
1994	*1.24*	*3.37*	*4.61*
1995	*1.22*	*3.31*	*4.53*
1996	*1.21*	*3.27*	*4.48*
1997	*1.19*	*3.24*	*4.43*
1998	*1.18*	*3.21*	*4.39*
1999	*1.17*	*3.18*	*4.35*
2000	*1.16*	*3.15*	*4.31*
2001	*1.15*	*3.12*	*4.27*
2002	*1.13*	*3.08*	*4.21*
2003	*1.12*	*3.05*	*4.17*
2004	*1.11*	*3.02*	*4.13*
2005	*1.10*	*2.98*	*4.08*
2006	*1.09*	*2.95*	*4.04*
2007	*1.08*	*2.93*	*4.01*
2008	*0.89*	*2.90*	*3.80*
2009	*1.53*	*2.87*	*4.39*
2010	*1.51*	*2.81*	*4.32*
2011	*1.98*	*2.74*	*4.73*
2012	*1.82*	*2.71*	*4.53*
2013	*1.95*	*2.59*	*4.54*
2014	*2.01*	*2.47*	*4.48*
2015	*2.12*	*2.36*	*4.48*
2016	*2.02*	*2.26*	*4.27*
2017	*2.26*	*2.16*	*4.42*
2018	*2.32*	*2.12*	*4.44*
2019	*2.14*	*2.11*	*4.25*
2020	*1.53*	*2.10*	*3.62*
2020 vs 2019	*-28.45%*	*-0.64%*	*-14.64%*
2020 vs 1990	*17.32%*	*-40.73%*	*-25.10%*

4.8.2.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty of available activity data for anaesthesia under CRF 2.G.3.a N_2O emissions from anesthesia was 2% in 2020. EF uncertainty is assumed to be 2%. Time series consistency was ensured by using one method for all time series.

As the activity data (number of cans) of CRF 2.G.3.b N_2O emissions from aerosol cans is estimated on the basis of the average European consumption, the uncertainty is considered high.

4.8.2.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the Other product manufacture and use (2.G.3) sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

All estimations of the emissions done in the LEGMC also are checked on the logical mistakes by checking the time series of the activity data, EFs and emissions consistency to display all significant and illogic changes in the activity data and emissions.

Quality control check list is filled for each category taking into account criteria given in QA/QC plan approved in the National legislation. All findings were documented and introduced in GHG inventory. All corrections are archived in centralized archiving system.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

4.8.2.5 Category-specific recalculations

No recalculations were done for this sector.

4.8.2.6 Category-specific planned improvements

No improvements are planned for this sector.

4.9 *OTHER PRODUCTION (CRF 2.H)*

4.9.1 Category description

Other Production sub-sector includes emissions of precursors from:

- Pulp and Paper (2.H.1);
- Food and beverages industry (2.H.2).

In 2020, NMVOC emissions constituted 1.27 kt and it is 3.0% lower than in 2019. NMVOC emissions are decreased compared to 1990 by 62.4%.

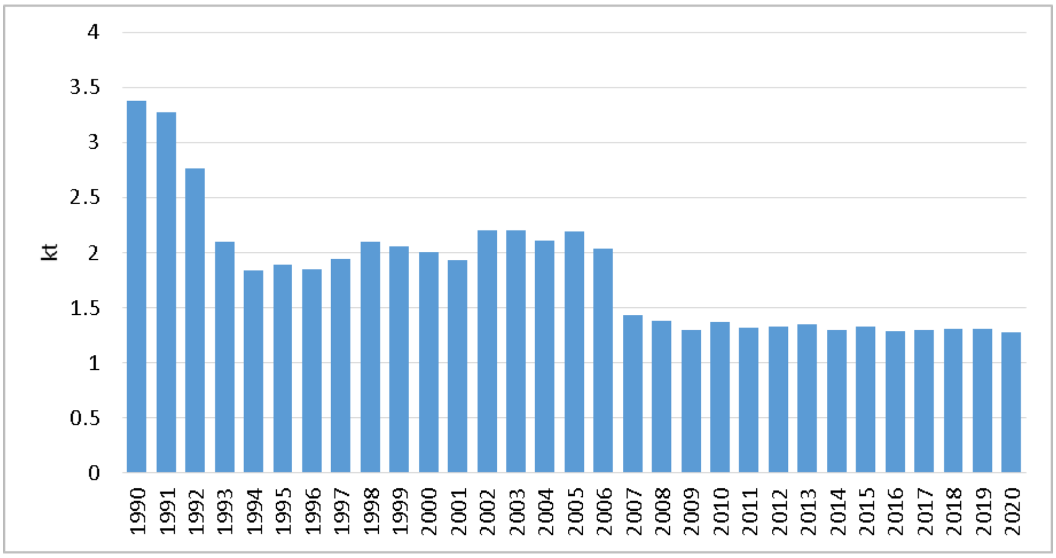

Figure 4.22 NMVOC emissions from 2.H Other Production in 1990–2020 (kt)

Considerable fluctuations occurred in time period 1991–1993 due to changes in economic situation in country (Figure 4.22). Decrease of NMVOC emissions in time period 1999–2001 is explained with decresing demand of Food and beverages export to Commonwealth of Independent States (CIS). In 2005-2008 NMVOC emissions decreased by 36.9% due to decrease of produced spirits by 28.4% and closure of sugar production plants. Sugar is no longer produced in Latvia since 2007.

For time period 2005-2006 data of used limestone in sugar production are reported. CO_2 emissions were calculated as two sugar production plants entered into the EU ETS as stationary installations and detailed information became available from annual GHG reports. After these two years sugar production plants stopped their activities and were closed. Since 2007 the total amount of food and beverages industry sector decrease. That could be explained with economic crisis in 2008-2009 as well with rise in prices of national and imported production.

SO_2 emissions are reported for time period 1990–1996 when pulp and paper was produced. Since 1996 such facilities are closed.

4.9.2 Methodological issues

Reported emissions and calculation methods for the 2.H Other in the Latvian inventory are summarized in Table 4.57.

Table 4.57 GHG emission categories, methods and gases reported from 2.H Other

Category	Method used	Gases reported
Pulp & Paper	*Tier1*	*SO_2*
Food and beverages industry	*Tier1*	*NMVOC, CO_2*

Activity data

Activity data for calculation of the NMVOC emissions from the food and drink industry is obtained from the CSB. Activity data of pulp and paper subsector also were taken from CSB (Table 4.58). LEGMC has signed an agreement with CSB to get data of total production of products from sectors where data are confidential. Data for the categories – wine and spirits production, was classified as confidential. That is why for this category 2006 data was used also for 2007-2020.

Table 4.58 Activity data of 2.H Other Production sector

Year	Pulp and Paper	Wine	Beer	Spirits	Meat, fish, poultry	Sugar	Limestone use in sugar production	Cakes, biscuits, breakfast cereals	Bread	Animal forage
	Kt	hl	hl	hl	kt	kt	kt	kt	kt	kt
1990	*36.60*	*19880.00*	*87380.00*	*324500.00*	*569.30*	*31.00*	*NO*	*54.80*	*314.00*	*200.00*
1995	*1.50*	*159190.00*	*652820.00*	*341500.00*	*82.80*	*29.30*	*NO*	*24.40*	*145.40*	*214.40*
2000	*NO*	*C*	*945146.59*	*C*	*197.30*	*C*	*NO*	*24.30*	*121.10*	*173.80*
2005	*NO*	*C*	*1293300.00*	*C*	*243.80*	*C*	*11.00*	*53.60*	*116.30*	*248.60*
2006	*NO*	*C*	*1383048.62*	*C*	*288.40*	*C*	*10.70*	*45.00*	*107.30*	*244.20*
2007	*NO*	*C*	*1414258.56*	*C*	*286.00*	*NO*	*NO*	*46.50*	*102.30*	*336.80*
2008	*NO*	*C*	*1333800.00*	*C*	*297.70*	*NO*	*NO*	*38.50*	*100.70*	*307.30*
2009	*NO*	*C*	*1292446.65*	*C*	*253.50*	*NO*	*NO*	*33.30*	*95.90*	*299.28*
2010	*NO*	*C*	*1484924.59*	*C*	*252.70*	*NO*	*NO*	*38.00*	*90.00*	*409.83*
2011	*NO*	*C*	*1626594.61*	*C*	*261.50*	*NO*	*NO*	*39.70*	*88.60*	*360.90*
2012	*NO*	*C*	*1488504.18*	*C*	*264.30*	*NO*	*NO*	*44.50*	*91.40*	*348.25*
2013	*NO*	*C*	*1513696.66*	*C*	*286.20*	*NO*	*NO*	*56.40*	*88.10*	*380.07*
2014	*NO*	*C*	*967477.92*	*C*	*270.70*	*NO*	*NO*	*50.40*	*84.90*	*379.53*
2015	*NO*	*C*	*887837.62*	*C*	*260.38*	*NO*	*NO*	*51.80*	*86.95*	*396.75*
2016	*NO*	*C*	*760810.73*	*C*	*234.90*	*NO*	*NO*	*58.44*	*82.90*	*389.71*
2017	*NO*	*C*	*845904.91*	*C*	*235.69*	*NO*	*NO*	*61.31*	*80.67*	*415.27*
2018	*NO*	*C*	*821050.75*	*C*	*253.37*	*NO*	*NO*	*75.07*	*78.58*	*424.12*
2019	*NO*	*C*	*779138.54*	*C*	*249.26*	*NO*	*NO*	*84.55*	*75.94*	*442.44*
2020	*NO*	*C*	*747290.67*	*C*	*259.55*	*NO*	*NO*	*91.87*	*72.68*	*420.37*

Emission factors and calculations

NMVOC emissions from the food and beverages industry as well as SO_2 emissions from pulp and paper are calculated. Emissions are calculated according to the 2006 IPCC Guidelines default methodology.

SO_2 EF 2 (kg/Mg air dried pulp) is taken from EMEP/EEA 2019[118].

NMVOC EFs (Table 4.59) are taken from the EMEP/EEA 2019[119]. CSB provided aggregated statistical data where it can be seen that 95.5% of all spirits produced in Latvia is produced from grains (sheer alcohol or spirits) and no brandy and whiskey is produced in Latvia. That is why EF for Other Spirits 0.4 kg/hl (alcohol) is used.

[118] *EMEP/EEA air pollutant emission inventory guidebook 2019 2.H.1. Pulp and paper industry. Available: https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/2-industrial-processes/2-h-other-industry-production/2-h-1-pulp-and/view*

[119] *EMEP/EEA air pollutant emission inventory guidebook 2019 2.H.2. Pulp and beverages industry. Available: https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/2-industrial-processes/2-h-other-industry-production/2-h-2-food-and/view*

Table 4.59 NMVOC emission factors for food and beverages industries

Production	Emission factors
Wine	*0.08 kg/hl*
Beer	*0.035 kg/hl*
Spirits	*0.4 kg/hl*
Meat, fish, poultry	*0.3 kg/t*
Sugar	*10 kg/t*
Cakes, biscuits, breakfast cereals	*1 kg/t*
Bread	*8 kg/t*
Animal forage	*1 kg/t*

4.9.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty of activity data was assumed as 2% for 1990-2006 because statistical data from CSB were used. For 2007-2008 the uncertainty is assumed higher – 10%, as no precise information is available about wine production. SO_2 and NMVOC EF uncertainty were assigned as 50% because default EFs were used.

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

Time series consistency was checked by verifying IEF, AD and emission changes that increased 10% level. There are no such issues.

4.9.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the IPPU sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

Activity data used in NMVOC and SO_2 emissions was reported by CSB to LEGMC within National Inventory System. CSB has the internal QA/QC procedures based on mathematical model and analysis to avoid logic mistakes. The activity data used in estimations is repeatedly verified by CSB energy experts by checking the data input in data estimation database and reported in the NIR. All estimations of the emissions done in the LEGMC also are checked on the logical mistakes by checking the time series of the activity data, EFs and emissions consistency to display all significant and illogic changes in the activity data and emissions.

Emissions are checked using time series consistency check for the IEF estimated in CRF Reporter and all IEF changes in time series are double-checked and reasonable explanation for IEF changes has to be found under each subsector source category description.

The QC form has been filled in for each category taking into account criteria given in QA/QC plan approved in National legislation.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

4.9.5 Category-specific recalculations

No recalculations were done for this sector.

4.9.6 Category-specific planned improvements

No improvements are planned for this sector.

5 AGRICULTURE (CRF 3)

5.1 *OVERVIEW OF SECTOR*

In 2020, the Agriculture sector contributed 2250.88 kt CO_2 eq. of the total national GHG emissions in Latvia. Agriculture was the second largest GHG emission sector after the Energy sector with a 21.5% share of the total GHG emissions in 2020. Overview of GHG emission sources for the Agriculture sector in 2020 is shown in Figure 5.1.

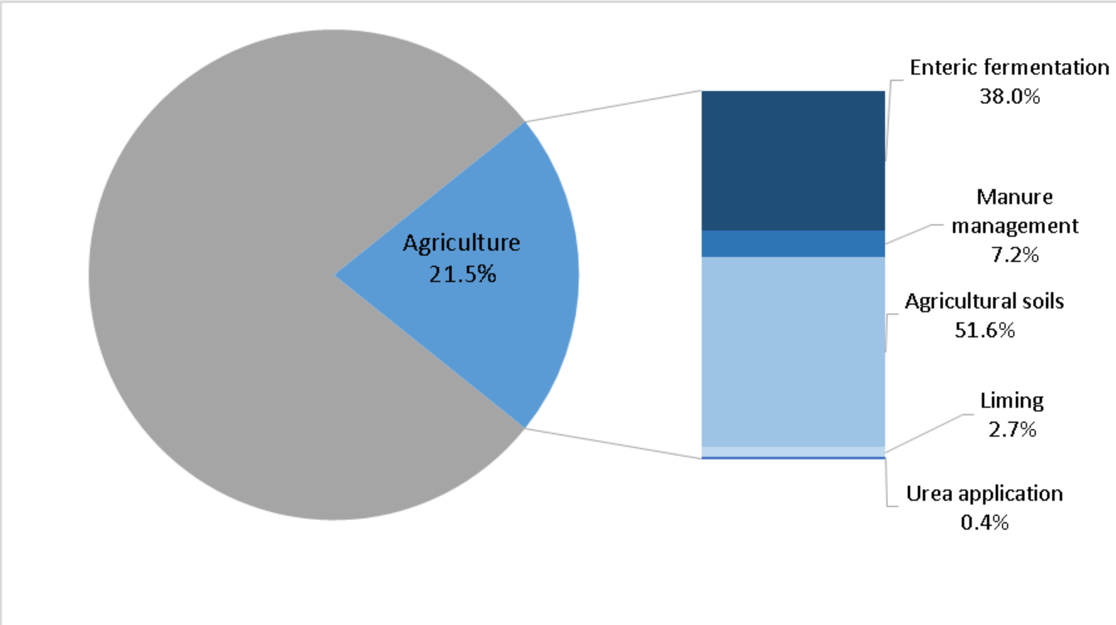

Figure 5.1 Emissions from the Agriculture sector compared with the total emissions in 2020

GHG emissions from the Agriculture sector in Latvia include:

1. methane (CH_4) emissions from Enteric fermentation of domestic livestock and Manure management (3.A and 3.B);
2. nitrous oxide (N_2O) emissions from Manure management and Agricultural soils (3.B and 3.D);
3. carbon dioxide (CO_2) emissions from Liming and Urea application (3.G and 3.H).

Emissions from managed soils include:

-) direct nitrous oxide emissions from:

1. application of synthetic nitrogen (N) fertilizer;
2. application of animal manure, compost, sewage sludge and other organic fertilizers;
3. urine and dung N deposited by grazing animals on pasture, range and paddock;
4. N release from crop residues;
5. cultivation of organic soil in croplands and grasslands;
6. N mineralisation associated with loss of soil organic matter resulting from change of land use or management of mineral soils.

-) indirect nitrous oxide emissions from atmospheric deposition and nitrogen leaching/run-off:

1. volatilized N from agricultural inputs of N;

2. N from fertilizers and other agricultural inputs that is lost through leaching and run-off.

Rice cultivation (3.C) and Savannas (3.E) are not typical for Latvia, therefore these categories are reported as "NO" in CRF tables. Legislative measures and agricultural residue management practices prohibit agricultural residues burning on fields, therefore a notation key "NO" is used in CRF tables under the category Field Burning of Agricultural Residues (3.F). Emissions of other carbon-containing fertilizers are characterized as emissions below the threshold of significance in Latvia. Notation key "NE" is used in CRF tables under the category Other Carbon-containig Fertilizers (3.I).

The calculation of emissions is based on the 2006 IPCC Guidelines and EMEP/EEA 2019 methodology. Detailed information about methods is provided under each subcategory.

In 2020, GHG emissions from the agriculture sector in Latvia increased by 2.2% compared to 2019. However, annual emissions have been reduced by 54.9% since 1990 due to decrease mainly in the number of livestock, sown area and nitrogen fertilizers (Table 5.1).

Table 5.1 Greenhouse gas emissions in the Agricultural sector, 1990–2020 (kt CO_2 eq.)

Year	CH_4	N_2O	CO_2	Total
1990	*2411.4*	*2209.6*	*364.8*	*4985.8*
1991	*2312.6*	*2054.2*	*229.7*	*4596.5*
1992	*1912.6*	*1586.7*	*36.2*	*3535.5*
1993	*1256.2*	*1198.8*	*3.9*	*2458.9*
1994	*1102.6*	*1063.2*	*2.4*	*2168.2*
1995	*1074.6*	*927.7*	*1.9*	*2004.2*
1996	*1028.4*	*933.7*	*1.5*	*1963.6*
1997	*1006.4*	*938.3*	*1.3*	*1946.0*
1998	*936.5*	*902.0*	*3.3*	*1841.7*
1999	*807.2*	*842.7*	*3.4*	*1653.3*
2000	*811.7*	*860.7*	*6.0*	*1678.5*
2001	*857.8*	*929.6*	*2.2*	*1789.5*
2002	*849.7*	*891.4*	*19.5*	*1760.7*
2003	*849.8*	*928.4*	*26.1*	*1804.3*
2004	*822.3*	*905.3*	*2.4*	*1730.1*
2005	*847.7*	*942.6*	*2.9*	*1793.2*
2006	*854.9*	*935.1*	*2.8*	*1792.7*
2007	*894.3*	*974.0*	*6.3*	*1874.6*
2008	*868.7*	*962.9*	*5.9*	*1837.6*
2009	*866.6*	*984.4*	*8.3*	*1859.3*
2010	*860.4*	*1012.3*	*6.0*	*1878.8*
2011	*870.3*	*1008.3*	*12.2*	*1890.8*
2012	*889.8*	*1068.7*	*15.7*	*1974.2*
2013	*923.7*	*1091.9*	*17.3*	*2033.0*
2014	*958.2*	*1127.9*	*23.7*	*2109.8*
2015	*959.4*	*1172.6*	*26.1*	*2158.2*
2016	*963.2*	*1173.2*	*30.5*	*2166.9*
2017	*970.6*	*1175.3*	*33.9*	*2179.8*
2018	*939.9*	*1111.8*	*44.5*	*2096.2*
2019	*944.5*	*1201.99*	*54.9*	*2201.39*

Year	CH_4	N_2O	CO_2	Total
2020	*944.9*	*1235.05*	*71.0*	*2250.88*
Share of total % in 2020	*42.0%*	*54.9%*	*3.2%*	*100.0%*
2020 versus 2019	*+0.03%*	*+2.8%*	*+29.4%*	*+2.2%*
2020 versus 1990	*-60.8%*	*-44.1%*	*-80.5%*	*-54.9%*

**In all tables non-rounded values are used to calculate percentage*

In 2020, agricultural soils were responsible for 51.6% of the total emissions from agriculture. The second largest emission source was enteric fermentation by contributing 38.0% of the total agricultural emissions. Manure management constituted 7.2% from the agricultural emissions in 2020. Liming and urea application were less significant emission sources producing 3.2% of the total agricultural emissions in 2020.

Nitrous oxide emissions constituted 54.9% (1235.05 kt CO_2 eq.) and methane emissions resulted in 41.9% (944.9 kt CO_2 eq.) of the total GHG emissions from agricultural sector. Remaining 3.2% (71.0 kt CO_2) of the total GHG emissions from agriculture originated from liming and urea fertilization. Over the year, the most intensive increase of emissions in the agriculture sector was observed for category: liming (3.G). This could be explained by the increase of lime consumption. In 2020, 137.2 kt of liming materials were used, and it is 37.9% more than in 2019. 90.6% of the total agriculture sector methane emissions resulted from enteric fermentation and 9.4% - from manure management. The largest part (94.1%) of total nitrous oxide emissions resulted from direct-indirect emissions of managed soils, only 5.9% of the total nitrous oxide emissions related to manure management.

Information regarding results of key category analysis for the Agriculture sector is presented in Table 5.2.

Table 5.2 Key categories in Agriculture sector in 2022 submission

Category	Gas	Identification criteria	with LULUCF	without LULUCF
3.A.1 Enteric Fermentation - Cattle	*CH_4*	*L1,L2,T1,T2*	*X*	*X*
3.B.1.1 Manure Management - Cattle	*CH_4*	*L1,L2,T1,L2*	*X*	*X*
3.B.2.1 Manure Management - Cattle	*N_2O*	*L1,L2,T1,T2*		*X*
3.B.5 Indirect N_2O emissions from Manure Management	*N_2O*	*L1,L2,T2*	*X*	*X*
3.B.2.3 Manure Management - Swaine	*N_2O*	*T2*		*X*
3.D.1. Direct N_2O emissions from managed soils	*N_2O*	*L1,L2,T1,T2*	*X*	*X*
3.D.2 Indirect N_2O Emissions from managed soils	*N_2O*	*L1,L2,T1,T2*	*X*	*X*
3.G. Liming	*CO_2*	*L1,L2,T1,T2*	*X*	*X*

Interannual variation of emissions, which can be noticed from the time series, was mainly caused by fluctuation in activity data among the years due to changes in the number of animals, which had been significantly affected by economic situation in the country, as well as agricultural policy. Methane and nitrous oxide emissions from manure management were affected by the fluctuation in the number of animals and the proportion of manure managed in different manure management systems which vary depending on animal species. Nitrous oxide emissions from managed soils generally were affected by the numbers describing managed organic soils area, amount of synthetic fertilizers consumption, and the number of grazing livestock, sown area and crop yields, which have large variation among the years.

Emissions from agriculture noticeably decreased in the beginning of 1990s after the Soviet system and large state or collective farms collapses. However, in the recent years it is possible to observe a slight increase of sown area, use of synthetic N-fertilizers, non-dairy, sheep, swine and poultry numbers. State effort to improve animal manure management systems (MMS) and expansion of anaerobic digestion in the largest farms is the main reason that reduces the increase of emissions from manure management. In the last years, dairy farming in Latvia turns to liquid slurry management system according to closing of small farms and reflection to the trend to this management system in developed countries, however liquid slurry produces more methane and results in increase of this type of emissions.

The number of cattle, sheep, swine, goats, horses, poultry, rabbits and fur-bearing animals population, as well as data on milk production and fat content in milk are obtained from the CSB Database[120] and statistical yearbooks[121] or no open access Database. Similarly to the number of livestock, also statistical information about amounts of synthetic fertilizer N application and crop production is obtained from the CSB Database. The information of deer breeding in Latvia is also available from informative reports prepared by Ministry of Agriculture [122] and Wild Animal Breeders Association[123]. Calculation of the MMS distribution is done based on national research results and methodology provided by LULST[124].

Statistical information about livestock number in Latvia is included in Table 5.3. The number of fur-bearing animals is not available for 1990-1992 and 1995, therefore interpolation and extrapolation is used to fill in the gaps of time series.

Table 5.3 Number of livestock, 1990–2020 (thsd heads)

Year	Dairy cattle	Non-dairy cattle	Sheep	Swine	Goats	Horses	Poultry	Rabbits	Fur-bearing animals	Deer
1990	*535.1*	*904.2*	*164.6*	*1401.1*	*5.4*	*30.9*	*10321.1*	*193.9*	*260.2*	*NO*
1995	*291.9*	*245.2*	*72.2*	*552.8*	*8.9*	*27.2*	*4198.3*	*152.5*	*213.5*	*NO*
2000	*204.5*	*162.2*	*28.6*	*393.5*	*10.4*	*19.9*	*3104.6*	*110.9*	*97.2*	*NO*
2005	*185.2*	*200.0*	*41.6*	*427.9*	*14.9*	*13.9*	*4092.3*	*97.9*	*140.8*	*NO*
2006	*182.4*	*194.7*	*41.3*	*416.8*	*14.3*	*13.6*	*4488.1*	*92.9*	*181.9*	*3.3*
2007	*180.4*	*218.3*	*53.9*	*414.4*	*13.0*	*13.0*	*4756.8*	*96.4*	*176.1*	*4.0*
2008	*170.4*	*209.8*	*67.1*	*383.7*	*12.9*	*13.1*	*4620.5*	*57.4*	*197.5*	*5.3*
2009	*165.5*	*212.7*	*70.7*	*376.5*	*13.2*	*12.6*	*4828.9*	*43.9*	*164.4*	*7.8*

[120] *Agriculture, Forestry and Fishery. Available: http://data.csb.gov.lv/pxweb/en/lauks/?rxid=a79839fe-11ba-4ecd-8cc3-4035692c5fc8*

[121] *Agriculture in Latvia. Collection of Statistical Data. Rīga (2021) 92 p. Available: https://admin.stat.gov.lv/system/files/publication/2021-06/Nr_14_Latvijas_Lauksaimnieciba_2021_%2821_00%29_LV_EN_0.pdf*

[122] *Ministry of Agriculture. Available: https://www.zm.gov.lv/lauksaimnieciba/statiskas-lapas/lauksaimniecibas-gada-zinojumi?nid=531#jump*

[123] *Wild Animal Breeders Association. Available: http://www.losp.lv/sites/default/files/articles/attachments/publications/22.12.2011_-_1500/17_savvalas_dzivnieki.pdf*

[124] *Project "Development of the national system for greenhouse gas (GHG) inventory and reporting on policies, measures and projections". Available: http://www.varam.gov.lv/eng/fondi/EEA_Norv/european_economic_area_financial_mechanism_programme__national_climate_policy/?doc=18431*

Year	Dairy cattle	Non-dairy cattle	Sheep	Swine	Goats	Horses	Poultry	Rabbits	Fur-bearing animals	Deer
2010	*164.1*	*215.4*	*76.8*	*389.7*	*13.5*	*12.0*	*4948.7*	*33.5*	*166.1*	*7.6*
2011	*164.1*	*216.5*	*79.7*	*375.0*	*13.4*	*11.5*	*4417.9*	*39.3*	*183.7*	*9.6*
2012	*164.6*	*228.5*	*83.6*	*355.2*	*13.3*	*10.9*	*4910.9*	*37.3*	*231.6*	*9.3*
2013	*165.0*	*241.5*	*84.8*	*367.5*	*12.6*	*10.7*	*4985.8*	*38.9*	*231.6*	*11.5*
2014	*165.9*	*256.1*	*92.5*	*349.4*	*12.3*	*10.1*	*4413.9*	*38.3*	*313.9*	*13.2*
2015	*162.4*	*256.7*	*102.3*	*334.2*	*12.7*	*9.6*	*4532.0*	*39.8*	*272.2*	*12.6*
2016	*154.0*	*258.3*	*106.6*	*336.4*	*13.2*	*9.3*	*4711.7*	*34.9*	*243.3*	*13.4*
2017	*150.4*	*255.4*	*112.2*	*320.6*	*12.8*	*8.9*	*4943.8*	*29.1*	*298.4*	*15.3*
2018	*144.5*	*250.9*	*107.3*	*304.9*	*12.2*	*8.4*	*5403.1*	*25.8*	*154.1*	*15.4*
2019	*138.4*	*256.9*	*99.8*	*314.2*	*11.7*	*8.3*	*5690.4*	*26.2*	*140.3*	*16.0*
2020	*136.0*	*263.0*	*91.9*	*306.8*	*11.5*	*8.3*	*5837.9*	*24.3*	*138.1*	*17.0*
2020 versus 2019	*-1.7%*	*+2.4%*	*-7.9%*	*-2.3%*	*-1.7%*	*0.0%*	*+2.6%*	*-7.3%*	*-1.6%*	*+6.3%*
2020 versus 1990	*-74.6%*	*-70.9%*	*-44.2%*	*-78.1%*	*113%*	*-73.1%*	*-43.4%*	*-87.5%*	*46.9%*	*NO*

Latvian livestock industry has been influenced by historical events and economical situation. Particularly significant changes in the livestock industry began in 1992 after the restoration of Latvian independence when the most of big farms went into liquidation. Since the Soviet Union had a planned economy, most of the output of livestock products was carried out in other Soviet republics. Reorientation of livestock product export to Western markets was more difficult in terms of market saturation. Latvian farmers were forced to reduce production levels of milk, meat and crop. Consequently, livestock numbers declined most rapidly in 1990-1994 in all sectors, except for goat farming. All the above-mentioned social and economic changes lead to also eliminating of stud-farms. The horses were sold, only the strongest stud-farms continued to work. Starting from 2004, according to Latvia's accession to the European Union (EU), the number of livestock has stabilized. The increase of production indicators was characteristic for beef cattle, sheep, goat and poultry industries.

Dairy farming is one of the most important branches of agriculture in Latvia. In 2020, 990.1 thousand tonnes of milk (incl. goat milk) were produced, which is 8.7 thousand tonnes or 0.9% higher than in 2019. The increase in milk production was influenced by an increase in milk output on average per dairy cow, although there was also a reduction in the number of dairy cows. Average milk yield increased by 272 kg or 3.9%, reaching 7163 kg per year.

According to CSB information[125], at the end of 2020, agricultural holdings were breeding 399 thousand cattle, which is higher by 3.7 thousand than a year ago. The number of dairy cows reduced by 2.4 thousand or 1.7% to the end of 2020, whereas the number of other cows rose by 6.1 thousand or 2.4%. The number of pig decrease at the end of 2020 by 7.4 thousand or 2.3%. The number of sheep fell by 7.9 thousand or 7.9% to the end of 2020. At the end of 2020, as compared to the year before, the number of goats has dropped by 0.2 thousand or 1.7%. The number of horses in Latvia at the end of 2020 remained the same. At the end of 2020, the number of poultry increased by 147.5 thousand or 2.6%.

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[125] *Agriculture in Latvia. Collection of Statistical Data. Rīga (2021) 92 p. Available: https://stat.gov.lv/lv/statistikas-temas/noz/zivsaimn/publikacijas-un-infografikas/7268-latvijas-lauksaimnieciba-2021?themeCode=LA and https://stat.gov.lv/lv/statistikas-temas/noz/lauksaimn/tabulas/lag020-lauksaimniecibas-kulturaugu-sejumu-platiba-kopraza*

Since 2009 the number of large farms has increased, while small farms have been closed, however dairy and other farms in Latvia are characterized by a low herd size in comparison with other European countries.

Statistical surveys are the source of data on crop production in commercial companies, private farms and individual merchants. Fluctuations in activity data is observed due to economic situation in the country. Since 2007 two sugar factories have stopped their activity therefore no data is presented further. Agricultural statistics data fulfil criteria determined by the EU and requirements are determined in the legislative acts. The Project Documentation System (ADS) is established at CSB. It is a quality metadata system for internal and external users. There are methodological descriptions of all statistical surveys and calculations. Annual samples are made up as stratified simple samples. Holdings are selected by economic size (standard output – SO) and type of farming. SO is a standard indicator characterizing the economic activity of agricultural holding, i.e., value acquired from one hectare of agricultural crops or one livestock head (unit), estimated at prices of the corresponding region and expressed in EUR. A total standard output characterises the economic size of the holding in monetary terms. Farms with SO >= 50000 EUR are included for 100% statistical surveys; farms with 1500 EUR <SO < 50000 EUR are selected by economic size and type of farming. Sample size for annual sample (Crop and Animal survey) includes 3.8 thousand holdings. Small holdings with SO < 1500 EUR are not included in annual Crop and Animal surveys, but information for these holdings is estimated using experts' method. For this estimation CSB uses information from Agricultural Censuses and surveys of small farms, which are organized between Censuses.

In 2020, the highest harvested production of grain in the history of Latvia was obtained - 3.5 million tonnes, which is 333.9 thousand tonnes or 10.6% more than in the previous year. Last year, the highest cereal yield was also achieved - on average 46.4 quintals per one hectare (in 2019 - 42.6 quintals). The winter of the previous year was favourable for the overwintering of winter cereals as well as the summer - for harvesting, which in 2020 significantly affected the increase in the average yield of winter cereals per hectare up to 55.3 quintals, which is the highest yield of winter cereals in the history of Latvia. The total yield of winter cereals reached 2.4 million tonnes or 9.8% more than in 2019, with sown areas increasing by only 2.9 thousand hectares or 0.7%. In 2020, 753.7 thousand hectares were sown with cereals, which is 11.4 thousand hectares or 1.5% more than in the previous year, and it is the largest area of cereals in Latvian agriculture.

Last year, the largest total production of winter wheat was obtained - 2.2 million tonnes or 62.2% of the total grain production. The average yield per hectare reached 56.9 quintals, which is the highest winter wheat yield in the history of Latvia. In Zemgale region, winter wheat yield reached as much as 64.0 quintals per hectare (55.2 quintals in 2019), and their total production reached 893.8 thousand tonnes or 41.1% of the total winter wheat production in the country (39.8% in 2019).

In 2020, 83.0% of the purchased grain volume was wheat (in 2019 – 81.4%), of which 80.2% was food quality wheat (in 2019 – 85.5%). The share of food rye in the total volume of rye purchased has also decreased from 82.9% in 2019 to 74.9% in 2020.

In 2020, the total potato harvested production was 377.5 thousand tonnes, which is by 124.3 thousand tonnes or 24.8% less than a year ago. The area of potato plantations has decreased by 4.3 thousand hectares or 19.3%, but their average yield per hectare has decreased from 224 quintals in 2019 to 208 quintals in 2020. Last year, the weather was not favourable for growing vegetables in the open field. Their average yield per hectare decreased from 192 quintals in 2019 to 177 quintals last year. In 2020, a total of 159.1 thousand tonnes of vegetables were grown (including those grown in greenhouses), which is 13.8 thousand tonnes or 8.0% less than in 2019. The amount of vegetables grown in greenhouses increased by 0.8 thousand tonnes or 7.4%.

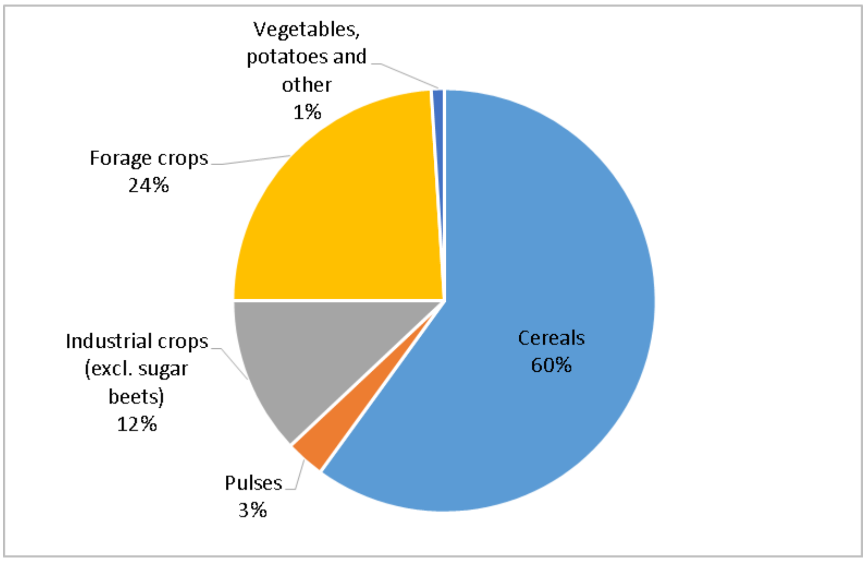

Figure 5.2 Share of the main crops on sown area in Latvia in 2020 (%)

Statistical information about crop production in Latvia for calculation of nitrous oxide emissions is included in Table 5.4 and Table 5.5.

Table 5.4 Sown area of agricultural crops, 1990–2020 (thsd ha)

Year	Wheat	Barley	Triticale	Oats	Rye	Buckwheat	Pulses
1990	*141.5*	*306.9*	*1.1*	*82.4*	*130.7*	*0.1*	*10.5*
1995	*109.6*	*203.3*	*2.7*	*45.6*	*40.4*	*0.1*	*3.0*
2000	*158.1*	*134.9*	*5.9*	*45.5*	*54.8*	*6.2*	*2.1*
2005	*187.4*	*148.7*	*13.3*	*58.0*	*39.3*	*10.4*	*2.2*
2006	*215.1*	*154.2*	*11.3*	*62.9*	*42.8*	*14.0*	*1.4*
2007	*224.6*	*145.3*	*12.4*	*62.4*	*57.5*	*10.7*	*1.6*
2008	*256.6*	*131.2*	*13.8*	*66.2*	*59.0*	*10.4*	*1.6*
2009	*285.7*	*104.6*	*13.1*	*60.6*	*59.0*	*10.1*	*2.5*
2010	*307.6*	*106.5*	*12.1*	*63.3*	*34.6*	*8.2*	*2.7*
2011	*311.3*	*98.7*	*9.9*	*59.3*	*28.4*	*9.5*	*3.8*
2012	*354.7*	*87.9*	*13.3*	*62.0*	*37.0*	*11.7*	*4.6*
2013	*371.8*	*85.4*	*14.2*	*62.4*	*29.1*	*10.6*	*7.0*
2014	*402.5*	*119.9*	*10.7*	*66.8*	*32.3*	*10.2*	*11.9*
2015	*448.2*	*99.6*	*10.4*	*60.3*	*37.4*	*10.5*	*31.6*
2016	*482.9*	*96.1*	*11.1*	*64.6*	*36.3*	*17.9*	*41.8*
2017	*471.6*	*81.5*	*8.5*	*70.9*	*34.0*	*30.9*	*57.4*
2018	*419.9*	*120.2*	*4.5*	*90.5*	*22.0*	*27.9*	*53.7*
2019	*495.5*	*87.6*	*7.7*	*84.3*	*43.9*	*16.2*	*40.4*
2020	*498.8*	*84.7*	*7.1*	*98.9*	*41.6*	*15.7*	*43.7*
2020 versus 2019	*+0.7%*	*-3.3%*	*-7.8%*	*+17.3%*	*-5.2%*	*-3.1%*	*+8.2%*

Year	Wheat	Barley	Triticale	Oats	Rye	Buckwheat	Pulses
2020 versus 1990	+252.5%	-72.4%	+545.5%	+20.0%	-68.2%	+15600.0%	+316.0%

Data about sown area of oil flax (1990-1999) are not available, but was 0.1 thsd ha in 2020; therefore data for filling gaps in the time series are extrapolated from the closest numbers. Other statistical data are included in relevant subchapters.

Table 5.5 Sown area of agricultural crops, 1990–2020 (thsd ha)

Year	Sugar beet	Fodder roots	Potatoes	Maize for silage and forage	Crops for green feed and silage	Perennial grass	Flax	Rape
1990	14.7	37.0	80.3	44.8	73.9	664.0	12.2	1.9
1995	9.5	19.8	75.3	0.6	17.8	374.7	1.7	1.1
2000	12.7	9.0	51.3	1.2	11.4	347.2	1.9	6.9
2005	13.5	3.8	45.1	2.9	8.7	360.6	2.4	71.4
2006	12.7	2.8	45.1	3.5	11.4	425.8	1.7	83.2
2007	0.3	2.3	40.3	5.1	11.1	427.1	1.5	99.2
2008	NO	0.9	37.8	5.9	8.2	413.1	0.6	82.6
2009	NO	0.7	30	9.8	7.2	413.7	0.3	93.3
2010	NO	0.9	30.1	7.1	6.3	387.3	1.1	110.6
2011	NO	0.8	29.7	11.3	5.7	370.8	1.5	121.3
2012	NO	0.6	28.2	20.6	10.6	351.4	0.9	117.5
2013	NO	0.3	27.3	20.4	7.7	356.7	0.3	128.2
2014	NO	0.2	26.8	21.7	7.3	312.4	0.6	100.1
2015	NO	0.2	24.8	25.6	8.6	304.3	0.3	89.0
2016	NO	0.2	23.3	27.3	8.5	298.7	0.2	101.1
2017	NO	0.2	22.7	25.7	1.6	270.3	0.4	117.4
2018	NO	0.2	22.3	25.6	2.0	272.6	0.1	123.6
2019	NO	0.2	22.4	25.4	2.0	273.3	0.2	140.1
2020	NO	0.1	18.1	23.3	1.6	274.5	0.2	145.9
2020 versus 2019	NO	-50.0%	-19,2%	-8.3%	-20.0%	+0.4%	0.0%	+4.1%
2020 versus 1990	NA	-99.7%	-77.5%	-48.0%	-97.8%	-58.7%	-98.4%	+7578.9%

5.2 *ENTERIC FERMENTATION (CRF 3.A)*

5.2.1 Category description

Methane emissions from enteric fermentation of domestic livestock comprised 37.7% of total emissions in the agriculture sector, being 856.03 kt CO_2 eq. in 2020. CH_4 is emitted as a by-product of the normal livestock digestive process, in which microbes resident in the animals' digestive system ferment the feed consumed by the animal. This fermentation process is also known as enteric fermentation[126]. Ruminant livestock (cattle, sheep and goats) are the primary source of methane emissions. The amount of enteric methane emitted is driven primarily by the number and size of domestic animals, the type of digestive system, and the type and

[126] *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, 2000. Available: https://www.ipcc-nggip.iges.or.jp/public/gp/english/*

amount of feed consumed[127]. Latvia reports emissions from cattle (including dairy cows, other mature non-dairy cattle and growing cattle according to CRF Option B), sheep, swine, goats, horses, rabbits, and fur-bearing animals (Table 5.6).

Table 5.6 Reported emissions under the subcategory enteric fermentation

CRF	Source	Emissions reported	Level
3.A 1	*Dairy cattle / Non-dairy cattle (other mature and growing cattle)*	*CH_4*	*Tier 2*
3.A 2	*Sheep*	*CH_4*	*Tier 1*
3.A 3	*Swine*	*CH_4*	*Tier 1*
3.A 4	*Other – Buffalo*	*NO*	*Tier 1*
3.A 4	*Other – Camels*	*NO*	*Tier 1*
3.A 4	*Other – Deer*	*CH_4*	*Tier 1*
3.A 4	*Other – Goats*	*CH_4*	*Tier 1*
3.A 4	*Other – Horses*	*CH_4*	*Tier 1*
3.A 4	*Other – Mules and asses*	*NO*	*Tier 1*
3.A 4	*Other – Poultry*	*NE*	*Tier 1*
3.A 4	*Other – Rabbits*	*CH_4*	*Tier 1*
3.A 4	*Other – Fur-bearing animals*	*CH_4*	*Tier 1*

Emissions from poultry enteric fermentation have not been estimated. According to the 2006 IPCC Guidelines, methodology for enteric fermentation calculation from poultry is not developed. Methane emissions from poultry are calculated only in the manure management category.

Cattle are the largest source of enteric fermentation methane emissions (94.8% from total enteric fermentation methane emissions) in Latvia. In 2020, dairy cattle produced 58.9% and non-dairy cattle – 35.9% of methane emissions. Emissions from sheep formed 2.1%, from swine – 1.3% and from other livestock – 1.7% of the total emissions from enteric fermentation. In 2020, the total methane emissions from enteric fermentation of domestic livestock increased by 0.24 kt or 0.7%, compared to 2019. This is caused by the increase of the number of all non-dairy cattle and productivity of dairy cows. Since 1990 generally due to the evident fall of the number of livestock, methane emissions decreased by 61.5% (Table 5.7).

Table 5.7 Methane emissions from enteric fermentation by livestock category 1990–2020 (kt)

Year	Dairy cattle	Non-dairy cattle	Sheep	Swine	Goats	Horses	Rabbits	Fur-bearing animals	Deer	Total, CH_4
1990	*55.11*	*29.61*	*1.32*	*2.10*	*0.03*	*0.56*	*0.11*	*0.03*	*NO*	*88.86*
1995	*29.41*	*7.69*	*0.58*	*0.83*	*0.04*	*0.49*	*0.09*	*0.02*	*NO*	*39.16*
2000	*23.03*	*4.99*	*0.23*	*0.59*	*0.05*	*0.36*	*0.07*	*0.01*	*NO*	*29.33*
2005	*22.19*	*6.54*	*0.33*	*0.64*	*0.07*	*0.25*	*0.06*	*0.01*	*NO*	*30.11*
2006	*22.26*	*6.61*	*0.33*	*0.63*	*0.07*	*0.24*	*0.05*	*0.02*	*0.07*	*30.28*
2007	*22.42*	*7.71*	*0.43*	*0.62*	*0.07*	*0.23*	*0.06*	*0.02*	*0.08*	*31.64*
2008	*21.57*	*7.52*	*0.54*	*0.58*	*0.06*	*0.24*	*0.03*	*0.02*	*0.11*	*30.66*

[127] *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, 2000. Available: https://www.ipcc-nggip.iges.or.jp/public/gp/english/*

Year	Dairy cattle	Non-dairy cattle	Sheep	Swine	Goats	Horses	Rabbits	Fur-bearing animals	Deer	Total, CH_4
2009	*21.13*	*7.81*	*0.57*	*0.56*	*0.07*	*0.23*	*0.03*	*0.02*	*0.16*	*30.56*
2010	*20.70*	*8.15*	*0.61*	*0.58*	*0.07*	*0.22*	*0.02*	*0.02*	*0.15*	*30.52*
2011	*20.80*	*8.39*	*0.64*	*0.56*	*0.07*	*0.21*	*0.02*	*0.02*	*0.19*	*30.90*
2012	*21.17*	*9.04*	*0.67*	*0.53*	*0.07*	*0.20*	*0.02*	*0.02*	*0.19*	*31.91*
2013	*21.65*	*9.87*	*0.68*	*0.55*	*0.06*	*0.19*	*0.02*	*0.02*	*0.23*	*33.28*
2014	*22.06*	*10.58*	*0.74*	*0.52*	*0.06*	*0.18*	*0.02*	*0.03*	*0.26*	*34.46*
2015	*21.51*	*10.96*	*0.82*	*0.50*	*0.06*	*0.17*	*0.02*	*0.03*	*0.25*	*34.33*
2016	*21.23*	*11.34*	*0.85*	*0.50*	*0.07*	*0.17*	*0.02*	*0.02*	*0.27*	*34.47*
2017	*21.29*	*11.50*	*0.90*	*0.48*	*0.06*	*0.16*	*0.02*	*0.03*	*0.31*	*34.75*
2018	*20.62*	*11.51*	*0.86*	*0.46*	*0.06*	*0.15*	*0.02*	*0.02*	*0.31*	*34.00*
2019	*20.22*	*11.95*	*0.80*	*0.47*	*0.06*	*0.15*	*0.02*	*0.01*	*0.32*	*34.00*
2020	*20.17*	*12.30*	*0.74*	*0.46*	*0.06*	*0.15*	*0.01*	*0.01*	*0.34*	*34.24*
Share of total % in 2020	*58.9%*	*35.9%*	*2.1%*	*1.3%*	*0.2%*	*0.4%*	*0.0%*	*0.0%*	*1.0%*	*100.0%*
2020 versus 2019	*-0.2%*	*+2.9%*	*-7.9%*	*-2.4%*	*-1.7%*	*0.0%*	*-7.3%*	*-1.6%*	*+6.3%*	*+0.7%*
2020 versus 1990	*-63.4%*	*-58.5%*	*-44.2%*	*-78.1%*	*113.0%*	*-73.1%*	*-87.5%*	*-46.9%*	*NA*	*-61.5%*

5.2.2 Methodological issues

5.2.2.1 Methods

The Tier 1 approach of the 2006 IPCC Guidelines relies on default emissions factors. For Tier 1 methodology Latvia collecting data on the numbers of animals for specific livestock category. The Tier 2 approach is more complex based on country-specific information about animal and feed characteristics. The Tier 2 approach for Latvia is implemented to estimate methane emissions for cattle. Emissions from enteric fermentation of domestic livestock in Latvia have been calculated by using the IPCC Tier 1 and Tier 2 methodologies presented in the 2006 IPCC Guidelines (Volume 4, Chapter 10.3).

Methane emissions from enteric fermentation for sheep, swine, goats, horses, rabbits, fur-bearing animals and deer (reindeer do not appear in Latvia according to data of Organic Farmers and Wildlife Animal Breeders Association as well as Agricultural Data Centre) have been calculated by using the Equation 10.19 (2006 IPCC Guidelines, page 10.28) according to the IPCC Tier 1 methodology by multiplying the number of the animals in each category with the IPCC default EF or other origin EF of the respective livestock category:

$$\boldsymbol{Emissions = EF_{(T)} * (\frac{N_{(T)}}{10^6})} \tag{5.1}$$

where:

Emissions - methane emissions from Enteric Fermentation, 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

The default EFs as for developed countries (2006 IPCC Guidelines, Table 10.10, page 10.28) were used to calculate methane emissions from enteric fermentation for sheep, swine, goats, horses and deer. As default the 2006 IPCC Guidlines and national EFs for rabbits and fur-bearing animals are not available, other origin EFs as Norwegian[128] for fur-bearing animals and Russian[129] for rabbits were used for enteric fermentation emissions calculations similarly by experience of the neighboring countries (Table 5.8).

Table 5.8 Default methane emission factors from enteric fermentation

Livestock category	EF (kg CH_4 head^{-1} yr^{-1})
Sheep	*8.00*
Swine	*1.50*
Goats	*5.00*
Horses	*18.00*
Rabbits	*0.59*
Fur-bearing animals	*0.10*
Deer	*20.0*

The Tier 2 approach to estimate emissions is implemented for cattle, because emissions from cattle make up the biggest part of total agricultural sector methane emissions. With the Tier 2 methodology methane emissions have been calculated as in the Tier 1 methodology mentioned above, but EFs for dairy cattle and young and mature non-dairy cattle have been calculated according to the 2006 IPCC Guidelines methodology represented in Equation 10.21, page 10.31:

$$\boldsymbol{EF} = \left[\frac{GE*\left(\frac{Y_m}{100}\right)*365}{55.65}\right] \tag{5.2}$$

where:

EF - emission factor, kg CH_4 head^{-1} yr^{-1}
GE - gross energy intake, MJ head^{-1} day^{-1}
Y_m - methane conversion factor, % of gross energy in feed converted to methane (default values in table 10.12, page 10.30 from 2006 IPCC Guidelines)
The factor 55.65 (MJ/kg CH_4) is the energy content of methane

For cattle, the gross energy intake (GE) has been calculated according to the 2006 IPCC Guidelines Equation 10.16, page 10.21:

$$\boldsymbol{GE} = \left[\frac{\left(\frac{NE_m+NE_a+NE_j+NE_{work}+NE_p}{REM}\right)+\left(\frac{NE_g}{REG}\right)}{\frac{DE\%}{100}}\right] \tag{5.3}$$

where:

GE - gross energy, MJ day^{-1}
NE_m - net energy required by the animal for maintenance, MJ day^{-1}
NE_a - net energy for animal activity, MJ day^{-1}
NE_l - net energy for lactation, MJ day^{-1}
NE_{work} - net energy for work, MJ day^{-1}
NE_p - net energy required for pregnancy, MJ day^{-1}

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[128] Greenhouse Gas Emissions 1990-2019, National Inventory Report. The Norwegian Environment Agency, 2021, p. 314, Table 5.11. Available: https://unfccc.int/ghg-inventories-annex-i-parties/2021
[129] Национальный доклад о кадастре антропогенных выбросов из источников и абсорбции поглотителями парниковых газов не регулируемых Монреальским протоколом за 1990 – 2019 гг. Часть 1. Москва, 2021., с. 178, Таблица 5.7. Available: https://unfccc.int/ghg-inventories-annex-i-parties/2021

REM - ratio of net energy available in a diet for maintenance to digestible energy consumed
NEg - net energy needed for growth, MJ day^{-1}
REG - ratio of net energy available for growth in a diet to digestible energy consumed
DE% - digestible energy expressed as a percentage of gross energy

The equations for calculating NE_m (Equation 10.3, page 10.15), NE_a (Equation 10.4, page 10.16), NE_l (Equation 10.8, page 10.18), NE_p (Equation 10.13, page 10.20), NE_g (Equation 10.6, page 10.17), REM (Equation 10.14, page 10.20) and REG (Equation 10.15, page 10.20) are:

$$\boldsymbol{NE_m = Cf_i * (Weight)^{0.75}}$$

$$\boldsymbol{NE_a = C_a * NE_m}$$

$$\boldsymbol{NE_l = Milk * (1.47 + 0.40 * Fat)}$$

$$\boldsymbol{NE_p = C_{pregrancy} * NE_m}$$

$$\boldsymbol{NE_g = 22.02 * \frac{BW}{C * MW}^{0.75} * WG^{1.097}}$$

$$\boldsymbol{REM = \left[1.123 - (4.092 * 10^{-3} * DE\%) + \left[1.126 * 10^{-5} * (DE\%)^2\right] - \left(\frac{25.4}{DE\%}\right)\right]}$$

$$\boldsymbol{REG = \left[1.164 - \left(5.160 * 10^{-3} * DE\%\right) + \left[1.308 * 10^{-5} * (DE\%)^2\right] - \left(\frac{37.4}{DE\%}\right)\right]} \quad (5.4)$$

where:

Cf_i - maintenance coefficient (default values from 2006 IPCC Guidelines. Volume 4, Chapter 10, Table 10.4, page 10.16 are used)
Weight - animal weight, kg
Ca - coefficient corresponding to animals feeding situation (default values from 2006 IPCC Guidelines. Volume 4, Chapter 10, Table 10.5, page 10.17 are used)
Milk - amount of milk produced, kg of milk day^{-1}
Fat - fat content of milk, % by weight
$C_{pregnancy}$ - pregnancy coefficient (default values from 2006 IPCC Guidelines. Volume 4, Chapter 10, Table 10.7, page 10.20 are used)
BW - the average live body weight (BW) of the animals in the population, kg
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}
C - a coefficient with a value of 0.8 for females, 1.0 for castrates and 1.2 for bulls
REM - ratio of net energy available in a diet for maintenance to digestible energy consumed
REG - ratio of net energy available for growth in a diet to digestible energy consumed
DE% - digestible energy, %

When using NEp to calculate GE, the NEp estimate must be weighted by the portion of the mature females that actually go through gestation in a year. According to animal breeding national expert calculations based on data of Agricultural Data Centre Republic of Latvia Register, 83% of the NEp value for dairy cattle is used in the GE equation.

Methane conversion factor (Ym) of zero is assumed for juveniles consuming only milk (2006 IPCC Guidelines, p.10.30). In Latvia, it was supposed that calves feed milk and milk substitute no longer than of age 3 months. Therefore it was assumed that methane conversion rate of young growing cattle group (under 1 year old) is 5.5% in 2020. The rate was estimated from the 2006 IPCC Guidelines default Ym 6.5%, based on an assumption that for calves between 0 and 3 months Ym is 0%.

Feed digestibility (DE) 65% for dairy cattle is used in calculations according to the average value represented in the 2006 IPCC Guidelines Table 10.2 (page 10.14) for 1990-2009, because detailed information on feed digestibility are not available in the country for this period. DE 66% is used for 2010-2014 and 67% for 2015-2020 based on national studies. For non-dairy cattle DE 65% is used. Assumptions of DE are done based on national research results[130] described below.

Forage quality, level of concentrates in the diet and feed digestibility directly affect enteric methane production in the rumen, therefore the chemical content of typical forage used for cattle feeding was analysed from all regions of Latvia at the LULST Scientific Laboratory of Agronomic Analysis. Research activities were done according to the tasks of the pre-defined project "Development of the National System for Greenhouse Gas Inventory and Reporting on Policies, Measures and Projections" under 2009 – 2014 EEA Grants Programme National Climate Policy[131] and financial support for the project "Agricultural sector GHG emissions calculation methods and data analysis with the modelling tool development, integrating climate change".

The cattle feed samples were collected from January until December in 2015. The chemical analysis of animal feed was made according to generally accepted methods of feed analysis: dry matter (DM) %, crude protein (CP) %, insoluble protein, %, soluble protein, %, undegraded intake protein (UIP) %, crude fiber (CF) %, acid detergent fiber (ADF) %, neutral detergent fiber (NDF) %, ash %, Ca and P %, according ISO 5983, ISO 6490/2 and ISO 6491 standards. Digestibility was determined using the cellulase method. Special attention was given to ADF and NDF values, because they could be used also for calculation of feed digestibility. The ADF value refers to the cell wall portions of the forage that are made up of cellulose and lignin and relate to the ability of an animal to digest the forage. As ADF increases, the ability to digest the forage decreases. The NDF value is the total cell wall which is comprised of the ADF fraction plus hemicellulose. NDF values reflect the amount of forage the animal can consume.

The research results showed that NDF content and digestibility vary significantly for analysed forage samples. Depending on the growth stage of green biomass in the harvesting period, the content of NDF in hay was found within 51-71%, 24-48% in silage, 38-62% in haylage and 30-45 % in total mixed ration (TMR) of DM. The average determined digestibility of forage for natural meadow hay was 52.3±4.3% and 53.8±5.2% for cereal grass hay; for grass silage with preservative 65.2±6.1%, without preservative 62.8±4.9%; and for corn silage, respectively 71.1±0.6%, 68.2±3.1%; for haylage 62.6±4.1%, for TMR 71.7±5.7%. Detailed description of the research results is available in the scientific literature[132]. All forage quality analysis results are

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[130] Project "Development of the national system for greenhouse gas (GHG) inventory and reporting on policies, measures and projections". Available: http://www.varam.gov.lv/eng/fondi/EEA_Norv/european_economic_area_financial_mechanism_programme__national_climate_policy/?doc=18431

[131] Project "Development of the national system for greenhouse gas (GHG) inventory and reporting on policies, measures and projections". Available: http://www.varam.gov.lv/eng/fondi/EEA_Norv/european_economic_area_financial_mechanism_programme__national_climate_policy/?doc=18431

[132]Degola L. Trupa A., Aplocina E. (2016) Forage quality and digestibility for calculation of enteric methane emission from cattle /15th International scientific conference "Engineering for Rural Development" : proceedings, Jelgava, Latvia, May 25 - 27, 2016 Latvia University of Agriculture. Faculty of Engineering. - Jelgava, 2016. - Vol.15, p. 456-461. Available: http://tf.llu.lv/conference/proceedings2016/Papers/N084.pdf

summarized and included in the catalogue of forage digestibility and chemical analysis results[133].

The interviews with agricultural and academic experts in the field of animal feeding as additional study were conducted with the main aim to identify the country typical feed rations for dairy cows and other cattle. According to the survey results, the feed ration of dairy cows consists in average of 71% (58.1-84.4%) of grass forage and 29% (15.6-41.9%) of concentrates based on dry matter intake. Other cattle feed ration includes grass forage and concentrates in following proportions: for 1-2 years old cattle – 92% and 8%, for beef cattle over 2 years old – 91% and 9%, and other cattle over 2 years old – 83% and 17% of the dry matter intake, respectively. Based on detailed calculations of the cattle feed quality parameters and feeding rations in 2015, it was concluded to use in the inventory DE 67% for dairy cows for the same and latter years. Based on historical records of feed quality analysis and feeding rations, it was set to use DE 66% for the time period 2010-2014, taking in to account that since 2010 the number of farms with higher proportion of concentrates in the dairy cow diet showed tendency to increase. Overall analysis of other cattle feeding lead to conclusion that digestibility of feed for other cattle fluctuates around DE 65% in the case of typical conditions for Latvia.

5.2.2.2 Activity data

The calculation of GE for dairy cattle is strongly based on the milk production and fat content in milk. Trends about milk production and fat content in milk are presented in Table 5.9. Values of milk fat content for 1990-1997 are derived by extrapolation based on an assumption that fat content in milk was around 3.5% in 1990; all other information is adopted from CSB of Latvia.

Table 5.9 Average milk yield per cow and fat content, 1990-2020

Year	Average milk yield, kg year^{-1}	Fat content, %
1990	*3437*	*3.50*
1995	*3074*	*3.92*
2000	*3898*	*4.08*
2005	*4364*	*4.25*
2006	*4492*	*4.26*
2007	*4636*	*4.31*
2008	*4822*	*4.29*
2009	*4892*	*4.31*
2010	*4998*	*4.29*
2011	*5064*	*4.22*
2012	*5250*	*4.16*
2013	*5508*	*4.08*
2014	*5812*	*3.86*
2015	*5905*	*3.99*
2016	*6182*	*4.15*
2017	*6525*	*4.10*
2018	*6614*	*4.10*
2019	*6891*	*4.10*

[133] Degola L., Trūpa A., Aplociņa E. Lopbarības ķīmiskās analīzes un sagremojamība, 2016. 52. lpp. Available: http://www.vbf.llu.lv/sites/vbf/files/files/lapas/Lopbar%C4%ABbas%20%C4%B7%C4%ABmisk%C4%81s....pdf

Year	Average milk yield, kg year^{-1}	Fat content, %
2020	*7163*	*4.01*
2020 versus 2019	*+3.9%*	*-2.2%*
2020 versus 1990	*+90.8%*	*+0.25%*

In Latvian GHG inventory livestock category Cattle (CRF 3.A.1) is reported in three sub-categories: mature dairy cattle, other mature cattle and growing cattle. Calculations of methane emission from enteric fermentation for dairy cattle are not divided into smaller sub-groups. Estimation of methane emissions from non-dairy cattle is split in seven age and production type sub-groups according to the records in the database of CSB of Latvia. Growing cattle group is represented by young cattle under 1 year and young cattle aged from 1 to 2 years. These two growing cattle groups are segregated for dairy and beef cattle. Other mature cattle group include bulls, heifers and other cows aged over 2 years old. The numbers of non-dairy cattle by sub-categories are presented in Table 5.10. Activity data and calculations of emissions for non-dairy are divided in mentioned sub-categories of cattle because:

- the inventory is strongly linked to data base of CSB and therefore provide consistency with EUROSTAT and other official statistical data;
- it promotes easer reporting of cattle weights and feeding situation;
- it facilates proper estimation of MMS, that significantly differs by defined cattle types in the herd.

Table 5.10 The number of non-dairy cattle by sub-categories in Latvia, 1990-2020 (thsd heads)

Year	Growing cattle		Other mature cattle		
	Young cattle under 1 year	Young cattle aged from 1 to 2 years	Mature non-dairy cattle over 2 years		
	total	total	bulls	heifers	other cows
1990	*525.2*	*302.6*	*12.0*	*54.3*	*10.1*
1995	*134.8*	*82.0*	*3.2*	*14.7*	*2.8*
2000	*97.9*	*51.6*	*0.8*	*9.8*	*2.1*
2005	*118.9*	*59.6*	*1.6*	*11.9*	*8.0*
2006	*107.5*	*62.9*	*1.8*	*13.1*	*9.5*
2007	*114.9*	*72.5*	*1.2*	*14.6*	*15.2*
2008	*108.4*	*66.2*	*2.6*	*19.9*	*12.7*
2009	*107.4*	*66.8*	*3.0*	*19.9*	*15.5*
2010	*105.6*	*67.6*	*3.2*	*20.3*	*18.7*
2011	*103.9*	*66.7*	*3.1*	*20.9*	*22.0*
2012	*108.4*	*70.0*	*3.5*	*21.0*	*25.6*
2013	*109.3*	*75.3*	*4.3*	*23.4*	*29.2*
2014	*118.4*	*74.9*	*4.4*	*24.3*	*34.2*
2015	*113.6*	*76.2*	*4.4*	*23.6*	*38.9*
2016	*113.0*	*72.5*	*4.3*	*23.8*	*44.7*
2017	*108.2*	*69.7*	*3.9*	*25.0*	*48.6*
2018	*105.9*	*64.9*	*4.0*	*24.5*	*51.6*
2019	*108.2*	*64.7*	*4.1*	*23.6*	*56.4*
2020	*111.5*	*65.4*	*4.2*	*21.8*	*60.0*
2020 versus 2019	*+3.1%*	*+1.1%*	*+2.4%*	*-7.6%*	*+6.4%*
2020 versus 1990	*-78.8%*	*-78.4%*	*-65.0%*	*-59.9%*	*+494.1%*

Missing data or no available data for 1990-1995 are created by linear extrapolation. The total numbers of young cattle under 1 year and aged 1 to 2 years are provided by CSB. Data of young dairy and beef cattle are calculated by LULST experts based on CSB totals of mentioned young cattle groups. All numbers of other mature cattle over 2 years are original data obtained from CSB data base.

Results of gross energy intake (GE) calculation for dairy and non-dairy cattle from enteric fermentation are summarized in Table 5.11. Two breeds prevailing in the herds of dairy cows – Latvian Brown (Red breed group) and Black and White Holstein. Based on animal breeding programms data, the documented weight for Latvian Brown breed is 530-580 kg[134], for Black and White Holstein breed – 600-900[135] kg. For the period 1990-1999, mostly Latvian Brown breed were observed in the herds, later the number of Black and White Holstein breed showed tendency to increase, therefore the average weight for dairy cows is updated every 5 years, since 2000. The average weight for other cattle is calculated based on data from Agricultural Data Center[136], which operates the national recording scheme, provided information about most important meat cattle breed's standard weights[137]. For GE calculation weight is important parameter, that is only one parameter that changes in average for other mature non-dairy cattle to relation of livestock number in mentioned groups. It is possible to observe evidence that from 2004 to 2005 and the from 2007 to 2008 numbers of bulls, heifers and other cows changes significantly that gives also significant fluctuation to EF of whole group of other mature cattle. Livestock numbers are sensitive to economic situation in the country, as well as agricultural policy in Latvia.

Table 5.11 Average gross energy (GE) intake (MJ day^{-1}) and methane emission factors (EF) from enteric fermentation (kg CH_4 head^{-1} year^{-1}) and cattle weight (kg head^{-1} year^{-1}) 1990-2020

Year	Dairy cows			Growing cattle			Other mature cattle		
	Weight	GE	EF	Weight	GE	EF	Weight	GE	EF
1990	*550*	*241.6*	*103.0*	*272*	*80.4*	*29.8*	*581*	*152.9*	*65.2*
1995	*550*	*236.3*	*100.8*	*272*	*78.6*	*29.3*	*580*	*152.9*	*65.2*
2000	*555*	*264.2*	*112.6*	*262*	*76.0*	*28.1*	*542*	*147.6*	*62.9*
2005	*555*	*281.1*	*119.8*	*261*	*76.1*	*28.0*	*563*	*167.3*	*71.3*
2006	*560*	*286.2*	*122.0*	*268*	*76.4*	*28.5*	*564*	*168.8*	*72.0*
2007	*560*	*291.5*	*124.3*	*271*	*77.1*	*28.8*	*557*	*174.8*	*74.5*
2008	*560*	*296.9*	*126.6*	*269*	*76.5*	*28.5*	*561*	*165.2*	*70.4*
2009	*560*	*299.4*	*127.7*	*271*	*77.1*	*28.8*	*567*	*170.5*	*72.7*
2010	*560*	*295.8*	*126.1*	*272*	*77.5*	*29.0*	*570*	*173.8*	*74.1*
2011	*565*	*297.4*	*126.8*	*272*	*77.2*	*28.9*	*569*	*176.2*	*75.1*
2012	*565*	*301.7*	*128.6*	*274*	*77.9*	*29.2*	*572*	*179.4*	*76.5*
2013	*565*	*307.8*	*131.2*	*278*	*79.1*	*29.8*	*575*	*180.1*	*76.8*
2014	*565*	*311.8*	*132.9*	*274*	*78.7*	*29.4*	*575*	*182.4*	*77.8*
2015	*565*	*310.7*	*132.5*	*278*	*79.6*	*29.9*	*576*	*185.4*	*79.0*
2016	*570*	*323.3*	*137.8*	*276*	*79.5*	*29.7*	*576*	*187.8*	*80.1*
2017	*570*	*332.1*	*141.6*	*276*	*79.4*	*29.7*	*576*	*188.2*	*80.2*

[134]Ciltsdarba programma sarkano šķirņu govju selekcijā 2013.-2017. gadam un tuvākajai perspektīvai. Available: http://www.ldc.gov.lv/upload/doc/sarkano_skirnu_ciltsdarba_programma_2013_2017.pdf

[135] Holšteinas šķirnes govju audzēšanas programma. Available: http://www.holstein.lv/uploads/images/ProgrammaLHA.pdf

[136] Agricultural data centre. Available at https://www.ldc.gov.lv/en

[137] Gaļas šķirņu govju ciltsdarba programma 2013. – 2017. gadam. Available: http://www.ldc.gov.lv/upload/doc/citsdarba.programma._2013-2017.pdf

Year	Dairy cows			Growing cattle			Other mature cattle		
	Weight	GE	EF	Weight	GE	EF	Weight	GE	EF
2018	*570*	*334.7*	*142.7*	*273*	*79.0*	*29.5*	*574*	*189.7*	*80.9*
2019	*570*	*342.8*	*146.1*	*272*	*78.7*	*29.3*	*576*	*192.0*	*81.8*
2020	*570*	*348.0*	*148.3*	*271*	*78.5*	*29.2*	*578*	*194.4*	*82.9*

Results of gross energy intake and EFs calculation for non-dairy cattle from enteric fermentation are summarized in Table 5.12.

Table 5.12 Gross energy (GE) intake (MJ day^{-1}) and methane emission factors (EF) from enteric fermentation for non-dairy cattle sub-groups (kg CH_4 head-1 year^{-1}) in 2020

Non-dairy cattle sub-groups		GE	EF
Young cattle under 1 year	*dairy cattle calves*	*58.1*	*18.6*
	beef cattle calves	*74.8*	*23.9*
Young cattle aged from 1 to 2 years	*dairy cattle*	*95.9*	*40.9*
	beef cattle	*123.2*	*52.5*
Mature non-dairy cattle over 2 years	*bulls*	*215.3*	*91.8*
	heifers	*127.1*	*54.2*
	other cows	*217.4*	*92.7*
IPCC default			*57.0*

5.2.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

The uncertainty associated with livestock population varies widely depending on the source, but according to the 2006 IPCC Guidelines is set as 20%. According to received information from CSB of Latvia, the uncertainty of activity data provided by the institution must be set as 2%.

The 2006 IPCC Guidelines suggest that EFs estimated using the Tier 1 method are to be known more accurately than 30% and may be uncertain to 50%. Tier 2 method is likely to be in the order of 20% (2006 IPCC Guidelines: Volume 4, Chapter 10, page 10.33). According to the assumptions above, Tier 1 method EFs are set to be uncertain of 50%, but uncertainty of EFs estimated by the Tier 2 is set as 20%. Inter-annual changes of CH_4 EF values for cattle are primarily a result of changes in the activity data that occur in response to agricultural policy, the economic situation and market demands.

5.2.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the agriculture sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings. All information on activity data and emission calculations are stored and archived in the common FTP folder.

Activity data check. Livestock data were checked by an inventory compiler and CSB specialist. Livestock age sub-groups data that were collected by extrapolating methods are compared with statistical data of CSB to achieve correct total numbers. Data collection methods are documented in agriculture sector inventory compilers data base for GHG inventory purposes.

Review of emission factors. Country-specific EFs derived with Tier 2 method are cross-checked against the IPCC 2006 Guidelines defaults. Results of comparison of EFs for methane emission from enteric fermentation of dairy cows and non-dairy cattle are shown below (Table 5.13).

Table 5.13 Review of emission factors for enteric fermentation methane emissions

Category	Source	EF (kg CH_4 head^{-1}year^{-1})
Dairy cows	*Latvia, Tier 2, 2020*	*148.3*
	2006 IPCC Guidelines (Western Europe, Table 10.11, page 10.29)	*117.0*
Non-dairy cattle	*Latvia, Tier 2, 2020 (in average)*	*46.7*
	2006 IPCC Guidelines(Western Europe, Table 10.11, page 10.29)	*57.0*

Latvia uses higher EF for dairy cows based on a different feeding situation that is not totally characterized as stall fed (set for Tier 1). Also digestibility used for calculations of emission coefficient is lower (65%-67% against 70% for Tier 1). Detailed information on feeding situation is included in chapter 5.2.2.1. In average enteric fermentation methane EF for non-dairy cattle is slightly lower than the 2006 IPCC Guidelines default. Emissions from non-dairy cattle are calculated from three groups (Table 5.12). Growing cattle are included in two sub-groups of animals: (1) cattle under 1 year; and (2) cattle aged 1–2 years old. In 2020, 67.3% of the non-cattle population was included in these two sub-groups, and 63% of them was under 1 year old with a reported value of 0% for methane conversion rate (Ym) recommended for between 0 and 3 months old cattle. Another reason for the lower EF is that Latvia uses lower calf weights (180–200 kg), which are country specific.

5.2.5 Category-specific recalculations

No recalculations were done for this sector.

5.2.6 Category-specific planned improvements

Evaluation of excreted nitrogen values for swine, according to the latest study results of feeding situation data is planned for the 2023 submission. Preliminary analysis shows that according to implemented emission reduction measures excreted nitrogen values decreasing in the last years.

5.3 *MANURE MANAGEMENT (CRF 3.B)*

5.3.1 Category description

GHG emissions from manure management constituted 163.05 kt CO_2 eq. (7.2% from the total emissions originated from agriculture). Nitrous oxide emissions from manure management were 3.3% and methane emissions 3.9% of total emissions in the agriculture sector in 2020. Both emission sources cover management of manure from domestic livestock. Latvia reports CH_4 and N_2O emissions from cattle (including groups represented in the chapter 1.2), sheep, swine (including mature swine as breeding sows and boars, piglets under 50 kg of weight, young breeding sows and fattening pigs), horses, goats and poultry (including layers, broilers, turkeys, ducks, geese and other poultry), as well as rabbits, fur-bearing animals and deer (Table 5.14).

Table 5.14 Reported emissions under the subcategory manure management

CRF	Source	Emissions reported	Level
3.B 1	*Dairy cattle / Non-dairy cattle (other mature and growing cattle)*	*CH_4, N_2O*	*Tier 2, Tier 2*
3.B 2	*Sheep*	*CH_4, N_2O*	*Tier 1, Tier 2*
3.B 3	*Swine*	*CH_4, N_2O*	*Tier 2, Tier 2*
3.B 4	*Other – Buffalo*	*NO*	*NA*
3.B 4	*Other – Camels*	*NO*	*NA*
3.B 4	*Other – Deer*	*CH_4, N_2O*	*Tier 1, Tier 2*
3.B 4	*Other – Goats*	*CH_4, N_2O*	*Tier 1, Tier 2*
3.B 4	*Other – Horses*	*CH_4, N_2O*	*Tier 1, Tier 2*
3.B 4	*Other – Mules and asses*	*NO*	*NA*
3.B 4	*Other – Poultry*	*CH_4, N_2O*	*Tier 1, Tier 2*
3.B 4	*Other – Rabbits*	*N_2O*	*Tier 1, Tier 1*
3.B 4	*Other – Fur-bearing animals*	*N_2O*	*Tier 1, Tier 1*

Methane emissions from manure management have decreased by 53.2% over the time period of 1990-2020 (Table 5.15). In 2020, methane emissions from manure management of domestic livestock decreased by 0.22 kt or 5.9% compared to 2019 due to decrease of the livestock number and the decrease of slurry manure share.

Table 5.15 Methane emissions from manure management by livestock category 1990-2020 (kt)

Year	Dairy cattle	Non-dairy cattle	Sheep	Swine	Goats	Horses	Poultry	Rabbits	Fur-bearing animals	Deer	Total CH_4
1990	*3.42*	*1.02*	*0.03*	*2.62*	*0.001*	*0.05*	*0.26*	*0.0155*	*0.18*	*NO*	*7.59*
1995	*2.00*	*0.28*	*0.01*	*1.23*	*0.001*	*0.04*	*0.10*	*0.0122*	*0.15*	*NO*	*3.83*
2000	*1.82*	*0.19*	*0.01*	*0.93*	*0.001*	*0.03*	*0.08*	*0.0089*	*0.07*	*NO*	*3.14*
2005	*2.11*	*0.23*	*0.01*	*1.21*	*0.002*	*0.02*	*0.10*	*0.0078*	*0.10*	*NO*	*3.80*
2006	*2.18*	*0.24*	*0.01*	*1.22*	*0.002*	*0.02*	*0.11*	*0.0074*	*0.12*	*0.0007*	*3.92*
2007	*2.31*	*0.27*	*0.01*	*1.27*	*0.002*	*0.02*	*0.12*	*0.0077*	*0.12*	*0.0009*	*4.13*
2008	*2.34*	*0.26*	*0.01*	*1.20*	*0.002*	*0.02*	*0.11*	*0.0046*	*0.13*	*0.0012*	*4.09*
2009	*2.39*	*0.27*	*0.01*	*1.18*	*0.002*	*0.02*	*0.12*	*0.0035*	*0.11*	*0.0017*	*4.10*
2010	*2.20*	*0.28*	*0.01*	*1.15*	*0.002*	*0.02*	*0.12*	*0.0027*	*0.11*	*0.0017*	*3.90*
2011	*2.27*	*0.28*	*0.02*	*1.09*	*0.002*	*0.02*	*0.10*	*0.0031*	*0.12*	*0.0021*	*3.91*
2012	*2.18*	*0.30*	*0.02*	*0.91*	*0.002*	*0.02*	*0.10*	*0.0030*	*0.16*	*0.0021*	*3.68*
2013	*2.17*	*0.32*	*0.02*	*0.88*	*0.002*	*0.02*	*0.10*	*0.0031*	*0.16*	*0.0025*	*3.67*
2014	*2.37*	*0.34*	*0.02*	*0.83*	*0.002*	*0.02*	*0.08*	*0.0031*	*0.21*	*0.0029*	*3.86*
2015	*2.50*	*0.35*	*0.02*	*0.88*	*0.002*	*0.01*	*0.09*	*0.0032*	*0.19*	*0.0028*	*4.05*
2016	*2.54*	*0.35*	*0.02*	*0.87*	*0.002*	*0.01*	*0.09*	*0.0028*	*0.17*	*0.0029*	*4.06*
2017	*2.61*	*0.35*	*0.02*	*0.79*	*0.002*	*0.01*	*0.07*	*0.0023*	*0.20*	*0.0034*	*4.07*
2018	*2.29*	*0.35*	*0.02*	*0.74*	*0.0016*	*0.01*	*0.07*	*0.0021*	*0.10*	*0.0034*	*3.60*
2019	*2.48*	*0.36*	*0.02*	*0.73*	*0.0015*	*0.01*	*0.07*	*0.0021*	*0.09*	*0.0035*	*3.78*
2020	*2.29*	*0.37*	*0.02*	*0.67*	*0.0015*	*0.01*	*0.09*	*0.0019*	*0.09*	*0.0037*	*3.55*
Share of total % in 2020	*64.4%*	*10.5%*	*0.5%*	*18.9%*	*0.0%*	*0.4%*	*2.6%*	*0.1%*	*2.6%*	*0.1%*	*100.0%*

Year	Dairy cattle	Non-dairy cattle	Sheep	Swine	Goats	Horses	Poultry	Rabbits	Fur-bearing animals	Deer	Total CH_4
2020 versus 2019	-7.6%	+2.8%	-7.9%	-8.0%	-1.7%	0.0%	+22.7%	-7.3%	-1.6%	+6.3%	-5.9%
2020 versus 1990	-33.1%	-63.5%	-44.2%	-74.4%	+113.0%	-73.1%	-64.8%	-87.5%	-46.9%	NA	-53.2%

In 2020, direct nitrous oxide emissions reached 0.16 kt (-5.5% compared to 2019), however over the time period of 1990-2020 nitrous oxide emissions decreased by 74.7% due to decrease mainly of the livestock number. In 2020, indirect N_2O emissions from manure management decreased by 1.4% compared to 2019 and 72.0% compared to 1990. Total emissions of N_2O from manure management decreased by 4.1% over the year and by 73.8% since 1990. The fluctuation of emissions is related to the variation of animal numbers, as well as changes in the distribution of livestock MMS (Table 5.16).

Table 5.16 Nitrous oxide emissions from manure management by livestock category 1990-2020* (kt)

Year	Dairy cattle	Non-dairy cattle	Sheep	Swine	Goats	Horses	Poultry	Rabbits	Fur-bearing animals	Deer	Total direct, N_2O	Total indirect, N_2O
1990	0.32	0.09	0.016	0.135	0.001	0.009	0.035	0.012	0.009	NO	0.62	0.33
1995	0.17	0.03	0.007	0.056	0.001	0.008	0.015	0.010	0.008	NO	0.30	0.16
2000	0.14	0.02	0.003	0.035	0.001	0.006	0.012	0.007	0.004	NO	0.23	0.12
2005	0.14	0.02	0.004	0.036	0.002	0.004	0.015	0.006	0.005	NO	0.23	0.12
2006	0.14	0.02	0.004	0.035	0.002	0.004	0.016	0.006	0.007	0.000	0.23	0.12
2007	0.14	0.03	0.005	0.036	0.001	0.004	0.017	0.006	0.006	0.000	0.24	0.12
2008	0.13	0.02	0.006	0.033	0.001	0.004	0.016	0.004	0.007	0.000	0.23	0.11
2009	0.13	0.02	0.007	0.032	0.001	0.004	0.017	0.003	0.006	0.000	0.22	0.11
2010	0.12	0.02	0.007	0.030	0.001	0.004	0.017	0.002	0.006	0.000	0.21	0.11
2011	0.12	0.02	0.008	0.028	0.001	0.004	0.015	0.003	0.007	0.000	0.21	0.10
2012	0.11	0.02	0.008	0.022	0.001	0.003	0.015	0.002	0.008	0.000	0.20	0.10
2013	0.11	0.02	0.008	0.021	0.001	0.003	0.014	0.002	0.008	0.000	0.19	0.10
2014	0.12	0.03	0.009	0.019	0.001	0.003	0.011	0.002	0.011	0.000	0.20	0.10
2015	0.11	0.03	0.009	0.020	0.001	0.003	0.013	0.003	0.010	0.000	0.20	0.10
2016	0.11	0.03	0.009	0.019	0.001	0.003	0.013	0.002	0.009	0.000	0.19	0.10
2017	0.11	0.03	0.010	0.017	0.001	0.002	0.010	0.002	0.011	0.000	0.19	0.10
2018	0.10	0.02	0.009	0.015	0.001	0.002	0.009	0.002	0.006	0.000	0.17	0.09
2019	0.10	0.03	0.008	0.015	0.001	0.002	0.010	0.002	0.005	0.000	0.17	0.09
2020	0.09	0.02	0.007	0.013	0.001	0.002	0.013	0.002	0.005	0.000	0.16	0.09
Share of total % in 2020	57.6%	15.7%	4.3%	8.3%	0.8%	1.2%	8.0%	1.0%	3.2%	0.0%	100%	
2020 vs 2019	-8.5%	-1.2%	-13.1%	-11.0%	-1.6%	-7.4%	+24.4 %	-7.3%	-1.6%	NA	-5.5%	-1.4%
2020 vs 1990	-71.5%	-71.1%	-56.4%	-90.3%	+115.1%	-80.4%	-64.3%	-87.5%	-46.9%	NA	-74.7%	-72.0%

*****emissions from pasture not included, they are reported under 3.D Managed soils*

When organic matter in livestock manure decomposes in anaerobic environment, methanogenic bacteria produce methane. The amount of methane produced from manure depends on livestock type and diet, special feeding and digestibility of food, as well as animal waste management system. The nitrous oxide estimated in this section is the nitrous oxide produced during the storage and treatment of manure before it is applied to land. Production of nitrous oxide during storage and treatment of animal waste occurs via combined nitrification-denitrification of nitrogen in animal waste.

5.3.2 Methodological issues

5.3.2.1 Methods

Emissions from manure management of domestic livestock in Latvia have been calculated by using methodologies presented in the 2006 IPCC Guidelines (Volume 4, Chapter 10.4 and 10.5). The 2006 IPCC Guidelines include two Tiers to estimate emissions from livestock manure. The Tier 1 approach requires livestock population data by animal species/category and climate region in order to estimate emissions. Tier 2 approach requires detailed information on animal characteristics and the manner in which manure is managed; it is encouraged to be used if a particular livestock species/category represents a significant share of emissions. The process of developing Tier 2 EFs involves determining the mass of volatile solids excreted by the animals (VS, in kg) along with the maximum methane producing capacity for the manure (Bo, in m^3 kg of VS). In addition, a methane conversion factor (MCF) that accounts for the influence of climate on methane production must be obtained for each manure management system. Latvia uses Tier 2 for estimation methane emissions from cattle and swine and Tier 2 for estimation nitrous oxide emissions for all categories, except rabbits and fur-bearing animals.

Methane emissions from manure management for sheep, goats, horses, poultry (divided as layers/broilers, turkeys, ducks, geese and others), rabbits, fur-bearing animals and deer were calculated by using Tier 1 methodology by multiplying the number of the animals with the default EF for each animal category according to the 2006 IPCC Guidelines (Equation 10.22, page 10.37):

$$\boldsymbol{CH_4 manure} = \sum_{(\boldsymbol{T})} \frac{\boldsymbol{EF_{(T)} * N_{(T)}}}{\boldsymbol{10^6}} \quad (5.5)$$

where:

$CH_{4Manure}$ - 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

EFs for Tier 1 methodology calculations were chosen as for *cool* climate region and are represented in Table 5.17. The original source of default EFs is the 2006 IPCC Guidelines (Tables 10.15 and 10.16, page 10.40-10.41).

Table 5.17 Methane emission factors from manure management

Animal category	Emission factor (kg head^{-1} year^{-1})
Sheep	*0.19*
Goats	*0.13*
Horses	*1.56*
Layers	*0.03*
Broilers and others	*0.02*
Turkeys	*0.09*
Ducks	*0.02*
Geese	*0.02*
Rabbits	*0.08*
Fur-bearing animals	*0.68*
Deer	*0.22*

According to the 2006 IPCC Guidelines (table 10A-9) Manure Management System MCFs for sheep, goats, horses, rabbits and ducks could be set as 1%; for layers, broilers and turkeys as 1.5%; for fur-bearing animals as 8%.

For dairy cattle, non-dairy cattle and swine Tier 2 approach was used for estimating methane emissions from manure management systems as dairy cattle and swine represent a significant share of total emissions from agriculture sector. This method requires detailed information on animal characteristics and the manner in which manure is managed. Methane EFs for cattle and swine were derived from the 2006 IPCC Guidelines (Equation 10.23, page 10.41):

$$\boldsymbol{EF_T = (VS_T * 365) * \left[B_{O(T)} * 0.67\,\frac{kg}{m^3} * \sum_{S,k} \frac{MCF_{S,k}}{100} * MS_{T,S,k}\right]} \quad (5.6)$$

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}
$Bo_{(T)}$ - maximum methane producing capacity for manure produced by livestock category T, m^3 CH_4 kg^{-1}of VS excreted
$MCF_{(S,k)}$ - methane conversion factors for each manure management system by climate region k, % (as represented in table 10.17, page 10.44, 2006 IPCC)
$MS_{(T,S,k)}$ - fraction of livestock category manure handled using manure management system in climate region k, dimensionless
0.67 - conversion factor of m^3 CH_4 to kilograms CH_4
365 - basis for calculating annual VS production, days yr^{-1}

The manure management systems (MMS) reported in the inventory are:

- liquid system;
- solid storage;
- pasture/range/paddock;
- anaerobic digester.

The manure management systems used in practice have been changed in Latvia over the time. In the last decade of the 20th century, milk cows were mainly stanchioned, producing farmyard manure, whereas now there is a gradual transition to producing the liquid manure.

Distribution of MMS is based on Cabinet Regulation No. 829 Special Requirements for the Performance of Polluting Activities in Animal Housing (adopted 23 December 2014)[138]. In the regulation does not provide for separate accounting of solid manure and deep litter manure in Latvia. Latvia, calves and young cattle could be kept on deep litter. Pregnant young cattle are kept tied (in small barns) or in boxes (large barns) shortly before birth. In the large barns, the birth takes place in separate pens and may be used a deep litter system, but as this system is not officially declared in normative acts, there are no statistics on deep liter use.

IPCC 2006 Guidelines, Vol 4, Table 10.18, Page 10.49 states that cattle deep bedding means, that bedding is continually added to absorb moisture over a production cycle and possibly for as long as 6 to 12 months, however such rare frequency of deep bedding removing was typical for Latvia only before 1990. One of the most comprehensive research on manure management was done in 2016 when several national experts evaluated manure management systems in Latvia – and deep bedding was not considered in this research[139]. Alternative research[140] also confirms typical manure management systems approved for Latvia.

Since 2007 the production of biogas by partially using the manure of livestock is observed in Latvia. Detailed description of methodology of calculation of manure management systems distributions is available at scientific publication *Calculation Methodology for Cattle Manure Management Systems Based on the 2006 IPCC Guidelines* by J.Priekulis and A. Aboltins[141].

Calculation of manure management systems distribution is revived every year due to quality control procedure by scientists of Latvia University of Life Sciences. The following input data were used to calculate manure management systems distribution:

- Cabinet Regulation No. 834[142] determines the amount of manure excretion, t/year, depending on the livestock species, age, type of keeping, productivity of dairy cows;

- Cabinet Regulation No. 834[142] determines dry matter content of the manure;

- Annual reports of the Ministry of Agriculture and the Central Statistical Bureau on the percentage distribution of various livestock at the national level by their herd size;

- Annual information of the Latvian Biogas Association and the Rural Support Service on the number of biogas plants established in Latvia and the type and quantity of raw materials used in each plant, t/year;

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[138] *Cabinet Regulation No. 829. Available: https://likumi.lv/ta/en/en/id/271374-special-requirements-for-the-performance-of-polluting-activities-in-animal-housing*

[139] *Pētījuma „Lauksaimniecības sektora SEG emisiju aprēķina metodoloģijas un datu analīzes ar modelēšanas rīku izstrāde, integrējot klimata pārmaiņas" līguma Nr.2014/94 5.posma pārskats un gala pārskats. Available: http://petijumi.mk.gov.lv/sites/default/files/title_file/petijums_VARAM_2017_Lauksaimn_SEG_emisij_aprek_metodolog_un_datu_analiz_ar_model_riku_izstrad_integrej_klim_mainas.pdf*

[140] *Myrbeck A., Kaasik A., Luostarinen S. Manure data collection - experiences from pilot farms. Available: https://projects.luke.fi/manurestandards/wp-content/uploads/sites/25/2020/04/Manure-data-collection-experiences-from-pilot-farms.pdf)*

[141] *J. Priekulis, A. Āboltiņš Calculation methodology for cattle manure management systems based on the 2006 IPCC guidelines. NJF 25th Congress, 2015. Available: http://www.vbf.llu.lv/sites/vbf/files/files/lapas/Calculation....pdf*

[142] *Republic of Latvia, Cabinet Regulation No. 834. 2014. Regulation Regarding Protection of Water and Soil from Pollution with Nitrates Caused by Agricultural Activity. Available: http://extwprlegs1.fao.org/docs/pdf/lat172823.pdf*

- Research results of LULST on the size of dairy herds, pigs and laying hens, at which the transition from solid manure to liquid manure system takes place[143];

- Lengths of the grazing period of livestock, h/year, determined in the research of LULST[143].

For calculation of MMS for calves and young cattle of dairy cows, it is considered that part of the manure remains in the pasture. In addition, it is assumed that only calves and young cattle kept in small enclosures grazing and there also dairy cows graze. Other parametrs consider for dairy cows are:

- yield of solid manure - 15 t / animal per year;
- yield of liquid manure - 19 t / animal / year;
- dry matter content of solid manure - 20%;
- dry matter content of fresh manure - 12%;
- pasture utilization rate - 0.188.

Solid manure is obtained from beef cattle and part of the manure remains in the pasture. In addition, the share of manure obtained in pastures is calculated according to the pasture utilization coefficient determined by research of LULST.

Solid manure and slurry are obtained from pig farming. The share of liquid manure is calculated using statistical data on the distribution of pig herds in the country according to the size of their herd and according to the results of LULST research, at which herd size the transition from solid manure to liquid manure production takes place.

Laying hens are kept in cage batteries. This part of the poultry is calculated according to the percentage distribution of the laying hen herd at the national level, as well as the data of the LULST study on the size of the laying hen herds at which the transition from free-range laying to caging batteries takes place. The amount of manure remaining in the pasture is calculated according to the number of free-range birds and the pasture utilization rate.

From sheep, goats and horses, part of the manure remains in the stables, part in the pastures. The part remaining outside the holding shall be determined by means of the grazing coefficient. The distribution of manure for geese, ducks and turkeys is calculated similarly.

In order to determine the proportion of manure used for biogas production, statistics on the amount and type of manure processed in biogas plants have been considered. Usually manure from fattening (meat) cattle could not be used for biogas because they contain increased soil admixture. It is also not possible to use manure from small holdings, as this leads to significant transportation costs.

According to the 2006 IPCC Guidelines, default methane conversion factor or MCF values for manure management systems: solid storage – 2%, liquid storage (with crust) – 10%, pasture/range/paddock – 1% (Table 10.17, page 10.44)*;* as well as methane producing

[143] *Pētījuma „Lauksaimniecības sektora SEG emisiju aprēķina metodoloģijas un datu analīzes ar modelēšanas rīku izstrāde, integrējot klimata pārmaiņas" Līguma Nr.2014/94. Pētījuma 5.posma pārskats un gala pārskats. Available: https://cupdf.com/document/petijuma-5posma-parskats-un-gala-pa-1-slaucamo-govju-skaits-centralas.html*

capacities B_0 0.24 for dairy cows, 0.17 for other cattle and 0.45 for swine (Table 10A-4, 10A-5, 10A-7, page 10.77-10.80) are used for Latvia's National GHG Inventory purposes.

In response to question raised by Technical expert review team during European Union ESD voluntary review in 2015, MCF value 2% for methane emissions from anaerobic digesters was implemented according to recommendation from the country biogas production experts. For anaerobic digester the 2006 IPCC Guidelines recommends MCF in the range from 0 to 100%. Based on available information and expert judgement from Latvian Biogas Association, it is assumed that anaerobic digestation completely is referred to energy production and consequently storage of manure before transfer to the digester is not typical for Latvia.

Almost all biogas plants are built on large dairy or pig farms. Therefore, they rarely use manure from other farms. Biogas plants receiving manure from the farm where it is located. It is also very expensive to transport manure to biogas plants from other farms. Manure from large farm is pumped to the biogas plants every day. Manure storage facilities for long periods storage are therefore not typical for Latvia. Methane leakage emissions are included and reported in the category 3.B.1.4. MCF value and leakage around 2% are derived form Swedish and national studies[144;145].

In 2020, significant part of laying hens manure was used for biogas production. According to information provided above, methane emissions form laying hens estimated by Tier 1 are corrected by fallowing assumption:

$$\boldsymbol{CH_{4\,layer\,manure} = N_{(L)} * EF_{(L)} * \left(1 - MMS(anaerobic\ digester)\right) + N_{(L)} * EF_{(L)} * MMS(anaerobic\ digester) * 2\%} \quad (5.7)$$

where:

CH_4 layer manure - CH_4 emissions from manure management, for laying hens, kt CH_4 yr^{-1}
$N_{(L)}$ - the number of laying hens
$EF_{(L)}$ - emission factor for the laying hens population, kg CH_4 $head^{-1}$ yr^{-1}, Table 5.17
MMS (anaerobic digester) - share of manure digested

Daily volatile solid excretion rate (per day on a dry-matter weight basis) was estimated as represented in the 2006 IPCC Guidelines (equation 20.24, page 10.42):

$$\boldsymbol{VS = \left[GE * \left(1 - \frac{DE\%}{100}\right) + (UE * GE)\right] * \left[\left(\frac{1-ASH}{18.45}\right)\right]} \quad (5.8)$$

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 (67% for dairy cows, 65% for other cattle, 80% for breeding swine and fattening pigs, 85% for piglets under 50 kg)
(UE • GE) - urinary energy expressed as fraction of GE (0.04•GE are considered as urinary energy)
ASH - the ash content of manure calculated as a fraction of the dry matter feed intake (0.08 for cattle and 0.02 for swine)

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[144] *Swedish research. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/786756/Methodology_to_Assess_Methane_Leakage_from_AD_Plants_final_report_part1.pdf) and Greenhouse Gas Balances of Bioenergy Systems. Patricia Thornley, Paul Adams. Academic Press (2017) p. 286.*

[145] *National research project: Vilis Dubrovskis (2016) ATSKAITE: Latvijas lauksaimniecības SEG inventarizācijas starptautiskajā pārbaudē pieprasītā precizētā informācija par kūtsmēslu izmantošanu biogāzes ražošanai / Trial review of the 2015 greenhouse gas inventory of Latvia under the Effort Sharing Decision, 2015. Dr.sc. ing. Vilis Dubrovskis, 2016-05-17*

18.45 - conversion factor for dietary GE per kg of dry matter (MJ kg^{-1})

Results of calculation of the country specific methane emissions factors from manure management are included in Table 5.18.

Table 5.18 Daily volatile solid (VS) values and methane emission factors (EF) of manure management for cattle, 1990-2020

Year	Dairy cows		Growing cattle		Other mature cattle	
	VS (kg day^{-1})	EF (kg CH_4 $head^{-1}$ $year^{-1}$)	VS (kg day^{-1})	EF (kg CH_4 $head^{-1}$ $year^{-1}$)	VS (kg day^{-1})	EF (kg CH_4 $head^{-1}$ $year^{-1}$)
1990	*4.70*	*6.39*	*1.56*	*1.09*	*2.97*	*1.59*
1995	*4.60*	*6.84*	*1.53*	*1.12*	*2.97*	*1.59*
2000	*5.14*	*8.90*	*1.48*	*1.11*	*2.87*	*1.53*
2005	*5.47*	*11.42*	*1.48*	*1.10*	*3.25*	*1.74*
2006	*5.57*	*11.95*	*1.49*	*1.14*	*3.28*	*1.75*
2007	*5.67*	*12.82*	*1.50*	*1.15*	*3.40*	*1.82*
2008	*5.77*	*13.72*	*1.49*	*1.15*	*3.21*	*1.72*
2009	*5.82*	*14.44*	*1.50*	*1.15*	*3.31*	*1.77*
2010	*5.61*	*13.44*	*1.51*	*1.15*	*3.38*	*1.80*
2011	*5.63*	*13.86*	*1.50*	*1.15*	*3.43*	*1.83*
2012	*5.72*	*13.21*	*1.52*	*1.15*	*3.49*	*1.86*
2013	*5.83*	*13.16*	*1.54*	*1.15*	*3.50*	*1.87*
2014	*5.91*	*14.29*	*1.53*	*1.13*	*3.55*	*1.89*
2015	*5.73*	*15.42*	*1.55*	*1.14*	*3.61*	*1.93*
2016	*5.96*	*16.42*	*1.55*	*1.13*	*3.65*	*1.95*
2017	*6.13*	*17.28*	*1.54*	*1.13*	*3.66*	*1.95*
2018	*6.18*	*15.87*	*1.54*	*1.13*	*3.69*	*1.97*
2019	*6.32*	*17.89*	*1.53*	*1.12*	*3.73*	*1.99*
2020	*6.42*	*16.82*	*1.53*	*1.12*	*3.78*	*2.02*

Country specific methane emissions factors for non-dairy cattle groups are lower than IPCC default EF, because the amount of manure stored in liquid/ slurry based systems for non-dairy cattle in Latvia is assumed to be zero, that is lower than IPCC default share (Table 5.18, Table 5.19).

Table 5.19 Daily volatile solid (VS) values and methane emission factors (EF) of manure management for non-dairy cattle sub-groups, 2020

Non-dairy cattle sub-groups		VS (kg day^{-1})	EF (kg CH_4 $head^{-1}$ $year^{-1}$)
Young cattle under 1 year	dairy cattle calves	*1.13*	*0.96*
	beef cattle calves	*1.46*	*0.78*
Young cattle aged from 1 to 2 years	dairy cattle	*1.86*	*1.59*
	beef cattle	*2.40*	*1.28*
Mature non-dairy cattle over 2 years	bulls	*4.19*	*2.24*
	heifers	*2.47*	*1.32*
	other cows	*4.23*	*2.26*
IPCC default (Table 10.14, page 10.38)			*6*

As Tier 2 methodology to estimate methane emissions from manure management requires information of gross energy intake by swine, but enteric fermentation emission for swine was derived by Tier 1 methodology. Gross energy intake calculation for swine is based on swine live weight and digestible energy:

$$GE = \frac{ME}{DE\%} \quad (5.9)$$

where:

GE - gross energy intake, MJ day^{-1}
DE% - digestible energy as percentage of gross energy, %
ME - 2.0 x W = energy intake for maintenance and growth MJ day^{-1}
W - live weight of swine, kg

Feed digestibility data for swine are taken from the 2006 IPCC Guidelines: 80% for breeding sows, boars, young breeding sows and fattening pigs (suggested range 70-80% for confinement mature swine) and 85% for piglets (suggested range 80-90% (Table 10.2, page 10.14) for confinement growing swine). Several publications were revised including national and nearest neighbor countries level to calculate emissions from swine as close as possible to national values. It could be concluded that digestibility for mature and growing swine ranges around 80%, and up to 80% for young swine. Additionally, consultations about swine digestibility were took place with Latvian Pig Breeding Association experts. Experts confirmed that swine feeding strategies in Latvia show digestibility up to 80% in Latvia. Therefore it was concluded to use upper limit of DE% for sows and fattening pigs represented by IPCC (70-80%), because middle point can't show appropriate situation with digestibility in the country. However, values of DE, % for piglets could be characterized within the IPCC suggested range midpoint (80-90%).

Results of the calculation of methane emission from manure management for swine are presented in Table 5.20.

Table 5.20 Estimation parameters and emission factors (EF) of methane emission from manure management for swine 1990-2020

Year	Weight (head^{-1} year^{-1})	GE (MJ day^{-1})	VS (kg day^{-1})	EF (kg CH_4 head^{-1} year^{-1})
1990	*75.11*	*35.46*	*0.40*	*1.87*
1995	*80.70*	*36.94*	*0.41*	*2.23*
2000	*69.23*	*33.51*	*0.37*	*2.38*
2005	*65.12*	*31.93*	*0.35*	*2.83*
2006	*65.93*	*32.17*	*0.35*	*2.94*
2007	*66.97*	*32.57*	*0.36*	*3.07*
2008	*66.35*	*32.41*	*0.35*	*3.13*
2009	*64.98*	*31.85*	*0.35*	*3.13*
2010	*65.44*	*31.98*	*0.35*	*2.95*
2011	*64.51*	*31.64*	*0.34*	*2.91*
2012	*62.85*	*31.23*	*0.34*	*2.56*
2013	*62.48*	*31.06*	*0.34*	*2.40*
2014	*64.33*	*31.84*	*0.35*	*2.36*
2015	*64.85*	*32.16*	*0.35*	*2.63*
2016	*63.95*	*31.66*	*0.34*	*2.58*
2017	*64.00*	*31.69*	*0.35*	*2.47*
2018	*62.78*	*31.31*	*0.34*	*2.44*
2019	*64.74*	*32.09*	*0.35*	*2.32*
2020	*64.18*	*31.84*	*0.35*	*2.19*

Table 5.21 shows the main methane emissions calculation results for all swine sub-groups and default manure management methane emission coefficients recommended by the 2006 IPCC Guidelines for Western Europe. Swine weight data are based on the judgement of LULST and

Latvian Pig Breeding Association experts. Swine weight decreasing due to the increase of the number of piglets. Estimated emission coefficients are lower than the 2006 IPCC Guidelines default mainly explained by different distribution of manure management systems.

Table 5.21 Typical animal weight, average gross energy (GE) intake, volatile solid (VS) values and emission factors (EF) for estimation of methane emission from manure management for swine sub-groups, 2020

Swine sub-groups	Number, (thousand heads)	Weight, ($head^{-1}$ $year^{-1}$)	GE, (MJ day^{-1})	VS, (kg day^{-1})	EF, (kg CH_4 $head^{-1}$ $year^{-1}$)
Piglets under 50 kg of weight (under 4 months)	*147.8*	*27.5*	*19.0*	*0.17*	*1.08*
Young breeding sows and fattening pigs	*135.4*	*75.0*	*38.0*	*0.44*	*2.79*
Mature breeding sows and boars	*23.7*	*231*	*77.1*	*0.90*	*5.67*
IPCC default (Table 10.14, page 10.38 (Western Europe)					*6-9*

The 2006 IPCC Guidelines methodology was used for estimating nitrous oxide emission from manure management by multiplying the total amount of N excretion (from all animal species/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 systems. Direct nitrous oxide emissions (kg N_2O yr^{-1}) from manure management have been calculated by using the 2006 IPCC Guidelines (Equation 20.25, page 10.54):

$$\boldsymbol{N_2O_{D(mm)}} = \left[\sum_{S}\left[\sum_{T}(\boldsymbol{N_{(T)}} * \boldsymbol{Nex_{(T)*MS_{(T,S)}}})\right] * \boldsymbol{EF_{3(S)}}\right] * \frac{\boldsymbol{44}}{\boldsymbol{28}} \qquad (5.10)$$

where:

$N_2O_{D(mm)}$ - direct N_2O emissions from Manure Management in the country, 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 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^{-1} N in manure management system
S - manure management system
T - species/category of livestock

The annually excreted amount of nitrogen is categorized by manure management system and multiplied with the 2006 IPCC Guidelines default EF for each manure management system.

Following EFs for direct nitrous oxide emissions from manure management were implemented: EF_3 = 0.005 for liquid manure/slurry with natural crust cover; EF_3 = 0.005 for solid storage; EF_3 = 0 for pasture/range/paddock; EF_3 = 0 for digester (2006 IPCC Guidelines: Table 10.21, page 10.62). Data about the distribution of MMS (as fraction of livestock category manure handled using manure management system) according to the national studies are available in the Annex A.3.6 Agriculture. Nitrous oxide emissions from pasture are calculated under manure management, but are reported under category *Urine and dung deposited by grazing animals* in the CRF 3.D.

5.3.2.2 Activity data

Data of N excretion during the year per each livestock category used for the inventory are country specific and are obtained from national studies[146] and research projects outcomes[147] or calculated fallowing by the 2006 IPCC Guidelines. The 2006 IPCC Guidelines default annual average nitrogen excretion rate was used for rabbits (Table 10.19, page 10.59). EMEP/EEA recommended N excretion value is used for turkeys and fur-bearing animals (Table 3.9, page 29) [148]. N excretion rate for deer is adopted from Norwegian inventory[149]. All N excretion values used in the inventory are represented in Table 5.22.

Table 5.22 Average N excretions per head of animal (N, kg year^{-1})

Livestock category	1990-2020	Source
Sheep	*15.30*	*National studies*
Goats	*15.80*	*National studies*
Horses	*44.00*	*National studies*
Layers	*0.55*	*National studies*
Broilers and others	*0.35*	*National studies*
Turkeys	*1.64*	*EMEP/EEA 2019*
Ducks	*0.58*	*National studies*
Geese	*1.12*	*National studies*
Rabbit	*8.10*	*2006 IPCC default*
Fur – bearing animals	*4.60*	*EMEP/EEA 2019*
Deer	*12.00*	*Norwegian NIR*

Values about annual N excretion (Nex) per animal for dairy cattle and non-dairy cattle were calculated according to the 2006 IPCC Gudelines Tier 2 methodology (Equation 10.31, page 10.58) :

$$\boldsymbol{Nex_{(T)}} = \boldsymbol{N_{intake}} * (\mathbf{1} - \boldsymbol{N_{rentention}}) \tag{5.11}$$

where:

$Nex_{(T)}$ - annual N excretion rates, kg N animal^{-1} yr^{-1}
$N_{intake\ (T)}$ - the annual N intake per head of animal of species/category T, kg N animal^{-1} yr^{-1}
$N_{retention\ (T)}$ - fraction of annual N intake that is retained by animal of species/category T, dimensionless

The daily N intake per head of each cattle category is calculated as (Equation 10.32, page 10.58):

$$\boldsymbol{N_{intake\ (T)}} = \frac{\boldsymbol{GE}}{\mathbf{18.45}} * \left(\frac{\frac{\boldsymbol{CP\%}}{\mathbf{100}}}{\mathbf{6.25}}\right) \tag{5.12}$$

where:

$N_{intake\ (T)}$ - daily N consumed per animal of category T, kg N animal^{-1} day^{-1}
GE - gross energy intake of the animal, MJ animal^{-1} day^{1}

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[146] *Fertiliser Recommendations for Agricultural Crops (2013) Ed.A. Karklins and A.Ruza. Jelgava: LLU, 55 p.*
[147] *Priekulis J. Pētījuma "Lauksaimniecības sektora SEG emisiju aprēķina metodoloģijas un datu analīzes un modelēšanas rīku izstrāde, integrējot klimata pārmaiņas, Līguma Nr.2014/94. Pētījuma 4.ceturkšņa progresa ziņojums. Jelgava, 2016*
[148] *EMEP/EEA Air pollutant emission inventory guidebook (2019) 3.B Manure management. European Environment Agency. Table 3.9, page 31. Available:https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/4-agriculture/3-b-manure-management/view*
[149] *Greenhouse Gas Emissions 1990-2018, National Inventory Report. The Norwegian Environment Agency, 2020, p.311, Table 5.14. Available: https://unfccc.int/documents/215704*

18.45 - conversion factor for dietary GE per kg of dry matter, MJ kg^{-1}
CP% - percent crude protein in diet, input
6.25 - conversion from kg of dietary protein to kg of dietary N, kg feed protein (kg N^{-1})

The daily N retention per animal head of species/category is estimated as (Equation 10.33, page 10.60):

$$\boldsymbol{N_{retention\,(T)}} = \left[\frac{\boldsymbol{Milk} * \frac{(\boldsymbol{MilkPR\%})}{\boldsymbol{100}}}{\boldsymbol{6.38}}\right] + \left[\frac{\boldsymbol{WG} * \left[\boldsymbol{268} - \left(\frac{\boldsymbol{7.03NE_g}}{\boldsymbol{WG}}\right)\right]}{\frac{\boldsymbol{1000}}{\boldsymbol{6.25}}}\right] \tag{5.13}$$

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} (dairy cows only)
*Milk PR% - percent of protein in milk, calculated as [1.9 + 0.4 * %Fat]*
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
Neg - net energy for growth, MJ day^{-1}
6.25 - conversion from kg dietary protein to kg dietary N, kg Protein (kg N)$^{-1}$

Crude protein (CP) values are adopted from national studies regarding to feeding requirements for cattle[150] based on milk yield and milk fat content data, CP=14% (1990-1995) and CP=15% is set for dairy cows. For other cattle CP values ranging from 9% to 14%.

Annual N excretion rate for swine is derived from the 2006 IPCC Guidelines (Equation 10.30, page 10.57) by using typical animal mass (TAM) data:

$$\boldsymbol{Nex_{(T)}} = \boldsymbol{N_{rate}} * \frac{\boldsymbol{TAM}}{\boldsymbol{1000}} * \boldsymbol{365} \tag{5.14}$$

where:

$N_{ex(T)}$ - annual N excretion rates, kg N animal^{-1} yr^{-1}
$N_{rate\,(T)}$ - default N excretion rate, kg N (1000 kg mass)$^{-1}$ day^{-1}(Market swine=0.52, Breeding swine=0.42 according to 2006 IPCC Guidelines. Volume 4, Chapter 10, Table 10.19, page 10.59)
TAM - typical anima mass, kg livestock^{-1}

Calculated values of N excretion per animal for dairy cattle, non-dairy cattle and swine for reporting in CRF are represented in Table 5.23.

Table 5.23 N excretion rates for dairy, non-dairy cattle and swine, 1990-2020 (kg N animal^{-1} yr^{-1})

Year	Dairy cattle	Growing cattle	Other mature cattle	Swine
1990	*85.8*	*20.1*	*58.6*	*12.3*
1995	*84.7*	*20.0*	*58.5*	*12.8*
2000	*99.6*	*19.5*	*55.0*	*11.5*
2005	*104.0*	*19.4*	*58.9*	*10.7*
2006	*105.5*	*19.5*	*59.1*	*10.8*
2007	*106.9*	*19.8*	*59.2*	*11.0*
2008	*108.3*	*19.7*	*58.4*	*11.0*
2009	*108.9*	*19.7*	*59.6*	*10.7*
2010	*106.6*	*19.8*	*60.1*	*10.7*
2011	*107.1*	*19.7*	*60.3*	*10.6*
2012	*108.2*	*19.8*	*61.0*	*10.5*

[150] *Latvietis J. (1994) Govju ēdināšanas normas. Jelgava: LLU, p.102*

Year	Dairy cattle	Growing cattle	Other mature cattle	Swine
2013	*109.6*	*20.0*	*61.3*	*10.4*
2014	*110.5*	*19.9*	*61.5*	*10.7*
2015	*108.8*	*20.0*	*61.9*	*10.9*
2016	*112.2*	*20.0*	*62.2*	*10.7*
2017	*114.4*	*20.0*	*62.0*	*10.7*
2018	*115.0*	*19.9*	*62.3*	*10.5*
2019	*117.0*	*19.8*	*62.7*	*10.9*
2020	*118.2*	*19.8*	*63.1*	*10.8*

Calculations of N excretion for cattle have been based on the 2006 IPCC Guidelines. Detailed information of estimated N excretion for cattle and swine sub-groups by IPCC methodology is represented in Table 5.24. During 2014-2017 Latvia made efforts to update country-specific N excretion values based on national research data, therefore in the 2020 inventory Latvia used country-specific data for nitrogen excretion from sheep, swine, horses, goats and poultry.

Table 5.24 N excretion rates (Nex) for nitrous oxide emissions estimation of non-dairy cattle and swine subgroups, 2020

Non-dairy cattle sub-groups		Nex (kg N animal^{-1} yr^{-1})
Young cattle under 1 year	*dairy cattle calves*	*15.6*
	beef cattle calves	*18.5*
Young cattle aged from 1 to 2 years	*dairy cattle*	*24.7*
	beef cattle	*26.4*
Mature non-dairy cattle over 2 years	*bulls*	*93.9*
	heifers	*49.4*
	other cows	*65.9*
Swine sub-groups		
Piglets under 50 kg of weight (under 4 months)		*5.1*
Young breeding sows and fattening pigs		*14.0*
Mature breeding sows and boars		*27.6*

The total quantity of excreted N by livestock among MMS implemented in Latvia and estimation results of managed manure N available for application to managed soils is summarized in Table 5.25.

Table 5.25 N excretion (Nex) per manure management system (MMS) and manure N available for application (N MMS_Avb) to managed soils (kg, N yr^{-1}), 1990-2020

Year	Manure management system (MMS)				Total Nex per MMS	N_{MMS_Avb}
	solid storage	liquid systems	pasture range and paddock	anaerobic digester		
1990	*71856740*	*7404768*	*16360390*	*0*	*95621898*	*51153382*
1995	*33772538*	*4571694*	*5559145*	*0*	*43903377*	*25211831*
2000	*24226599*	*4848148*	*3761259*	*0*	*32836006*	*18880378*
2005	*22178083*	*7087773*	*4139005*	*0*	*33404861*	*18849655*
2006	*22187767*	*7381551*	*4102430*	*0*	*33671748*	*19034045*
2007	*22275546*	*8004449*	*4486673*	*0*	*34766669*	*19460768*
2008	*20854354*	*8088914*	*4512765*	*0*	*33456034*	*18604919*
2009	*19926222*	*8332127*	*4672807*	*20687*	*32951842*	*18086525*
2010	*19107227*	*7729066*	*4791130*	*1299746*	*32927170*	*17207299*
2011	*18578212*	*7823793*	*4906461*	*1610653*	*32919120*	*17011815*

Year	Manure management system (MMS)				Total Nex per MMS	N MMS_Avb
	solid storage	liquid systems	pasture range and paddock	anaerobic digester		
2012	*18459162*	*6745609*	*5220517*	*3332466*	*33757753*	*16384434*
2013	*18205827*	*6476007*	*5683365*	*4435129*	*34800329*	*16074363*
2014	*18067368*	*6986285*	*6096340*	*4657942*	*35807934*	*16470432*
2015	*16908034*	*8032716*	*6230376*	*4068834*	*35239961*	*16258130*
2016	*16168536*	*8135361*	*6565511*	*4178977*	*35048384*	*15778417*
2017	*15581303*	*8120082*	*6772505*	*4845921*	*35319812*	*15484538*
2018	*14136411*	*6873589*	*6887667*	*6113284*	*34010951*	*13640942*
2019	*13666616*	*7540267*	*7089670*	*5778129*	*34074682*	*13673690*
2020	*13422571*	*6597046*	*7224448*	*6767146*	*34011211*	*12873489*
Share of total % in 2020	*39.5%*	*19.4%*	*21.2%*	*19.9%*	*100.0%*	*100.0%*
2020 versus 2019	*-1.8%*	*-12.5%*	*+1.9%*	*+17.1%*	*-0.2%*	*-5.9%*
2020 versus 1990	*-81.3%*	*-10.9%*	*-55.8%*	*NA*	*-64.4%*	*-74.8%*

Nitrous oxide emissions calculation is prepared according to the 2006 IPCC Guidelines Tier 2 methodology, because country specific data is included in the estimation (country specific N excretion rates).

The indirect nitrous oxide emissions from volatilisation of N in forms of NH_3 and NO_x from manure management are estimated as (2006 IPCC Guidelines: Equation 10.29 page 10.57):

$$\boldsymbol{N_2O_{G(mm)}} = (\boldsymbol{N_{volatilization-MMS}} * \boldsymbol{EF_4}) \tag{5.15}$$

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}
$N_{volatilization\text{-}MMS}$ - amount of manure nitrogen that is lost due to volatilisation of NH_3 and NO_x, kg N 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 volatilised)$^{-1}$; default value 0.01 kg N_2O-N (kg NH_3-N +NO_x-N volatilised)$^{-1}$ is used

The indirect nitrous oxide emissions from leaching and runoff of N from manure management systems are estimated as (2006 IPCC Guidelines: Equation 10.27 page 10.56):

$$\boldsymbol{N_2O_{L(mm)}} = (\boldsymbol{N_{leaching-MMS}} * \boldsymbol{EF_5}) \tag{5.16}$$

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}
$N_{leaching\text{-}MMS}$ - amount of manure nitrogen that leached from manure management systems, kg N yr^{-1}
EF_5 - emission factor for N_2O emissions from nitrogen leaching and runoff, kg N_2O-N/kg N leached and runoff (default value 0.0075 kg N_2O-N (kg N leaching/runoff)$^{-1}$

The amount of manure nitrogen that is lost due to volatilisation of NH_3 and NO_x is assigned to Tier 2 approach to calculate N that is lost due to volatilisation of NH_3 and NO_x from the livestock buildings and manure storage facilities is adopted from EMEP/EEA 2019[151]. All EFs used for calculations are explained in EMEP/EEA 2019 Guidelines chapter 3.B Manure management Table 3.9.

Probability of risks related to the agricultural point source pollution of surface waters by N leaching and run-off from manure storages must be considered for Latvia, because there are a

151 EMEP/EEA Air pollutant emission inventory guidebook. (2019) 3.B Manure management. European Environment Agency, P. 20 –26 number of farms with high livestock number (more than 250 animal units), especially from pig-breeding and poultry farming branches. Many of large livestock farms as potential point source polluters in the Nitrate Vulnerable Zone are located within the catchment basin closer than 500 m of distance to the water bodies of national importance, because of high density of hydrographic network in this region. Additionally, the proportion of livestock on larger farms continues to grow gradually regarding to CSB information (Table 5.26).

Table 5.26 Grouping of farms 2019-2020

By the number of pigs and breeding sows at end of year								
Pigs	2019				2020			
	Farms with the respective livestock		Livestock		Farms with the respective livestock		Livestock	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
	2 772	*100*	*314 204*	*100*	*2762*	*100*	*306 821*	*100*
2000-4999	*11*	*0.4*	30 742	9.8	*9*	*0.3*	*25 415*	*8.3*
>=5000	*15*	*0.5*	256 576	81.7	*14*	*0.5*	*252 152*	*82.2*
By the number of cattle and dairy cows at end of year								
Dairy cows	2019				2020			
	Farms with the respective livestock		Livestock		Farms with the respective livestock		Livestock	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
	12 424	*100*	*138 413*	*100*	*11 266*	*100*	*136 035*	*100*
200-299	*37*	*0.3*	*8726*	*6.3*	*29*	*0.3*	*6792*	*5.0*
>=300	*50*	*0.4*	*28677*	*21.0*	*55*	*0.5*	*31209*	*22.9*

Based on the measures taken at the national level in order to reduce the pollution of surface waters caused by agricultural production, the long-term agricultural point source pollution monitoring observations results indicate that concentrations of pollutants show negative trends, but still should be taken into account[152].

Values of FracLeach is based on expert conclusions who are involved in national agricultural point source monitoring activities under Agricultural Runoff programme. In 1990-2004, FracLeach is set to 10% by reducing the value to 1% for slurry storages and 5% to solid storages till 2019. The amount of manure N that is leached from manure management systems is derived from the 2006 IPCC Guidelines (Equation 10.28, page, 10.56). 2006 IPCC guidelines declare typical range 1-20% for FracleachMS or managed manure nitrogen losses for livestock due to runoff and leaching during solid and liquid storage of manure. Agriculture point source runoff monitoring data showed that approximately 10% of N from manure storages was loss during 1990-1994, when the largest number of cattle in Latvia was observed in the time series. After this period the numbers of cattle dropped. Situation with N loss was improved also after implementation of Nitrates Directive in Latvia, and after Latvia become the member of the

[152]*Berzina L. (2014) Analysis of Point Source Pollution from Agricultural Production Influence on Surface Water Quality in Highly Vulnerable Zones. Summary of the Thesis for Doctoral Degree in Engineering Sciences, Environmental Science branch, Environmental Engineering subbranch. 91 p.*

Europe Union (2004). Then many financial mechanisms were available for manure management improvement. It was assumed that all manure storages comply with the requirements of the Nitrates Directive, however agriculture point source runoff monitoring data showed that FracleachMS can't be set exactly as 0% for all state. Regarding to requirements of slurry manure storage, the lowest value of FracleachMS as 1% is set for last years (2013-2018). It is allowed for small farms (less than 5 animal units) to avoid building of solid manure storage, therefore 5% of FracleachMS is set for solid storages. 10% of FracleachMS is set till 2005 when manure storages went to progress of improvement. Values between 10% and 5 to 1% are interpolated for 2005-2013, because agriculture point source runoff monitoring data show the highest quality of waters since 2013.

5.3.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

The uncertainty of the manure management system usage data depends on the characteristics of each country's livestock industry and how information on manure management is collected. The 2006 IPCC Guidelines show that for one type of management system, the uncertainty associated with management system usage data can be 10% or less. However, for countries where there is a wide variety of management systems, the uncertainty range in management system usage data can be much higher, in the range of 25% to 50%, depending on the availability of reliable and representative survey data that differentiates animal populations by system usage (2006 IPCC Guidelines: page 10.50). For Latvia uncertainty of 25% is set, because only three manure management systems are used without pastures. Latvia also uses country specific values for N excretion rates to reduce uncertainty of activity data to 25%. IPCC expert judgment shows that uncertainty ranges for the default N excretion rates are estimated at about 50% (2006 IPCC Guidelines: page 10.66)

The uncertainty for the default EFs is estimated to be 30%. Improvements achieved by Tier 2 methodologies are evaluated to reduce uncertainty ranges in EFs to 20% for Latvia.

5.3.4 Category-specific QA/QC and verification

Activity data check. The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3.General QC procedures including quality checks related to calculations, data processing, completeness, and documentation were used during the inventory. Defined manure management systems in the inventory are consistent with definitions that are presented in the 2006 IPCC Guidelines (Table 10.18, page 10.49). Latvia uses country specific methodology to determine distribution of manure management systems that is available in scientific literature[153].

All information on activity data and emission calculations are stored and archived in the common FTP folder.

[153] *Priekulis J., Āboltiņš A. (2015) Calculation Methodology for Cattle Manure Management Systems Based on the 2006 IPCC Guidelines. Proceedings of the 25th NJF Congress Nordic View to Sustainable Rural Development. Riga, pp.274-280*

Review of emission factors. Country-specific EFs were compared to the 2006 IPCC Guidelines defaults. EFs were chosen as for cool climate region by average annual temperature ≤10°C. Review results are presented in the chapter 5.3.2.1.

Latvia uses country specific nitrogen excretion rates, according to the latest research results. Calculated and measured nitrogen excretion rates are compared with other countries inventory data and default factors. No significant differences were found for rates used for inventory that are within the range of values reported in other EU countries.

5.3.5 Category-specific recalculations

For 2022 submission recalculations for period 1990-2019 were done, based on the corrected numbers of nitrogen that is lost due to volatilisation of NH_3 and NOx due to use EMEP/EEA 2019 Guidelines instead of EMEP/EEA 2016 Guidelines and improvements of calculations. Overview of the recalculation effects are summarised in Table 5.27.

Table 5.27 Recalculations of indirect N_2O manure management emissions, 1990-2019

Year	N_2O emission from atmospheric deposition , kt N/yr		
	before recalculation	*after recalculation*	*relative difference*
1990	*0.230*	*0.233*	*+1.4%*
1995	*0.110*	*0.111*	*+1.2%*
2000	*0.085*	*0.085*	*+0.1%*
2005	*0.089*	*0.087*	*-2.2%*
2006	*0.091*	*0.088*	*-2.6%*
2007	*0.094*	*0.091*	*-2.5%*
2008	*0.091*	*0.089*	*-2.8%*
2009	*0.090*	*0.087*	*-2.8%*
2010	*0.089*	*0.087*	*-3.0%*
2011	*0.089*	*0.086*	*-3.4%*
2012	*0.090*	*0.087*	*-2.7%*
2013	*0.091*	*0.089*	*-2.8%*
2014	*0.093*	*0.090*	*-3.2%*
2015	*0.092*	*0.089*	*-3.1%*
2016	*0.092*	*0.089*	*-3.1%*
2017	*0.092*	*0.089*	*-3.0%*
2018	*0.086*	*0.083*	*-2.9%*
2019	*0.086*	*0.084*	*-2.9%*

5.3.6 Category-specific planned improvements

No improvements are planned for this sector.

5.4 *AGRICULTURAL SOILS (CRF 3.D)*

5.4.1 Category description

Nitrous oxide emissions from agricultural soils (CRF 3.D) are a significant emission source comprising about 1160.83 kt CO_2 eq. or 51.6% of total agricultural emissions in 2020. According to the 2006 IPCC Guidelines, direct and indirect emissions of nitrous oxide from managed soils must be estimated separately. The following N sources are included in the inventory for estimating direct nitrous oxide emissions from managed soils:

- synthetic N fertilizers (F_{SN});
- organic N fertilizers (e.g., animal manure, compost, sewage sludge, digestate) (F_{ON});
- urine and dung N deposited on pasture, range and paddock by grazing animals (F_{PRP});
- N in crop residues (above-ground and below-ground), including from N-fixing crops and from forages during pasture renewal (F_{CR});
- drainage/management of organic soils (F_{OS}).

Indirect nitrous oxide emissions from managed soils are determined for volatilization and leaching processes. Nitrous oxide emissions included in the inventory are reported in Table 5.28.

Table 5.28 Reported emissions under the subcategory agricultural soils

CRF	Source	Emissions reported	Level
3.D 1.1	*Inorganic N fertilizers*	*N_2O*	*Tier 1*
3.D 1.2.a	*Animal manure applied to soils*	*N_2O*	*Tier 1*
3.D 1.2.b	*Sewage sludge applied to soils*	*N_2O*	*Tier 1*
3.D 1.2.c	*Other organic fertilizer applied to soils*	*N_2O*	*Tier 1*
3.D 1.3	*Urine and dung deposited on soils*	*N_2O*	*Tier 1*
3.D 1.4	*Crop residues*	*N_2O*	*Tier 1*
3.D 1.5	*Mineralization/immobilization associated with loss/gain of soil organic matter*	*NO*	*NA*
3.D 1.6	*Cultivation of organic soils*	*N_2O*	*Tier 3*
3.D 1.7	*Other*	*NO*	*NA*
3.D 2.1	*Atmospheric deposition*	*N_2O*	*Tier 1*
3.D 2.2	*Nitrogen leaching and run-off*	*N_2O*	*Tier 1*

The total nitrous oxide emission from managed soils reached 3.9 kt in 2020; which is 3.2% more than in 2019. In general, emission has decreased in 2020 by 29.8% compared to 1990. The main reason for that was decreasing of all livestock numbers that affected the amount of nitrogen excreted annually to soil and lower consumption of fertilizers. In 2020, nitrous oxide emission increased by 0.12 kt compared to 2019 (Table 5.29). The main reasons of the increase of emission absolute number is increased amount of urine and dung N deposited by grazing animals and increased amount of nitrogen fertilizer use. In 2020, the total nitrous oxide emission from managed soils originated as 84.6% from direct sources. Indirect nitrous oxide emission from volatilization formed 5.4% and from leaching – 10.1% of the nitrous oxide total emission (Table 5.29).

Table 5.29 Nitrous oxide emissions from managed soils, 1990-2020 (kt)

Year	N_2O direct emission	N_2O indirect emission from atmospheric deposition	N_2O indirect emission from leaching and run-off	Total
1990	*5.42*	*0.42*	*0.63*	*6.47*
1995	*2.39*	*0.11*	*0.15*	*2.65*
2000	*2.28*	*0.11*	*0.16*	*2.54*
2005	*2.45*	*0.14*	*0.22*	*2.81*
2006	*2.42*	*0.14*	*0.22*	*2.79*
2007	*2.52*	*0.15*	*0.25*	*2.91*
2008	*2.49*	*0.15*	*0.25*	*2.89*
2009	*2.56*	*0.15*	*0.26*	*2.97*
2010	*2.64*	*0.17*	*0.28*	*3.08*
2011	*2.63*	*0.16*	*0.28*	*3.07*
2012	*2.80*	*0.17*	*0.31*	*3.29*
2013	*2.87*	*0.18*	*0.32*	*3.37*
2014	*2.96*	*0.19*	*0.34*	*3.49*
2015	*3.08*	*0.20*	*0.36*	*3.64*
2016	*3.09*	*0.20*	*0.36*	*3.65*
2017	*3.10*	*0.20*	*0.36*	*3.66*
2018	*2.95*	*0.19*	*0.33*	*3.47*
2019	*3.20*	*0.20*	*0.38*	*3.77*
2020	*3.29*	*0.21*	*0.39*	*3.90*
Share of total % in 2020	*84.8%*	*5.3%*	*9.9%*	*100.0%*
2020 versus 2019	*+3.1%*	*+2.9%*	*+4.4%*	*+3.2%*
2020 versus 1990	*-39.2%*	*-50.2%*	*-37.4%*	*-39.8%*

In 2020, synthetic fertilizers formed the major part of total direct emissions (40.2%), following by emission from managed organic soils (27.9%), crop residues (17.3%), animal manure applied to soils (6.1%), urine and dung deposited on pasture (6.5%), and other organic N additions applied to soils (1.8%) (Table 5.30). Overall, nitrous oxide emissions from pastures and application of N fertilizer increasing most rapidly in last years. This could be explained by the fact of increased number of beef cattle grazing on pastures and expanding of sown area. The amount of harvested production is mainly affected by the cereal crop area and yield. In 2020, also increased the share of organic N additions as digestate. According to CSB information in 2020, 151.3 thousand t of mineral fertilizers (expressed as 100% of nutrients) were used on the sown area of agricultural crops – 8.7% more than in 2019. The increase in the volume of mineral fertilizers used per hectare (from 108 kg in 2018 to 110 kg in 2019 or by 1.9% over the year) was facilitated by the growth of winter cereal and winter rape sown areas – of 21% and 57%, respectively. The increase in the volume of mineral fertilizers used per hectare (from 110 kg in 2019 to 118 kg in 2020 or by 7.3% over the year) was facilitated mainly by the growth of the volume of mineral fertilizers used per hectare of cereals and industrial crops respectively by 5.0% and 5.6%[154].

[154] *Agriculture in Latvia. Collection of Statistical Data. Rīga (2021) 92 p. Available: https://stat.gov.lv/en/statistics-themes/business-sectors/fishery-and-aquaculture/publications-and-infographics/7268*

Table 5.30 Nitrous oxide emissions from N inputs to managed soils, 1990-2020 (kt)

Year	F_{SN}	F_{ON} (animal manure)	F_{ON} (sludge)	F_{ON} (other)	F_{PRP}	F_{CR}	F_{OS}
1990	*2.06*	*0.80*	*NA*	*NA*	*0.50*	*0.51*	*1.54*
1995	*0.18*	*0.40*	*NA*	*NA*	*0.17*	*0.22*	*1.43*
2000	*0.36*	*0.30*	*NA*	*NA*	*0.11*	*0.19*	*1.31*
2005	*0.64*	*0.30*	*0.005*	*NA*	*0.13*	*0.28*	*1.10*
2006	*0.67*	*0.30*	*0.007*	*NA*	*0.12*	*0.26*	*1.06*
2007	*0.72*	*0.31*	*0.007*	*NA*	*0.14*	*0.32*	*1.02*
2008	*0.75*	*0.29*	*0.004*	*NA*	*0.14*	*0.33*	*0.98*
2009	*0.82*	*0.28*	*0.005*	*NA*	*0.14*	*0.34*	*0.97*
2010	*0.94*	*0.27*	*0.008*	*0.008*	*0.14*	*0.31*	*0.96*
2011	*0.94*	*0.27*	*0.007*	*0.004*	*0.15*	*0.31*	*0.95*
2012	*1.02*	*0.26*	*0.006*	*0.010*	*0.16*	*0.41*	*0.94*
2013	*1.10*	*0.25*	*0.006*	*0.022*	*0.17*	*0.39*	*0.93*
2014	*1.15*	*0.26*	*0.006*	*0.029*	*0.18*	*0.41*	*0.92*
2015	*1.19*	*0.26*	*0.004*	*0.025*	*0.19*	*0.51*	*0.92*
2016	*1.23*	*0.25*	*0.003*	*0.019*	*0.20*	*0.48*	*0.91*
2017	*1.22*	*0.24*	*0.003*	*0.049*	*0.20*	*0.47*	*0.91*
2018	*1.17*	*0.21*	*0.004*	*0.046*	*0.20*	*0.39*	*0.91*
2019	*1.27*	*0.21*	*0.005*	*0.048*	*0.21*	*0.53*	*0.92*
2020	*1.32*	*0.20*	*0.005*	*0.059*	*0.21*	*0.57*	*0.92*
Share of total % in 2020	*40.2%*	*6.1%*	*0.2%*	*1.8%*	*6.5%*	*17.3%*	*27.9%*
2020 versus 2019	*+4.5%*	*-5.9%*	*+3.7%*	*+22.9%*	*+1.7%*	*+7.2%*	*+0.2%*
2020 versus 1990	*-35.8%*	*-74.8%*	*NA*	*NA*	*-57.7%*	*11.6%*	*-40.2%*

F_{SN} = synthetic N fertilizer, F_{ON} = organic N additions, F_{PRP} = urine and dang N deposited on pasture, F_{CR} = N in crop residues, F_{OS} = managed organic soil in grassland and cropland.

5.4.2 Methodological issues and activity data

Emissions from managed soils, and emissions from lime and urea application in Latvia have been calculated by using methodologies presented in the 2006 IPCC Guidelines (Volume 4, Chapter 11). For estimation of nitrous oxide emissions from managed soils the Tier 1 methodology was used. Direct nitrous oxide emissions from agricultural soils have been calculated using the following equation according to the 2006 IPCC Guidelines (Equation 11.1, page 11.7):

$$\boldsymbol{N_2O_{direct} - N = N_2O - N_{N\ inputs} + N_2O - N_{OS} + N_2O - N_{PRP}}$$

$$\boldsymbol{N_2O - N_{N\ inputs} = (F_{SN} + F_{ON} + F_{CR} + F_{SOM}) * EF_1}$$

$$\boldsymbol{N_2O - N_{OS} = (F_{OS} * EF_2)}$$

$$\boldsymbol{N_2O - N_{PRP} = [(F_{PRP} * EF_3)]} \tag{5.17}$$

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}
N_2O–N_{OS} - annual direct N_2O–N emissions from managed organic soils, kg N_2O–N yr^{-1}
N_2O–N_{PRP} - annual direct N_2O–N emissions from urine and dung inputs to grazed soils, kg N_2O–N yr^{-1}
F_{SN} - annual amount of synthetic fertilizer N applied to soils, kg N yr^{-1}

F_{ON} - annual amount of animal manure, compost, sewage sludge and other organic N additions applied to soils, kg N yr^{-1}
F_{CR} - annual amount of N in crop residues (above-ground and below-ground), including N-fixing crops, and from forage/pasture renewal, returned to soils, kg N yr^{-1}
F_{SOM} - annual amount of N in mineral soils that is mineralised, in association with loss of soils C from soils 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 in grasslands and croplands, ha
F_{PRP} - annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr^{-1}
EF_1 - emission factor for N_2O emissions from N inputs, kg N_2O–N kg^{-1} N input
EF_2 - emission factor for N_2O emissions from drained/managed organic soils, kg N_2O–N ha^{-1} yr^{-1}
EF_3 - 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

Inorganic N fertilizers: CRF 3.D 1.1

Annual amount of the synthetic fertilizer N is one of the parameters to estimate direct nitrous oxide emission from N inputs to managed soils. Data of inorganic fertilizer N applied to soils are provided by CSB of Latvia. Input values for direct nitrous oxide emission calculation from inorganic N fertilizers are represented in Table 5.36.

Organic N fertilizers: CRF 3.D 1.2

Amount of the organic N fertilizer (F_{ON}) applied to soils is calculated using methodology represented in the 2006 IPCC Guidelines (Equation 11.3, page 11.12). This includes applied to soils animal manure, sewage, compost, as well as other organic amendments of regional importance to agriculture:

$$\boldsymbol{F_{ON} = F_{AM} + F_{SEW} + F_{COMP} + F_{OOA}} \tag{5.18}$$

where:

F_{ON} - total annual amount of organic N fertilizer 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}
F_{OOA} - annual amount of other organic amendments used as fertilizer, kg N yr^{-1}

Data on the amount of sewage sludge applied to managed soils are provided by LEGMC, other data of organic N fertilizer applied to soils are obtained from CSB. Application of sewage sludge as fertilizer is relatively small in Latvia. Other organic amendments used as fertilizer mainly refer to digestate. Amount of nitrogen in sewage sludge, digestate and composts are calculated based on agriculture research results done by LULST scientists,[155] and other research projects[156]. Statistics of different types of organic N fertilizers applied to soils are limited in Latvia. Available data are represented in Table 5.31. Applied amounts of composts and digestate are represented in fresh weight.

Table 5.31 Statistics of organic N fertilizers applied to soils, 2001-2020

Year	Sewage sludge applied to managed soils, t dry matter	Composts applied to managed soils, thousand t	Other organic N (including digestate) applied to managed soils, thousand t
2001	*30946.7*	*NA*	*NA*
2002	*22513.9*	*NA*	*NA*

[155] *Gemste I., Vucāns A. (2010) Notekūdeņu dūņas. Jelgava, LLU, 276 lpp.*
[156] *Litiņa I. (2013) Digestāta kā mēslošanas līdzekļa efektivitātes novērtējums kukurūzas sējumā. Zinātniski praktiskā konference LAUKSAIMNIECĪBAS ZINĀTNE VEIKSMĪGAI SAIMNIEKOŠANAI. Jelgava, LLU, 206-209 lpp.*

Year	Sewage sludge applied to managed soils, t dry matter	Composts applied to managed soils, thousand t	Other organic N (including digestate) applied to managed soils, thousand t
2003	*9230.9*	*NA*	*NA*
2004	*7683.7*	*NA*	*NA*
2005	*6545.5*	*NA*	*NA*
2006	*8936.4*	*NA*	*NA*
2007	*8131.6*	*NA*	*NA*
2008	*5251.4*	*NA*	*NA*
2009	*6686.9*	*NA*	*NA*
2010	*9306.2*	*95.5*	*3.7*
2011	*8758.6*	*39.9*	*6.1*
2012	*7470.5*	*62.2*	*82.5*
2013	*7479.2*	*40.4*	*289.9*
2014	*6861.2*	*36.2*	*413.9*
2015	*4706.0*	*15.3*	*369.5*
2016	*4249.5*	*30.7*	*261.8*
2017	*3315.7*	*15.9*	*740.1*
2018	*4288.5*	*16.7*	*690.5*
2019	*6229.4*	*18.9*	*718.3*
2020	*6460.7*	*21.0*	*885.8*
2020 versus 2019	*+3.7%*	*+11.1%*	*+23.3%*

Animal manure N (F_{AM}) emits from agricultural soil through manure application to fields as an organic fertilizer. Calculation of emissions from nitrogen input through application of animal manure is done according to the 2006 IPCC Guidelines (Equation 11.4, page 11.13):

$$\boldsymbol{F_{AM} = N_{MMS\,Avb} * [1 - (Frac_{FEED} + Frac_{FUEL} + Frac_{CNST})]} \tag{5.19}$$

where:

F_{AM} - annual amount of animal manure N applied to soils, kg N yr^{-1}
$N_{MMS\,Avb}$ - amount of managed manure N available for soil application, feed, fuel or construction, kg Nyr^{-1}
$Frac_{FEED}$ - fraction of managed manure used for feed
$Frac_{FUEL}$ - fraction of managed manure used for fuel
$Frac_{CNST}$ - fraction of managed manure used for construction

Total annual amount of the managed manure N available for soil application (F_{MMS_Avb}) is determined by the 2006 IPCC Guidelines (Chapter 10.5.4) according to the directions of estimation of N lost from manure management systems to final application on managed soils. Calculation of F_{MMS_Avb} is done by fully adopted IPCC methodology (2006 IPCC Guidelines, Volume 4, Chapter 10, Equation 10.34, p.10.65; fallowing by default values for total N loss from manure management represented in Table 10.23, p.10.67). There is no data available on the fraction of manure being used as feed, fuel or material of construction therefore F_{AM} is considered to be equal to N_{MMSAbv}. Total annual amount of managed manure N available for soil application is calculated under CRF category 3B Manure management and is represented in Table 5.25, Chapter 5.3.2.2.

Urine and dung deposited by grazing animals: CRF 3.D 1.3

The term F_{PRP} refers to the annual amount of N deposited on pasture, range and paddock soils by grazing animals. F_{PRP} is estimated using the 2006 IPCC Guidelines from the number of animals in each livestock species/category T($N_{(T)}$), the annual average amount of N excreted by each livestock species/category T ($Nex_{(T)}$), and the fraction of this N deposited on pasture, range and paddock soils by each livestock species/category T ($MS_{(T,PRP)}$), (2006 IPCC Guidelines: Equation 11.5, page 11.13):

$$\boldsymbol{F_{PRP}} = \sum_{\boldsymbol{T}}\left[\left(\boldsymbol{N_{(T)}} * \boldsymbol{Nex_{(T)}}\right) * \boldsymbol{MS_{(T,PRP)}}\right] \tag{5.20}$$

Total annual amount of N deposited on pasture, range and paddock soils by grazing animals is determined under CRF category 3B Manure management and is represented in Table 5.25.

Total annual amount of N deposited on pasture, range and paddock soils separately for two groups: $F_{PRP,CPP}$ (cattle, poultry and swine) and $F_{PRP,SO}$ (other livestock), according to directions of nitrous oxide emissions estimation by 2006 IPCC is summarized in Table 5.36.

Crop residues: CRF 3.D 1.4

The annual production of the amount of crop residue N (F_{CR}) is estimated based on 2006 the IPCC Guidelines Tier 1 methodology (Equation 11.6, page 11.14) :

$$= \sum_{\boldsymbol{T}}^{\boldsymbol{F_{CR}}}\left\{\boldsymbol{Crop_{(T)}} * \boldsymbol{Frac_{Renew\,(T)}} * \left[\left(\boldsymbol{Area_{(T)}} - \boldsymbol{Area\ burnt_{(T)}} * \boldsymbol{C_f}\right) * \boldsymbol{R_{AG\,(T)}} * \boldsymbol{N_{AG\,(T)}} * \left(\boldsymbol{1} - \boldsymbol{Frac_{Remove\,(T)}}\right) + \boldsymbol{Area_{(T)}} * \boldsymbol{R_{EG\,(T)}} * \boldsymbol{N_{EG\,(T)}}\right]\right\} \tag{5.21}$$

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
$Frac_{Renew\,(T)}$ - fraction of total area under crop T
$R_{AG(T)}$ - ratio of above-ground residues dry matter to harvested yield for crop T
$N_{AG(T)}$ - 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.

Correction factor to estimate dry matter yields ($Crop_{(T)}$) is determined as (Equation 11.7, page 11.15):

$$\boldsymbol{Crop_{(T)}} = \boldsymbol{Yield\ Fresh_{(T)}} * \boldsymbol{DRY} \tag{5.22}$$

where:

$Crop_{(T)}$ - harvested dry matter yield for crop T, kg d.m. ha^{-1}
Yield $Fresh_{(T)}$ - harvested fresh yield for crop T, kg fresh weight ha^{-1}
DRY - dry matter fraction of harvested crop T, kg d.m. (kg fresh weight)$^{-1}$

Mainly default data were used to estimate N that is returned to soils by crop residues, except data of crop production (area and yield) that originates from CSB Database. Dry matter fractions of harvested crop are collected as combination of 2006 IPCC default and national values[157] (Table 5.32).

Table 5.32 Dry matter fraction (DRY) of harvested crop (kg fresh weight^{-1})

Crop	DRY
Wheat	*0.86*
Barley	*0.86*
Triticale	*0.86*
Oats	*0.86*
Rye	*0.86*
Buckwheat	*0.86*
Pulses	*0.86*
Fodder roots	*0.15*
Potatoes	*0.22*
Vegetable	*0.12*
Maize for silage and forage	*0.30*
Crops for green feed and silage	*0.20*
Perennial grass	*0.84*
Rape	*0.92*
Flax straw/seed	*0.81/0.88*

Calculations on annual amount of N in crop residues are done based on default factors represented in the 2006 IPCC Guidelines (Table 11.2, page 11.17) with the exception of wheat. According to long-term national studies N_{AG}=0.005, N_{BG}=0.006 (Ruža A. Project Report No. S293. Setting maximum levels for fertilizers for crops) and R_{AG} or ratio of above-ground residues dry matter to harvested yield in the range from 1.00 to 1.10 is set for wheat. National research results show that R_{AG} is equal to 1.10 or 1.00 or 0.85 if yield is below 2.5, 2.5-5 and up to 5 tonnes from hectare, respectively[158]. All data sources to calculate N that is returned to soil by crop residues are represented in Table 5.33.

Table 5.33 Data sources for estimation of N in crop residues

Input parameter	Data source
Crop harvested yield	*CSB*
Crop harvested area	*CSB*
Burnt crop area	*NO*
$Frac_{Renew}$	*Expert judgement, IPCC default*
$Frac_{Remove}$	*Expert judgement, IPCC default*
AG_{DM}	*2006 IPCC, Table 11.2*
N_{AG}	*2006 IPCC, Table 11.2, national research values for wheat*
$R_{BG\text{-}BIO}$	*2006 IPCC, Table 11.2*
N_{BG}	*2006 IPCC, Table 11.22, national research values for wheat*

[157] *Kārkliņš A., Līpenīte I. (2018). Aprēķinu metodes un normatīvi augsnes iekultivēšanai un mēslošanas līdzekļu lietošanai. Jelgava: LLU. 200 lpp.*

[158] *Kārkliņš A., Līpenīte I. (2018). Aprēķinu metodes un normatīvi augsnes iekultivēšanai un mēslošanas līdzekļu lietošanai. Jelgava: LLU. 200 lpp.*

Input parameter	Data source
R_{AG}	*2006 IPCC, Page 11.4*
R_{GB}	*2006 IPCC, Page 11.4*

There is no field burning of agricultural residues observed in Latvia and area burnt is set to zero. It is estimated by LULST experts that approximately 30% of above-ground residues of all main crops (wheat, oats, barley and rye) are removed annually for purposes such as feeding, bedding and construction ($Frac_{Remove}$). This number is set as 70%, for 1900-2000, by rapid decrease till 2010. Till 2000 above-ground crop residues were widely used for bedding and feeding. Also the total number of cattle was the highest for that period. And the share of solid manure management systems was higher. After 2000 it became more popular to incorporate residues in the soil, also the number of cattle continued to fall down. Since 2010 it is assumed that specialization of farms in Latvia was stabilized and now crop farms use crop residues for crop production purposes. Only farms located near to cattle farms and mixed specialization farms remove crop residues for bedding possibilities. Largest cattle farms after 2000 turned to slurry based manure management systems. Situation between 2000 and 2010 was strongly changing therefore $Frac_{Remove}$ value for the time period is interpolated from 70% to 30%. No other data to estimate the fraction of above-ground residues of crop removed for purposes such as feed, bedding and construction is available. According to national expert conclusions, perennial grass is renewed on average every 4 years. For annual crops $Frac_{Renew}$ 1 was set, as also proposed in the 2006 IPCC Guidelines. Final results of estimation of annual amount of N in crop residues are available in Table 5.36.

Mineralization/immobilization associated with loss/gain of soil organic matter: CRF 3.D 1.5

Average annual loss of soils carbon due to land use or management systems change was obtained from LULUCF sector. The net annual amount of N mineralised in mineral soils as a result from loss of soil organic C stocks due land use change is accounted under LULUCF sector and reported under activities listed in paragraph 3.3 of the Kyoto protocol (deforestation). The net annual amount of N mineralised in mineral soils as a result from loss of soil organic C stocks due to management activities, including conversion of cropland to grassland, is assumed to be NO, because of the net removals of CO_2 in soil in cropland and grassland due to management activities[159;160]. In relation to Latvian State Forest Research Institute "Silava" research outcome, similar research results also are applicable to mineral soils from cropland remaining cropland.

Cultivation of organic soils: CRF 3.D 1.6

Data on annual area of managed organic soils are adopted from the LULUCF sector. For the LULUCF sector data are prepared by Latvian State Forest Research Institute "Silava". Nitrous oxide emissions from cultivated organic soils have been calculated with the country specific emissions factors: EF = 7.1 ± 3.29 kg N_2O-N/ha/yr for drained cropland and EF = 0.3 ± 0.25 kg N_2O-N/ha/yr for drained grassland[161]. The area of cultivated organic soils is shown in Table 5.34.

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[159] *Lupikis, A., Bardule, A., Lazdins, A., Stola, J., & Butlers, A. (2017). Carbon stock changes in drained arable organic soils in Latvia: results of a pilot study. Agroonomy Research, 15(3), 788–798*

[160] *Bārdulis, A., Lupiķis, A., & Stola, J. (2017). Carbon balance in forest mineral soils in Latvia modelled with Yasso07 soil carbon model. In Research for Rural Development (Vol. 1, pp. 28–34). Latvia University of Agriculture*

[161] *Licite I., Lupikis, A. 2020. Impact of land use practices on greenhouse gas emissions from agriculture land on organic soils. Proceedings of 19th International Scientific Conference Engineering for Rural Development, 1823–1830. DOI: 10.22616/ERDev.2020.19.TF492*

Table 5.34 Area of cultivated organic soil, 1990-2020 (thsd ha)

Year	Organic soil in cropland	Organic soil in grassland	Total
1990	*135.1*	*59.9*	*195.1*
1995	*125.4*	*59.4*	*184.7*
2000	*114.7*	*57.4*	*172.1*
2005	*95.5*	*71.4*	*166.9*
2006	*91.9*	*74.1*	*166.0*
2007	*88.3*	*76.8*	*165.1*
2008	*84.8*	*79.5*	*164.3*
2009	*83.8*	*79.7*	*163.5*
2010	*82.9*	*80.0*	*162.8*
2011	*81.9*	*80.2*	*162.1*
2012	*81.0*	*80.5*	*161.5*
2013	*80.1*	*80.8*	*160.8*
2014	*79.4*	*80.4*	*159.8*
2015	*78.8*	*80.0*	*158.7*
2016	*78.1*	*79.6*	*157.7*
2017	*78.4*	*79.6*	*158.0*
2018	*78.6*	*79.7*	*158.3*
2019	*78.8*	*80.2*	*159.0*
2020	*79.0*	*80.7*	*159.6*
Share of total % in 2020	*49.5%*	*50.5%*	*100%*
2020 versus 2019	*+0.2%*	*+0.6%*	*+0.4%*
2020 versus 1990	*-41.6%*	*-34.6%*	*-18.2%*

Atmospheric deposition: CRF 3.D 2.1

The nitrous oxide emission from atmospheric deposition of N volatilised from managed soil is estimated using the 2006 IPCC Guidelines (Equation 11.9, page 11.21):

$$\boldsymbol{N_2O_{(ATD)} - N = \left[(F_{SN} * Frac_{GASF}) + ((F_{ON} + F_{PRP}) * Frac_{GASM})\right] * EF_4} \quad (5.23)$$

where:

$N_2O_{(ATD)}$-N - annual amount of N_2O–N produced from atmospheric deposition of N volatilised from managed soils, kg N_2O–N yr^{-1}

F_{SN} - annual amount of synthetic fertilizer N applied to soils, kg N yr^{-1}

$Frac_{GASF}$ - fraction of synthetic fertilizer N that volatilises as NH_3 and NO_x, kg N volatilised (kg of N applied)$^{-1}$

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}

$Frac_{GASM}$ - fraction of applied organic N fertilizer materials (F_{ON}) and of urine and dung N deposited by grazing animals (F_{PRP}) that volatilises as NH_3 and NO_x, kg N volatilised (kg of N applied or deposited)$^{-1}$

EF_4 - Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, kg N_2O-N/kg NH_3-N and NO_x-N emitted

Results of estimation are available in Table 5.29.

Nitrogen leaching and run-off: CRF 3.D 2.2

The nitrous oxide emission from nitrogen loss from agricultural soils through leaching and runoff is estimated as shown in the 2006 IPCC Guidelines (Equation 11.10, page 11.2):

$$N_2O_{(L)} - N = (F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}) * Frac_{LEACH-(H)} * EF_5 \quad (5.24)$$

where:

$N_2O_{(L)}$–N - annual amount of N_2O–N produced from leaching and runoff, kg N_2O–N yr^{-1}
F_{CR} - amount of N in crop residues (above- and below-ground), including N-fixing crops, and from forage/pasture renewal, kg N yr^{-1}
F_{SOM} - annual amount of N mineralised in mineral soils, kg N yr^{-1}
$Frac_{LEACH-(H)}$ - Fraction of N input that is lost through leaching and runoff, kg N (kg of N additions)$^{-1}$
EF_5 - emission factor for N_2O emissions from N leaching and runoff, kg N_2O–N (kg N leached and runoff)$^{-1}$

The results of estimation of nitrous oxide emission from nitrogen loss from agricultural soils through leaching and runoff are available in Table 5.29. All EFs and fractions for direct and indirect emissions estimation from managed soils are summarized in Table 5.35.

Table 5.35 Default emission, volatilization and leaching factors for direct and indirect nitrous oxide emissions calculation

Factor	Value	Uncertainty range	Source
EF_1 for N additions from mineral fertilizers, organic amendments and crop residues [kg N_2O–N (kg N)$^{-1}$]	*0.01*	*0.003 – 0.03*	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, page 11.11, Table 11.1
EF_{2C}, for boreal and temperate drained organic cropland soil (kgN_2O–N ha^{-1}) EF_{2G}, for temperate organic soil grassland, deep drained, nutrient-rich (kgN_2O–N ha^{-1})	*7.1* *0.3*	*7.1 ± 3.29* *0.3 ± 0.25*	Licite I., Lupikis, A. 2020. Impact of land use practices on greenhouse gas emissions from agriculture land on organic soils DOI: 10.22616/ERDev.2020.19.TF492
$EF_{3PRP, CPP}$ for cattle (dairy, non dairy), poultry and pigs [kg N_2O–N (kg N) $^{-1}$]	*0.02*	*0.007 – 0.06*	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, page 11.11, Table 11.1
$EF_{3PRP, SO}$ for sheep and other animals [kg N_2O–N (kg N) $^{-1}$]	*0.01*	*0.003 – 0.03*	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, page 11.11, Table 11.1
EF_4 [N volatilization and re-deposition], kg N_2O–N [kg NH_3–N + NO_X–volatilized]	*0.010*	*0.002 – 0.05*	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4., page 11.24, Table 11.3
EF_5 (leaching/runoff), kg N_2O–N [kg N leaching/runoff]	*0.0075*	*0.0005 -0.025*	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, page 11.24, Table 11.3
$Frac_{GASF}$ (Volatilization from synthetic fertilizer), (kg NH_3–N + NO_x–N) [kg N applied] $^{-1}$	*0.10*	*0.03 – 0.3*	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, page 11.24, Table 11.3
$Frac_{GASM}$ (Volatilization from all organic N fertilizers applied, and dung and urine deposited by grazing animals), [kg NH_3–N + NO_x–N] [kg N applied or deposited] $^{-1}$	*0.20*	*0.05 – 0.5*	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, page 11.24, Table 11.3

Factor	Value	Uncertainty range	Source
$Frac_{LEACH-(H)}$,N losses by leaching/runoff [kg N lost from kg N input]	*0.23*	*0.18 – 0.27*	Sudars R., Berzina L., Grinberga L. Analysis of Agricultural Run-Off Monitoring Program Results for Estimation of Nitrous Oxide Indirect Emissions in Latvia[162].

The Department of Environment and Water Management of LULST has been responsible for monitoring agricultural runoff since 1994. The aim of monitoring is to determine and evaluate the impact of agricultural activities on water quality, paying increased attention to nutrient inputs at interrelated research levels. To determine the nitrogen leaching coefficient, the monitoring data of agricultural runoff from 1998-2014 obtained at the Department of Environment and Water Management were analysed. The observation data used for calculations, comparison, evaluation and specification of the obtained results were obtained at the monitoring stations "Mellupīte", and also from "Bērze" and "Vienziemīte" located in Saldus, Dobele and Jaunpiebalga counties, respectively.The following levels of research are used to assess agricultural pollution in different combinations: drained plot; drainage field; small catchment area. Based on a comprehensive analysis of monitoring object data, the following conclusions have been made. When mineral fertilizers with an annual use of up to 130 kg N / ha are applied to the test plots, without taking into account additional nitrogen from plant residues, but taking into account the nitrogen background leakage, the N leaching coefficient in different test variants was from 0.146 - 0.19 (on average 0.163). At the level of drainage systems with an annual nitrogen use of up to 167 kg N / ha, the average nitrogen leaching coefficient obtained in two monitoring objects, taking into account the background leakage, was on average 0.13. Considering the possible risk factors when applying fertilizer and the fact that the amount of applied nitrogen may increase in the future, it is recommended to use the maximum value of the leaching coefficient - 0.19 in further calculations. When applying organic fertilizer with an annual nitrogen rate of up to 78 kg N / ha (without nitrogen in plant residues), the nitrogen leaching coefficient, considering its background leakage, reaches 0.264. In order to find out how fertilizer application in the monitoring objects correspond to the use of nitrogen fertilizer in agriculture in the current period, and whether the results obtained in the monitoring objects can be applied to Latvia as a whole, an analysis of nitrogen application norms and sown area was performed. By taking into account general situation in Latvia with sown area and used nitrogen for fertilization scientists conclude that weighted average nitrogen leaching factor in agricultural areas never have been estimated higher as FracLeach=0.23. These results also are approved in the monograph "Possibilities for Reducing Greenhouse Gas Emissions with Climate-Friendly Agriculture and Forestry in Latvia" prepared on the basis of the projects of the National Research Program "Latvian Ecosystem Value and Its Dynamics under Climate Influence (EVIDEnT) 3.2. "Analysis of GHG emissions from the agricultural sector and economic assessment of emission reduction measures " and 3.3. "Analysis of the contribution of the forestry sector to the fulfillment of climate policy goals.

[162] *Sudars R., Berzina L., Grinberga L. (2016) Analysis of Agricultural Run-Off Monitoring Program Results for Estimation of Nitrous Oxide Indirect Emissions in Latvia. ENGINEERING FOR RURAL DEVELOPMENT. Jelgava. Available: http://tf.llu.lv/conference/proceedings2016/Papers/N198.pdf*

Summary of input variables for direct nitrous oxide emission estimation according to methodology explained above are provided in Table 5.36.

Table 5.36 Input values for direct nitrous oxide emission calculations from managed soils 1990-2020

Year	F_{SN}	F_{ON}	$F_{PRP, CPP}$	$F_{PRP, SO}$	F_{CR}
1990	*131.40*	*51.15*	*15.67*	*0.69*	*32.56*
1995	*11.50*	*25.21*	*5.18*	*0.38*	*13.74*
2000	*23.00*	*18.88*	*3.55*	*0.21*	*12.41*
2005	*40.90*	*19.19*	*3.91*	*0.23*	*18.02*
2006	*42.70*	*19.50*	*3.84*	*0.26*	*16.48*
2007	*46.10*	*19.88*	*4.18*	*0.31*	*20.42*
2008	*47.50*	*18.88*	*4.15*	*0.37*	*21.01*
2009	*51.90*	*18.43*	*4.27*	*0.41*	*21.48*
2010	*59.50*	*18.18*	*4.37*	*0.42*	*19.79*
2011	*59.80*	*17.69*	*4.46*	*0.45*	*20.03*
2012	*65.20*	*17.42*	*4.76*	*0.46*	*25.97*
2013	*69.70*	*17.85*	*5.20*	*0.49*	*24.70*
2014	*72.90*	*18.70*	*5.57*	*0.53*	*26.18*
2015	*75.80*	*18.09*	*5.63*	*0.60*	*32.20*
2016	*78.29*	*17.23*	*5.89*	*0.68*	*30.74*
2017	*77.40*	*18.77*	*5.98*	*0.79*	*30.05*
2018	*74.50*	*16.78*	*6.07*	*0.82*	*25.10*
2019	*80.70*	*17.03*	*6.24*	*0.85*	*33.91*
2020	*84.30*	*16.94*	*6.33*	*0.89*	*36.35*
2020 versus 2019	*+4.5%*	*-0.5%*	*+1.5%*	*+4.8%*	*+7.2%*
2020 versus 1990	*-35.8%*	*-66.9%*	*-59.6%*	*+28.7%*	*+11.6%*

F_{SN} - annual amount of synthetic fertilizer N applied to soils, kt N yr^{-1}
F_{ON} - annual amount of organic N fertilizer applied to soils, kt N yr^{-1}
F_{PRPCPP} - annual amount of urine and dung N deposited by grazing cattle, swine and poultry on pasture, kt N yr^{-1}
F_{PRPSO} - annual amount of urine and dung N deposited by grazing other animals on pasture, kt N yr^{-1}
F_{CR} - annual amount of N in crop residues (above and below ground), kt N yr^{-1}

5.4.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

The uncertainty of activity data is set to 2% according to CSB of Latvia. Uncertainty for organic soils is used the same as in the LULUCF sector. The uncertainty of the default EFs are based on the 2006 IPCC Guidelines and represented in Table 5.35.

5.4.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the national inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the agriculture sector in order to achieve quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings. A complete coverage of the direct and indirect nitrous oxide emissions from managed land requires estimation of emissions for all anthropogenic inputs and activities as F_{SN}, F_{ON}, F_{CR}, F_{PRP}, F_{SOM} and F_{OS}, that is implemented in the inventory. N excretion data are consistent with those used for the manure management emissions calculation. National crop production and synthetic fertilizer consumption statistics is compared with FAO. CSB of Latvia shows efforts to reduce differences between national statistics and FAO data. All calculations mostly are done according to Tier 1. Fluctuations in time series are explained by fluctuations of statistical data, showing that agricultural production numbers in Latvia are highly variable. As production levels are strongly associated with support of famers from state, situation on agriculture products market, agricultural products price changes, local demand of agricultural products and other. All information on activity data and emission calculations are stored and archived in the common FTP folder.

5.4.5 Category-specific recalculations

Recalculations were done due to implementation of recalculated numbers of organic soils area for calculations of N_2O emissions from cultivation of organic soils. Effects on relevant emissions are summarized in in Table 5.37.

Table 5.37 Recalculations of nitrous oxide emissions from organic soils, 1990-2019

Year	N_2O emissions from cultivation of organic soils		
	before recalculation	after recalculation	relative difference
	kt		%
1990	*1.53585*	*1.53585*	*0.0000%*
1991	*1.51371*	*1.51371*	*0.0000%*
1992	*1.49172*	*1.49172*	*0.0000%*
1993	*1.46987*	*1.46987*	*0.0000%*
1994	*1.44817*	*1.44817*	*0.0000%*
1995	*1.42662*	*1.42662*	*0.0000%*
1996	*1.40221*	*1.40221*	*0.0000%*
1997	*1.37806*	*1.37806*	*0.0000%*
1998	*1.35416*	*1.35416*	*0.0000%*
1999	*1.33051*	*1.33051*	*0.0000%*
2000	*1.30712*	*1.30712*	*0.0001%*
2001	*1.26397*	*1.26397*	*0.0001%*
2002	*1.22159*	*1.22158*	*0.0001%*
2003	*1.17997*	*1.17997*	*0.0002%*
2004	*1.13913*	*1.13913*	*0.0002%*
2005	*1.09905*	*1.09905*	*0.0003%*
2006	*1.05975*	*1.05975*	*0.0003%*
2007	*1.02122*	*1.02121*	*0.0004%*
2008	*0.98345*	*0.98345*	*0.0004%*
2009	*0.97269*	*0.97270*	*-0.0018%*
2010	*0.96212*	*0.96213*	*-0.0013%*
2011	*0.95173*	*0.95174*	*-0.0008%*
2012	*0.94152*	*0.94152*	*-0.0003%*
2013	*0.93148*	*0.93148*	*0.0002%*
2014	*0.92392*	*0.92394*	*-0.0017%*
2015	*0.91642*	*0.91643*	*-0.0016%*

Year	N_2O emissions from cultivation of organic soils		
	before recalculation	after recalculation	relative difference
	kt		%
2016	*0.90893*	*0.90895*	*-0.0016%*
2017	*0.91187*	*0.91188*	*-0.0015%*
2018	*0.91481*	*0.91482*	*-0.0014%*
2019	*0.91778*	*0.91700*	*-0.0850%*

5.4.6 Category-specific planned improvements

No improvements are planned for this sector.

5.5 *FIELD BURNING OF AGRICULTURAL RESIDUES (CRF 3.F)*

Notation key – NO is used for reporting field burning of agricultural residues in Latvia. Legislative measures and agricultural residue management practices prohibit field burning of agricultural residues. This is explained by Latvian Administrative Violations Code Section 179 Violation of Fire Safety Regulations.

5.6 *LIMING (CRF 3.G)*

Liming is used to reduce soil acidity and improve plant growth in managed systems, particularly agricultural lands and managed forests. Adding carbonates to soils in the form of lime (e.g., calcic limestone ($CaCO_3$), or dolomite (CA $Mg(CO_3)_2$) leads to CO_2 emissions as the carbonate limes dissolve and release bicarbonate ($2HCO_3^-$), which evolves into CO_2 and water (H_2O). CO_2 emission from additions of carbonate limes to soils are estimated using Tier 1 methodology with the formula from the 2006 IPCC Guidelines (Equation 11.12, page 11.27):

$$\boldsymbol{CO_2 - C\ Emission} = (\boldsymbol{M_{Limestone}} * \boldsymbol{EF_{Limestone}}) + (\boldsymbol{M_{Dolomite}} * \boldsymbol{EF_{Dolomite}}) \tag{5.25}$$

where:

CO_2–C Emission - annual C emissions from lime application, tonnes C yr^{-1}
M - annual amount of calcic limestone ($CaCO_3$) or dolomite (CA $Mg(CO_3)_2$), tonnes yr^{-1}
EF - emission factor, tonne of C (tonne of limestone or dolomite) $^{-1}$

2006 IPCC default emission factors EF=0.12 for limestone and EF=0.13 for dolomite is used for inventory purposes. The uncertainty of them is set as 50%. Statistical data in Latvia provides information on overall consumption of liming material (uncertainty of them is 2%). Amount of used lime and dolomite for this period is estimated based on national expert judgement, according to assumption that both liming materials limestone and dolomite are intensively used in Latvia and create share of consumption 50:50 (1990-2016). In 2017, CSB of Latvia started to report information on use of lime and dolomite 41.0 thousand t and 13.4 thousand t, respectively. For 2018 CSB of Latvia provided information on use of lime and dolomite 59.5 thousand t and 17.2 thousand t, respectively. In 2019, the use of lime and dolomite achieved 76.2 thousand t and 23.3 thousand t, respectively. In 2020, reported numbers are 96.2 and 41.0 housand t, respectively. Activity data and calculated emissions are represented Table 5.38.

Table 5.38 Consumed lime and calculated CO_2 emissions, 1990-2020

Year	Annual amount of consumed liming material (kt year^{-1})	CO_2 emissions (kt)
1990	*779.2*	*357.1*
1995	*2.7*	*1.2*
2000	*10.2*	*4.7*
2005	*3.3*	*1.5*
2006	*3.0*	*1.4*
2007	*10.7*	*4.9*
2008	*6.0*	*2.8*
2009	*8.7*	*4.0*
2010	*4.3*	*2.0*
2011	*17.4*	*8.0*
2012	*21.6*	*9.9*
2013	*28.9*	*13.2*
2014	*41.3*	*18.9*
2015	*43.5*	*19.9*
2016	*49.3*	*22.6*
2017	*54.4*	*24.4*
2018	*76.7*	*34.4*
2019	*99.5*	*44.6*
2020	*137.2*	*61.9*
2020 versus 2019	*+38.6%*	*+38.6%*
2020 versus 1990	*-82.7%*	*-82.7%*

Latvian agricultural land has a tendency of soil acidification. According to information provided by State Plant Protection Service, almost half of agricultural land in Latvia needs both the annual maintenance liming and basic liming of soil to neutralize the soil acidity. Since 1992 soil liming has to be characterized as insufficient. However, liming activities rapidly increase in the last 5 years.

There have been no recalculations performed for this source category this year. There are no planned activities this year that will improve the data quality for this source category.

5.7 *UREA APPLICATION (CRF 3.H)*

CO_2 emission from urea fertilization is estimated with the Equation 11.13 from the 2006 IPCC Guidelines (page 11.32):

$$\boldsymbol{CO_2 - C\ Emission = M * EF} \quad (5.26)$$

where:

CO_2–C Emission - annual C emissions from urea application, tonnes C yr^{-1}
M - annual amount of urea fertilization, tonnes urea yr^{-1}
EF - emission factor, tonne of C (tonnes of urea)$^{-1}$

EF of 0.20 for urea application emission is used for calculations. The default 50% of uncertainty is applied for EF and activity data uncertainty is evaluated as 2%. CSB of Latvia data of urea application is available from 2007. FAO data for 2002 and 2003 is also available. Data for all other years are derived by extrapolation of available statistical values. Therefore, higher uncertainty for urea application in the base year is set for activity data.

Table 5.39 represents activity data and estimated CO_2 emissions from urea fertilization. Urea application on agriculture soils is a minor source of CO_2 emissions in the inventory and contributes with about 0.40% of the agriculture GHG emissions in 2020. However, slight decrease in urea use is observed during last year.

Table 5.39 Urea statistics and calculated CO_2 emissions, 1990-2020

Year	Annual amount of urea fertilization (tonnes yr^{-1})	CO_2 emissions (kt)
1990	*10512*	*7.71*
1995	*920*	*0.67*
2000	*1840*	*1.35*
2001	*2528*	*1.85*
2002	*6078*	*4.46*
2003	*1942*	*1.42*
2004	*1943*	*1.42*
2005	*1944*	*1.43*
2006	*1945*	*1.43*
2007	*1946*	*1.43*
2008	*4323*	*3.17*
2009	*5930*	*4.35*
2010	*5459*	*4.00*
2011	*5798*	*4.25*
2012	*7901*	*5.79*
2013	*5558*	*4.08*
2014	*6445*	*4.73*
2015	*8468*	*6.21*
2016	*10815*	*7.93*
2017	*12921*	*9.48*
2018	*13787*	*10.11*
2019	*13958*	*10.24*
2020	*12413*	*9.10*
2020 versus 2019	*-11.1%*	*-11.1%*
2020 versus 1990	*+18.1%*	*+18.1%*

There have been no recalculations performed for this source category this year. There are no planned activities that will improve the data quality for this source category.

5.8 *OTHER CARBON-CONTAINING FERTILIZERS (CRF 3.I)*

According to information represented by FAO and CSB emissions of other carbon-containing fertilizers are below the 5% (0.004-0.007%) of the national total GHG emissions and could be characterized as emissions below the threshold of significance in Latvia. Therefore for Latvia notation key NE is used.

5.9 *OTHER (CRF 3J)*

There is no information on other sources in Latvia. Notation key – NO is used.

6 LAND-USE, LAND-USE CHANGE AND FORESTRY (CRF 4)

6.1 *OVERVIEW OF SECTOR*

From 1990 to 2013 and from 2016 to 2019 Land Use, Land Use Change and Forestry (LULUCF) sector was a net sink (as the removals in the sector exceeded the emissions). In 2020, total emissions of aggregated GHGs in LULUCF sector were 646.57 kt CO_2 eq. (Figure 6.1, Table 6.1, Table 6.2). Aggregated net removals of the GHG reduced by 105% in 2020 compared to 1990 mostly due to increase of harvest rate; however, ageing of forests resulted in the increase of natural mortality and reduction of increment. Increased harvest rate impact is reflected also in the decrease of the net CO_2 removals in living biomass in Forest Land in 2014, 2015 and 2020 when LULUCF sector was a net source of GHG emissions. The harvest rate is dependant on increased availability of forest resources in mature forests.

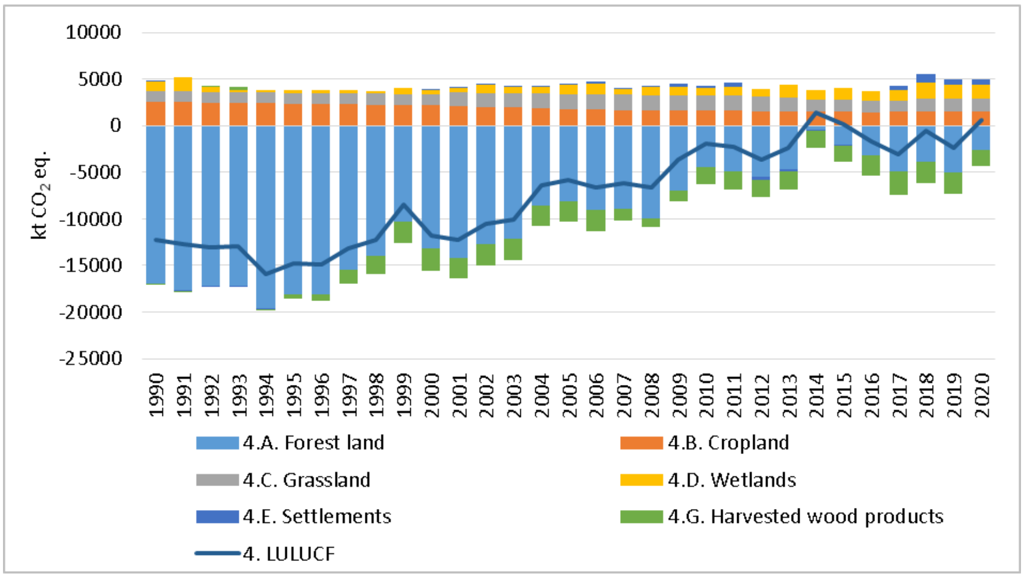

Figure 6.1 Summary of net emissions (positive sign) and removals (negative sign) in the LULUCF sector by land-use category and HWP (kt CO_2 eq.)

According to the 2006 IPCC Guidelines land area is divided into six land-use categories (Forest Land, Cropland, Grassland, Wetlands, Settlements and Other Land). In Latvia, LULUCF sector comprises emissions and removals arising from Forest Land, Cropland, Grassland, Wetlands and Settlements divided into the subcategories "lands remaining in the same land-use category for the last 20 years" and "lands converted to present land use during the past 20 years". Other land is considered as unmanaged land and does not contain considerable amount of organic carbon in any of carbon pools and the emissions and removals are not reported. Emissions and removals from HWP are included in the LULUCF estimates. The information about area of all land use categories since 2009 comes from the National forest inventory (NFI). Until submission 2019 land use changes were identified by using NFI data supported with other spatial data (e.g., aerial photographs and satellite images). Since submission 2020 land use changes are calculated by the method that uses the most recent NFI data and auxiliary information provided by the land parcel information system (LPIS) and stand-wise forest inventory[163]. The new

[163] *Krumsteds L.L., Ivanovs J., Jansons J., Lazdins A. 2019. Development of Latvian land use and land use change matrix using geospatial data of National Forest Inventory. Agronomy Research 17(6), p. 2295–2305, DOI: 10.15159/AR.19.195.*

method introduces elaborated GIS and spreadsheet tools that considerably improve the quality of the activity data by eliminating possible errors of manual calculations and by reducing non-existing land use changes like conversion of cropland to grassland and vice versa, through linearization of the land use change trends.

Summary of net emissions and removals in the LULUCF sector by land-use category and HWP is shown in Table 6.1. Decrease of CO_2 removals in living biomass in forest land is associated with increase of the harvesting rate, increase of mortality and reduction of increment of living biomass in forest land.

Table 6.1 Summary of net emissions and removals in the LULUCF sector by land-use category and HWP (positive figures indicate emissions, negative removals) (kt CO_2 eq.)

Category	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
4. LULUCF	*-12300.85*	*-14745.99*	*-11754.19*	*-5830.39*	*-1879.51*	*189.49*	*-1649.05*	*-3102.18*	*-576.89*	*-2405.88*	*646.57*
4.A Forest Land	*-16911.59*	*-18097.81*	*-13137.99*	*-8136.25*	*-4457.84*	*-1991.78*	*-3176.33*	*-4901.74*	*-3817.46*	*-5012.00*	*-2610.22*
living biomass	*-17804.84*	*-17845.63*	*-11783.12*	*-6886.02*	*-492.59*	*-1517.16*	*-2390.01*	*-4216.30*	*-3761.20*	*-5085.04*	*-2952.74*
dead wood	*-546.24*	*-1778.40*	*-3000.38*	*-2679.13*	*-5431.58*	*-2053.42*	*-2414.38*	*-2344.18*	*-2172.59*	*-1725.49*	*-1375.11*
litter	*-6.45*	*-8.52*	*-23.26*	*-31.01*	*-35.62*	*-44.30*	*-41.92*	*-39.54*	*-37.15*	*-34.97*	*-40.13*
organic soils	*1393.62*	*1436.81*	*1442.06*	*1431.64*	*1447.33*	*1548.46*	*1598.77*	*1649.09*	*1699.40*	*1696.42*	*1701.75*
biomass burning	*52.32*	*97.94*	*226.71*	*28.27*	*54.63*	*74.64*	*71.20*	*49.18*	*454.09*	*137.08*	*56.01*
4.B Cropland	*2567.26*	*2380.65*	*2178.47*	*1812.46*	*1620.72*	*1472.76*	*1462.15*	*1512.28*	*1543.56*	*1557.04*	*1524.42*
living biomass	*-6.46*	*-7.30*	*-7.30*	*-7.08*	*-2.49*	*-68.68*	*-67.68*	*-23.52*	*1.84*	*-0.09*	*-37.21*
dead organic matter	*-1.24*	*-0.90*	*-0.55*	*-0.16*	*43.80*	*38.98*	*39.66*	*40.46*	*41.19*	*53.02*	*53.95*
mineral soils	*0.00*	*0.00*	*0.00*	*0.00*	*0.45*	*1.48*	*1.66*	*1.83*	*2.01*	*2.24*	*2.47*
organic soils	*2574.96*	*2388.85*	*2186.31*	*1819.70*	*1578.93*	*1500.86*	*1488.38*	*1493.36*	*1498.34*	*1501.67*	*1504.99*
4(III) N mineralization	*0.00*	*0.00*	*0.00*	*0.00*	*0.04*	*0.13*	*0.14*	*0.16*	*0.17*	*0.19*	*0.21*
4.C Grassland	*1139.65*	*1125.35*	*1151.77*	*1610.66*	*1629.53*	*1264.36*	*1250.49*	*1126.50*	*1332.29*	*1351.63*	*1365.31*
living biomass	*-20.23*	*-22.01*	*-0.12*	*72.21*	*31.95*	*-73.72*	*-63.29*	*-171.20*	*17.16*	*-89.17*	*-79.81*
dead organic matter	*-3.88*	*-2.99*	*43.70*	*244.05*	*233.88*	*60.16*	*51.32*	*41.91*	*66.00*	*180.97*	*180.78*
organic soils	*1163.66*	*1150.26*	*1107.77*	*1294.02*	*1363.24*	*1277.31*	*1262.34*	*1255.55*	*1248.76*	*1259.33*	*1264.17*
biomass burning	*0.10*	*0.10*	*0.42*	*0.38*	*0.47*	*0.61*	*0.13*	*0.23*	*0.38*	*0.50*	*0.17*
4.D Wetlands	*1042.57*	*343.45*	*472.87*	*924.79*	*747.67*	*1361.36*	*965.51*	*1132.83*	*1796.63*	*1472.61*	*1493.78*
living biomass	*-68.17*	*-96.37*	*-104.72*	*-101.76*	*-165.36*	*-63.72*	*-63.53*	*-66.95*	*1.58*	*-26.35*	*5.63*
dead organic matter	*-13.09*	*-13.60*	*-10.63*	*-8.46*	*-41.38*	*-62.57*	*-57.68*	*-65.63*	*52.96*	*52.32*	*50.86*
organic soils	*1123.83*	*453.42*	*588.22*	*1035.02*	*954.41*	*1487.65*	*1086.72*	*1265.41*	*1742.09*	*1446.64*	*1437.29*
4.E Settlements	*27.38*	*-22.39*	*3.15*	*149.05*	*340.72*	*-98.86*	*-51.99*	*520.53*	*862.50*	*555.04*	*596.88*
living biomass	*20.32*	*-59.23*	*-58.76*	*-18.05*	*10.95*	*-633.28*	*-631.05*	*-99.64*	*190.49*	*-76.14*	*-65.37*
dead organic matter	*-5.82*	*-4.96*	*2.71*	*52.00*	*121.47*	*172.30*	*176.95*	*178.17*	*190.10*	*124.16*	*130.15*
mineral soils	*0.00*	*9.79*	*10.82*	*23.27*	*47.20*	*84.42*	*95.37*	*106.32*	*117.27*	*123.87*	*130.46*
organic soils	*10.64*	*21.37*	*34.82*	*68.96*	*120.49*	*205.82*	*225.26*	*244.62*	*263.98*	*277.07*	*290.15*
4(III) N mineralization	*2.24*	*10.65*	*13.56*	*22.88*	*40.61*	*71.88*	*81.48*	*91.07*	*100.66*	*106.08*	*111.50*
4.G Harvested Wood Products	*-166.11*	*-475.42*	*-2422.65*	*-2191.54*	*-1761.23*	*-1819.98*	*-2100.74*	*-2494.66*	*-2296.69*	*-2332.62*	*-1726.14*
4(IV) Indirect N_2O Emissions from Managed	*0.00*	*0.19*	*0.21*	*0.45*	*0.91*	*1.65*	*1.86*	*2.07*	*2.29*	*2.42*	*2.55*

Category	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
Soils											

Table 6.2 Summary of net emissions and removals in the LULUCF sector by different gases (positive figures indicate emissions, negative removals)

Emissions, unit	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020
Total emissions, kt CO_2 eq.	*-12300.85*	*-14745.99*	*-11754.19*	*-5830.39*	*-1879.51*	*189.49*	*-1649.05*	*-3102.18*	*-576.89*	*-2405.88*	*646.57*
CO_2 kt	*-13401.95*	*-15874.86*	*-12897.27*	*-6918.30*	*-2996.67*	*-1045.33*	*-2929.77*	*-4430.08*	*-1994.47*	*-3803.72*	*-758.81*
CH_4 kt	*22.20*	*22.28*	*22.54*	*20.37*	*21.20*	*25.57*	*27.05*	*28.58*	*31.62*	*31.02*	*31.29*
N_2O kt	*1.83*	*1.92*	*1.95*	*1.94*	*1.97*	*2.00*	*2.03*	*2.06*	*2.10*	*2.09*	*2.09*
NO_x kt	*0.18*	*0.27*	*0.47*	*0.10*	*0.09*	*0.11*	*0.09*	*0.08*	*0.35*	*0.15*	*0.09*
CO kt	*12.86*	*18.86*	*32.87*	*6.09*	*5.81*	*6.86*	*6.51*	*5.56*	*24.07*	*9.64*	*5.97*

The definitions (based of NFI) of carbon pools are as follows:

- Living biomass consist of above-ground biomass (all biomass of living vegetation, both woody and herbaceous, above the soil including stems, stumps, branches, bark, seeds, and foliage and below-ground biomass (all biomass of live roots and stump, fine roots of less than 2 mm diameter are excluded because these often cannot be distinguished empirically from soil organic matter or litter)). Forest understory is a relatively small component of the above-ground biomass carbon pool and it is excluded from calculation in the inventory time series.
- Dead wood consists of all non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface, dead roots down to a diameter of 2 mm, and stumps. Litter includes all non-living biomass with a size greater than the limit for soil organic matter (2 mm) and less than the minimum diameter chosen for dead wood (bottom diameter above 6 cm), lying dead, in various states of decomposition above or within the mineral or organic soil. This includes the litter layer as usually defined in soil typologies. Live fine roots above the mineral or organic soil (with diameter less than 2 mm) are included in litter where they cannot be distinguished from it empirically.
- Soil carbon is organic carbon in mineral and organic soils (including peat) to a 30 cm depth. Live fine roots of less than 2 mm are included with soil organic matter.

The LULUCF sector is important in Latvia's GHG balance due to the fact that more than half of the country area is covered with forests and due to long history of sustainable forest management which secured continuous increase of growing stock in forests since beginning of 20th century (from 101 m^3 ha^{-1} in 1935 to 218 m^3 ha^{-1} in 2020)[164]. According to data provided by NFI[165] total forest area (including afforested lands) in 2020 was 3241.51 kha (50.2% of total country area). Total area of land converted to forest land in 2020 was 110.56 kha. Twenty years transition period is considered for land use changes, therefore area of forest land remaining forest land is increasing during recent years, but area of lands converted to forest is decreasing, because area converted to forest until 2000 (including) is now reported as forest land remaining forest land. The same approach is applied to conversion of cropland to grassland and other land use changes.

Overview of calculation methods and types of EFs for the LULUCF sector is shown in Table 6.3. In the forest land category removals and emissions associated with living biomass and soil were estimated using mixed approach of Tier 1 and Tier 2 and country specific activity data, like increment and harvesting figures, mortality rate in forests, wood density values, biomass expansion factors (BEFs), carbon stock in biomass, as well as the land use information.

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[164] *Latvia's Forests During 20 Years of Independence. Available: https://www.zm.gov.lv/public/ck/files/ZM/mezhi/buklets/MN_20_EN.pdf and NFI data http://www.silava.lv/userfiles/file/Meza%20statistiska%20inventarizacija/Kopsavilkumi%202014%20II%20cikls%204gadi.xlsx; http://www.silava.lv/userfiles/file/Meza%20statistiska%20inventarizacija/Kopsavilkumi_2019_III_cikls(3).xlsx*

[165] *Methodology of Activity 1.1 "Monitoring of Forest Resources" of the National Forest Inventory (Nacionālā meža monitoringa 1.1. aktivitātes ''Meža resursu monitorings'' metodika). Available: http://www.silava.lv/userfiles/file/Nacionalais%20meza%20monitorings/Me%C5%BEa%20resursu%20monitoringa%20metodika%2026_04_2013.pdf (in Latvian). Translation in english is included in Report "Improvement of quality assurance and quality control system in land use, land use change and forestry sector in Latvia", pp. 33-65. Available: https://drive.google.com/drive/folders/0Bxv4jQ_04jXZNTM5aGNDTVdRVzQ.*

Estimation of conversion of land use from cropland to grassland was introduced in 2011 to represent land use changes associated with reduction of area of cropland. According to the results of study by Bardule et al. (2017), soil carbon stock changes (CSCs) in mineral soils should not be reported when the land use change from cropland to grassland or vice versa are estimated by the NFI, because there is not statistically significant difference between soil carbon stock in these land use categories[166].

Table 6.3 Overview of methods and emission factors used in calculations of GHG emissions from the LULUCF sector

CRF	Source	CO_2		CH_4		N_2O	
		Methods	EF	Methods	EF	Methods	EF
4.A	**Forest land**						
4.A.1	Forest Land Remaining Forest Land	*Tier 1, Tier 2*	*CS, D*	*Tier 1, Tier 2*	*D*	*Tier 1, Tier 2*	*D*
4.A.1	4(V) Biomass Burning	*Tier 1*	*D*	*Tier 1, Tier 2*	*D*	*Tier 1, Tier 2*	*D*
4.A.2	Land Converted to Forest Land	*Tier 2*	*CS*	-	-	-	-
4(II)	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	*Tier 1*	*D*	*Tier 1*	*D*	*Tier 1*	*D*
4.B	***Cropland***						
4.B.1	Cropland Remaining Cropland	*Tier 2*	*CS*	-	-	-	-
4.B.2	Land Converted to Cropland	*Tier 2, Tier 3*	*CS*	-	-	*Tier 1*	*CS*
4(II)	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	-	-	*Tier 1*	*D*	-	-
4.C	***Grassland***						
4.C.1	Grassland Remaining Grassland	*Tier 2*	*CS*	*Tier 1*	*D*	*Tier 1*	*D*
4.C.1	4(V) Biomass Burning	-	-	*Tier 1*	*D*	*Tier 1*	*D*
4.C.2	Land Converted to Grassland	*Tier 1, Tier 2 Tier 3*	*CS, D*	-	-	-	-
4(II)	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	-	-	*Tier 2*	*CS*	-	-
4.D	***Wetland***						
4.D.1	Wetlands Remaining Wetlands	*Tier 2*	*CS*	-	-	-	-
4.D.2	Land Converted to Wetlands	*Tier 1*	*D*	-	-	-	-
4(II)	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	*Tier 1, Tier 2*	*CS, D*	*Tier 1, Tier 2*	*CS,D*	*Tier 2*	*CS*
4.E	***Settlements***						
4.E.1	Settlements Remaining Settlements	*Tier 2*	*CS*	-	-	*Tier 1*	*D*
4.E.2	Land Converted to Settlements	*Tier 1, Tier 2*	*CS, D*	-	-	*Tier 1*	*D*
4.G	**Harvested Wood Products**	*Tier 2*	*CS*	-	-	-	-

[166] *Bardule A., Lupikis A., Butlers A., Lazdins A. 2017. Organic carbon stock in different types of mineral soils in cropland and grassland in Latvia. Zemdirbyste-Agriculture, 104, 1, p. 3–8.*

Emissions of GHG due to forest fires in LULUCF sector are calculated using data about areas of forest fires provided by the State Forest Service (SFS).

Net emissions due to production of the HWPs are calculated according to methodology of 2013 IPCC Kyoto Protocol Supplement. CO_2 emissions due to roundwood production in deforested land are calculated using instantaneous oxidation method.

Knowledge about dynamics of dead wood in forest lands improves by adding more recent data from NFI inventories, both in terms of mortality rate and decay periods, because forest management principles have significantly changed since 1990, for instance, in the 80^{ths} it was a common practice to debark stumps and to incinerate harvesting residues to reduce risk of distribution of pests. Nowadays this practice is not used any more in State owned forests and in very limited amount is used in private forests. Instead of that extraction of the residues for biofuel production becomes more common. Comparison of different sources of information about dead wood (NFI and internationally reported data) demonstrates constant increase of dead wood stock in forests during the last decade; however, it could be also result of several extreme weather events. Mortality rate excluding extreme events was elaborated in 2012 on the base of the NFI data (sample plots measured in 2006 and 2012) for the FMRL calculations[167]. Both, mortality rate and increment factors improve by usage of newly available NFI and research data.

Emissions from drained organic and mineral soils are calculated using both default EFs of the IPCC Wetlands Supplement and country-specific EFs (results of scientific studies), as well as national activity data. CO_2 emissions from drained organic soils in forest land, cropland, grassland and peatlands drained for peat extraction are calculated using results of scientific studies (country-specific EFs: 0.52 tonnes C ha^{-1} annually in forest land, 4.8 tonnes C ha^{-1} in cropland, 4.4 tonnes C ha^{-1} in grassland, and 1.2 tonnes C ha^{-1} in peatlands drained for peat extraction) [168,169,170]. Information about area of drained mineral and organic soils in forest land is taken from the NFI (total area of forest types on drained soils). Until submission 2018 information on area of organic soils in farmland was taken from summaries of land surveys based on field measurements completed in 60^{ths}, 70^{ths} and early 80^{ths}, but since submission 2018 area of organic soils in cropland and grassland is reported according to the research results[171].

[167] *Lazdiņš A., Donis J., Strūve L. 2012. Projekts "Latvijas meža apsaimniekošanas radītās ogļskābās gāzes (CO_2) piesaistes un siltumnīcefekta gāzu (SEG) emisiju references līmeņa aprēķina modeļa izstrāde" (Project "Elaboration of model for estimation of GHG emissions and CO_2 removals due to forest management").*

[168] *Lupikis A., Lazdins A. 2017. Soil carbon stock changes in transitional mire drained for forestry in Latvia: A case study. Proceedings of 23rd Annual International Scientific Conference "Research for Rural Development 2017", p. 55-61, DOI: 10.22616/rrd.23.2017.008.*

[169] *Licite I., Lupikis, A. 2020. Impact of land use practices on greenhouse gas emissions from agriculture land on organic soils. Proceedings of 19th International Scientific Conference Engineering for Rural Development, 1823–1830. DOI: 10.22616/ERDev.2020.19.TF492*

[170] *Lazdiņš A., Lupiķis A. 2019. LIFE REstore project contribution to the greenhouse gas emission accounts in Latvia. In: A. Priede, A. Gancone (Eds.), Sustainable and responsible after-use of peat extraction areas (pp. 21–52). Baltijas Krasti.*

[171] *Lazdiņš A., Bārdule A., Butlers A., Lupiķis A., Okmanis M., Bebre I., … Petaja G. 2016. Projekts "Aramzemes un ilggadīgo zālāju apsaimniekošanas radīto siltumnīcefekta gāzu (SEG) emisiju un oglekļa dioksīda (CO_2) piesaistes uzskaites sistēmas pilnveidošana un atbilstošu metodisko risinājumu izstrādāšana" (Project "Improving the accounting system of CO_2 removals and GHG emissions due to management practices in cropland and grassland and development of methodological solutions"). 2016. gada starpziņojums, No. 101115/S109, p. 123. Available: https://drive.google.com/open?id=0Bxv4jQ_04jXZRExSMWhPMWhDNDg.*

The further implementation of improved quantitative results of modelling (using Yasso) to characterize CSCs in mineral soils in forest land, cropland and grassland is in progress according to improvement plan (summary in Chapter 10.4).

Key categories in LULUCF sector in 2020 in Latvia are summarised in Table 6.4. The most significant key category according to the level assessment (Approach 1) and trend assessment (Approach 1) relates to Forest land remaining forest land.

Table 6.4 Key categories in LULUCF in 2022 submission

Category	*Gas*	*Identification criteria*
4.A.1 Forest Land remaining Forest Land – Carbon stock change, dead wood	CO_2	*L1,L2,T1,T2*
4.A.1 Forest Land remaining Forest Land – Carbon stock change, living biomass	CO_2	*L1,L2,T1,T2*
4.A.1 Forest Land remaining Forest Land – Carbon stock change, organic soil	CO_2	*L1,L2,T1,T2*
4.A. Forest land – 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils, total organic soils	CO_2	*L1,L2*
4.A. Forest land – 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils, total organic soils	N_2O	*L1,L2,T1,T2*
4.A. Forest land – 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils, total organic soils	CH_4	*L1,L2,T1,T2*
4.A.2 Land converted to Forest Land – Carbon stock change, living biomass	CO_2	*L1,T1*
4.B. Cropland 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	*L1,L2,T2*
4.B.1 Cropland remaining Cropland – Carbon stock change, organic soil	CO_2	*L1,L2,T1,T2*
4.B.1 Land converted to Cropland – Carbon stock change, forest land converted to cropland, dead organic matter	CO_2	*L1*
4.B.1 Cropland remaining Cropland – Carbon stock change, living biomass	CO_2	*L2,T2*
4.B.2 Land converted to Cropland – Carbon stock change, organic soil	CO_2	*L1,L2,T1,T2*
4.C. Grassland – 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils	CH_4	*L1,L2,T2*
4.C.1 Grassland remaining Grassland – Carbon stock change, organic soil	CO_2	*L1,L2,T1,T2*
4.C.1 Grassland remaining Grassland – Carbon stock change, living biomass	CO_2	*L2,L2,T1,T2*
4.C.2 Land converted to Grassland – Carbon stock change, organic soil	CO_2	*L1,L2,T1,T2*
4.C.2 Land converted to Grassland – Carbon stock change, forest land converted to grassland, living biomass	CO_2	*L1*
4.C.2 Land converted to Grassland – Carbon stock change, forest land converted to grassland, dead organic matter	CO_2	*L1,L2*
4.D. Wetlands 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils, Peat extraction from lands, rewetted organic soils	CO_2	*L2,T2*
4.D. Wetlands 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils, Peat extraction from lands, rewetted organic soils	CH_4	*L1,L2,T2*
4.D. Wetlands 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils, Peat extraction from lands, drained organic soils	CO_2	*L1,L2,T1*
4.D.1 Wetlands remaining Wetlands – Carbon stock change, dead organic matter	CO_2	*L1,T1*
4.D.1 Wetlands remaining Wetlands – Carbon stock change, living biomass	CO_2	*T1,T2*
4.D.1 Wetlands remaining Wetlands – Carbon stock change, organic soils	CO_2	*L1,L2*
4.D.2 Land Converted to Wetland - Carbon stock change, organic soils	CO_2	*L2,T2*

Category	Gas	Identification criteria
4.E.1 Settlements remaining Settlements – Carbon stock change, living biomass	CO_2	L1,L2,T1,T2
4.E.2 Land converted to Settlements – Carbon stock change, dead organic matter	CO_2	L1
4.E.2 Land converted to Settlements – Carbon stock change, living biomass	CO_2	L1,L2,T2
4.E.2 Land converted to Settlements – Carbon stock change, mineral soils	CO_2	L1
4.E.2 Land converted to Settlements – Carbon stock change, organic soils	CO_2	L1,L2,T1,T2
4.E.2 Lands converted to settlements – Direct nitrous oxide (N_2O) emissions from nitrogen (N) mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils	N_2O	L1,L2,T1,T2
4.G. Harvested wood products	CO_2	L1,L2,T1,T2

The most important improvements in this submission are related to continuous improvement of activity data.

6.2 LAND-USE DEFINITIONS AND THE CLASSIFICATION SYSTEMS USED AND THEIR CORRESPONDENCE TO THE LULUCF CATEGORIES

For the GHG inventory, land area and inland water bodies are classified according to the 2006 IPCC Guidelines. Definitions of the IPCC land-use categories in the national GHG inventory is provided in Table 6.5.

Table 6.5 National application of IPCC land-use categories

IPCC category	National land use categories and definitions fits to IPCC categories
Forest land	*Land of a minimum area of 0.1 ha with potential tree crown cover of more than 20% and with the potential of trees to reach a minimum height of 5 m at maturity. Young natural stands and all plantations established for the forestry purposes, which have to reach a crown density of 20% or tree height of 5 m. Areas normally forming part of the forest area, which are temporarily unstocked as a result of human intervention or natural causes, but which are expected to revert to forest. For linear formations, a minimum width of 20 m is applied.*
Cropland	*Arable land, including orchards and extensively managed arable lands (ploughed at least once per 20 years). Animal feeding glades (periodically ploughed areas if forest used for wild animal feeding), which according to national land use classification belong to forest land.*
Grassland	*Pastures, glades and bush-land which do not fit to forest definition. Vegetated areas on non-forest lands complying to forest definition where land use type can be easily returned to grassland by cutting grass and small trees without legal requirement of transformation of the land use, but except grassland used in forage production and extensively managed cropland reported under cropland. Non-forest lands with average diameter of trees at the breast height less than 2 cm are reported under grassland's category.*
Wetlands	*All inland water bodies (rivers, ponds, lakes), swamps (constantly wet areas where height of trees cannot reach more than 5 m and ground vegetation consists mostly of sphagnum and different sword grasses), flood-lands (usually small areas suffering from exceeding water periodically); alluvial lands (larger glades and bush-lands suffering from exceeding water).*
Settlements	*Land under buildings including yards and gardens as well as land necessary to maintain and to access those buildings, land under roads including buffer zones, forest infrastructure including ditches and their management bands, as well as seed orchards, forest nurseries and fire-breaks, drainage systems in cropland and grassland, other infrastructure – buffer zones of industrial networks, quarries*

IPCC category	National land use categories and definitions fits to IPCC categories
	etc., but excluding peat extraction sites.
Other land	*Dunes not covered by woody vegetation.*

The information about area of all land use categories since 2009 comes from the NFI. Information about grassland, cropland, wetlands and other lands provided by the State Land Service of Latvia are used for reference – to estimate potential errors in the NFI data as well as to estimate the area of cropland and grassland in 1990.

Until submission 2019 conversion of cropland to grassland was estimated using remote sensing method comparing vegetation index in the NFI sample plots listed as cropland or grassland[172].

Since submission 2020 new method for calculation of land use changes using the most recent NFI data and auxiliary information provided by the land parcel information system (LPIS) and stand-wise forest inventory was implemented (Krumsteds et al., 2019)[173]. In general, the new method introduces elaborated GIS tools that considerably improve the quality of the activity data by eliminating possible errors of manual calculations and by reducing non-existing land use changes like conversion of cropland to grassland and vice versa, through linearisation of the land use change trends, e.g., NFI teams mark area as a grassland if the area is not ploughed for several years, in spite the area is used for crop production during the previous visit of NFI team. In most of the cases it is temporal abandonment due to crop rotation and in the next visit (in 5 years) the area will be sown again. Such temporal changes affects 5-10% of farmlands annually and about 200 kha (8% of farmlands) during 5 years cycle, resulting in very messy land use matrix. New methodology was necessary to exclude temporal changes from accounting of land use changes. After implementation of new methodology reported land use changes decreased in average more then 10 times. Temporal changes are successfully eliminated from the land use matrix. LPIS data and NFI at the same time ensures correct crop/biomass production data from all areas. According to Krumsteds et al. (2019), new calculation method considerably reduces uncertainty of the land-use estimates by usage of auxiliary data that increase accuracy of determination of final land-use category. Information of recalculated land use data are used to determine more precise land use information for each individual plot. Added auxiliary data is land parcel information system (LPIS), which is maintained by Rural Support Service. LPIS data provides information about permanent and cultivated grassland and cropland areas. If grassland in NFI plot intersects with a polygon of sown grassland in LPIS the land use category is changed to cropland. This eliminates potential errors where field measurement teams during field work have reported grassland as a land use category, but the grassland is sown and regularly cultivated and possibly will be ploughed next season to change the cultivated crop. Furthermore, the method already contains the solution for non-completed NFI cycles. Basically, the land use changes are estimated on the base of 20%, 40%, 60%, 80% and, finally, 100% of NFI data, as soon as new measurement years are added. For the NFI plots where land use category depends on the most recent inventory data, but those are not available, the model takes land use data from the previous NFI cycle (in some cases it means land use changes, in some cases changes are avoided). Additionally, in cropland and grassland LPIS data are used to set actual land use category.

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[172] *Lazdiņš A., Zariņš J. 2012. Projekts "Vēsturiskās (1990. gada) apsaimniekoto aramzemju platības noteikšana un līdz 2009. gadam notikušo aramzemju platības izmaiņu novērtēšana" (Project "Estimation of area of managed croplands and change of cropland's area until 2009").*

[173] *Krumsteds L.L., Ivanovs J., Jansons J., Lazdins A. 2019. Development of Latvian land use and land use change matrix using geospatial data of National forest inventory. Agronomy Research 17(6), p. 2295–2305, DOI: 10.15159/AR.19.195.*

The areas of IPCC land-use categories based on the NFI data and Latvia's total land area according to the CSB data are given in Table 6.6.

Table 6.6 Areas of IPCC land-use classes in 1990-2020 (1000 ha)

Year	Total country area	Forest land	Cropland	Grassland	Settlements	Wetland	Other land
1990	*6458.95*	*3177.53*	*2061.23*	*547.31*	*292.55*	*374.90*	*5.44*
1991	*6458.95*	*3178.92*	*2051.31*	*555.93*	*292.62*	*374.72*	*5.44*
1992	*6458.95*	*3180.32*	*2041.39*	*564.56*	*292.70*	*374.55*	*5.44*
1993	*6458.95*	*3181.72*	*2031.47*	*573.18*	*292.77*	*374.37*	*5.44*
1994	*6458.95*	*3183.12*	*2021.55*	*581.80*	*292.85*	*374.20*	*5.44*
1995	*6458.95*	*3184.51*	*2011.63*	*590.43*	*292.92*	*374.03*	*5.44*
1996	*6458.95*	*3193.17*	*1995.08*	*597.38*	*293.08*	*374.80*	*5.44*
1997	*6458.95*	*3201.82*	*1978.52*	*604.34*	*293.24*	*375.58*	*5.44*
1998	*6458.95*	*3210.48*	*1961.97*	*611.30*	*293.40*	*376.36*	*5.44*
1999	*6458.95*	*3219.13*	*1945.42*	*618.25*	*293.56*	*377.14*	*5.44*
2000	*6458.95*	*3227.79*	*1928.87*	*625.21*	*293.72*	*377.92*	*5.44*
2001	*6458.95*	*3228.03*	*1877.69*	*675.46*	*292.40*	*379.94*	*5.44*
2002	*6458.95*	*3228.27*	*1826.50*	*725.71*	*291.08*	*381.95*	*5.44*
2003	*6458.95*	*3228.50*	*1775.32*	*775.95*	*289.76*	*383.97*	*5.44*
2004	*6458.95*	*3228.74*	*1724.14*	*826.20*	*288.44*	*385.99*	*5.44*
2005	*6458.95*	*3228.98*	*1672.95*	*876.45*	*287.12*	*388.01*	*5.44*
2006	*6458.95*	*3229.22*	*1621.77*	*926.70*	*285.80*	*390.03*	*5.44*
2007	*6458.95*	*3229.46*	*1570.59*	*976.94*	*284.48*	*392.04*	*5.44*
2008	*6458.95*	*3229.69*	*1519.40*	*1027.19*	*283.16*	*394.06*	*5.44*
2009	*6458.95*	*3234.06*	*1509.90*	*1030.05*	*284.34*	*395.16*	*5.44*
2010	*6458.95*	*3238.43*	*1500.39*	*1032.91*	*285.51*	*396.27*	*5.44*
2011	*6458.95*	*3242.80*	*1490.89*	*1035.77*	*286.69*	*397.37*	*5.44*
2012	*6458.95*	*3247.17*	*1481.38*	*1038.63*	*287.86*	*398.47*	*5.44*
2013	*6458.95*	*3251.54*	*1471.88*	*1041.48*	*289.04*	*399.57*	*5.44*
2014	*6458.95*	*3250.22*	*1471.56*	*1039.00*	*293.11*	*399.63*	*5.44*
2015	*6458.95*	*3248.89*	*1471.24*	*1036.51*	*297.18*	*399.69*	*5.44*
2016	*6458.95*	*3247.57*	*1470.92*	*1034.02*	*301.25*	*399.75*	*5.44*
2017	*6458.95*	*3246.25*	*1470.61*	*1031.54*	*305.32*	*399.81*	*5.44*
2018	*6458.95*	*3244.92*	*1470.29*	*1029.05*	*309.39*	*399.86*	*5.44*
2019	*6458.95*	*3243.21*	*1467.72*	*1031.88*	*311.04*	*399.69*	*5.40*
2020	*6458.95*	*3241.51*	*1465.16*	*1034.71*	*312.69*	*399.52*	*5.37*

Area of cropland and grassland in LULUCF reporting is synchronized with Agriculture reporting. It is considered that all forest land, grassland, cropland and settlements are managed. Detailed land use change matrices are provided in Table 6.8; summary – in Table 6.7.

Table 6.7 Summary of land use change matrix (1000 ha)

Changes	To Forest land	To Cropland	To Grassland	To Settlements	From Wetland (managed)	To Wetland	To Other land
1990 (initial area)	*3155.79*	*2073.22*	*560.73*	*289.06*	*48.15*	*326.56*	*5.44*
From Forest land	-	*5.26*	*46.57*	*25.61*	*0.00*	*25.81*	*0.00*
From Cropland	*57.40*	-	*632.95*	*15.25*	*0.00*	*12.66*	*0.00*
From Grassland	*96.56*	*97.22*	-	*12.26*	*0.00*	*12.67*	*0.00*
From Settlements	*21.04*	*3.90*	*5.86*	-	*0.00*	*1.30*	*0.00*
From Wetland	*6.45*	*0.90*	*0.00*	*2.30*	-	*6.37*	*0.00*

Changes	To Forest land	To Cropland	To Grassland	To Settlements	From Wetland (managed)	To Wetland	To Other land
(managed)							
From Wetland	7.46	2.92	7.29	0.31	0.00	-	0.00
From Other land	0.07	0.00	0.00	0.00	0.00	0.00	-
2020 (final area)	3241.51	1465.16	1034.71	312.69	32.13	367.39	5.37

Table 6.8 Land use change matrix (1000 ha)

Changes	To Forest land	To Cropland	To Grassland	To Settlements	From Wetland (managed)	To Wetland	To Other land
	Land use change 1990						
Initial area	3155.79	2073.22	560.73	289.06	48.15	326.56	5.44
From Forest land	3155.79*	NO	NO	NO	NO	NO	NO
From Cropland	5.34	2057.97*	7.78	1.91	NO	0.21	NO
From Grassland	16.19	3.23	539.53*	1.50	NO	0.29	NO
From Settlements	NO	NO	NO	289.06*	NO	NO	NO
From Wetland (managed)	0.21	0.03	NO	0.07	47.63*	0.21	NO
From Wetland	NO	NO	NO	NO	NO	326.56*	NO
From Other land	NO	NO	NO	NO	NO	NO	5.44*
Final area	3177.53	2061.23	547.31	292.55	47.63	327.26	5.44
	Land use change 1995						
From Forest land	3183.12*	NO	NO	NO	NO	NO	NO
From Cropland	0.54	2011.28*	9.60	NO	NO	0.14	NO
From Grassland	0.65	0.32	580.83*	NO	NO	NO	NO
From Settlements	NO	NO	NO	292.85*	NO	NO	NO
From Wetland (managed)	0.21	0.03	NO	0.07	45.05*	0.21	NO
From Wetland	NO	NO	NO	NO	NO	328.63*	NO
From Other land	NO	NO	NO	NO	NO	NO	5.44*
Final area	3184.51	2011.63	590.43	292.92	45.05	328.98	5.44
	Land use change 2000						
From Forest land	3217.85*	NO	0.61	0.09	NO	0.58	NO
From Cropland	3.60	1927.75*	13.77	NO	NO	0.31	NO
From Grassland	6.13	0.96	610.83*	NO	NO	0.33	NO
From Settlements	NO	NO	NO	293.56*	NO	NO	NO
From Wetland (managed)	0.21	0.03	NO	0.07	42.47*	0.21	NO
From Wetland	NO	0.13	NO	NO	NO	334.03*	NO
From Other land	NO	NO	NO	NO	NO	NO	5.44*
Final area	3227.79	1928.87	625.21	293.72	42.47	335.45	5.44
	Land use change 2001						
From Forest land	3222.81*	NO	2.93	0.66	NO	1.40	NO
From Cropland	1.63	1871.41*	54.88	0.26	NO	0.69	NO
From Grassland	1.36	6.17	616.91*	0.06	NO	0.72	NO

Changes	To Forest land	To Cropland	To Grassland	To Settlements	From Wetland (managed)	To Wetland	To Other land
From Settlements	*1.89*	*0.08*	*0.37*	*291.36**	*NO*	*0.03*	*NO*
From Wetland (managed)	*0.21*	*0.03*	*NO*	*0.07*	*41.95**	*0.21*	*NO*
From Wetland	*0.14*	*NO*	*0.36*	*NO*	*NO*	*334.95**	*NO*
From Other land	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*5.44**
Final area	*3228.03*	*1877.69*	*675.46*	*292.40*	*41.95*	*337.99*	*5.44*
	Land use change 2002						
From Forest land	*3223.04**	*NO*	*2.93*	*0.66*	*NO*	*1.40*	*NO*
From Cropland	*1.63*	*1820.23**	*54.88*	*0.26*	*NO*	*0.69*	*NO*
From Grassland	*1.36*	*6.17*	*667.15**	*0.06*	*NO*	*0.72*	*NO*
From Settlements	*1.89*	*0.08*	*0.37*	*290.04**	*NO*	*0.03*	*NO*
From Wetland (managed)	*0.21*	*0.03*	*NO*	*0.07*	*41.43**	*0.21*	*NO*
From Wetland (unmanaged)	*0.14*	*NO*	*0.36*	*NO*	*NO*	*337.48**	*NO*
From Other land	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*5.44**
Final area	*3228.27*	*1826.50*	*725.71*	*291.08*	*41.43*	*340.52*	*5.44*
	Land use change 2003						
From Forest land	*3223.28**	*NO*	*2.93*	*0.66*	*NO*	*1.40*	*NO*
From Cropland	*1.63*	*1769.05**	*54.88*	*0.26*	*NO*	*0.69*	*NO*
From Grassland	*1.36*	*6.17*	*717.40**	*0.06*	*NO*	*0.72*	*NO*
From Settlements	*1.89*	*0.08*	*0.37*	*288.71**	*NO*	*0.03*	*NO*
From Wetland (managed)	*0.21*	*0.03*	*NO*	*0.07*	*40.92**	*0.21*	*NO*
From Wetland	*0.14*	*NO*	*0.36*	*NO*	*NO*	*340.02**	*NO*
From Other land	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*5.44**
Final area	*3228.50*	*1775.32*	*775.95*	*289.76*	*40.92*	*343.06*	*5.44*
	Land use change 2004						
From Forest land	*3223.52**	*NO*	*2.93*	*0.66*	*NO*	*1.40*	*NO*
From Cropland	*1.63*	*1717.86**	*54.88*	*0.26*	*NO*	*0.69*	*NO*
From Grassland	*1.36*	*6.17*	*767.65**	*0.06*	*NO*	*0.72*	*NO*
From Settlements	*1.89*	*0.08*	*0.37*	*287.39**	*NO*	*0.03*	*NO*
From Wetland (managed)	*0.21*	*0.03*	*NO*	*0.07*	*40.40**	*0.21*	*NO*
From Wetland	*0.14*	*NO*	*0.36*	*NO*	*NO*	*342.55**	*NO*
From Other land	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*5.44**
Final area	*3228.74*	*1724.14*	*826.20*	*288.44*	*40.40*	*345.59*	*5.44*
	Land use change 2005						
From Forest land	*3223.76**	*NO*	*2.93*	*0.66*	*NO*	*1.40*	*NO*
From Cropland	*1.63*	*1666.68**	*54.88*	*0.26*	*NO*	*0.69*	*NO*
From Grassland	*1.36*	*6.17*	*817.90**	*0.06*	*NO*	*0.72*	*NO*
From Settlements	*1.89*	*0.08*	*0.37*	*286.07**	*NO*	*0.03*	*NO*
From Wetland	*0.21*	*0.03*	*NO*	*0.07*	*39.88**	*0.21*	*NO*

Changes	To Forest land	To Cropland	To Grassland	To Settlements	From Wetland (managed)	To Wetland	To Other land
(managed)							
From Wetland	*0.14*	*NO*	*0.36*	*NO*	*NO*	*345.09**	*NO*
From Other land	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*5.44**
Final area	*3228.98*	*1672.95*	*876.45*	*287.12*	*39.88*	*348.13*	*5.44*
	Land use change 2006						
From Forest land	*3224.00**	*NO*	*2.93*	*0.66*	*NO*	*1.40*	*NO*
From Cropland	*1.63*	*1615.50**	*54.88*	*0.26*	*NO*	*0.69*	*NO*
From Grassland	*1.36*	*6.17*	*868.14**	*0.06*	*NO*	*0.72*	*NO*
From Settlements	*1.89*	*0.08*	*0.37*	*284.75**	*NO*	*0.03*	*NO*
From Wetland (managed)	*0.21*	*0.03*	*NO*	*0.07*	*39.37**	*0.21*	*NO*
From Wetland	*0.14*	*NO*	*0.36*	*NO*	*NO*	*347.62**	*NO*
From Other land	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*5.44**
Final area	*3229.22*	*1621.77*	*926.70*	*285.80*	*39.37*	*350.66*	*5.44*
	Land use change 2007						
From Forest land	*3224.23**	*NO*	*2.93*	*0.66*	*NO*	*1.40*	*NO*
From Cropland	*1.63*	*1564.31**	*54.88*	*0.26*	*NO*	*0.69*	*NO*
From Grassland	*1.36*	*6.17*	*918.39**	*0.06*	*NO*	*0.72*	*NO*
From Settlements	*1.89*	*0.08*	*0.37*	*283.43**	*NO*	*0.03*	*NO*
From Wetland (managed)	*0.21*	*0.03*	*NO*	*0.07*	*38.85**	*0.21*	*NO*
From Wetland	*0.14*	*NO*	*0.36*	*NO*	*NO*	*350.16**	*NO*
From Other land	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*5.44**
Final area	*3229.46*	*1570.59*	*976.94*	*284.48*	*38.85*	*353.19*	*5.44*
	Land use change 2008						
From Forest land	*3224.47**	*NO*	*2.93*	*0.66*	*NO*	*1.40*	*NO*
From Cropland	*1.63*	*1513.13**	*54.88*	*0.26*	*NO*	*0.69*	*NO*
From Grassland	*1.36*	*6.17*	*968.64**	*0.06*	*NO*	*0.72*	*NO*
From Settlements	*1.89*	*0.08*	*0.37*	*282.11**	*NO*	*0.03*	*NO*
From Wetland (managed)	*0.21*	*0.03*	*NO*	*0.07*	*38.33**	*0.21*	*NO*
From Wetland	*0.14*	*NO*	*0.36*	*NO*	*NO*	*352.69**	*NO*
From Other land	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*5.44**
Final area	*3229.69*	*1519.40*	*1027.19*	*283.16*	*38.33*	*355.73*	*5.44*
	Land use change 2009						
From Forest land	*3223.25**	*0.48*	*2.70*	*1.50*	*NO*	*1.77*	*NO*
From Cropland	*3.25*	*1503.18**	*11.30*	*1.01*	*NO*	*0.66*	*NO*
From Grassland	*5.45*	*5.47*	*1014.96**	*0.58*	*NO*	*0.73*	*NO*
From Settlements	*0.93*	*0.50*	*0.49*	*281.14**	*NO*	*0.10*	*NO*
From Wetland (managed)	*0.21*	*0.03*	*NO*	*0.07*	*37.82**	*0.21*	*NO*
From Wetland	*0.97*	*0.24*	*0.61*	*0.03*	*NO*	*353.88**	*NO*
From Other land	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*5.44**
Final area	*3234.06*	*1509.90*	*1030.05*	*284.34*	*37.82*	*357.35*	*5.44*

Changes	To Forest land	To Cropland	To Grassland	To Settlements	From Wetland (managed)	To Wetland	To Other land
	Land use change 2010						
From Forest land	3227.62*	0.48	2.70	1.50	NO	1.77	NO
From Cropland	3.25	1493.67*	11.30	1.01	NO	0.66	NO
From Grassland	5.45	5.47	1017.81*	0.58	NO	0.73	NO
From Settlements	0.93	0.50	0.49	282.31*	NO	0.10	NO
From Wetland (managed)	0.21	0.03	NO	0.07	37.30*	0.21	NO
From Wetland	0.97	0.24	0.61	0.03	NO	355.50*	NO
From Other land	NO	NO	NO	NO	NO	NO	5.44*
Final area	3238.43	1500.39	1032.91	285.51	37.30	358.97	5.44
	Land use change 2011						
From Forest land	3231.99*	0.48	2.70	1.50	NO	1.77	NO
From Cropland	3.25	1484.17*	11.30	1.01	NO	0.66	NO
From Grassland	5.45	5.47	1020.67*	0.58	NO	0.73	NO
From Settlements	0.93	0.50	0.49	283.49*	NO	0.10	NO
From Wetland (managed)	0.21	0.03	NO	0.07	36.78*	0.21	NO
From Wetland	0.97	0.24	0.61	0.03	NO	357.11*	NO
From Other land	NO	NO	NO	NO	NO	NO	5.44*
Final area	3242.80	1490.89	1035.77	286.69	36.78	360.59	5.44
	Land use change 2012						
From Forest land	3236.36*	0.48	2.70	1.50	NO	1.77	NO
From Cropland	3.25	1474.66*	11.30	1.01	NO	0.66	NO
From Grassland	5.45	5.47	1023.53*	0.58	NO	0.73	NO
From Settlements	0.93	0.50	0.49	284.66*	NO	0.10	NO
From Wetland (managed)	0.21	0.03	NO	0.07	36.27*	0.21	NO
From Wetland	0.97	0.24	0.61	0.03	NO	358.73*	NO
From Other land	NO	NO	NO	NO	NO	NO	5.44*
Final area	3247.17	1481.38	1038.63	287.86	36.27	362.20	5.44
	Land use change 2013						
From Forest land	3240.73*	0.48	2.70	1.50	NO	1.77	NO
From Cropland	3.25	1465.16*	11.30	1.01	NO	0.66	NO
From Grassland	5.45	5.47	1026.39*	0.58	NO	0.73	NO
From Settlements	0.93	0.50	0.49	285.84*	NO	0.10	NO
From Wetland (managed)	0.21	0.03	NO	0.07	35.75*	0.21	NO
From Wetland	0.97	0.24	0.61	0.03	NO	360.35*	NO
From Other land	NO	NO	NO	NO	NO	NO	5.44*
Final area	3251.54	1471.88	1041.48	289.04	35.75	363.82	5.44
	Land use change 2014						
From Forest land	3248.31*	0.38	0.56	1.92	NO	0.36	NO
From Cropland	0.26	1468.90*	1.48	1.00	NO	0.23	NO

Changes	To Forest land	To Cropland	To Grassland	To Settlements	From Wetland (managed)	To Wetland	To Other land
From Grassland	1.27	2.03	1036.72*	1.25	NO	0.22	NO
From Settlements	0.05	0.09	NO	288.83*	NO	0.07	NO
From Wetland (managed)	0.21	0.03	NO	0.07	35.23*	0.21	NO
From Wetland	0.12	0.13	0.23	0.03	NO	363.31*	NO
From Other land	NO	NO	NO	NO	NO	NO	5.44*
Final area	3250.22	1471.56	1039.00	293.11	35.23	364.40	5.44
	Land use change 2015						
From Forest land	3246.99*	0.38	0.56	1.92	NO	0.36	NO
From Cropland	0.26	1468.58*	1.48	1.00	NO	0.23	NO
From Grassland	1.27	2.03	1034.23*	1.25	NO	0.22	NO
From Settlements	0.05	0.09	NO	292.90*	NO	0.07	NO
From Wetland (managed)	0.21	0.03	NO	0.07	34.72*	0.21	NO
From Wetland	0.12	0.13	0.23	0.03	NO	363.88*	NO
From Other land	NO	NO	NO	NO	NO	NO	5.44*
Final area	3248.89	1471.24	1036.51	297.18	34.72	364.97	5.44
	Land use change 2016						
From Forest land	3245.66*	0.38	0.56	1.92	NO	0.36	NO
From Cropland	0.26	1468.26*	1.48	1.00	NO	0.23	NO
From Grassland	1.27	2.03	1031.75*	1.25	NO	0.22	NO
From Settlements	0.05	0.09	NO	296.97*	NO	0.07	NO
From Wetland (managed)	0.21	0.03	NO	0.07	34.20*	0.21	NO
From Wetland	0.12	0.13	0.23	0.03	NO	364.46*	NO
From Other land	NO	NO	NO	NO	NO	NO	5.44*
Final area	3247.57	1470.92	1034.02	301.25	34.20	365.55	5.44
	Land use change 2017						
From Forest land	3244.34*	0.38	0.56	1.92	NO	0.36	NO
From Cropland	0.26	1467.94*	1.48	1.00	NO	0.23	NO
From Grassland	1.27	2.03	1029.26*	1.25	NO	0.22	NO
From Settlements	0.05	0.09	NO	301.04*	NO	0.07	NO
From Wetland (managed)	0.21	0.03	NO	0.07	33.68*	0.21	NO
From Wetland (unmanaged)	0.12	0.13	0.23	0.03	NO	365.03*	NO
From Other land	NO	NO	NO	NO	NO	NO	5.44*
Final area	3246.25	1470.61	1031.54	305.32	33.68	366.12	5.44
	Land use change 2018						
From Forest land	3243.02*	0.38	0.56	1.92	NO	0.36	NO
From Cropland	0.26	1467.62*	1.48	1.00	NO	0.23	NO
From Grassland	1.27	2.03	1026.77*	1.25	NO	0.22	NO
From Settlements	0.05	0.09	NO	305.11*	NO	0.07	NO

Changes	To Forest land	To Cropland	To Grassland	To Settlements	From Wetland (managed)	To Wetland	To Other land
From Wetland (managed)	*0.21*	*0.03*	*NO*	*0.07*	*33.17**	*0.21*	*NO*
From Wetland (unmanaged)	*0.12*	*0.13*	*0.23*	*0.03*	*NO*	*365.61**	*NO*
From Other land	*NO*	*NO*	*NO*	*NO*	*NO*	*NO*	*5.44**
Final area	*3244.92*	*1470.29*	*1029.05*	*309.39*	*33.17*	*366.70*	*5.44*
	Land use change 2019						
From Forest land	*3240.61**	*0.49*	*1.88*	*1.41*	*NO*	*0.54*	*NO*
From Cropland	*0.42*	*1466.47**	*2.67*	*0.60*	*NO*	*0.12*	*NO*
From Grassland	*0.99*	*0.36*	*1027.00**	*0.57*	*NO*	*0.13*	*NO*
From Settlements	*0.53*	*0.18*	*0.21*	*308.38**	*NO*	*0.08*	*NO*
From Wetland (managed)	*0.21*	*0.03*	*NO*	*0.07*	*32.65**	*0.21*	*NO*
From Wetland (unmanaged)	*0.42*	*0.20*	*0.11*	*NO*	*NO*	*365.97**	*NO*
From Other land	*0.04*	*NO*	*NO*	*NO*	*NO*	*NO*	*5.40**
Final area	*3243.21*	*1467.72*	*1031.88*	*311.04*	*32.65*	*367.04*	*5.40*
	Land use change 2020						
From Forest land	*3238.90**	*0.49*	*1.88*	*1.41*	*NO*	*0.54*	*NO*
From Cropland	*0.42*	*1463.91**	*2.67*	*0.60*	*NO*	*0.12*	*NO*
From Grassland	*0.99*	*0.36*	*1029.83**	*0.57*	*NO*	*0.13*	*NO*
From Settlements	*0.53*	*0.18*	*0.21*	*310.03**	*NO*	*0.08*	*NO*
From Wetland (managed)	*0.21*	*0.03*	*NO*	*0.07*	*32.13**	*0.21*	*NO*
From Wetland (unmanaged)	*0.42*	*0.20*	*0.11*	*NO*	*NO*	*366.31**	*NO*
From Other land	*0.04*	*NO*	*NO*	*NO*	*NO*	*NO*	*5.37**
Final area	*3241.51*	*1465.16*	*1034.71*	*312.69*	*32.13*	*367.39*	*5.37*

** total area of land remaining in the same land-use category.*

6.3 INFORMATION ON APPROACHES USED FOR REPRESENTING LAND AREAS AND ON LAND-USE DATABASES USED FOR THE INVENTORY PREPARATION

Spatial approach is used to represent area of forest land, grassland, cropland, wetlands, settlements and other lands. Activity data are provided by the NFI[174]. Source data of the inventory (about 16000 plots representing 400 ha each) are used in calculations of land use and land use changes, as well as drainage and rewetting of forest land. The NFI data are adapted to the harmonized country area for the whole reporting period and to land use categories used in the GHG inventory. Four cycles of the NFI (2004-2008, 2009-2013 and 2014-2018 and 2019-2020, the first two years of 4th cycle) are used in the GHG inventory to determine stock change

[174] *Summary of National Forest Inventory. Available: http://www.silava.lv/userfiles/file/Meza%20statistiska%20inventarizacija/Kopsavilkumi%202014%20I%20cikls%20(2).xlsx; http://www.silava.lv/userfiles/file/Meza%20statistiska%20inventarizacija/Kopsavilkumi%202014%20II%20cikls%20(2).xlsx; http://www.silava.lv/userfiles/file/Meza%20statistiska%20inventarizacija/Kopsavilkumi_2019_III_cikls(3).xlsx*

in living biomass. Average data constructed from the most recent 5 years measurement period of the NFI are used for calculation of mortality and harvest rate.

Until submission 2019 research data (remote sensing studies based on LANDSAT images) was used to identify Forest Land and woody areas converted to Cropland and Settlements. The same approach was applied for identification of extensively managed croplands (e.g., organic farms, where considerable area of arable land is set aside for a longer time period and can be reported in NFI as grassland or forest land, depending on the vegetation). Vegetation index was estimated in all the NFI plots (including outside forest) in satellite image series from 1990, 1995 and 2000 with aim to identify plots where vegetation index permanently changed from the values characteristic for forest to the values characteristic for settlements, grassland and cropland. Area of cropland considerably increased and area of grasslands decreased, when research data were applied, in comparison to the original NFI data, because extensively managed farmlands (organic farms and grassland utilized in forage production) were reported under cropland category as well as lands, which at least once during last 10 years had value of vegetation index typical for cropland.

Area of land converted to settlements before 2004 was estimated using LANDSAT satellite images within the scope of the project "Elaboration and integration into National greenhouse gas inventory report matrices of land use changes of areas belonging to Kyoto protocol article 3.3 and 3.4 activities"[175].

Since submission 2020 new method for calculation of land use changes using the most recent NFI data was implemented[176].

6.4 *FOREST LAND (CRF 4.A)*

6.4.1 Category description

In Latvia, forest land is a net sink, total GHG removals in forest lands, excluding HWP in 2020 were 2610.22 kt CO_2 eq. (Figure 6.2, Figure 6.3).

Forest land category includes emissions and removals resulting from CSCs in living biomass, litter, dead wood, and emissions from drainage and rewetting of organic soils, and biomass burning. Forest land category is subdivided into Forest land remaining forest land (CRF 4.A.1) and Land converted to forest land less than 20 years ago (CRF 4.A.2). The aggregated net GHG emissions from forest land remaining forest land were -3395.27 kt CO_2 eq. in Latvia in 2020, excluding removals in HWP (respectively -1726.14 kt CO_2) and emissions from drainage and rewetting of organic soils (respectively 973.84 kt CO_2 eq.). The net emissions from land converted to forest land in 2020 were -188.80 kt CO_2.

[175]Lazdiņš A., Zariņš J. 2010. Projekts "Mežu zemes izmantošanas maiņas matricas izstrādāšana un integrēšanu nacionālajā siltumnīcefekta gāzu inventarizācijas pārskatā par Kioto protokola 3.3 un 3.4 pantā minētajiem pasākumiem" (Project "Elaboration and integration into National greenhouse gas inventory report matrices of land use changes of areas belonging to Kyoto protocol Article 3.3 and 3.4 activities").

[176] Krumsteds L.L., Ivanovs J., Jansons J., Lazdins A. 2019. Development of Latvian land use and land use change matrix using geospatial data of National forest inventory. Agronomy Research 17(6), p. 2295–2305, DOI: 10.15159/AR.19.195.

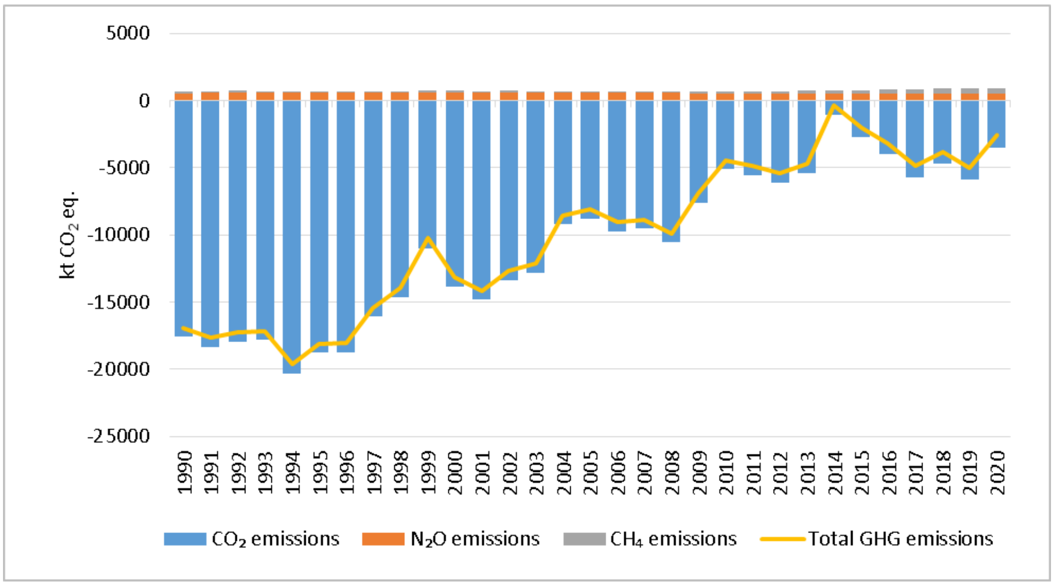

Figure 6.2 Summary of GHG emissions in forest land (kt CO_2 eq.)

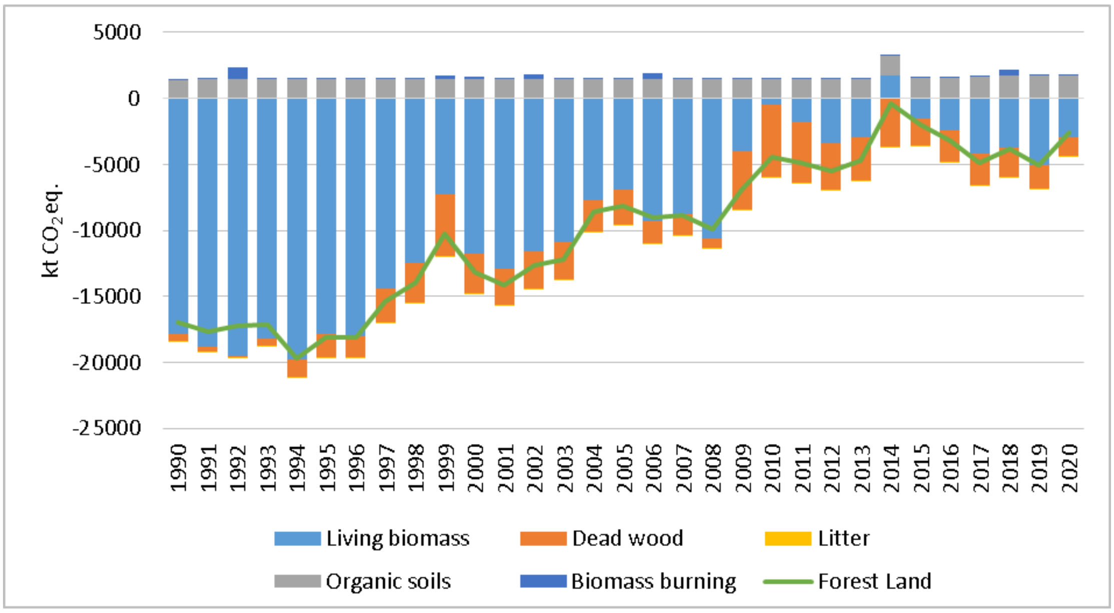

Figure 6.3 Summary of GHG emissions in forest land (kt CO_2 eq.) by source and sink categories

There are several key source and sink categories in forest land in Latvia – CO_2 in Forest Land remaining Forest Land and as well as 3 key source categories (CO_2, CH_4 and N_2O) under 4 (II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils. The NFI and research data are used to estimate time series for areas and gross increment[177]. Species specific mortality rate is applied according to the most recent NFI data as the 5 year average value. Distinction between forest land remaining forest land and land converted to forest land is made according to the age of dominant species in forests on afforested land – if age of dominant species was less than zero in 1990, it is considered as land converted to forest land, in other cases it is considered as forest land remaining forest land.

[177] *Summary of NFI. Available: http://www.silava.lv/petijumi/nacionlais-mea-monitorings.aspx*

Carbon stock changes in above and below ground living and dead biomass are reported in the submission. Decay factor for dead wood including harvesting residues not incinerated on-site is considered 20 years. In forest land remaining forest land, changes of organic carbon in litter and mineral soil organic matter in naturally dry and wet soils are assumed to be zero according to the national research data on carbon stock in forest soil in 2006 and 2012[178]. In addition, results of Yasso modelling proved that mineral soils in forest lands are not a source of emissions (Bārdulis et al., 2017[179]; Lupiķis and Lazdiņš, 2017[180]; Lupiķis, 2017[181]).

Carbon stock changes are reported separately on naturally dry and wet mineral and organic soils and drained mineral and organic soils. Soils are considered organic as defined in the NFI: a soil is classified as organic if the organic layer (H horizon) is at least 20 cm deep. Distribution of the forest site types according to the NFI is shown in Table 6.9. Conversion of forest stands on drained mineral or organic soil to initially wet conditions is reported as rewetting.

Table 6.9 Distribution of drained, naturally dry and wet mineral and organic soils in Latvia's forests (forest land remaining forest land except land converted to forest land > 20 years ago) (1000 ha)

Year	Forest at the end of year	Forest on dry mineral soils	Forest on drained mineral soils	Forest on wet mineral soils	Forest on drained organic soils	Forest on wet organic soils
1990	*3155.79*	*1546.09*	*572.88*	*335.31*	*404.98*	*296.54*
1995	*3155.79*	*1551.31*	*601.72*	*306.38*	*416.96*	*279.42*
2000	*3149.38*	*1548.16*	*600.50*	*305.76*	*416.11*	*278.85*
2001	*3144.40*	*1545.71*	*599.55*	*305.28*	*415.46*	*278.41*
2002	*3139.41*	*1543.26*	*598.60*	*304.79*	*414.80*	*277.97*
2003	*3134.43*	*1540.81*	*597.65*	*304.31*	*414.14*	*277.53*
2004	*3129.45*	*1538.36*	*596.70*	*303.82*	*413.48*	*277.09*
2005	*3124.46*	*1535.91*	*595.75*	*303.34*	*412.82*	*276.65*
2006	*3119.48*	*1533.46*	*594.80*	*302.86*	*412.16*	*276.20*
2007	*3114.49*	*1531.01*	*593.85*	*302.37*	*411.50*	*275.76*
2008	*3109.51*	*1528.56*	*592.89*	*301.89*	*410.85*	*275.32*
2009	*3103.07*	*1538.02*	*569.78*	*297.62*	*406.60*	*291.04*
2010	*3096.63*	*1534.83*	*568.60*	*297.00*	*405.76*	*290.44*
2011	*3090.18*	*1531.64*	*567.42*	*296.38*	*404.92*	*289.83*
2012	*3083.74*	*1528.44*	*566.23*	*295.76*	*404.07*	*289.23*
2013	*3077.30*	*1525.25*	*565.05*	*295.14*	*403.23*	*288.63*
2014	*3074.07*	*1535.54*	*543.01*	*291.31*	*388.23*	*315.98*
2015	*3070.84*	*1533.93*	*542.44*	*291.00*	*387.82*	*315.64*
2016	*3067.61*	*1532.32*	*541.87*	*290.70*	*387.41*	*315.31*
2017	*3064.39*	*1530.71*	*541.30*	*290.39*	*387.01*	*314.98*

[178] *Lazdiņš et al. 2011.-2015. Projekts "Mežsaimniecisko darbību ietekmes uz siltumnīcefekta gāzu emisijām un CO_2 piesaisti novērtējums" (Project "Evaluation of impact of forest management practices on greenhouse gas emissions and CO_2 removals").*
[179] *Bārdulis, A., Lupiķis, A., Stola, J. 2017. Carbon balance in forest mineral soils in Latvia modelled with Yasso07 soil carbon model. Research for Rural Development, 1, p.28–34.*
[180] *Lupiķis, A., Lazdiņš, A. 2017. Oglekļa aprite minerālaugsnēs Latvijas mežos: Modelēts ar Yasso07 augsnes oglekļa modeli [Carbon cycling in mineral soils in Latvian forests: modelled using YASSO07 soil carbon model]. Starptautiskā zinātniski prakstiskā konference Zinātne un prakse nozares attīstībai Mežzinātnes un augstākās mežizsglītības loma nozares konkurētspējas paaugstināšanā tēzes, 17.*
[181] *Lupiķis, A. (31.01.2017). Meža zemju augsnes oglekļa aprite modelēta ar Yasso07 augsnes oglekļa modeli [The soil carbon cycling in forest land modelled using the Yasso07 soil carbon model]. Latvijas Universitātes 75. konference, Rīga, Latvija.*

Year	Forest at the end of year	Forest on dry mineral soils	Forest on drained mineral soils	Forest on wet mineral soils	Forest on drained organic soils	Forest on wet organic soils
2018	*3061.16*	*1529.09*	*540.73*	*290.09*	*386.60*	*314.65*
2019	*3056.85*	*1537.46*	*537.07*	*286.02*	*381.28*	*315.02*
2020	*3052.54*	*1546.14*	*528.09*	*283.99*	*378.38*	*315.93*

The CSC in living biomass is estimated with the Tier 2 method of the 2006 IPCC Guidelines – carbon uptake and release of the living biomass correspond to the mean gross annual increment of forest growing stock, annual harvesting of trees and decay due to natural mortality (Table 6.14). The time series for gross annual increment of growing stock of trees on a forest land remaining forest land are given in Figure 6.4.

Land converted to forest land provides relatively small net increment of growing stock of trees – about 0.09 mill. m^3 in 2020 (Table 6.10). Areas afforested 20 years ago (in 1990-2000) are reported under the forest land remaining forest land. Losses due to harvesting and natural mortality are reported using NFI data.

The dynamics of CSCs in living biomass are very much affected by commercial felling. The accessibility of forest resources was low at the beginning of the 1990s due to implementation of land reform (only privatized forests were available for felling); therefore, felling was also at a low level and the CO_2 sink of living biomass was higher. The felling stock increased during 1990s with implementation of the land reform and reached top average in early 2000s. Updated figures according to the results of the NFI of felling, including biofuel gathering, are shown in Table 6.11.

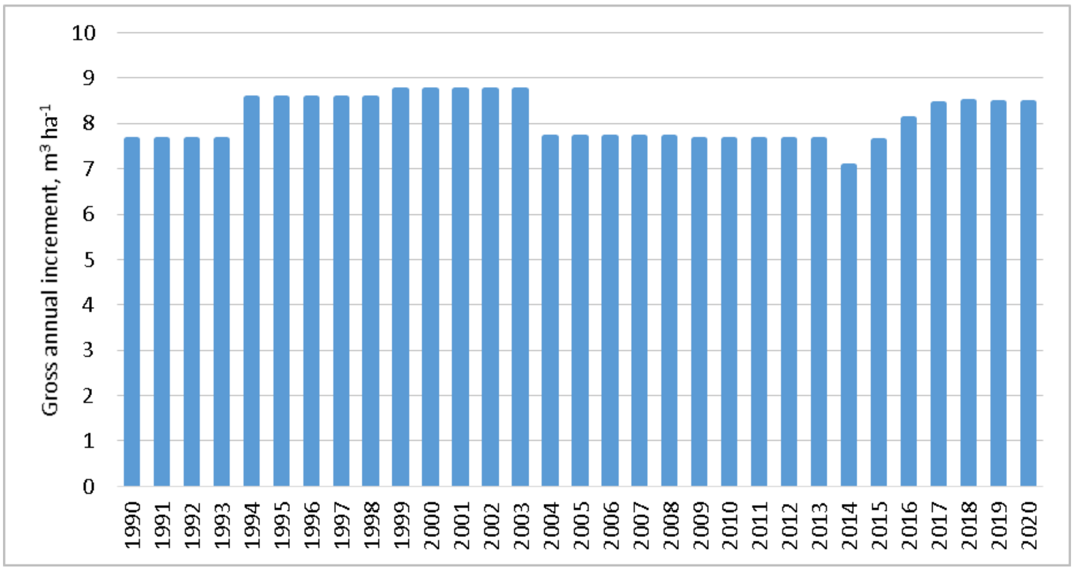

Figure 6.4 Gross annual increment in forest land remaining forest land (m^3 ha^{-1} yr^1)

Table 6.10 Changes of growing stock of timber on the Land converted to forest land[182]

Year	Stock changes, m^3	Stem biomass, 1000 tonnes	Crown biomass, 1000 tonnes	Below-ground biomass, 1000 tonnes	Total biomass, 1000 tonnes
1990	*576.03*	*0.26*	*0.06*	*0.08*	*0.39*

[182] Lazdiņš A. Zariņš J. 2010. Projekts "Mežu zemes izmantošanas maiņas matricas izstrādāšana un integrēšanu nacionālajā siltumnīcefekta gāzu inventarizācijas pārskatā par Kioto protokola 3.3 un 3.4 pantā minētajiem pasākumiem" (Project

Year	Stock changes, m^3	Stem biomass, 1000 tonnes	Crown biomass, 1000 tonnes	Below-ground biomass, 1000 tonnes	Total biomass, 1000 tonnes
1995	*7746.15*	*3.42*	*0.81*	*1.05*	*5.28*
2000	*25505.06*	*11.24*	*2.70*	*3.48*	*17.42*
2001	*31110.87*	*13.71*	*3.30*	*4.24*	*21.25*
2002	*37350.32*	*16.46*	*3.96*	*5.10*	*25.51*
2003	*44216.43*	*19.48*	*4.68*	*6.03*	*30.20*
2004	*51709.74*	*22.72*	*5.53*	*7.06*	*35.31*
2005	*59834.18*	*26.29*	*6.40*	*8.17*	*40.86*
2006	*68595.52*	*30.13*	*7.34*	*9.37*	*46.84*
2007	*78000.56*	*34.27*	*8.35*	*10.65*	*53.26*
2008	*88056.74*	*38.68*	*9.42*	*12.02*	*60.13*
2009	*98919.99*	*43.11*	*10.50*	*13.32*	*66.93*
2010	*72007.97*	*31.39*	*7.64*	*9.70*	*48.72*
2011	*79687.01*	*34.73*	*8.45*	*10.73*	*53.92*
2012	*88169.27*	*38.43*	*9.35*	*11.87*	*59.66*
2013	*97494.64*	*42.49*	*10.34*	*13.13*	*65.97*
2014	*107462.57*	*46.76*	*11.28*	*14.38*	*72.42*
2015	*117962.34*	*51.32*	*12.44*	*15.83*	*79.58*
2016	*113744.67*	*49.26*	*12.06*	*15.23*	*76.55*
2017	*108961.06*	*47.99*	*11.55*	*14.88*	*74.42*
2018	*103567.03*	*44.92*	*11.09*	*13.96*	*69.97*
2019	*97542.71*	*42.78*	*10.39*	*13.24*	*66.41*
2020	*90865.16*	*38.35*	*9.80*	*11.94*	*60.09*

Table 6.11 Harvesting stock (1000 m^3)

Year	Total excluding deforestation	Aspen	Grey alder	Birch	Spruce	Black alder	Oak, ash	Other	Pine
1990	*6297.93*	*577.09*	*302.98*	*1863.39*	*1757.86*	*112.59*	*22.93*	*0.09*	*1773.67*
1991	*5532.35*	*506.94*	*266.15*	*1636.87*	*1544.18*	*98.90*	*20.14*	*0.08*	*1558.06*
1992	*5056.73*	*463.36*	*243.27*	*1496.15*	*1411.42*	*90.40*	*18.41*	*0.07*	*1424.12*
1993	*5992.10*	*549.07*	*288.27*	*1772.90*	*1672.50*	*107.12*	*21.82*	*0.09*	*1687.54*
1994	*7217.42*	*661.35*	*347.22*	*2135.44*	*2014.51*	*129.02*	*26.28*	*0.11*	*2032.63*
1995	*8673.13*	*794.74*	*417.25*	*2566.14*	*2420.83*	*155.05*	*31.58*	*0.13*	*2442.59*
1996	*8515.39*	*780.28*	*409.66*	*2519.47*	*2376.80*	*152.23*	*31.00*	*0.12*	*2398.17*
1997	*11235.71*	*1029.55*	*540.53*	*3324.34*	*3136.09*	*200.86*	*40.91*	*0.16*	*3164.29*
1998	*12628.94*	*1157.22*	*607.56*	*3736.56*	*3524.96*	*225.76*	*45.98*	*0.18*	*3556.66*
1999	*16921.99*	*1550.60*	*814.09*	*5006.76*	*4723.23*	*302.51*	*61.61*	*0.25*	*4765.70*
2000	*13852.01*	*1313.01*	*630.98*	*3839.58*	*3607.21*	*247.63*	*36.73*	*0.20*	*4176.87*
2001	*13007.50*	*1291.82*	*753.41*	*3673.92*	*3242.51*	*206.77*	*37.39*	*0.19*	*3801.69*
2002	*14061.40*	*1419.32*	*959.65*	*3799.35*	*3178.35*	*223.34*	*47.12*	*0.21*	*4434.26*
2003	*14570.14*	*1380.21*	*1157.26*	*4083.51*	*3157.61*	*265.38*	*49.19*	*0.21*	*4476.99*
2004	*13513.26*	*805.82*	*798.72*	*3421.10*	*3523.77*	*248.51*	*79.02*	*0.20*	*4636.34*
2005	*14179.71*	*1356.31*	*988.96*	*4092.22*	*2735.16*	*293.35*	*60.38*	*0.21*	*4653.33*
2006	*12310.61*	*1137.91*	*1038.95*	*3720.67*	*2460.53*	*246.04*	*62.30*	*0.18*	*3644.03*
2007	*12723.12*	*1116.19*	*1007.91*	*3713.93*	*2234.98*	*289.59*	*51.98*	*8.45*	*4308.54*
2008	*11258.48*	*1011.51*	*639.51*	*3298.83*	*1796.04*	*212.35*	*45.94*	*7.47*	*4254.29*
2009	*13439.21*	*1170.55*	*852.24*	*4693.99*	*1970.39*	*308.04*	*46.42*	*8.92*	*4397.57*
2010	*16276.81*	*1450.63*	*1267.45*	*4443.05*	*2782.50*	*285.33*	*84.70*	*10.81*	*5952.35*
2011	*15948.18*	*1263.47*	*4753.57*	*1357.38*	*2561.80*	*236.51*	*62.02*	*11.67*	*5701.76*

"Elaboration and integration into National greenhouse gas inventory report matrices of land use changes of areas belonging to Kyoto protocol Article 3.3 and 3.4 activities").

Year	Total excluding deforestation	Aspen	Grey alder	Birch	Spruce	Black alder	Oak, ash	Other	Pine
2012	*14696.66*	*1189.39*	*4315.33*	*1306.49*	*2415.80*	*285.76*	*76.36*	*9.64*	*5097.89*
2013	*14612.01*	*2694.18*	*1258.01*	*2415.04*	*2042.73*	*824.02*	*118.95*	*2744.15*	*2514.95*
2014	*16473.55*	*3790.71*	*1748.38*	*3378.72*	*2719.85*	*1107.23*	*184.66*	*163.09*	*3380.91*
2015	*16930.17*	*3746.85*	*1996.39*	*3474.33*	*3028.40*	*1049.41*	*153.27*	*180.73*	*3300.79*
2016	*17279.62*	*3501.70*	*2270.45*	*3730.84*	*3070.50*	*1104.79*	*197.09*	*330.18*	*3074.07*
2017	*17238.73*	*3493.41*	*2265.08*	*3722.01*	*3063.23*	*1102.17*	*196.62*	*329.40*	*3066.80*
2018	*17587.98*	*3577.99*	*2635.99*	*3754.46*	*3268.26*	*1093.04*	*172.63*	*349.09*	*2736.52*
2019	*16976.46*	*3378.42*	*3575.81*	*2487.22*	*3249.45*	*1138.84*	*130.63*	*346.46*	*2669.63*
2020	*17655.96*	*1458.62*	*1205.75*	*5783.72*	*3002.71*	*947.38*	*113.27*	*278.02*	*4866.50*

The total area of the land converted to forest land is shown in Table 6.12 and Table 6.13. In 2016 it started to reduce, because area afforested in 1990-2000 in the convention reporting is reported under the forest land remaining forest land category.

Table 6.12 The cumulative area of land converted to forest land (1000 ha)

Year	Land converted to forest land at the end of year	Forest on dry mineral soils	Forest on drained mineral soils	Forest on wet mineral soils	Forest on drained organic soils	Forest on wet organic soils
1990	*21.74*	*21.31*	*0.38*	*0.00*	*0.00*	*0.05*
1991	*23.13*	*21.39*	*1.70*	*0.00*	*0.00*	*0.05*
1992	*24.53*	*22.26*	*1.76*	*0.29*	*0.17*	*0.05*
1993	*25.93*	*22.64*	*2.38*	*0.29*	*0.57*	*0.05*
1994	*27.33*	*22.20*	*3.82*	*0.69*	*0.57*	*0.05*
1995	*28.72*	*23.22*	*4.19*	*0.69*	*0.57*	*0.05*
1996	*38.66*	*31.38*	*5.17*	*0.69*	*1.36*	*0.05*
1997	*48.60*	*40.63*	*5.25*	*0.69*	*1.58*	*0.45*
1998	*58.53*	*48.43*	*6.26*	*0.86*	*2.54*	*0.45*
1999	*68.47*	*57.16*	*7.46*	*0.86*	*2.54*	*0.45*
2000	*78.41*	*64.86*	*8.58*	*1.58*	*2.94*	*0.45*
2001	*83.63*	*68.88*	*9.79*	*1.58*	*2.94*	*0.45*
2002	*88.85*	*73.53*	*10.35*	*1.58*	*2.94*	*0.45*
2003	*94.07*	*78.76*	*10.35*	*1.58*	*2.94*	*0.45*
2004	*99.30*	*83.13*	*10.56*	*1.89*	*3.27*	*0.45*
2005	*104.52*	*87.55*	*11.36*	*1.89*	*3.27*	*0.45*
2006	*109.74*	*91.67*	*12.46*	*1.89*	*3.27*	*0.45*
2007	*114.96*	*96.24*	*12.72*	*1.89*	*3.27*	*0.85*
2008	*120.18*	*101.46*	*12.72*	*1.89*	*3.27*	*0.85*
2009	*131.00*	*112.05*	*12.72*	*2.10*	*3.27*	*0.85*
2010	*120.07*	*101.49*	*12.34*	*2.10*	*3.33*	*0.80*
2011	*129.48*	*111.94*	*11.02*	*2.39*	*3.33*	*0.80*
2012	*138.90*	*121.88*	*10.96*	*2.10*	*3.17*	*0.80*
2013	*148.31*	*131.86*	*10.79*	*2.10*	*2.77*	*0.80*
2014	*148.82*	*133.88*	*9.68*	*1.70*	*2.77*	*0.80*
2015	*149.33*	*134.76*	*9.31*	*1.70*	*2.77*	*0.80*
2016	*141.30*	*128.30*	*8.47*	*1.72*	*2.01*	*0.80*
2017	*133.26*	*120.75*	*8.54*	*1.75*	*1.83*	*0.40*
2018	*125.23*	*114.64*	*7.67*	*1.60*	*0.90*	*0.41*
2019	*117.90*	*108.21*	*6.67*	*1.64*	*0.95*	*0.42*
2020	*110.56*	*102.83*	*5.75*	*0.95*	*0.60*	*0.43*

Table 6.13 Cumulative area of the land converted to forest land more than 20 years ago (1000 ha)

Year	Land Converted to Forest Land >20 years ago	Forest on dry mineral soils	Forest on drained mineral soils	Forest on wet mineral soils	Forest on drained organic soils	Forest on wet organic soils
2010	*21.74*	*21.31*	*0.38*	*0.00*	*0.00*	*0.05*
2011	*23.13*	*21.39*	*1.70*	*0.00*	*0.00*	*0.05*
2012	*24.53*	*22.26*	*1.76*	*0.29*	*0.17*	*0.05*
2013	*25.93*	*22.64*	*2.38*	*0.29*	*0.57*	*0.05*
2014	*27.33*	*22.20*	*3.82*	*0.69*	*0.57*	*0.05*
2015	*28.72*	*23.22*	*4.19*	*0.69*	*0.57*	*0.05*
2016	*38.66*	*31.38*	*5.17*	*0.69*	*1.36*	*0.05*
2017	*48.60*	*40.63*	*5.25*	*0.69*	*1.58*	*0.45*
2018	*58.53*	*48.43*	*6.26*	*0.86*	*2.54*	*0.45*
2019	*68.47*	*57.16*	*7.46*	*0.86*	*2.54*	*0.45*
2020	*78.41*	*64.86*	*8.58*	*1.58*	*2.94*	*0.45*

Summary of assumptions for calculation of forest growing stock changes in forest land remaining forest land is shown in Table 6.14.

Table 6.14 Summary of data for calculation of forest growing stock changes in forest land remaining forest land

Year	Harvesting stock, 1000 m^3	Average mortality, 1000 m^3	Gross annual increment, 1000 m^3	Annual living biomass stock changes (including deforestation), 1000 m^3
1990	*6297.93*	*4066.07*	*24181.15*	*13817.16*
1991	*5532.35*	*4066.07*	*24181.15*	*14582.73*
1992	*5056.73*	*4066.07*	*24181.15*	*15058.35*
1993	*5992.10*	*4066.07*	*24181.15*	*14122.99*
1994	*7217.42*	*4391.08*	*27051.16*	*15442.66*
1995	*8673.13*	*4391.08*	*27051.16*	*13986.96*
1996	*8519.33*	*4389.30*	*27040.18*	*14131.55*
1997	*11239.66*	*4387.51*	*27029.20*	*11402.02*
1998	*12632.89*	*4385.73*	*27018.21*	*9999.60*
1999	*16925.93*	*4549.15*	*27539.16*	*6064.07*
2000	*13855.94*	*4547.30*	*27527.96*	*9124.71*
2001	*13037.34*	*4540.11*	*27484.40*	*9906.95*
2002	*14091.23*	*4532.91*	*27440.83*	*8816.68*
2003	*14599.98*	*4525.72*	*27397.27*	*8271.57*
2004	*13543.06*	*4606.98*	*24070.56*	*5920.51*
2005	*14209.51*	*4599.65*	*24032.22*	*5223.06*
2006	*12340.41*	*4592.31*	*23993.88*	*7061.16*
2007	*12752.92*	*4584.97*	*23955.55*	*6617.65*
2008	*11288.28*	*4577.63*	*23917.21*	*8051.30*
2009	*13512.71*	*6975.11*	*23719.29*	*3231.48*
2010	*16350.30*	*7009.49*	*23836.20*	*476.42*
2011	*16021.67*	*6998.14*	*23797.63*	*777.82*
2012	*14770.15*	*6986.80*	*23759.07*	*2002.11*
2013	*14685.51*	*6975.46*	*23720.50*	*2059.53*
2014	*16565.94*	*6941.09*	*21911.39*	*-1595.65*
2015	*17022.54*	*5771.65*	*23637.10*	*842.92*
2016	*17372.25*	*6147.21*	*25166.92*	*1647.46*
2017	*17329.96*	*6272.22*	*26312.66*	*2710.48*

Year	Harvesting stock, 1000 m^3	Average mortality, 1000 m^3	Gross annual increment, 1000 m^3	Annual living biomass stock changes (including deforestation), 1000 m^3
2018	*17680.17*	*6247.08*	*26480.09*	*2552.84*
2019	*17045.04*	*6240.14*	*26449.88*	*3164.71*
2020	*17726.70*	*5829.94*	*26528.62*	*2971.98*

Further improvement of quantitative results of Yasso modelling to characterize CSCs in mineral soils is in progress according to improvement plan. New/improved results of studies on carbon input through above- and below-ground litter will be available for inclusion in GHG inventory as soon as results will be statistically analyzed and published in peer-reviewed scientific journal.

6.4.2 Methodological issues

6.4.2.1 Forest land remaining forest land (CRF 4.A.1)

Calculations of CSCs and GHG emissions in forest lands are based on activity data provided by the NFI (area, living biomass and dead wood) and Level I forest monitoring data (soil organic carbon). National statistics (SFS) are used to estimate historical commercial felling (1990-2011) related emissions and removals, but since 2012 NFI data are used to estimate emissions due to commercial felling. Historical data are recalculated using empirical coefficient characterizing average ratio between the NFI and stand wise inventory data to retain integrity with recent, NFI base data. The calculation of GHG emissions and CO_2 removals in historical forest lands is based on research report "Elaboration of the model for calculation of the CO_2 removals and GHG emissions due to forest management"[183] and factors and coefficients elaborated within the scope of the research program on impact of forest management on GHG emissions and CO_2 removals[184].

Changes of the carbon stock and GHG emissions are estimated according to the Tier 2 method with country specific data. Tier 2 method (the carbon loss to be subtracted from the carbon removals for the reporting year) is used in calculations of removals and emissions of CO_2 in living biomass.

Methodologies for estimation of CSCs and GHG emissions are merged together into the "Emissions projection & inventory model (EPIM)" spreadsheet tool. Input data are harmonized for UNFCCC reporting and Kyoto Protocol accounting needs.

The concept of the EPIM:

- land use and land use change data are elaborated separately to simplify the structure of the tool, the connection is organized as linked tables;
- main input data – area under different growth and management conditions, gross annual increment, mortality per area, harvesting rate and species composition and others;

[183] *Lazdiņš A., Donis J., Strūve L. 2012. Projekts "Latvijas meža apsaimniekošanas radītās oglskābās gāzes (CO2) piesaistes un siltumnīcefekta gāzu (SEG) emisiju references līmeņa aprēķina modeļa izstrāde" (Project "Elaboration of the model for calculation of the CO2 removals and GHG emissions due to forest management") (No. 5.5-9.1-0070-101-12-91). LVMI Silava, Salaspils. Lazdiņš A., Donis J., Strūve L., 2012b. Latvia's national methodology for reference level of forest management activities (English summary).*

[184] *Lazdiņš et al. 2011-2015. Projekts "Mežsaimniecisko darbību ietekmes uz siltumnīcefekta gāzu emisijām un CO_2 piesaisti novērtējums" (Project "Evaluation of impact of forest management practices on greenhouse gas emissions and CO_2 removals").*

- calculations are done on annual basis using periodic (5 year period) and annual input data;
- historical data (1990-2004) – backward calculation on the base of the NFI data; for 1970-1989 research data and expert judgement assuming linearized data on land use changes are utilized;
- all modules in the spreadsheet are merged together following to the forest management cycle (from growth to decay);
- the tool combines all land use and land use change categories.

Content of the tool (separate calculation sheets):

- living biomass (annual gross increment of living biomass, summary of growing stock and characteristics of biomass);
- mortality (natural reduction of number of living trees, estimation of decay of harvesting residues, calculation of dynamics of carbon stock in dead biomass);
- commercial harvesting (input to the HWP, losses in above-ground and below-ground biomass);
- HWP (CSC in locally originated and consumed HWP);
- emissions from soils (CO_2, CH_4 and N_2O from drained organic soils and CH_4, CO_2 emissions from rewetted soils in forest land and wetlands);
- fire (emissions of CO_2, CH_4 and N_2O due to incineration of harvesting residues and wildfires);
- conversion from forests land to other land uses (CSC in living biomass, dead wood, litter and soil);
- conversion of other land uses to forest land (CSC in living biomass, dead wood, litter and soil);
- cropland (emissions from soil, CSC in living and dead biomass);
- grassland (emissions from soil, CSC in living and dead biomass, wildfires);
- settlements (CSC in soil, living and dead biomass);
- land use changes (CSC in living biomass, dead wood, litter and soil);
- managed wetlands including peat extraction sites, rewetted and flooded lands (emissions from soil, CSC in living and dead biomass).

Module for estimation of the gross annual increment of trees (at the beginning of the calculation period):

- increment figures on the base of the NFI data on growing stock changes and mortality rate[185];

[185] *Donis J. 2011. Projekts "Latvijas meža resursu ilgtspējīgas, ekonomiski pamatotas izmantošanas un prognozēšanas modeļu izstrāde" (Project "Developing models for sustainable and economically feasible utilization and prediction of the availability of forest resources in Latvia"); Lazdiņš A., Donis J., Strūve L. 2012. Projekts "Latvijas meža apsaimniekošanas radītās ogļskābās*

- species, age of stands and dimensions specific gross increment equations for the most common tree species (values specific for birch are used for other tree species);
- species specific wood densities (Table 6.15) and BEFs[186] used for verification of the biomass calculation in NFI (Table 6.16);
- average carbon stock in biomass is provided in Table 6.17.

Biomass equations elaborated by Liepiņš et al. (2017)[187] and the carbon fraction factor are applied at a single tree level already in the NFI database and GHG inventory team receives data recalculated to volume, biomass and carbon stock per NFI plot and extrapolated to country area.

The figures of the gross annual increment of living trees is calculated according to stock change in forest stands with different dominant tree species.

Table 6.15 Wood density[188]

Species	Density, tonnes m^{-3}
Aspen	*0.40*
Grey alder	*0.39*
Birch	*0.49*
Spruce	*0.39*
Black alder	*0.49*
Oak, ash	*0.49*
Other species (mostly *Salix* sp.)	*0.46*
Pine	*0.44*

gāzes (CO_2) piesaistes un siltumnīcefekta gāzu (SEG) emisiju references līmeņa aprēķina modeļa izstrāde" (Project "Elaboration of calculation model for evaluation of GHG emissions and CO_2 removals due to forest management").

[186] Liepiņš J., Lazdiņš A., Liepiņš K. 2015. Above- and below-ground biomass functions for four most commonn trees species in Latvia, in: Abstracts from the International Scientific Conference Knowledge based forest sector, Riga, Latvia, pp. 51–53. Liepins J., Liepins K., Lazdins A. 2015. Biomass equations for the most common tree species in Latvia. Presented at the Adaptation and mitigation: strategies for management of forest ecosystems, Airport hotel ABC, pp. 47–50.

Liepiņš J., Liepiņš K., Lazdiņš A. 2016. Estimation of the biomass stock from growing stock volume, in: Collection of Abstracts. Presented at the 11th International Scientific Conference Students on Their Way to Science, Jelgava, p. 120.

[187] Liepiņš, J., Lazdiņš, A., Liepiņš, K. 2017. Equations for estimating above- and belowground biomass of Norway spruce, Scots pine, birch spp. and European aspen in Latvia. Scandinavian Journal of Forest Research, 1–43, DOI: 10.1080/02827581.2017.1337923.

[188] Lazdiņš et al. 2011-2015. Projekts "Mežsaimniecisko darbību ietekmes uz siltumnīcefekta gāzu emisijām un CO_2 piesaisti novērtējums" (Project "Evaluation of impact of forest management practices on greenhouse gas emissions and CO_2 removals").

Table 6.16 Country specific tree biomass expansion factors to calculate crown and below-ground biomass from stem biomass[189, 190]

Species	Stem biomass to crown biomass	Stem biomass to below-ground biomass
Aspen	*1.20*	*0.27*
Grey alder	*1.22*	*0.28*
Birch	*1.19*	*0.31*
Spruce	*1.41*	*0.39*
Black alder	*1.19*	*0.30*
Oak, ash	*1.19*	*0.30*
Other species	*1.21*	*0.30*
Pine	*1.22*	*0.29*

Table 6.17 Average carbon stock in living biomass[191]

Species	C, kg in tonne of dry biomass (dried at 105 °C temperature)
Aspen	*507*
Grey alder, black alder, oak, ash and other species	*522*
Birch	*521*
Spruce	*528*
Pine	*531*

Mortality and decay:

- species specific coefficients of mortality (Table 6.18) do not depend on size of dominant or undergrowth trees, but on the stand age and average dimensions of trees;
- calculations on the base of the NFI using backward calculation for 5 year period, assuming equal rate of commercial thinning in the 1990s;
- 20 year decomposition period (mortality since 1970 considered in the calculation);
- constant mortality values considered for the period before 1990.

The increase of mortality after 2008 are associated with long-term impact of wind-throws in 2007 and 2010, which reflected in 2nd cycle (2009-2013) of NFI. Another reason for continuous increase of mortality is ageing of forests.

[189] Liepiņš J., Lazdiņš A., Liepiņš K. 2015. Above- and below-ground biomass functions for four most commonn trees species in Latvia, in: Abstracts from the International Scientific Conference Knowledge based forest sector, Riga, Latvia, pp. 51–53. Liepins J., Liepins K., Lazdins A. 2015. Biomass equations for the most common tree species in Latvia. Presented at the Adaptation and mitigation: strategies for management of forest ecosystems, Airport hotel ABC, pp. 47–50.
Liepiņš J., Liepiņš K., Lazdiņš A. 2016. Estimation of the biomass stock from growing stock volume, in: Collection of Abstracts. Presented at the 11th International Scientific Conference Students on Their Way to Science, Jelgava, p. 120.
Liepiņš, J., Lazdiņš, A., Liepiņš, K. 2017. Equations for estimating above- and belowground biomass of Norway spruce, Scots pine, birch spp. and European aspen in Latvia. Scandinavian Journal of Forest Research, 1–43, DOI: 10.1080/02827581.2017.1337923.
[190] Not used in calculation, but for verification of the NFI data and comparison with the default BEFs in the IPCC guidelines
[191] Muiznieks E., Liepins J., Lazdins A. 2015. Carbon content in biomass of the most common tree species in Latvia. Presented at the Latvia University of Agriculture 10th International Scientific Conference „Students on their way to science", Jelgava.

Table 6.18 Average periodic mortality ($m^3 ha^{-1} yr^{-1}$)[192]

Species	1970 - 1993	1994 - 1998	1999 - 2003	2004 - 2008	2009 - 2013	2014	2015	2016	2017	2018	2019	2020
Aspen	*1.64*	*1.95*	*1.97*	*1.92*	*3.35*	*2.99*	*2.57*	*2.60*	*2.54*	*2.60*	*2.33*	*2.36*
Grey alder	*0.30*	*0.33*	*0.36*	*0.48*	*2.41*	*2.56*	*2.18*	*2.29*	*1.79*	*2.33*	*1.75*	*1.80*
Birch	*1.59*	*1.67*	*1.58*	*1.43*	*2.12*	*2.12*	*1.77*	*1.90*	*2.18*	*1.90*	*2.05*	*2.32*
Spruce	*1.61*	*1.76*	*1.94*	*2.05*	*2.77*	*2.79*	*2.38*	*2.22*	*2.18*	*2.15*	*1.92*	*2.02*
Black alder	*1.30*	*1.42*	*1.47*	*1.64*	*2.67*	*2.67*	*2.41*	*2.56*	*2.53*	*2.69*	*2.38*	*2.42*
Oak, ash	*2.29*	*2.66*	*2.67*	*2.87*	*4.43*	*4.90*	*3.50*	*4.07*	*3.52*	*3.73*	*3.76*	*3.31*
Other species	*0.75*	*0.66*	*0.67*	*0.77*	*1.26*	*0.98*	*1.37*	*1.77*	*1.56*	*2.05*	*1.54*	*2.20*
Pine	*1.16*	*1.24*	*1.38*	*1.48*	*1.69*	*1.82*	*1.56*	*1.62*	*1.62*	*1.67*	*2.09*	*1.49*

Commercial felling:

- dominant species specific harvesting data since 1970 (1970-1989 research data[193], 1990-2013 CSB data in combination with NFI data, since 2014 NFI data);
- decomposition of crown and underground biomass – 20 years; species specific wood densities and different BEFs for coniferous and deciduous trees (Table 6.15 and Table 6.16).

Carbon stock in deadwood is calculated by using NFI data on mortality (Table 6.18), harvesting rate (Table 6.11) and share of harvesting residues left on site. Share of carbon stock in deadwood is calculated using NFI data of natural mortality expressed as standing volume of trees that changed destiny from alive to dead between NFI cycles. To calculate deadwood C stock same values of BEF, above- below-ground ratio and ratio of C content are used to recalculate from mortality in volume to mortality in C as for calculation of carbon stock of living biomass. Initial C stock in deadwood is calculated by the same approach as for living biomass (except by using volume of decayed trees instead of living trees) and by adding 20 year decomposition period. Same approach is applied to calculate deadwood from harvesting – amount of deadwood from harvesting residues is calculated by using felling stock 20 year decomposition period is applied. Share of harvesting residues incinerated are deducted from calculation. Trend of carbon stock in deadwood is affected by harvest rate and natural mortality, which in turn is affected by dynamics of forest age class and species distribution. Carbon stock dynamics may seem significant between years in absolute numbers, but relative to dynamics of harvesting rate and annual increment of carbon stock in deadwood is rather consistent, with a higher rate in last decade due to changes in forest age structure.

[192] *Lazdiņš et al. 2011-2015. Projekts "Mežsaimniecisko darbību ietekmes uz siltumnīcefekta gāzu emisijām un CO_2 piesaisti novērtējums" (Project "Evaluation of impact of forest management practices on greenhouse gas emissions and CO_2 removals"); Lazdiņš A., Donis J., Strūve L. 2012. Projekts "Latvijas meža apsaimniekošanas radītās ogļskābās gāzes (CO_2) piesaistes un siltumnīcefekta gāzu (SEG) emisiju references līmeņa aprēķina modeļa izstrāde" (Project "Elaboration of calculation model for evaluation of GHG emissions and CO_2 removals due to forest management").*

[193] *Saliņš Z. 2002. Mežs - Latvijas Nacionālā Bagātība (Forest - The National Wealth of Latvia), Jelgava: Jelgavas tipogrāfija; Saliņš Z. 1999. Meža izmantošana Latvijā: stāvoklis, perspektīvas (Forest use in Latvia: status, perspectives), Jelgava: LLU Meza izmantosanas katedra.*

The methodology for HWP is based on Rüter, S. (2011)[194]. More detailed description follows in further chapters.

Area of organic soils in the forest lands is reported according to structure of distribution of the forest stand types. Total area of organic soils as well as total area of forests was updated according to the research data on land use structure based on the NFI[195].

CO_2 EFs for drained organic soils provided by the IPCC Wetlands Supplement are built on results of few studies implemented in different climatic conditions (western and central Europe) and therefore do not represent conditions in Baltic countries. Thus, several national research projects were conducted[196,197] and national CO_2 EF for drained organic soils in forest land (0.52 tonnes CO_2-C ha^{-1} yr^{-1}) was developed[198]. The study was based on the subsistance and CSC measurements. Since submission 2019, this national CO_2 EF is used to report CO_2 emissions from drained organic soils in forest land. Applied country-specific value (0.52 tonnes CO_2-C ha^{-1} yr^{-1}) is much lower than that in the IPCC Wetlands Supplement (2.6 tonnes CO_2-C ha^{-1} yr^{-1}); however, it is still within the range of the uncertainty of the default factors. The difference is caused by a number of factors. The most important is that the IPCC Wetlands Supplement EFs that theoretically correspond to climate in Latvia, were calculated on the basis of results obtained in the central, western or south-eastern parts of Europe. Taking into account that climatic factors have a significant impact on CO_2 emissions and that in warmer climatic conditions higher emissions occur, the current IPCC Wetlands Supplement factors are not applicable to conditions in Latvia. Also, results of LIFE REstore project show that in Latvia carbon losses in forests with organic soils is 0.23-0.96 tonnes CO_2-C ha^{-1} yr^{-1} depending from soil moisture regime[199]. The studies on CSCs in organic soils continues within the scope of LIFE OrgBalt project and future inventories will be based on country specific Tier 3 modelling approach. In addition, CO_2 EF for drained organic soils in forest land used in other Baltic countries (0.68 t CO_2-C ha^{-1} yr^{-1} in Lithuania and 0.329 t CO_2-C ha^{-1} yr^{-1} in Estonia) are more similar to Latvia's national EFs than EF provided by the IPCC Wetlands Supplement.

Drained organic soil in forest land is source of N_2O and CH_4 emissions. The N_2O EF for drained organic soils is 2.8 kg N_2O-N ha^{-1} yr^{-1} (Table 2.5 of IPCC Wetlands Supplement). CH_4 emissions are calculated by equation 2.6 in the IPCC Wetlands Supplement (equation No. 6.1 in the NIR).

$$\boldsymbol{CH_{4\_organic} = A * ((1 - Frac_{ditch}) * EF_{CH\_4\_land} + Frac_{ditch} * EF_{CH\_4\_ditch})} \quad (6.1)$$

where:

$CH_{4\_organic}$ – annual CH_4 loss from drained organic soils, kg CH_4 yr^{-1}

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[194]Rüter S. 2011. Projection of net emissions from harvested wood products in European Countries. Hamburg: Johann Heinrich von Thünen-Institute (vTI), 63 p, Work Report of the Institute of Wood Tech- nology and Wood Biology, Report No: 2011/1

[195]Lazdiņš A. and Zariņš J. "Elaboration and integration into National greenhouse gas inventory report matrices of land use changes of areas belonging to Kyoto protocol article 3.3 and 3.4 activities".

[196] OÜ Severitas. 2018. Approbation of greenhouse gas measurement methodology in peatlands in Latvia within the scope of LIFE REstore (LIFE14 CCM/LV/001103) project. Author Kairi Sepp, Monitoring report, 15 p.

[197] OÜ Severitas. 2019. Approbation of greenhouse gas measurement methodology in peatlands in Latvia within the scope of LIFE REstore (LIFE14 CCM/LV/001103) project. Author Kairi Sepp, Final report, 20 p.

[198] Lupikis A., Lazdins A. 2017. Soil carbon stock changes in transitional mire drained for forestry in Latvia: A case study. Proceedings of 23rd Annual International Scientific Conference "Research for Rural Development 2017".

[199] Lazdiņš A., Lupiķis, A. 2019. LIFE REstore project contribution to the greenhouse gas emission accounts in Latvia. In: Sustainable and responsible after-use of peat extraction areas, A. Priede & A. Gancone (Eds.), Baltijas Krasti, pp. 21–52. Lazdiņa, D., Lazdiņš, A., Bebre, I., Lupiķis, A., Makovskis, K., Spalva, G., Sarkanābols, T., Okmanis, M., Krīgere, I., Dreimanis, I., Kalniņa, L. 2019. Afforestation. In: Sustainable and responsible after-use of peat extraction areas, A. Priede & A. Gancone (Eds.), Baltijas Krasti, pp. 178–183.

A – land area of drained organic soils in a land-use category, ha
$EF_{CH\_4\_land}$ – emission factor for direct CH_4 emissions from drained organic soils, kg CH_4 ha^{-1} yr^{-1}
$EF_{CH\_4\_ditch}$ – emission factor for CH_4 emissions from drainage ditches, kg CH_4 ha^{-1} yr^{-1}
$Frac_{ditch}$ – fraction of the total area of drained organic soil which is occupied by ditches

The CH_4 EF for organic soils of drained forest land (Table 2.3 and Table 2.4 in the IPCC Wetlands Supplement) is 2.5 kg CH_4 ha^{-1} yr^{-1} and EF for drainage ditches is 217 kg CH_4 ha^{-1} yr^{-1}. Fraction of the total area of drained organic soil that is occupied by ditches is 0.025 (Table 2.4 in the IPCC Wetlands Supplement).

GHG emissions from rewetted organic soils are estimated according to the Tier 1 methods. CO_2 emissions are calculated using equation 3.3 of the IPCC Wetlands Supplement:

$$\boldsymbol{CO_2 - C_{rewetted\ org\ soil} = CO_2 - C_{composite} + CO_2 - C_{DOC}} \tag{6.2}$$

where:

$CO_2 – C_{rewetted\ org\ soil}$ – CO_2 – C emissions/removals from rewetted organic soils, tonnes C yr^{-1}
$CO_2 – C_{composite}$ – CO_2 – C emissions/removals from the soil and non-tree vegetation, tonnes C yr^{-1}
$CO_2 – C_{DOC}$ – off – site CO_2 – C emissions from dissolved organic carbon exported from rewetted organic soils, tonnes C yr^{-1}

Complemented by equations 3.4 and 3.5 of the IPCC Wetlands Supplement.

$$\boldsymbol{CO_2 - C_{composite} = \textstyle\sum_{c,n}(A * EF_{CO_2})} \tag{6.3}$$

where:

$A_{c,n}$ – area of rewetted organic soild in climate zone c and nutrient status n, ha
$EF_{CO2c,n}$ – CO_2 – C emission factor for rewetted organic soils in climate zone c, nutrient status n, tonnes C ha^{-1} yr^{-1}

$$\boldsymbol{CO_2 - C_{DOC} = \textstyle\sum_{c}(A * EF_{DOC\_REWETTED})} \tag{6.4}$$

where:

A_c- area of rewetted organic soils in climate zone c, ha
$EF_{DOC\_rewetted,c}$ – CO_2 – C emission factor from DOC exported from rewetted organic soils in climate zone c, tonnes C ha^{-1} yr^{-1}

EF for CO_2-C (0.5 tonnes CO_2-C ha^{-1} yr^{-1}) is taken from Table 3.1 of the IPCC Wetlands Supplement. N_2O emissions from rewetted organic soils according to the the Tier 1 method are assumed to be negligible and are not estimated ("NA" notation key is reported), CH_4 emissions are calculated applying Tier 1 method using equation 3.7 of the IPCC Wetlands Supplement (equation No. 6.5). Default EF (216 kg CH_4-C ha^{-1} yr^{-1}) from Table 3.3 of IPCC Wetlands Supplement was used (Table 6.19).

$$\boldsymbol{CH_4 - C_{rewetted\ org\ soil} = \frac{\sum_{c,n}(A*EF_{CH4soil})c,n}{1000}} \tag{6.5}$$

where:

$CH_4 – C_{rewetted\ org\ soil}$ – CH_4 – C emissions/removals from rewetted organic soils, tonnes C yr^{-1}
$A_{c,n}$ – area of rewetted organic soils in climate zone c and nutrient status n, ha
$EF_{CH4soils}$ – emission factor from rewetted organic soils in climate zone c and nutrient status n, kg CH_4 – C ha^{-1} yr^{-1}

Table 6.19 Emission factors for rewetted organic soils (tonnes C ha^{-1} yr^{-1})

No	GHG	Emission factor
1	*CO_2*	*0.5*

No	GHG	Emission factor
2	*CH_4*	*0.216*

Rewetting is reported under forest land – conversion of forests on drained organic soils to forest on initially wet soil. The conversion is usually approved by changes in ground vegetation and groundwater table during the site visits. Rewetting usually takes place due to wearing of drainage systems. In 2020, total rewetted area according to comparison of the NFI data is 39.11 kha. It is assumed, that the rewetted area increases linearly during 5 year period – 2.0 kha of forests were rewetted every year from 2009 to 2013, 5.2 kha of forests were rewetted every year from 2014 to 2018, and 1.5 kha of forests were rewetted every year from 2019 to 2020 according to an average figures provided by the NFI. Total emissions from soil due to rewetting in 2020 was 387.76 kt CO_2 eq. (Figure 6.5).

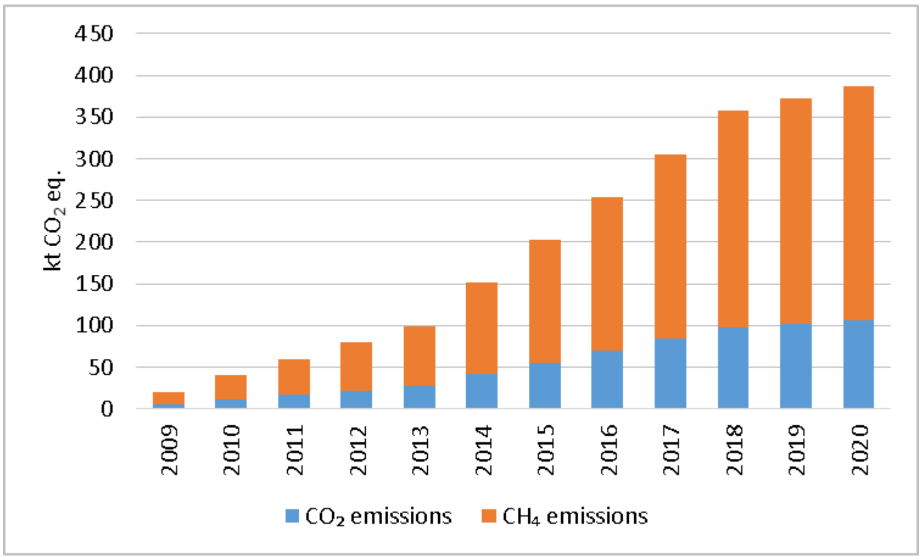

Figure 6.5 Emissions due to rewetting (kt CO_2 eq.)

6.4.2.2 Land converted to forest land (CRF 4.A.2)

Latvia reports CSC in living biomass, dead wood and litter for cropland converted to forest land, grassland converted to forest land, wetland converted to forest land and settlements converted to forest land as well as in organic soils (cropland converted to forest land, grassland converted to forest land, wetland converted to forest land).

Carbon stock change in living biomass in land converted to forest land is calculated using Tier 2 method. C stock changes in living biomass in area of Land converted to Forest land categories are estimated by stock change method, therefore it is not possible to quantify C stock gains and losess separately. C stock losses in living biomass are reported as "IE" and included in C stock gains in living biomass. Losses in living biomass are reported as natural mortality. If by some reasons (for instance, thinning) harvesting took place on afforested area it is also reported in national statistics and reported as C-stock changes related to harvesting in forest land remaining forest land to avoid underestimation of C losses.

Weighted average wood density for a particular year in forest land remaining forest land is used to convert stem volume to biomass. Similarly, average carbon stock in living biomass and BEFs characteristic for particular year were applied to calculation.

It is assumed according to the NFI data based expert judgement that average stock of dead wood, and consequently in litter in forest land remaining forest land and land converted to forest land becomes equal at certain stand age. The assumption is based on the NFI field measurements considering that increment of the dead wood stock in afforested areas will follow linear regression and will reach values characteristic for the forest land (12.6 tonnes C ha^{-1}) within 150 years, which corresponds to 2 generations of trees. The main difference between the 1^{st} and following generations of trees is presence of trees, which corresponds to about 20% of carbon stock in living biomass in mature stands.

Values of average carbon stock in dead wood in 1990-2020 were used in calculation. Similarly, weighted average above-ground and below-ground biomass expansion factors and carbon content in living biomass for a particular year obtained in living biomass calculations are used to convert stem biomass to the total biomass. Two generations of trees (150 years) were considered to properly encompass carbon stock in harvesting residues, stumps and the above-ground fraction of dead trees.

Average carbon stock in litter is 12.14 tonnes C ha^{-1} according to the BioSoil project forest soil inventory data[200]. The same transformation period of 150 years is considered.

Emissions from organic soils in afforested lands were calculated using the same approach as for emissions from drained organic soils on lands remaining forest.

No removals in mineral soil are reported due to conversion to forest land, because there are no scientific evidences of increase of carbon stock in soil after afforestation. The research project that started in 2012 on comparison of carbon stock in cropland remaining cropland and grassland remaining grassland shows no difference in carbon stock between grassland, recently afforest land and forest land remaining forest land in the upper soil layer (0-40 cm)[201].

Methodological work for estimating CSC in living biomass, deadwood and litter for cropland converted to forest land, wetlands converted to forest land and settlements converted to forest land as well as in mineral soils (cropland converted to forest land and settlements converted to forest land) and organic soils (wetlands converted to forest land) is in progress. The preliminary results of the study are published[202]; however, work is continuing to reduce uncertainty, particularly, within the scope of ERAGAS INVENT project.

6.4.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in the Annex 2. Overall description of uncertainty analysis is included in the Section 1.6.

Uncertainties are estimated on the base of the NFI and expert judgement. Uncertainty of emissions from soil are estimated according to data obtained within the scope of the

[200] *Bārdule, A., Bāders, E., Stola, J., Lazdiņš, A. 2009. Forest soil characteristic in Latvia according results of the demonstration project BioSoil. Mežzinātne / Forest Science 20(53): 105-124. Aavailable: http://www.silava.lv/userfiles/file/Mezzinatne%2020(53)2009/8_Bardule_MZ_20-2009.pdf*

[201] *Lazdins, A., Bardule, A., Butlers, A. 2015. Preliminary results of comparison of carbon stock in soil in grassland, cropland and forest land. 54–57; Lazdiņš, A., Bārdule, A., & Stola, J. (2013). Preliminary results of evaluation of carbon stock in historical cropland and grassland. Abstracts of International Baltic Sea Regional Scientific Conference, 56–57.*

[202] *Krumsteds L.L., Lazdins A., Butlers A., Ivanovs J. 2019. Recalculation of forest increment, mortality and harvest rate in Latvia according to updated land use data. Rural Development 2019 (1): 295–299. DOI:10.15544/RD.2019.037*

international forest soil monitoring project BioSoil, study by Lupikis A. & Lazdins A. (2017)[203] and values provided in the IPCC Wetlands Supplement.

The uncertainty of area (Table 6.20) is estimated as standard error of proportion.

Table 6.20 Uncertainty of the forest land use data in 2022 submission

Land use category	Number of NFI plots	Share of NFI plots, %	Uncertainty, %
Forest land	*8322*	*51.5*	*1.5*
forest land remaining forest land	*7885*	*48.8*	*1.6*
drained organic soil	*1116*	*6.9*	*5.3*
other soil	*5040*	*31.2*	*2.3*
land converted to forest land	*437*	*2.7*	*8.0*
drained organic soil	*10*	*0.1*	*43.5*
other soil	*380*	*2.4*	*8.7*

In cases with large data sets, the uncertainty in the mean calculated as plus or minus 1.96 (or approximately 2) multiples of the standard error according to the 2006 IPCC Guidelines Volume 1, Chapter 3. Combined category uncertainty is calculated according to the 2006 IPCC Guidelines Tier 1 – simple propagation of errors.

According to the NFI, uncertainty of growing stock of trees in forest land remaining forest land is 2.3%, in land converted to forest land – 15.6%. Uncertainty of annual increment of growing stock of trees is 2.2%. BEFs utilized in calculations have uncertainty level of 2.2% in average according to the study results. For harvesting stock, uncertainty according to forest regulations is 10%. Uncertainty of dead wood stock is 3.9%. Uncertainty of average carbon stock in litter is 23.1%. Uncertainty of carbon content in wood is 0.14%.

Uncertainty of CSC in organic solis is 296%[204].

95% confidence interval for CH_4 EF for drained organic soil of forest land is -0.6-+5.7 kg CH_4 ha^{-1} yr^{-1} (average uncertainty is 126%), uncertainty range of CH_4 EF for drainage ditches in drained forest land is 41-393 kg CH_4 ha^{-1} yr^{-1} (average uncertainty is 81%) according to the IPCC Wetlands Supplement Table 2.3 and Table 2.4. 95% confidence interval for N_2O-N EF for drained organic soils is -0.57-+6.1 kg N_2O-N ha^{-1} yr^{-1} (average uncertainty is 119%) according to the IPCC Wetlands Supplement, Table 2.5. Uncertainty range of CO_2-C EF for rewetted organic soils is -0.71-+1.71 tonnes CO_2-C ha^{-1} yr^{-1} (average uncertainty is 242%) according to the IPCC Wetlands Supplement, Table 3.1. Uncertainty range of CO_2-C EF for DOC exported from rewetted organic soils is 0.14-0.36 tonnes CO_2-C $ha^{-1}yr^{-1}$ (average uncertainty is 45.8%) according to the IPCC Wetlands Supplement, Table 3.2. 95% range of CH_4-C EF for rewetted organic soils is 0-856 kg CH_4-C ha^{-1} yr^{-1} (average uncertainty is 198%) according to the IPCC Wetlands Supplement, Table 3.3.

6.4.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the LULUCF

[203] Lupikis A., Lazdins A. 2017. Soil carbon stock changes in transitional mire drained for forestry in Latvia: A case study. Proceedings of 23rd Annual International Scientific Conference "Research for Rural Development 2017".

[204] Lupikis A., Lazdins A. 2017. Soil carbon stock changes in transitional mire drained for forestry in Latvia: A case study. Proceedings of 23rd Annual International Scientific Conference "Research for Rural Development 2017".

sector in order to achieve these quality objectives. General and source-specific QC activities are carried out by LSFRI Silava according to the QA/QC guidelines[205].

Quality control procedures listed in the 2006 IPCC Guidelines Chapter 4.4.3 were implemented for all calculations, including elaboration of country specific allometric biomass equations, wood density and carbon content factors. Issues related to QA/QC and verification are discussed at the sectoral meetings.

Manual data check is introduced to compare figures imported into the CRF Reporter and actually calculated values.

Several improvements of inventory were implemented based on the recommendations (findings) of the Trial review of the 2021 GHG inventory for the LULUCF sector of Latvia and the centralized UNFCCC review conducted in 2020.

The NFI data have gone through the following QC measures:

- field gauges and instruments were checked and calibrated;
- new instruments were tested to find possible differences in measurement results compared with the old ones;
- before field surveying, the personnel has had a training period to ascertain that observers are able to use the equipment correctly, that observers do measurements and classifications correctly and that the guidelines and instructions are understood correctly;
- verification measurements were carried out during field seasons in 10% of the NFI plots;
- field data are checked by evaluation if all sample plots are measured, no required information is missing (if missing entries are found, they are completed and re-measurement is done, if necessary), the compatibility between data variables is checked using logical controls;
- calculated results are compared with the results of previous inventories. If considerable or unexpected changes are found, reasons for the changes were clarified and explained.

Work on improvement of tree height and timber equations used in calculations in the NFI and development of verification tools continues therefore changes in the input data provided by the NFI are possible.

The NFI team applies quality guidelines and QA/QC measures to the all work stages. Documentation is in Latvian with brief descriptions of NFI methods and measurements in English[206].

The data based on forest statistics were produced by the LSFRI Silava[207]. Data descriptions are available including the applied definitions, methods of data compilation, reliability and comparability. It was confirmed that all data used in this section cover whole land area of Latvia.

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[205] *Improvement of quality assurance and quality control system in Land Use, Land Use Change and Forestry Sector in Latvia. Available: https://drive.google.com/open?id=0Bxv4jQ_04jXZdEhJVFJ4OVRPTkE*

[206] *Latvijas Republikas Zemkopības ministrija, 2004. Meža statistiskās inventarizācijas veikšanas un mežaudzes sekundāro parametru aprēķināšanas metodika (instrukcija Nr. 10 no 17.03.2004.,). Available: https://drive.google.com/open?id=1PxbGhS0VoIJw-hsgiV3gOfd_h44cBylO*

[207] *Summary of NFI results. Available: http://www.silava.lv/userfiles/file/2010%20nov%20MRM_visi%20mezi_04-08g.xls*

All information related to the preparation of the annual inventory is archived in the centralized archiving system (common FTP folder) in accordance with QA/QC plan.

The country-specific EF used to estimate CO_2 emissions from drained organic soils in forest land was published as a peer-reviewed article and compared to EF used in other countries in the Baltic Sea region. The Latvian value was within uncertainty range of CS EF of other countries in the region.

6.4.5 Category-specific recalculations

For the period from 1990 to 2018, impact of recalculation in negligible (< 1%). For 2019, recalculation is introduced due to improvement of activity data including area of forest land remaining forest land and land converted to forest land. The main reason for recalculation of activity data (area) is delayed accumulation of land use changes data (addition 20% of NFI sample plots are surveyed annually, acquired cumulative data are extrapolated to whole country area) till final recalculation of NFI data at the end of every 5 years period (completed NFI cycle with 100% sample plots surveyed). Summary of the impact of recalculation on the aggregated net GHG emissions from forest land is shown in Figure 6.6.

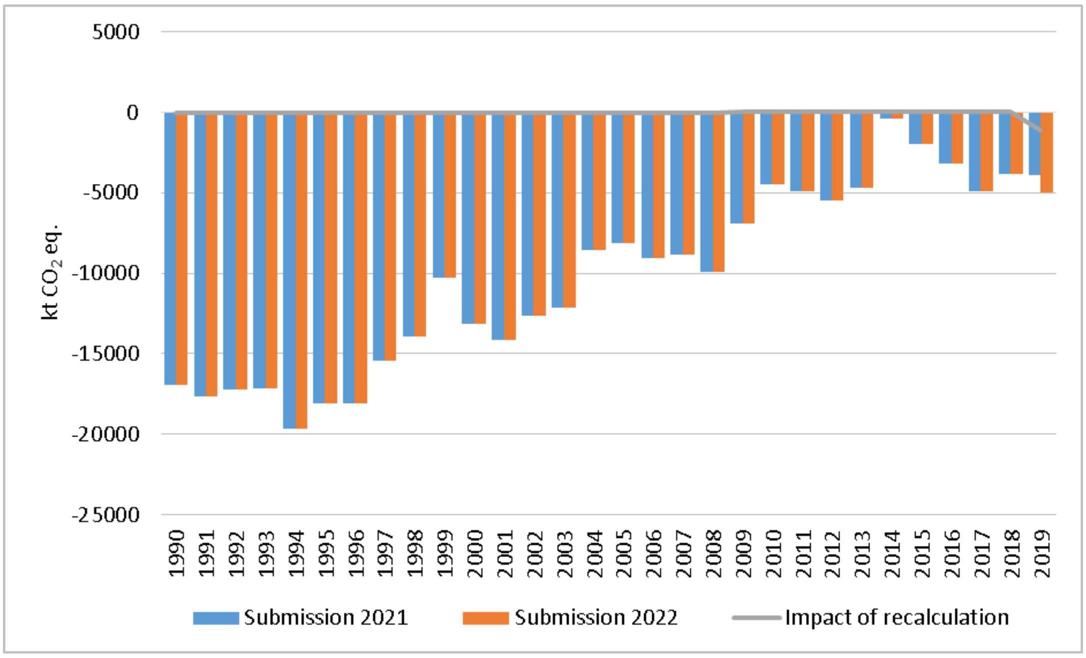

Figure 6.6 Impact of recalculation on the aggregated net GHG emissions from forest land (including biomass burning)(kt CO_2 eq.)

6.4.6 Category-specific planned improvements

It is planned to improve quantitative results of modelling (using Yasso) for calculation of CSCs in mineral soil, dead wood and litter.

6.5 *CROPLAND (CRF 4.B)*

6.5.1 Category description

Cropland remaining cropland and land converted to cropland is a key category of CO_2 emissions (Figure 6.7). Under the cropland's category emissions from soils (CO_2, N_2O and CH_4), living and dead woody biomass (CO_2) are reported. Net aggregated emissions from cropland remaining cropland were 1139.66 kt CO_2 in 2020 (excluding 115.01 kt CO_2 eq. emissions from drained organic soils, Figure 6.8). Slight decrease of CO_2 emissions in cropland remaining cropland is associated with land use change from cropland to grassland. The net GHG emissions from land converted to croplands in 2020 (excluding emissions from drainage of organic soils) were 269.75 kt CO_2 eq. (Figure 6.9).

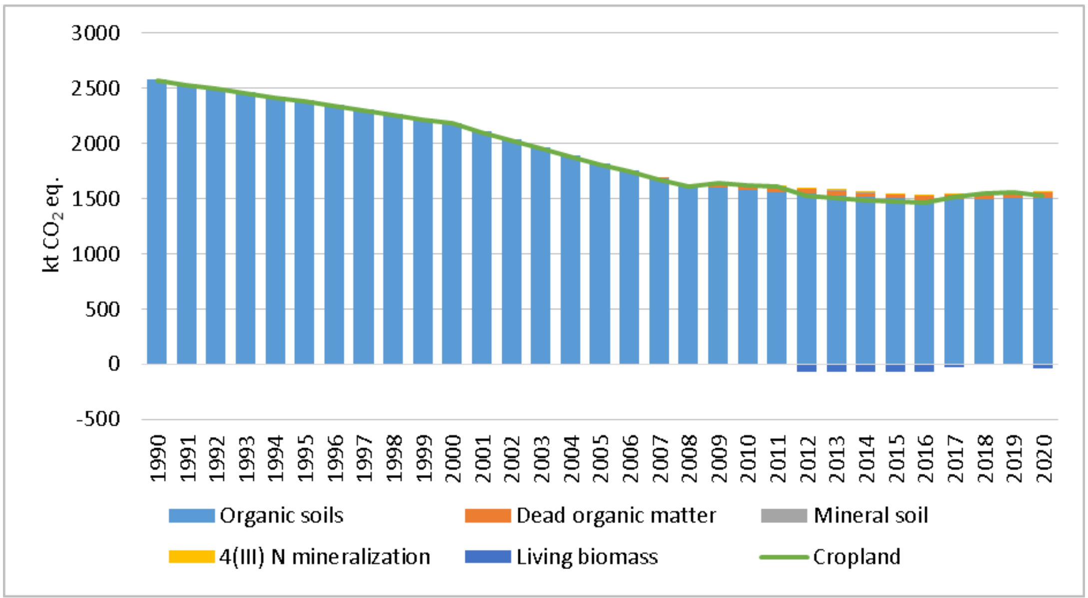

Figure 6.7 Summary of GHG emissions in cropland (kt CO_2 eq.) by source categories

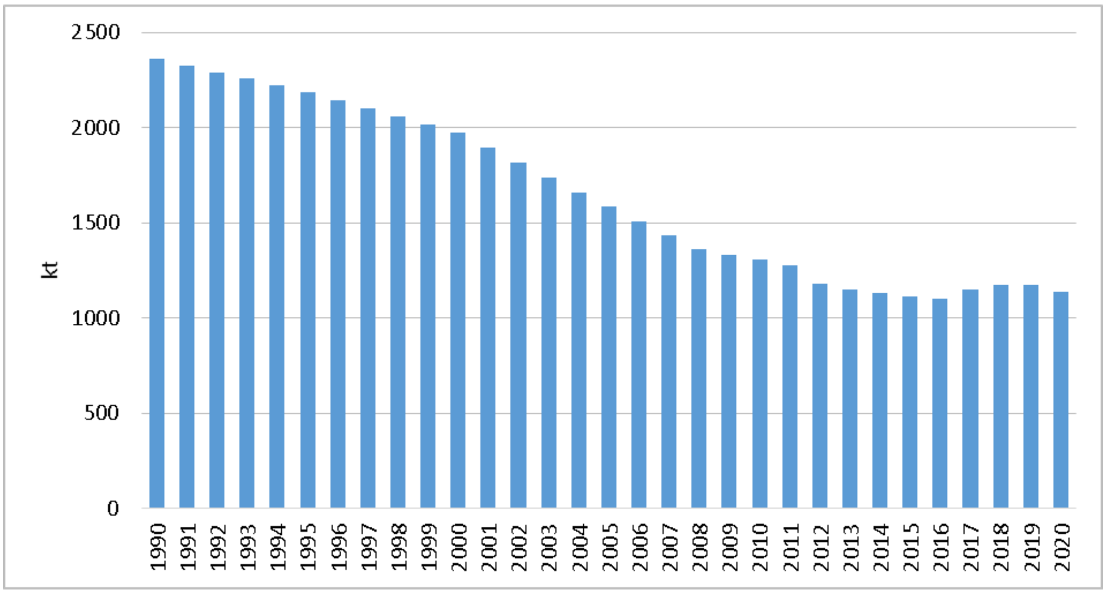

Figure 6.8 Summary of CO_2 emissions in cropland remaining cropland (kt)

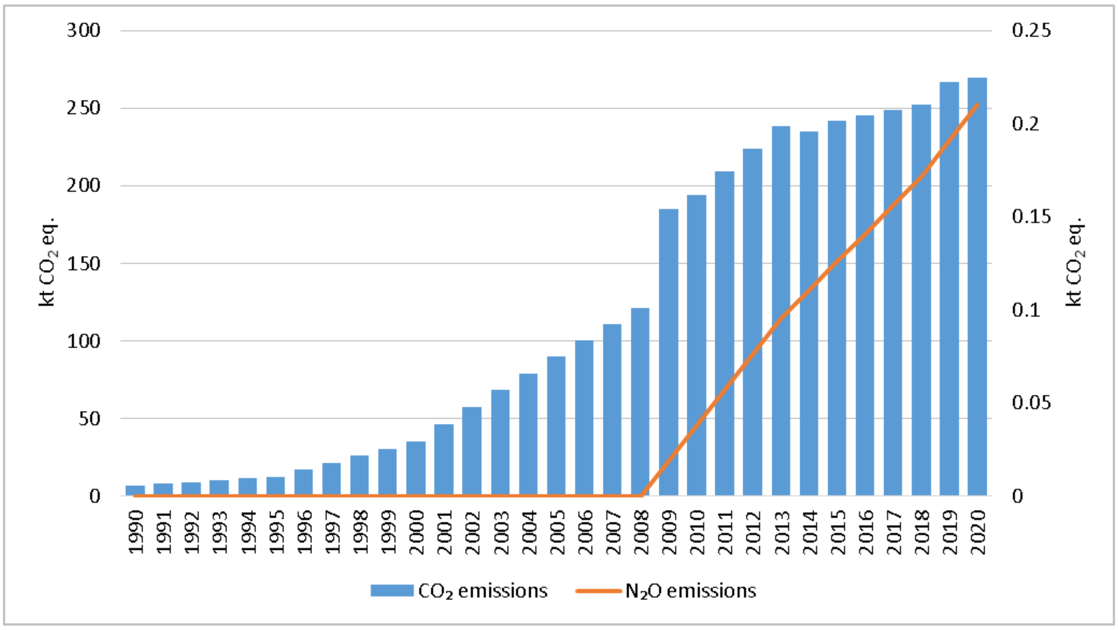

Figure 6.9 Summary of GHG emissions from land converted to cropland, N_2O on secondary axis (kt CO_2 eq.)

Updated values of area of organic and other soils split into cropland remaining cropland (including land converted to cropland at least 20 years ago) and land converted to cropland less than 20 years ago are shown in Table 6.21. The stock change (between recent available NFI measurements period) method was applied to characterize biomass of living trees in cropland on the base of stock changes during 5 year period.

Table 6.21 Area of cropland (1000 ha)

Year	Cropland	Land remaining cropland		Land converted to cropland	
		organic soil	other soils	organic soil	other soils
1990	*2061.23*	*134.74*	*1923.24*	*0.39*	*2.87*
1991	*2051.31*	*132.69*	*1915.01*	*0.45*	*3.15*
1992	*2041.39*	*130.66*	*1906.77*	*0.52*	*3.44*
1993	*2031.47*	*128.64*	*1898.52*	*0.58*	*3.72*
1994	*2021.55*	*126.64*	*1890.25*	*0.64*	*4.01*
1995	*2011.63*	*124.65*	*1881.97*	*0.71*	*4.30*
1996	*1995.08*	*122.22*	*1866.73*	*0.97*	*5.16*
1997	*1978.52*	*119.81*	*1851.47*	*1.22*	*6.02*
1998	*1961.97*	*117.43*	*1836.18*	*1.48*	*6.88*
1999	*1945.42*	*115.07*	*1820.87*	*1.74*	*7.74*
2000	*1928.87*	*112.74*	*1805.53*	*1.99*	*8.61*
2001	*1877.69*	*108.11*	*1752.70*	*2.63*	*14.24*
2002	*1826.50*	*103.57*	*1699.79*	*3.26*	*19.89*
2003	*1775.32*	*99.10*	*1646.80*	*3.88*	*25.54*
2004	*1724.14*	*94.70*	*1593.74*	*4.49*	*31.20*
2005	*1672.95*	*90.39*	*1540.60*	*5.10*	*36.87*
2006	*1621.77*	*86.15*	*1487.38*	*5.70*	*42.54*
2007	*1570.59*	*81.99*	*1434.09*	*6.29*	*48.22*
2008	*1519.40*	*77.90*	*1380.71*	*6.88*	*53.91*
2009	*1509.90*	*76.07*	*1366.32*	*7.74*	*59.77*

Year	Cropland	Land remaining cropland		Land converted to cropland	
		organic soil	other soils	organic soil	other soils
2010	*1500.39*	*74.65*	*1354.78*	*8.21*	*62.76*
2011	*1490.89*	*72.92*	*1340.63*	*8.99*	*68.35*
2012	*1481.38*	*71.22*	*1326.45*	*9.77*	*73.94*
2013	*1471.88*	*69.54*	*1312.26*	*10.54*	*79.54*
2014	*1471.56*	*68.53*	*1310.63*	*10.89*	*81.51*
2015	*1471.24*	*67.53*	*1309.00*	*11.23*	*83.48*
2016	*1470.92*	*66.73*	*1307.95*	*11.38*	*84.87*
2017	*1470.61*	*66.84*	*1305.97*	*11.53*	*86.27*
2018	*1470.29*	*66.95*	*1303.99*	*11.67*	*87.67*
2019	*1467.72*	*67.03*	*1301.22*	*11.78*	*87.70*
2020	*1465.16*	*67.10*	*1298.45*	*11.88*	*87.73*

N_2O emissions from managed organic soils in cropland are reported under Agriculture sector (detailed methodology is described in section 5.4.2).

The improvement of quantitative results of modelling (using Yasso) to characterize CSCs in mineral soils is in progress according to improvement plan. Studies continues, for instance, to elaborate biomass expansion factors and data on carbon turnover in cropland and grassland. The study "Improvement of GHG emission calculations from managed croplands and grasslands and development of appropriate methodological solutions" provides additional C input information and BEFs for different agricultural crops. The study results will be available for inclusion in GHG inventory as soon as results will be statistically analyzed and published in peer-reviewed scientific journal.

6.5.2 Methodological issues

6.5.2.1 Cropland remaining cropland (CRF 4.B.1)

Area of land remaining cropland is estimated using NFI data and research results[208]. Until submission 2018 it was assumed that area of organic soils in farmland according to summaries of land surveys[209] is 5.18 ± 0.5 %. This value characterizes area of organic soils in cropland before 1990 because it is based on field measurements completed in 60[ths], 70[ths] and early 80[ths]. Since submission 2018 area of organic soils in cropland is reported according to the results of research projects[210,211]. According to the results of research project there were 67.10 kha organic soil (4.9% of total area) in cropland remaining cropland in 2020.

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[208] *Krumsteds, L. L., Ivanovs, J., Jansons, J., Lazdiņš, A. 2019. Development of Latvian land use and land use change matrix using geospatial data of National forest inventory. Agronomy Research, 17(6), p. 2295–2305, DOI: 10.15159/AR.19.195.*

[209] *L.U. Consulting. 2010. Augšņu un reljefa izejas datu sagatavošana un Eiropas Komisijas izstrādāto augsnes un reljefa kritēriju mazāk labvēlīgo apvidu noteikšanai piemērošanas simulācija. Projekta kopsavilkuma ziņojums (Elaboration of soil and terrain data and simulation of application of the criteria elaborated by the European Commission for identification of less valuable regions. Summary of the project report), Latvijas Republikas Zemkopības Ministrija.*

[210] *Lazdiņš A., Bārdule A., Butlers A., Lupiķis A., Okmanis M., Bebre I., … Petaja G. 2016. Projekts "Aramzemes un ilggadīgo zālāju apsaimniekošanas radīto siltumnīcefekta gāzu (SEG) emisiju un oglekļa dioksīda (CO_2) piesaistes uzskaites sistēmas pilnveidošana un atbilstošu metodisko risinājumu izstrādāšana" (Project "Improving the accounting system of CO_2 removals and GHG emissions due to management practices in cropland and grassland and development of methodological solutions"). 2016. gada starpziņojums, No. 101115/S109, Salaspils, p. 123. Available: https://drive.google.com/open?id=0Bxv4jQ_04jXZRExSMWhPMWhDNDg*

[211] *Vēsturiskā augsnes digitāla datubāze (Digital database of historical soils). Available: https://geolatvija.lv/geo/p/239*

Carbon stock change in living and dead woody biomass is based on activity data provided by the NFI. Carbon stock changes in cropland are calculated using recent NFI data by comparison stock changes in living biomass during recent 5 years and mortality of trees. Carbon stock in living and dead biomass is calculated using the same coefficients as in calculations of CSCs in forested land. The conversion factors for estimation of carbon in biomass are developed domestically[212].

The assumptions used in EPIM tool for estimation of CSC in living and dead biomass are shown in Table 6.22, default 20 years decay period is considered for dead wood. Years 2017-2019 (especially, 2018) were very favourable for biofuel production due to considerable increase of demand and prices of all roundwood assortments including biofuel. Due to this reason farmers harvested roadsides, ditch sides and other groups of trees in croplands not conforming to the forest definition for biofuel production. Therefore gross increment of woody biomass in cropland considerably decreased in 2017-2019.

Table 6.22 Assumptions for calculation of CSC in living and dead biomass in cropland

Year	Cropland with woody vegetation, 1000 ha	Gross increment of living biomass		Wood density, kg m^{-3}	Natural mortality, m^3 ha^{-1}	BEFs		Carbon content, kg t^{-1}
		mill. m^3	m^3 ha^{-1}			stem to crown	stem to below-ground	
1990	*2.34*	*0.01*	*2.52*	*0.44*	*0.42*	*0.24*	*0.31*	*523.30*
1991	*2.34*	*0.01*	*2.52*	*0.44*	*0.42*	*0.24*	*0.31*	*523.30*
1992	*2.34*	*0.01*	*2.52*	*0.44*	*0.42*	*0.24*	*0.31*	*523.30*
1993	*2.34*	*0.01*	*2.52*	*0.44*	*0.42*	*0.24*	*0.31*	*523.30*
1994	*2.65*	*0.01*	*2.52*	*0.44*	*0.42*	*0.24*	*0.31*	*522.95*
1995	*2.65*	*0.01*	*2.52*	*0.44*	*0.42*	*0.24*	*0.31*	*522.95*
1996	*2.65*	*0.01*	*2.52*	*0.44*	*0.42*	*0.24*	*0.31*	*522.95*
1997	*2.65*	*0.01*	*2.52*	*0.44*	*0.42*	*0.24*	*0.31*	*522.95*
1998	*2.65*	*0.01*	*2.52*	*0.44*	*0.42*	*0.24*	*0.31*	*522.95*
1999	*2.65*	*0.01*	*2.52*	*0.44*	*0.42*	*0.24*	*0.31*	*523.34*
2000	*2.65*	*0.01*	*2.52*	*0.44*	*0.42*	*0.24*	*0.31*	*523.34*
2001	*2.65*	*0.01*	*2.52*	*0.44*	*0.42*	*0.24*	*0.31*	*523.34*
2002	*2.65*	*0.01*	*2.52*	*0.44*	*0.42*	*0.24*	*0.31*	*523.34*
2003	*2.65*	*0.01*	*2.52*	*0.44*	*0.42*	*0.24*	*0.31*	*523.34*
2004	*2.65*	*0.01*	*2.52*	*0.44*	*0.48*	*0.24*	*0.31*	*524.03*
2005	*2.65*	*0.01*	*2.52*	*0.44*	*0.48*	*0.24*	*0.31*	*524.03*
2006	*2.65*	*0.01*	*2.52*	*0.44*	*0.48*	*0.24*	*0.31*	*524.03*
2007	*1.45*	*0.01*	*6.19*	*0.44*	*1.18*	*0.24*	*0.31*	*524.03*
2008	*1.45*	*0.01*	*6.19*	*0.44*	*1.18*	*0.24*	*0.31*	*524.03*
2009	*1.45*	*0.01*	*6.19*	*0.44*	*1.82*	*0.24*	*0.31*	*522.56*
2010	*1.45*	*0.01*	*6.19*	*0.44*	*1.82*	*0.24*	*0.31*	*522.56*
2011	*1.45*	*0.01*	*6.19*	*0.44*	*1.82*	*0.24*	*0.31*	*522.56*
2012	*3.07*	*0.06*	*19.09*	*0.44*	*0.61*	*0.24*	*0.31*	*522.56*
2013	*3.07*	*0.06*	*19.09*	*0.44*	*0.61*	*0.24*	*0.31*	*522.56*
2014	*3.07*	*0.06*	*19.09*	*0.44*	*0.61*	*0.24*	*0.31*	*522.62*
2015	*3.07*	*0.06*	*19.09*	*0.44*	*0.61*	*0.24*	*0.31*	*522.15*
2016	*4.07*	*0.06*	*14.40*	*0.43*	*0.61*	*0.24*	*0.31*	*521.93*
2017	*6.69*	*0.03*	*3.80*	*0.44*	*0.59*	*0.24*	*0.31*	*522.18*

[212] *Lazdiņš et al. 2011.-2015. Projekts "Mežsaimniecisko darbību ietekmes uz siltumnīcefekta gāzu emisijām un CO_2 piesaisti novērtējums" (Project "Evaluation of impact of forest management practices on greenhouse gas emissions and CO_2 removals")*

Year	Cropland with woody vegetation, 1000 ha	Gross increment of living biomass		Wood density, kg m^{-3}	Natural mortality, m^3 ha^{-1}	BEFs		Carbon content, kg t^{-1}
		mill. m^3	m^3 ha^{-1}			stem to crown	stem to below-ground	
2018	*6.43*	*0.01*	*0.91*	*0.43*	*0.58*	*0.25*	*0.31*	*522.42*
2019	*7.25*	*0.01*	*1.45*	*0.44*	*0.82*	*0.24*	*0.31*	*523.79*
2020	*7.39*	*0.04*	*5.40*	*0.42*	*0.80*	*0.26*	*0.31*	*522.82*

Pilot study on implementation of Yasso07 model on mineral soils in cropland and grassland approved that there are not net carbon losses in mineral soil in cropland[213], thus net CSCs in mineral soil in cropland are reported as not a source ("NA" notation key).

Since submission 2021 national CO_2 EF (4.80 t CO_2-C ha^{-1} yr^{-1})[214] for drained organic soils in cropland was used. National CO_2 EF was developed within the scope of LIFE REstore project. Within the project, two methods were used for CO_2 measurements – manual autotrophic measurements with opaque closed chambers and air sampling and manual ecosystem flux measurements with closed transparent chambers. Applied country-specific value (4.80 t CO_2-C ha^{-1} yr^{-1}) is lower than that in the IPCC Wetlands Supplement (7.9 tonnes CO_2-C ha^{-1} yr^{-1}). The values of EFs mainly differ due to the variance in climatic factors between central and western parts of Europe (where IPCC Wetlands Supplement default EFs were developed) and condition in Latvia; in warmer climatic conditions higher emissions occur. In addition, use of a similar CO_2 EFs in other Baltic countries (5 t CO_2-C ha^{-1} yr^{-1} in Lithuania and 6.1 t CO_2-C ha^{-1} yr^{-1} in Estonia) confirms compliance of Latvia's national CO_2 EF with climatic conditions in region.

Drained organic soil in cropland is source of CH_4 emissions. CH_4 emissions are calculated by equation 2.6 in the IPCC Wetlands Supplement. The EF for organic soils (Table 2.3 and table 2.4 in the IPCC Wetlands Supplement) is 0±2.8 kg CH_4 ha^{-1} yr^{-1} (cropland, drained) and EF for drainage ditches 1165±830 kg CH_4 ha^{-1} yr^{-1} (deep – drained cropland); respectively, only CH_4 emissions from ditches are calculated. Drainage systems on organic soils are considered. Fraction of the total area of drained organic soil which is occupied by ditches is 0.05 (Table 2.4 in the IPCC Wetlands Supplement).

In category 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils (Total Organic Soils, Drained Organic Soils) only area of drainage ditches and corresponding CH_4 emissions in cropland remaining cropland and land converted to cropland is reported (3.95 kha in 2020), as CH_4 EF for drained organic soils is 0 according to the 2006 IPCC guidelines.

6.5.2.2 Land converted to cropland (CRF 4.B.2)

Carbon stock changes in living biomass, dead organic matter and mineral soil are reported for forest land converted to cropland. Carbon stock changes in organic soil are reported for forest

[213] *Lazdiņš A., Bārdule A., Butlers A., Lupiķis A., Okmanis M., Bebre I., … Petaja G. 2016. Projekts "Aramzemes un ilggadīgo zālāju apsaimniekošanas radīto siltumnīcefekta gāzu (SEG) emisiju un oglekļa dioksīda (CO_2) piesaistes uzskaites sistēmas pilnveidošana un atbilstošu metodisko risinājumu izstrādāšana" (Project "Improving the accounting system of CO_2 removals and GHG emissions due to management practices in cropland and grassland and development of methodological solutions"). 2016. gada starpziņojums, No. 101115/S109, Salaspils, p. 123. Available: https://drive.google.com/open?id=0Bxv4jQ_04jXZRExSMWhPMWhDNDg*

[214] *Licite I., Lupikis, A. 2020. Impact of land use practices on greenhouse gas emissions from agriculture land on organic soils. Proceedings of 19th International Scientific Conference Engineering for Rural Development, 1823–1830. DOI: 10.22616/ERDev.2020.19.TF492*

land converted to cropland, grassland converted to cropland and wetlands converted to cropland.

Transition period for all land use changes is considered 20 years; respectively, land converted to cropland in 1990 is reported under the cropland remaining cropland category in 2010. New method for calculation of land use changes using the most recent NFI data was implemented in 2019 (Krumsteds et al., 2019)[215].

Area of organic soil in land converted to cropland is calculated using different approach than in cropland remaining cropland - the values characteristic for initial land use are applied. Respectively, if share of organic soil in forest land remaining forest land in 1990 is 22%, it is considered, that area of organic soil in forest land converted to cropland in 1990 is 22%[216]. These values will be updated with actual field measurement data during implementation of 4th NFI cycle (more precise implementation period not yet defined).

In forest land converted to cropland, unlike to cropland remaining cropland, CSC in living biomass is calculated as losses in living biomass due to felling of trees, considering that losses in living biomass are equal to average growing stock in forest land converted to cropland (BEFs, carbon content and wood density are considered as weighted by total biomass distribution between species). Instant oxidation method is applied to living biomass carbon pool.

Losses in dead wood are reported as loss of average carbon stock in dead organic matter in the most recent 5 year period in all NFI plots where the changes are detected. Carbon stock in litter is considered as constant value 12.14 t C ha^{-1} according to the BioSoil project results in fertile stand types (*Hylocomiosa, Oxalidosa, Myrtilloso-sphagnosa, Myrtillosoi-polytrichosa, Myrtillosa mel., Mercurialosa mel.*). Carbon stock change in dead organic matter in the forest land converted to cropland is reported using instant oxidation method and depends from the average carbon stock in dead organic matter in forest land converted to cropland during the specified reporting period according to the NFI data. Due to the fact that CSCs in dead organic matter if forest land converted to cropland is reported using instant oxidation method, "NO" is used for years when conversion of forest land to cropland is not reported by the NFI.

Changes in living biomass and dead organic matter for grassland converted to cropland are not reported ("IE" notation key) to avoid double accounting, because input of C in soil through biomass is included in calculation of CSC in mineral soil using Yasso model. Improvement referred to the use of country-specific biomass expansion factors to estimate CSC in the living biomass pool is proposed within the improvement plan for the next annual submission (2023). The resources for this activity are allocated and, so far, initial results on the estimation of country-specific biomass expansion factors soon will be published in a scientific peer-reviewed publication.

As IPCC 2006 guidelines does not provide default EFs, "NE" is used for reporting C stock changes in living biomass (gains, losses and net change) and dead organic matter for wetlands converted to cropland.

[215] *Krumsteds L.L., Ivanovs J., Jansons J., Lazdins A. 2019. Development of Latvian land use and land use change matrix using geospatial data of National forest inventory. Agronomy Research 17(6), p. 2295–2305, DOI: 10.15159/AR.19.195.*

[216] *Lazdiņš, A., Bārdule, A., Stola, J. 2013. Preliminary results of evaluation of area of organic soils in arable lands in Latvia. Abstracts of International Baltic Sea Regional Scientific Conference, 79–80.*

In forest land converted to cropland, CSCs in mineral soil are estimated using Equation 2.25 of the 2006 IPCC Guidelines. Impact factors for calculations of the CSC under different management activities are taken from Table 5.5 in the 2006 IPCC Guidelines:

- FLU 0.69 (Long-term cultivated, Temperate moist);
- FMG 1.00 (Full tillage, Temperate dry and wet);
- FI 1.00 (Medium input, all).

The initial carbon stock in mineral forest soil at 0-30 cm depth (reference C stock) is 82.6 t ha^{-1} according to the forest soil monitoring project BioSoil[217]. Forest stand types similar to agricultural lands are selected to calculate average carbon stock in forest soil (*Hylocomiosa, Oxalidosa, Myrtilloso-sphagnosa, Myrtillosoi-polytrichosa, Myrtillosa mel., Mercurialosa mel.*). The carbon stock in forest land converted to cropland after transition period of 20 years according to the equation 2.25 is 79.4 t C ha^{-1} at 0-30 cm depth (default reference soil organic C stock for mineral soils 115 t C ha^{-1} according to the Table 2.3. in the 2006 IPCC Guidelines was used for calculation). Respectively, reduction of carbon stock in mineral soils is 3.3 t ha^{-1} or 0.16 t C ha^{-1} annually.

In organic soil of forest land converted to cropland, grassland converted to cropland and wetlands converted to cropland the factor for cropland remaining cropland (4.80 t CO_2-C ha^{-1} annually) is used to estimate CSCs. The same approach as for cropland remaining cropland is used to calculate CH_4 emissions from drainage ditches.

6.5.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in the Annex 2. Overall description of uncertainty analysis is included in the Section 1.6.

Uncertainty of area estimates is provided in Table 6.23.

Table 6.23 Uncertainty of the cropland use data in 2022 submission

Land use category	Number of NFI plots	Share of NFI plots, %	Uncertainty, %
Cropland	*4295*	*26.6*	*2.6*
cropland remaining cropland	*4255*	*26.3*	*2.6*
organic soil	*221*	*1.4*	*13.3*
other soil	*4034*	*25.0*	*2.7*
land converted to cropland	*40*	*0.3*	*53.4*
organic soil	*5*	*0.03*	*113.9*
other soil	*35*	*0.2*	*64.5*

According to the NFI, uncertainty of growing stock is 135%. Uncertainty of annual increment of growing stock of trees is 2.20%. BEFs utilized in calculations have uncertainty level of 2.2% in average according to the study results. Uncertainty of dead wood stock is 3.9%. Uncertainty of carbon content in wood is 0.14%. Uncertainty of average carbon stock in litter in forest land is 23.1%.

[217] *Lazdiņš et al. 2011.-2015. Projekts "Mežsaimniecisko darbību ietekmes uz siltumnīcefekta gāzu emisijām un CO_2 piesaisti novērtējums" (Project "Evaluation of impact of forest management practices on greenhouse gas emissions and CO_2 removals").*

The uncertainty of CO_2 EF for organic soils (13.3%) is determined according to the results of LIFE REstore project[218]. According to Table 5.5 of the 2006 IPCC Guidelines the uncertainty of impact factor for different management practices applied in croplands is 12% for long term cultivating. No uncertainty is considered for full tillage and medium input (impact factor – 1). Uncertainty of carbon stock in mineral soil in forest land at 0-30 cm is 18.8%. Uncertainty of CH_4 EF for drainage ditches is 71.2% (Table 2.4 in the IPCC Wetlands Supplement).

Consistency of time series of calculations is secured by use of the NFI data for the cropland and grassland area and the NFI based remote sensing analysis for land use changes.

6.5.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the LULUCF sector in order to achieve these quality objectives.

The QA/QC plans for the cropland category includes the QC measures based on the IPCC (2006 IPCC Guidelines, Chapter 5.4.3, Tier 1 based QA/QC). The QA/QC procedures are implemented during every inventory. Issues related to QA/QC and verification are discussed at the sectoral meetings. Potential errors and inconsistencies are documented and corrections are made if necessary. Land use, as well as carbon stock in living and dead biomass related QA/QC procedures is implemented within the scope of the standard NFI procedure by re-measuring of 10% of all sample plots. Training of the NFI field teams takes place every spring before starting the field works.

Manual data check is introduced to compare figures imported into the CRF Reporter and actually calculated values. The mathematical errors identified during the previous review are corrected in the EPIM model used for calculation of GHG emissions in LULUCF sector.

All information related to the preparation of the annual inventory is archived in the centralized archiving system (common FTP folder) in accordance with QA/QC plan.

The country-specific EF used to estimate CO_2 emissions from drained organic soils in cropland was published as a peer-reviewed article and compared to EF used in other countries in the Baltic Sea region. The Latvian value was within uncertainty range of CS EF of other countries in the region.

6.5.5 Category-specific recalculations

Recalculations are done due to continuous improvement of activity data including area of cropland remaining cropland and land converted to cropland. In 2019, net aggregated emissions in cropland slightly increased by 10.60 kt CO_2 eq. The main reason for recalculation of activity data (area) is delayed accumulation of land use changes data (addition 20% of NFI sample plots are surveyed annually, acquired cumulative data are extrapolated to whole country area) till final recalculation of NFI data at the end of every 5 years period (completed NFI cycle with 100% sample plots surveyed). Summary of the impact of recalculation on the aggregated net GHG emissions from cropland is shown in Figure 6.10.

[218] *Licite I., Lupikis, A. 2020. Impact of land use practices on greenhouse gas emissions from agriculture land on organic soils. Proceedings of 19th International Scientific Conference Engineering for Rural Development, 1823–1830, DOI: 10.22616/ERDev.2020.19.TF492*

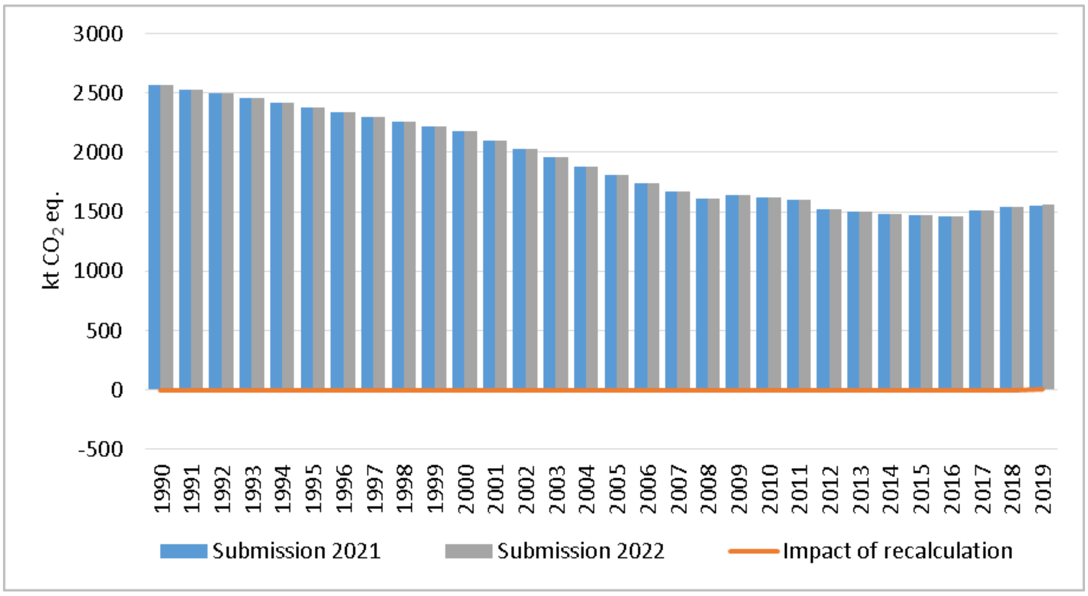

Figure 6.10 Impact of recalculation on the aggregated net GHG emissions from cropland (kt CO_2 eq.)

6.5.6 Category-specific planned improvements

There are several improvements proposed for the following inventories:

- The implementation of improved quantitative results of Yasso modelling to characterize CSCs in mineral soils according to improvement plan;
- Elaboration of climate, moisture regime and soil fertility driven modelling solution and activity data for organic soil in cropland (LIFE OrgBalt project, since 2025).

6.6 *GRASSLAND (CRF 4.C)*

6.6.1 Category description

The grassland's is a key category of CO_2 emissions from soils and living biomass (Figure 6.11). Total area of grassland in Latvia in 2020 was 1034.71 kha, including 469.69 kha of grassland remaining grassland. Grassland remaining grassland is divided into mineral and organic soils. Area of the grassland is estimated using research data[219] on the base of remote sensing and NFI data analysis. The net emissions from grassland remaining grassland were 410.50 kt CO_2 eq. (including emissions from biomass burning) in Latvia in 2020 (Figure 6.12). CO_2 removals are reported in living and dead biomass in grasslands not fulfilling criteria of forest definition. Other peaks in time series of N_2O and CH_4 emissions in 2003, 2006, 2009 and 2014 (Figure 6.12) are due to increase of area of wildfires in grassland.

[219] *Krumsteds, L. L., Ivanovs, J., Jansons, J., Lazdiņš, A. 2019. Development of Latvian land use and land use change matrix using geospatial data of National forest inventory. Agronomy Research, 17(6), p. 2295–2305, DOI: 10.15159/AR.19.195.*

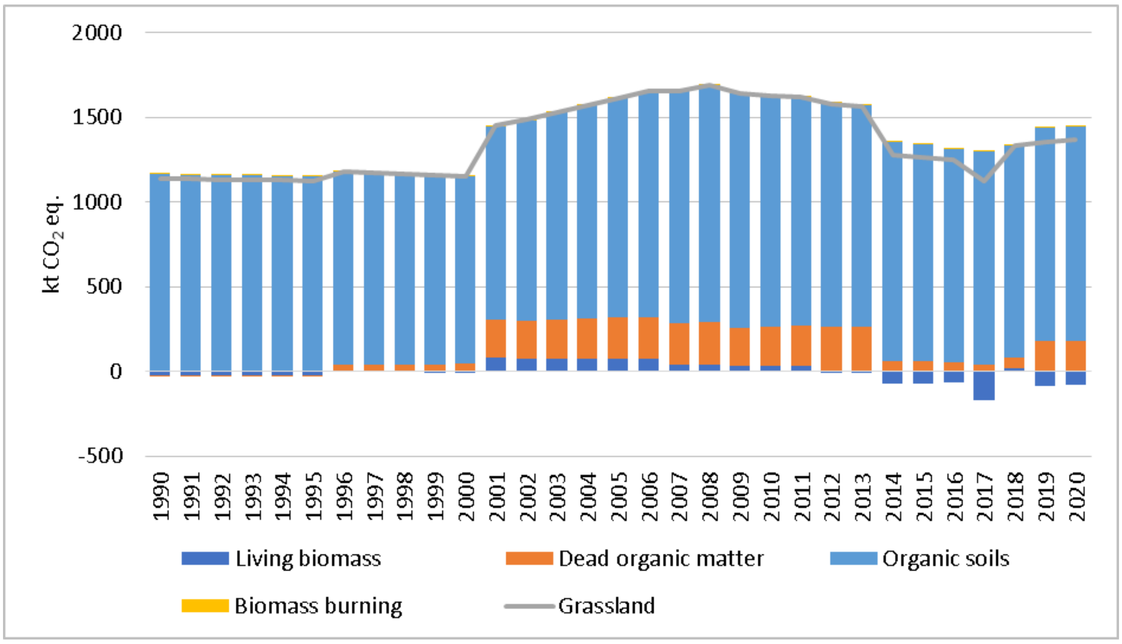

Figure 6.11 Summary of GHG emissions in grassland (kt CO_2 eq.) by source and sink categories

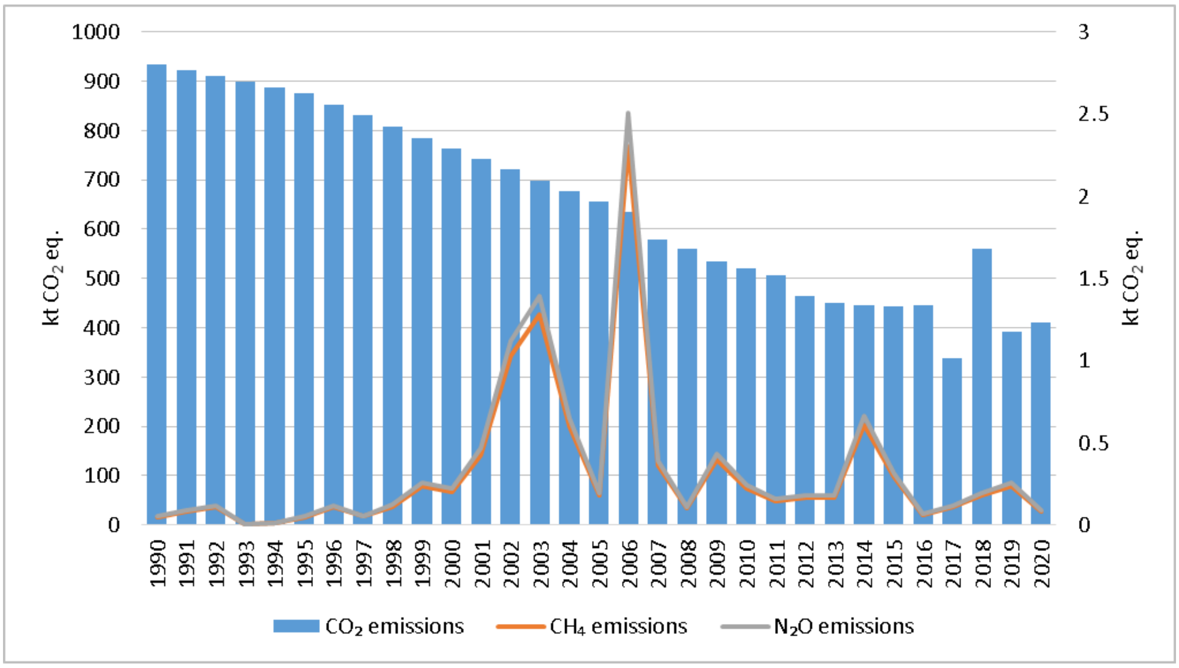

Figure 6.12 Summary of GHG emissions from grassland remaining grassland, CH_4 and N_2O emissions on secondary axis (kt CO_2 eq.)

The total area of lands converted to grassland less than 20 years ago[220] is estimated to be 565.02 kha in 2020. Net GHG emissions in land category land converted to grassland excluding

[220] *Lazdiņš A., Zariņš J. 2010. Projekts "Mežu zemes izmantošanas maiņas matricas izstrādāšana un integrēšanu nacionālajā siltumnīcefekta gāzu inventarizācijas pārskatā par Kioto protokola 3.3 un 3.4 pantā minētajiem pasākumiem" (Project "Elaboration and integration into National greenhouse gas inventory report matrices of land use changes of areas belonging to Kyoto protocol Article 3.3 and 3.4 activities"); Lazdiņš A. Harmonization of land use matrix in Latvia according to requirements of international greenhouse gas reporting system - extending outputs of National Forest Inventory program; Lazdiņš A., Čugunovs M. 2013. Projekts "Oglekļa dioksīda (CO_2) piesaistes un siltumnīcefekta gāzu (SEG) emisiju un zemes lietojuma veida ietekmes novērtējums iIntensīvi un ekstensīvi kultivētās aramzemēs, daudzgadīgos zālājos un bioloģiski vērtīgos zālājos" (Project*

emissions from drained organic soil in 2020 were 758.23 kt CO_2 eq. (Figure 6.13). Increased values of CO_2 emissions in period from 2001 to 2008, in 2019 and in 2020 are related to conversion of forest land to grassland resulting in emissions from living biomass, dead organic matter and organic soils.

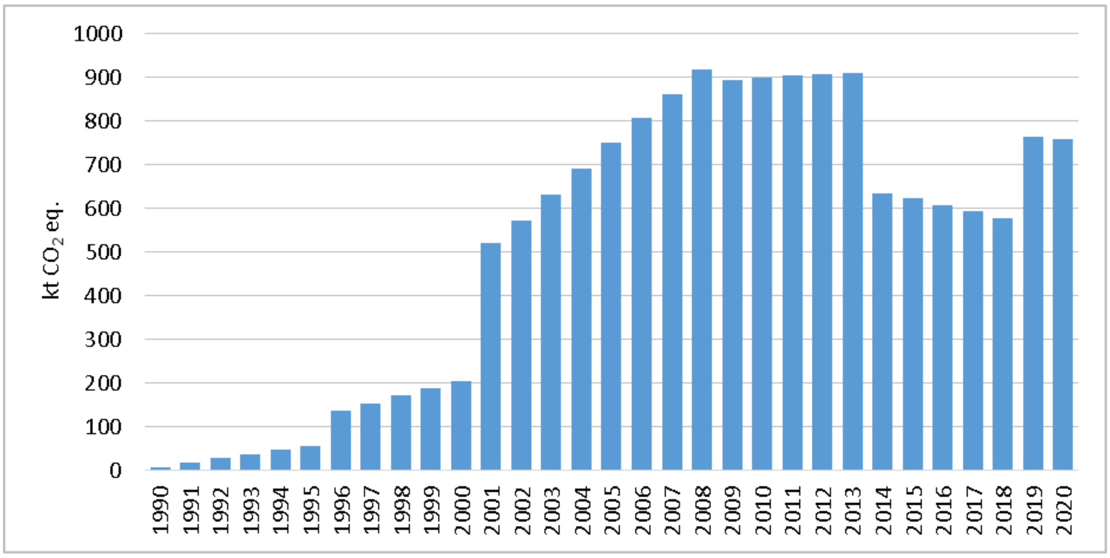

Figure 6.13 Summary of CO_2 emissions in land converted to grassland (kt)

Grassland remaining grassland is divided into mineral and organic soils according to the results of research project implemented in 2016[221]. It is assumed that mineral soils are neither a source nor sink of CO_2. It could be changed depending on management level (degraded or improved) in grasslands; however, according to the expert judgement it was considered that all grasslands are managed in a way that there are no degraded or improved grasslands. The judgement is based on a pilot study of implementation of the Yasso07 model in grassland approving that soil CSCs in grassland remaining grassland are not significant. This type of management systems is not associated with decrease of carbon stock in soil. Organic soils are considerable source of CO_2 emissions. Organic soils and drainage ditches in grasslands are reported as a source of methane according to the IPCC Wetlands Supplement Chapter 2.

Increase of the area of organic soils in the land converted to grassland category is associated with conversion of cropland to grassland during the 1990s and during the last decade. Opposite process – reduction of area of grassland – took place due to afforestation (both natural expansion of forest and planting) of the grassland.

Updated values of area of organic and other soils split into grassland remaining grassland (including land converted to grassland at least 20 years ago) and land converted to grassland less than 20 years ago are shown in Table 6.24.

"Evaluation of carbon dioxide (CO_2) removals and greenhouse gas (GHG) emissions, and impact of land use in intensive and extensive cultivated cropland, grassland and biologically valuable grassland").

[221] *Lazdiņš A., Bārdule A., Butlers A., Lupiķis A., Okmanis M., Bebre I., … Petaja G. 2016. Projekts "Aramzemes un ilggadīgo zālāju apsaimniekošanas radīto siltumnīcefekta gāzu (SEG) emisiju un oglekļa dioksīda (CO_2) piesaistes uzskaites sistēmas pilnveidošana un atbilstošu metodisko risinājumu izstrādāšana" (Project "Improving the accounting system of CO2 removals and GHG emissions due to management practices in cropland and grassland and development of methodological solutions"). 2016. gada starpziņojums, No. 101115/S109, Salaspils, p. 123. Available: https://drive.google.com/open?id=0Bxv4jQ_04jXZRExSMWhPMWhDNDg*

Table 6.24 Area of grassland (1000 ha)

Year	Grassland	Land remaining grassland		Land converted to grassland	
		organic soil	other soils	organic soil	other soils
1990	*547.31*	*59.42*	*480.10*	*0.51*	*7.27*
1991	*555.93*	*58.69*	*479.87*	*1.14*	*16.23*
1992	*564.56*	*57.95*	*479.63*	*1.76*	*25.21*
1993	*573.18*	*57.22*	*479.39*	*2.38*	*34.19*
1994	*581.80*	*56.49*	*479.15*	*2.99*	*43.18*
1995	*590.43*	*55.76*	*478.91*	*3.59*	*52.17*
1996	*597.38*	*54.37*	*472.87*	*4.58*	*65.56*
1997	*604.34*	*53.00*	*466.82*	*5.56*	*78.96*
1998	*611.30*	*51.64*	*460.76*	*6.53*	*92.37*
1999	*618.25*	*50.30*	*454.67*	*7.49*	*105.79*
2000	*625.21*	*48.98*	*448.57*	*8.44*	*119.22*
2001	*675.46*	*47.59*	*441.66*	*12.66*	*173.55*
2002	*725.71*	*46.22*	*434.72*	*16.84*	*227.93*
2003	*775.95*	*44.87*	*427.77*	*20.98*	*282.34*
2004	*826.20*	*43.54*	*420.80*	*25.08*	*336.78*
2005	*876.45*	*42.22*	*413.81*	*29.15*	*391.27*
2006	*926.70*	*40.93*	*406.79*	*33.18*	*445.79*
2007	*976.94*	*39.66*	*399.76*	*37.17*	*500.35*
2008	*1027.19*	*38.40*	*392.71*	*41.12*	*554.95*
2009	*1030.05*	*36.82*	*382.06*	*42.91*	*568.26*
2010	*1032.91*	*35.79*	*378.64*	*44.17*	*574.31*
2011	*1035.77*	*34.89*	*376.90*	*45.31*	*578.66*
2012	*1038.63*	*34.02*	*375.13*	*46.45*	*583.02*
2013	*1041.48*	*33.17*	*373.34*	*47.59*	*587.39*
2014	*1039.00*	*32.96*	*378.39*	*47.40*	*580.25*
2015	*1036.51*	*32.75*	*383.43*	*47.23*	*573.11*
2016	*1034.02*	*32.93*	*392.86*	*46.66*	*561.57*
2017	*1031.54*	*33.53*	*401.88*	*46.11*	*550.02*
2018	*1029.05*	*34.12*	*410.90*	*45.56*	*538.46*
2019	*1031.88*	*34.92*	*422.44*	*45.25*	*529.27*
2020	*1034.71*	*35.71*	*433.98*	*44.95*	*520.07*

The improvement of quantitative results of Yasso modelling to characterize CSCs in mineral soils is in progress according to improvement plan. Studies continues, for instance, to elaborate biomass expansion factors and data on carbon turnover in cropland and grassland. The study "Improvement of GHG emission calculations from managed croplands and grasslands and development of appropriate methodological solutions" provides additional C input information and BEFs for the most common farm crops and management systems. The study results will be available for inclusion in GHG inventory as soon as results will be statistically analyzed and published in peer-reviewed scientific journal.

6.6.2 Methodological issues

6.6.2.1 Grassland remaining grassland (CRF 4.C.1)

Activity data are provided by the NFI. Woody biomass increment figures for 2004-2020 are taken from the NFI. Four cycles of the NFI (2004-2008, 2009-2013, 2014-2018 and the first two years of the 4th cycle) are used. For the earlier years the results of recalculation of increment of living biomass in grassland are considered[222]. Mortality rate in wooden areas are taken from the NFI using the most recent 5 years period. Decay period for dead wood is considered 20 years according to the 2006 IPCC Guidelines.

Calculations are done in EPIM tool. Assumptions used in EPIM tool are shown in Table 6.25, default 20 years decay period is considered for dead wood.

Table 6.25 Assumptions for calculation of CSC in living and dead biomass in grassland

Year	Grassland with woody vegetation, 1000 ha	Gross increment of living biomass		Wood density, kg m^{-3}	Natural mortality, m^3 ha^{-1}	BEFs		Carbon content, kg t^{-1}
		mill. m^3	m^3 ha^{-1}			stem to crown	stem to below-ground	
1990	*19.13*	*0.02*	*0.97*	*0.44*	*0.16*	*0.24*	*0.31*	*523.30*
1991	*19.44*	*0.02*	*0.95*	*0.44*	*0.16*	*0.24*	*0.31*	*523.30*
1992	*19.75*	*0.02*	*1.00*	*0.44*	*0.17*	*0.24*	*0.31*	*523.30*
1993	*20.07*	*0.02*	*0.99*	*0.44*	*0.17*	*0.24*	*0.31*	*523.30*
1994	*20.38*	*0.02*	*0.99*	*0.44*	*0.16*	*0.24*	*0.31*	*522.95*
1995	*20.69*	*0.02*	*0.97*	*0.44*	*0.16*	*0.24*	*0.31*	*522.95*
1996	*21.00*	*0.02*	*0.96*	*0.44*	*0.16*	*0.24*	*0.31*	*522.95*
1997	*21.32*	*0.02*	*0.96*	*0.44*	*0.16*	*0.24*	*0.31*	*522.95*
1998	*21.63*	*0.02*	*0.94*	*0.44*	*0.15*	*0.24*	*0.31*	*522.95*
1999	*21.94*	*0.02*	*0.98*	*0.44*	*0.16*	*0.24*	*0.31*	*523.34*
2000	*22.26*	*0.02*	*0.97*	*0.44*	*0.16*	*0.24*	*0.31*	*523.34*
2001	*22.57*	*0.02*	*0.96*	*0.44*	*0.16*	*0.24*	*0.31*	*523.34*
2002	*22.88*	*0.02*	*0.94*	*0.44*	*0.16*	*0.24*	*0.31*	*523.34*
2003	*23.19*	*0.02*	*0.93*	*0.44*	*0.15*	*0.24*	*0.31*	*523.34*
2004	*23.51*	*0.02*	*0.92*	*0.44*	*0.18*	*0.24*	*0.31*	*524.03*
2005	*23.82*	*0.02*	*0.91*	*0.44*	*0.17*	*0.24*	*0.31*	*524.03*
2006	*24.13*	*0.02*	*0.89*	*0.44*	*0.17*	*0.24*	*0.31*	*524.03*
2007	*23.54*	*0.05*	*2.12*	*0.44*	*0.41*	*0.24*	*0.31*	*524.03*
2008	*23.54*	*0.05*	*2.12*	*0.44*	*0.41*	*0.24*	*0.31*	*524.03*
2009	*23.54*	*0.05*	*2.12*	*0.44*	*0.62*	*0.24*	*0.31*	*522.56*
2010	*23.54*	*0.05*	*2.12*	*0.44*	*0.62*	*0.24*	*0.31*	*522.56*
2011	*23.54*	*0.05*	*2.12*	*0.44*	*0.62*	*0.24*	*0.31*	*522.56*
2012	*38.80*	*0.07*	*1.85*	*0.44*	*0.06*	*0.24*	*0.31*	*522.56*
2013	*38.80*	*0.07*	*1.85*	*0.44*	*0.06*	*0.24*	*0.31*	*522.56*
2014	*38.80*	*0.07*	*1.85*	*0.44*	*0.06*	*0.24*	*0.31*	*522.62*
2015	*38.80*	*0.07*	*1.85*	*0.44*	*0.06*	*0.24*	*0.31*	*522.15*
2016	*166.04*	*0.07*	*0.43*	*0.43*	*0.06*	*0.24*	*0.31*	*521.93*
2017	*181.58*	*0.16*	*0.89*	*0.44*	*0.10*	*0.24*	*0.31*	*522.18*
2018	*180.25*	*0.00*	*0.00*	*0.43*	*0.00*	*0.25*	*0.31*	*522.42*
2019	*177.07*	*0.14*	*0.79*	*0.44*	*0.12*	*0.24*	*0.31*	*523.79*
2020	*176.41*	*0.14*	*0.79*	*0.42*	*0.15*	*0.26*	*0.31*	*522.82*

[222] *Jansons, J. 2007. Methods utilized to recalculate historical forest increment data (p. 21). Available: https://drive.google.com/file/d/1yXUg6yf7NQ4PF2ff7HhPS6xOqPs2QpOo/view?usp=sharing*

National CO_2 EF (4.40 t CO_2-C ha^{-1} yr^{-1})[223] for drained organic soils in grasland was developed within the scope of LIFE REstore project and used to report CO_2 emissions from drained organic soils since submission 2021. Within the LIFE REstore project, two methods were used for CO_2 measurements – manual autotrophic measurements with opaque closed chambers and air sampling and manual ecosystem flux measurements with closed transparent chambers. Applied country-specific value (4.40 t CO_2-C ha^{-1} yr^{-1}) is lower than that in the IPCC Wetlands Supplement (6.1 tonnes CO_2-C ha^{-1} yr^{-1}). Values of EFs mainly differ due to the variance in climatic factors between central and western parts of Europe (where IPCC Wetlands Supplement default EFs were developed) and condition in Latvia; in warmer climatic conditions higher emissions occur. In addition, CO_2 EFs for grassland currently used in other Baltic countries (0.25 t CO_2-C ha^{-1} yr^{-1} in Lithuania and 1.50 t CO_2-C ha^{-1} yr^{-1} in Estonia) are even more lower if comapare to the Latvia's national EF or default EF provided by the IPCC Wetlands Supplement. It reinforce that Latvia's national CO_2 EF more reflects the climatic conditions in the region than default EF provided by the IPCC Wetlands Supplement.

EFs for CH_4 emissions from drained organic soil and drainage ditches are, respectively, 57.80 kg CH_4-C ha^{-1} yr^{-1} and 1165 kg CH_4 ha^{-1} yr^{-1} according to research results[224] and Table 2.4 in IPCC Wetlands Supplement. Fraction of the total area of drained organic soil that is occupied by ditches is 0.05 (Table 2.4 in the IPCC Wetlands Supplement).

N_2O emissions from managed organic soils in grassland are reported under Agriculture sector (detailed methodology is described in section 5.4.2).

Yasso07 is used to estimate CSCs in grassland on mineral soils. According to the study results[225] demonstrating that grassland remaining grassland on mineral soils is not a source of GHG emissions this category is not reported. Removals in soil obtained by the study are within a range of uncertainty therefore they are not reported in the inventory.

N_2O and CH_4 emissions from biomass burning are calculated according to methodology described in following chapter on Biomass burning.

6.6.2.2 Land converted to grassland (CRF 4.C.2)

In forest land converted to grassland, CSCs in living biomass, dead organic matter and organic soil are reported. Carbon stock change in living biomass is calculated as losses in living biomass due to felling of trees, considering that losses in living biomass are equal to average growing stock in forest land converted to grassland (BEFs, carbon content and wood density are considered as weighted by total biomass distribution between species). Gains in living biomass is calculated using default biomass stock present on grassland 13.6 tonnes d.m. ha^{-1} and carbon fraction 0.47 tonne C (tonne d.m.)$^{-1}$ for herbaceous biomass according to 2006 IPCC Guidelines (T1 method). Carbon stock changes in mineral soil from conversion of forest land to grassland is calculated by Tier 1 methodology, results of calculations show that there are no changes in

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[223] *Licite I., Lupikis, A. 2020. Impact of land use practices on greenhouse gas emissions from agriculture land on organic soils. Proceedings of 19th International Scientific Conference Engineering for Rural Development, 1823–1830. DOI: 10.22616/ERDev.2020.19.TF492*

[224] *Licite, I., Lupikis, A. 2020. Impact of land use practices on greenhouse gas emissions from agriculture land on organic soils. Proceedings of 19th International Scientific Conference Engineering for Rural Development, 1823–1830, DOI: 10.22616/ERDev.2020.19.TF492*

[225] *Lupiķis, A., Lazdiņš, A. 2017. Oglekļa aprite minerālaugsnēs Latvijas mežos: modelēts ar Yasso07 augsnes oglekļa modeli (Carbon cycling in mineral soils in forest land in Latvia: modeled by Yasso07 soil carbon model). In Starptautiskā zinātniski prakstiskā konference Zinātne un prakse nozares attīstībai, Mežzinātnes un augstākās mežizsglītības loma nozares konkurētspējas paaugstināšanā, tēzes, p. 17, Jelgava, LLU.*

carbon stock in mineral soil due to conversion. Naturally afforested lands are usually converted back to grasslands or croplands at relatively early development stage, when soil carbon input into soil does not differ significantly in forest land and grassland. BioSoil and NFI soil monitoring data prove that soil organic carbon stock difference in forest land and grassland on fertile mineral soils (that are typical for grasslands) is insignificant[226].

In cropland converted to grassland, CSCs in organic soil are reported. Changes in living biomass and dead organic matter for cropland converted to grassland are not reported (”IE” notation key) to avoid double accounting, because input of C in soil through biomass is included in calculation of CSC in mineral soil using Yasso model.

Carbon stock changes in mineral soils in cropland converted to grassland are reported as ”NA” notation key according to the research data[227] and results of study on carbon stock in mineral soils in cropland and grassland[228]. Methane emissions from ditches on organic soils have been included in estimates also for lands converted to grasslands and it is calculated with the same approach as grassland remaining grassland.

In wetlands converted to grassland, CSCs in living biomass and organic soil are reported. Gains in living biomass are calculated by T1 method using default biomass stock present on grassland 13.6 tonnes d.m. ha^{-1} and carbon fraction 0.47 tonne C (tonne d.m.)$^{-1}$ for herbaceous biomass according to 2006 IPCC Guidelines. Loses in living biomass and CSCs in dead organic matter are reported as ”NE” notation key) due to 2006 IPCC guidelines does not provide T1 EF.

In settlements converted to grassland, CSCs in living biomass are reported. Gains in living biomass are calculated by T1 method using default biomass stock present on grassland 13.6 tonnes d.m. ha^{-1} and carbon fraction 0.47 tonne C (tonne d.m.)$^{-1}$ for herbaceous biomass according to 2006 IPCC Guidelines. Loses in living biomass and CSCs in dead organic matter are reported as “NE” notation key) due to 2006 IPCC guidelines does not provide T1 EF. Carbon stock changes in mineral soil are reported reported as not occurring (”NA” notation key). According to IPCC tier 1 methodology C removals would be reported in settlements converted to grassland, but it is not done to avoid overestimation of C removals and to stay consistant with the national conditions. Information available from NFI approves that the most common type of such land use conversion is abandonment of industrial and military infrastructure.

Methodological work for estimating CSC in living biomass, deadwood and litter, as well as in mineral soils and organic soils is in progess. T1 method for calculation of CSCs in living biomass in wetlands converted to grassland and settlements converted to grassland will be replaced by actual values of C-stock changes after improvement of NFI data processing system, that will allow to track C-stock changes in living biomass and dead organic matter directly associated with land use changes at separate NFI plot level. The preliminary results of the study are published[229]; however, work is continuing to reduce uncertainty.

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[226] *Lazdiņš A. et al. 2013. Temporary carbon stock changes in forest soil in Latvia', in Abstracts of International Baltic Sea Regional Scientific Conference, Riga, LSFRI Silava, 2013, p. 51–52; Bardule A., Lupikis A., Butlers A., Lazdins A. 2017. Organic carbon stock in different types of mineral soils in cropland and grassland in Latvia. Zemdirbyste-Agriculture, 104, 1, p. 3–8.*

[227] *Projekts "Augsnes oglekļa krājumu novērtēšana aramzemē un pļavās" (Project "Evaluation of soil carbon stocks in cropland and grassland"). Available: https://drive.google.com/file/d/0Bxv4jQ_04jXZUTJ5c28za2c1eW8/view*

[228] *Bardule A., Lupikis A., Butlers A., Lazdins A. 2017. Organic carbon stock in different types of mineral soils in cropland and grassland in Latvia. Zemdirbyste-Agriculture, 104, 1, p. 3–8.*

[229] *Krumsteds L.L., Lazdins A., Butlers A., Ivanovs J. 2019. Recalculation of forest increment, mortality and harvest rate in Latvia according to updated land use data. Rural Development 2019 (1): 295–299, DOI:10.15544/RD.2019.037*

Carbon stock changes in organic soil for forest land, cropland and wetlands converted to grassland are reported. National CO_2 EF (4.40 t CO_2-C ha^{-1} yr^{-1})[230] for drained organic soils was used to report CO_2 emissions from drained organic soils since submission 2021. Due to limited information available on area of organic soils in wetlands converted to grassland it is assumed in the calculation that all wetlands converted to grasslands have organic soils and the national CO_2 EF for organic soils in grassland is applied in calculation of soil CSCs. This approach avoids potential underestimation of CO_2 emissions from soil.

6.6.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in the Annex 2. Overall description of uncertainty analysis is included in the Section 1.6.

Uncertainty of area estimates is provided in Table 6.26.

Table 6.26 Uncertainty of the grassland use data in 2022 submission

Land use category	Number of NFI plots	Share of NFI plots, %	Uncertainty, %
Grassland	*1747*	*10.8*	*4.2*
grassland remaining grassland	*1407*	*8.7*	*5.0*
organic soil	*73*	*0.5*	*25.7*
other soil	*1334*	*8.3*	*5.1*
land converted to grassland	*340*	*2.1*	*9.8*
organic soil	*17*	*0.1*	*55.1*
other soil	*324*	*2.0*	*10.0*

According to the NFI, uncertainty of growing stock is 55.5%. Uncertainty of annual increment of growing stock of trees is 2.20%. BEFs utilized in calculations have uncertainty level of 2.2% in average according to the study results. Uncertainty of dead wood stock is 3.9%. Uncertainty of carbon content in wood is 0.14%. Uncertainty of average carbon stock in litter in forest land is 23.1%.

The uncertainty estimate for the CO_2 EF for organic soils is 39.7 % according to the the results of LIFE REstore project[231].

Uncertainties for EFs used in calculation of CH_4 emissions from organic soils and drainage ditches are 153.2% and 71.2% according to the results of LIFE REstore project[232] and Table 2.4 in the IPCC Wetlands Supplement, respectively.

[230] *Licite I., Lupikis, A. 2020. Impact of land use practices on greenhouse gas emissions from agriculture land on organic soils. Proceedings of 19th International Scientific Conference Engineering for Rural Development, 1823–1830, DOI: 10.22616/ERDev.2020.19.TF492*

[231] *Licite I., Lupikis, A. 2020. Impact of land use practices on greenhouse gas emissions from agriculture land on organic soils. Proceedings of 19th International Scientific Conference Engineering for Rural Development, 1823–1830, DOI: 10.22616/ERDev.2020.19.TF492*

[232] *Licite I., Lupikis, A. 2020. Impact of land use practices on greenhouse gas emissions from agriculture land on organic soils. Proceedings of 19th International Scientific Conference Engineering for Rural Development, 1823–1830, DOI: 10.22616/ERDev.2020.19.TF492*

6.6.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the LULUCF sector in order to achieve these quality objectives.

The QA/QC plans for the Grassland's category includes the QC measures based on the IPCC (2006 IPCC Guidelines, Chapter 6.4.3, Tier 1 approach). These measures are implemented every year during the inventory. Potential errors and inconsistencies are documented and corrections are made if necessary. The files and documents used in preparation of the inventory are archived annually and back-up copies are made weekly. Issues related to QA/QC and verification are discussed at the sectoral meetings.

Manual data check is introduced to compare figures imported into the CRF Reporter and actually calculated values. The mathematical errors identified during the previous review are corrected in the EPIM model used for calculation of GHG emissions in LULUCF sector.

All information related to the preparation of the annual inventory is archived in the centralized archiving system (common FTP folder) in accordance with QA/QC plan.

Country-specific EFs[233] used to estimate CO_2 and CH_4 emissions from drained organic soils in grassland were published as a peer-reviewed article and compared to EFs used in other countries in the Baltic Sea region. Latvian values were within uncertainty ranges of CS EFs of other countries in the region.

6.6.5 Category-specific recalculations

Recalculations are done due to continuous improvement of activity data including area of grassland remaining grassland and land converted to grassland. In 2019, net aggregated emissions in grassland increased by 206.29 kt CO_2 eq. The main reason for recalculation of activity data (area) is delayed accumulation of land use changes data (addition 20% of NFI sample plots are surveyed annually, acquired cumulative data are extrapolated to whole country area) till final recalculation of NFI data at the end of every 5 years period (completed NFI cycle with 100% sample plots surveyed). Summary of the impact of recalculation on the aggregated net GHG emissions from grassland is shown in Figure 6.14.

[233] *Licite I., Lupikis, A. 2020. Impact of land use practices on greenhouse gas emissions from agriculture land on organic soils. Proceedings of 19th International Scientific Conference Engineering for Rural Development, 1823–1830. DOI: 10.22616/ERDev.2020.19.TF492*

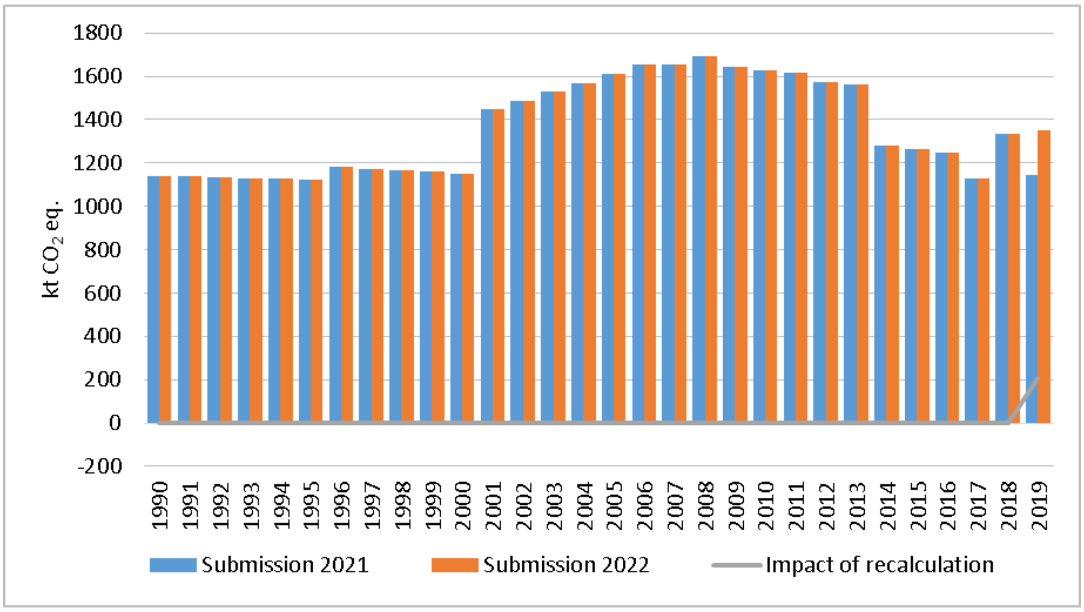

Figure 6.14 Impact of recalculation on the aggregated net GHG emissions from grassland (kt CO_2 eq.)

6.6.6 Category-specific planned improvements

There are several improvements proposed for the following inventories:

- The implementation of improved quantitative results of Yasso modelling to characterize CSCs in mineral soils according to improvement plan;
- Elaboration of model based estimates of GHG emissions and activity data for organic soil in grassland (LIFE OrgBalt project, since 2025).

6.7 *WETLANDS (CRF 4.D)*

6.7.1 Category description

The net GHG emissions in wetlands in 2020 were 1493.78 kt CO_2 eq. (Figure 6.15, Figure 6.16, Figure 6.17). Wetlands remaining wetlands is a key category of CO_2 emissions mainly due to peat extraction for horticulture which contributed 89.2% (1332.01 kt CO_2 eq. sum of on-site and off-site emissions) from total net GHG emissions from Wetland category in 2020. N_2O and CH_4 emissions from drainage and rewetting (described in Section 6.7.2.3) contribute to about 0.5% and 6.4% (6.62 and 92.19 kt CO_2 eq., respectively) of total emissions from organic soils (1437.29 kt CO_2 eq., sum of on-site and off-site GHG emissions) in 2020.

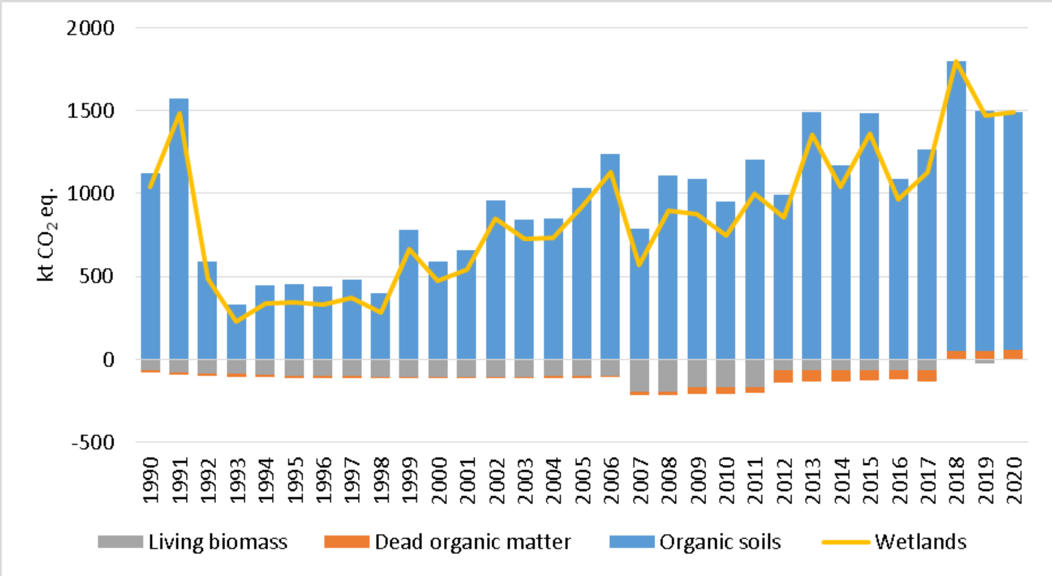

Figure 6.15 Summary of GHG emissions from wetlands (kt CO_2 eq.) by source and sink categories

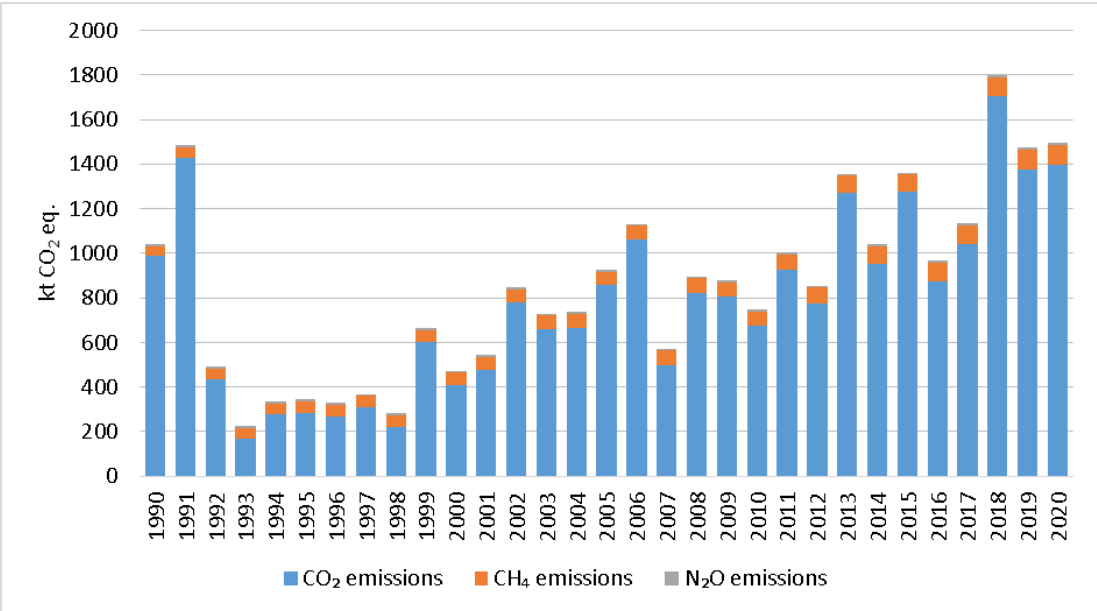

Figure 6.16 Summary of GHG emissions from wetlands (kt CO_2 eq.)

According to the 2006 IPCC Guidelines wetlands include land that is covered or saturated by water for all or part of the year and that does not fall into the forest land, cropland, and grassland or settlement categories. In 2020, total area of wetlands was 399.52 kha, including 32.13 kha of peatlands drained for peat extraction based on the results of the LIFE REstore project, 7.32 kha of wetlands with woody vegetation not meeting threshold for definition of forest land, and 4.52 kha of flooded land remaining flooded land (including rewetted land). Managed wetlands are determined within the scope of LIFE REstore project[234].

[234] *Pētersons J., Lazdiņš A., Kasakovskis A. 2019. LIFE REstore database on areas affected by peat extraction. In Priede A., Gancone A. (Eds.), Sustainable and responsible after-use of peat extraction areas (pp. 122–129). Baltijas Krasti; Butlers A., Ivanovs, J. 2018. Improved activity data for accounting greenhouse gas emissions due to management of wetlands. Annual 24th International Scientific Conference Research for Rural Development 2018, 1, 27–33, DOI: 10.22616/rrd.24.2018.004.*

Table 6.27 Subcategories of Wetlands remaining wetlands (4.D.1) and Land converted to Wetlands (4.D.2)

CRF classification		Land use types included in this category	Type of emissions and removals included in the CRF subcategory
CRF category	CRF subcategory		
4.D.1 Wetlands Remaining Wetlands	*4.D.1.1 Peat Extraction Remaining Peat Extraction*	*Peatlands drained for peat extraction*	*CSC in organic soils (on-site CO_2 emissions) is reported.*
	4.D.1.2 Flooded Land Remaining Flooded Land	*Flooded and rewetted wetlands*	*"IE" notification key is reported for CSC in living biomass and dead organic matter. Included in CRF sybcategory other wetlands remaining other wetlands (CRF 4.D.1.3).* *"IE" notification key is reported for CSC in organic soils (on-site CO_2 emissions). Included in CRF category 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils (Peat Extraction Lands, Rewetted Organic Soils).*
	4.D.1.3 Other Wetlands Remaining Other Wetlands	*Wetlands with woody vegetation and other wetlands*	*CSC in living biomass and dead organic matter is reported.*
4.D.2 Land Converted to Wetlands	*4.D.2.1 Land Converted for Peat Extraction*	-	-
	4.D.2.2 Land Converted to Flooded Land	*Land converted to flooded and rewetted wetlands*	*"IE" notification key is reported for CSCs in living biomass and dead organic matter. Included in CRF sybcategory other wetlands remaining other wetlands (CRF 4.D.1.3).* *"IE" notification key is reported for CSC in organic soils (on-site CO_2 emissions). Included in CRF category 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils (Peat Extraction Lands, Rewetted Organic Soils).*
	4.D.2.3 Land Converted to Other Wetlands	*Land converted to wetlands with woody vegetation and other wetlands*	*"IE" notification key is reported for CSCs in living biomass and dead organic matter. Included in CRF sybcategory other wetlands remaining other wetlands (CRF 4.D.1.3).* *CSC in organic soils (on-site CO_2 emissions) is reported.*

Table 6.28 Distribution of wetlands remaining wetlands (CRF 4.D.1) and land converted to wetlands (CRF 4.D.2) (1000 ha)

Year	Wetlands remaining wetlands				Land converted to wetlands			
	Peat extraction	Flooded land		Other wetlands	Peat extraction	Flooded land		Other wetlands
		Flooded land	Rewetted land			Flooded land	Rewetted land	
1990	*47.63*	*NO*	*NO*	*326.56*	*NO*	*0.20*	*0.00*	*0.50*
1991	*47.12*	*NO*	*NO*	*326.56*	*NO*	*0.41*	*0.00*	*0.64*
1992	*46.60*	*NO*	*NO*	*326.56*	*NO*	*0.61*	*0.00*	*0.77*
1993	*46.08*	*NO*	*NO*	*326.56*	*NO*	*0.82*	*0.00*	*0.91*
1994	*45.57*	*NO*	*NO*	*326.56*	*NO*	*1.02*	*0.00*	*1.05*
1995	*45.05*	*NO*	*NO*	*326.56*	*NO*	*1.23*	*0.00*	*1.18*
1996	*44.53*	*NO*	*NO*	*326.43*	*NO*	*1.43*	*0.00*	*2.40*
1997	*44.02*	*NO*	*NO*	*326.30*	*NO*	*1.64*	*0.00*	*3.62*
1998	*43.50*	*NO*	*NO*	*326.17*	*NO*	*1.84*	*0.01*	*4.84*
1999	*42.98*	*NO*	*NO*	*326.04*	*NO*	*2.05*	*0.01*	*6.07*
2000	*42.47*	*NO*	*NO*	*325.91*	*NO*	*2.25*	*0.01*	*7.29*
2001	*41.95*	*NO*	*NO*	*325.40*	*NO*	*2.46*	*0.01*	*10.12*
2002	*41.43*	*NO*	*NO*	*324.90*	*NO*	*2.66*	*0.01*	*12.95*
2003	*40.92*	*NO*	*NO*	*324.39*	*NO*	*2.87*	*0.01*	*15.78*
2004	*40.40*	*NO*	*NO*	*323.89*	*NO*	*3.07*	*0.01*	*18.62*
2005	*39.88*	*NO*	*NO*	*323.39*	*NO*	*3.28*	*0.01*	*21.45*
2006	*39.37*	*NO*	*NO*	*322.88*	*NO*	*3.48*	*0.01*	*24.28*
2007	*38.85*	*NO*	*NO*	*322.38*	*NO*	*3.69*	*0.01*	*27.12*
2008	*38.33*	*NO*	*NO*	*321.87*	*NO*	*3.89*	*0.01*	*29.95*
2009	*37.82*	*NO*	*NO*	*320.02*	*NO*	*4.10*	*0.01*	*33.21*
2010	*37.30*	*0.41*	*0.00*	*318.46*	*NO*	*4.10*	*0.01*	*35.98*
2011	*36.78*	*0.82*	*0.00*	*316.54*	*NO*	*4.10*	*0.01*	*39.11*
2012	*36.27*	*1.23*	*0.00*	*314.62*	*NO*	*4.10*	*0.01*	*42.24*
2013	*35.75*	*1.64*	*0.00*	*312.70*	*NO*	*4.10*	*0.01*	*45.37*
2014	*35.23*	*2.05*	*0.01*	*312.12*	*NO*	*4.10*	*0.01*	*46.11*
2015	*34.72*	*2.46*	*0.01*	*311.53*	*NO*	*4.10*	*0.01*	*46.86*
2016	*34.20*	*2.87*	*0.01*	*312.03*	*NO*	*4.10*	*0.01*	*46.53*
2017	*33.68*	*3.28*	*0.01*	*312.53*	*NO*	*4.10*	*0.01*	*46.19*
2018	*33.17*	*3.69*	*0.01*	*313.03*	*NO*	*4.10*	*0.01*	*45.85*
2019	*32.65*	*4.10*	*0.01*	*313.32*	*NO*	*4.10*	*0.01*	*45.50*
2020	*32.13*	*4.51*	*0.01*	*313.60*	*NO*	*4.10*	*0.01*	*45.15*

In the Wetlands category, Latvia reports emissions (on-site and off-site) associated with industrial peat extraction. Off-site CO_2–C emissions are associated with the horticultural (non-energy) use of extracted peat. Off-site emissions from peat used for energy are reported in the Energy Sector (1.A.1. Energy industries, 1.A.2. Manufacturing industries and construction and 1.A.4. Other sectors), and is therefore not included here. Summary of on-site and off-site CO_2 emissions associated with industrial peat extraction is shown in Figure 6.17.

The rest of the area of wetlands is not managed (remains undrained) and therefore CO_2 emissions are not calculated. The exception are areas with woody vegetation (mainly narrow bands of trees) located adjacent to water courses, water bodies or swamps which do not fit under the definition of Forest Land category – shorelines of rivers and lakes, that are usually maintained as buffer zones because of environmental restrictions. Removals in this category (4.D.1.3 Other Wetlands Remaining Other Wetlands) are reported in living biomass and dead organic matter. Other types of wetlands remaining wetlands included in CRF table 4.D.1 are lower, upper and transitional bogs and water bodies, excluding drainage ditches and channels.

All these types of lands are estimated using the NFI data and a consistent methodology, therefore no overlapping is possible.

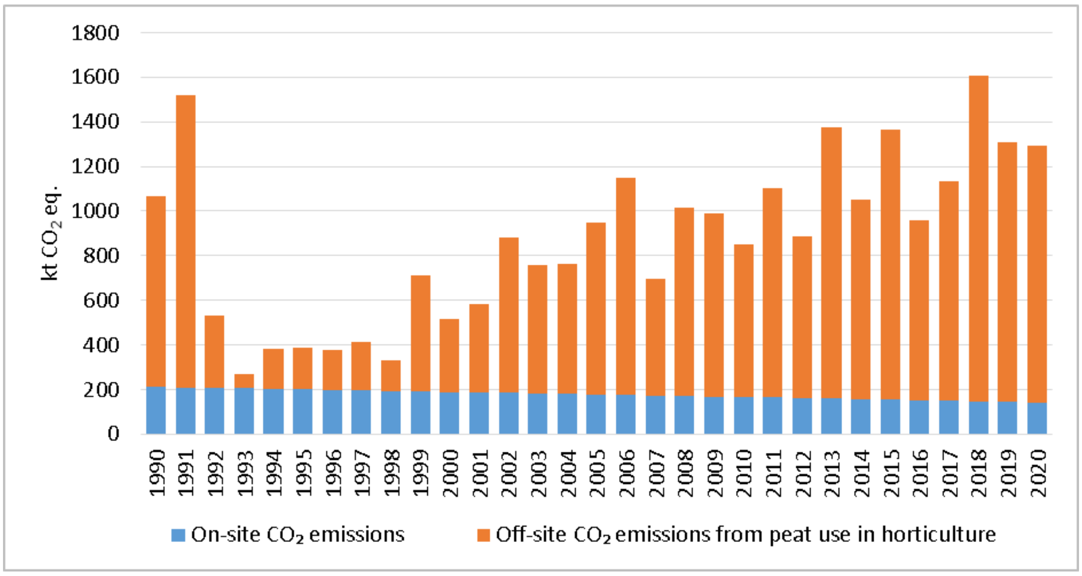

Figure 6.17 Summary of CO_2 emissions associated with industrial peat extraction (kt CO_2 eq.)

6.7.2 Methodological issues

6.7.2.1 Wetlands Remaining Wetlands (CRF 4.D.1)

Under category Wetlands Remaining Wetlands emissions and CO_2 removals are reported in following sub-categories:

- Peat Extraction Remaining Peat Extraction (CRF 4.D.1.1);
- Flooded Land Remaining Flooded Land (CRF 4.D.1.2);
- Other Wetlands Remaining Other Wetlands (CRF 4.D.1.3).

6.7.2.1.1 Peat Extraction Remaining Peat Extraction (4.D.1.1)

Under this category CSC in organic soils (on-site CO_2 emissions) is reported using Tier 2 method. CO_2 emissions are calculated from peatlands drained for peat extraction. Since submission 2019 country specific data of area of peat extraction remaining peat extraction was implemented according to the results of the LIFE REstore project[235] (32.13 kha in 2020). Since submission 2021 national CO_2 EF (1.21 t CO_2-C ha^{-1} yr^{-1}) developed within the scope of LIFE REstore project[236] for organic soils in drained peat extraction areas was used for reporting. Within the LIFE REstore project, two methods were used for CO_2 measurements – manual autotrophic measurements with opaque closed chambers and air sampling and manual ecosystem flux measurements with closed transparent chambers. Although the elaborated country-specific EF (1.21 t CO_2-C ha^{-1} yr^{-1}) is lower than that in the IPCC Wetlands Supplement (2.8 tonnes CO_2-C ha^{-1} yr^{-1}), it is within uncertainty range of the IPCC Wetlands Supplement provided value (Table 6.30). Reason for these differences is mainly the climatic factors - significant difference

[235]Priede A., Gancone A. (eds.) 2019. Sustainable and responsible after-use of peat extraction areas. Baltijas krasti, Riga. Available: https://restore.daba.gov.lv/public/lat/jaunumi/117/

[236] Lazdiņš A., Lupiķis A. 2019. LIFE REstore project contribution to the greenhouse gas emission accounts in Latvia. In: Priede, A., Gancone A.(Eds.), Sustainable and responsible after-use of peat extraction areas (pp. 21–52). Baltijas Krasti.

between central and western parts of Europe where IPCC Wetlands Supplement EFs were developed and condition in Latvia (in warmer climatic conditions higher emissions occur). In addition, use of a similar CO_2 EFs in other Baltic countries (0.2-1.1 t CO_2-C ha^{-1} yr^{-1} in Lithuania[237] and 1.74 t CO_2-C ha^{-1} yr^{-1} in Estonia[238]) confirms compliance of Latvia's national CO_2 EF with climatic conditions in the region.

6.7.2.1.2 *Flooded Land Remaining Flooded Land (CRF 4.D.1.2)*

Carbon stock change in living biomass and dead organic matter in flooded land remaining flooded land is included in category other wetlands remaining other wetlands (CRF 4.D.1.3). Carbon stock change in organic soils in flooded land remaining flooded land is included in category 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils (Rewetted Organic Soils).

6.7.2.1.3 *Other Wetlands Remaining Other Wetlands (CRF 4.D.1.3)*

Under this category CSC in living biomass and dead organic matter in wetlands with woody vegetation is reported. The assumptions for calculations of CSC in living biomass and dead organic matter used in EPIM tool are shown in Table 6.29, default 20 years decay period is considered for dead wood.

Table 6.29 Assumptions for calculation of CSC in living and dead biomass in wetlands

Year	Wetlands with woody vegetation, 1000 ha	Gross increment of living biomass		Wood density, kg m^{-3}	Natural mortality, m^3 ha^{-1}	BEFs		Carbon content, kg $tonne^{-1}$
		mill. m^3	m^3 ha^{-1}			stem to crown	stem to below-ground	
1990	*189.25*	*0.06*	*0.33*	*0.44*	*0.06*	*0.24*	*0.31*	*523.30*
1991	*191.55*	*0.07*	*0.37*	*0.44*	*0.06*	*0.24*	*0.31*	*523.30*
1992	*193.42*	*0.08*	*0.41*	*0.44*	*0.07*	*0.24*	*0.31*	*523.30*
1993	*194.24*	*0.08*	*0.42*	*0.44*	*0.07*	*0.24*	*0.31*	*523.30*
1994	*195.72*	*0.09*	*0.44*	*0.44*	*0.07*	*0.24*	*0.31*	*522.95*
1995	*196.29*	*0.09*	*0.45*	*0.44*	*0.07*	*0.24*	*0.31*	*522.95*
1996	*197.92*	*0.09*	*0.46*	*0.44*	*0.07*	*0.24*	*0.31*	*522.95*
1997	*199.26*	*0.09*	*0.46*	*0.44*	*0.08*	*0.24*	*0.31*	*522.95*
1998	*201.05*	*0.09*	*0.47*	*0.44*	*0.08*	*0.24*	*0.31*	*522.95*
1999	*201.20*	*0.09*	*0.47*	*0.44*	*0.08*	*0.24*	*0.31*	*523.34*
2000	*202.54*	*0.10*	*0.47*	*0.44*	*0.08*	*0.24*	*0.31*	*523.34*
2001	*203.12*	*0.10*	*0.47*	*0.44*	*0.08*	*0.24*	*0.31*	*523.34*
2002	*204.27*	*0.10*	*0.47*	*0.44*	*0.08*	*0.24*	*0.31*	*523.34*
2003	*205.96*	*0.10*	*0.47*	*0.44*	*0.08*	*0.24*	*0.31*	*523.34*
2004	*206.59*	*0.10*	*0.46*	*0.44*	*0.09*	*0.24*	*0.31*	*524.03*
2005	*206.71*	*0.10*	*0.46*	*0.44*	*0.09*	*0.24*	*0.31*	*524.03*
2006	*210.16*	*0.10*	*0.46*	*0.44*	*0.09*	*0.24*	*0.31*	*524.03*
2007	*97.62*	*0.18*	*1.85*	*0.44*	*0.35*	*0.24*	*0.31*	*524.03*
2008	*97.62*	*0.18*	*1.85*	*0.44*	*0.35*	*0.24*	*0.31*	*524.03*
2009	*97.62*	*0.18*	*1.85*	*0.44*	*0.54*	*0.24*	*0.31*	*522.56*
2010	*97.62*	*0.18*	*1.85*	*0.44*	*0.54*	*0.24*	*0.31*	*522.56*
2011	*97.62*	*0.18*	*1.85*	*0.44*	*0.54*	*0.24*	*0.31*	*522.56*
2012	*75.64*	*0.14*	*1.79*	*0.44*	*1.14*	*0.24*	*0.31*	*522.56*

[237] *Lithuania's Greenhouse Gas Inventory Report 2021. Available: https://unfccc.int/ghg-inventories-annex-i-parties/2021*
[238] *Estonia's National Inventory Report 2021. Available: https://unfccc.int/ghg-inventories-annex-i-parties/2021*

Year	Wetlands with woody vegetation, 1000 ha	Gross increment of living biomass		Wood density, kg m^{-3}	Natural mortality, m^3 ha^{-1}	BEFs		Carbon content, kg $tonne^{-1}$
		mill. m^3	m^3 ha^{-1}			stem to crown	stem to below-ground	
2013	*75.64*	*0.14*	*1.79*	*0.44*	*1.14*	*0.24*	*0.31*	*522.56*
2014	*75.64*	*0.14*	*1.79*	*0.44*	*1.14*	*0.24*	*0.31*	*522.62*
2015	*75.64*	*0.14*	*1.79*	*0.44*	*1.14*	*0.24*	*0.31*	*522.15*
2016	*75.64*	*0.14*	*1.79*	*0.43*	*1.14*	*0.24*	*0.31*	*521.93*
2017	*73.85*	*0.15*	*1.98*	*0.44*	*1.29*	*0.24*	*0.31*	*522.18*
2018	*7.57*	*0.00*	*0.35*	*0.43*	*0.51*	*0.25*	*0.31*	*522.42*
2019	*7.85*	*0.02*	*3.06*	*0.44*	*0.49*	*0.24*	*0.31*	*523.79*
2020	*7.32*	*0.00*	*-0.52*	*0.42*	*0.61*	*0.26*	*0.31*	*522.82*

Area of other wetlands remaining other wetlands on mineral soils is included in total area of other wetlands remaining other wetlands on organic soils (the "IE" notation key is reported for area of mineral soils) due to lack of data about share of mineral soils in category other wetlands remaining other wetlands.

6.7.2.2 Land Converted to Wetlands (CRF 4.D.2)

Under this category areas of Land Converted to Flooded Land and Land Converted to Other Wetlands are reported. Area of land converted to other wetlands is divided into mineral soil and organic soil.

Carbon stock change in organic soils in Land Converted to Other Wetlands is reported using Tier 1 method. Default EF for CO_2 (EF_{CO2}) is 0.50 t CO_2-C ha^{-1} yr^{-1} (Table 3.1 from IPCC Wetlands Supplement), but $EF_{DOC\_REWETTED}$ value (0.24 t CO_2-C ha^{-1} yr^{-1}) is provided in Table 3.2 from IPCC Wetlands Supplement. "IE" for CSCs in living biomass and dead organic matter for Land Converted to Flooded Land and Land Converted to Other Wetlands are reported (CSC is reported under category Other Wetlands Remaining Other Wetlands).

Carbon stock changes in organic soils in Land Converted to Flooded Land is included in category 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils (Peat Extraction Lands, Rewetted Organic Soils), "IE" notation key is reported.

6.7.2.3 Emissions and removals from drainage and rewetting and other management of organic and mineral soils (CRF 4(II))

Under this category off-site CO_2 and on-site CH_4 and N_2O emissions from peat extraction fields (drained organic soils) are reported.

Off-site CO_2-C emissions associated to the horticultural (non-energy) use of peat extracted and removed are reported using instant oxidation method (Tier 2 method). Data on peat extraction for horticulture purposes is taken from statistical reports of CSB (statistics table VIM010[239] and ENB050[240] Figure 6.18). Carbon content in peat is considered 45% according to the Table 7.5[241]

[239] *Material flow accounts-domestic extraction (thsd tonnes) 1995 – 2020. Available: https://data.stat.gov.lv/pxweb/en/OSP_PUB/START__ENV__VI__VIM/VIM010/table/tableViewLayout1/*
[240] *Energy balance, in natural units (NACE Rev.2) 2008 – 2020. Available: https://data.stat.gov.lv/pxweb/lv/OSP_PUB/START__NOZ__EN__ENB/ENB050/table/tableViewLayout1/*
[241] *Conversion factors for CO_2-C for volume and weight production data (Boreal and Temperate, Nutrient-Poor)*

of the IPCC Wetlands Supplement, relative moisture – 40% (CSB data) according to a methodology used in statistical data.

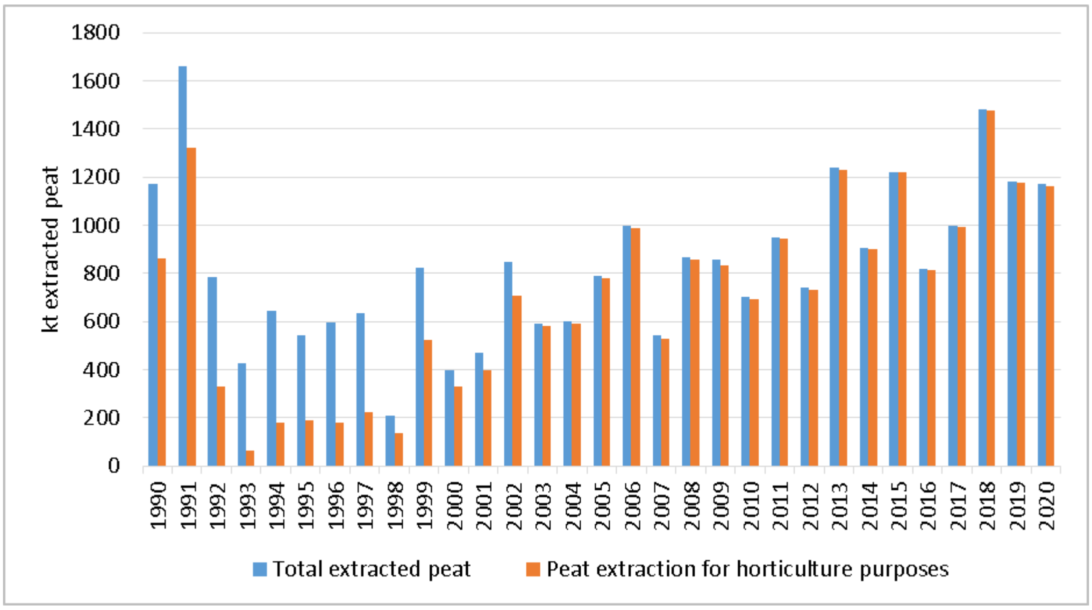

Figure 6.18 Activity data for calculation of off-site CO_2-C emissions associated to the horticultural use of peat[242] (kt extracted peat)

On-site CH_4 and N_2O emissions from organic soils in peatlands drained for peat extraction (32.13 kha in 2020 based on the results of the LIFE REstore project[243]) are calculated using Tier 2 method. Since submission 2021 national CH_4 and N_2O EFs for organic soils in drained peat extraction areas (10.83 kg CH_4 ha^{-1} yr^{-1} and 0.44 kg N_2O-N ha^{-1} yr^{-1})[244] developed within the scope of the LIFE REstore project is used for reporting. Although applied country-specific CH_4 and N_2O EFs are slightly higher than that in the IPCC Wetlands Supplement (6.1 kg CH_4 ha^{-1} yr^{-1} and 0.3 kg N_2O-N ha^{-1} yr^{-1}, respectively), they are within uncertainty ranges of both IPCC Wetlands Supplement provided EFs values (Table 6.30) and EFs used in other countries in the region.

Table 6.30 Comparison of country-specific and IPCC default emission factors (on-site) for peatlands drained for peat extraction

Emission factor	CO_2, t CO_2-C ha^{-1} yr^{-1}	CH_4, kg CH_4 ha^{-1} yr^{-1}	N_2O, kg N_2O-N ha^{-1} yr^{-1}
Country-specific	*1.21*	*10.83*	*0.44*
IPCC Wetlands Supplement (95% confidence interval)	*1.1…4.2*	*1.6…11*	*-0.03…0.64*

On-site CH_4 emissions from drainage ditches in peatlands drained for peat extraction are calculated using Tier 1 method. Default CH_4 EF for drainage ditches (542 kg CH_4 ha^{-1} yr^{-1}

[242] *CSB data*

[243] *EU LIFE program project "Sustainable and responsible management and re-use of degraded peatlands in Latvia" (LIFE REstore). Available: https://restore.daba.gov.lv/public/eng/about_the_project/*

[244] *Lazdiņš A., Lupiķis A. 2019. LIFE REstore project contribution to the greenhouse gas emission accounts in Latvia. In: Priede A., Gancone A. (Eds.), Sustainable and responsible after-use of peat extraction areas (pp. 21–52). Baltijas Krasti.*

according to the Table 2.4 of the IPCC Wetlands Supplement) are utilized. Density of ditches is considered 0.05 ha per 1 ha of peatland (Table 2.4 in the IPCC Wetlands Supplement).

Under category 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils (Peat Extraction Lands, Rewetted Organic Soils) on-site CO_2 and CH_4 emissions from rewetted organic soils are reported. Under this category area of rewetted and flooded land is reported. GHG emissions from rewetted organic soils are estimated according to the Tier 1 methods. EF for CO_2-C (0.5 tonnes CO_2-C ha^{-1} yr^{-1}) is taken from Table 3.1 of the IPCC Wetlands Supplement. CO_2–C EF from DOC exported from rewetted organic soils is 0.24 tonnes CO_2-C ha^{-1} yr^{-1} (Table 3.2 of the IPCC Wetlands Supplement). CH_4 emissions are calculated applying Tier 1 method using equation 3.7 of the IPCC Wetlands Supplement, default EF (216 kg CH_4-C ha^{-1} yr^{-1}) from Table 3.3 of IPCC Wetlands Supplement was used. N_2O emissions from rewetted organic soils according to the the Tier 1 method are assumed to be negligible and are not estimated ("NA" notation key is reported).

6.7.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty of area estimates is provided in Table 6.31.

Table 6.31 Uncertainty of the wetland use data in 2022 submission

Land use category	Number of NFI plots	Share of NFI plots, %	Uncertainty, %
Wetlands	*1123*	*7.0*	*5.7*
wetlands remaining wetlands	*1119*	*6.9*	*5.9*
land converted to wetlands	*4*	*0.03*	*13.4*

According to the NFI, average uncertainty of growing stock is 109%. Uncertainty of annual increment of growing stock of trees is 2.20%. BEFs utilized in calculations have uncertainty level of 2.2% in average according to the study results. Uncertainty of dead wood stock is 3.9%. Uncertainty of carbon content in wood is 0.14%.

Uncertainty of off-site CO_2 emissions from peat use in horticulture reported under the 4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils (Peat Extraction Lands, Drained Organic Soils) is 5% according to the CSB.

Uncertainty range of CH_4 EF for drainage ditches is 102-981 kg CH_4 ha^{-1} yr^{-1} (81.1%) according to the Table 2.3 and Table 2.4 in the IPCC Wetlands Supplement.

Uncertainty range of CO_2-C EF for rewetted organic soils is -0.71-+1.71 tonnes CO_2-C ha^{-1} yr^{-1} (average uncertainty is 242%) according to the IPCC Wetlands Supplement, Table 3.1. Uncertainty range of CO_2-C EF for DOC exported from rewetted organic soils is 0.14-0.36 tonnes CO_2-C $ha^{-1}yr^{-1}$ (average uncertainty is 45.8%) according to the IPCC Wetlands Supplement, Table 3.2. 95% range of CH_4-C EF for rewetted organic soils is 0-856 kg CH_4-C ha^{-1} yr^{-1} (average uncertainty is 198%) according to the IPCC Wetlands Supplement, Table 3.3.

Complete consistency of the time-series is secured by use of the same data source for estimation of area and emissions for the whole time period.

6.7.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the LULUCF sector in order to achieve these quality objectives.

Quality control procedures listed in the 2006 IPCC Guidelines were done, particularly, data about peat extraction were compiled from different sources (national statistics and Union of peat producers) as well as EFs provided by different authors were compared. Issues related to QA/QC and verification are discussed at the sectoral meetings.

Manual data check is introduced to compare figures imported into the CRF Reporter and actually calculated values. The mathematical errors identified during the previous review are corrected in the EPIM model which is used for calculation of GHG emissions in LULUCF sector.

Several improvements of inventory were implemented based on the recommendations (findings) of the Trial review of the 2021 GHG inventory for the LULUCF sector of Latvia and the centralized UNFCCC review conducted in 2020.

All information related to the preparation of the annual inventory is archived in the centralized archiving system (common FTP folder) in accordance with QA/QC plan.

Country-specific EFs[245] used to estimate on-site CO_2, CH_4 and N_2O emissions from peatlands drained for peat extraction were compared to EFs used in other countries in the Baltic Sea region. The Latvian values were within uncertainty ranges of CS EFs of other countries in the region.

6.7.5 Category-specific recalculations

Recalculations are done due to continuous improvement of activity data (Figure 6.19).

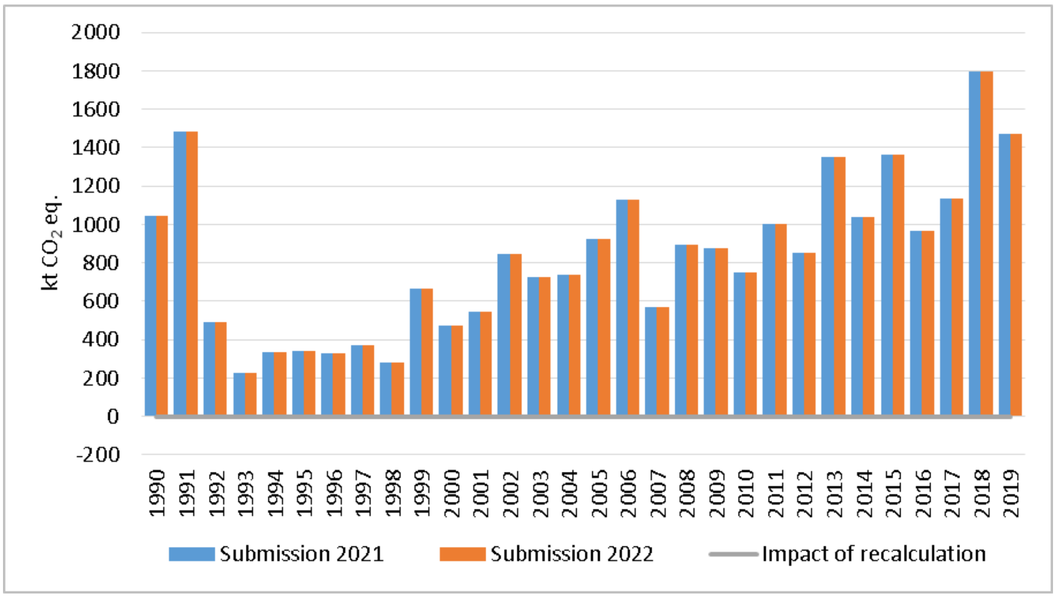

Figure 6.19 Impact of recalculation on the aggregated net GHG emissions from wetland (kt CO_2 eq.)

[245] *Lazdiņš A., Lupiķis A. 2019. LIFE REstore project contribution to the greenhouse gas emission accounts in Latvia. In: Priede A., Gancone A. (Eds.), Sustainable and responsible after-use of peat extraction areas (pp. 21–52). Baltijas Krasti.*

6.7.6 Category-specific planned improvements

Specific improvements in wetlands category are related to continuation of implementation of country specific EFs for managed wetlands, including CO_2, N_2O and CH_4 EFs for rewetted areas and peatland managed as berry plantations (excluding drainage ditches) (since 2023).

6.8 *SETTLEMENTS (CRF 4.E)*

6.8.1 Category description

Net CO_2 emissions from settlements in 2020 were 596.88 kt CO_2 (Figure 6.20). Net CO_2 emissions from land converted to settlements in 2020 were 749.29 kt CO_2 (Figure 6.22). From 1991 to 1999 and from 2012 to 2016 emissions from organic and mineral soils (mainly due to land use change from forest land to settlements) are compensated by the CO_2 removals in living biomass in settlements remaining settlements category (Figure 6.21). This increase of carbon stock in living biomass in settlements remaining settlements reflects increase of age and gross increment of trees growing on settlements (according to NFI average annual net increment increased from 0.11 million m^3 in period 2007-2011 to 0.65 million m^3 in 2012-2016), as well as area of settlements covered by woody vegetation (Table 6.32). From 2017 to 2020 (especially in 2018), CO_2 removals in settlements remaining settlements covered by woody and herbaceous vegetation decreased significantly in comparison to 2012-2016 due to significant increase of biofuel extraction during these years including non-forest lands, e.g. roadsides, power lines and other settlements covered by woody vegetation. This resulted in decrease of annual gross increment of trees growing on settlements to 0.23, 0.004, 0.18 and 0.17 million m^3, respectively. The losses due to extraction of wood in settlements is reported using instant oxidation method, in contrast to natural mortality, which is decomposing during 20 years period according to the applied assumptions.

The significant inter-annual fluctuations of the estimates of the CSCs in living biomass can be explained by the application of so called "floating NFI cycle" to the calculations. Every next year the data set used in calculations of stock changes is moved forward by one year and quality issues related changes (corrections in area of polygons belonging to specific land use) are implemented. Gross increment is calculated as stock changes during 5 year period + mortality + harvest rate during the period, respectively, the whole data set used to calculate stock changes represents 10 years period and vary not only because of adding of the latest data, but also because of moving of the whole calculation period.

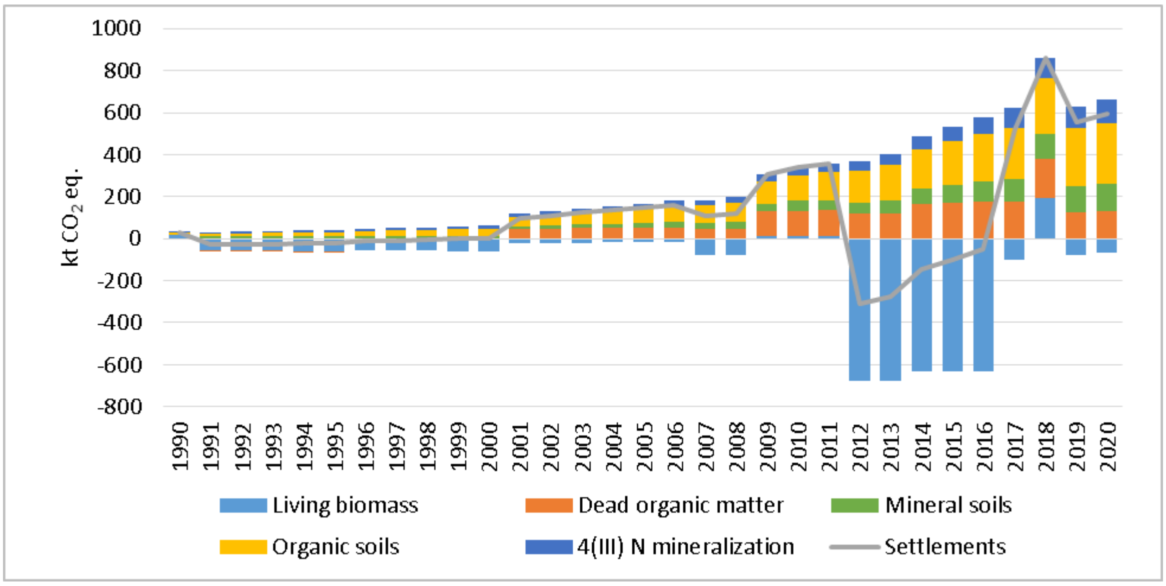

Figure 6.20 Summary of net GHG emissions from settlements (kt CO_2 eq.) by source categories

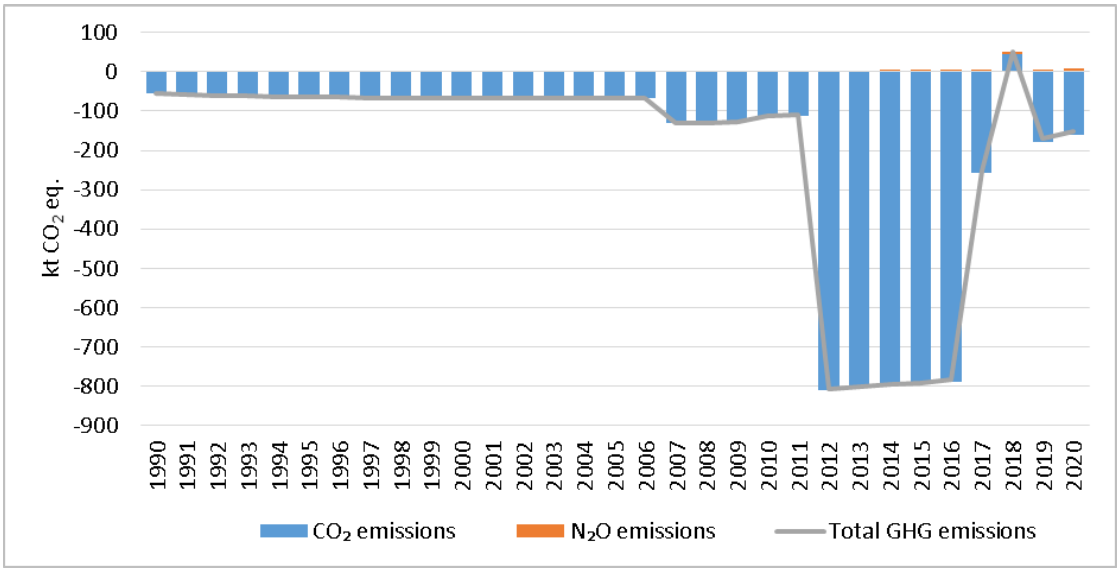

Figure 6.21 Summary of net GHG emissions from settlements remaining settlements (kt CO_2 eq.)

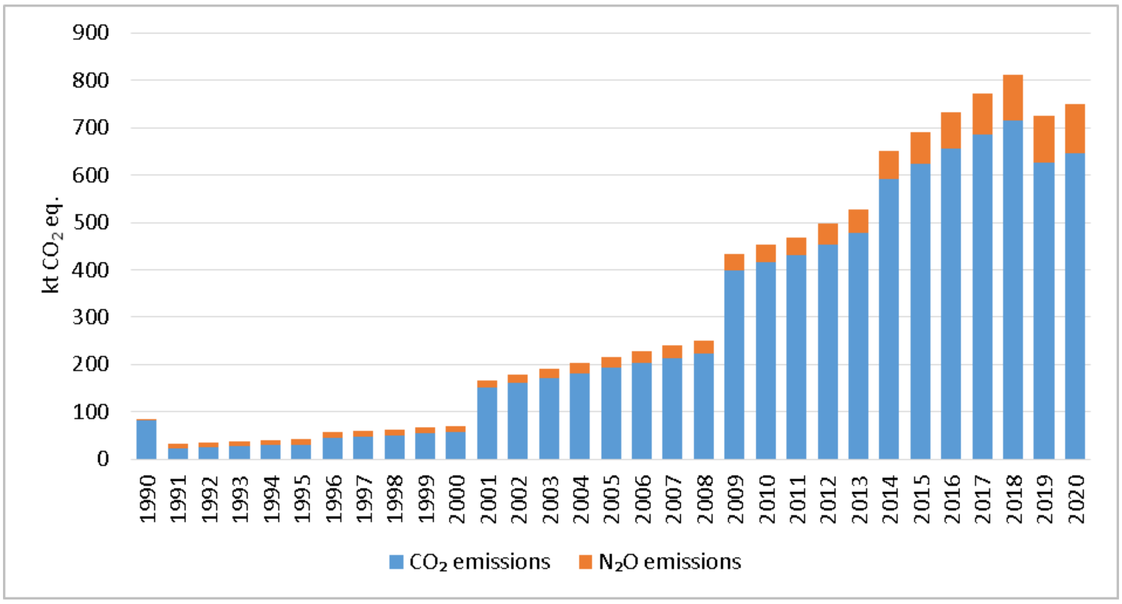

Figure 6.22 Summary of net GHG emissions from land converted to settlements (kt CO_2 eq.)

The assumptions used in EPIM tool are shown in Table 6.32, default 20 years decay period is considered for dead wood.

Table 6.32 Assumptions for calculation of CSC in living and dead biomass in settlements

Year	Settlements with woody vegetation, 1000 ha	Gross increment of living biomass		Wood density, kg m^{-3}	Natural mortality, m^3 ha^{-1}	BEFs		Carbon content, kg $tonne^{-1}$
		mill. m^3	m^3 ha^{-1}			stem to crown	stem to below-ground	
1990	63.40	0.04	0.68	0.44	0.11	0.24	0.31	523.30
1991	64.11	0.05	0.71	0.44	0.12	0.24	0.31	523.30
1992	65.45	0.05	0.73	0.44	0.12	0.24	0.31	523.30
1993	65.45	0.05	0.73	0.44	0.12	0.24	0.31	523.30
1994	67.45	0.05	0.74	0.44	0.12	0.24	0.31	522.95
1995	69.22	0.05	0.73	0.44	0.12	0.24	0.31	522.95
1996	70.01	0.05	0.73	0.44	0.12	0.24	0.31	522.95
1997	71.53	0.05	0.75	0.44	0.12	0.24	0.31	522.95
1998	72.11	0.05	0.74	0.44	0.12	0.24	0.31	522.95
1999	73.34	0.05	0.74	0.44	0.12	0.24	0.31	523.34
2000	73.89	0.05	0.74	0.44	0.12	0.24	0.31	523.34
2001	74.58	0.05	0.73	0.44	0.12	0.24	0.31	523.34
2002	75.10	0.05	0.73	0.44	0.12	0.24	0.31	523.34
2003	75.40	0.05	0.73	0.44	0.12	0.24	0.31	523.34
2004	75.62	0.05	0.72	0.44	0.14	0.24	0.31	524.03
2005	76.90	0.05	0.71	0.44	0.14	0.24	0.31	524.03
2006	76.90	0.05	0.71	0.44	0.14	0.24	0.31	524.03
2007	37.35	0.11	2.81	0.44	0.54	0.24	0.31	524.03
2008	37.35	0.11	2.81	0.44	0.54	0.24	0.31	524.03
2009	37.35	0.11	2.81	0.44	0.83	0.24	0.31	522.56
2010	37.35	0.11	2.81	0.44	0.83	0.24	0.31	522.56
2011	37.35	0.11	2.81	0.44	0.83	0.24	0.31	522.56
2012	68.12	0.65	9.47	0.44	0.66	0.24	0.31	522.56
2013	68.12	0.65	9.47	0.44	0.66	0.24	0.31	522.56

Year	Settlements with woody vegetation, 1000 ha	Gross increment of living biomass		Wood density, kg m^{-3}	Natural mortality, m^3 ha^{-1}	BEFs		Carbon content, kg $tonne^{-1}$
		mill. m^3	m^3 ha^{-1}			stem to crown	stem to below-ground	
2014	*68.12*	*0.65*	*9.47*	*0.44*	*0.66*	*0.24*	*0.31*	*522.62*
2015	*68.12*	*0.65*	*9.47*	*0.44*	*0.66*	*0.24*	*0.31*	*522.15*
2016	*68.14*	*0.65*	*9.47*	*0.43*	*0.66*	*0.24*	*0.31*	*521.93*
2017	*68.04*	*0.23*	*3.41*	*0.44*	*0.71*	*0.24*	*0.31*	*522.18*
2018	*67.94*	*0.00*	*0.06*	*0.43*	*0.58*	*0.25*	*0.31*	*522.42*
2019	*69.35*	*0.18*	*2.57*	*0.44*	*0.83*	*0.24*	*0.31*	*523.79*
2020	*71.88*	*0.17*	*2.42*	*0.42*	*0.80*	*0.26*	*0.31*	*522.82*

Land converted to settlements is a key category of CO_2 and N_2O emissions according to trend and level assessment due to losses of soil carbon pool. The role of conversion of forest land to settlements is increasing with a growth of economic activity and road construction in rural regions, because more than half of the country area is covered by forests, so any new constructions are usually associated with conversion of forest lands. At the same time conversion of grassland to forest land is more intensive in terms of the converted area; however, young forests on farmlands can not fully compensate emissions due to the forest lands conversion to settlements.

Under the settlements category emissions from soils, litter, living and dead biomass due to conversion of land use type are reported. Removals in living and dead biomass in settlements are reported using the NFI data on increment of growing stock in settlements, which is represented mostly by overgrowing of roadsides, power lines and other infrastructure.

Total area of settlements in 2020 was 312.69 kha. The total area of settlements is estimated according to the information provided by the NFI. The increase of area of settlements during last 20 years occurred due to conversion of forest land. Increase of area of settlements is generally associated with road construction. All roads, including forest roads are reported in the settlements category; therefore, the deforested area is considerably higher than official statistics, where forest roads are not reported as deforested area and still belong to forest land category.

6.8.2 Methodological issues

6.8.2.1 Settlements remaining settlements (CRF 4.E.1)

The CO_2 removals are reported for living and dead biomass categories in settlements remaining settlements based on the NFI data. Removals are reported based on weighed (by area) gross increment, mortality rate, BEFs, carbon content and wood density in a particular year in forest land remaining forest land. For emissions from dead wood pool in settlements remaining settlements 20 years transition period is considered. Age of woody vegetation on settlements is counted backwards and as soon as age of trees reach "0", it is considered, that there is no more vegetation and no increment calculations are done. EPIM tool is used in calculations.

Emissions from soils in settlements remaining settlements are calculated according to the 2006 IPCC Guidelines. It is assumed that inputs equal outputs so that settlement mineral soil C stocks do not change in settlements remaining settlements. Emissions from organic soils in settlements remaining settlements are calculated using equation 2.26 in the 2006 IPCC Guidelines (equation No. 6). If soils are drained and the peat is not removed, the emissions are calculated using EFs for cultivated organic soils, due to deep drainage in settlements similar to cropland. The default EF for cultivated organic soils in cool temperate climate zone is 7.9 tonnes CO_2-C ha^{-1} yr^{-1} (Table 2.1 in IPCC Wetlands Supplement).

$$\boldsymbol{L_{Organic}} = \sum_{c}(\boldsymbol{A} * \boldsymbol{EF})_{c} \tag{6.6}$$

where:

$L_{Organic}$ – annual carbon loss from drained organic soils, tonnes C yr^{-1}
A – land area of drained organic soils in climate type c, ha
EF – emission factor for climate type c, tonnes C ha^{-1} yr^{-1}

6.8.2.2 Land converted to settlements (CRF 4.E.2)

NFI data are used to estimate land converted to settlements in 2009-2020. New method for calculation of land use changes using the most recent NFI data was implemented in 2019 (Krumsteds et al., 2019)[246]. Total area of land converted to settlements in 2020 was 51.07 kha.

Under category forest land converted to settlements, the emissions (losses in carbon pools) are reported. Carbon stock changes associated with commercial felling are reported considering that losses in living biomass are equal to average growing stock in forest land converted to settlements (BEFs, carbon content and wood density are considered as weighted by total biomass distribution between species). Dead wood stock in forest land remaining forest land in a particular year is considered as carbon losses from dead wood due to conversion of forest land to settlements. Instant oxidation method is considered for living and dead wood carbon pools. Carbon stock changes in dead biomass are reported using instant oxidation method considering that all dead biomass converts to emissions in the year of the land use change. Average carbon stock in dead biomass (12.14 tonnes C ha^{-1} in litter according to the BioSoil project forest soil inventory data[247] and 6.0 tonnes C ha^{-1} in dead wood according to the NFI) is used in calculations.

Under categories cropland converted to settlements and grassland converted to settlements, CSCs in living biomass and dead organic matter are calculated using Tier 1 method. According to the Tier 1 method CSCs in dead organic matter for cropland converted to settlements and grassland converted to settlements is zero.

Carbon stock changes in living biomass and dead organic matter for wetlands converted to settlements are not calculated due to lack of default C-stock values (not provided by the 2006 IPCC Guidelines).

The total change in soil C stocks for land converted to settlements is computed using equation 2.24 in the 2006 IPCC Guidelines, which combines the change in soil organic C stocks for mineral soils and organic soils. Change in soil organic C stocks is estimated for mineral soils with land-use conversion to settlements using equation 2.25 in the 2006 IPCC Guidelines (equation No. 7). Emission from mineral soil due to land use change from forest land to settlements is reported according to average carbon stock in forest mineral soil, assuming that carbon

[246] Krumsteds L.L., Ivanovs J., Jansons J., Lazdins A. 2019. Development of Latvian land use and land use change matrix using geospatial data of NFI. Agronomy Research 17(6), p. 2295–2305, DOI: 10.15159/AR.19.195.
[247] Bārdule, A., Bāders, E., Stola, J., Lazdiņš, A. 2009. Forest soil characteristic in Latvia according results of the demonstration project BioSoil. Mežzinātne / Forest Science 20(53): 105-124. Available: http://www.silava.lv/userfiles/file/Mezzinatne%2020(53)2009/8_Bardule_MZ_20-2009.pdf

accumulated in upper 30 cm (82.6 tonnes C ha^{-1}) partially turns into emissions within 20 years (0.8 tonnes C h^{-1} annually). The impact factor (F_{LU} x F_{MG} x F_I) is 0.8.

$$\Delta \boldsymbol{C_{Mineral}} = \frac{(\boldsymbol{SOC_0} - \boldsymbol{SOC_{(0-T)}})}{\boldsymbol{D}}$$

$$\boldsymbol{SOC} = \sum_{c,s,i} (\boldsymbol{SOC_{REFc,s,i}} * \boldsymbol{F_{LUc,s,i}} * \boldsymbol{F_{MGc,s,i}} * \boldsymbol{F_{Ic,s,i}} * \boldsymbol{A_{c,s,i}}) \quad (6.7)$$

where:

$\Delta C_{Mineral}$ – annual change in carbon stocks in mineral soils, tonnes C yr^{-1}
SOC_0 – soil organic carbon stock in the last year of an inventory time period, tonnes C
$SOC_{(0-T)}$ – soil organic carbon stock at the beginning of the inventory time period, tonnes C
D – time dependence of stock change factors which is the default time period for transistion between equilibrium SOC values, yr
c – represents the climate zones
s - the soil types
i – the set of management systems that are present 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

Land converted to settlements on organic soils within the inventory time period is treated the same as settlements remaining settlements. Carbon losses are computed using equation 2.26 in the 2006 IPCC Guidelines.

Methodological work for estimating CSC in living biomass and dead organic matter is improved based on national research study aimed to determine increment, mortality and harvest rate in Latvia (Krumsteds et al., 2019)[248].

6.8.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty of area estimates is provided in Table 6.33.

Table 6.33 Uncertainty of the settlements use data in 2022 submission

Land use category	Number of NFI plots	Share of NFI plots, %	Uncertainty, %
Settlements	*661*	*4.1*	*7.8*
settlements remaining settlements	*570*	*3.5*	*8.7*
organic soil	*1*	*0.01*	*-*
other soil	*569*	*3.5*	*8.7*
land converted to settlements	*91*	*0.6*	*19.6*
organic soil	*12*	*0.1*	*47.0*
other soil	*78*	*0.5*	*22.0*

According to the NFI, uncertainty of growing stock is 83.5%. Uncertainty of annual increment of growing stock of trees is 2.20%. BEFs utilized in calculations have uncertainty level of 2.2%

[248] *Krumsteds, L., Lazdins, A., Butlers, A., Ivanovs, J. 2019. Recalculation of forest increment, mortality and harvest rate in Latvia according to updated land use data. Rural Development 2019 (1): 295–299, DOI:10.15544/RD.2019.037*

in average according to the study results. Uncertainty of dead wood stock is 3.9%. Uncertainty of carbon content in wood is 0.14%. Uncertainty of average carbon stock in litter in forest land is 23.1%.

Uncertainty of annual CSC factor (EF) for cultivated organic soils in cool temperate climatic temperature regime is 18.4% (IPCC Wetlands Supplement, Table 2.1). Uncertainty of carbon stock in 0-30 cm soil layer in mineral soils in forest land is 9.4%.

Uncertainties of EFs for estimation of CH_4 emissions from drained organic soils are indicated under chapter Cropland.

Consistency of time series is secured by using the same activity data (NFI) for the whole period.

6.8.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the LULUCF sector in order to achieve these quality objectives.

The QA/QC plans for the settlements' category include the QC measures based on the 2006 IPCC Guidelines. Specific QA/QC checks across the settlements methodology were done. Potential errors and inconsistencies are documented and corrections are made if necessary. The files and documents used in preparation of the inventory are archived annually and back-up copies are made weekly. Issues related to QA/QC and verification are discussed at the sectoral meetings.

Manual data check is introduced to compare figures imported into the CRF Reporter and actually calculated values. The mathematical errors identified during the previous review are corrected in the EPIM model used for calculation of GHG emissions in LULUCF sector.

All information related to the preparation of the annual inventory is archived in the centralized archiving system (common FTP folder) in accordance with QA/QC plan.

6.8.5 Category-specific recalculations

Recalculations (Figure 6.23) are done due to continuous improvement of activity data including area of settlements remaining settlements and land converted to settlements. In 2019, net aggregated emissions in settlements decreased by 128.4 kt CO_2 eq. The main reason for recalculation of activity data (area) is delayed accumulation of land use changes data (addition 20% of NFI sample plots are surveyed annually, acquired cumulative data are extrapolated to whole country area) till final recalculation of NFI data at the end of every 5 years period (completed NFI cycle with 100% sample plots surveyed).

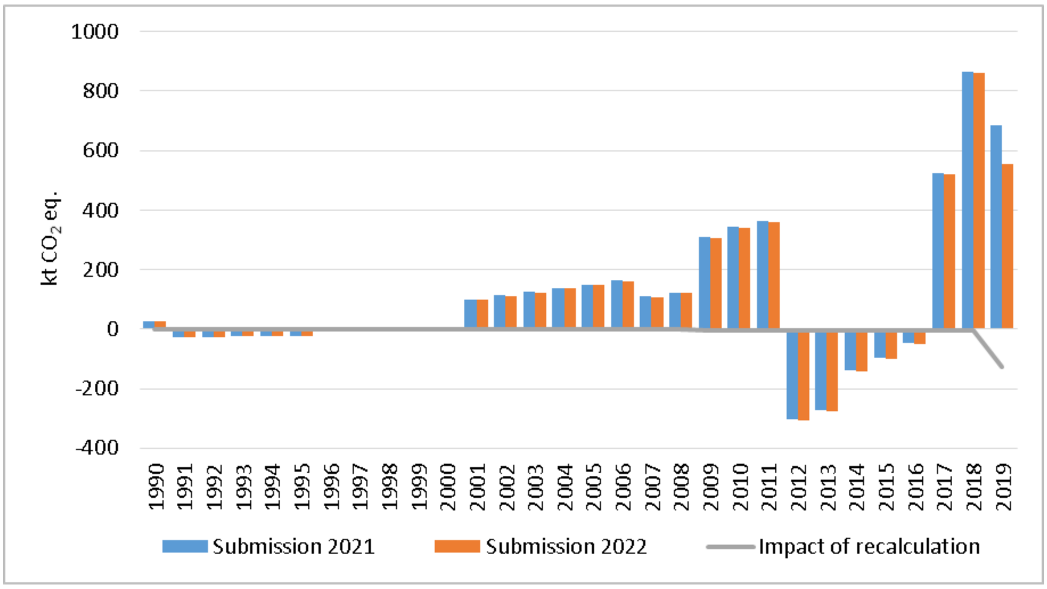

Figure 6.23 Impact of recalculation on the aggregated net GHG emissions from settlements (kt CO_2 eq.)

6.8.6 Category-specific planned improvements

No improvements are planned for this sector.

6.9 *OTHER LAND (CRF 4.F)*

According to the 2006 IPCC Guidelines other lands are territories without vegetation like rocks, glaciers as well as the rest of unmanaged lands which are not included in other land use categories. According to the national land use statistics (State Land Service data) other lands include unmanaged lands, wetlands and settlements (1 459.3 mill. ha in 2008). Instead national land use statistics since 2009 the NFI is used to estimate area of other lands. It is assumed that other lands are dunes not covered by woody vegetation. In 2020, total area of these lands was 5.37 kha. No GHG emissions or CO_2 removals are reported in this category.

6.10 *BIOMASS BURNING (CRF 4(V))*

6.10.1 Source category description

This source category includes greenhouse gas emissions (CO_2, CH_4, N_2O) and other emissions (NO_x and CO) from biomass burning on forest land comprising wildfires and controlled burning, as well as wildfires in grassland. Total aggregated emissions from biomass burning in 2020 were 56.18 kt of CO_2 eq. (Figure 6.24). In 2020, GHG emissions significantly decrease when compared to 2018-2019 mostly due to decrease of the total area of wildfires in forest land and grassland.

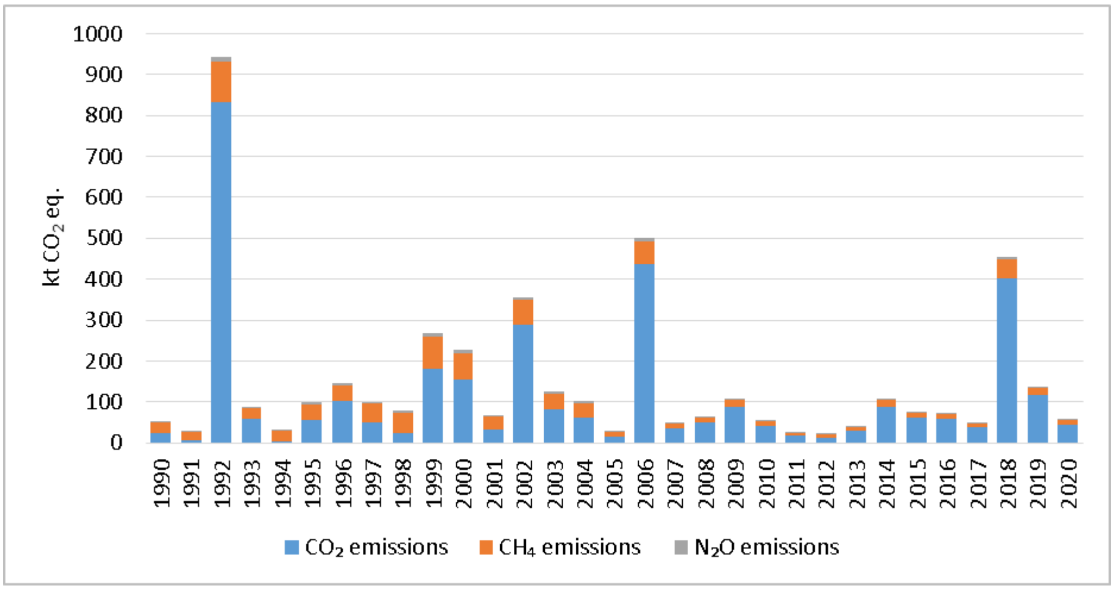

Figure 6.24 Aggregated emissions from biomass burning (kt CO_2 eq.)

Biomass burning occurs in forest land and grassland. Taking into account that wetlands (bogs and fens) belong to forest land according to the national land use definitions, emissions associated with wildfires in wetlands cannot be separated and are reported under forest lands remaining forests. According to NFI data, no evidences of forest fires or grassland wildfires are found in land converted to forest land category, therefore it is considered that no forest fires takes place in afforested area. The approach used in the Latvia's GHG inventory (reporting emissions under land use categories according to the national statistics) secures that emissions from biomass burning are not overlapping.

Statistical data on area impacted by forest wildfires is compiled by SFS on the basis of local unit level information. Area of forest fires and biomass in burned area is shown in Figure 6.25.

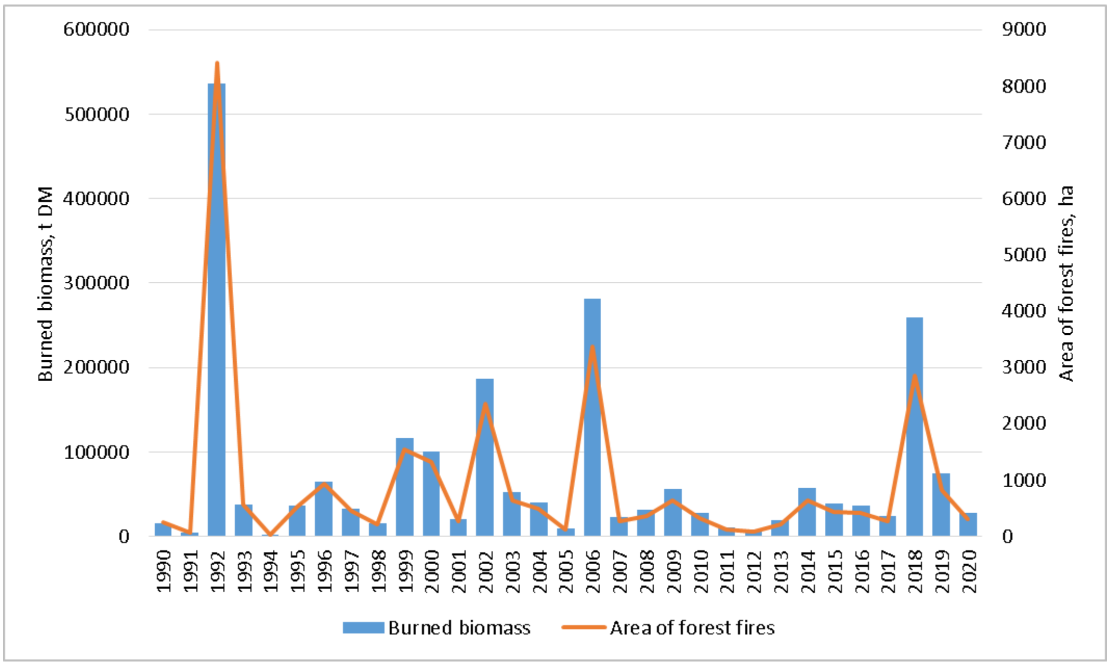

Figure 6.25 Area of forest fires and biomass in burned area (t DM; ha)

Area of grassland burning is provided by the SFRS, cartographic information about location of wildfires in grasslands since 2005 is provided by the Rural Support Service. Wildfires in grasslands are more common in south eastern part of the country and around Riga. Concentration of wildfires in the south-east correlates with area of abandoned farmlands. Total area of burned grassland is shown in Figure 6.26. For 1990-1992 no statistical information exists. It was decided to use extrapolated burned area of following years period for 1990-1992 instead of notification key NO.

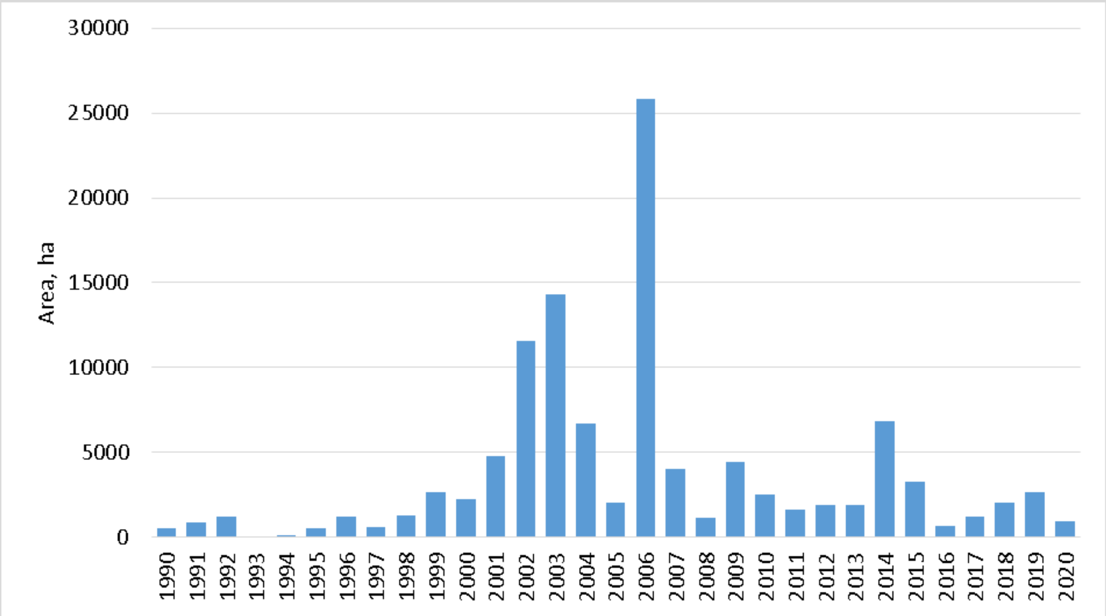

Figure 6.26 Burned area of grassland since 1990 (ha)

Emissions from biomass burning are represented by incineration of harvesting residues during forest logging operations (Figure 6.25). Amount of harvesting residues is calculated using biomass equations[249] from stem wood over bark. Data on share of harvesting residues left for incineration was based on study conducted by Līpiņš (2004)[250] and questionnaire of forest owners on forest management[251].

Since no commercial felling takes place in forest stands younger than 20 years in Land Converted to Forest Land category, all emissions of on site incineration of harvesting residues during commercial harvesting are attributed to the Forest Land Remaining Forest Land category.

[249] *Liepiņš J., Lazdiņš A., Liepiņš K. 2017. Equations for estimating above- and belowground biomass of Norway spruce, Scots pine, birch spp. and European aspen in Latvia. Scandinavian Journal of Forest Research, June 2017, 1–43, DOI: 10.1080/02827581.2017.1337923.*

[250] *Līpiņš L. 2004. Assessment of wood resources and efficiency of wood utilization (Koksnes izejvielu resursu un to izmantošanas efektivitātes novērtējums), LLU.*

[251] *Lazdiņš A., Zariņš J., 2013. Meža ugunsgrēku un mežizstrādes atlieku dedzināšanas radītās siltumnīcefekta gāzu emisijas Latvijā (Greenhouse gas emissions in Latvia due to incineration of harvesting residues and forest fires), in: Referātu Tēzes. Presented at the Latvijas Universitātes 71. zinātniskā konference "Ģeogrāfija, ģeoloģija, vides zinātne", Latvijas Universitāte, Rīga, pp. 133–137.*

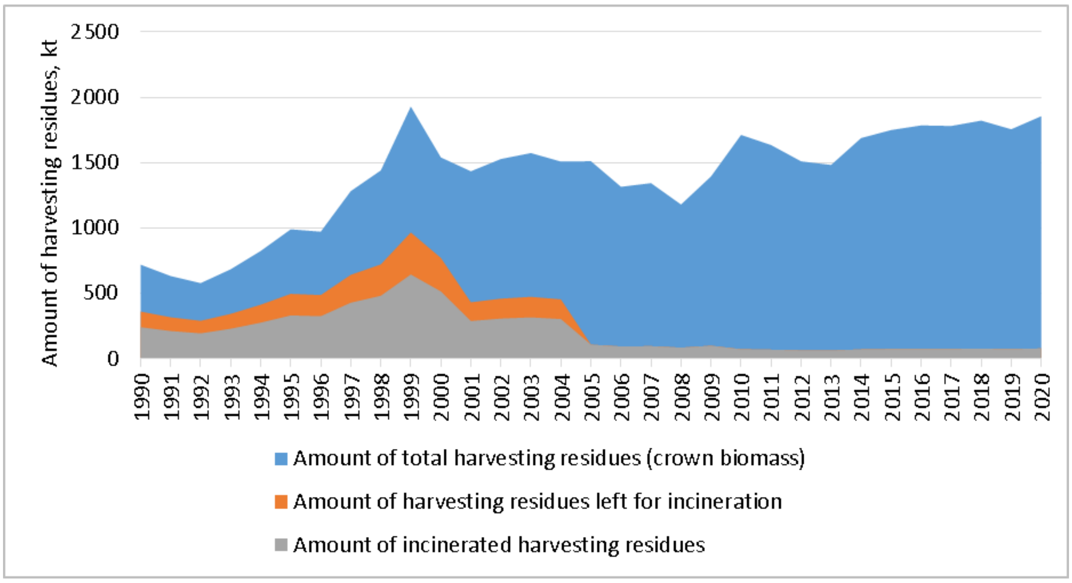

Figure 6.27 Amount of harvesting residues (kt)

6.10.2 Methodological issues

Tier 1 and 2 methods of calculation provided in the 2006 IPCC Guidelines were utilized. Emissions from any type of fires were calculated using equation 2.27 of the 2006 IPCC Guidelines:

$$L_{fire} = A * M_B * C_f * G_{ef} * 10^{-3} \quad (6.8)$$

where:

L_{fire} – amount of GHG emissions from fire, tonnes of each GHG e.g. CH_4, N_2O etc.
A – area burnt, ha
M_B – mass of fuel available for combustion, tonnes ha^{-1}. This includes biomass, ground litter and dead wood. When Tier1 methods are used then litter and dead wood pools are assumed zero, except where there is a land-use change
C_f – combustion factor dimensionless
G_{ef} – emission factor, g kg^{-1} d.m. burnt

6.10.2.1 Forest wildfires

Tier 1 method and default EFs of calculation provided in the 2006 IPCC Guidelines was utilized. Amount of burned biomass is considered according to average growing stock of living biomass, dead wood and litter in a particular year. Combustion efficiency or fraction of biomass combusted (dimension-less) is considered 0.45 according to Table 2.6 of the 2006 IPCC Guidelines[252]. EFs are shown in Table 6.34.

Table 6.34 Emission factor for each GHG (g kg^{-1} d.m. burned)

Gas	CH_4	CO	N_2O	NO_x	CO_2
Emission factor	*6.1±2.2*	*78±31*	*0.06*	*1.1±0.6*	*1550±95*

6.10.2.2 Grassland wildfires

Tier 1 method and default EFs of calculation provided in the 2006 IPCC Guidelines was utilized. Emissions from wildfires in grassland were calculated using equation 2.27 of the 2006 IPCC

[252] *Combustion factor values (proportion of prefire biomass consumed) for fires in a range of vegetation types.*

Guidelines. Mass of available fuel in grassland fires – 2.1 t dm ha^{-1} (Table 2.4 of 2006 IPCC Guidelines[253]), fraction of the biomass combusted 0.74 (Table 2.6 of the 2006 IPCC Guidelines[254]). EFs for grassland fires are shown in Table 6.35.

Table 6.35 Emission factors for grassland wildfires[255]

No	Gas	Factor, g kg^{-1} d.m. burned
1.	*CO*	*65±20*
2.	*CH_4*	*2.3±0.9*
3.	*NO_x*	*3.9±2.4*
4.	*N_2O*	*0.21±0.10*

6.10.2.3 Controlled fires in forests

Tier 2 method and default EFs of calculation provided in the 2006 IPCC Guidelines was utilized. Emissions from controlled fires were calculated considering average stock of harvesting residues (BEF for conversion of stem biomass over bark to above-ground biomass), which considerably increased due to increase of harvesting stock.

Data on share of harvesting residues left for incineration in Latvia is provided by study conducted by Līpiņš (2004)[256] (characterizing forest management before 2000) and results of questionnaire[257] of forest owners on forest management, including section characterizing utilization of harvesting residues (characterizing forest management after 2005). Based on the knowledge gained from mentioned study and questionnaire, the following expert judgements have been made for burned harvesting residues calculation:

- 1990 to 2000 – 50% of harvesting residues are left for incineration and 67% of the left residues are incinerated, the rest are left to decay;
- 2001 to 2004 – 30% of harvesting residues are left for incineration and 67% of the left residues are incinerated, the rest are left to decay;
- 2005 to 2009 – 7% of harvesting residues are left for incineration and 100% of the left residues are incinerated; the rest of the residues are left for decay or extracted for bioenergy production.
- starting from 2010 – 4% of harvesting residues are left for incineration and 100% of the left residues are incinerated; the rest of the residues are left for decay or extracted for bioenergy production.

Factors of emissions are shown in Table 6.34. CO_2 emissions are calculated only from wildfires taking into account that carbon located in harvesting residues is already reported as losses in living biomass. Incinerated residues are extracted from removals in dead wood. CO_2 emissions

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[253] *Fuel (dead organic matter plus live biomass) biomass consumption values for fires in a range of vegetation types.*
[254] *Combustion factor values (proportion of prefire biomass consumed) for fires in a range of vegetation types.*
[255] *IPCC 2006 Guidelines, Table 2.5: Emission factors (g kg^{-1} dry matter burned) for various types of burning.*
[256] *Liepiņš J., Lazdiņš A., Liepiņš K. 2017. Equations for estimating above- and belowground biomass of Norway spruce, Scots pine, birch spp. and European aspen in Latvia. Scandinavian Journal of Forest Research, June 2017, 1–43, DOI: 10.1080/02827581.2017.1337923.*
[257] *Lazdiņš A., Zariņš J., 2013. Meža ugunsgrēku un mežizstrādes atlieku dedzināšanas radītās siltumnīcefekta gāzu emisijas Latvijā (Greenhouse gas emissions in Latvia due to incineration of harvesting residues and forest fires), in: Referātu Tēzes. Presented at the Latvijas Universitātes 71. zinātniskā konference "Ģeogrāfija, ģeoloģija, vides zinātne", Latvijas Universitāte, Rīga, pp. 133–137.*

are reported using instant oxidation method and do not appear in the inventory as removals in dead wood.

6.10.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty in activity data (area) for biomass burning is estimated at ± 10% based on expert judgement. Uncertainty concerning combustion efficiencies in combined is ± 10% according to the expert judgement. Uncertainties in EFs are based on the 2006 IPCC Guidelines (Table 2.5.) default values.

6.10.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the LULUCF sector in order to achieve these quality objectives.

Quality control procedures listed in the 2006 IPCC Guidelines were done. Possible overlapping in emission/removal estimation with other sources has been checked as far as it is possible on the base of existing data. Land areas of wildfires and controlled burning were reviewed with latest statistics. It was confirmed that all data used in this section cover whole land area of Latvia. Issues related to QA/QC and verification are discussed at the sectoral meetings.

Manual data check is introduced to compare figures imported into the CRF Reporter and actually calculated values. The mathematical errors identified during the previous review are corrected in the EPIM model used for calculation of GHG emissions in LULUCF sector.

All information related to the preparation of the annual inventory is archived in the centralized archiving system (common FTP folder) in accordance with QA/QC plan.

6.10.5 Category-specific recalculations

Cause of negligible difference (< 1%) in total net emissions in sub-sector comparing to previous submission is rounding of numbers (Figure 6.28).

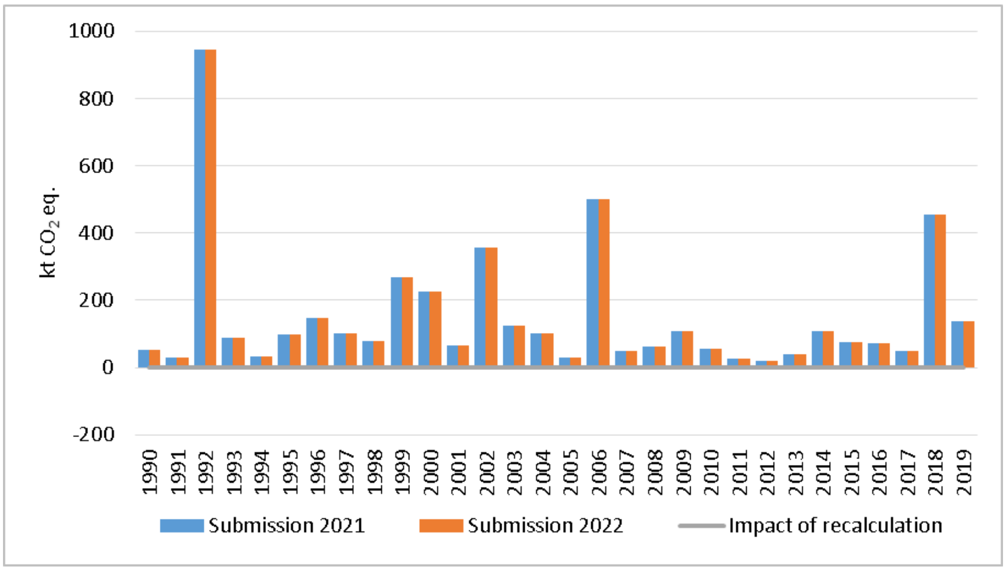

Figure 6.28 Impact of recalculation on the aggregated net GHG emissions from biomass burning (kt CO_2 eq.)

6.10.6 Category-specific planned improvements

No improvements are planned for this sector.

6.11 *HARVESTED WOOD PRODUCTS (CRF 4.G)*

6.11.1 Category description

The category HWP is a key category of CO_2 removals. The net emissions in HWP in 2020 were -1726.14 kt CO_2. The net emissions during the reporting period are shown in Figure 6.29. Increase of removals in the HWP during the last decade is associated with increase of harvesting rate and implementation of more advanced timber processing technologies. Approach B is used in calculation.

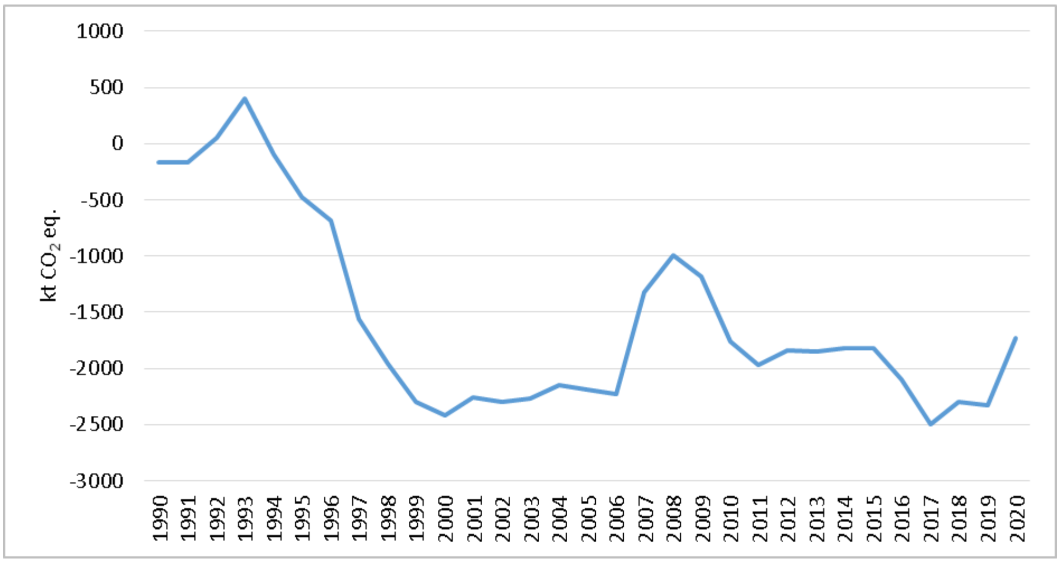

Figure 6.29 Net emissions from HWP during period 1990-2020 (kt CO_2 eq.)

Net emissions due to production of the HWP are calculated according to methodology in the 2013 IPCC Kyoto Protocol Supplement. CO_2 emissions due to roundwood production in deforested land are reported using instantaneous oxidation method.

6.11.2 Methodological issues

The net emissions from the HWP are calculated according to the methodology elaborated by S. Rüter (2011) which refers to approach B in CRF Reporter. The methodology corresponds to Tier 2 for HWP in the 2013 IPCC Kyoto Protocol Supplement for HWP. Three main HWP groups are used in calculations – sawnwood, wood based panels and paper and paperboard with more detailed division on products in Table 6.36 (according to Table 2.8.1 of the 2013 IPCC Kyoto Protocol Supplement).

Table 6.36 HWP categories and their subcategories

HWP category	HWP subcategory
Sawn wood	*Coniferous sawnwood*
	Non-coniferous sawnwood
Wood-based panels	*Hardboard (HDF)*
	Insulating board (Other board, LDF)
	Fibreboard compressed
	Medium-density fibreboard (MDF)
	Particle board
	Plywood
	Veneer sheets
Paper and paperboard	-

The calculation is based on harvesting statistics collected by the SFS, production statistics by the Latvian Forest Industry Federation[258], FAO and EUROSTAT[259]. Data on production and import for 1990-1991 is calculated as average value from data on the first 5 years available in statistics (1992-1996). Export data for 1990-1991 were derived based on linear function for sawn timber and exponential function for wood-based panels (data from period 1992-1996 are used to obtain functions). Linkage with land area used in the commercial felling is secured through the SFS stand wise forest inventory system, where all commercial harvesting activities are recorded. Only locally harvested wood is reported in estimates.

The proportion is calculated by equation No. 6.9 to estimate the share of harvesting stock extracted due to deforestation and is used to calculate share of domestic industrial roundwood. The data to calculate the proportion is obtained from CSB of Latvia and is collected by the SFS. This proportion is applied to HWP to estimate how much HWP could be produced from wood obtained in deforested areas. Instant oxidation is applied to the proportion of HWP potentially produced from the wood obtained in deforested areas.

$$\boldsymbol{IRW_{p(i)} = \left(1 - \frac{D + M_{avg}}{MH_{total}}\right) * IRW_{total\,(i)}} \qquad (6.9)$$

where:

$IRW_{p(i)}$ – production of industrial roundwood excluding roundwood from deforested area in year i, Gg C yr^{-1}
D – annual deforested area, ha
M_{avg} – average growing stock in country, m^3 ha^{-1}

[258] The Latvian Forest Industry Federation. Available: https://www.lvkoks.lv/aboutus/
[259] FAO, EUROSTAT. Available: http://fenixservices.fao.org/faostat/static/bulkdownloads/Forestry_E_Europe.zip

MH_{total} – total harvested stock volume, m^3
$IRW_{total}(i)$ – total industrial domestic roundwood production

Historical data on production, import and export of HWP, as well as the share of different types of the products are used in calculation. The coefficients and numeric values used in calculation are default conversion factors recommended in the 2013 IPCC Kyoto Protocol Supplement (Table 2.8.1) and are provided in Table 6.37 and Table 6.38. Net emissions due to decay of harvesting residues are reported separately considering 20 years transition period for above and below ground biomass. Instant oxidation is considered for the firewood assortment.

Table 6.37 Assumptions for estimation of carbon stock in HWP

HWP categories	Density (oven dry mass over air dry volume), Mg m^{-3}	C conversion factor (per air dry volume), C m^{-3}
Sawnwood – Coniferous	*0.450*	*0.225*
Sawnwood – Non-Coniferous	*0.560*	*0.280*
Veneer sheets	*0.505*	*0.253*
Plywood	*0.542*	*0.267*
Particle board	*0.596*	*0.269*
Hardboard	*0.788*	*0.335*
MDF (Medium density fibreboard)	*0.691*	*0.295*
Fibreboard compressed	*0.739*	*0.315*
Insulating board	*0.159*	*0.075*
-	*oven dry mass over air dry mass, Mg Mg^{-1}*	*per air dry mass, Mg C Mg^{-1}*
Paper and paperboard (aggregate)	*0.900*	*0.386*

Share of locally originated wood in HWP is calculated using equation No. 6.10.

$$\boldsymbol{f_{IRW}(i) = \frac{IRW_P(i) - IRW_{EX}(i)}{IRW_P(i) + IRW_{(IM)}(I) - IRW_{EX}(i)}} \quad (6.10)$$

where:

$f_{IRW}(i)$ – share of industrial roundwood for the domestic production of HWP originating from domestic forests in year i
$IRW_P(i)$ – production of industrial roundwood excluding roundwood from deforested area in year i, Gg C yr^{-1}
$IRW_{EX}(i)$ – export of industrial roundwood in year i, Gg C yr^{-1}
$IRW_{(IM)}(I)$ – import of industrial roundwood in year i, Gg C yr^{-1}

Organic carbon in HWP originated from domestic wood is calculated using equation No. 6.11.

$$\boldsymbol{CHWP = f_{IRW}(i) * HWP_D} \quad (6.11)$$

where:

CHWP – organic carbon in domestically produced HWP excluding HWP from wood produced in deforested area, Gg C yr^{-1}
HWPD – domestic production of HWP, Gg C yr^{-1}

The rate of the CO_2 emissions and removals in HWP is calculated using equations No. 6.12 and 6.13.

$$\boldsymbol{C(i+1) = e^{-k} * C(i) + \left[\frac{1-e^{-k}}{k}\right] * inflow(i)} \quad (6.12)$$

where:

C(i+1) – annual carbon stock, Gg C yr^{-1}
e – exponential constant

k – decay constant for each HWP category, units yr^{-1}
C(i) – carbon stock in particular category at the beginning of year i, Gg C
inflow (i) – the inflow to the particular HWP category during year i, Gg C yr^{-1}

$$\boldsymbol{k = \frac{\ln(2)}{HL}} \tag{6.13}$$

where:

HL – the number of years it takes to lose one-half of the material currently in the pool, yr

$$\boldsymbol{\Delta C(i) = C(i+1) - C(i)} \tag{6.14}$$

where:

ΔC(i) – carbon stock change of the HWP category during year i, GG C yr^{-1}

Table 6.38 Common coefficients to estimate balance between CO_2 emissions and removals in HWP

Factors	Numeric value		
Common coefficients:			
e	*2.718282*		
ln(2)	*0.6931*		
Assortment specific coefficients:			
Assortment	Sawnwood	Platewood	Pulpwood
HL	*35*	*25*	*2*
k	*0.02*	*0.03*	*0.35*
e^{-k}	*0.98*	*0.97*	*0.71*
$\boldsymbol{k = \frac{1-\ln(2)}{H*L}}$	*0.99*	*0.99*	*0.85*

The equations of calculation of the HWP are included into the National tool for calculation of the net emissions due to forest management as separate module.

6.11.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty level of the activity data for the whole time series is assumed 15% in 1990-2019.

6.11.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the LULUCF sector in order to achieve these quality objectives.

Harvesting rate and production of HWP used in the calculations is compared with other data sources, particularly statistics collected by the Latvia Forest industry federation. Issues related to QA/QC and verification are discussed at the sectoral meetings.

Manual data check is introduced to compare figures imported into the CRF Reporter and actually calculated values. The mathematical errors identified during the previous review are corrected in the EPIM model used for calculation of GHG emissions in LULUCF sector.

All information related to the preparation of the annual inventory is archived in the centralized archiving system (common FTP folder) in accordance with QA/QC plan.

6.11.5 Category-specific recalculations, if applicable, including changes made in response to the review process

Recalculations are done due to continuous improvement of activity data. Summary of the impact of recalculation on CO_2 emissions from HWP is shown in Figure 6.30.

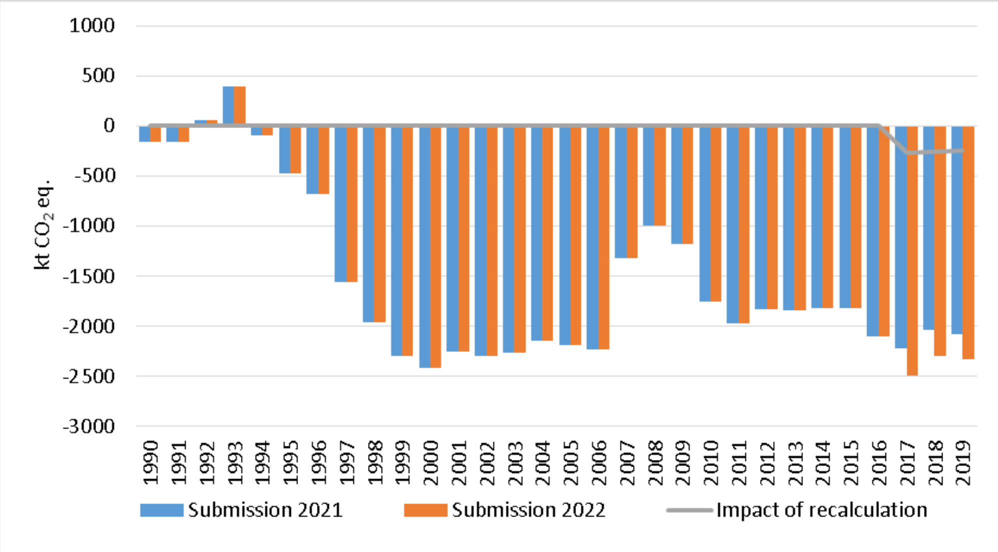

Figure 6.30 Impact of recalculation on CO_2 emissions from HWP (kt CO_2 eq.)

6.11.6 Category-specific planned improvements

No improvements are planned for this sector.

6.12 *DIRECT N_2O EMISSIONS FROM MANAGED SOILS*

6.12.1 Category description

Direct N_2O emissions from drainage of organic soils are estimated for forest land, settlements and wetlands. Direct N_2O emissions from nitrogen mineralisation associated with loss of soil organic matter from change of land use or management are estimated for settlements remaining settlements and land-use change to croplands and settlements. Total aggregated direct N_2O emissions from managed soils in 2020 were 2.08 kt N_2O.

6.12.2 Methodological issues

Direct emissions of N_2O due to drainage of organic soils are calculated according equation No. 6.15 (Equation 2.7 of the IPCC Wetlands Supplement).

$$\boldsymbol{N_2O - N_{OS} = \left[\left(F_{OS,CG,Temp} * EF_{2CG,Temp}\right) + \left(F_{OS,F,Temp,NR} * EF_{2F,Temp,NR}\right)\right]} \qquad (6.15)$$

where:

$N_2O - N_{OS}$ – annual direct N_2O–N emissions from managed/drained organic soil, kg N_2O-N yr^{-1}
F_{OS} – annual area of managed/drained organic soils, ha. The subscripts CG, F, Temp, NR refer to cropland and grassland, forestland, temperate and nutrient rich, respectively
EF_2 – emission factor for N_2O emissions from drained/maganed organic soils, kg N_2O-N ha^{-1} yr^{-1}

Activity data consist of areas of land remaining in a land-use category and land converted to other land-use category on drained organic soils. Default N_2O EFs for drained organic soils in forest land is 2.8 kg N_2O-N ha^{-1} yr^{-1} according to Table 2.5 of the IPCC Wetlands Supplement. Default N_2O EFs for drained organic soils in cropland (13 kg N_2O-N ha^{-1} yr^{-1} according to Table 2.5 of the IPCC Wetlands Supplement) is used to report N_2O emissions from drained organic soil in settlements remaining settlements. Since submission 2021 national N_2O EFs for organic soils in drained peat extraction areas (0.44 kg N_2O-N ha^{-1} yr^{-1})[260] developed within the scope of LIFE REstore project is used for reporting.

N_2O emissions from land converted to another land-use category on drained organic soils are calculated in the same way as emissions from land remaining in a land-use category.

Direct N_2O emissions from N inputs to managed soils and from N mineralisation resulted from loss of soil organic C stocks in mineral soils due to land-use change are estimated by Tier 1 methodology using equation No. 6.15 (equation 11.1 of the 2006 IPCC Guidelines):

$$\boldsymbol{N_2O - N_{N\ inputs} = F_{SOM} * EF_1} \quad (6.16)$$

where:

N_2O-$N_{N\ inputs}$ – annual direct N_2O-N emissions from N inputs to managed soils, kg N_2O-N yr^{-1}
EF_1 – emission factor for N mineralized from mineral soil as a results of loss of soil carbon, kg N_2O-N $(kg\ N)^{-1}$

The equation No. 15 is supplemented by equation 11.8 from the 2006 IPCC Guidelines (equation No. 17 in the NIR). Default EF for N mineralised from mineral soil as a result of loss of soil carbon (0.01 kg N_2O-N $(kg\ N)^{-1}$) from Table 11.1 of the 2006 IPCC Guidelines is used. Default C:N ratio (15) for soil organic matter is utilized for estimation of annual amount of N mineralised in mineral soils as a result of loss of soil carbon due to land use change to cropland (2006 IPCC Guidelines). As there is no fixed default EFs for settlements provided by IPCC guidelines, default EFs of croplands land-use category are applied, C:N ratio for soil organic matter applied based on expert judgement is 15, and annual carbon losses in organic soil in settlements are reported using default emissions factor from cropland – 7.9 tonnes CO_2-C ha^{-1} yearly (Table 2.1 of IPCC Wetlands Supplement).

6.12.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty of soil nitrogen (N_2O) emissions are estimated according to data obtained within the scope of the international forest soil monitoring project BioSoil[261] and values provided in the 2006 IPCC Guidelines. Uncertainty range of EFs for N_2O emissions from drained organic soils in forest land and cropland is shown in Table 2.5 of the IPCC Wetlands Supplement.

Uncertainty range of EF for N mineralised from mineral soil as a result of loss of soil carbon is 0.003-0.03 kg N_2O-N $(kg\ N)^{-1}$ (average uncertainty is 135%). Uncertainty range of C:N ratio of the soil organic matter for land-use change is 10-30 (67%).

[260] Lazdiņš A., Lupiķis A. 2019. LIFE REstore project contribution to the greenhouse gas emission accounts in Latvia. In: Priede A., Gancone A.(Eds.), Sustainable and responsible after-use of peat extraction areas (pp. 21–52). Baltijas Krasti.
[261] Bārdule, A., Bāders, E., Stola, J., Lazdiņš, A. 2009. Forest soil characteristic in Latvia according results of the demonstration project BioSoil. Mežzinātne / Forest Science 20(53): 105-124. Available: http://www.silava.lv/userfiles/file/Mezzinatne%2020(53)2009/8_Bardule_MZ_20-2009.pdf

6.12.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the LULUCF sector in order to achieve these quality objectives.

QA/QC procedures include double check of area affected by the land use change and soil CO_2 emissions – under calculation of land use changes and during calculation of N_2O emissions. Issues related to QA/QC and verification are discussed at the sectoral meetings.

Manual data check is introduced to compare figures imported into the CRF Reporter and actually calculated values. The mathematical errors identified during the previous review are corrected in the EPIM model used for calculation of GHG emissions in LULUCF sector.

All information related to the preparation of the annual inventory is archived in the centralized archiving system (common FTP folder) by March 15 in accordance with QA/QC plan.

6.12.5 Category-specific recalculations

Recalculations are done due to continuous improvement of activity data.

6.12.6 Category-specific planned improvements

It is planned to elaborate specific N_2O EFs for wetlands on organic soils (high N_2O emissions) and mineral soils (low N_2O emissions) (LIFE OrgBalt project, since 2025).

6.13 *INDIRECT N_2O EMISSIONS FROM MANAGED SOILS (CRF 4 (IV))*

6.13.1 Category description

Indirect N_2O emissions from N mineralisation associated with loss of soil organic matter from change of land use or management are estimated for land-use change to croplands and settlements on mineral soils. Total aggregated indirect N_2O emissions from N mineralisation in 2020 were 0.0085 kt N_2O. Indirect N_2O emissions from organic soils are not calculated, because the 2006 IPCC Guidelines does not include such a methodology.

6.13.2 Methodological issues

Indirect N_2O emissions from land use change to cropland are calculated according to the 2006 IPCC Guidelines. Amount of N_2O-N emissions produced from leaching and run-off as a result from land use change to cropland are estimated by Tier 1 methodology using equation 11.10 (equation No. 6.17 in the NIR).

$$\boldsymbol{N_2O_{(L)} - N = F_{SOM} * Frac_{LEACH-H} * EF_5} \tag{6.17}$$

where:

$N_2O_{(L)}$-N – annual amount of N_2O-N produced from leaching and runoff of N additions to managed soils where leaching/runoff occurs, kg N_2O-N yr^{-1}
$Frac_{LEACH(H)}$ – fraction of all N added to/mineralised in managed soils in regions where leaching/runoff occurs that is lost though leaching and runoff, kg N (kg of N additions)$^{-1}$
EF_5 – emission factor for N_2O emissions from leaching and runoff, kg N_2O-N (kg N leached and runoff)$^{-1}$)

It is supplemented by equation 11.8 from the 2006 IPCC Guidelines (equation No. 6.18 in the NIR).

$$F_{SOM} = (\Delta C_{Mineral} * \frac{1}{R}) * 1000 \quad (6.18)$$

where:

F_{SOM} – the net annual amount of N mineralised in mineral soils as a result of loss of soil carbon throught change in land use or management, kg N
$\Delta C_{Mineral}$ – average annual loss of soil carbon for land-use type, tonnes C R-C:N ratio of the soil organic matter

Default C:N ratio (15) for soil organic matter (2006 IPCC Guidelines) is utilized for estimation of the net annual amount of N mineralised in mineral soils as a result of leaching/run-off associated with loss of soil carbon through land use change to cropland. Carbon losses are calculated according to the Tier 1 method of the 2006 IPCC Guidelines. Default values of fraction of all N added to/mineralised in managed soils due to leaching and run-off (0.3 kg N (kg of N additions)$^{-1}$) and EF for N_2O emissions from N leaching and run-off (0.0075 kg N_2O-N (kg N leached and run-off)$^{-1}$) are taken from table 11.3 of the 2006 IPCC Guidelines.

Indirect N_2O emissions from land use change to settlements are also reported using the 2006 IPCC Guidelines Tier 1 method. Amount of N_2O-N emissions produced from leaching and run-off as a result from land use change to settlements are estimated by Tier 1 methodology using equation 11.10 supplemented by equation 11.8 from the 2006 IPCC Guidelines. C:N ratio 15 for soil organic matter based on expert judgement is utilized for estimation of annual amount of N mineralised in mineral soils as a result of leaching/run-off associated with loss of soil carbon thorough land use change to settlements. Tier 1 method of the 2006 IPCC Guidelines (loss of 20 % of soil carbon in land converted to settlement) is used to estimate CSCs. Default values of fraction of all N added to mineralised in managed soils due to leaching and run-off (0.3 kg N per kg of N added^{-1}) and EF for N_2O emissions from N leaching and run-off (0.0075 kg N_2O-N per kg N leached and run-off^{-1}) are taken from table 11.3 of the 2006 IPCC Guidelines.

6.13.3 Uncertainties and time-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

Uncertainty range of C:N ratio of the soil organic matter for land-use change from Forest Land or Grassland to Cropland is 10-30 (average uncertainty is 67%). Uncertainty range of fraction of all N added to or mineralised in managed soils in regions where leaching/run-off occurs that is lost through leaching a run-off is 0.1-0.8 kg N (kg of N additions^{-1}), average uncertainty is 117%. Uncertainty range of EF for N_2O emissions from N leaching and run-off according to the 2006 IPCC Guidelines is 0.0005-0.025 kg N_2O-N (kg N leached and run-off^{-1}), average uncertainty is 163%.

6.13.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the LULUCF sector in order to achieve these quality objectives. QA/QC procedures include double check of area affected by the land use change and soil CO_2 emissions – under calculation of land use changes and during calculation of N_2O emissions. Issues related to QA/QC and verification are discussed at the sectoral meetings.

Manual data check is introduced to compare figures imported into the CRF Reporter and actually calculated values. The mathematical errors identified during the previous review are corrected in the EPIM model used for calculation of GHG emissions in LULUCF sector.

All information related to the preparation of the annual inventory is archived in the centralized archiving system (common FTP folder) in accordance with QA/QC plan.

6.13.5 Category-specific recalculations

Recalculations are done due to continuous improvement of activity data. In 2019, indirect N_2O emissions slightly decreased due to recalculation of area of forest land converted to croplands and settlements. Summary of the impact of recalculation on indirect N_2O emissions from managed soils is shown in Figure 6.31.

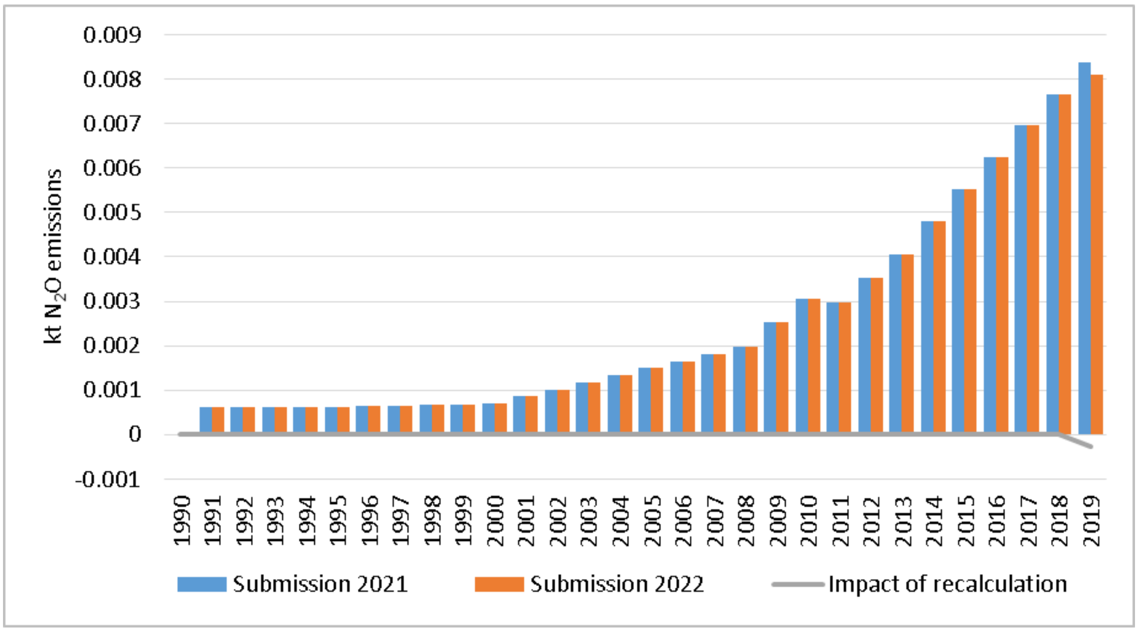

Figure 6.31 Impact of recalculation on indirect N_2O emissions from managed soils (kt)

6.13.6 Category-specific planned improvements

No improvements are planned for this sector.

7 WASTE (CRF 5)

7.1 *OVERVIEW OF SECTOR*

In 2020, emissions from the Waste sector were 547.25 kt CO_2 eq.; it contributes about 5.2% of total GHG emissions (excluding LULUCF, including indirect CO_2) (Figure 7.1). Solid waste disposal and wastewater handling sectors are the main sources of GHG emissions in Waste sector producing accordingly 69.3% and 19.1% of all Waste sector emissions in 2020. Incineration and Biological treatment of solid waste together contribute only 11.6% of GHG emissions from Waste sector in 2020.

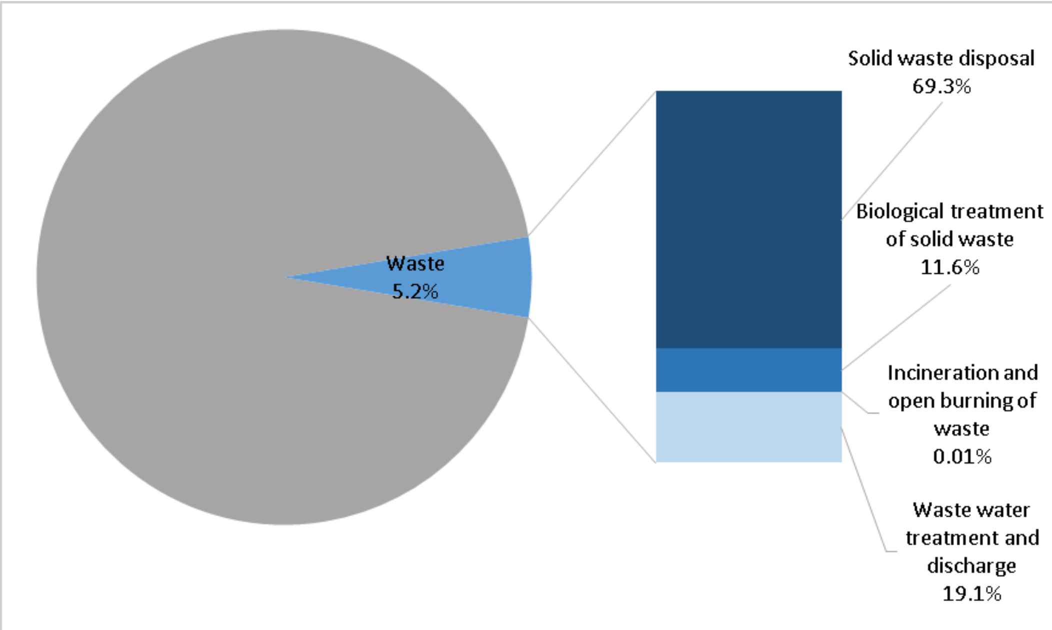

Figure 7.1 Emissions from the waste sector compared with the total emissions in 2020

Emission categories reported under Waste sector as well as used methods and EFs are summarized in Table 7.1.

Table 7.1 Waste sector reported emissions and methods

Sector categories	Reported GHG	Methods	EF
A. Solid waste disposal			
1. Managed waste disposal sites	*CH_4*	*Tier 2 (D)*	*CS, D*
2. Unmanaged waste disposal sites	*CH_4*	*Tier 2 (D)*	*CS, D*
3. Uncategorized waste disposal sites	*NO*	*NA*	*NA*
B. Biological treatment of solid waste			
1. Composting	*CH_4, N_2O*	*D*	*D*
2. Anaerobic digestion at biogas facilities	*CH_4*	*D*	*D*
C. Incineration and open burning of waste			
1. Waste incineration	*CO_2, N_2O*	*D*	*D*
2. Open burning of waste	*NO*	*NA*	*NA*
D. Wastewater treatment and discharge			
1. Domestic wastewater	*CH_4, N_2O, NMVOC*	*Tier 1, Tier 2*	*CS, D*

Sector categories	Reported GHG	Methods	EF
2. Industrial wastewater	*CH_4, N_2O, NMVOC*	*Tier 1*	*CS, D, PS*
3. Other (as specified in table 6.B)	*NMVOC*	*D*	*D*
E. Other (please specify)	*NO*	*NA*	*NA*

GHG emissions from Waste sector have been fluctuated from 1990-2020. In 2020, emissions have decreased by 25.2% compared to 1990.

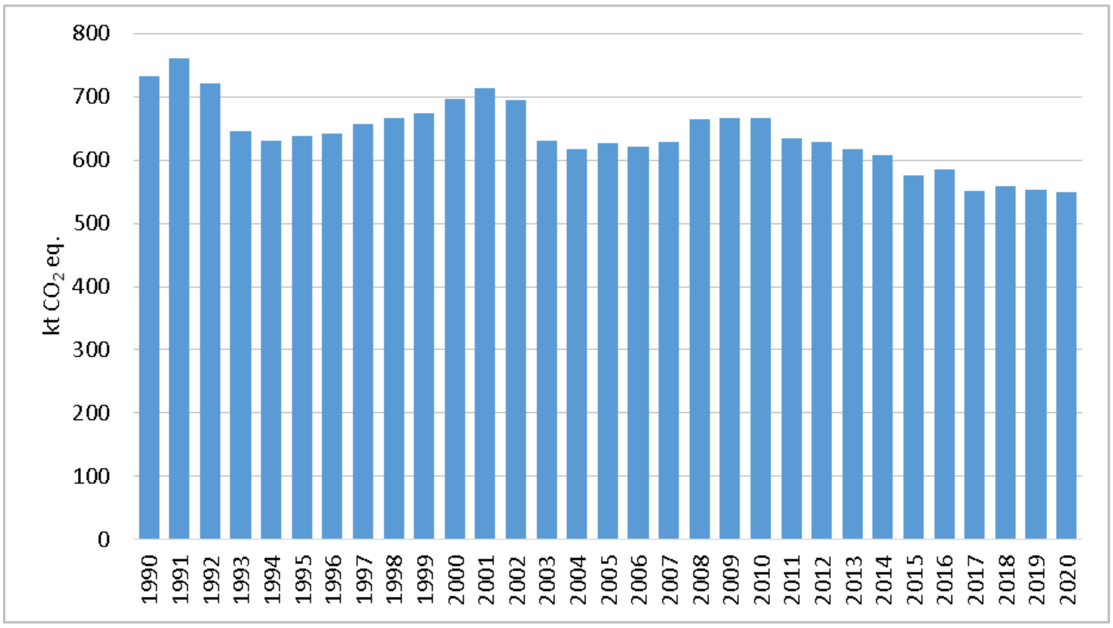

Figure 7.2 Total GHG emissions from Waste sector 1990-2020 (kt CO_2 eq.)

Fluctuations in total GHG emissions in Waste sector could be explained with changes of economic situation in last 30 years (Figure 7.2). Some industry sectors were almost closed in the middle of 1990s. Biggest influence to total emission trend in the beginning on 1990s gives GHG emissions from Wastewater handling, decrease of total emissions in years 2002-2004 is due to starting of methane collection in landfills.

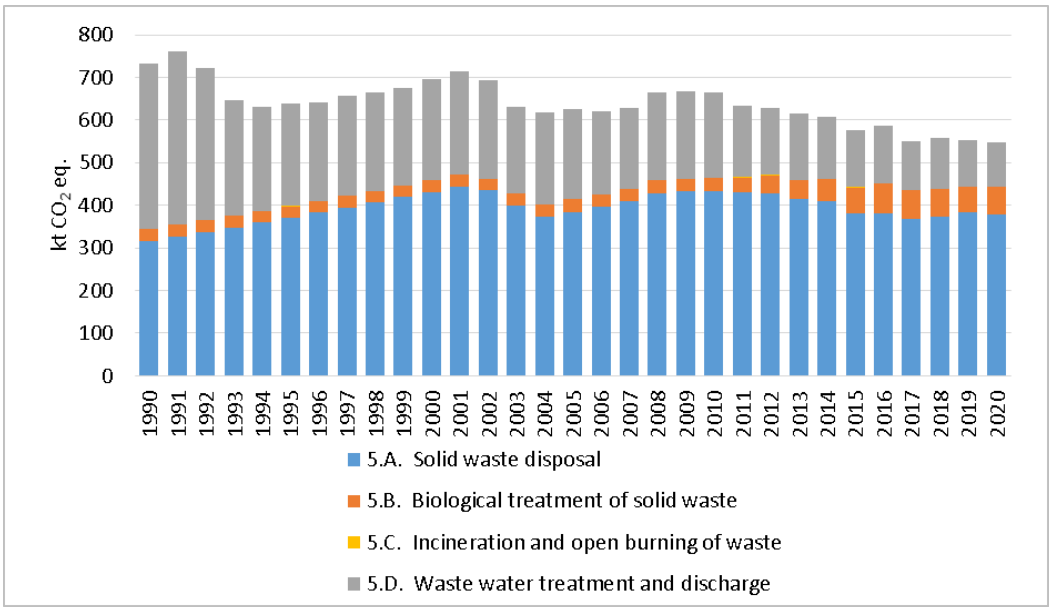

Figure 7.3 GHG Emissions in Waste subsectors 1990-2020 (kt CO_2 eq.)

Emissions from 5.C and 5.B in last years, when emissions from these sectors were calculated, are very small compared to other sectors – 5.A Solid waste disposal (SWD) and 5.D Waste water treatment and discharge (WWH).

N_2O is emitted as the release from sewage purification system and waste incineration.

Data on CO_2 and N_2O emissions from waste incineration are available only since 1999. Emissions are estimated since 1990, data on incinerated amount 1990–1998 are extrapolated according to disposed and incinerated waste amounts proportion. Calculation of precursors emissions from cremation is shown in Section 7.4.1.1. Emissions from waste incineration with energy recovery are allocated under Energy sector (CRF 1.A.2.f Non-metalic minerals).

CH_4 and N_2O are emitted from waste composting. Enterprises data available only since 2003, when composting facilities started to report within state statistical survey about waste composting. Emissions from household waste composting are estimated since 1990. 2006 IPCC Guidelines and default EFs are used to calculate emissions.

Key categories from Waste sector are summarized in Table 7.2.

Table 7.2 Key categories in Waste sector in 2022 submission

Category	Gas	Identification criteria	with LULUCF	without LULUCF
5.A.1. Managed Waste Disposal on Land	*CH_4*	*L1,L2*	*X*	*X*
5.A.2. Unmanaged Waste Disposal Sites	*CH_4*	*L1,L2,T1,T2*	*X*	*X*
5.B.1. Composting	*CH_4*	*L1,L2,T1,T2*		*X*
5.B.1. Composting	*N_2O*	*L2,T2*		*X*
5.B.2. Anaerobic digestion at biogas facilities	*CH_4*	*L2*		*X*
5.D.1 Domestic Wastewater	*CH_4*	*L1,L2,T1,T2*	*X*	*X*
5.D.1 Domestic Wastewater	*N_2O*	*L1*		*X*
5.D.2 Industrial Wastewater	*CH_4*	*T1,T2*	*X*	*X*

According to the annual waste statistics report[262] the total generated amount of waste is shown in Table 7.3.

Table 7.3 Generated waste in Latvia (kt)

Year	Municipal (all non-hazardous) waste	Hazardous waste	Total
2006	*1420.46*	*54.37*	*1474.83*
2007	*1386.57*	*41.61*	*1428.18*
2008	*1368.79*	*46.40*	*1415.16*
2009	*1033.91*	*55.56*	*1089.47*
2010	*1131.40*	*55.09*	*1186.49*
2011	*1535.06*	*58.48*	*1593.53*
2012	*1799.44*	*85.12*	*1884.56*
2013	*1902.01*	*109.23*	*2011.24*
2014	*2128.73*	*80.98*	*2209.70*
2015	*2087.51*	*86.60*	*2174.11*
2016	*1980.28*	*63.66*	*2043.94*
2017	*2141.21*	*68.76*	*2209.97*
2018	*1587.74*	*118.14*	*1705.88*
2019	*1698.71*	*115.46*	*1814.17*
2020	*1605.95*	*150.03*	*1455.97*

Waste management has acquired prior significance in the environmental protection policy as one of the instruments for sustainable use of natural resources. The main directions in the waste management are the development of the construction of polygons and collecting system for non–hazardous municipal waste and the development of system for the collection and treatment of hazardous waste. At the moment 11 non-hazardous waste polygons and two polygons for hazardous waste got "A" category permits according to integrated pollution prevention and control (IPPC) directive. Biogas collection and use for energy production from biodegradable waste and sludge is set as one of waste management priorities in Latvia.

Main activity data sources for GHG emissions calculations in Waste sector are databases[263] "3-Waste", "2-Water" and data from CSB.

Data on hazardous waste in Latvia have been collected and compiled by LEGMC since 1997, but data on municipal (non-hazardous) waste since 2001. Until then the waste volume was determined on the basis of separate pilot projects and the assessments and projections by waste management experts.

Since 2002 databases about hazardous and municipal waste are combined in one database "3-Waste". Data in this database are gathered from State Statistical survey about waste, which is conducted annually.

Statistical survey must be completed annually by all enterprises, which have permits on polluting activities (A and B category) and all enterprises, which have permits on waste

[262]*Waste statistics report. Available: https://videscentrs.lvgmc.lv/lapas/atkritumi-un-radiacijas-objekti*
[263]*Databases. Available: http://parissrv.lvgmc.lv/public_reports*

management operations. To estimate disposed waste amounts in preliminary years; data from Landfill research 2016[264] were used.

"2-Water" database was developed by LEGMC as well. Data of water abstraction and use, wastewater treatment and discharge have been collected since 1991 in the frame of state statistical survey "2–Water". State statistical survey "2-Water" must be reported by all enterprises which have issued permits on water use, water resources use or mineral deposits quarry use, or IPPC permit. Both LEGMC "2-Water" and CSB data are used as activity data for emission calculation - CSB and "2-Water" data for CH_4 emission from Domestic Waste Water Handling, Industrial Wastewater Handling and Sewage Sludge, N_2O emission from Industrial Wastewater Handling and NMVOC emission, and CSB for CH_4 emission from industrial wastewater handling and N_2O from Domestic Wastewater Handling.

7.2 *SOLID WASTE DISPOSAL (CRF 5.A)*

7.2.1 Category description

Methane emission is calculated from SWD (Table 7.4). It is main GHG source from Waste sector in Latvia. Compared to 2019, CH_4 emissions have decreased by 1.1% in 2020. Compared to 1990, CH_4 emissions have increased by 65 kt CO_2 eq. due to First order decay calculation method. In 2002, CH_4 recovery started in Latvia waste polygons. Recovery gives effort for small decrease of emissions in 2003 – 2007. IPCC Waste Model from the 2006 IPCC Gudelines is used.

Table 7.4 Reported emissions under subcategory Solid Waste Disposal on Land

CRF	Source	Emissions reported
5.A.1	*Managed Waste Disposal on Land*	*CH_4, NMVOC*
5.A.2	*Unmanaged Waste disposal Sites*	*CH_4, NMVOC*
5.A.3	*Uncategorized Waste disposal Sites*	*Not occurring*

To estimate CH_4 emissions with IPCC Waste Model (First Order Decay (Tier2)) was used. Time series for disposed waste amounts till 1950 was developed. The base year for estimation of disposed amount is 1975. According to Landfill research made in 2016[265], disposed amount in 1975 was 249 860 tonns. Reaserch estimation is based on information from questionaires, what was filled by municipalities about landfill situation in their territory. During the research municipalities were asked to provide information on:

- active and closed landfills names;
- years of each landfil activity;
- disposed amounts in each landfills (volume or mass);
- landfill recovery statuss;
- number in contaminated sites register;

List of landfills was selected, which was already active in 1975 and for which information was available on the active operational period and disposed waste.

[264] *"Landfill data collection and compilation for GHG estimates", 2016, LEGMC. Available:https://www.meteo.lv/lapas/atkritumu-izgaztuvju-datu-savaksana-un-apkoposana-seg-aprekiniem?id=2182*
[265] *"Landfill data collection and compilation for GHG estimates", 2016, LEGMC. Available:https://www.meteo.lv/lapas/atkritumu-izgaztuvju-datu-savaksana-un-apkoposana-seg-aprekiniem?id=2182*

To perform calculations - information about 62 landfills was available in 1975. From these 62 landfills full information, including the amount of disposed waste and active operational period, was available for 50 landfills.

Using the information on the active operational period - it was possible to determine how much waste were landfilled by dividing the total amount of disposed waste with active years. The amount of waste disposed in accordance with the research calculations in 1975 was 249 860 tons.

Amount for disposed waste 1950–1974 was assumed the same like in 1975. Disposed amount for years 1976–2001 were estimated like steady growth till year 2002 amount, when data became available from data base "3-Waste" (Table 7.5).

Table 7.5 Estimated disposed waste amounts from 1950–2001

Year	Disposed solid waste amount (kt)	Population in rural areas (%)	Population in urban areas (%)	Disposed waste in rural areas (kt) (MCF=0.4)	Disposed waste in urban areas (kt) (MCF= 0.8)
1950-1974	*249.86*	*39%*	*61%*	*97.44*	*152.41*
1975	*249.86*	*39%*	*61%*	*97.44*	*152.41*
1976	*263.90*	*33%*	*67%*	*87.08*	*176.81*
1977	*277.94*	*33%*	*67%*	*91.72*	*186.22*
1978	*291.98*	*33%*	*67%*	*96.35*	*195.63*
1979	*306.02*	*33%*	*67%*	*100.98*	*205.03*
1980	*320.06*	*33%*	*67%*	*105.61*	*214.44*
1981	*334.1*	*32%*	*68%*	*106.91*	*227.19*
1982	*348.14*	*32%*	*68%*	*111.40*	*236.73*
1983	*362.18*	*32%*	*68%*	*115.89*	*246.28*
1984	*376.23*	*32%*	*68%*	*120.39*	*255.84*
1985	*390.27*	*32%*	*68%*	*124.88*	*265.38*
1986	*404.31*	*31%*	*69%*	*125.33*	*278.97*
1987	*418.35*	*31%*	*69%*	*129.68*	*288.66*
1988	*432.39*	*31%*	*69%*	*134.04*	*298.34*
1989	*446.43*	*31%*	*69%*	*138.39*	*308.03*
1990	*460.47*	*31%*	*69%*	*142.74*	*317.72*
1991	*474.51*	*31%*	*69%*	*147.09*	*327.41*
1992	*488.55*	*31%*	*69%*	*151.45*	*337.07*
1993	*502.59*	*31%*	*69%*	*155.80*	*346.78*
1994	*516.63*	*31%*	*69%*	*160.15*	*356.47*
1995	*530.67*	*31%*	*69%*	*164.50*	*366.16*
1996	*544.71*	*31%*	*69%*	*168.86*	*375.84*
1997	*558.75*	*31%*	*69%*	*173.21*	*385.53*
1998	*572.79*	*31%*	*69%*	*177.56*	*395.22*
1999	*586.83*	*31%*	*69%*	*181.91*	*404.91*
2000	*600.87*	*31%*	*69%*	*186.26*	*414.60*
2001	*614.91*	*31%*	*69%*	*190.62*	*424.28*

Landfills from 1950–2001 are assumed as unmanaged[266]. Disposed amount is divided between rural and urban areas, according to the proportion of population between these areas.

[266] *"Degradable organic carbon in disposed waste", 2011, Ltd Virsma*

Methane correction factors (MCF) for CH_4 emissions calculations in urban areas (deep sites - 0.8) and rural areas (shallow sites - 0.4) are used.

Data about waste disposal on land for 2002-2020 are taken from database "3-Waste" (Table 7.6). Starting from 2002, according to data base information, biggest sites could be assumed as managed sites (polygons) and MCF-1 was started. For each year (2002-2020) in polygons disposed amount are determined according to disposing site profile from "3-Waste" data base.

From 2016 bioreactor in the Latvia's biggest polygon Getlini starts to operate.

Table 7.6 Disposed solid waste amounts from 2002-2020 (kt)

Year	Total disposed solid waste amount	Disposed in polygons (MCF=1)	Stored in bioreactor	Disposed in deep unmanaged sites (urban area, MCF=0.8)	Disposed in shallow unmanaged sites (rural area, MCF=0.4)
2002	*658.00*	*217.46*	*NO*	*303.97*	*136.57*
2003	*578.90*	*207.74*	*NO*	*256.07*	*115.05*
2004	*631.70*	*282.84*	*NO*	*240.71*	*108.15*
2005	*610.90*	*370.43*	*NO*	*165.89*	*74.53*
2006	*670.00*	*454.39*	*NO*	*148.78*	*66.84*
2007	*775.10*	*553.27*	*NO*	*153.09*	*68.78*
2008	*704.80*	*566.89*	*NO*	*95.12*	*42.74*
2009	*637.50*	*549.50*	*NO*	*60.71*	*27.28*
2010	*605.40*	*586.90*	*NO*	*12.73*	*5.72*
2011	*548.70*	*543.50*	*NO*	*2.60*	*2.60*
2012	*529.50*	*525.50*	*NO*	*1.98*	*1.98*
2013	*534.20*	*534.20*	*NO*	*NO*	*NO*
2014	*505.20*	*505.20*	*NO*	*NO*	*NO*
2015	*503.90*	*503.90*	*NO*	*NO*	*NO*
2016	*515.70*	*353.90*	*161.90*	*NO*	*NO*
2017	*517.90*	*230.60*	*287.20*	*NO*	*NO*
2018	*508.80*	*219.30*	*289.50*	*NO*	*NO*
2019	*506.39*	*202.78*	*303.61*	*NO*	*NO*
2020	*494.35*	*218.61*	*275.74*	*NO*	*NO*

Two separate IPCC Waste Model calculations were used. One for unmanaged sites and other for managed (waste polygons since 2002 and bioreactor since 2016). For unmanaged sites calculation method for bulk waste was used, because there are no correct information about disposed waste content available. According to Ltd Virsma research, DOC factor for these calculations is 0.17. Other factors are default from the 2006 IPCC guidelines.

For managed sites method "waste by composition" in IPCC Waste Model was used. Data on waste composition was taken from Ltd Virsma research (Table 7.7).

Table 7.7 Disposed waste composition in Latvia waste polygons

Polygons	Samples	Organic fraction (%)					Inorganic fraction (%)		
		Paper	Plastics	Organic (food, hygiene waste, other organics)	Wood	Textile, rubber	Minerals (ceramics)	Glass	Metals
Pentuli	*No1*	*3.8*	*19.5*	*45.4*	*4.1*	*3.6*	*7.2*	*15.6*	*0.8*
	No2	*14.3*	*5.2*	*37.8*	*8.3*	*0.6*	*9.4*	*8.2*	*16.2*
	No3	*9.7*	*6.9*	*52.9*	*0.5*	*2.2*	*10.4*	*15.5*	*1.9*
	No4	*11.6*	*8.7*	*59.5*	*1.5*	*3.7*	*5.3*	*6.1*	*3.6*
	No5	*4.6*	*6.5*	*72*	*0.7*	*0.8*	*8.3*	*5.7*	*1.4*
	No6	*4.1*	*23.9*	*42.8*	*3.9*	*2.3*	*7.4*	*14.5*	*1.1*
Pentuli average		***8.02***	***11.78***	***51.73***	***3.16***	***2.2***	***8***	***10.93***	***4.16***
Ķivites	*No1*	*5.1*	*2.2*	*58.3*	*0.2*	*3.9*	*11.6*	*14*	*4.7*
	No2	*6.1*	*5.6*	*51.4*	*0.6*	*3.1*	*10.5*	*19.6*	*3.1*
	No3	*1.3*	*5*	*56.9*	*2.1*	*0.3*	*9.7*	*18.2*	*6.5*
	No4	*11.3*	*6*	*31*	*3.9*	*33.3*	*2.8*	*8.1*	*3.6*
	No5	*4.5*	*4.8*	*62*	*3.2*	*2.6*	*12.7*	*9.2*	*1*
Kivites average		***5.66***	***4.72***	***51.92***	***2***	***8.64***	***9.46***	***13.82***	***3.78***
Getlini	*No1*	*6.4*	*5.8*	*42.3*	*1.1*	*1.2*	*19.9*	*21.6*	*1.7*
	No2	*19.4*	*20*	*41*	*1.1*	*0*	*1.8*	*16.3*	*0.4*
	No3	*2.2*	*4.8*	*58.7*	*1.6*	*0.7*	*0.9*	*23.7*	*7.4*
	No4	*3.9*	*5.8*	*57.2*	*0*	*11.1*	*6.6*	*14.9*	*0.5*
	No5	*3.2*	*14.9*	*52.3*	*4.6*	*1.8*	*4.5*	*18.7*	*0*
Getlini average		***7.02***	***10.26***	***50.3***	***1.68***	***2.96***	***6.74***	***19.04***	***2***
Daibe	*No1*	*3.1*	*4.8*	*40.2*	*1.4*	*0.2*	*14.3*	*35.3*	*0.7*
	No2	*4.9*	*5.8*	*19.3*	*3.9*	*0.9*	*22.3*	*42.8*	*0.1*
	No3	*3.7*	*2.1*	*73.8*	*1.8*	*0.3*	*3.4*	*14.7*	*0.2*
	No4	*3*	*4.7*	*18*	*2.1*	*0.2*	*16.7*	*55.2*	*0.1*
	No5	*3.5*	*2.3*	*12.9*	*3.2*	*0.4*	*15.7*	*61.9*	*0.1*
Daibe average		***3.64***	***3.94***	***32.84***	***2.48***	***0.40***	***14.48***	***41.98***	***0.24***
Average in Country		***6.40***	***8.54***	***47.90***	***2.11***	***3.35***	***8.69***	***20.64***	***2.36***

To determine average waste composition from 4 biggest waste polygons in Latvia - size of polygons was taken into account. In Getlini 50% of all waste are disposed. Getlini composition gives the biggest influence to determine average waste composition in country. Organic waste for IPCC Waste Model calculations is assumed as Food and Garden fractions.

Tha same waste compositon for all years since 2002 was used.

According to the Latvia`s Waste management plan 2013–2020[267], 11 waste disposing polygons are operating in Latvia. All other waste disposal sites are planned to close. In 2020 – 10 solid waste polygons are operating, all these sites are assumed as managed.

Since October 2002 CH_4 recovery from landfills was started. For 2020 only in four waste polygons (*SIA Getlini EKO, SIA Liepajas RAS, SIA ZAAO Daibe, SIA Jelgavas komunalie pakalpojumi Brakski*) CH_4 recovery was realized. In *SIA Getlini EKO* polygon methane was collected from old waste disposing area, from new waste disposing cells, which is specially built

[267] *Waste management plan 2013–2020. Available: https://likumi.lv/ta/id/255629-par-atkritumu-apsaimniekosanas-valsts-planu-20132020gadam*

for waste disposing with biogas collection and bioreactor. In *SIA Liepajas RAS* methane collection also is developed in old landfill *Skede* and in new polygon *Kivites*. In *SIA ZAAO* polygon *Daibe* methane collection was started in the middle of 2009. In *SIA Jelgavas komunalie pakalpojumi* polygon *Brakski* methane is started to collect in year 2013. In total 6.783 kt CH_4 was collected and recovered in 2020. Information about recovered methane amount is collected directly from waste disposal sites operators. They provided regular report about waste polygon management according to Latvian legislation. Methane concentration and volume of collected polygon gas are provided. CH_4 recovery is estimated based on the monitoring of produced amount of electricity from the gas. All assumptions used in the estimation of the CH_4 recovery are in accordance with the 2006 IPCC Guidelines (vol. 5, ch. 3, p.3.19).

Methane recovery is distributed between Unmanaged deep (MCF = 0.8) and Managed (MCF = 1) landfills. In the biggest landfill in Latvia *Getlini* CH_4 recovery occurs from old landfill part and from new disposal cells. Information about distribution between old landfill, new disposal cells and bioreactor are received from polygon Getlini. See distribution of CH_4 recovery in Table 7.8.

Table 7.8 Recovered CH_4 in Latvia landfills (kt)

Year	Total	MCF (0.8) unmanaged	MCF 1 managed
2002	*0.859*	*0.859*	*NO*
2003	*3.016*	*3.016*	*NO*
2004	*4.507*	*4.507*	*NO*
2005	*4.687*	*4.000*	*0.687*
2006	*4.833*	*2.434*	*2.400*
2007	*5.055*	*2.469*	*2.586*
2008	*5.250*	*2.500*	*2.750*
2009	*5.847*	*2.300*	*3.547*
2010	*6.173*	*2.100*	*4.073*
2011	*6.499*	*1.900*	*4.599*
2012	*6.463*	*1.700*	*4.763*
2013	*6.917*	*1.500*	*5.417*
2014	*6.881*	*1.300*	*5.581*
2015	*7.834*	*1.100*	*6.734*
2016	*7.623*	*1.000*	*5.753*
2017	*7.863*	*0.986*	*5.397*
2018	*7.54*	*0.903*	*6.637*
2019	*6.804*	*0.900*	*5.904*
2020	*6.783*	*0.900*	*5.883*

According to the Latvia's Waste Management plan 2013-2020, CH_4 recovery from landfills is one of priorities in waste management. CH_4 emission from waste disposing in SWD sites is presented in Figure 7.4.

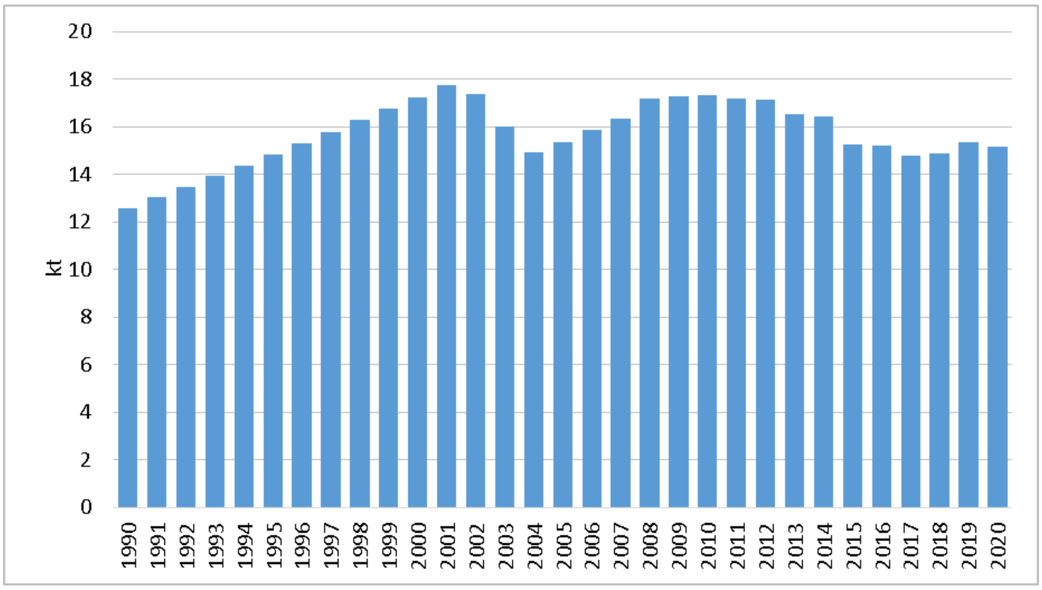

Figure 7.4 CH_4 emissions from waste disposing (kt)

7.2.2 Methodological issues

Tier 2 method from the 2006 IPCC Guidelines is used for CH_4 emissions calculation and is based on IPCC Waste Model.

Emission factors used in IPCC Waste Model

Factors for managed site emissions calculations:

MCF (CH_4 correction factor) Managed sites – 1:

Table 7.9 DOC values for waste streams in managed sites (2006 IPCC Guidelines)

Food waste	*0.17*
Garden	*0.20*
Paper	*0.40*
Wood and straw	*0.43*
Textiles	*0.24*
Sewage sludge	*0.05*

Table 7.10 methane generation rate constant (k) (2006 IPCC Guidelines)

Food waste	*0.185*
Garden	*0.10*
Paper	*0.06*
Wood and straw	*0.03*
Textiles	*0.06*
Sewage sludge	*0.185*

DOCf – fraction of DOC dissimilated - 0.5
F – fraction of CH_4 landfill gas - 0.5
Delay time – 6 month

Factors for unmanaged site emissions calculations:

Deep unmanaged sites - 0.8
Shallow unmanaged sites - 0.4

DOC – degradable organic carbon - 0.17
DOCf – fraction of DOC dissimilated - 0.5
F – fraction of CH_4 landfill gas - 0.5
k- methane generation rate - 0.09
OX – oxidation factor (default 0.09 – used for unamanged sites calculation since year 2008).

DOC value 0.17 is used according to research which was carried out in Latvia in 2011 ("Degradable organic carbon in disposed waste", 2011, Ltd Virsma). Other EFs are default from the 2006 IPCC Guidelines.

Oxidation factor 0.09 is used, because almost all old unmanaged SWDS in Latvia are covered by a soil layer and that it applied the default oxidation factor, 0.1, to them. Based on national research[268], Latvia assumes 10% of old unmanaged SWDS are not covered by soils. To include this aspect in emissions calculations the oxidation factor is used as 0.09 (reduced by 10%). Oxidation factor 0.09 has been used from year 2008, because unmanaged SWDS were covered till year 2007. Till year 2008 oxidising was not applied for unmanaged landfills. Covering was realised with Europen Commision funds financing in 3 stages.

Fraction of CH_4 in landfill gas is estimated as 0.5 according to information, which is received from methane collection enterprises. Methane collection enterprises provide information about collected methane amount and also about methane concentration in landfill gas. Methane concentration is mutable, it diversifies from 0.47 – 0.54 depending on time frame and weather conditions.

7.2.3 Uncertainties and times-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

To calculate CH_4 emissions from SWD many EFs are used. According to the 2006 IPCC Guidelines for each factor uncertainty is estimated as:

DOC – 20%;
DOCf – 30%;
MCF – 10%;
CH_4 fraction F – 5%;
k – 40%.

$$\boldsymbol{EF_{uncert.}} = \sqrt{\boldsymbol{DOC^2 + DOCf^2 + MCF^2 + F^2 + k^2}} \quad (7.1)$$

Combined uncertainty for EFs from SWD is 52%.

Uncertainty for activity data is estimated as 5.65%.

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[268] *Landfill data collection and compilation for GHG estimates", 2016, LEGMC Availlabe: https://www.meteo.lv/lapas/atkritumu-izgaztuvju-datu-savaksana-un-apkoposana-seg-aprekiniem?&id=2182&nid=909*

Uncertainty assessment of activity data is done using the proportion between disposed amount and population (2002-2020). Uncertainty is calculated as the standard medium of the average from linear trend line.

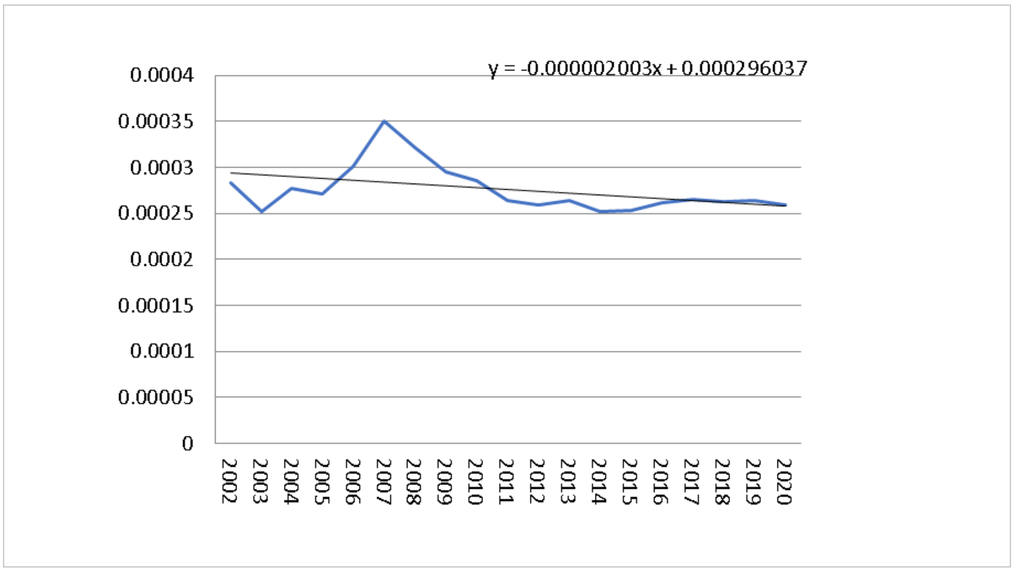

Figure 7.5 Trendline and proportion waste-to-population for waste disposal

7.2.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the waste sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

Disposed waste amount since 2002 is taken from waste data base "3-Waste". Data in this data base are checked and approved by Regional Environmental Boards.

National factor of DOC is determined in national research "Degradable organic carbon in disposed waste", 2011, Ltd Virsma. Distribution between managed and unmanaged sites is also described in this research which is available in QA/QC documentation.

Information regarding CH_4 recovery is taken directly from waste polygon reports. These reports are collected and checked by LEGMC every year. Latvia's waste polygon report is published in LEGMC website every year.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

7.2.5 Category-specific recalculations

Waste composition was updated in IPCC model for managed sites.

7.2.6 Category-specific planned improvements

It is planned to work on improvements to obtain data on disposed waste composition.

7.3 *BIOLOGICAL TREATMENT AND SOLID WASTE (CRF 5.B)*

7.3.1 Composting (CRF 5.B.1)

7.3.1.1 Category description

Under 5.B.1 sector CH_4 and N_2O emissions from waste composting are calculated. Composting is set as one of priorities in waste treatment in Latvia. For composting biological degradable waste are useful. In Latvia these are mostly "park - garden" and "food production" waste.

Data about industrial composting become available since 2003, when waste treatment companies started waste composting and get IPPC permits on this activity.

Composting in private households has been very popular for many years. Composted waste amount in households is estimated according to the household statistics from CSB[269]. To estimate composted amount research[270] done by Waste Management Association of Latvia in 2015 about composting was taken into account.

Table 7.11 Reported emissions under composting

CRF	Source	Emissions reported
5.B.1.	*Compost production*	*CH_4, N_2O*

From composting CH_4 and N_2O emissions are calculated according to the 2006 IPCC Guidelines. Data regarding composted waste are taken from "3-Waste" database.

Sharp increase of composting emissions in 2016 compared to previous years can be observed due to increase of industrial composted waste amounts (Figure 7.6). Sorting out of biological waste before waste disposal in polygons occur in larger volumes. Emissions from composting in 2020 have increased by 61.4% compared to 1990 due to industrial composting activities since 2003. Compared to 2019 total GHG emissions from composting have increased by 8.7%.

[269] *CSB data. Available: https://www.csp.gov.lv/lv/majsaimniecibas-un-gimenes*
[270] *"Composting emission factor development from waste and waste water sectors and methane correction factor estimation for Latvia landfills", 2015, Waste Management Association of Latvia*

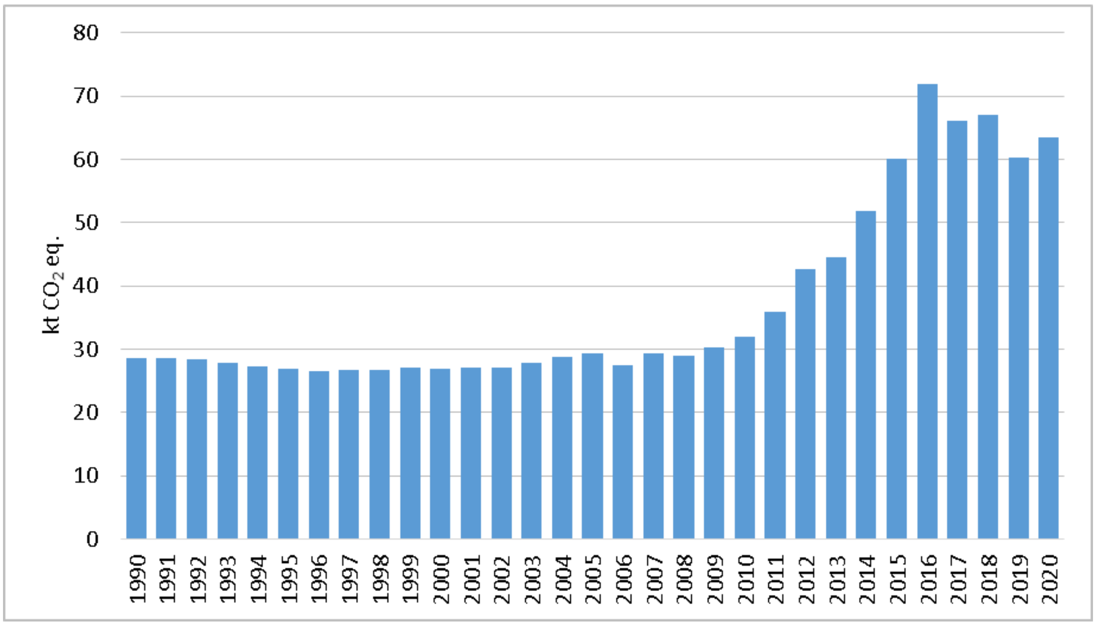

Figure 7.6 Total emissions from waste composting (kt CO_2 eq.)

7.3.1.2 Methodological issues

Default method from the 2006 IPCC Guidelines is used for emission calculations from composting. Composted waste amount is multiplied with default EF. Composted waste amount is taken from "3-Waste" database, R3 - Recycling/reclamation of organic substances that are not used as solvents (including composting and other biological transformation processes), recovery operation for determination of composted amounts was used. Not all amounts, which are classified under recovery as R3, are composted. To determine composted waste amount, each enterprise, which reports recovery operations R3, working profile must be taken into account. Since 2014 special R code (R3A) for composting was implemented in Latvian legislation. Data selection for emission calculations become more simplified.

Default EFs for composting were used from the 2006 IPCC Guidelines:

Industrial and home composting:

1. 4 g CH_4/ kg composted waste;
2. 0.24 g N_2O/ kg composted waste.

Table 7.12 Composted waste amounts and emissions (kt)

Year	Composted amounts in households (kt)	Industrial composted amount (kt)	CH_4 emission (kt)	N_2O emission (kt)
1990	*166.8863*	-	*0.6675*	*0.0401*
1991	*166.2622*	-	*0.6650*	*0.0399*
1992	*165.3139*	-	*0.6613*	*0.0397*
1993	*161.7283*	-	*0.6469*	*0.0388*
1994	*158.9280*	-	*0.6357*	*0.0381*
1995	*156.4058*	-	*0.6256*	*0.0375*
1996	*154.4638*	-	*0.6179*	*0.0371*
1997	*155.3406*	-	*0.6214*	*0.0373*
1998	*155.9775*	-	*0.6239*	*0.0374*

Year	Composted amounts in households (kt)	Industrial composted amount (kt)	CH_4 emission (kt)	N_2O emission (kt)
1999	*157.3667*	-	*0.6295*	*0.0378*
2000	*157.1398*	-	*0.6286*	*0.0377*
2001	*158.1811*	-	*0.6327*	*0.0380*
2002	*158.1800*	-	*0.6327*	*0.0380*
2003	*159.4941*	*2.224*	*0.6469*	*0.0388*
2004	*160.0516*	*7.905*	*0.6718*	*0.0403*
2005	*164.9071*	*6.564*	*0.6859*	*0.0412*
2006	*148.1782*	*11.698*	*0.6395*	*0.0384*
2007	*161.8781*	*9.416*	*0.6852*	*0.0411*
2008	*159.2327*	*9.282*	*0.6741*	*0.0404*
2009	*161.1365*	*15.11*	*0.7050*	*0.0423*
2010	*165.1933*	*18.55*	*0.7350*	*0.0441*
2011	*168.7196*	*23.699*	*0.7697*	*0.0462*
2012	*170.7857*	*17.62*	*0.7536*	*0.0452*
2013	*166.7016*	*14.367*	*0.7243*	*0.0435*
2014	*168.2496*	*40.038*	*0.8332*	*0.0500*
2015	*170.5342*	*67.577*	*0.9524*	*0.0571*
2016	*167.8159*	*135.224*	*1.2122*	*0.0727*
2017	*166.1008*	*98.90*	*1.0600*	*0.0636*
2018	*166.1743*	*112.25*	*1.1137*	*0.0668*
2019	*165.8701*	*81.942*	*0.9912*	*0.0595*
2020	*173.829*	*95.483*	*1.0772*	*0.0646*
2020 versus 2019			*+8.7%*	*+8.7%*
2020 versus 1990			*+61.4%*	*+61.4%*

7.3.1.3 Uncertainties and times-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

EF uncertainties are calculated according to the range, which is published in the 2006 IPCC Guidelines, Volume 5, Chapter 4, for N_2O range is 0.06 – 0.6, for CH_4 0.03 – 8, Uncertainty for N_2O EF is 90%, for CH_4 – 100%.

Time series for composting begin in 1990.

Uncertainty for households composted amounts are assumed as 20% as expert judgement.

Activity data uncertainty for industrial composting is estimated as 28%.

Uncertainty assessment of activity data for industrial composting is done using the proportion between composted amount and population (2004-2020). Uncertainty is calculated as the standard medium of the average from exponential trend line.

Total uncertainity for composting activity data ir 28.42%.

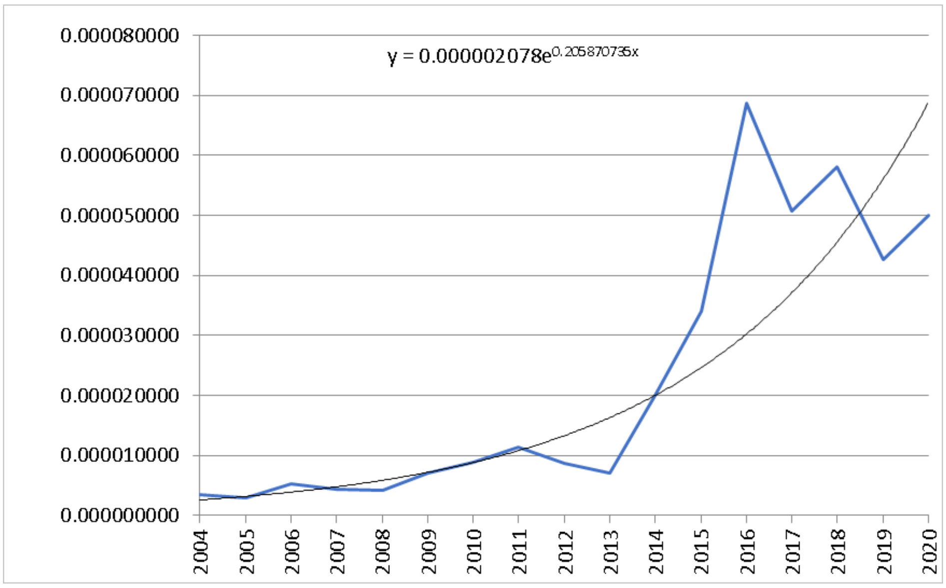

Figure 7.7 Trendline and proportion waste-to-population for waste industrial composting

7.3.1.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the waste sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

Industrial composted waste amounts are taken from from "3-Waste" data base. Data in this data bases are checked and approved by Regional Environmental Boards.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

7.3.1.5 Category-specific recalculations

No recalculations were done for this sector.

7.3.1.6 Category-specific planned improvements

Update of home composting data for next submissions will be done.

7.3.2 Anaerobic Digestion at Biogas Facilities (CRF 5.B.2)

Anaerobic Digestion at biogas facilities is carried out in Latvia. Emissions are allocated under Energy sector and Agriculture sector. All biogas is used for energy production.

According to the 2006 IPCC Guidelines Volume 5, Chapter 4.1 leakages are 5% from collected biogas volume. In Latvia for 2019 operates 42 anaerobic digestion biogas facilities. The main feedstocks are agriculture crops, agriculture remains, manure, organic remains from food production and organic waste. Total amount of biogas is taken from CSB Energy Balance. Amount of landfill and sludge gas is excluded. CH_4 emission is estimated from total biogas volume according to the amount of waste and organic remains from food production in feedstock. Waste contributes about ¼ of all feedstock. ¾ of feedstock consist of manure and agriculture crops. Average CH_4 concentration is assumed as 54%, feedstock dry matter is 14%, CH_4 density – 0.6687 kg/m^3 (reference – Biogas association research, 2020), Table 7.13.

Table 7.13 CH_4 emissions from waste anaerobic digestion at biogas facilities

Year	Biogas collected in Latvia, mil. m^3	CH_4 collected, mil. m^3	CH_4, kt	CH_4 from waste, kt	5% leakages, emission of CH_4, kt	Amount of waste treated (wet), kt	Amount of waste treated (dry), kt
2010	*3.32*	*1.80*	*1.20*	*0.30*	*0.02*	*0.38*	*9.79*
2011	*24.66*	*13.39*	*8.95*	*2.24*	*0.11*	*2.80*	*72.72*
2012	*90.76*	*49.28*	*32.95*	*8.24*	*0.41*	*10.30*	*267.64*
2013	*119.35*	*64.81*	*43.34*	*10.83*	*0.54*	*13.54*	*351.96*
2014	*141.32*	*76.74*	*51.32*	*12.83*	*0.64*	*16.04*	*416.76*
2015	*170.29*	*92.47*	*61.83*	*15.46*	*0.77*	*19.32*	*502.20*
2016	*174.88*	*94.96*	*63.50*	*15.88*	*0.79*	*19.84*	*515.72*
2017	*181.98*	*98.81*	*66.08*	*16.52*	*0.83*	*20.65*	*536.64*
2018	*170.45*	*92.56*	*61.89*	*15.47*	*0.77*	*19.34*	*502.66*
2019	*156.15*	*84.79*	*56.70*	*14.16*	*0.71*	*17.71*	*460.15*
2020	*151.98*	*82.53*	*55.18*	*13.79*	*0.69*	*17.23*	*447.86*

7.4 *INCINERATION AND OPEN BURNING OF WASTE (CRF 5.C)*

7.4.1 Waste Incineration (CRF 5.C.1)

7.4.1.1 Category description

Data on amount of waste incinerated in Latvia can be found in databases that are created and maintained by LEGMC. Data on hazardous waste incineration are available since 1999. In the hazardous waste data base there is a separate entry for 1997-2001 on the amount of incinerated waste. Since 2002 the database also contains entries for recovery (R) and disposal (D) of waste, which is consistent with the EU Waste legislation.

Table 7.14 Reported emissions under category Waste Incineration

CRF	Source	Emissions reported
5.C 1	*Biogenic (cremation)*	*SO_2, NMVOC, CO, NO_x*
5.C 2	*Other – non biogenic (clinical (animal) and hazardous (industrial) waste)*	*CO_2, N_2O, SO_2, NMVOC, CO, NO_x*

Currently there are no large amounts of waste being incinerated in Latvia without energy recovery. The main source of emissions refer to the hazardous and clinical waste incineration. Amounts of incinerated clinical waste are registered in the hazardous waste database (from 2002 in "3-Waste" data base) as *Health service for humans and animals as well as related research waste*. Amount of incenerated animal waste (dead animals) are assumed as Clinical waste. The rest of the incinerated waste from hazardous waste database is considered as hazardous (industrial) waste.

In 2001, large increase of emissions can be observed, because one enterprise reported huge amount of incinerated waste. Incinerated amounts for 1990–1998 are extrapolated according to average value of incinerated amount for 2002–2013 which refers to disposed waste value.

In latest years incinerated amount of waste has decreased due the reason that hazardous waste incineration is not occuring in full scale. CO_2 emissions from Waste Incineration are presented in Figure 7.8.

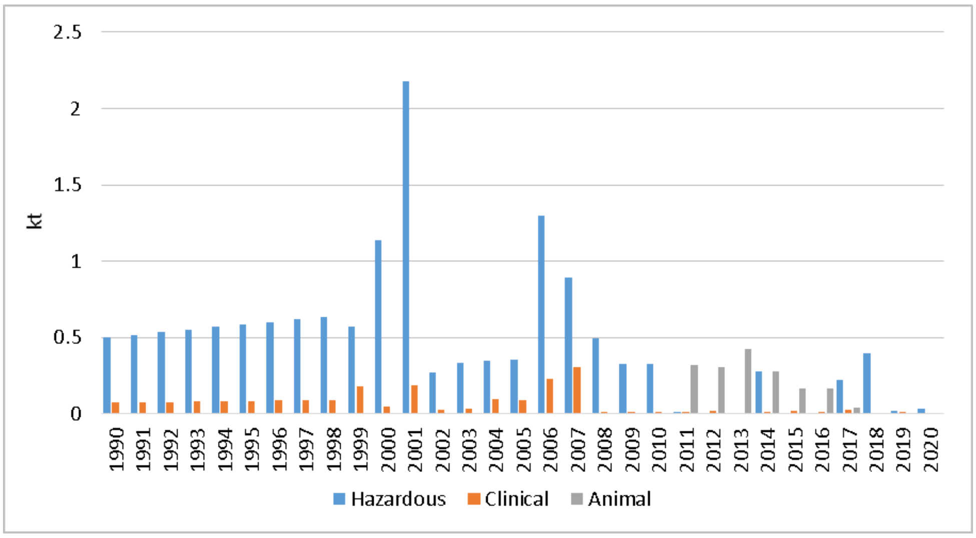

Figure 7.8 CO_2 emissions from Waste Incineration by waste type (kt)

Data about burned bodies is available from Riga crematorium since 1994 and Valmiera crematorium since 2016. Calculations of emissions are done in accordance with the EMEP/EEA 2016 methodology. The main gases emitted during cremation are SO_x, NO_x, CO, and NMVOC, and all of them have to be reported in the inventory as precursors. These amounts are reported under general 5C sector.

Table 7.15 Burned bodies in crematoriums

Year	Burned bodies
1994	*54*
1995	*564*
1996	*819*
1997	*817*
1998	*869*
1999	*982*
2000	*1127*
2001	*1297*
2002	*1293*
2003	*1389*
2004	*1391*
2005	*1529*
2006	*1630*
2007	*1959*
2008	*2227*
2009	*1977*
2010	*2102*
2011	*2158*
2012	*1970*
2013	*2150*
2014	*2222*
2015	*2395*
2016	*2909*

Year	Burned bodies
2017	*3443*
2018	*3708*
2019	*4029*
2020	*4100*

7.4.1.2 Methodological issues

According to the 2006 IPCC Guidelines CO_2 and N_2O emissions are calculated from Waste Incineration. CH_4 emissions in well-functioning incinerators are usually very small. CH_4 emissions are particularly relevant for open burning. Usually CO_2 emissions are substantially larger than emissions of N_2O. Emissions from waste incineration without energy production are considered under the Waste sector, while emissions from waste incineration with energy production are considered under the Energy sector (CRF 1.A.2.f Non-metalic minerals).

CO_2 emissions were calculated using following the 2006 IPCC Guidelines equation:

$$\boldsymbol{CO_{2\ emissions}} = \sum_i [\boldsymbol{SW_{ix}} * \boldsymbol{CF_i} * \boldsymbol{FCF_i} * \boldsymbol{OX_i} * \mathbf{44/12}]\ \boldsymbol{kt/year} \quad (7.2)$$

where:
i = waste type (hazardous waste, clinical waste)
SW_i = amounts of type i waste incinerated. (kt/year)
CF_i = carbon contents in the type i waste
FCF_i = fossil carbon contents in the type i waste
OX_i = oxidation factor of type i waste
44/12 = conversion of C into CO_2

There are no national factors for carbon and fossil carbon amounts in each type of waste; therefore default EFs from the 2006 IPCC Guidelines were used.

Table 7.16 Default emission factors for CO_2 emission calculation

Emission factor	Clinical (animal) waste	Hazardous (industrial) waste
C contents in waste (CCW)	*0.6*	*0.5*
Fossil C contents in waste (FCF)	*0.4*	*0.9*
Oxidation factor (OX)	*100%*	*100%*

N_2O emissions from Waste incineration are calculated according to the 2006 IPCC Guidelines, Volume 5 Table 5.6. Factor 100 (g N_2O/t waste) is used. This factor is determined for Industrial waste in wet weight. Latvia's incinerated hazardous waste are used oils, solvents and other liquids. Clinical waste is not dried before burning. The same factor also is used for N_2O emission calculation from clinical waste.

Table 7.17 Incinerated waste amounts without energy recovery

Year	Hazardous waste (kt)	Clinical waste (kt)	Animal waste (kt)	Total (kt)
1990	*0.4291*	*0.1167*	*NO*	*0.5458*
1991	*0.4050*	*0.1102*	*NO*	*0.5151*
1992	*0.3808*	*0.1036*	*NO*	*0.4845*
1993	*0.3567*	*0.0970*	*NO*	*0.4538*
1994	*0.3326*	*0.0905*	*NO*	*0.4231*
1995	*0.3085*	*0.0839*	*NO*	*0.3924*

Year	Hazardous waste (kt)	Clinical waste (kt)	Animal waste (kt)	Total (kt)
1996	*0.3214*	*0.0874*	*NO*	*0.4089*
1997	*0.3419*	*0.0930*	*NO*	*0.4349*
1998	*0.3624*	*0.0986*	*NO*	*0.4610*
1999	*0.3472*	*0.2014*	*NO*	*0.5486*
2000	*0.6903*	*0.0564*	*NO*	*0.7467*
2001	*1.3193*	*0.2133*	*NO*	*1.5326*
2002	*0.1656*	*0.0322*	*NO*	*0.1979*
2003	*0.2018*	*0.0406*	*NO*	*0.2424*
2004	*0.2101*	*0.1123*	*NO*	*0.3225*
2005	*0.2151*	*0.1021*	*NO*	*0.3173*
2006	*0.7862*	*0.2619*	*NO*	*1.0481*
2007	*0.5405*	*0.3509*	*NO*	*0.8914*
2008	*0.2998*	*0.0124*	*NO*	*0.3121*
2009	*0.2000*	*0.0117*	*NO*	*0.2117*
2010	*0.2000*	*0.0128*	*NO*	*0.2128*
2011	*0.0063*	*0.0127*	*0.3661*	*0.3851*
2012	*NO*	*0.0180*	*0.3489*	*0.3669*
2013	*NO*	*0.0059*	*0.4798*	*0.4857*
2014	*0.1669*	*0.0103*	*0.3166*	*0.4933*
2015	*NO*	*0.0185*	*0.1855*	*0.2040*
2016	*NO*	*0.0102*	*0.1865*	*0.1967*
2017	*0.1354*	*0.0291*	*0.0421*	*0.2066*
2018	*0.2396*	*0.0014*	*NO*	*0.2410*
2019	*0.0100*	*0.0141*	*NO*	*0.0241*
2020	*0.0192*	*0.0081*	*NO*	*0.0273*

Precursors are calculated from waste incineration according to EMEP/EEA 2016 (Table 7.18).

Table 7.18 Emission factors for precursors

Gas	Clinical waste (kg/Mg)	Hazardous waste (kg/Mg)
NMVOC	*0.7*	*7.4*
CO	*0.19*	*0.07*
SO_2	*0.24*	*0.047*
NO_x	*2.3*	*0.87*

CH_4 emissions estimation from waste incineration

Default EF CH_4 – 300 kg/TJ (IPCC 2006; Volume 2: Energy; Chapter 2.Stationary combustion table 2.5 page 2.23). CH_4 emissions from waste incineration are very small (Table 7.19). Value for 2019 – 0.0018 kt CO_2 eq. is under 0.05% of total emissions and it means that is under the threshold of significance. In 2020, raw activity data are lower than in 2019 and it means that emissions are below 0.05% of total emissions in Latvia. Latvia could not investigate the dominant incineration technology and process (e.g. batch-type/continuous/semi-continuous) used, because waste incineration without energy recovery reports different small installations in different years. This installation do not have any filters or semi combustion cameras and it worked only few hours in the week. In CRF CH_4 emissions from incineration are reported as NE.

Table 7.19 Raw estimations of CH_4 emissions from waste incineration

Year	Waste amount incinerated (kt)	CH_4 EF kg/TJ	NCV TJ/kt	CH_4 emissions (kt)	CO_2 eq. (kt)
1990	*0.3869*	*300*	*10*	*0.0012*	*0.0290*
1991	*0.3997*	*300*	*10*	*0.0012*	*0.0300*
1992	*0.4125*	*300*	*10*	*0.0012*	*0.0309*
1993	*0.4253*	*300*	*10*	*0.0013*	*0.0319*
1994	*0.4381*	*300*	*10*	*0.0013*	*0.0329*
1995	*0.4509*	*300*	*10*	*0.0014*	*0.0338*
1996	*0.4637*	*300*	*10*	*0.0014*	*0.0348*
1997	*0.4765*	*300*	*10*	*0.0014*	*0.0357*
1998	*0.4893*	*300*	*10*	*0.0015*	*0.0367*
1999	*0.5486*	*300*	*10*	*0.0016*	*0.0411*
2000	*0.7467*	*300*	*10*	*0.0022*	*0.0560*
2001	*1.5326*	*300*	*10*	*0.0046*	*0.1149*
2002	*0.1979*	*300*	*10*	*0.0006*	*0.0148*
2003	*0.2424*	*300*	*10*	*0.0007*	*0.0182*
2004	*0.3225*	*300*	*10*	*0.0010*	*0.0242*
2005	*0.3173*	*300*	*10*	*0.0010*	*0.0238*
2006	*1.0481*	*300*	*10*	*0.0031*	*0.0786*
2007	*0.8914*	*300*	*10*	*0.0027*	*0.0669*
2008	*0.3121*	*300*	*10*	*0.0009*	*0.0234*
2009	*0.2117*	*300*	*10*	*0.0006*	*0.0159*
2010	*0.2128*	*300*	*10*	*0.0006*	*0.0160*
2011	*0.3851*	*300*	*10*	*0.0012*	*0.0289*
2012	*0.3669*	*300*	*10*	*0.0011*	*0.0275*
2013	*0.4857*	*300*	*10*	*0.0015*	*0.0364*
2014	*0.4933*	*300*	*10*	*0.0015*	*0.0370*
2015	*0.2040*	*300*	*10*	*0.0006*	*0.0153*
2016	*0.1967*	*300*	*10*	*0.0006*	*0.0148*
2017	*0.2066*	*300*	*10*	*0.0006*	*0.0155*
2018	*0.2410*	*300*	*10*	*0.0007*	*0.0181*
2019	*0.0241*	*300*	*10*	*0.0001*	*0.0018*

Cremation

Emissions of precursors from cremation were calculated by multiplying the number of bodies burned with the corresponding EF. Calculations were based on EFs given in the EMEP/EEA 2016 (Table 7.20).

Table 7.20 Emission factors for precursors from cremation

Precursor	Emission factor (kg/body)
NMVOC	*0.013*
CO	*0.140*
SO_2	*0.113*
NO_x	*0.825*

7.4.1.3 Uncertainties and times-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

CO_2 EF uncertainty is estimated as 40%, according to the 2006 IPCC Guidelines, because no correct information on carbon content in incinerated waste is known. Uncertainty for N_2O EF is 100%.

Activity data uncertainty for waste incineration is estimated as 49.57%.

Uncertainty assessment of activity data for waste incineration is done using the proportion between incinerated amount and population (years 2002-2020). Uncertainty is calculated as the standard medium of the average from linear trend line.

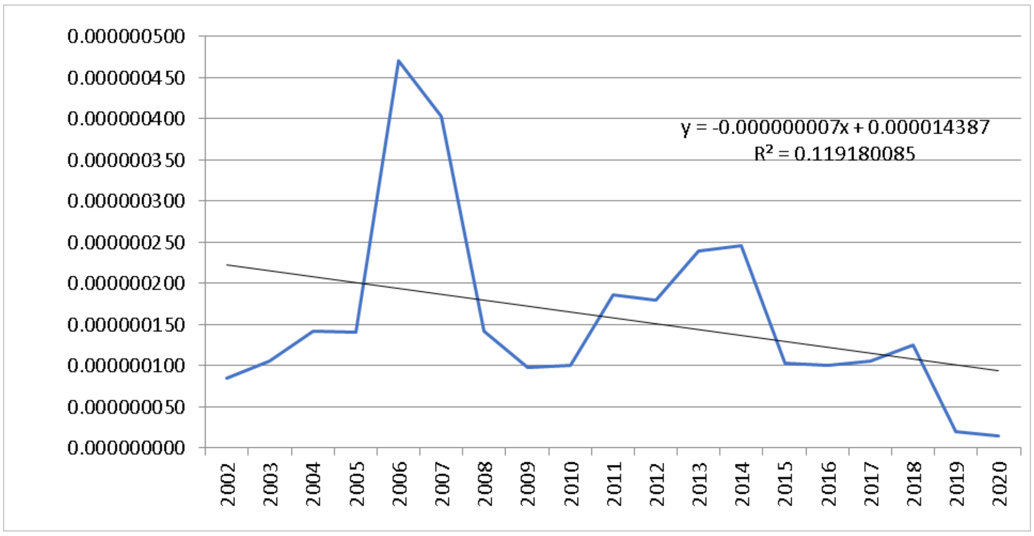

Figure 7.9 Trendline and proportion waste-to-population for waste incineration

7.4.1.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the waste sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

QA/QC procedures for waste incineration are done. Incinerated waste amounts are taken from "3-Waste" data base. Data in this data bases are checked and approved by Regional Environmental Boards.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

7.4.1.5 Category-specific recalculations

No recalculations were done for this sector.

7.4.1.6 Category-specific planned improvements

No improvements are planned for this sector.

7.4.2 Open Burning of Waste (CRF 5.C.2)

Open burning of waste is reported as NE (Not estimated). Open burning is not allowed in Latvia according to the Waste Management Law[271].

If emissions are occurred then it is very negligible amount. Evaluation of possible emissions:

- Number of detached houses in Latvia – 213 004 according to Central statistical bureau data;
- 30% of them are in rural regions – 63 901 (population distribution in Latvia CSB data);
- Estimation that in one house lives 2 inhabitants (expert judgment) – 127 802 inhabitants;
- Total generated amount of Municipal solid waste in 2018 are 802 000 tons for – 1 934 379 inhabitants;
- 127 802 inhabitants generated - 52 987 tonns;
- Assumption is made that 1-2% of these wastes are burned (Estonia`s estimation) – it was used average value - 1.5% from 52987 – **795** tonns in year 2018;
- Net Calorific value for MSW is 10 TJ/Gg (IPCC 2006; Volume 2: Energy; Chapter 1: Introduction; Table 1.2 Default NCVs and lower and upper limits of the 95% confidence intervals). Default EFs for MSW (with biomass) CO_2 - 100 000 kg/TJ (IPCC 2006; Volume 2: Energy; Chapter 2.Stationary combustion Table 2.5, page 2.23);
- 0.795 Gg *10 = 7.95 TJ;
- **CO_2 emissions** calculated 7.95*100 000 = 795 000 kg that is **0.795 kt** CO_2 eq.;
- **CH_4 emissions** calculated 7.95 * 300 kg/TJ = 2385 kg that is **0.002385 kt CH_4** and **0.059625 kt CO_2 eq.;**
- **N_2O emissions** calculated 7.95*4 kg/TJ= 31.8 kg that is **0.0000318 kt N_2O** and **0.0094764 kt CO_2 eq.;**
- 0.795 + 0.059625 + 0.0094764 = **0.8641014 kt** CO_2 eq. that is below the 0.05% of national total GHG emissions and could be characterized as emissions below the threshold of significance in Latvia. Therefore for Latvia emissions are considered as negligible. In CRF emissions are reported as NE.

7.5 *WASTEWATER TREATMENT AND DISCHARGE (CRF 5.D)*

7.5.1 Domestic Wastewater (CRF 5.D.1)

7.5.1.1 Category description

The emission sources cover handling of collected and uncollected domestic wastewater for CH_4 from both wastewater and sewage sludge and N_2O emissions from human sewage.

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[271] *Waste Management Law. Available: https://likumi.lv/ta/id/221378-atkritumu-apsaimniekosanas-likums*

In most cases urban wastewater is treated in well managed biological treatment plants in Latvia. However, certain part of national population still is not connected to a centralized collection and treatment systems and are served with septic tanks and latrines.

Data on type of treatment plant and its treatment level is available within national database on water use "2-Water", and all the treatment plants and number of population they serve is distributed by their type and level of treatment. Share of septic tank and latrine use is estimated, according to data on urbanization and default values from the 2006 IPPC Guidelines.

CH_4 is main pollutant in the Domestic Wastewater sector, making 68.4% of total GHG emissions of this sector, while N_2O corresponds for 31.6% in 2020.

In total, taking into account of recovered CH_4 as well, emissions from Domestic Waste water Handling sector made 101.47 kt CO_2 eq. in 2020, what makes decrease of 59.2% compared to 1990 and decrease of 4.7% compared to 2019 (Figure 7.10). In 2020, GHG emissions from Domestic Wastewater handling contributes 96.9% of total GHG emissions from Wastewater handling sector and 18.5% of total GHG emissions in Waste sector.

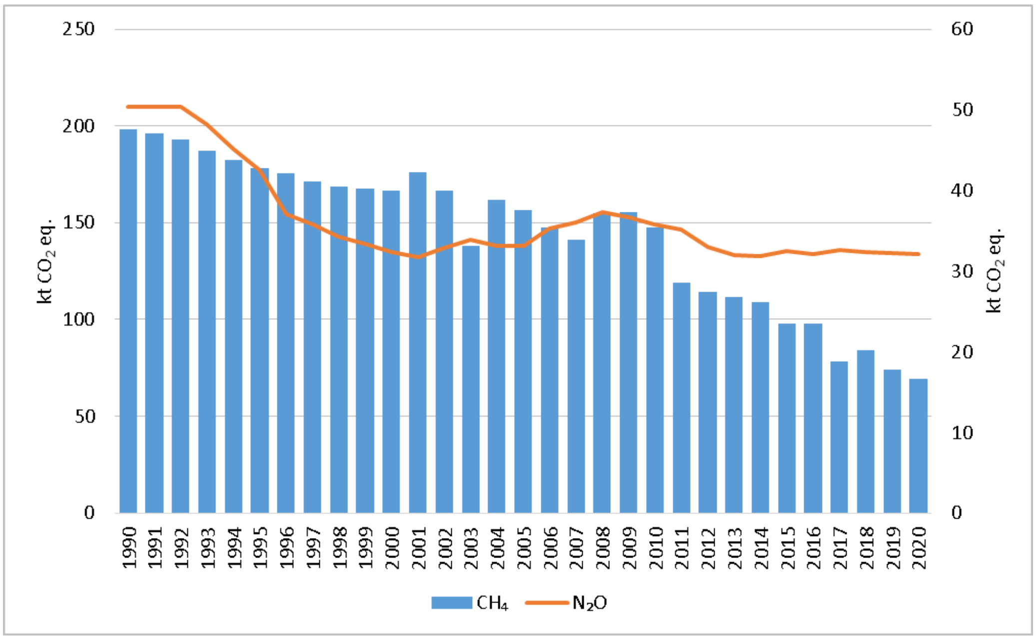

Figure 7.10 Emissions from Domestic Waste Water Handling (N_2O on secondary axis) (kt CO_2 eq.)

7.5.1.2 Methodological issues

Calculation of CH_4 emission from Domestic Waste Water Handling is based on amount of BOD_5 (biochemical oxygen demand, 5-day test) produced by national population. However, different methane conversion factors (MCFs) are applied depending of type and level of treatment of certain treatment plant. Data on treatment type and level of certain wastewater treatment plant serving certain number of population is available in national data base "2-Water"[272], collecting treatment plant-level data on water abstraction and use, wastewater treatment and discharge. Distribution of national population by type and level of wastewater treatment was extrapolated for period, uncovered by water statistics (1990-1999).

[272] *Public acces of surveys of official environment statistics. Avaiable: http://parissrv.lvgmc.lv/public_reports*

Default formula from the 2006 IPCC Guidelines, chapter 6.2.2 „Domestic Wastewater" was used for calculation of CH_4 emission from Domestic Wastewater Handling sector. However, distribution of national population by treatment type and level is used instead of distribution of national population by income level.

$$\boldsymbol{CH_4 Emissions} = \left[\sum_i (\boldsymbol{U_i} * \boldsymbol{EF_i})\right] * (\boldsymbol{TOW} - \boldsymbol{S}) - \boldsymbol{R} \tag{7.3}$$

where
CH_4Emissions – CH_4 emissions in the inventory year, kg CH_4/yr
TOW – total organics in wastewater in inventory year, kg BOD/yr
S – organic component removed as sludge in inventory year, kg BOD/yr
U_i – degree of national population receiving certain wastewater treatment type and level, %
i – wastewater treatment type and level (well-managed biological, poor-managed biological, non-biological, septic tanks and latrines)
EFi – emission factor for each treatment type fraction, kg CH_4/kg BOD
R – amount of CH_4 recovered in inventory year, kg CH_4/yr

$$\boldsymbol{EF_i} = \boldsymbol{B_O} * \boldsymbol{MCF_i} \tag{7.4}$$

where:
EFi – emission factor for each treatment type fraction, kg CH_4/kg BOD
i – wastewater treatment type and level (well-managed biological, poor-managed biological, non-biological, septic tanks and latrines)
B_o – maximum CH_4 producing capacity, kg CH_4/kg BOD
MCF_i – methane correction factor for each treatment type and level

$$\boldsymbol{TOW} = \boldsymbol{P} * \boldsymbol{BOD} * \boldsymbol{0.001} * \boldsymbol{I} * \boldsymbol{365} \tag{7.5}$$

where
TOW – total organics in wastewater in inventory year, kg BOD/yr
P – country population in inventory year, persons
BOD – country-specific per capita BOD in inventory year, g/person/day
I – correction factor for additional industrial BOD discharged into sewers

CH_4 emissions from anaerobic sewage sludge were calculated using default formula from „Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual"; chapter 6.3.5 „Methodology for Estimating Emissions from Wastewater Handling". In this case IPCC 1996 were used because the 2006 IPCC Guidelines do not provide methodology to estimate emissions from anaerobic sewage sludge.

$$\boldsymbol{SM} = \boldsymbol{TOS} * \boldsymbol{EF} \tag{7.6}$$

where:
SM – total CH_4 emission from sewage sludge, kg CH_4
TOS – total organic content of sludge, kg COD/yr
EF – emission factor for sludge, kg CH_4/kg COD

$$\boldsymbol{EF} = \boldsymbol{B_o} * \boldsymbol{MCF} \tag{7.7}$$

where:
EF – emission factor for anaerobic sewage sludge, kg CH_4/kg COD
Bo – maximum CH_4 producing capacity, kg CH_4/kg COD
MCF – methane correction factor

Methane Conversion Factors (MCFs) were applied depending of treatment type and level. The 2006 IPCC Guidelines were used as source of MCF values; however, expert judgment was performed to choose values applicable for Latvian conditions (Table 7.21).

Table 7.21 MCF values applied depending on type and level of treatment

Treatment type and level	MCF
Biological treatment with secondary or higher treatment level	*0*
Biological treatment with treatment level lower than secondary	*0.3*
Mechanical and chemical treatment	*0.1*
Not connected to centralized waste water treatment plants	*0.5 (septic tanks)* *0.7 (latrines)*

According to recommendations of "Issues on waste during ESD-review 2020" webinar (Oct 6, 2020), MCF value 0.1 were applied to the flow of non-biological (mechanical and chemical) treatment instead of previously used value of 0.3.

Organic load – so called "population equivalent" or 60 g of BOD per person per day – is determined by National legislation (Cabinet Regulation No. 34 "Regulations regarding Discharge of Polluting Substances into Water" (22.01.2002)[273]).

Activity data, used for calculation of CH_4 emissions from domestic wastewater, are summarized in Table 7.22.

Table 7.22 Activity data for calculation CH_4 emissions from Domestic Wastewater Handling sector

Year	Population received well-managed biological treatment	Population receiving poor-managed biological treatment	Population receiving non-biological treatment	Population receiving no centralized treatment	Amount of anaerobic sludge, t/y (dry solids)	Amount of recovered CH_4, kt/y	Total CH_4 emission produced, kt
1990	*1 459 034*	*410 363*	*69 301*	*729 442*	*14 446*	*0*	*7.93*
1995	*1 367 407*	*384 592*	*64 949*	*683 633*	*8 993*	*0.36*	*7.13*
2000	*1 300 118*	*373 987*	*53 326*	*654 284*	*5 470*	*0.80*	*6.66*
2005	*1 455 262*	*83 078*	*36 973*	*674 411*	*9 324*	*1.77*	*6.27*
2010	*1 270 798*	*141 699*	*21 499*	*686 508*	*4 477*	*2.25*	*5.91*
2011	*1 471 797*	*92 118*	*18 788*	*491 902*	*7 092*	*1.97*	*4.77*
2012	*1 399 086*	*106 959*	*35 537*	*503 231*	*4 453*	*2.06*	*4.56*
2013	*1 417 698*	*94 504*	*30 802*	*480 821*	*5 454*	*1.90*	*4.46*
2014	*1 443 058*	*46 606*	*26 244*	*485 560*	*5 573*	*1.79*	*4.37*
2015	*1 472 508*	*34 259*	*27 912*	*451 417*	*4 161*	*1.96*	*3.92*
2016	*1 471 555*	*24 600*	*28 256*	*444 546*	*4 663*	*2.17*	*3.91*
2017	*1 549 964*	*18 992*	*26 913*	*354 247*	*3 667*	*2.11*	*3.13*
2018	*1 504 162*	*16 460*	*25 852*	*387 905*	*3 865*	*1.72*	*3.37*
2019	*1 547 482*	*21 082*	*11 198*	*340 206*	*3 302*	*1.92*	*2.97*
2020	*1 907 675*	*5 972*	*14 852*	*319 528*	*3 304*	*1.58*	*2.78*
Share of total CH_4 emissions in Waste sector in 2020, %							*14.0%*
2020 versus 1990							*-62.0%*
2020 versus 2019							*-6.6%*

Some assumptions are made to calculate emissions from domestic wastewater handling:

- Total organically degradable carbon, removed from domestic wastewater with sludge, is divided proportionally between types of treatment. Type of treatment "not connected" removes no carbon in sludge.

[273] Cabinet Regulation No. 34 "Regulations regarding Discharge of Polluting Substances into Water". Available: https://likumi.lv/ta/en/en/id/58276

- Only temporal storage of sewage sludge with dry solid content less then 20% could be considered as anaerobic conditions, since all other ways or conditions of sewage sludge (for example, storage after dewatering procedures, what results in content of dry solids 20% and more) does not allow to use MCF value for "deep anaerobic lagoons", as it was recommended by TERT, especially, if dewatered sewage sludge is being stored in the piles. An expert judgment was performed and documented to establish the 20% solid content threshold value to divide sudge in anaerobic/aerobic[274].

Figure 7.11 Dewatered sewage sludge storage shed. Considered to be no source of CH_4 emissions

[274] *Expert judgment protocol EJ_Waste_5D_2016_001*

Figure 7.12 Liquid sewage sludge storage basin. Considered to be source of CH_4 emissions (deep anaerobic lagoon)

Example of methane emission calculation for 2020 is shown in Table 7.23.

Table 7.23 Calculation of CH_4 emission from Domestic Waste Water Handling sector (2020)

Treatment type	Population (persons)	Total DC (kt BOD/yr)	DC WW w/o sludge (kt BOD/yr)	Correction factor for additional industrial discharges of BOD into a sewer	Maximum CH_4 producing capacity B_o, kg CH_4/kg BOD	MCF	Emission factor	Emission (kt of CH_4)
Well managed biological	*1 567 323*	*34.324*	*19.476*	*1.25*	*0.6*	*0*	*0*	*0*
Poor managed biological	*5 972*	*0.131*	*0.074*	*1.25*	*0.6*	*0.3*	*0.18*	*0.017*
Non-biological	*14 852*	*0.325*	*0.185*	*1.25*	*0.6*	*0.1*	*0.06*	*0.014*
Not connected to centralized treatment plants*	*319 528*	*6.998*	*6.998*	*1*				*2.236*
Total:	***1 907 675***	***41.778***	***26.733***					***2.267***

**See detailed calculations in the Table 7.26.*

Assumptions regarding sewage sludge are shown in Table 7.24.

Table 7.24 Characteristics of sewage sludge in Latvia

Characteristic	Value
Average content of dry solids in sludge, %[275]	*14*[276]
Average content of COD in dry solids, %	*65*[277]
Average content of N in dry solids, %	*5.2*[278]

Extrapolation was used to estimate amount of sewage sludge produced and treated anaerobically for period 1990 – 1997, where statistic data were not available. Based on trend of statistics available (1998 – 2008), assumption was made about the part of anaerobically stored sludge. Emissions from sludge, used as fertilizer in agriculture or disposed in landfills, are reported under corresponding sectors.

Data on recovery of CH_4 from wastewater handling are plant specific data from treatment plant *"Daugavgrīva"*, operated by largest Latvian water supply and wastewater Treatment Company *"Rīgas ūdens"*. Recovery of CH_4 is also performed by its daughter company *"Rigens"*, starting from 2002. 1.578 kt of CH_4 was recovered from wastewater handling in 2020, and 0.003 kt of recovered CH_4 was flared. Recovered amount of CH_4 is being used as fuel in the cogeneration plant, and emissions from it are reported under the Energy sector. It is assumed, that density of CH_4 is 0.6687 kg/m^3, and data from enterprise suggests that content of CH_4 in the recovered biogas by volume is 59.4%.

[275] *It is used to estimate content of dry solids for years where statistic data are not available (1998-2002)*
[276] *"Notekūdeņu dūņas un to izmantošana" („Sewage Sludge and Disposal of it"), Gemste I., Vucāns A., Jelgava, 2002.*
[277] *Average data of 1996*
[278] *"Notekūdeņu dūņas" ("Sewage Sludge"), Gemste I., Vucāns A., Jelgava, 2007.*

Since CH_4 is recovered from the sewage sludge, already removed from the wastewater in well managed treatment plant, therefore this amount of methane is not being subtracted from total emissions of CH_4.

According to the 2006 IPCC Guidelines, there are emissions of recovered CH_4 in the form of leakage from the recovery. Default value of 5% of leakage was used to estimate amount of CH_4 emissions of this source, thus giving emission of 5% of 1.578 kt CH_4 = 0.079 kt CH_4 in 2020.

Example of CH_4 emission calculation from sewage sludge is shown in Table 7.25.

Table 7.25 Calculation of CH_4 emission from anaerobic sewage sludge in 2020

Total DC sludge (kt COD/yr)	Maximum CH_4 producing capacity Bo, kg CH_4/kg COD	MCF for deep anaerobic lagoons	Emission factor for sludge (kg CH_4/ kg COD)	Emission of sludge (kt CH_4)
2.148	*0.25*	*0.8*	*0.2*	*0.430*

To estimate emission from part of national population, not connected to centralized waste water treatment plants, recommendations from TERT were followed and estimation of use of septic tanks and latrines among national population was performed.

Proportion of urban (68.0% of national population) and rural (32.0%) population (2020) was taken from the demographic statistics of CSB (IRD070)[279], default "suggested values for urbanisation and degree of utilization of treatment, pathway or method" from the 2006 IPCC Guidelines were used (since there wasn't Latvia in the list, values for neighbour country Russian Federation were used).

It was estimated, that 83.7% from national population, not connected to centralized wastewater treatment, are served by septic tanks, while 16.3% - with latrines (2020). Corresponding default MCF values from the 2006 IPCC Guidelines were chosen to estimate emissions of CH_4 from this source (Table 7.26).

Table 7.26 Estimation of CH_4 emissions from national population, not connected to centralized wastewater treatment plants in 2020

Type of treatment or discharge pathway	Part of not connected national population, using treatment or discharge pathway	Population, using treatment or discharge pathway	Total DC (kt BOD/yr)	MCF	Emission factor, kg CH_4/kg BOD	Emissions of CH_4, kt
Septic tanks	*83.7%*	*267 346*	*5.855*	*0.5*	*0.3*	*1.756*
Latrines	*16.3%*	*52 182*	*1.143*	*0.7*	*0.42*	*0.480*
Total:						*2.236*

Thus, total CH_4 emission from Domestic Wastewater handling and sewage sludge in 2020 is 2.775 kt of CH_4, making decrease of 65.0% in comparison of emissions in 1990 and decrease of 6.61% in comparison of emissions in 2019. It also makes 12.6% from GHG emissions in the Waste sector in 2020 (Table 7.27).

[279] *CSB database. Available: https://data.stat.gov.lv/pxweb/lv/OSP_PUB/START__POP__IR__IRD/IRD070*

Table 7.27 Total CH_4 emissions from domestic wastewater handling sector in 2020

Source of CH_4 emissions	Emissions of CH_4, kt
Emissions from waste water, treated in waste water treatment plants	*0.031*
Emissions from leakage from recovered CH_4	*0.079*
Emissions from anaerobic sewage sludge	*0.430*
Emissions from national population, not connected to centralized treatment plant	*2.236*
Total:	*2.775*

Calculation of emissions of N_2O from Domestic Wastewater handling is based on amount of nitrogen, generated from the protein consumption by national population. Number of national population is taken from national statistics (CSB) while country specific values of protein consumption are obtained ourworldindata.org web site[280] (Table 7.28).

Table 7.28 Consumption of protein in Latvia per capita, sludge produced and emissions of N_2O (1990-2020)

Year	g/person/day	kg/person/yr	Amount of sludge produced, t	N in the effluent, kt	Emissions of N_2O, kt
1990	*109.3*	*39.9*	*36 115*	*21.5*	*0.169*
1995	*97.1*	*35.4*	*25 695*	*18.2*	*0.143*
2000	*77.0*	*28.2*	*18 234*	*13.8*	*0.109*
2005	*85.8*	*31.3*	*25 449*	*14.2*	*0.111*
2010	*96.3*	*35.2*	*21 388*	*15.3*	*0.120*
2011	*96.5*	*35.2*	*19 985*	*15.0*	*0.118*
2012	*92.1*	*33.7*	*20.135*	*14.1*	*0.111*
2013	*91.4*	*33.4*	*22 924*	*13.7*	*0.107*
2014	*91.9*	*33.5*	*22 322*	*13.6*	*0.107*
2015	*94.5*	*34.5*	*22 462*	*13.9*	*0.109*
2016	*95.4*	*34.9*	*26 654*	*13.7*	*0.108*
2017	*97.3*	*35.5*	*25 619*	*13.9*	*0.109*
2018	*97.3*	*35.5*	*25 134*	*13.8*	*0.108*
2019	*97.3*	*35.5*	*24 182*	*13.7*	*0.108*
2020	*97.3*	*35.5*	*23 146*	*13.7*	*0.108*

When compared with similar data with Latvian neighbour countries (Estonia, Lithuania, Russian Federation and Belarus), Latvian data shows consistent value (Table 7.29).

Table 7.29 Comparison of Latvian protein consumption data with data from neighbour countries

Country	g/person/day	kg/person/yr
Latvia	*77.0…109.3*	*28.2…39.9*
Estonia	*84.9…103.9***	*31.0…37.9**
Lithuania	*63.6…81.9****	*23.6…29.3***
Russian Federation	*61.0…103.5*****	*31.1…38.0*****
Belarus	*77.5***	*28.3******

**Data taken from Estonian NIR (2019)*
***Recalculated for comparison*
****Data taken from Lithuaninan NIR (2021)*
*****Data taken from NIR of Russian Federation (2021)*
******Data taken from NIR of Belarus (2021)*

[280] *Daily protein supply. Available: https://ourworldindata.org/grapher/daily-per-capita-protein-supply?tab=table&time=earliest..latest*

Amount of N_2O emission from Domestic Wastewater Handling is calculated according to the 2006 IPCC Guidelines; Chapter 6.3.1 „Methodological issues".

$$N_2O_{Emissions} = N_{Effluent} * EF_{Effluent} * 44/28 \quad (7.8)$$

where:
$N_2O_{Emissions}$ – N_2O emission in inventory year, kg N_2O/yr
$N_{Effluent}$ – Nitrogen in the effluent discharged to aquatic environment
$EF_{Effluent}$ – Emission factor for N_2O emissions from discharged wastewater, kg N_2O-N/kg N

$$N_{Effluent} = (P * Protein * F_{NPR} * F_{NON-CON} * F_{IND-COM}) - N_{Sludge} \quad (7.9)$$

where:
$N_{Effluent}$ – Total annual amount of nitrogen in wastewater effluent, kg N/yr
P – National population
Protein – Annual per capita protein consumption, kg/pers/y
F_{NPR} – Fraction of nitrogen in protein, kg N/kg protein
$F_{NON-COM}$ – Factor for non-consumed protein added to wastewater
$F_{IND-COM}$ – Factor for industrial and commercial co-discharged protein into a sewer system
N_{Sludge} – Nitrogen removed with sludge, kg N/y

Default value for nitrogen fraction in protein – 0.16 kg N/kg protein – is used in calculation. Default EF – 0.005 kg N_2O-N/kg N – was used as well. Both values were taken from the 2006 IPCC Guidelines, as well as factors for non-consumed (for countries with no garbage disposals) and industrial and commercial protein co-discharged in the sewer system.

Content of nitrogen in the dry solids of sewage sludge was already shown in the table with characteristics of sewage sludge in Latvia (Table 7.24).

N_2O emissions from centralized wastewater treatment processes are estimated as well.

$$N_2O_{Plants} = P * T_{Plant} * F_{IND-COM} * EF_{Plant} \quad (7.10)$$

where:
N_2O_{Plants} – Total N_2O emissions from plants in the inventory year, kg N_2O/y
P – Human population
T_{Plant} – Degree of utilization of modern, centralized treatment plants, %
$F_{IND-COM}$ – Fraction of industrial and commercial co-discharged protein
EF_{Plant} – Emission factor, g N_2O/pers/y

According to Note from BOX 6.1 (Chapter 6.3.1.3.) of 2006 IPCC Guidelines, amount of nitrogen associated with emissions from modern centralized treatment plants is back calculated (using molecular weight of nitrogren and N_2O molecule) and subtracted from the $N_{Effluent}$.

Wastewater treatment plants, providing tertiary treatment (i.e. removal of nitrogen of phosphorus), are considered to be in compliance with requirements for "modern, centralized treatment plants". Degree of their utilization is estimated based on number of national population, provided with such treatment. National wastewater database "2-Water" provides according statistical data (starting from 2000). Constant value of 3% was used for years, previous to 2000.

Activity data for estimation emissions of N_2O from Domestic Wastewater Handling sector are shown in the following Table 7.30.

Table 7.30 Activity data for estimation emissions of N_2O from Domestic Wastewater Handling sector

Year	Population	Degree of utilization of modern, centralized treatment plants, %	N_2O emissions from modern, centralized treatment plants, kt
1990	*2 668 140*	*3.0*	*0.00032*
1995	*2 500 580*	*3.0*	*0.00030*
2000	*2 377 383*	*0.8*	*0.00008*
2005	*2 249 724*	*8.4*	*0.00076*
2010	*2 120 504*	*16.4*	*0.00139*
2011	*2 070 371*	*18.2*	*0.00151*
2012	*2 044 813*	*17.7*	*0.00145*
2013	*2 023 825*	*17.4*	*0.00141*
2014	*2 001 468*	*56.3*	*0.00451*
2015	*1 986 096*	*56.9*	*0.00452*
2016	*1 968 957*	*58.3*	*0.00459*
2017	*1 950 116*	*62.1*	*0.00484*
2018	*1 934 379*	*60.4*	*0.00468*
2019	*1 919 968*	*60.6*	*0.00465*
2020	*1 907 675*	*60.7*	*0.00463*

Considerable increase of share of population, served with modern, centralized treatment plants in last years can be explained by intensive implementing of Urban Wastewater Treatment Directive 91/271/EEC.

Default values from the 2006 IPCC Guidelines are used for fraction of industrial and commercial co-discharged protein and EF (correspondingly, 1.25 and 3.2 g N_2O/pers/y). Total emission of N_2O from Domestic Wastewater Handling in 2020 was 0.108 kt N_2O, what makes decrease by 36.4% compared to 1990 and decrease by 0.3% compared to 2019. Share of N_2O emissions from Domestic Wastewater handling is 5.9% from total GHG emissions in the Waste sector (2020).

Treated domestic waste water is also source of NMVOC emissions. Emissions of NMVOC was calculated and using default EMEP EF from EMEP/EEA 2019 was used for this calculation – 15 mg of NMVOC per m^3 of treated wastewater discharged (95 mio m^3, 2020), giving emissions of 0.00143 kt of NMVOC (2020). It makes decrease by 61.2% compared to 1990, and increase by 0.9% compared to 2019. Domestic Waste Water handling sector is main source of NMVOC in the Waste sector (Table 7.31).

Table 7.31 Activity data for calculation domestic NMVOC emissions from Wastewater Handling sector

Year	Amount of treated domestic waste water discharged, mio m^3	Emissions of NMVOC, kt
1990	*246*	*0.00369*
1995	*155*	*0.00233*
2000	*117*	*0.00175*
2005	*104*	*0.00156*
2010	*104*	*0.00156*
2011	*105*	*0.00158*
2012	*101*	*0.00151*
2013	*103*	*0.00155*

Year	Amount of treated domestic waste water discharged, mio m^3	Emissions of NMVOC, kt
2014	*98*	*0.00147*
2015	*98*	*0.00147*
2016	*100*	*0.00150*
2017	*105*	*0.00158*
2018	*93*	*0.00139*
2019	*95*	*0.00142*
2020	*95*	*0.00143*
Share of total NMVOC emissions in Waste sector in 2020, %		*75.8%*
2020 versus 1990		*-61.2%*
2020 versus 2019		*+0.9%*

7.5.1.3 Uncertainties and times-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

The following uncertainties were used for Domestic Wastewater Handling sector for activity data and EFs (Table 7.32).

Table 7.32 Uncertainties for Domestic Wastewater Handling sector

Gas	Activity data	Emission factor
CH_4	7%	30%*
N_2O	6%	30%*
NMVOC	8%	-

**30% - default uncertainty from the 2006 IPCC Guidelines*

Uncertainties for activity data of each subsector are estimated using similar methodology. To estimate an uncertainty for certain subsector, its activity data are drawn on chart for each year, then the mathematical relationship of activity data timeline is found as equation of the trend line. Then "theoretical values" of activity data is calculated for each year, using the equation of the trend line, and uncertainty being calculated as deviation (in %) of "actual" value from the "theoretical" one (Figure 7.13).

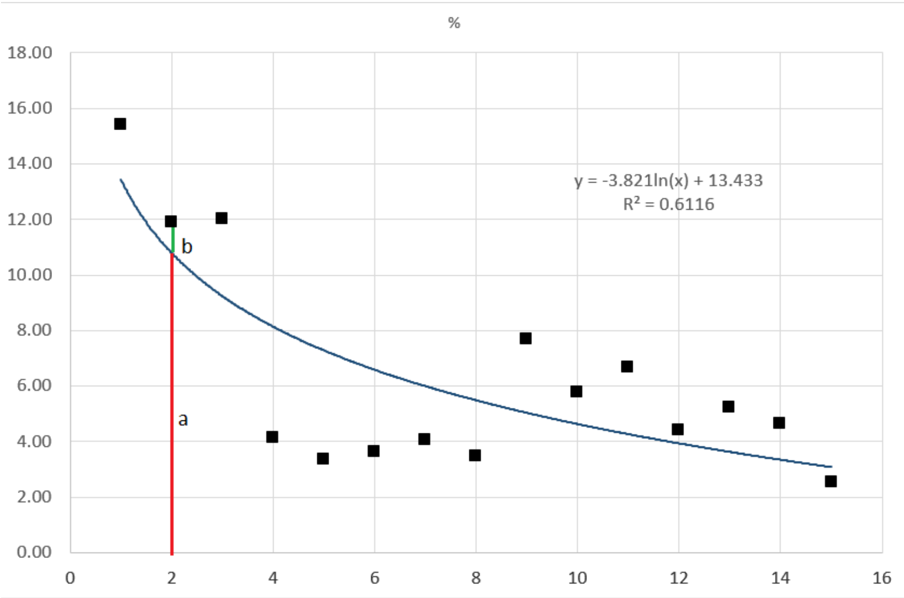

Figure 7.13 Example of estimation of uncertainties in Wastewater Handling sector

Each deviance is calculated as:

$$\boldsymbol{Uncertainty}, \% = \frac{\mathbf{100} * |\boldsymbol{b}|}{\boldsymbol{a}} \tag{7.11}$$

where:
a – "theoretical" value of activity data, calculated through equation of the trend line
b – difference between "theoretical" and "actual" value of activity data for certain year

Total uncertainty for certain type of activity data is calculated as average for entire timeline. Then total uncertainty U_{tot} for subsector is being calculated, using following formula of combined uncertainty:

$$\boldsymbol{U_{tot}} = \frac{\sqrt{(\boldsymbol{x_1 U_1})^2 + (\boldsymbol{x_2 U_2})^2}}{\boldsymbol{x_1} + \boldsymbol{x_2}} \tag{7.12}$$

where:
x – emissions from certain pathway/subsector
U – uncertainties for each type of activity data for certain subsector associated with emissions from the same pathway/subsector

Default uncertainty values for CH_4 and N_2O EFs were taken from IPCC 2006 Guidelines. EMEP/EEA 2019 does not provide uncertainty for NMVOC EFs or methodology to estimate it.

Time series mostly show continuous decrease of emissions in the entire timeline. Main reason of this decrease is implementation of more and better technologies in wastewater treatment plants, decrease of national population and consumption of protein also can be observed. However, the same driving force (implementing of more stringent and advanced wastewater treatment technologies) is reason for increase of N_2O emissions from subsector of modern centralized treatment plants.

Inconsistencies in data (for example, potential outlier of CH_4 emissions in 2003, as well as considerable fluctuations in 2003 and from 2010 to 2011) can be explained with quality of activity data. Although data collection system on population, receiving certain grade of wastewater treatment is generally well-designed and allows to collect data on plant level, the actual data quality still largely depends on competence of person in enterprise, responsible for reporting these data, as well as inspector of regional environmental board, who assesses and accepts the survey with plant level data. Some additional and retrospective data checks are performed occasionally, which leads to recalculations and overall improvement and reliability of statistic data.

NMVOC emission time series show gradual decrease in the entire reporting period, what can be explained with more efficient water use and and decrease of national population.

7.5.1.4 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the 2.G. sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

Following procedures of quality assurance and quality control were carried out:

- Statistic data of national population, served by certain treatment type and level, as well as amount of sludge produced and disposed are collected through annual state statistical survey "2-Water". In frames of this survey, enterprises, performing collection and treatment of wastewater, submit their data using online database. Reported data are checked by Latvian State Environment Service, whose environment inspectors approve reports or return them to submitters for correcting of data;
- Units of measurement were checked during comparison with results of previous reports;
- Number of national population was cross-checked with activity data, used in others sectors (solvents and waste disposal);
- Amount of CH_4 recovery from sewage sludge was checked by comparing data from Energetic sector on amount of sludge gas burned in waste water treatment facility;
- Protein consumption data were compared with values with neighbour countries of Latvia – Lithuania, Estonia, Belarus and Russian Federation (see Table 7.29);
- Comments in CRF Reporter were checked in process of entering data of calculation and recalculation results in CRF tables.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

7.5.1.5 Category-specific recalculation

N_2O emissions were recalculated for entire reporting period 1990-2019 due to correction of error in the calculation and correction of AD for year 2000. As result, emission values changed unsignificantly, less than 1% for each year.

7.5.1.6 Category-specific planned improvements

For the next submission it is planned to review data on characteristics of sewage sludge if National Strategy on Sewage Sludge will be adopted officially.

7.5.2 Industrial Wastewater (CRF 5.D.2)

7.5.2.1 Category description

Industrial Wastewater Handling is responsible for CH_4 and N_2O emissions. Fluctuations of methane emission from Industrial Wastewater Handling are connected with fluctuations of amount of production produced, which is activity data for this sector. Significant decrease in methane emission in period 1993–1999 is due to decrease of economic activity after collapse of Soviet Union.

Main pollutant in Industrial Wastewater sector is CH_4, making 95.5% of the emissions, while emissions of N_2O corresponds only for 4.5% of this sector (2020).

In total, emissions from Industrial Waste Water Handling sector made 3.22 kt CO_2 eq. in 2020, what makes decrease by 97.7% compared to 1990 and increase by 58.9% compared to 2019 (Figure 7.14). GHG emissions from Industrial Wastewater handling contributes 3.1% of total GHG emissions from Wastewater handling sector and 0.6% of total GHG emissions in Waste sector (2020).

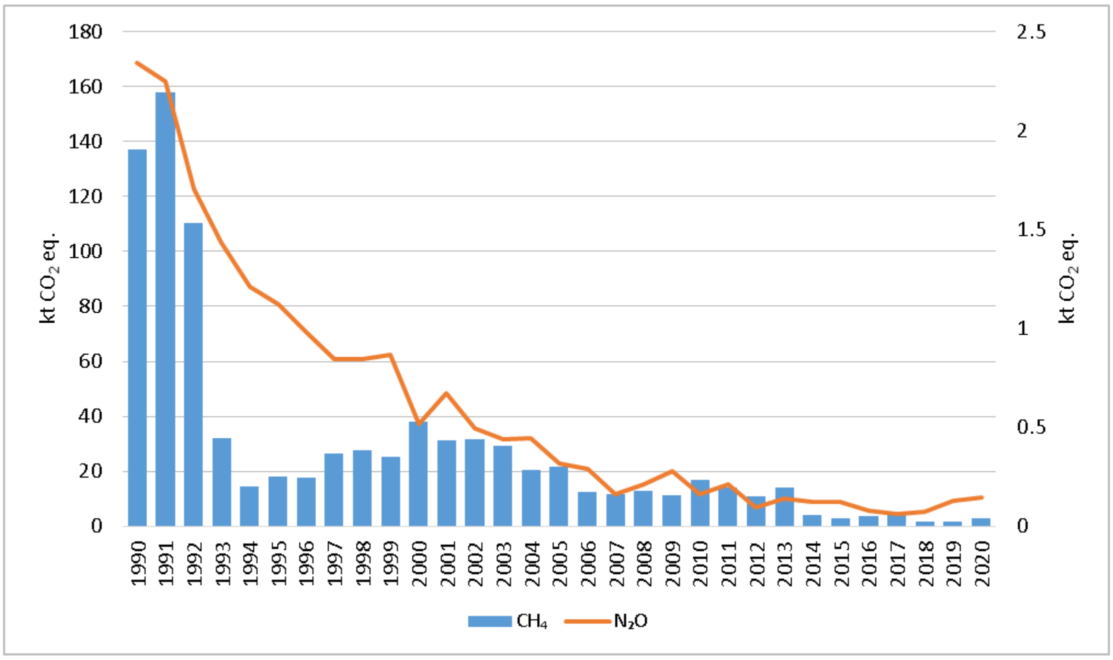

Figure 7.14 Emissions from Industrial Wastewater Handling sector (N_2O on secondary axis) (kt CO_2 eq.)

7.5.2.2 Methodological issues

Emissions of CH_4 from Industrial Waste Water Handling is calculated from amount of total organic product (expressed as COD – chemical oxygen demand) and total nitrogen in waste water, generated in certain branches of industry (mostly food-processing industry).

The 2006 IPCC Guidelines general equation from chapter 6.2.3 „Industrial Wastewater" was used for calculation of CH_4 emission from Industrial Wastewater Handling sector.

$$\boldsymbol{CH_4} = \sum_i [(\boldsymbol{TOW_i} - \boldsymbol{S_i}) * \boldsymbol{EF_i} - \boldsymbol{R_i}] \qquad (7.13)$$

where:
CH_4– CH_4 emissions in inventory year, kg CH_4/yr
TOW_i – total organically degradable material in industrial wastewater from industry i in inventory year, kg COD/yr
i – industrial sector

S_i – organic component removed with sludge in the inventory year, kg COD/yr
EF_i – emission factor for industry i, kg CH_4/kg COD
R_i – amount of CH_4 recovered in inventory year, kg CH_4

$$EF_i = B_o * MCF_i \tag{7.14}$$

where:
EFi – emission factor for each industry i, kg CH_4/kg COD
i – each type of industry
B_o – maximum CH_4 producing capacity, kg CH_4/kg COD
MCFi – methane correction factor for each type of industry

$$TOW_i = P_i * W_i * COD_i \tag{7.15}$$

where:
TOW_i – total organically degradable material for industry i, kg COD/yr
i – industrial sector
P_i – total industrial product for industry i, t/yr
W_i – waste water generated for each type of industry, m^3/t product
COD_i – industrial degradable organic component in wastewater, kg COD/m^3

Activity data (amount of certain industrial products) was taken from national statistics – CSB data base. Default IPCC value 0.25 kg CH_4/kg COD was used for maximum methane producing capacity, as it is recommended in the 2006 IPCC Guidelines. Amount on generation of waste water per certain type of product and organic component in that wastewater were taken as default values from the 2006 IPCC Guidelines.

Plant specific survey was performed during 2012, to obtain MCF values for certain industries. The average weighted MCF for each industry were estimated depending of level of contribution of said industry in terms of amount of waste water generated and its fate (level of treatment or transfer to certain urban waste water treatment plant). Average results of this survey were applied to estimate CH_4 emissions for this period.

Activity data (amount of discharged industrial wastewater) for period 2000–2020 was taken from national statistics – data base "2-Water" on water abstraction and use, treatment and discharge of wastewater. This data base also was used as data source to obtain plant-level MCF value for each enterprise/wastewater discharge.

Assumptions for all relevant industries are summarized in Table 7.33.

Table 7.33 Assumptions used for calculation of CH_4 emissions from Industrial Wastewater Handling

Industry type	Generation of waste water, m^3/t of product*	Organic component in waste water, kg COD/m^3*	Weighted MCF value**
Milk	*7*	*2.7*	*0.10*
Meat	*13*	*4.1*	*0.15*
Fish	*13*	*2.5*	*0.05*
Beer	*6.3*	*2.9*	*0.04*
Fruits and vegetables	*20*	*5*	*0.13*
Sugar	*11*	*3.2*	*0.50*
Paper and pulp	*162*	*9*	*0.30*
Plastics	*0.6*	*3.7*	*0.14*
Organic chemicals	*67*	*3*	*0.03*

**Assumptions used from the 2006 IPCC Guidelines*
***rounded to 2 decimal positions*

Organic component removed with sludge and amount of recovered CH_4 under this sector is assumed to be 0 – all sewage sludge is included elsewhere (in Domestic Wastewater sector).

There were totally 41 relevant direct discharges of industrial waste water registered in 2020. Main industries were milk production (10 discharges) and fish processing (10 discharges) and meat processing (7 discharges). While number of discharges is the same as in 2019, there is slight increase of emissions in the period 2018 – 2020 despite of decrease of emission in the long-term period.

Default IPCC methane conversion factors (MCF) were applied for each discharge depending type and level of treatment of the corresponding waste water flow. Thus, MCFs are considered to be plant-specific. Due to most mechanical waste water treatment plants are small and deal will small amounts of waste water, MCF of anaerobic shallow lagoon was chosen for according pathway (Table 7.34).

Table 7.34 Choice of MCF values for CH_4 emission calcuulation from industrial wastewater

IPCC MCF description	According fate of industrial waste water	MCF value
Aerobic treatment plant, well managed	At least secondary treatment with waste water treated to standards	*0*
Direct discharge of untreated waste water	No treatment	*0.1*
Ananerobic shallow lagoon	Primary treatment	*0.1*
Aerobic treatment plant, not well managed or overloaded	Secondary treatment failing to treat waste water to standards	*0.3*

Taking into account that plant-level amounts of wastewater are used for period 2000 – 2020 and there are no complete data on content of COD (especially incoming values), method is considered to be Tier 1 method.

There is no CH_4 recovery from the sludge of industrial waste water in Latvia.

Thus, total emission of CH_4 from Industrial Waste Water treatment in 2020 was 0.123 kt of CH_4, what makes 97.8% decrease if compared to 1990 and 62.1% increase if compared to 2019. Share of CH_4 emissions from Industrial Wastewater handling is 0.6% from total GHG emissions in the Waste sector (2020).

N_2O emission from Industrial Wastewater Handling was calculated, using default method from the 2006 IPCC Guidelines, chapter 6.3.1 "Nitrous Oxide Emissions from Wastewater". Calculation is based on load of nitrogen in the industrial wastewater:

$$\boldsymbol{WM = N_{ef} * EF * \frac{44}{28} * 10^{-6}} \quad (7.16)$$

where:
WM – total emission of N_2O from industrial wastewater handling in kt N_2O
N_{ef} – load of nitrogen, kg/yr
EF – emission factor, kg N_2O-N/kg N

Default value (0.005 kg N_2O-N/kg N) from the 2006 IPCC Guidelines was used for calculation.

Activity data, used for calculation of N_2O emissions from Industrial Wastewater Handling, are summarized in Table 7.35.

Table 7.35 Activity data for calculation N_2O emissions from Industrial Waste Water Handling sector

Year	Load of N in industrial waste water, t/yr	Emissions of N_2O, kt
1990	*1 000*	*0.00786*
1995	*480*	*0.00377*
2000	*221*	*0.00173*
2005	*135*	*0.00106*
2010	*69*	*0.00054*
2011	*91*	*0.00071*
2012	*42*	*0.00033*
2013	*60*	*0.00047*
2014	*53*	*0.00042*
2015	*54*	*0.00042*
2016	*34*	*0.00027*
2017	*27*	*0.00021*
2018	*32*	*0.00025*
2019	*55*	*0.00044*
2020	*62*	*0.00049*
Share of total N_2O emissions in Waste sector in 2020, %		*0.03%*
2020 versus 1990		*-93.8%*
2020 versus 2019		*+11.4%*

N_2O emission from Industrial Wastewater Handling is negligible – 0.00049 kt/yr (2020), what makes decrease by 93.8% compared to 1990 and increase by 11.4% compared to 2019. It makes 0.03% from total GHG emissions from Waste sector (2020).

Treated industrial wastewater is also source of NMVOC emissions. Emissions of NMVOC was calculated and default EMEP EF from EMEP/EEA 2019 was used for this calculation – 15 mg of NMVOC per m^3 of treated wastewater discharged (5.06 mio m^3, 2020), giving emissions of 0.000076 kt of NMVOC (2020). It makes decrease by 92.0% compared to 1990, and increase by 23.3% compared to 2019 (Table 7.36).

Table 7.36 Activity data for calculation industrial NMVOC emissions from Wastewater Handling sector

Year	Amount of treated industrial wastewater discharged, mio m^3	Emissions of NMVOC, kt
1990	*63.6*	*0.000954*
1995	*32.8*	*0.000493*
2000	*19.5*	*0.000293*
2005	*12.2*	*0.000182*
2010	*6.28*	*0.000094*
2011	*8.76*	*0.000131*
2012	*8.72*	*0.000131*
2013	*9.70*	*0.000145*
2014	*9.40*	*0.000141*
2015	*9.74*	*0.000146*
2016	*4.64*	*0.000070*
2017	*4.48*	*0.000067*
2018	*4.21*	*0.000063*
2019	*4.10*	*0.000062*
2020	*5.06*	*0.000076*

Year	Amount of treated industrial wastewater discharged, mio m^3	Emissions of NMVOC, kt
Share of total NMVOC emissions in Waste sector in 2020, %		*4.02%*
2020 versus 1990		*-92.0%*
2020 versus 2019		*+23.3%*

7.5.2.3 Uncertainties and times-series consistency

Uncertainty analysis for 2022 submission is carried out by using Approach 1. Quantitative estimates of uncertainties are provided in Annex 2. Overall description of uncertainty analysis is included in Section 1.6.

The following uncertainties were used for Industrial Wastewater Handling sector for activity data and EFs (Table 7.37).

Table 7.37 Uncertainties for Industrial Wastewater Handling sector

Gas	Activity data	Emission factor
CH_4	*46%*	*30%**
N_2O	*19%*	*30%**
NMVOC	*23%*	-

**default uncertainty from the 2006 IPCC Guidelines*

In estimation of emissions from Industrial Wastewater Handling uncertainties for activity data in Industrial Wastewater Handling are estimated similarly as uncertainties for activity data for Domestic Wastewater subsector (see Chapter 7.5.1.3).

Fluctuation of AD is the main reason for percent of AD uncertainty. Gradual changes of AD for N_2O emissions were observed during the period 1990–2000, in the years following the 2001 decrease of AD was still in place, but values tend to fluctuate more significantly, leading to increase of uncertainty for 2020.

Emissions in the Industrial Wastewater Handling sector show clear trends to decrease over entire timeline for all gases. It is connected both with rapid decrease of industrial activities after 1990 due to collapse of Soviet Union and use of better environmental technologies in the treatment wastewater, as well rate of transfer of industrial wastewater to urban waste water treatment plants. However, signs of some stabilization can be observed for the period 2014 – 2020.

7.5.2.4 Source-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the 2.G. sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

Following procedures of quality assurance and quality control were carried out:

- Statistic data on amounts wastewater produced/discharged and nitrogen load in wastewater are collected through annual state statistical survey "2-Water". In frames of this survey, enterprises, performing collection and treatment of wastewater, submit their data using online database. Reported data are checked by Latvian State

Environment Service, whose environment inspectors approve reports or return them to submitters for correcting of data;

- Units of measurement were checked during comparison with results of previous reports;
- Comments in CRF Reporter were checked in process of entering data of calculation and recalculation results in CRF tables.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

7.5.2.5 Source-specific recalculations

No recalculations were done for this sector.

7.5.2.6 Source-specific planned improvements

No improvements are planned for this sector.

7.5.3 Other (CRF 5.D.3)

7.5.3.1 Category description

Data from annual state statistical survey "2-Water" shows there were total 192 mio m^3 of waste water discharged in Latvia (2020). Most of national population (83.3%, 2020) is served by centralized urban wastewater collecting and treatment. Certain amount of NMVOC is produced from Wastewater Handling sector.

7.5.3.2 Methodological issues

Emissions of NMVOC was calculated and using default EMEP EF from EMEP/EEA 2019 was used for this calculation – 15 mg of NMVOC per m^3 of treated other wastewater discharged (12 mio m^3, 2020), what gives 0.00018 kt of NMVOC (2020). It makes decrease by 73.7% compared to 1990 and decrease by 56.3% compared to 2019.

Activity data, used for this calculation, are summarized in the following Table 7.38.

Table 7.38 Activity data for calculation NMVOC emissions from Wastewater Handling sector

Year	Amount of treated other waste water discharged, mio m^3	Emissions of NMVOC, kt
1990	*45.6*	*0.000684*
1995	*27.1*	*0.000407*
2000	*17.4*	*0.000260*
2005	*16.2*	*0.000243*
2010	*21.9*	*0.000328*
2011	*14.1*	*0.000211*
2012	*9.58*	*0.000144*
2013	*14.3*	*0.000214*
2014	*17.0*	*0.000256*
2015	*14.2*	*0.000213*
2016	*9.57*	*0.000144*
2017	*33.0*	*0.000494*
2018	*26.8*	*0.000401*

Year	Amount of treated other waste water discharged, mio m^3	Emissions of NMVOC, kt
2019	*27.4*	*0.000411*
2020	*12.0*	*0.000180*
Share of total NMVOC emissions in Waste sector in 2020, %		*9.5%*
2020 versus 1990		*-73.7%*
2020 versus 2019		*-56.3%*

7.5.3.3 Uncertainties and time-series consistency

Uncertainty for activity data regarding NMVOC emissions is 29%. It is calculated the same way as uncertainties for Domestic and Industrial Wastewater Handling (See Chapter 7.5.1.3 for description). EMEP/EEA 2019 does not provide uncertainty for EFs or methodology to estimate it.

Consistency of NMVOC emission time series in this subsector is good for period 1990–2009, showing gradual decrease of emissions. However, it fluctuates considerably in the period 2010-2020.

7.5.3.4 Source-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in the 2.G. sector in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

Statistic data of amount of waste water produced and discharged are collected through annual state statistical survey "2-Water". In frames of this survey, enterprises, performing collection and treatment of wastewater, submit their data using online database. Reported data are checked by Latvian State Environment Service, whose environment inspectors approve reports or return them to submitters for correcting of data;

Units of measurement were checked during comparison with results of previous reports.

All information on activity data and emission calculations are stored and archived in the common FTP folder.

7.5.3.5 Source-specific recalculations

No recalculations were done for this sector.

7.5.3.6 Source-specific planned improvements

No improvements are planned for this sector.

8 OTHER (CRF 6)

Latvia does not report emissions under CRF 6 Other.

9 INDIRECT CO_2 AND NITROUS OXIDE EMISSIONS

9.1 *CATEGORY DESCRIPTION*

In accordance with UNFCCC reporting guidelines Annex I Parties may report indirect CO_2 from the atmospheric oxidation of CH_4, CO and NMVOCs.

Sources of indirect CO_2 emissions in Latvian inventory are indirect CO_2 from the atmospheric oxidation of CH_4 and NMVOCs under Energy and IPPU sectors.

The estimation of indirect CO_2 emissions is based on the official Latvian inventories reported under the United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution (CLRTAP).

9.1.1 Methodological issues

Indirect CO_2 emissions are generally calculated using the methodology described in the 2006 IPCC Guidelines.

In order for consistency with the reporting done by Latvia under the first commitment period of the Kyoto Protocol, the indirect CO_2 emissions from NMVOCs in solvent use, road paving with asphalt, asphalt roofing and glass fibre production are reported under CRF 2.D.3 Other in accordance with UNFCCC reporting guidelines. Other sources of indirect CO_2 emissions occurring in Energy and Transport sectors are calculated and reported in CRF Table 6.

According to the 2006 IPCC Guidelines, there are sources in Energy sector that produce indirect CO_2 emissions from CH_4 and NMVOCs. Those sources in case of Latvia are NMVOC emissions from gasoline evaporation in road traffic cars (Transport sector) as well as CH_4 and NMVOC emissions from natural gas leakages and NMVOC emissions from gasoline distribution (Energy sector). The general equations to calculate indirect CO_2 emissions are provided below:

$$\boldsymbol{from\ CH_4: inputs_{CO_2} = emissions_{CH_4} * 44/16}$$

$$\boldsymbol{from\ NMVOC: inputs_{CO_2} = emissions_{NMVOC} * C * 44/12} \tag{9.1}$$

where:
c – fraction of carbon

The 2006 IPCC Guidelines provide a default factor – 0.6 – for the fraction of carbon in NMVOC. Separate sources and emissions are presented in Table 9.1.

Table 9.1 Indirect CO_2 emissions from Energy (kt)

Year	Indirect CO_2 from gas leakage (NMVOC)	Indirect CO_2 from gas leakage (CH_4)	Indirect CO_2 from gasoline distribution (NMVOC)	Indirect CO_2 from gasoline evaporation (NMVOC)	Total Indirect CO_2 emissions
1990	*6.52*	*27.23*	*2.68*	*3.97*	*40.41*
1991	*6.28*	*26.23*	*2.26*	*3.61*	*38.39*
1992	*5.73*	*23.92*	*2.17*	*3.72*	*35.53*
1993	*5.48*	*22.87*	*2.10*	*3.15*	*33.60*
1994	*5.35*	*22.35*	*2.01*	*3.28*	*33.00*
1995	*5.21*	*21.77*	*1.81*	*3.24*	*32.03*
1996	*5.02*	*20.97*	*1.79*	*2.98*	*30.77*
1997	*4.69*	*19.58*	*1.65*	*2.96*	*28.87*

Year	Indirect CO_2 from gas leakage (NMVOC)	Indirect CO_2 from gas leakage (CH_4)	Indirect CO_2 from gasoline distribution (NMVOC)	Indirect CO_2 from gasoline evaporation (NMVOC)	Total Indirect CO_2 emissions
1998	*4.50*	*18.78*	*1.54*	*2.59*	*27.41*
1999	*4.29*	*17.91*	*1.49*	*3.00*	*26.68*
2000	*3.97*	*16.57*	*1.48*	*2.76*	*24.78*
2001	*3.87*	*16.07*	*1.55*	*2.68*	*24.18*
2002	*4.02*	*16.78*	*1.52*	*2.68*	*25.01*
2003	*3.14*	*13.10*	*1.52*	*2.13*	*19.89*
2004	*3.11*	*12.97*	*1.54*	*1.86*	*19.46*
2005	*3.51*	*14.65*	*1.51*	*1.67*	*21.35*
2006	*2.52*	*10.51*	*1.68*	*1.87*	*16.57*
2007	*4.16*	*10.79*	*1.83*	*1.52*	*18.29*
2008	*3.82*	*11.08*	*1.67*	*1.31*	*17.88*
2009	*3.98*	*10.46*	*1.40*	*1.08*	*16.93*
2010	*3.90*	*10.08*	*1.27*	*1.03*	*16.27*
2011	*1.89*	*6.93*	*1.19*	*0.90*	*10.92*
2012	*2.16*	*8.76*	*1.02*	*0.68*	*12.61*
2013	*2.83*	*11.11*	*0.93*	*0.63*	*15.50*
2014	*4.24*	*14.88*	*0.90*	*0.55*	*20.58*
2015	*4.39*	*11.31*	*0.89*	*0.45*	*17.04*
2016	*3.66*	*12.82*	*0.88*	*0.41*	*17.77*
2017	*1.17*	*16.80*	*0.84*	*0.32*	*19.13*
2018	*0.62*	*10.02*	*0.80*	*0.37*	*11.80*
2019	*0.80*	*10.78*	*0.76*	*0.33*	*12.67*
2020	*0.98*	*11.06*	*0.73*	*0.32*	*13.10*

As it can be seen in Table 9.1 the largest part of indirect CO_2 emissions in all years contributes to natural gas leakage. In 2020, natural gas leakages made 91.9% of total indirect CO_2 emissions.

9.1.2 Category-specific QA/QC and verification

The quality objectives and the QA/QC plan for the Latvia's GHG inventory at the National Inventory level are presented in Section 1.2.3. The QC procedures are performed according to the QA/QC plan in order to achieve these quality objectives. Issues related to QA/QC and verification are discussed at the sectoral meetings.

9.1.3 Category-specific recalculations

In road transport recalculations have been done due to switch from COPERT 5.3 model version to COPERT 5.5 model version (corrected EF for EU standards (Convention, Euro 1-3).

9.1.4 Category-specific improvements

No improvements are planned for this sector.

10 RECALCULATIONS AND IMPROVEMENTS

10.1 *EXPLANATIONS AND JUSTIFICATIONS FOR RECALCULATIONS, INCLUDING KP-LULUCF INVENTORY*

10.1.1 GHG inventory

The changes in inventory since the previous submission to the UNFCCC were done according to:

- ESD 2021 annual review of national GHG inventory data;
- Updated activity data and input mistakes;
- Implemention of sector specific research results.

Overall impacts of recalculations since 1990 are summarized in Table 10.1.

Table 10.1 Impacts of recalculations on national emissions

Year		Previous submission	Latest submission	Difference	Difference
		kt CO_2 eq.			(%)
1990	Total CO_2 eq. emissions with LULUCF	*13567.37*	*13567.40*	*0.04*	*0.0003*
	Total CO_2 eq. emissions without LULUCF	*25868.20*	*25868.25*	*0.05*	*0.0002*
1991	Total CO_2 eq. emissions with LULUCF	*11254.33*	*11254.72*	*0.39*	*0.003*
	Total CO_2 eq. emissions without LULUCF	*23972.13*	*23972.53*	*0.41*	*0.002*
1992	Total CO_2 eq. emissions with LULUCF	*6120.82*	*6120.58*	*-0.24*	*-0.004*
	Total CO_2 eq. emissions without LULUCF	*19200.11*	*19199.88*	*-0.23*	*-0.001*
1993	Total CO_2 eq. emissions with LULUCF	*2800.97*	*2800.95*	*-0.02*	*-0.001*
	Total CO_2 eq. emissions without LULUCF	*15782.96*	*15782.96*	*0.00*	*0.000003*
1994	Total CO_2 eq. emissions with LULUCF	*-2053.19*	*-2053.07*	*0.12*	*-0.01*
	Total CO_2 eq. emissions without LULUCF	*13831.35*	*13831.49*	*0.14*	*0.001*
1995	Total CO_2 eq. emissions with LULUCF	*-2298.02*	*-2297.51*	*0.51*	*-0.02*
	Total CO_2 eq. emissions without LULUCF	*12447.95*	*12448.48*	*0.53*	*0.004*
1996	Total CO_2 eq. emissions with LULUCF	*-2400.93*	*-2400.56*	*0.37*	*-0.02*
	Total CO_2 eq. emissions without LULUCF	*12502.59*	*12503.06*	*0.47*	*0.004*
1997	Total CO_2 eq. emissions with LULUCF	*-1190.17*	*-1189.87*	*0.30*	*-0.03*
	Total CO_2 eq. emissions without LULUCF	*11948.96*	*11949.36*	*0.40*	*0.003*
1998	Total CO_2 eq. emissions with LULUCF	*-741.63*	*-741.26*	*0.37*	*-0.05*
	Total CO_2 eq. emissions without LULUCF	*11450.55*	*11451.02*	*0.47*	*0.004*
1999	Total CO_2 eq. emissions with LULUCF	*2163.11*	*2163.44*	*0.32*	*0.01*
	Total CO_2 eq. emissions without LULUCF	*10674.14*	*10674.57*	*0.43*	*0.004*
2000	Total CO_2 eq. emissions with LULUCF	*-1694.58*	*-1694.41*	*0.17*	*-0.01*
	Total CO_2 eq. emissions without LULUCF	*10059.49*	*10059.78*	*0.29*	*0.003*
2001	Total CO_2 eq. emissions with LULUCF	*-1576.05*	*-1576.17*	*-0.12*	*0.01*
	Total CO_2 eq. emissions without LULUCF	*10646.48*	*10646.93*	*0.45*	*0.004*
2002	Total CO_2 eq. emissions with LULUCF	*121.39*	*120.87*	*-0.51*	*-0.42*
	Total CO_2 eq. emissions without LULUCF	*10617.13*	*10617.17*	*0.04*	*0.0003*
2003	Total CO_2 eq. emissions with LULUCF	*698.51*	*695.34*	*-3.18*	*-0.45*
	Total CO_2 eq. emissions without LULUCF	*10791.90*	*10789.25*	*-2.65*	*-0.02*
2004	Total CO_2 eq. emissions with LULUCF	*4377.38*	*4372.62*	*-4.77*	*-0.11*
	Total CO_2 eq. emissions without LULUCF	*10759.86*	*10755.60*	*-4.26*	*-0.04*
2005	Total CO_2 eq. emissions with LULUCF	*5104.49*	*5097.49*	*-7.00*	*-0.14*

Year		Previous submission	Latest submission	Difference	Difference
		kt CO_2 eq.			(%)
	Total CO_2 eq. emissions without LULUCF	*10934.36*	*10927.87*	*-6.49*	*-0.06*
2006	Total CO_2 eq. emissions with LULUCF	*4826.78*	*4820.91*	*-5.86*	*-0.12*
	Total CO_2 eq. emissions without LULUCF	*11414.91*	*11409.54*	*-5.37*	*-0.05*
2007	Total CO_2 eq. emissions with LULUCF	*5675.32*	*5666.17*	*-9.15*	*-0.16*
	Total CO_2 eq. emissions without LULUCF	*11863.26*	*11854.58*	*-8.68*	*-0.07*
2008	Total CO_2 eq. emissions with LULUCF	*4840.97*	*4827.58*	*-13.39*	*-0.28*
	Total CO_2 eq. emissions without LULUCF	*11416.34*	*11403.40*	*-12.94*	*-0.11*
2009	Total CO_2 eq. emissions with LULUCF	*7075.77*	*7059.14*	*-16.63*	*-0.23*
	Total CO_2 eq. emissions without LULUCF	*10730.92*	*10715.26*	*-15.66*	*-0.15*
2010	Total CO_2 eq. emissions with LULUCF	*9941.56*	*9922.42*	*-19.14*	*-0.19*
	Total CO_2 eq. emissions without LULUCF	*11820.12*	*11801.93*	*-18.19*	*-0.15*
2011	Total CO_2 eq. emissions with LULUCF	*8746.71*	*8726.50*	*-20.21*	*-0.23*
	Total CO_2 eq. emissions without LULUCF	*11029.89*	*11010.68*	*-19.21*	*-0.17*
2012	Total CO_2 eq. emissions with LULUCF	*7205.73*	*7183.91*	*-21.82*	*-0.30*
	Total CO_2 eq. emissions without LULUCF	*10851.36*	*10830.48*	*-20.87*	*-0.19*
2013	Total CO_2 eq. emissions with LULUCF	*8386.46*	*8364.47*	*-21.99*	*-0.26*
	Total CO_2 eq. emissions without LULUCF	*10763.41*	*10742.25*	*-21.16*	*-0.20*
2014	Total CO_2 eq. emissions with LULUCF	*12128.49*	*12104.26*	*-24.23*	*-0.20*
	Total CO_2 eq. emissions without LULUCF	*10671.01*	*10647.80*	*-23.21*	*-0.22*
2015	Total CO_2 eq. emissions with LULUCF	*10915.32*	*10892.85*	*-22.47*	*-0.21*
	Total CO_2 eq. emissions without LULUCF	*10724.86*	*10703.36*	*-21.50*	*-0.20*
2016	Total CO_2 eq. emissions with LULUCF	*9068.36*	*9044.26*	*-24.10*	*-0.27*
	Total CO_2 eq. emissions without LULUCF	*10716.53*	*10693.31*	*-23.22*	*-0.22*
2017	Total CO_2 eq. emissions with LULUCF	*7925.37*	*7631.09*	*-294.28*	*-3.71*
	Total CO_2 eq. emissions without LULUCF	*10757.14*	*10733.28*	*-23.86*	*-0.22*
2018	Total CO_2 eq. emissions with LULUCF	*10945.41*	*10658.15*	*-287.26*	*-2.62*
	Total CO_2 eq. emissions without LULUCF	*11260.72*	*11235.04*	*-25.68*	*-0.23*
2019	Total CO_2 eq. emissions with LULUCF	*9979.23*	*8697.75*	*-1281.49*	*-12.84*
	Total CO_2 eq. emissions without LULUCF	*11132.13*	*11103.63*	*-28.51*	*-0.26*

Recalculations made for the 2021 inventory submission by CRF category and gas and their implications to the emission level in 1990 and 2018 as well as explanations for recalculations are provided:Table 10.2; Table 10.3 and Table 10.4.

Table 10.2 Recalculations made in 2022 submission (recalculated year 2019)

GHG SOURCE AND SINK CATEGORIES	Gas	Previous submission (CO_2 eq., kt)	Latest submission (CO_2 eq., kt)	Difference (CO_2 eq., kt)	Difference %	Impact of recalculation on total emissions excluding LULUCF %	Impact of recalculation on total emissions including LULUCF %	Explanation for recalculations
1. Energy	*CO_2*	*6975.52*	*6975.18*	*-0.345*	*-0.005*	*-0.003*	*-0.004*	
A. Fuel combustion activities	*CO_2*	*6975.51*	*6975.17*	*-0.345*	*-0.005*	*-0.003*	*-0.004*	
2. Manufacturing industries and construction	*CO_2*	*625.52*	*625.85*	*0.333*	*0.053*	*0.003*	*0.004*	*Corrected Natural gas consumption value.*
3. Transport	*CO_2*	*3282.67*	*3282.32*	*-0.345*	*-0.011*	*-0.003*	*-0.004*	*Recalculated CO_2 emissions from biodiesel (FAME) fuel that are of fossil origin due to updated statistics by CSB about biodiesel consumption in 2019.*
4. Other sectors	*CO_2*	*1260.53*	*1260.20*	*-0.333*	*-0.026*	*-0.003*	*-0.004*	*Corrected Natural gas consumption value.*
2. Industrial processes and product use	*CO_2*	*617.76*	*618.59*	*0.834*	*0.135*	*0.008*	*0.010*	
D. Non-energy products from fuels and solvent use	*CO_2*	*46.93*	*47.77*	*0.834*	*1.778*	*0.008*	*0.010*	*Recalculations in 2.D.1 Lubricant use are made due to precised Activity data. NMVOC emissions from Solvent use sector were recalculated taking into account that activity*

GHG SOURCE AND SINK CATEGORIES	Gas	Previous submission (CO_2 eq., kt)	Latest submission (CO_2 eq., kt)	Difference (CO_2 eq., kt)	Difference %	Impact of recalculation on total emissions excluding LULUCF %	Impact of recalculation on total emissions including LULUCF %	Explanation for recalculations
								data for year 2019 was specified and therefore emissions were recalculated for this year. Since 2022 submission emissions from use of tobacco combustion is calculated for time period 1990 – 2020. Recalculations in 2.D.3. Urea use are made due to precised Activity data.
4. Land use, land-use change and forestry (net)	*CO_2*	*-2580.99*	*-3803.72*	*-1222.730*	*47.374*		*-14.058*	
A. Forestland	*CO_2*	*-4831.92*	*-5893.54*	*-1061.623*	*21.971*		*-12.206*	*Recalculations are made due to to improvement of NFI based activity data. Addition 20% of NFI sample plots are surveyed annually, every year acquired cummulative LUC area data is extrapolated to whole country area - recalculations made till all NFI sample plots are suveyed in period of 5 years.*
B. Cropland	*CO_2*	*1431.37*	*1442.09*	*10.722*	*0.749*		*0.123*	*Recalculations are made due to to improvement of NFI based activity data. Addition 20% of NFI sample plots are surveyed annually, every year acquired cummulative LUC area data is extrapolated to whole country area - recalculations made till all NFI sample plots are suveyed in period of 5 years.*

GHG SOURCE AND SINK CATEGORIES	Gas	Previous submission (CO_2 eq., kt)	Latest submission (CO_2 eq., kt)	Difference (CO_2 eq., kt)	Difference %	Impact of recalculation on total emissions excluding LULUCF %	Impact of recalculation on total emissions including LULUCF %	Explanation for recalculations
C. Grassland	*CO_2*	*949.80*	*1155.22*	*205.417*	*21.627*		*2.362*	*Recalculations are made due to to improvement of NFI based activity data. Addition 20% of NFI sample plots are surveyed annually, every year acquired cummulative LUC area data is extrapolated to whole country area - recalculations made till all NFI sample plots are suveyed in period of 5 years.*
D. Wetlands	*CO_2*	*1376.10*	*1376.16*	*0.068*	*0.005*		*0.001*	*Recalculations are made due to to improvement of NFI based activity data. Addition 20% of NFI sample plots are surveyed annually, every year acquired cummulative LUC area data is extrapolated to whole country area - recalculations made till all NFI sample plots are suveyed in period of 5 years.*
E. Settlements	*CO_2*	*573.22*	*448.96*	*-124.258*	*-21.677*		*-1.429*	*Recalculations are made due to to improvement of NFI based activity data. Addition 20% of NFI sample plots are surveyed annually, every year acquired cummulative LUC area data is extrapolated to whole country area - recalculations made till all NFI sample plots are suveyed in period of 5 years.*
G. Harvested wood products	*CO_2*	*-2079.56*	*-2332.62*	*-253.055*	*12.169*		*-2.909*	*Recalculations are made due to to improvement of NFI based activity data. Addition 20% of NFI sample plots are surveyed*

GHG SOURCE AND SINK CATEGORIES	Gas	Previous submission (CO_2 eq., kt)	Latest submission (CO_2 eq., kt)	Difference (CO_2 eq., kt)	Difference %	Impact of recalculation on total emissions excluding LULUCF %	Impact of recalculation on total emissions including LULUCF %	Explanation for recalculations
								annually, every year acquired cummulative LUC area data is extrapolated to whole country area - recalculations made till all NFI sample plots are suveyed in period of 5 years.
CO_2 emissions from biomass	*CO_2*	*6954.74*	*6943.91*	*-10.826*	*-0.156*	*-0.098*	*-0.124*	*Sludge gas consumption values corrected to match CSB Energy Balance consumption of Sludge gas in CRF 1A1 and corrected Biodiesel consumption value in CRF 1A4.*
Indirect CO_2	*CO_2*	*12.67*	*12.67*	*0.000*	*0.000*	*0.000*	*0.000*	*Recalculations have been done due to switch from COPERT 5.3 model version to COPERT 5.5 model version (corrected EF for EU standards (Convention, Euro 1-3).*
1. Energy	*CH_4*	*296.22*	*296.27*	*0.053*	*0.018*	*0.000*	*0.001*	
A. Fuel combustion activities	*CH_4*	*198.26*	*198.32*	*0.053*	*0.027*	*0.000*	*0.001*	
1. Energy industries	*CH_4*	*16.12*	*16.12*	*0.000*	*-0.001*	*0.000*	*0.000*	*Sludge gas consumption values corrected to match CSB Energy Balance consumption of Sludge gas.*

GHG SOURCE AND SINK CATEGORIES	Gas	Previous submission (CO_2 eq., kt)	Latest submission (CO_2 eq., kt)	Difference (CO_2 eq., kt)	Difference %	Impact of recalculation on total emissions excluding LULUCF %	Impact of recalculation on total emissions including LULUCF %	Explanation for recalculations
2.Manufacturing industries and construction	*CH_4*	*14.62*	*14.62*	*0.000*	*0.001*	*0.000*	*0.000*	*Corrected Natural gas consumption value.*
3. Transport	*CH_4*	*3.30*	*3.36*	*0.053*	*1.601*	*0.000*	*0.001*	*Recalculations have been done due to switch from COPERT 5.3 model version to COPERT 5.5 model version (corrected EF for EU standards (Convention, Euro 1-3). In addition, GHG emissions for buses have been recalculates for 2015-2019, as the distribution of buses by group (Urban Buses Midi <=15 t, Urban Buses Standard 15 - 18 t, Urban Buses Articulated >18 t) has been clarified.*
4. Other sectors	*CH_4*	*164.17*	*164.17*	*0.000*	*0.000*	*0.000*	*0.000*	*Corrected Biodiesel and Natural gas consumption value.*
4. Land use, land-use change and forestry (net)	*CH_4*	*801.35*	*775.51*	*-25.847*	*-3.225*		*-0.297*	
A. Forestland	*CH_4*	*401.47*	*374.88*	*-26.590*	*-6.623*		*-0.306*	*Recalculations are made due to to improvement of NFI based activity data. Addition 20% of NFI sample plots are surveyed annually, every year acquired cummulative LUC area data is extrapolated to whole*

GHG SOURCE AND SINK CATEGORIES	Gas	Previous submission (CO_2 eq., kt)	Latest submission (CO_2 eq., kt)	Difference (CO_2 eq., kt)	Difference %	Impact of recalculation on total emissions excluding LULUCF %	Impact of recalculation on total emissions including LULUCF %	Explanation for recalculations
								country area - recalculations made till all NFI sample plots are suveyed in period of 5 years.
B. Cropland	*CH_4*	*114.88*	*114.76*	*-0.125*	*-0.109*		*-0.001*	*Recalculations are made due to to improvement of NFI based activity data. Addition 20% of NFI sample plots are surveyed annually, every year acquired cummulative LUC area data is extrapolated to whole country area - recalculations made till all NFI sample plots are suveyed in period of 5 years.*
C. Grassland	*CH_4*	*195.28*	*196.15*	*0.869*	*0.445*		*0.010*	*Recalculations are made due to to improvement of NFI based activity data. Addition 20% of NFI sample plots are surveyed annually, every year acquired cummulative LUC area data is extrapolated to whole country area - recalculations made till all NFI sample plots are suveyed in period of 5 years.*
D. Wetland	*CH_4*	*89.72*	*89.72*	*0.000*	*0.000*		*0.000*	*Recalculations are made due to to improvement of NFI based activity data. Addition 20% of NFI sample plots are surveyed annually, every year acquired cummulative LUC area data is extrapolated to whole country area - recalculations made till all NFI sample plots are suveyed in period of 5 years.*

GHG SOURCE AND SINK CATEGORIES	Gas	Previous submission (CO_2 eq., kt)	Latest submission (CO_2 eq., kt)	Difference (CO_2 eq., kt)	Difference %	Impact of recalculation on total emissions excluding LULUCF %	Impact of recalculation on total emissions including LULUCF %	Explanation for recalculations
5. Waste	*CH_4*	*530.49*	*502.22*	*-28.266*	*-5.328*	*-0.255*	*-0.325*	
A. Solid waste disposal	*CH_4*	*411.81*	*383.55*	*-28.266*	*-6.864*	*-0.255*	*-0.325*	*Waste composition was updated in IPCC model for managed sites because there was a mistake for 2019*
1. Energy	*N_2O*	*186.59*	*186.73*	*0.135*	*0.072*	*0.001*	*0.002*	
A. Fuel combustion activities	*N_2O*	*186.59*	*186.73*	*0.135*	*0.072*	*0.001*	*0.002*	
1. Energy industries	*N_2O*	*25.37*	*25.37*	*0.000*	*-0.001*	*0.000*	*0.000*	*Sludge gas consumption values corrected to match CSB Energy Balance consumption of Sludge gas.*
2.Manufacturing industries and construction	*N_2O*	*35.83*	*35.83*	*0.000*	*0.000*	*0.000*	*0.000*	*Corrected Natural gas consumption value.*

GHG SOURCE AND SINK CATEGORIES	Gas	Previous submission (CO_2 eq., kt)	Latest submission (CO_2 eq., kt)	Difference (CO_2 eq., kt)	Difference %	Impact of recalculation on total emissions excluding LULUCF %	Impact of recalculation on total emissions including LULUCF %	Explanation for recalculations
3. Transport	*N_2O*	*45.36*	*45.50*	*0.135*	*0.297*	*0.001*	*0.002*	*Recalculations have been done due to switch from COPERT 5.3 model version to COPERT 5.5 model version (corrected EF for EU standards (Convention, Euro 1-3). In addition, GHG emissions for buses have been recalculates for 2015-2019, as the distribution of buses by group (Urban Buses Midi <=15 t, Urban Buses Standard 15 - 18 t, Urban Buses Articulated >18 t) has been clarified.*
4. Other sectors	*N_2O*	*79.84*	*79.84*	*0.000*	*0.000*	*0.000*	*0.000*	*Corrected Biodiesel an Natural gas consumption value.*
3. Agriculture	*N_2O*	*1202.97*	*1201.99*	*-0.977*	*-0.081*	*-0.009*	*-0.011*	
B. Manure management	*N_2O*	*78.12*	*77.36*	*-0.754*	*-0.966*	*-0.007*	*-0.009*	*Recalculation is done for indirect emission of N20 to ensure consistency between GHG and air pollution inventories.*
D. Agricultural soils	*N_2O*	*1124.85*	*1124.62*	*-0.223*	*-0.020*	*-0.002*	*-0.003*	*Recalculation is done for direct emission of N20 from organic soils due to including updated numbers of organic soils area in calculations.*
4. Land use, land-use change and forestry (net)	*N_2O*	*626.74*	*622.34*	*-4.402*	*-0.702*		*-0.051*	

GHG SOURCE AND SINK CATEGORIES	Gas	Previous submission (CO_2 eq., kt)	Latest submission (CO_2 eq., kt)	Difference (CO_2 eq., kt)	Difference %	Impact of recalculation on total emissions excluding LULUCF %	Impact of recalculation on total emissions including LULUCF %	Explanation for recalculations
A. Forestland	*N_2O*	*506.83*	*506.66*	*-0.172*	*-0.034*		*-0.002*	*Recalculations are made due to to improvement of NFI based activity data. Addition 20% of NFI sample plots are surveyed annually, every year acquired cummulative LUC area data is extrapolated to whole country area - recalculations made till all NFI sample plots are suveyed in period of 5 years.*
B. Cropland	*N_2O*	*0.19*	*0.19*	*0.004*	*2.233*		*0.000*	*Recalculations are made due to to improvement of NFI based activity data. Addition 20% of NFI sample plots are surveyed annually, every year acquired cummulative LUC area data is extrapolated to whole country area - recalculations made till all NFI sample plots are suveyed in period of 5 years.*
E. Settlements	*N_2O*	*110.23*	*106.08*	*-4.151*	*-3.766*		*-0.048*	*Recalculations are made due to to improvement of NFI based activity data. Addition 20% of NFI sample plots are surveyed annually, every year acquired cummulative LUC area data is extrapolated to whole country area - recalculations made till all NFI sample plots are suveyed in period of 5 years.*
5. Waste	*N_2O*	*50.04*	*50.03*	*-0.007*	*-0.014*	*0.000*	*0.000*	

GHG SOURCE AND SINK CATEGORIES	Gas	Previous submission (CO_2 eq., kt)	Latest submission (CO_2 eq., kt)	Difference (CO_2 eq., kt)	Difference %	Impact of recalculation on total emissions excluding LULUCF %	Impact of recalculation on total emissions including LULUCF %	Explanation for recalculations
D. Waste water treatment and discharge	*N_2O*	*32.32*	*32.31*	*-0.007*	*-0.021*	*0.000*	*0.000*	*N_2O emissions were recalculated for entire reporting period 1990-2019 due to correction of error in the calculation and correction of AD for year 2000.*
International bunkers	*N_2O*	*100.53*	*100.02*	*-0.511*	*-0.509*	*-0.005*	*-0.006*	
Aviation	*N_2O*	*5.42*	*4.91*	*-0.511*	*-9.430*	*-0.005*	*-0.006*	*Recalculations have been done due to corrected EF of N_2O for LTO (based on analyses of EUROCONTROL data)*

Table 10.3 Recalculations made in 2022 submission (recalculated year 1990)

GHG SOURCE AND SINK CATEGORIES	Gas	Previous submission (CO_2 eq., kt)	Latest submission (CO_2 eq., kt)	Difference (CO_2 eq., kt)	Difference %	Impact of recalculation on total emissions excluding LULUCF %	Impact of recalculation on total emissions including LULUCF %	Explanation for recalculations
1. Energy	*CO_2*	*18644.96*	*18644.91*	*-0.048*	*0.000*	*0.000*	*0.000*	
A. Fuel combustion activities	*CO_2*	*18644.94*	*18644.90*	*-0.048*	*0.000*	*0.000*	*0.000*	
3. Transport	*CO_2*	*2940.00*	*2939.95*	*-0.048*	*-0.002*	*0.000*	*0.000*	

GHG SOURCE AND SINK CATEGORIES	Gas	Previous submission (CO_2 eq., kt)	Latest submission (CO_2 eq., kt)	Difference (CO_2 eq., kt)	Difference %	Impact of recalculation on total emissions excluding LULUCF %	Impact of recalculation on total emissions including LULUCF %	Explanation for recalculations
2. Industrial processes and product use	*CO_2*	*651.05*	*651.07*	*0.025*	*0.004*	*0.000*	*0.000*	
D. Non-energy products from fuels and solvent use	*CO_2*	*44.25*	*44.28*	*0.025*	*0.057*	*0.000*	*0.000*	*Recalculation in 2.D.1 Lubricant use was done due to precised Activity data. Since 2022 submission emissions from use of tobacco combustion is calculated for time period 1990 – 2020 therefore recalculation is made for 2.D3 Solvent use.*
4. Land use, land-use change and forestry (net)	*CO_2*	*-13401.94*	*-13401.95*	*-0.015*	*0.000*		*0.000*	
A. Forestland	*CO_2*	*-17561.01*	*-17561.03*	*-0.015*	*0.000*		*0.000*	*Cause of negligible difference comparing to previous submission is rounding of numbers.*
D. Wetlands	*CO_2*	*986.75*	*986.75*	*0.000*	*0.000*		*0.000*	*Cause of negligible difference comparing to previous submission is rounding of numbers.*
E. Settlements	*CO_2*	*25.15*	*25.15*	*0.000*	*0.000*		*0.000*	*Cause of negligible difference comparing to previous submission is rounding of numbers.*
Indirect CO_2	*CO_2*	*40.49*	*40.41*	*-0.079*	*-0.195*	*0.000*	*-0.001*	*Recalculations have been done due to switch from COPERT 5.3 model version to*

GHG SOURCE AND SINK CATEGORIES	Gas	Previous submission (CO_2 eq., kt)	Latest submission (CO_2 eq., kt)	Difference (CO_2 eq., kt)	Difference %	Impact of recalculation on total emissions excluding LULUCF %	Impact of recalculation on total emissions including LULUCF %	Explanation for recalculations
								COPERT 5.5 model version (corrected EF for EU standards (Convention, Euro 1-3).
1. Energy	*CH_4*	*545.76*	*545.54*	*-0.221*	*-0.041*	*-0.001*	*-0.002*	
A. Fuel combustion activities	*CH_4*	*298.18*	*297.96*	*-0.221*	*-0.074*	*-0.001*	*-0.002*	
3. Transport	*CH_4*	*19.85*	*19.62*	*-0.221*	*-1.114*	*-0.001*	*-0.002*	*Recalculations have been done due to switch from COPERT 5.3 model version to COPERT 5.5 model version (corrected EF for EU standards (Convention, Euro 1-3).*
4. Land use, land-use change and forestry (net)	*CH_4*	*555.06*	*555.06*	*0.000*	*0.000*		*0.000*	
D. Wetlands	*CH_4*	*46.00*	*46.00*	*0.000*	*0.000*		*0.000*	*Cause of negligible difference comparing to previous submission is rounding of numbers.*
1. Energy	*N_2O*	*304.61*	*303.93*	*-0.676*	*-0.222*	*-0.003*	*-0.005*	

GHG SOURCE AND SINK CATEGORIES	Gas	Previous submission (CO_2 eq., kt)	Latest submission (CO_2 eq., kt)	Difference (CO_2 eq., kt)	Difference %	Impact of recalculation on total emissions excluding LULUCF %	Impact of recalculation on total emissions including LULUCF %	Explanation for recalculations
A. Fuel combustion activities	*N_2O*	*304.61*	*303.93*	*-0.676*	*-0.222*	*-0.003*	*-0.005*	
3. Transport	*N_2O*	*81.50*	*80.82*	*-0.676*	*-0.829*	*-0.003*	*-0.005*	*Recalculations have been done due to switch from COPERT 5.3 model version to COPERT 5.5 model version (corrected EF for EU standards (Convention, Euro 1-3).*
3. Agriculture	*N_2O*	*2208.63*	*2209.60*	*0.973*	*0.044*	*0.004*	*0.007*	
B. Manure management	*N_2O*	*281.86*	*282.83*	*0.973*	*0.345*	*0.004*	*0.007*	*Recalculation is done for indirect emission of N_2O to ensure consistency between GHG and air pollution inventories.*
5. Waste	*N_2O*	*64.70*	*64.70*	*0.000*	*-0.001*	*0.000*	*0.000*	
D. Waste water treatment and discharge	*N_2O*	*52.76*	*52.75*	*0.000*	*-0.001*	*0.000*	*0.000*	*N_2O emissions were recalculated for entire reporting period 1990-2019 due to correction of error in the calculation and correction of AD for year 2000.*

Table 10.4 Recalculations made in 2022 submission (F-gases) (recalculated year 2019)

GHG SOURCE AND SINK CATEGORIES	Gas	Previous submission (CO_2 eq., kt)	Latest submission (CO_2 eq., kt)	Difference (CO_2 eq., kt)	Difference %	Impact of recalculation on total emissions excluding LULUCF %	Impact of recalculation on total emissions including LULUCF %	Explanation for recalculations
F-gases: Total actual Emissions	*HFCs*	*255.04*	*255.11*	*0.064*	*0.025*	*0.001*	*0.001*	
2.F.1. Refrigeration and air conditioning	*HFCs*	*249.75*	*249.82*	*0.064*	*0.026*	*0.001*	*0.001*	*Recalculations were done due to precised Activity data*

10.1.2 KP-LULUCF inventory

Recalculations are done due to continuous improvement of activity data.

10.2 *IMPLICATION FOR EMISSION LEVELS*

10.2.1 GHG inventory

See section 10.1.

10.2.2 KP-LULUCF inventory

For the period of 1990-2013, recalculation resulted in negligible (<0.5%) changes in total cumulative net removals in the KP-LULUCF inventory. For the period of 2014-2018, recalculation reduced total cumulative net removals in the KP-LULUCF inventory by average 36.9 kt CO_2 eq. (3.0%) annually. For 2019, recalculation increased total cumulative net removals in the KP-LULUCF inventory by 45.7 kt CO_2 eq. (2.1%). Recalculation is made due to implementation of improved NFI based activity data. Addition 20% of NFI sample plots are surveyed annually, every year acquired cumulative land use change area data is extrapolated to whole country area - recalculations made till all NFI sample plots are surveyed in period of 5 years.

10.3 *IMPLICATIONS FOR EMISSION TRENDS, INCLUDING TIME SERIES' CONSISTENCY*

10.3.1 GHG inventory

See section 10.1.

10.3.2 KP-LULUCF inventory

See section 10.1

10.4 *RECALCULATIONS, INCLUDING IN RESPONSE TO THE REVIEW PROCESS, AND PLANNED IMPROVEMENTS TO THE INVENTORY*

10.4.1 GHG inventory

The development of the GHG inventory aims to improve the calculation and reporting of the inventory. The improvement plan is discussed and approved by all experts and organizations involved in GHG inventory preparation process.

Table 10.5 shows the sector specific improvements planned for the forthcoming GHG inventories. More detailed information about planned improvements are described under sectoral chapters.

Table 10.5 Sector specific planned improvements for Latvia`s national GHG inventory

CRF category	Planned improvement	Tentative submission
LULUCF 4.A Forest land	*Implementation of improved quantitative results of Yasso07 model in calculation of CSCs in soil, dead wood and litter.*	*2023-2025*

CRF category	Planned improvement	Tentative submission
LULUCF 4.A.2 Land converted to forest land	*Improvement of methodology for estimating CSC in living biomass, deadwood and litter for cropland converted to forest land, wetlands converted to forest land and settlements converted to forest land as well as in mineral soils (cropland converted to forest land and settlements converted to forest land) and organic soils (wetlands converted to forest land), and report the estimates in the annual submission.*	*2023-2025*
LULUCF 4.B Cropland	*Implementation of improved quantitative results of Yasso modelling to characterize carbon stock changes in mineral soils (added value - biomass expansion factors for typical farm crops and management systems)*	*2023-2025*
LULUCF 4.B Cropland	*Elaboration of climate, moisture regime and soil fertility driven modelling solution and activity data for organic soil in cropland based on LIFE OrgBalt project results.*	*Since 2025*
LULUCF 4.C Grassland	*Implementation of improved quantitative results of Yasso modelling to characterize carbon stock changes in mineral soils (added value - biomass expansion factors and carbon input data for typical management systems)*	*2023-2025*
LULUCF 4.C Grassland	*Elaboration of model based estimates of GHG emissions and activity data for organic soil in grassland based on LIFE OrgBalt project results.*	*Since 2025*
LULUCF 4.D Wetlands	*Implementation of emissions factors for* N_2O*,* CH_4 *and* CO_2 *for rewetted areas, peatland managed as berry plantations as well as for wetlands converted to cropland, grassland, forest land after peat extraction.*	*Since 2023*
LULUCF 4.D Wetlands	*Implementation of carbon losses due to wind erosion in characterization of GHG emissions in peat extraction fields*	*Since 2025*

In Table 10.6 is summarised Latvia's responses on recommendations of UNFCCC Review Report of 2020[281] because Latvia did not have UNFCCC Review in 2021. Most of recommendations are already implemented in 2021 GHG inventory.

[281] *Report on the individual review of the annual submission of Latvia submitted in 2020. Available: https://unfccc.int/documents/268744*

Table 10.6 Responses to the centralized UNFCCC review process

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	LV Response (status of implementation)	Chapter/Section in the NIR
Key category analysis	Provide in the NIR a short description of the differences between the categories used for the key category analysis and the categories in the CRF tables that better reflect national circumstances, similar to the description provided during the review.	G.1	Additional information is included in NIR.	NIR Chapter 1.5.1.
Uncertainty analysis	Include a quantitative uncertainty assessment for the base year in the NIR.	G.3	Information is included in NIR and NIR Annexes A.2.1 and A.2.2.	NIR Chapter 1.6.1
National system	Improve the description of the national system and the roles and responsibilities of each organisation, including to provide further details on the responsibilities of the natural gas transmission, storage and distribution enterprises, to clarify that their responsibilities comprise data gathering, emission estimation, national model development, QAQC and verification, in order to improve the transparency of the submission.	G.5	Additional information and improved description is included in the NIR.	NIR Chapter 1.2.1, 1.2.2 and 1.4.1, Table 1.1, Table 1.3
National system	Review and where necessary strengthen the institutional, legal and procedural national system arrangements where data collection and estimations is carried out by organisations other than the inventory agency, such as for cement operators and natural gas transmission, storage and distribution enterprises, to collect sufficient additional information to ensure the quality of the Inventory per paragraph 7 of 19/CMP.1, including information required by paragraph 50(a) of the UNFCCC Annex I inventory reporting guidelines.	G.6	Additional information is included in the NIR.	NIR Chapter 1.2.3.1, 1.4.1. Table 1.3, Chapter 3.2.3, Chapter 4.2.2.4

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	LV Response (status of implementation)	Chapter/Section in the NIR
Uncertainty analysis	Correct the errors in the uncertainty values for the CO_2 EF for gaseous fuels for subcategory 1.A.4.c agriculture/forestry/fishing, and for the CO_2 and CH_4 EFs for subcategories 1.B.2.b natural gas and 1.B.2.c venting and flaring with the aim to improve the accuracy of the overall uncertainty assessment in the next annual submission. Include in the NIR the valid uncertainty values applied in the analysis, including the explanations provided to the ERT during the review and justifications for: (1) the high uncertainty estimate for 3.H urea application in 1990, (2) the higher uncertainty value for AD of fuels used in aviation and shipping in 1990 compared to the latest year, and (3) the variable AD uncertainty for N_2O in 5.D.2 industrial wastewater across the time series.	G.7	Additional information is included in NIR.	NIR Chapter 3.2.6.1, 5.7 and 7.5.2.3
Feedstocks, reductants and other non-energy use of fuels – all fuels – CO_2	Recalculate excluded C under reference approach in accordance with the 2006 IPCC Guidelines (vol. 2, chap. 6.6, equation 6.4) for the entire time series (the EFs for lubricants and coke were not consistent with the 2006 IPCC Guidelines and the excluded C for bitumen and other oil was reported as "NO").	E.5	Information is included in NIR.	NIR Chapter 3.2.3
1.A.1 Energy industries – Biomass CO_2	Provide information on the difference in the CO_2 EF for landfill gas and sludge gas between the IPCC default value and the value used by Latvia, or use the default CO_2 EF for these gases.	E.7	CO_2 emissions from biogas recalculated using IPCC 2006 default values	NIR Chapter 3.2.4.2, 3.2.5.2 and 3.2.7.2 Methodological issues
1.A.1.a Public electricity and heat production – solid fuels CO_2	Apply country-specific EFs for the whole time series.	E.8	CO_2 emissions from coal recalculated for all time series	NIR Chapter 3.2.4.2, 3.2.5.2, 3.2.7.2 Methodological issues

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	LV Response (status of implementation)	Chapter/Section in the NIR
1.B.2.b Natural gas – gaseous fuels - CH_4	Aggregate detailed individual data and present them in the NIR so as to highlight the information that is important for the transparency of the inventory without disclosing individual data that would compromise confidentiality.	E.10	Available individual data and information for 1.B.2.b Natural gas – gaseous fuels CH_4 emission estimations have been presented in NIR. The methodology used for emission calculations by natural gas companies is available to ERT after request.	NIR Chapter 3.3.2 Fugitive emissions from natural gas (CRF 1.B.2.b, CRF 1.B.2.c, CRF 1.B.2.d)
1.B.2.b Natural gas – geseous fuels - CH_4	Describe methods and data used in the NIR, including more detailed background information, such as on the length of the pipeline and the materials used for the distribution network, on the pressure conditions of the different parts of the network, on flow rates and on annual reconstruction rates to explain the improvements made to the network.	E.11	The information on relevant parameters, such as the materials used for the distribution network, the pressure conditions of the different parts of the network, gas flow rates are mentioned in NIR subchapter 3.3.2.1 Category description. The methodology used for emission calculations by natural gas companies is available to ERT after request.	NIR Chapter 3.3.2 Fugitive emissions from natural gas (CRF 1.B.2.b, CRF 1.B.2.c, CRF 1.B.2.d)
1.B.2.b Natural gas – gaseous fuels - CH_4	Obtain information on how the data provider generated the AD and CH_4 emissions and if necessary, conduct QA/QC procedures as described in the 2006 IPCC Guidelines (volume 2, chapter 4.2.3).	E.12	Additional QA/QC procedures are done using Tier 1 in NIR Chapter 3.3.2.4. Calculations are available to ERT after request.	NIR Chapter 3.3.2.4
Fuel combustion – reference approach – gaseous fuels - CO_2	Conduct a research in cooperation with the gas companies and the CSB (institution responsible for the energy balance) to: (a) clarify and document the scope of losses in the natural gas system, and (b) seek to harmonise reporting between the energy balance losses and the gas leakage reported in the GHG inventory, and document in the NIR of the next annual submission all the relevant findings of the research.	E.13	Information is included in NIR. For transparency purposes of reporting, the statistical differences and losses for the whole time series are presented in Annex A.3.1 of this report.	NIR Chapter 3.2.1.1 and NIR Annex A.3.1
Feedstocks, reductants and other non-energy use of fuels – liquid fuels - CO_2	Improve the data and documentation of lubricant consumption in the NIR and the consistency of reporting of lubricant NEU data across the NIR and CRF tables, including clear documentation of lubricant consumption in road transportation engines and resulting CO_2 emissions, and in inter-product	E.14	Additional explanations for the calculation and reporting of emissions from the consumption of lubricant in the transport sector are given in the NIR.	NIR Chapter 3.2.6.1.2 Road transport (CRF 1.A.3.b) and 3.2.3 Feedstocks and

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	LV Response (status of implementation)	Chapter/Section in the NIR
	transfers, to improve the transparency of future annual submissions.			non-energy use of fuels (CRF 1AD)
Feedstocks, reductants and other non-energy use of fuels – liquid fuels - CO_2	Investigate the scope of other oil data reported in the inventory, for example by consulting with CSB, clearly document the scope of fuels that are included within the other oil AD in the NIR, present disaggregated AD for all fuels reported under other oil across the time series, and provide consistent AD in the NIR and CRF tables according to the definition of the fuel types used in the 2006 IPCC Guidelines (vol.2, ch. 1, table 1.1, pp.1.12–1.16).	E.15	Information is included in NIR Chapter 3.2.3.2 and Table 3.14	NIR Chapter 3.2.3 Feedstocks and non-energy use of fuels (CRF 1.AD)
1.A.3.e.i Pipeline transport – all fuels - CO_2, CH_4 and N_2O	Revise the notation key used for liquid, solid and other fossil fuels, and biomass from "IE" to "NO" for the complete time series and report CO_2, CH_4 and N_2O emissions from natural gas under 1.A.3.e.i pipeline transport in the CRF table 1.A(a) (sheet 3) for the complete time series and provide in the NIR the relevant documentation on method, AD and EFs used in the estimates.	E.16	Notation key has changed to "NO" in CRF after consulation with CSB and natural gas provider comapny.	-
1.B.2.b Natural gas – gaseous fuels - CH_4	Provide in the NIR a time series of CH4 emission estimates for subcategories 1.B.2.b.4 transmission and storage and 1.B.2.b.5 distribution using the tier 1 method and default EFs presented in the 2006 IPCC Guidelines (vol. 2, ch. 4, p.4.41 and p.4.49, respectively) and provide information on the verification results and explanations of differences between tier 3 and tier 1 emission estimates in accordance with paragraph 41 of the UNFCCC Annex I inventory reporting guidelines.	E.17	Additional QA/QC procedures are done using Tier 1 in NIR Chapter 3.3.2.4. Calculations are available to ERT after request.	NIR Chapter 3.3.2.4

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	LV Response (status of implementation)	Chapter/Section in the NIR
1.B.2.b Natural gas – gaseous fuels - CO_2 and CH_4	Provide in the NIR detailed description of the methodology that the gas companies use for estimating fugitive CO_2 and CH_4 emissions for sub-category 1.B.2.b.6 other and provide clear explanations on the reported trend of emissions across the time series.	E.18	The methodology used for emission calculations by natural gas companies is available to ERT after request.	NIR Chapter 3.3.2 Fugitive emissions from natural gas (CRF 1.B.2.b, CRF 1.B.2.c, CRF 1.B.2.d)
2. General (IPPU)	Implement the planned improvement to undertake capacity-building projects to achieve better time-series consistency for several categories in the early years of the time series.	I.1	Detailed information about project implementation is included in NIR Chapter 4.1	NIR Chapter 4.1
2.A.2 Lime production – CO_2	Update the text in the NIR to reflect the revised EF calculation and AD for CO_2 emissions from lime production.	I.3	Additional information about revised EF and AD is included in NIR Chapter 4.2.3.2.	NIR Chapter 4.2.3.2
2.F.1 Refrigeration and air conditioning – HFCs	Provide an estimation of HFC emissions related to the management of refrigerant containers.	I.7	Additional paragraph and information about the management of refrigerant containers is included in NIR Chapter 4.7.1.1.	NIR Chapter 4.7.1.1
2.F.1 Refrigeration and air conditioning – HFCs	Include in its NIR detailed information on the methodology, assumptions, AD and EFs used for the estimation of HFC emissions from disposal of equipment for the subcategories 2.F.1.a commercial refrigeration, 2.F.1.c industrial refrigeration and 2.F.1.f stationary air conditioning, together with clear explanations on the use of notation keys for relevant years of the time series.	I.8	Detailed information on the methodology, assumptions, AD and EFs used for the estimation of HFC emissions from disposal of equipment, together with clear explanations on the use of notation keys is included in NIR	Across all NIR Chapter 4.7.1.
3.D.b.2 N leaching and run-off – N_2O	Provide in the NIR more information on the choice of a country-specific FracLEACH-(H) based on the results of agricultural run-off monitoring by Sudars et al. (2016), to improve transparency.	A.8	Recommendation has been implemented. Explanation is included in NIR Chapter 5.4.2 subchapter Nitrogen leaching and run-off: CRF 3.D 2.2.	NIR Chapter 5.4.2
3.A.1 Cattle – CH_4	Include in the NIR (or in an annex to the NIR), information on GE values for the whole timeseries for all subcategories of cattle.	A.9	Information is included in chapter 5.2.2.2. Table 5. 11. and 5.12. Table 5.12 includes details that are the same for each year.	Chapter 5.2.2.2.

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	LV Response (status of implementation)	Chapter/Section in the NIR
3.B Manure management – CH_4	Report information on the nature of the biogas plants in the NIR, including documentation on the fact that the residence time of the manure is short (daily emptying) and further documentation of the leakage assumed from the plants using references that are available to be reviewed as part of the next annual submission.	A.10	Detailed information and assumptions are included in the NIR, including references.	Chapter 5.3.2.1.
3.B Manure management – CH_4 and N_2O	Expand on the information provided in the NIR on how the MMS distribution has been derived for the time series, including what changes have been made compared to the cited paper by Priekulis and Aboltins, considering that Latvia has reported the same MMS distribution for 2013 in the CRF tables since 2016 without changes and that these values differ from the cited paper. Further, for each animal category or subcategory, as appropriate, provide information on the grazing days including references for the used values.	A.11	Recommendation has been implemented. NIR chapter 5.3.2.1 is supplemented by additional information and references about necessary information. References include normative documents and document with research outcome about grazing days.	Chapter 5.3.2.1
3.B.1 Cattle – CH_4 and N_2O	In the NIR of the next annual submission clarify if deep bedding is used in the cattle production and to what extent, and consider the possible use of deep bedding in the emission estimates of CH_4 and N_2O, considering the different default MCF and EFs compared to solid storage of manure.	A.12	Additional information is included in the NIR Chapter 5.3.2.1.	Chapter 5.3.2.1.
3.B.3 Swine – CH_4	Provide in the NIR the additional references and explanation provided to the ERT on the most accurate values of DE under Latvian conditions.	A.13	Additional information is included in the NIR Chapter 5.3.2.1.	Chapter 5.3.2.1.
3.D.a.4 Crop residues – N_2O	Include in the NIR information on which values used in the estimation of N_2O emissions from crop residues are country-specific and which are default values, and provide more information on the referenced national study, specifically on the different value for RAG compared to the value in the 2006 IPCC Guidelines.	A.14	Information on which values used in the estimation of N_2O emissions from crop residues are country-specific and which are default values are included in Table 5.33. Regarding to RAG reference to Project Report	Chapter 5.4.2

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	LV Response (status of implementation)	Chapter/Section in the NIR
			No. S293. Setting maximum levels for fertilizers for crops is included.	
3.D.a.6 Cultivation of organic soils (i.e. histosols) – N_2O	Expand the documentation in the NIR by including the explanations provided to the ERT on why changes (recalculations) in the area of organic soils can be expected to occur regularly, based on the results from the NFI.	A.15	Activity data recalculations are adopted from LULUCF sector. Documentations is included in LULUCF sector.	Chapter 6.5; 6.6
4. General (LULUCF)	Eliminate the inconsistencies between NIR tables 6.8 and 6.9 and CRF table 4.A for 1990, the inconsistent reporting of the area of organic soils for cropland and grassland within the CRF tables, and the errors in the EF used for estimating emissions from organic soils on grassland converted to cropland and the CO_2 emissions from biomass burning, and strengthen its QA/QC procedures to avoid such errors.	L.1	The inconsistencies between NIR tables 6.8 and 6.9 and CRF table 4.A for 1990 were eliminated. The inconsistent reporting of organic soils area among CRF tables 4.B and 4.C was corrected. The errors in the EF used for estimating emissions from organic soils on grassland converted to cropland and in the CO_2 emissions from biomass burning was corrected. QA/QC procedures have been established and implemented. Manual data checks have been introduced to compare figures imported into the CRF reporter and the actually calculated values. The mathematical errors identified during the previous review are corrected in the Emissions Projections and Inventory Model (EPIM) used for calculation of GHG emissions for the LULUCF sector and this information was provided in the NIR.	NIR Chapter 6.2, 6.5.2.2, 6.10.2
4. General (LULUCF) – CO_2	Implement the model in a consistent manner for the mineral soils pool for the forest land, cropland and grassland categories, paying particular attention to the balanced estimation of CSC during conversion.	L.2	Latest findings of studies that there is no significant difference between C stock in grasslands and croplands and between forest lands and grasslands are implemented in the GHG inventory:	NIR Chapter 6.1, 6.4.1, 6.5.1, 6.6.1

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	LV Response (status of implementation)	Chapter/Section in the NIR
			Lazdins, A., Bardule, A., Butlers, A. 2015. Preliminary results of comparison of carbon stock in soil in grassland, cropland and forest land. Adaptation and Mitigation: Strategies for Management of Forest Ecosystems, 54–57. Bardule A., Lupikis A., Butlers A., Lazdins A. 2017. Organic carbon stock in different types of mineral soils in cropland and grassland in Latvia. Zemdirbyste-Agriculture, 104(1), 3–8, DOI: 10.13080/z-a.2017.104.001	
4.A.1 Forest land remaining forest land – N_2O	Include in its NIR the justification for why its country-specific value (0.52 t C/ha) is much lower than that in the Wetlands Supplement (2.6 t C/ha).	L.4	Detailed justification was included in the NIR.	NIR Chapter 6.4.2.1
4.A.2 Land converted to forest land – CO_2	Provide in the NIR the following information to support the use of a 150-year transition period: progress on, or results of, the implementation of the Yasso model for afforestation to evaluate actual CSC in deadwood and soils on afforested land (the model has already been implemented for cropland, grassland and forest land).	L.6	Detailed information on progress of implementation of model is provided in the NIR.	NIR Chapter 6.4.1, 6.4.2.2
4.A.2 Land converted to forest land – CO_2	Continue the methodological work for estimating CSC in living biomass, deadwood and litter for cropland converted to forest land, wetlands converted to forest land and settlements converted to forest land as well as in mineral soils (cropland converted to forest land and settlements converted to forest land) and organic soils (wetlands converted to forest land), and report the estimates in the annual submission.	L.7	Detailed information on progress of methodological work is provided in the NIR Chapter 6.4.2.2.	NIR Chapter 6.4.2.2
4.B Cropland – CO_2 and CH_4	Include in the NIR an explanation for the specific area reported in CRF table 4(II).	L.8	Explanation for the specific area reported in CRF table 4(II) was include in the NIR Chapter 6.5.2.1.	NIR Chapter 6.5.2.1

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	LV Response (status of implementation)	Chapter/Section in the NIR
4.B.2.2 Grassland converted to cropland – CO_2	Use the country-specific factors for the GHG inventory to estimate CSC in the living biomass pool for this category as soon as they are available and provide detailed information on this in the NIR.	L.10	CSC in living biomass due to Grassland converted to Cropland is not a key category and is estimated by Tier 1 method.	NIR Chapter 6.5.2.2
4.C.2 Land converted to grassland – CO_2	Continue the methodological work for estimating CSC in living biomass, deadwood and litter for forest land converted to grassland, wetlands converted to grassland and settlements converted to grassland as well as in mineral soils (forest land converted to grassland and settlements converted to grassland) and organic soils (wetlands converted to grassland), and report the estimates in the annual submission.	L.11	Tier 1 method is implemented for category previously reported as NE.	NIR Chapter 6.6.2.2
4.E.2 Land converted to settlements – CO_2	Continue the methodological work for estimating CSC in living biomass and dead organic matter for cropland converted to settlements and grassland converted to settlements and report the estimates in the annual submission.	L.12	Tier 1 method is implemented for category previously reported as NE.	NIR Chapter 6.8.2.2
4(V) Biomass burning – CO_2, CH_4 and N_2O	Include information in the NIR justifying the basis for the reported ratios of harvesting residues affected by burning.	L.13	Detailed information is included in the NIR Chapter 6.10.2.3.	NIR Chapter 6.10.2.3
Land representation	Look into the use of the freely available Sentinel and other free satellite data streams (for example from the Copernicus program), which can provide high quality and high-resolution satellite data time series from which the AD estimation can greatly benefit, accompanied by indeed the NFI data. This will allow for consistency in the data series as well as to increase transparency in this rather complex methodology of merging NFI and land parcel information system data.	L.14	Sentinel II data are already used for interpolation of periodic land use change data in areas, where LPIS data are not available. However, due to rather low resolution of the Sentinel II in comparison to average area of NFI sectors where land use is changed and additional complexity due to cloudy conditions, possibility to use Sentinel II as a comprehensive solution is limited.	-
5.A Solid waste disposal on land – CH_4	Provide justification in the NIR and the CRF tables for reporting that there is no significant underestimation of emissions resulting from Latvia's use of solid waste disposal data from 1970, using as a proxy for this	W.1	Recalculation is done. Time series for waste disposal is prolonged till 1950. Explanation is included in NIR.	NIR chapter 7.2.1

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	LV Response (status of implementation)	Chapter/Section in the NIR
	significance determination the values contained in decision 24/CP.19, annex I, paragraph 37(b).			
5.A.2 Unmanaged waste disposal sites – CH_4	Correct the description in its NIR of the default oxidation factor of 0.09 (removing "default") and provide information on how the oxidation factor of 0.09 is calculated using assumptions and relevant information, including the national research.	W.3	Oxidation factor 0.09 is used, because almost all old unmanaged SWDS in Latvia are covered by a soil layer and that it applied the default oxidation factor, 0.1, to them. Based on national research, Latvia assumes 10% of old unmanaged SWDS are not covered by soils. To include this aspect in emissions calculations the oxidation factor is used as 0.09 (reduced by 10%). Oxidation factor 0.09 has been used from year 2008, because unmanaged SWDS were covered till year 2007. Description is included in NIR.	NIR Chapter 7.2.1
5.C.1 Waste incineration – CH_4	Estimate the CH_4 emissions using the CH_4 EF for fuel combustion in accordance with the 2006 IPCC Guidelines.	W.4	Raw estimation of CH_4 emissions from waste incineration is provided in NIR. Emissions are under the threshold of significance therefore in CRF is used notation key "NE" for CH_4 emissions. Detailed description is provided in NIR.	NIR Chapter 7.4.1.2
5.C.2 Open burning of waste – CO_2, CH_4 and N_2O	Investigate the possibility of applying AD from the CLRTAP inventory to estimate GHG emissions from accidental fires for the GHG inventory, or report "NE" with the justification that the emissions from open burning of waste are below the threshold defined in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines.	W.5	Raw estimation of emissions from open burning of waste is provided in NIR. Emissions are under the threshold of significance therefore in CRF is used notation key "NE" for CH_4 emissions. Detailed description is provided in NIR.	NIR Chapter 7.4.2
5.A Solid waste disposal on land – CH_4	Correct the reporting error in CRF table 5.A regarding the methane correction factor value, document the use of the a methane correction factor value of 0.64 in its future annual submissions enhance its QC	W.7	Correction is made in CRF table 5.A and QC procedures are implemented to ensure consistency between CRF and NIR.	-

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	LV Response (status of implementation)	Chapter/Section in the NIR
	procedures in order to ensure consistency of information reported in the NIR and the CRF tables.			
5.A Solid waste disposal on land – CH_4	Take into account changes in waste composition and DOC values as a result of changes in waste management practices, in particular for all years since 2002 and revise accordingly the estimates for this category as part of the planned improvements in its next annual submission.	W.8	This issue was discussed in detail and was concluded that in Latvia waste data collections about disposed waste composition is not implemented as annual reporting therefore we have to use the same waste composition for all time series since 2002, when managed sites starts to operate in Latvia. We are working on improvements to verify waste composition in CH_4 calculations.	-
5.A Solid waste disposal on land – CH_4	Provide clear information in the NIR on measurement methods used to estimate CH_4 recovery by landfill operators, including clearly described and justified all assumptions used in the estimation of the CH_4 recovery in accordance with the 2006 IPCC Guidelines (vol. 5, ch. 3, p.3.19).	W.9	Information is recieved directly from waste polygons operators. CH_4 recovery is estimated based on the monitoring of produced amount of electricity from the gas. All assumptions used in the estimation of the CH_4 recovery are in accordance with the 2006 IPCC Guidelines (vol. 5, ch. 3, p.3.19).	NIR Chapter 7.2.1
5.A Solid waste disposal on land – CH_4	Investigate the occurrence of co-firing of MSW in stationary combustion activities for the period 1970–2001 and report in the NIR on how it avoided the potential for double-counting of CH_4 emissions from waste disposed at SWDS for this period, when it used population as a driver to estimate the amount of MSW disposed. In addition, document in the NIR the assumptions used to account for the portion of MSW sent for combustion in cement production plants and any other stationary combustion activities.	W.10	We had a discussion with sectorial experts and it was concluded that no such activities as co-firing of MSW recognize in stationary combustions for years 1970 - 2001.	-
AR – CO_2	Provide figures in the NIR that demonstrate no statistically significant difference in the carbon stock in	KL.4	No soil carbon stock changes in mineral soils are considered for historical grassland and afforested land according to research data	NIR Chapter 11.3.1

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	LV Response (status of implementation)	Chapter/Section in the NIR
	mineral soils for historical grassland and afforested land.		demonstrating insignificant carbon stock differences in forest land and grassland. In Latvia, insignificant differences in soil carbon stock in mineral soils between grassland and afforested land are confirmed/proved by results of scientific studies, e.g., Kukuļs et al. (2015), Lazdins et al. (2015), Bardule et al. (2017): Kukuļs I., Nikodemus O., Kasparinskis R., Grāvelsiņa S., Prižavoite D. 2015. Carbon accumulation and humification in soils of abandoned former agricultural lands in the hemiboreal zone. Nordic view to sustainable rural development, NJF 25th Congress, 201 – 207. Lazdins, A., Bardule, A., Butlers, A. 2015. Preliminary results of comparison of carbon stock in soil in grassland, cropland and forest land. Adaptation and Mitigation: Strategies for Management of Forest Ecosystems, 54–57. Bardule A., Lupikis A., Butlers A., Lazdins A. 2017. Organic carbon stock in different types of mineral soils in cropland and grassland in Latvia. Zemdirbyste-Agriculture, 104(1), 3–8, DOI: 10.13080/z-a.2017.104.001	
FM – CO_2	Estimate the carbon losses due to harvesting that took place on AR areas and on FM areas separately and report this transparently in the NIR.	KL.7	No harvesting takes place in afforested lands; therefore, no emissions in living biomass due to commercial harvesting are reported in this	NIR Chapter 11.3.1.1

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	LV Response (status of implementation)	Chapter/Section in the NIR
			category. However, if by some reasons (for instance, thinning) harvesting took place on afforested area it is also reported in national statistics and is included in Forest management related carbon stock changes. Therefore, there is no risk of underestimation of emissions from living biomass. Methodology for separation of harvest in different land-use categories is improved. National research study (aimed to determine increment, mortality and harvest rate in Latvia) was published in a peer-reviewed publication (Krumsteds L. L., Lazdins A., Butlers A., and Ivanovs J. 2029. Recalculation of forest increment, mortality and harvest rate in Latvia according to updated land use data. Rural Development 2019 (1): 295–299. DOI:10.15544/RD.2019.037.)	
FM – CO_2	Transparently describe both qualitatively and quantitatively in the NIR the recalculation of forest land estimates in conjunction with technical corrections to the FMRL.	KL.8	Qualitative and quantitate description of technical corrections to the FMRL is provided in the NIR chapter 11.5.2.3.	NIR Chapter 11.5.2.3.
FM – CO_2	More accurately estimate emissions and removals from forest land and FM by including, and where necessary revising, soil and litter estimates, on the basis of the ongoing monitoring of NFI plots.	KL.9	Soil properties (carbon stock in litter and mineral soil) in forest lands was determined in permanent 16 x 16 km grid of 95 sample plots of the 1st level forest monitoring programme. The results of forest soil monitoring demonstrate that mineral soils in forest lands are not a source of emissions. In addition, it is proved by results of studies using Yasso modelling:	NIR Chapter 11.3.1

CRF Category/ Issue	Review Recommendation	Review Report/ Paragraph	LV Response (status of implementation)	Chapter/Section in the NIR
			Bārdulis, A., Lupiķis, A., Stola, J. 2017. Carbon balance in forest mineral soils in Latvia modelled with Yasso07 soil carbon model. Research for Rural Development, 1, 28–34. Lupiķis, A., Lazdiņš, A. 2017. Oglekļa aprite minerālaugsnēs Latvijas mežos: Modelēts ar Yasso07 augsnes oglekļa modeli [Carbon cycling in mineral soils in Latvian forests: modelled using YASSO07 soil carbon model]. Starptautiskā Zinātniski Prakstiskā Konference Zinātne Un Prakse Nozares Attīstībai Mežzinātnes Un Augstākās Mežizsglītības Loma Nozares Konkurētspējas Paaugstināšanā Tēzes, 17. Lupiķis, A. (31.01.2017). Meža zemju augsnes oglekļa aprite modelēta ar Yasso07 augsnes oglekļa modeli [The soil carbon cycling in forest land modelled using the Yasso07 soil carbon model]. Latvijas Universitātes 75. konference, Rīga, Latvija.	
General (KP-LULUCF) – CO_2	Clearly follow the established roadmap with the indicated milestones in order to allow the Party to get accurate results before the end of second commitment period of the Kyoto Protocol.	KL.10	Results of Yasso modelling indicated CO_2 removals in mineral soil in forest land however with high uncertainty, therefore a conservative approach is applied and assumed that mineral soils in forest land are not a source of emissions.	NIR Chapter 11.3.1

PART 2: SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1

11 KP-LULUCF

11.1 *GENERAL INFORMATION*

In this Chapter, Latvia reports supplementary information under Article 7 of the Kyoto Protocol (KP) from the LULUCF activities. Provided information on anthropogenic greenhouse gas emissions by sources and removals by sinks under Article 3, paragraphs 3 and 4 of the Kyoto Protocol is in accordance with the relevant CMP decisions and the 2006 IPCC Guidelines and 2013 IPCC Kyoto Protocol Supplement. Methodologies presented in the IPCC Wetlands Supplement are applied to the purpose to estimate certain emissions and removals for drained organic soils. Under Article 3, paragraph 3, Latvia reports emissions and removals from following activities:

- Afforestation/ Reforestation (AR);
- Deforestation (D).

Under Article 3, paragraph 4, Latvia reports emissions and removals from:

- Forest Management (FM).

Other additional activities under Article 3, paragraph 4, are not elected for the second commitment period (CP), as were not for the first CP. Latvia has elected accounting of each activity under Article 3, paragraphs 3 and 4, for the entire CP. Latvia is not reporting natural disturbances, therefore, accounting of lands reported under natural disturbances is not necessary, neither for AR nor for FM.

In 2020, net annual emissions from FM, AR and D activities were -701.33 kt CO_2 eq. This value is the total of all emissions and removals from activities under Article 3.3 (Figure 11.1 and Figure 11.2) and FM activity under Article 3.4 (Figure 11.3) of the Kyoto Protocol and includes:

- removals from the growth of forest and emissions from the conversion of land to forest after 1989;
- emissions from harvesting of forest remaining forest since 1990;
- emissions and removals from HWP from forest land;
- emissions from deforestation;
- emissions from biomass burning due to natural forest fires and incineration of harvesting residues;
- mineralization of soil nitrogen associated with afforestation or deforestation since 1990;
- and management of organic soils in forest land, afforested or reforested land and deforested land.

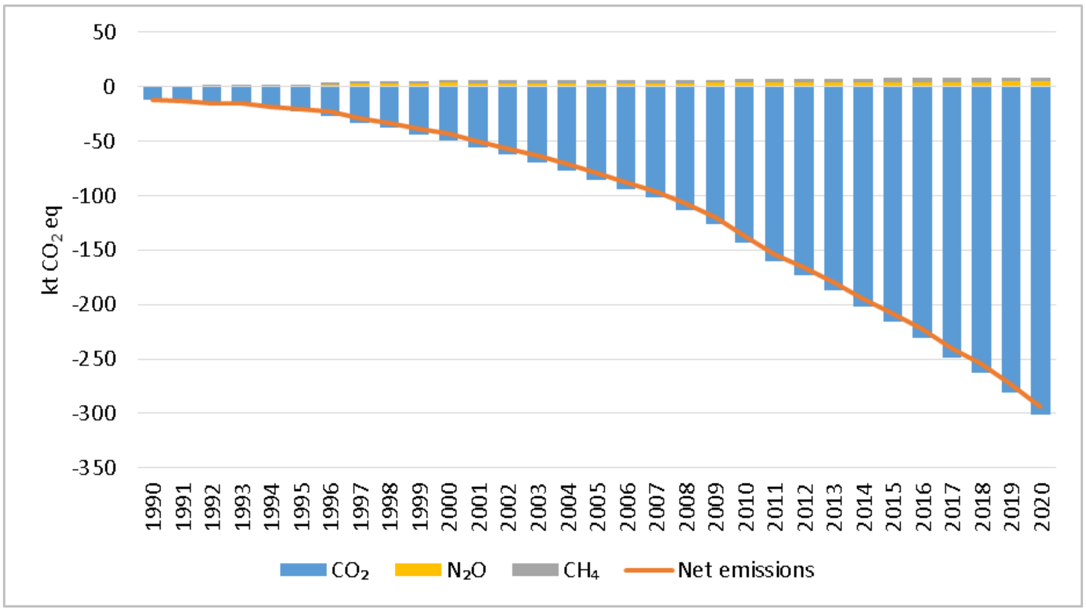

Figure 11.1 GHG emissions due to afforestation (kt CO_2 eq.)

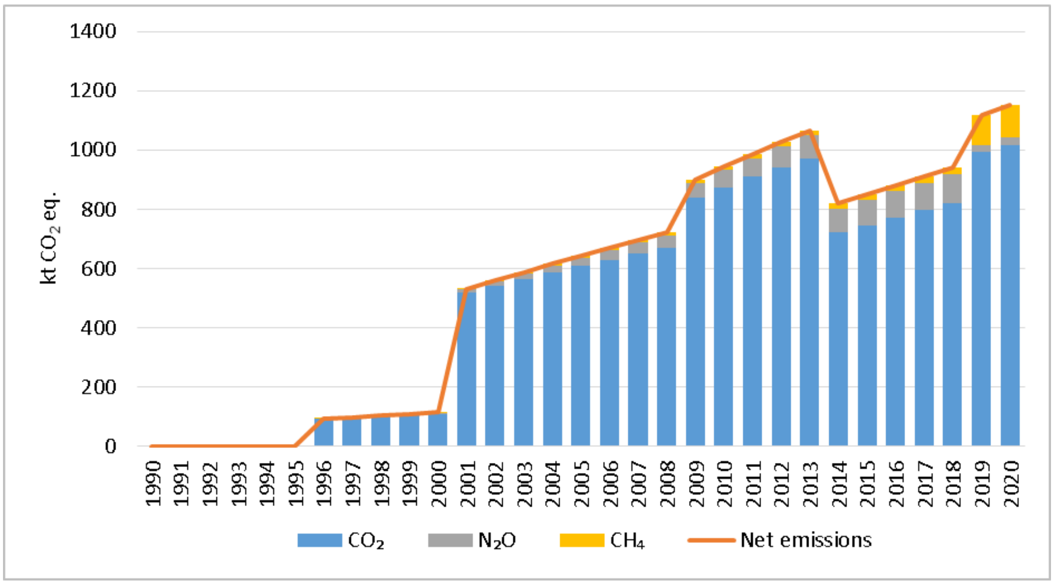

Figure 11.2 GHG emissions due to deforestation (kt CO_2 eq.)

Removals of CO_2 in living biomass is the most significant driver to have negative balance of the net GHG emissions during the reporting period; however, with reduction of CO_2 removals the role of other GHGs increases, particularly, N_2O and CH_4 emissions from organic soil is a key category of emissions (Figure 11.3).

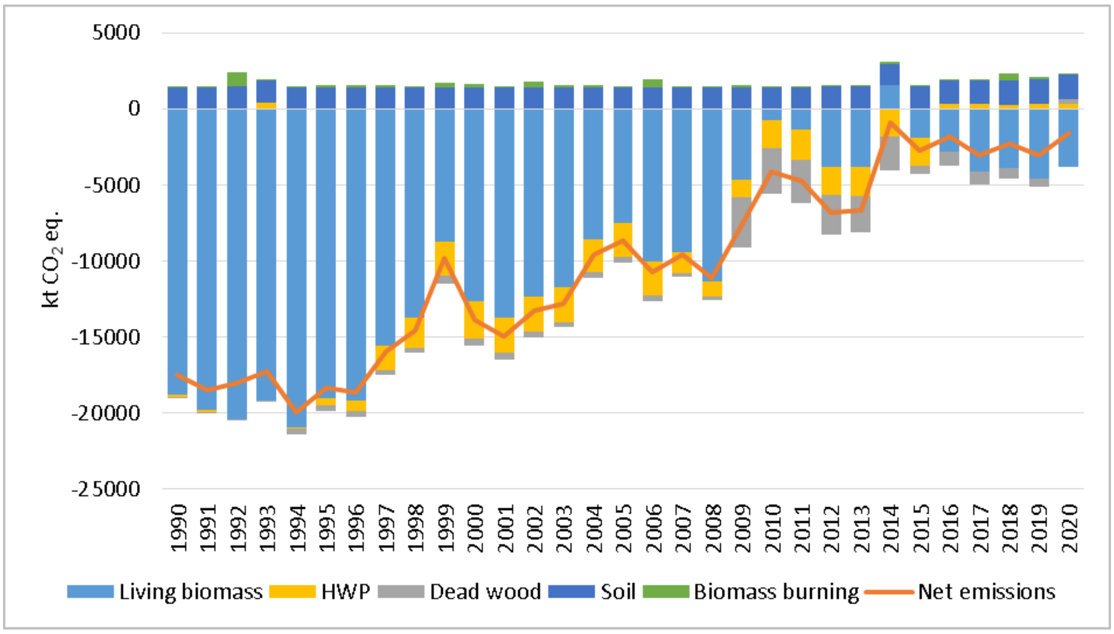

Figure 11.3 GHG emissions due to forest management (kt CO_2 eq.)

Net emissions and removals from Afforestation, Reforestation, Deforestation and Forest Management in 2013 to 2020 are shown in Table 11.1.

Table 11.1 Net emissions and removals from Afforestation, Reforestation, Deforestation and Forest Management in 2013 to 2020

Article 3, paragraphs 3 and 4	Gas, kt CO_2 eq.	Year							
		2013	2014	2015	2016	2017	2018	2019	2020
AR	CO_2	*-187.51*	*-201.83*	*-216.31*	*-230.59*	*-248.61*	*-262.56*	*-281.29*	*-301.45*
	CH_4	*4.33*	*4.33*	*4.36*	*4.40*	*4.45*	*4.50*	*4.55*	*4.63*
	N_2O	*3.38*	*3.38*	*3.40*	*3.44*	*3.48*	*3.51*	*3.58*	*3.58*
	Total	*-179.80*	*-194.12*	*-208.55*	*-222.75*	*-240.68*	*-254.55*	*-273.17*	*-293.25*
D	CO_2	*972.73*	*721.25*	*746.27*	*771.27*	*796.37*	*821.14*	*991.68*	*1017.35*
	CH_4	*17.45*	*18.47*	*19.49*	*20.51*	*21.53*	*22.55*	*23.85*	*25.15*
	N_2O	*76.22*	*80.51*	*84.81*	*89.08*	*93.34*	*97.61*	*103.11*	*108.17*
	Total	*1066.40*	*820.24*	*850.57*	*880.85*	*911.24*	*941.29*	*1118.63*	*1150.67*
FM	CO_2	*-7325.69*	*-1661.03*	*-3479.63*	*-2619.25*	*-3891.91*	*-3200.18*	*-3946.42*	*-2434.00*
	CH_4	*171.00*	*211.72*	*246.57*	*283.77*	*319.19*	*392.61*	*374.19*	*377.68*
	N_2O	*529.73*	*510.84*	*510.01*	*509.45*	*508.69*	*512.38*	*502.29*	*497.57*
	Total	*-6624.96*	*-938.46*	*-2723.06*	*-1826.03*	*-3064.03*	*-2295.19*	*-3069.94*	*-1558.75*
Total	Total	*-5738.35*	*-312.34*	*-2081.04*	*-1167.92*	*-2393.47*	*-1608.45*	*-2224.47*	*-701.33*

11.1.1 Definition of forest and any other criteria

Under the KP, Latvia has defined forest as land with a tree crown cover of 20 %, a minimum area of 0.1 ha and minimum height 5 m.

The applied forest definition for the reporting under KP is harmonized with the definition used within the NFI as well as in relevant chapters of the UNFCCC LULUCF reporting (Chapter 6.2).

The selected parameters are presented in Table 11.2. Additional criteria defined by the Law on Forests of Latvia[282] are width of rows of trees of artificial or natural origin – they should be at

[282] *Latvijas Republikas Saeima, 2000. Meža likums (Law on Forests), published in 24.02.2000.*

least 20 m wide to be reported as a forest. The whole country is considered as one sub-division in the reporting.

Table 11.2 Selected parameters defining forest in Latvia for the reporting

Parameter	Range in FAO definition	Value
Minimum land area	*0.05-1 ha*	*0.1 ha*
Minimum crown cover	*10-30 %*	*20 %*
Minimum height	*2-5 m*	*5 m*

Forest roads, cleared tracts, fire-breaks, seed orchards and other forest infrastructure with permanently removed vegetation and/or fertile soil layer are excluded from forest and are accounted under settlements; respectively, building of the forest road or drainage system is accounted as deforestation. Forest definition for the 2nd CP has not been changed since the 1st CP.

There is no official definition of "natural forests" in Latvia and GHG emissions and CO_2 removals are not accounted under separate categories such as "natural forests" or "planted forests". Latvia reports C-stock changes in naturally afforested lands under additional node under FM as explained in chapter 11.1.2.

11.1.2 Elected activities under Article 3, paragraph 4, of the Kyoto Protocol

In the 1st CP under Article 3, paragraph 4, of the Kyoto Protocol Latvia reported net removals from FM. All lands reported under FM in the 1st CP are included in the FM accounting in the 2nd CP, except deforested lands reported under D (Article 3.3 activities of the Kyoto Protocol).

Certain area of afforested lands reported under FM in the 1st CP are moved to AR category due to management activities (thinning, replanting) identified during the recent field visits of NFI teams or due to legal land use change in land register approving purposeful initiative of land owners. The rest of naturally afforested lands are reported as land converted to forest land under the UNFCCC and FM under the KP reporting. Land use changes are determined according to methodology elaborated by Krumsteds et al. (2019)[283].

Additional node "Naturally afforested lands" in CRF for reporting C-stock changes in naturally afforeseted lands have been separated from AR and reported under FM since submission 2019. Afforested lands, where natural forest regeneration methods are applied, active forest management takes place and forest owner completed legal procedure of the land use change, are reported under the Afforestation activity. Activity data for this category is delivered by the SFS (stand wise forest register) and NFI (land use history).

Considering uncertain status of recently afforested areas reported by the NFI (legal land use changes or management activities characteristic for the forest management may follow several years after the land parcel fulfils the threshold values of the forest land criteria), the decisions on reporting of the land as purposefully afforested is done after the first management activity or legal conversion of the area to forest land. Therefore the afforestation rate in recent years is considerably smaller than it is reported by the NFI. The afforestation trend in recent years is also reduced by implementation the rural development plan supporting maintenance of grasslands in temporarily abandoned farmlands instead of their afforestation.

[283] *Krumsteds, L. L., Ivanovs, J., Jansons, J., Lazdiņš, A. 2019. Development of Latvian land use and land use change matrix using geospatial data of National forest inventory. Agronomy Research, 17(6), p. 2295–2305, DOI: 10.15159/AR.19.195.*

Latvia is not reporting natural disturbances; therefore, accounting of lands reported under natural disturbances is not necessary, neither for AR nor for FM.

11.1.3 Description of how the definitions of each activity under Article 3.3 and each mandatory and elected activity under Article 3.4 have been implemented and applied consistently over time

On the basis of the definitions provided in the Decision 19/CMP.1, afforestation and reforestation that take place on agricultural land have to be included in the Article 3.3: a common forest management approach in Latvia is exploitation of natural re-growth by seeds of adjacent trees in forest regeneration and afforestation. In addition these transitions are essentially due to political decisions under the EEC Regulations 2080/92 and 1257/99 (art.10.1 and 31.1). However, only planted trees and managed forest stands, where natural regeneration is applied as the afforestation method, are reported under afforestation. The information is provided by the NFI and SFS. The rest of afforested lands are reported under forest management in the KP reporting.

Concerning deforestation activities, as mentioned above, in Latvia land use changes from forest to other land use categories are allowed in very limited circumstances; however, due to large share of forest lands the most of economic activities associated with building of new infrastructure takes place on forest lands. The most common type of land use change in this reporting is construction of forest roads which is not considered as land use change according to National legislation but from the point of view of emissions it is land use change. Conversion to agricultural land occurs to less extent and generally is associated with removal of woody vegetation from abandoned farmlands and it was more common in 1990s.

Latvia does not apply carbon equivalent forest conversion (CEFC).

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 activities Latvia reports only forest management; respectively, there is no need to build up a hierarchy between forest management and other Article 3.4 activities (i.e. forest has anyway higher hierarchical position in classification of activities on land).

11.2 *LAND-RELATED INFORMATION*

11.2.1 Spatial assessment unit used for determining the area of the units of land under Article 3.3

Latvia implements spatial explicit approach (Reporting approach 3 according to the 2006 IPCC Guidelines Chapter 3.3.1 and Reporting method 1 according to the 2013 IPCC Kyoto Protocol Supplement) in reporting of lands subject to Article 3.3. and Article 3.4 activities. The approach is consistent with calculations of land use changes under the UNFCCC LULUCF reporting. The spatial assessment units for the submission of the Kyoto Protocol and UNFCCC LULUCF reporting cover the entire territory of Latvia. Land use mapping for afforestation, reforestation and deforestation in Latvia starts from 0.1 ha.

11.2.2 Methodology used to develop the land transition matrix

The land use matrix is based on the results of land use changes to forest derived from the NFI of the period 2004-2008, 2009-2013, 2014-2018 and the first two years of 4th NFI cycle. Land use changes are determined according to methodology elaborated by Krumsteds et al. (2019)[284]. Methodology for estimation of earlier land use changes (including deforestation activities) is developed in the LSFRI Silava as a part of the NFI. The assessment methods at the NFI grid points are described below.

Historical figures of deforestation were estimated using remote sensing methods. LANDSAT satellite image series from 1990, 1995 and 2000 were geographically referenced to fit to the actual location of sample plots before satellite image analysis and non-guided classification of vegetation types. The information is updated in the study by Krumsteds et al. (2019)[285].

Cumulative information on area accounted under forest management, deforestation, afforestation and reforestation is provided in Table 11.3.

Table 11.3 Summary of area under forest management, afforestation & reforestation and deforestation accounting (kha)

[7. KP LULUCF][NIR-2]	Remaining afforestation and reforestation	Remaining deforestation	Remaining forest management
1990	*NO*	*NO*	*3155.79*
1991	*17.98*	*NO*	*3159.55*
1992	*19.29*	*NO*	*3159.64*
1993	*20.59*	*NO*	*3159.74*
1994	*21.94*	*NO*	*3159.77*
1995	*23.27*	*NO*	*3159.84*
1996	*24.60*	*NO*	*3158.63*
1997	*30.73*	*1.28*	*3161.15*
1998	*37.95*	*2.56*	*3162.59*
1999	*42.33*	*3.84*	*3166.87*
2000	*47.08*	*5.13*	*3170.78*
2001	*51.30*	*6.41*	*3171.51*
2002	*54.76*	*11.39*	*3168.29*
2003	*56.93*	*16.38*	*3166.35*
2004	*59.60*	*21.36*	*3163.92*
2005	*62.50*	*26.34*	*3161.26*
2006	*65.38*	*31.33*	*3158.61*
2007	*68.21*	*36.31*	*3156.03*
2008	*70.55*	*41.30*	*3153.93*
2009	*74.51*	*46.28*	*3148.74*
2010	*82.11*	*52.72*	*3145.51*
2011	*90.77*	*59.17*	*3141.22*
2012	*99.61*	*65.61*	*3136.75*
2013	*104.89*	*72.05*	*3135.84*
2014	*110.50*	*78.49*	*3137.81*
2015	*112.39*	*81.72*	*3134.60*
2016	*113.72*	*84.95*	*3131.95*
2017	*114.91*	*88.18*	*3129.43*
2018	*116.11*	*91.40*	*3126.91*
2019	*117.31*	*94.63*	*3123.30*
2020	*118.97*	*98.94*	*3119.93*

[284] *Krumsteds, L. L., Ivanovs, J., Jansons, J., Lazdiņš, A. 2019. Development of Latvian land use and land use change matrix using geospatial data of National forest inventory. Agronomy Research, 17(6), p. 2295–2305, DOI: 10.15159/AR.19.195.*
[285] *Krumsteds, L. L., Ivanovs, J., Jansons, J., Lazdiņš, A. 2019. Development of Latvian land use and land use change matrix using geospatial data of National forest inventory. Agronomy Research, 17(6), p. 2295–2305, DOI: 10.15159/AR.19.195.*

11.2.3 Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations

Since the geographical location of NFI sample plots is known, the results can be computed for geographically referenced areas. Geographical locations are identified by the coordinates of centres of the NFI sample plots.

The methodology for reporting is based on the NFI which uses a permanently below ground marked 4 x 4 km grid across all of Latvia with four permanent sample plots of 500 m^2 size at each grid point. Sample plots are split into up to 10 sectors if different land use categories or vegetation type in the same category are presented in a single plot.

In total, 23583 sectors in 16383 sample plots (Figure 11.4) were used for calculations of land use and CSC in living and dead biomass. Number of sectors may change from cycle to cycle, because of land use changes. Borders of sample plots are constant all the time. Each sector in average represents about 400 ha of the country area including internal water bodies.

ARD activities are accounted as long as the forest definition is met (minimum assessment unit 0.1 ha), except AR in extensively managed grassland and cropland, if the trees do not reach at least 2 m height, because growth of trees in such areas usually do not mean afforestation, but delayed grass cutting, as well as AR, if human induced afforestation cannot be approved (the main criteria are planting of trees or other early management activities targeted on increase of growing potential of the forest stand, afforestation is also considered in areas, where legal procedure of land use change is completed).

The sizes of the sub-areas with different land use at the permanent sample plots need to be larger than 1/10 (> 30 m^2) of the total sample plot area to be assessed. If this precondition is met the polygon that divides the different areas of land uses within the sub-plot is measured using polar-coordinates. At a site, sketches are drawn and the polygon data are entered into the geographic information system of the portable input device. If the former border line can be recognized in the follow-up NFI cycle, it is kept.

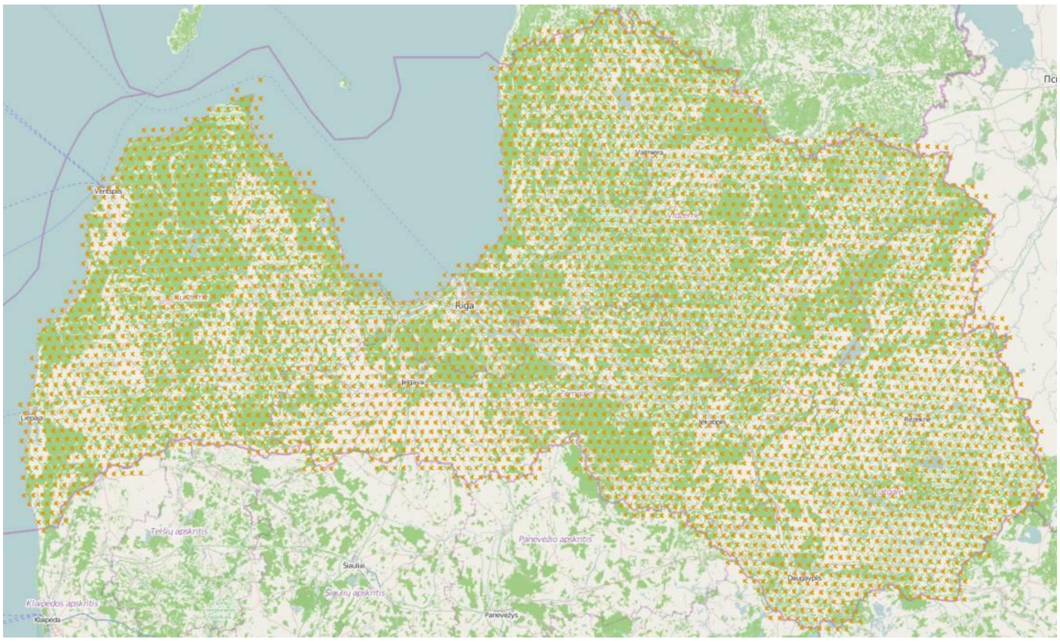

Figure 11.4 Permanent grid of the forest inventory plots

Changes in forest area were detected on the basis of the NFI data. During the 2nd, 3rd and 4th NFI cycle the fact of afforestation and deforestation is fixed by accounting area of sectors, where land use category is changed from one type to another and multiplying by area (in ha) represented by 1 m^2 of sample plots.

The following afforestation/reforestation activities that occurred or could have occurred on or after 1990 are included in the reporting of these activities:

- planted or sown grassland;
- afforested grassland which are converted to forest lands in land registers;
- other afforested lands where forest management activities (like tending and thinning) takes place demonstrating that afforestation is human induced.

In Latvia cropland, grassland, forest land, settlements are considered managed; therefore any land use change occurs between lands, consequently, is direct human-induced. Exception is unmanaged wetlands and other lands, CSC due to conversion to unmanaged wetlands or other lands are not accounted.

Afforested/reforested areas are to be considered legally bound by National legislation. Usually these activities have resulted from a decision to change the land use by planting or seeding or managing of afforested lands.

11.3 *ACTIVITY-SPECIFIC INFORMATION*

11.3.1 Methods for carbon stock change and GHG emission and removal estimates

The NFI of Latvia is the main data provider for the GHG reporting in LULUCF sector and Kyoto protocol Article 3, paragraph 3 and Article 3, paragraph 4 activities. Methods for estimating CSC in forests (for Article 3.3 afforestation, reforestation, deforestation and Article 3.4 forest management) are the same as those used for the UNFCCC LULUCF inventory reporting.

Soil properties (carbon stock in litter and mineral soil) in forest lands was determined in permanent 16 x 16 km grid of 95 sample plots of the 1st level forest monitoring programme (Figure 11.5). The results of forest soil monitoring demonstrate that mineral soils in forest lands are not a source of emissions. In addition, it is proved by results of studies using Yasso modelling (Bārdulis et al., 2017[286]; Lupiķis and Lazdiņš, 2017[287]; Lupiķis, 2017[288]). Results of Yasso modelling indicated CO_2 removals in mineral soil in forest land however with high uncertainty, therefore a conservative approach is applied and assumed that mineral soils in forest land are not a source of emissions.

No soil CSC in mineral soils are considered for historical grassland and afforested lands, according to research data demonstrating insignificant carbon stock differences in mineral soils in forest land and grassland. Insignificant differences in soil carbon stock between grassland

[286] *Bārdulis, A., Lupiķis, A., Stola, J. 2017. Carbon balance in forest mineral soils in Latvia modelled with Yasso07 soil carbon model. Research for Rural Development, 1, 28–34.*

[287] *Lupiķis, A., & Lazdiņš, A. 2017. Oglekļa aprite minerālaugsnēs Latvijas mežos: Modelēts ar Yasso07 augsnes oglekļa modeli [Carbon cycling in mineral soils in Latvian forests: modelled using YASSO07 soil carbon model]. Starptautiskā zinātniski prakstiskā konference Zinātne un prakse nozares attīstībai Mežzinātnes un augstākās mežizsglītības loma nozares konkurētspējas paaugstināšanā tēzes, 17.*

[288] *Lupiķis, A. (31.01.2017). Meža zemju augsnes oglekļa aprite modelēta ar Yasso07 augsnes oglekļa modeli [The soil carbon cycling in forest land modelled using the Yasso07 soil carbon model]. Latvijas Universitātes 75. konference, Rīga, Latvija.*

and afforested land are confirmed by results of scientific studies, e.g., Johnson (1992)[289], Paul et al. (2002)[290], Jandl et al. (2007)[291], Karhu et al. (2011)[292]. In Latvia, insignificant differences in soil carbon stock in mineral soils between grassland and afforested land are confirmed by results of scientific studies, e.g., Kukuļs et al. (2015)[293], Lazdins et al., 2015[294]; Bardule et al. (2017)[295].

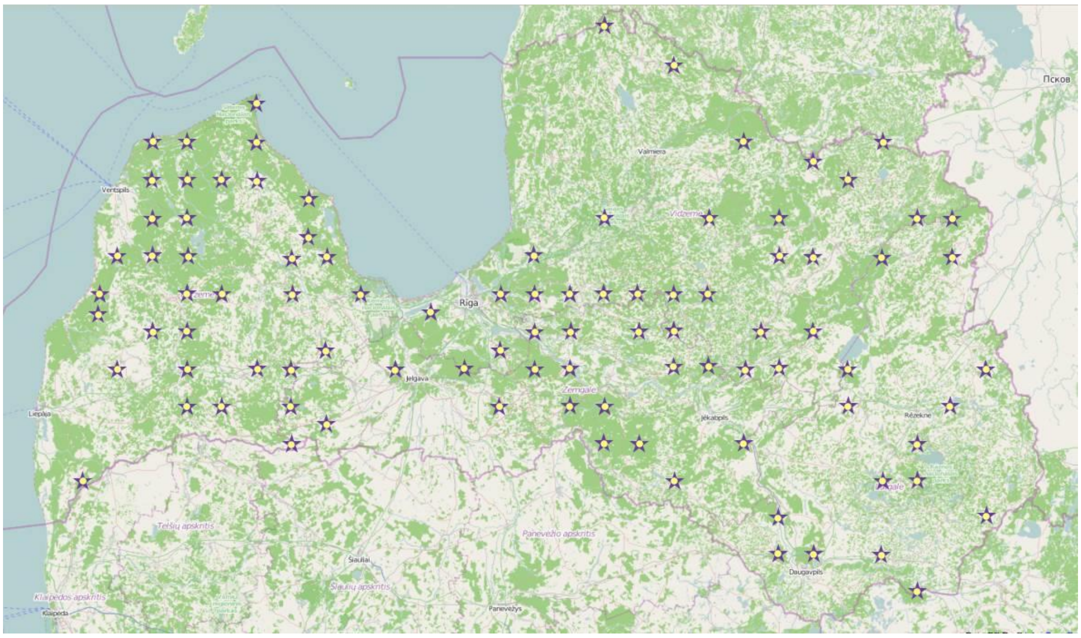

Figure 11.5 Permanent grid of the Level 1 forest monitoring plots

11.3.1.1 Description of the methodologies and the underlying assumptions used

Estimations of CSC in living biomass in forest land remaining forest land in the 1st cycle of the NFI are based on measurements of radial increment of growing trees and calculation of actual potential increment of timber volume of all living trees; in the 2nd, 3rd and 4th cycle, increment is calculated as stock difference of living trees; mortality is accounted as the stock of trees changing status (destiny) from living trees to dead and left in the stand; harvesting stock is accounted as stock of trees changing status (destiny) to dead and extracted. The NFI data are harmonized with the SFS data provided information by application of linear factor (+26%) to the whole accounting period, because the basics of the methodology used for calculation of harvesting stock in SFS is not changed for several decades.

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[289] *Johnson D.W. 1992. Effects of forest management on soil carbon storage. Water. Air. Soil Pollut. 64, 83–120, DOI: 10.1007/BF00477097*

[290] *Paul K.I., Polglase P.J., Nyakuengama J.G., Khanna P.K. 2002. Change in soil carbon following afforestation. For. Ecol. Manag. 168, 241–257, DOI: 10.1016/S0378-1127(01)00740-X*

[291] *Jandl R., Lindner M., Vesterdal L., Bauwens B., Baritz R., Hagedorn F., Johnson D.W., Minkkinen K., Byrne K.A. 2007. How strongly can forest management influence soil carbon sequestration?*

[292] *Karhu K., Wall A., Vanhala P., Liski J., Esala M., Regina K. 2011. Effects of afforestation and deforestation on boreal soil carbon stocks—Comparison of measured C stocks with Yasso07 model results. Geoderma 164, 33–45, DOI: 10.1016/j.geoderma.2011.05.008*

[293] *Kukuļs I., Nikodemus O., Kasparinskis R., Grāvelsiņa S., Prižavoite D. 2015. Carbon accumulation and humification in soils of abandoned former agricultural lands in the hemiboreal zone. Nordic view to sustainable rural development, NJF 25th Congress, 201 – 207.*

[294] *Lazdins, A., Bardule, A., Butlers, A. 2015. Preliminary results of comparison of carbon stock in soil in grassland, cropland and forest land. Adaptation and Mitigation: Strategies for Management of Forest Ecosystems, 54–57.*

[295] *Bardule A., Lupikis A., Butlers A., Lazdins A. 2017. Organic carbon stock in different types of mineral soils in cropland and grassland in Latvia. Zemdirbyste-Agriculture, 104(1), 3–8, DOI: 10.13080/z-a.2017.104.001*

The destiny of trees or change of status of tree is classified as follows:

- Living trees:
    - Still growing (trees remaining alive since the previous NFI cycle),
    - Ingrowth (new trees appearing in the NFI plot, measured first time),
- Commercial harvesting:
    - Harvested and extracted (living trees in previous NFI cycle, removed from the plot between previous and current measurement),
    - Diseased and extracted (mostly dead standing or laying trees in previous NFI cycle, removed from the plot between previous and current measurement),
- Mortality:
    - Harvested and left (living trees in previous NFI cycle, cut but left in the plot between previous and current measurement, mostly undergrowth trees),
    - Diseased (dry) and left (living trees in previous NFI cycle),
    - Thrown out (by wind) and left (living trees in previous NFI cycle, uprooted by wind),
    - Broken, dead (living trees in previous NFI cycle),
    - Damaged by beavers (living trees in previous NFI cycle, specific and common type of damages),
    - Broken top, living tree (such trees are accounted as 2 pieces – as living tree and dead wood).

There are 3 categories of dead trees, including dead standing trees, which might change their destiny to dead laying trees or rotten parts of trees. This conversion is excluded from mortality accounting.

Since research data are available, historical figures on mortality are recalculated and provided in the inventory considering 20 years decay period for dead biomass, respectively; calculations are done for the period 1970-2020. Removals of CO_2 in living biomass on afforested areas are calculated on the base of weighted average of timber stock changes in 1-25 years old forest stands on non-forest lands.

The difference between the SFS and NFI is not due to illegal felling. The permissions for timber extraction are given for area and the area of final felling is the same in NFI and SFS reports. There is considerably higher growing stock reported under the NFI and, respectively, extracted volumes. Additional timber, which does not appear in statistics of production of sawn products, is generally used as firewood in households and other small scale applications. The findings of NFI on additional harvested volumes fully comply with energy sector statistics considered overestimated in utilization of solid biofuel.

No harvesting takes place in afforested lands; therefore no emissions in living biomass due to commercial harvesting are reported in this category. However if by some reasons (for instance, thinning) harvesting took place on afforested area it is also reported in national statistics and is included in Forest management related CSC. Therefore there is no risk of underestimation of emissions from living biomass.

Losses in living and dead biomass due to deforestation are reported based on average growing stock in deforested land during the last NFI cycle. Average growing stock on deforested lands according to NFI are used to stratify total harvested rate in D from FM. All biomass, including stem, branches and below-ground biomass is considered instantly oxidized. Methodology for separation of harvest in different land-use categories is improved. National research study (aimed to determine increment, mortality and harvest rate in Latvia) was published in a peer-reviewed publication (Krumsteds et al., 2019)[296].

CSC in dead wood, litter and soils are reported under deforestation assuming that average carbon stock on forest lands remaining forest in dead biomass pools is instantly oxidizing during conversion. CSCs in mineral soil are estimated using Equation 2.25 of the 2006 IPCC Guidelines assuming that carbon accumulated in upper 30 cm (82.6 tonnes C ha^{-1} according to the forest soil monitoring project BioSoil[297]) partially turns into emissions within 20 years. The methods are described in previous sections under Croplands and Settlements.

According to the forest soil monitoring project BioSoil[298] average carbon stock in litter layer is 12.14 t ha^{-1}. Carbon stored in litter is assumed as instantenious oxidised due do deforestation, while due to afforestation C stock in litter reaches equilibrium of mentioned C stock in period of 150 years (assumtion of 2 forest management cycles).

The most important changes due to implementation of the 2006 IPCC Guidelines and the IPCC Wetlands Supplement are changes in EFs for CO_2, N_2O and CH_4 for drained organic soils, updates in calculation of HWP and carbon losses in soil due to disturbances caused by land use conversion from forest land to settlements and cropland. In forest management significant changes were implemented by application of the NFI data on harvest rate and mortality instead of the official statistics representing merchantable wood and underestimated mortality figures. Since submission 2019 national CO_2 EF (0.52 tonnes C ha^{-1} yr^{-1}) [299] for drained organic soils in forest land are used. Since submission 2021 new country-specific EFs for drained organic soils in cropland, grassland and wetlands (results of scientific studies)[300,301] are implemented.

11.3.1.2 Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected and mandatory activities under Article 3.4

The soil monitoring study initiated in 2012 by Joint Stock Company "Latvia`s State Forests" and Ministry of Agriculture demonstrates no statistically significant difference in carbon stock in mineral soil in grassland, forest land remaining forest land in fertile stand types and in afforested lands, i.e. no changes appear in soil organic matter (SOM) due to afforestation[302].

[296] *Krumsteds L. L., Lazdins A., Butlers A., Ivanovs J. 2019. Recalculation of forest increment, mortality and harvest rate in Latvia according to updated land use data. Rural Development 2019 (1): 295–299, DOI:10.15544/RD.2019.037*
[297] *Lazdiņš et al. 2011.-2015. Projekts "Mežsaimniecisko darbību ietekmes uz siltumnīcefekta gāzu emisijām un CO_2 piesaisti novērtējums" (Project "Evaluation of impact of forest management practices on greenhouse gas emissions and CO_2 removals").*
[298] *Lazdiņš et al. 2011.-2015. Projekts "Mežsaimniecisko darbību ietekmes uz siltumnīcefekta gāzu emisijām un CO_2 piesaisti novērtējums" (Project "Evaluation of impact of forest management practices on greenhouse gas emissions and CO_2 removals").*
[299] *Lupikis A., Lazdins A. 2017. Soil carbon stock changes in transitional mire drained for forestry in Latvia: A case study. Proceedings of 23rd Annual International Scientific Conference "Research for Rural Development 2017".*
[300] *Licite I., Lupikis, A. 2020. Impact of land use practices on greenhouse gas emissions from agriculture land on organic soils. Proceedings of 19th International Scientific Conference Engineering for Rural Development, 1823–1830, DOI: 10.22616/ERDev.2020.19.TF492*
[301] *Lazdiņš A., Lupiķis A. 2019. LIFE REstore project contribution to the greenhouse gas emission accounts in Latvia. In: A. Priede, A. Gancone (Eds.), Sustainable and responsible after-use of peat extraction areas (pp. 21–52). Baltijas Krasti.*
[302] *Support for the Climate Research Program. Available: https://drive.google.com/open?id=0Bxv4jQ_04jXZM1VDZHA1elVwV2M; https://drive.google.com/open?id=0Bxv4jQ_04jXZc3FBSENMNDZfLUU*

The results are based on 95 plots in forest, 34 plots in afforested lands and 40 plots in grassland; for each plot 4 repetitions have been taken.

It is assumed in calculation of CSC in afforested lands, that dead wood and litter will reach values characteristic for the forest lands (average figures of the 1st cycle of the NFI and 2nd round of forest soil monitoring, representing the same time period) in 150 years, which is twice average rotation of the most common tree species in afforested lands (birch and spruce). The rationale behind selection of 150 long transition period is decomposition of dead wood, which reach equality with forest lands at the end of the second rotation.

Data from the BioSoil net (95 plots) have been elaborated for the years 2006 and 2012 putting together the mineral soil and litter pools and then analyzing the trend in changes of the total carbon stock and its significance. The result shows that there is no statistically significant difference in total carbon stock between 2006 and 2012, respectively no CSC in these pools can be reported. This represents a quantitative demonstration that soil is neither sink or a source of CO_2 on short term. Emissions from natural and controlled biomass burning are estimated according to methodology described in chapter Biomass Burning. Activity data in CRF tables 4(KP-II)4 and 4(V) is harmonized.

11.3.1.3 Information on whether or not indirect and natural GHG emissions and removals have been factored out

It is recognized that:

- for Article 3, paragraph 4 activities, the issue of "factoring out" was solved during negotiations with the cap for Forest Management and with the net-net accounting for the other Article 3, paragraph 4 activities;
- for Article 3, paragraph 3 activities, the dynamic effect of age is not relevant since all these activities have occurred after 1990;
- for the elevated CO_2 concentration and the indirect nitrogen deposition, there are no methodologies adopted by the UNFCCC.

N_2O emissions from drained organic soils associated with conversion from forest land are reported using default EF provided by the IPCC Wetlands Supplement (Table 2.5).

CO_2 emissions from mineral soil associated with conversion to cropland and settlements are reported based on CSC due to losses of soil organic carbon stock.

CO_2 emissions from organic soil associated with conversion to cropland and grassland are calculated using national CO_2 EFs (4.80 t CO_2-C ha^{-1} yr^{-1} and 4.40 t CO_2-C ha^{-1} yr^{-1}, respectively). CO_2 emissions from organic soil associated with conversion to settlements are calculated using default EFs for cultivated organic soils, due to deep drainage in settlements similar to cropland (7.9 tonnes C ha^{-1} yr^{-1} according to the Table 2.1 in IPCC Wetlands Supplement).

11.3.1.4 Changes in data and methods since the previous submission (recalculations)

Implementation of changes due to improvement of activity data by the NFI team, which leads to minor changes in the whole time series. The most significant changes in activity data are associated with transfer of lands converted to forest lands with signs of human induced afforestation (as soon as these signs, like tending, thinning, supplementary planting or legal conversion of land use in forest register, are identified by the NFI teams) from the forest management activity to afforestation activity. Recalculations are done for the whole time series starting from the year of afforestation.

Since submission 2019 national CO_2 EF (0.52 tonnes C ha^{-1} yr^{-1})[303] for drained organic soils in forest land are used.

Since submission 2020 new method for calculation of land use changes using the most recent NFI data is implemented (Krumsteds et al., 2019)[304].

Since submission 2021 new country-specific EFs for drained organic soils in cropland and grassland (results of scientific studies)[305] are implemented.

Methodological consistency between the reference level and reporting for forest management during the 2nd CP, including the area accounted for the treatment of HWP is ensured by implementation of the same methodological approaches for the whole reporting period and recalculation of the whole time series according to a new methodology. A technical correction to FMRL is recalculated because of above-mentioned reasons (Table 11.10). Country specific method for estimation of FMRL and recalculation of historical data affecting the FMRL is implemented.

Manual data check is introduced to compare figures imported into the CRF Reporter and actually calculated values. The mathematical errors identified during the previous review are corrected in the EPIM model used for calculation of GHG emissions in LULUCF sector.

11.3.1.5 Uncertainty estimates

Uncertainty estimates are described under corresponding LULUCF chapters of NIR. It was assumed that uncertainty estimates developed for the UNFCCC LULUCF reporting apply also for lands under the Kyoto Protocol reporting (see Section 6.4.3, Section 6.5.3, Section 6.6.3, Section 6.7.3, Section 6.8.3, Section 6.10.3, Section 6.11.3). Uncertainties calculated according to the 2006 IPCC Guidelines Volume 1, Chapter 3 as twice the relative standard error. Combined category uncertainty is calculated according to the 2006 IPCC Guidelines Tier 1 – simple propagation of errors.

Uncertainty of annual increment of growing stock of trees in forest lands is 2.20%. The uncertainty of CSC of afforested lands is substantially larger due to higher sampling error for activity data. For harvesting stock, uncertainty according to forest regulations is 10%. BEFs utilized in calculations have uncertainty level of 2.24%.

Uncertainty of soil carbon (CO_2) emissions are estimated according to data obtained within the scientific study on CSC in drained organic soils in forest lands (A. Lupikis & A. Lazdins, 2017). The estimated change of carbon stock on afforestation sites is practically the same as that on Land Converted to Forest Land. Hence the uncertainty assessment in Section 6.4.3 applies also here.

For the deforestation areas, the uncertainty of land area range from 22 to 114% depending from soil type. The uncertainty for HWP is assumed 15% for the whole time series.

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[303] *Lupikis A., Lazdins A. 2017. Soil carbon stock changes in transitional mire drained for forestry in Latvia: A case study. Proceedings of 23rd Annual International Scientific Conference "Research for Rural Development 2017".*

[304] *Krumsteds L.L., Ivanovs J., Jansons J., Lazdins A. 2019. Development of Latvian land use and land use change matrix using geospatial data of National forest inventory. Agronomy Research 17, DOI: 10.15159/AR.19.195.*

[305] *Licite I., Lupikis, A. 2020. Impact of land use practices on greenhouse gas emissions from agriculture land on organic soils. Proceedings of 19th International Scientific Conference Engineering for Rural Development, 1823–1830, DOI: 10.22616/ERDev.2020.19.TF492*

Table 11.4 Combined uncertainties for Kyoto Protocol activities 3.3 and 3.4

KP LULUCF category	Emissions 2020, kt CO_2 eq.	Combined uncertainty, %
KP.A Article 3.3 Activities		
KP.A.1 Afforestation and Reforestation	*-293.25*	*± 14.1*
Carbon stock change	*-301.45*	*± 13.2*
CH_4 and N_2O emissions from drained and rewetted organic soils	*8.20*	*± 103.7*
KP.A.2 Deforestation	*1150.67*	*± 15.8*
Carbon stock change	*1017.35*	*± 16.5*
CH_4 and N_2O emissions from drained and rewetted organic soils	*126.77*	*± 56.4*
N_2O emissions from N mineralization/immobilization due to carbon loss/gain associated with land-use conversions and management change in mineral soils	*6.56*	*± 163.9*
KP.B Article 3.4 Activities		
KP.B.1 Forest Management	*-1558.75*	*± 175.7*
Carbon stock change (excluding HWP)	*-2780.90*	*± 85.5*
Carbon stock change in HWP	*303.39*	*± 15.0*
CH_4 and N_2O emissions from drained and rewetted organic soils	*862.32*	*± 94.6*
Biomass burning	*56.44*	*± 34.4*

11.3.1.6 Information on other methodological issues

The methodology used for reporting under the Kyoto Protocol is described in detail in previous sections.

11.3.1.7 The year of the onset of an activity, if after 2013

The starting year of the activities reported can directly be derived from the land-use change matrix (Table 6.8). The activities in the 2nd CP are reported starting with 2013.

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Lands that were subject to D activities since 1990 and on which subsequent regrowth of trees occur continue to be reported under D category. The previous land use of these lands was grasslands and croplands (abandoned farmlands), settlements (protective belts around roads, power lines and other objects of infrastructure) or wetlands (peat extraction sites).

The cumulative sum of areas afforested/reforested and deforested since 1990 is provided in Table 11.5. Emissions and removals due to ARD activities in 1990 to 2020 are provided in Table 11.6 and Table 11.7.

Table 11.5 Cumulative sums of areas under Article 3.3 activities for afforestation/reforestation and deforestation (ha)

Year	Afforestation	Deforestation	Total
1990	*17978.92*	*0.00*	*17978.92*
1995	*24597.38*	*0.00*	*24597.38*
2000	*51295.56*	*6407.06*	*57702.62*
2005	*65382.06*	*31327.59*	*96709.65*
2006	*68208.89*	*36311.70*	*104520.59*
2007	*70545.84*	*41295.81*	*111841.65*
2008	*74509.07*	*46279.91*	*120788.98*
2009	*82112.65*	*52722.54*	*134835.19*

Year	Afforestation	Deforestation	Total
2010	90771.46	59165.18	149936.64
2011	99606.53	65607.81	165214.34
2012	104889.39	72050.44	176939.83
2013	110502.37	78493.07	188995.44
2014	112387.47	81720.77	194108.24
2015	113716.86	84948.47	198665.34
2016	114914.10	88176.17	203090.28
2017	116111.34	91403.87	207515.22
2018	117308.58	94631.57	211940.16
2019	118970.00	98943.00	217913.00
2020	120632.00	103254.00	223886.00

Table 11.6 Net emissions and removals from Afforestation and Reforestation (kt CO_2 eq.)

Year	Biomass	DOM	SOM		Biomass burning	Drained organic soils		HWP	Total
			Mineral soils	Organic soils		N_2O	CH_4		
1990	-0.62	-10.98	NO,NA	0.00	NO	0	0	NO	-11.60
1991	-1.68	-11.78	NO,NA	0.00	NO	0	0	NO	-13.46
1992	-3.04	-12.57	NO,NA	0.32	NO	0.22	0.28	NO	-14.80
1993	-4.68	-13.40	NO,NA	1.08	NO	0.74	0.95	NO	-15.31
1994	-6.55	-14.21	NO,NA	1.08	NO	0.74	0.95	NO	-17.99
1995	-8.67	-15.02	NO,NA	1.08	NO	0.74	0.95	NO	-20.93
1996	-10.43	-18.77	NO,NA	2.60	NO	1.79	2.29	NO	-22.52
1997	-13.16	-23.18	NO,NA	3.00	NO	2.07	2.64	NO	-28.63
1998	-15.48	-25.85	NO,NA	3.28	NO	2.26	2.89	NO	-32.91
1999	-18.53	-28.75	NO,NA	3.27	NO	2.25	2.87	NO	-38.90
2000	-21.87	-31.33	NO,NA	4.07	NO	2.80	3.59	NO	-42.73
2001	-26.70	-33.44	NO,NA	3.92	NO	2.70	3.45	NO	-50.06
2002	-31.36	-34.77	NO,NA	3.83	NO	2.63	3.37	NO	-56.30
2003	-36.71	-36.40	NO,NA	3.85	NO	2.64	3.39	NO	-63.24
2004	-42.70	-38.17	NO,NA	3.82	NO	2.63	3.36	NO	-71.07
2005	-49.11	-39.93	NO,NA	3.73	NO	2.57	3.28	NO	-79.46
2006	-55.94	-41.66	NO,NA	3.71	NO	2.55	3.27	NO	-88.06
2007	-62.80	-43.08	NO,NA	3.78	NO	2.60	3.33	NO	-96.17
2008	-71.63	-45.50	NO,NA	3.86	NO	2.65	3.40	NO	-107.23
2009	-80.39	-50.15	NO,NA	4.06	NO	2.79	3.57	NO	-120.12
2010	-91.86	-55.43	NO,NA	4.26	NO	2.93	3.75	NO	-136.36
2011	-104.43	-60.83	NO,NA	4.46	NO	3.06	3.92	NO	-153.82
2012	-114.13	-64.06	NO,NA	4.72	NO	3.25	4.15	NO	-166.07
2013	-124.95	-67.48	NO,NA	4.92	NO	3.38	4.33	NO	-179.80
2014	-138.11	-68.64	NO,NA	4.92	NO	3.38	4.33	NO	-194.12
2015	-151.82	-69.45	NO,NA	4.95	NO	3.40	4.36	NO	-208.55
2016	-165.42	-70.18	NO,NA	5.00	NO	3.44	4.40	NO	-222.75
2017	-182.75	-70.91	NO,NA	5.06	NO	3.48	4.45	NO	-240.68
2018	-196.03	-71.64	NO,NA	5.11	NO	3.51	4.50	NO	-254.55
2019	-213.95	-72.52	NO,NA	5.18	NO	3.58	4.55	NO	-273.17
2020	-233.17	-73.54	NO,NA	5.25	NO	3.58	4.63	NO	-293.25

Table 11.7 Net emissions and removals from Deforestation (kt CO_2 eq.)

Year	Biomass	DOM	SOM		Minerali-sation N_2O	Biomass burning	Drained organic soils		HWP	Total
			Mineral soils	Organic soils			N_2O	CH_4		
1990	NO	NO	NO	NO	NO	NO	NO	NO	NA	NO,IE,NA
1991	NO	NO	NO	NO	NO	NO	NO	NO	NA	NO,IE,NA
1992	NO	NO	NO	NO	NO	NO	NO	NO	NA	NO,IE,NA
1993	NO	NO	NO	NO	NO	NO	NO	NO	NA	NO,IE,NA
1994	NO	NO	NO	NO	NO	NO	NO	NO	NA	NO,IE,NA
1995	NO	NO	NO	NO	NO	NO	NO	NO	NA	NO,IE,NA
1996	41.89	46.90	0.20	2.71	0.02	NO	0.93	0.21	NA	92.86
1997	41.89	47.89	0.41	5.41	0.04	NO	1.86	0.42	NA	97.92
1998	41.89	49.05	0.61	8.10	0.06	NO	2.78	0.63	NA	103.14
1999	41.89	50.76	0.82	10.79	0.09	NO	3.71	0.84	NA	108.89
2000	41.89	52.08	1.02	13.47	0.11	NO	4.63	1.05	NA	114.25
2001	215.36	273.46	2.58	27.79	0.27	NO	9.35	2.13	NA	530.94
2002	215.36	280.21	4.14	42.09	0.43	NO	14.06	3.20	NA	559.50
2003	215.36	287.00	5.70	56.37	0.59	NO	18.76	4.27	NA	588.06
2004	215.36	292.77	7.26	70.62	0.76	NO	23.46	5.34	NA	615.57
2005	215.36	299.39	8.82	84.86	0.92	NO	28.15	6.41	NA	643.91
2006	215.36	304.05	10.38	99.07	1.08	NO	32.83	7.48	NA	670.25
2007	215.36	308.84	11.94	113.26	1.25	NO	37.50	8.55	NA	696.71
2008	215.36	312.30	13.50	127.43	1.41	NO	42.17	9.61	NA	721.79
2009	259.25	414.96	17.29	148.13	1.80	NO	48.35	11.19	NA	900.96
2010	259.25	425.69	21.07	168.75	2.20	NO	54.50	12.76	NA	944.23
2011	259.25	435.70	24.86	189.31	2.59	NO	60.63	14.33	NA	986.68
2012	259.25	443.48	28.66	209.79	2.99	NO	66.74	15.89	NA	1026.81
2013	259.25	450.82	32.46	230.20	3.39	NO	72.83	17.45	NA	1066.40
2014	156.70	281.58	37.19	245.78	3.88	NO	76.64	18.47	NA	820.24
2015	156.70	286.29	41.93	261.35	4.37	NO	80.43	19.49	NA	850.57
2016	156.70	291.20	46.46	276.90	4.85	NO	84.23	20.51	NA	880.85
2017	156.70	296.22	50.99	292.45	5.32	NO	88.03	21.53	NA	911.24
2018	156.70	300.92	55.53	307.99	5.79	NO	91.82	22.55	NA	941.29
2019	204.97	402.62	58.89	325.20	6.26	NO	96.85	23.85	NA	1118.63
2020	204.97	407.76	62.25	342.37	6.56	NO	101.62	25.15	NA	1150.67

11.4.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2020 and are directly human-induced

Changes in the forest area are detected based on NFI sample plot data. The land use category at the end of 1989 was assessed by interpretation based on aerial photos and satellite images and with other auxiliary data.

Since the land use category just before 1 January 1990 was known, the reported land-use changes have occurred since then. Each type of land-use change since 1990 is known and the changes that were not directly human-induced have been excluded from the reporting. Changes that are not human-induced and not accounted under the KP, occur when due to water erosion lands including forests turns into water. In addition, the conversion from land use category Forest Land to Other Land and Wetlands are excluded since that transition type is not human-induced; rather, it is a natural occurrence. The reported AR activities are directly human-induced because those activities are based on decisions not to continue with the previous activities and to use the forest management activities instead. This means that the area is changed into forest land, conforms to the threshold values of forest land listed in the Forest Act and land owner implements forest management measures. The following criteria are used to identify areas afforested/reforested after 1990:

- trees planted or sown on grassland or abandoned cropland;
- management activities takes place in afforested lands (tending, thinning, soil scarification, harvesting);
- natural forest ingrowth methods are applied to proceed afforestation and area is legally transformed to forest land and managed according the forest act.

Areas where none of these criteria is implemented are not reported as afforested/reforested lands, but are reported under forest management. The unit of land, which is planted or sown is not accounted for as an afforestation/reforestation area until the threshold values listed in the Forest act are reached. The situation is fixed in the NFI plot that description during a site visit.

The reported deforestation activities are directly human-induced. Either a plan approved by the authorities or a permit is needed to change the land use from forest to other land use; however, the primary data source is NFI, which reports areas where the measures prohibiting regeneration of forest are implemented like building or ploughing. An exception is deforestation to wetlands. Carbon losses in this case are not accounted. Information provided by the authorities is used to verify NFI data and to elaborate projections of GHG emissions due to deforestation. Deforestation to wetlands due to abandonment of drainage systems becomes the most common type of conversion of forest lands to other land use categories. This type of conversion is not accounted as deforestation.

11.4.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

In Latvia temporarily unstocked areas (e.g. harvested area) remain forests and are not accounted as deforestation if no other activities prohibiting forest regeneration are implemented. The NFI teams are trained to distinguish between forest management and land use changes. The legal requirements for the forest regeneration are to reach certain dimensions and density of trees within 5-10 years, depending on forest site type. Normally these requirements will not be reached only in case of flooding or human induced prohibiting of forest regeneration, like building of road or storage yard in forest. In such cases conversion to non-forest land can be easily identified. Land use changes are determined according to methodology elaborated by Krumsteds et al. (2019)[306]. Afforested areas fulfil the criteria for the forest definition used in the Latvia's NFI, which besides other threshold values is minimum width of 20 m. Deforested areas are detected by using the same approach. Global Forest Watch data are introduced to improve interpolation of afforestation and deforestation; however this method is not very efficient in decripting small areas and afforested areas at early forest development stages. Land use changes are harmonized with LULUCF sector reporting.

Deforestation and relevant land use changes (construction of forest roads) are regulated by national legislation.

[306] *Krumsteds, L. L., Ivanovs, J., Jansons, J., Lazdiņš, A. 2019. Development of Latvian land use and land use change matrix using geospatial data of National forest inventory. Agronomy Research, 17(6), p. 2295–2305, DOI: 10.15159/AR.19.195*

Restocking is assumed for forest areas that have lost forest cover through harvesting or forest disturbance, unless there is deforestation as described above.

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

Information on the size and location of forest areas that have permanently lost forest cover (due to a tillage or construction) is collected on 5 year period basis by the NFI. These data can be validated by national statistics; however, no historical records since 1990 are available for statistics and only recent data can be used for the validation.

11.4.4 Information related to the natural disturbances provision under Article 3.3

Latvia decided not to report natural disturbances, because trees diseased due to natural disturbances are usually extracted in salvage logging (sanitary clear-felling or thinning); therefore, reporting of lands reported under natural disturbances is not necessary or even possible due to salvage logging, neither for AR nor for FM.

11.4.5 Information on Harvested Wood Products under Article 3.3

The emissions from the HWP pool that have been accounted during the 1st CP were not calculated on the basis of instantaneous oxidation; respectively, they should not be excluded from the reporting for the 2nd CP.

HWP resulting from D have been accounted on the basis of instantaneous oxidation using proportion approach; respectively, if the felling stock in deforested areas is 1% of the total felling stock, the proportion of HWP to which the instant oxidation approach is applied equals to 1% of the HWP.

The carbon dioxide emissions from HWP in solid waste disposal sites are not accounted, and the carbon dioxide emissions from wood harvested for energy purposes have been accounted on the basis of instantaneous oxidation under carbon losses from living biomass.

Land use changes including conversion of forest land to other land use categories under the UNFCCC reporting and deforestation under the Kyoto protocol reporting are accounted using the NFI data. NFI also provides information of losses of living and dead biomass during the land use changes. Since NFI plots are visited once per 5 years, it is assumed in the calculation of losses that trees continues to grow for 2.5 years according to growth rate curves in the conditions characterizing deforested area. The trees extracted during the land use change from forest land to other land use categories or deforestation (Kyoto protocol reporting) are subtracted from the total harvest rate and accounted as emissions using the instant oxidation approach. The trees which are extracted from previously deforested areas or areas where land use is changed from forest land to other land use categories less than 20 years ago are also calculated using instant oxidation approach due to limited information about further use of the extracted biomass. The quality of extracted trees in afforested areas usually is under quality threshold values for log wood production, therefore we are assuming that these trees are used for solid biofuel production. Land use change to establish plantation forests in former forest land is not eligible practice in Latvia.

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

The area of forest land reported for Afforestation/Reforestation and Deforestation under the KP is not equal to the area reported for Land use changes from and to forests in the UNFCCC GHG inventory, because lands afforested/deforested in 1990-2000 already completed 20 years transition period and under the UNFCCC GHG inventory they are accounted under land use categories retaining their land use status, respectively, lands afforested in 1990-2000 are reported in 2010-2020 under the forest land remaining forest land category. In the KP reporting transition period is not considered; therefore, afforested lands will always be afforested lands, except the case if they are deforested in future. The total area of forest lands, however, is the same in the both reports. All land use changes from and to forests take place on managed lands and therefore are considered to be human induced.

All forests are considered as managed land. Forest management activity is practised on the forest area as defined above.

The Law on Forests lays down provisions on management and utilisation of forest. Afforested lands are also considered as subjects of Law on Forests apart from reason of afforestation. Therefore all afforested lands are also considered managed.

11.5.2 Information relating to Forest Management

According to the Law on Forests[307] forest management in Latvia is sustainable utilization and management of forests and forest resources to preserve biodiversity, productivity and vitality of forests as well as ability to regenerate, while providing economic, social and cultural opportunities for the benefit of present and future generations. Consequently, all forests, as well as all forest lands according to national definitions are considered as managed land.

Forest management activity is practiced on the forest area (forest stands) as defined above. Total area reported under forest management is decreasing since 2001 as annually deforested area exceeds area of naturally afforested lands.

Emissions and removals from FM activity in 1990 to 2020 are given in Table 11.8. The area under FM for 1990 to 2020 is provided in Figure 11.6. Decrese in area under FM is related to the conversion of forest land to settlements (generally due to road construction), as well as to conversion of naturally afforested lands to cropland and grassland associated mostly to removal of woody vegetation from naturally afforested farmlands abandoned in 1980s and 1990s.

Table 11.8 Net emissions and removals from Forest management (kt CO_2 eq.)

Year	Biomass	DOM	SOM		Minerali-sation N_2O	Biomass burning	Drained organic soils		HWP	Total
			Mineral soils	Organic soils			N_2O	CH_4		
1990	*-18802.78*	*-2.30*	*NA*	*772.16*	*NA*	*52.32*	*531.01*	*90.46*	*-166.23*	*-17525.36*
1991	*-19810.84*	*-2.35*	*NA*	*795.01*	*NA*	*29.61*	*546.72*	*93.14*	*-162.81*	*-18511.52*
1992	*-20437.23*	*-2.41*	*NA*	*795.01*	*NA*	*943.94*	*546.72*	*93.14*	*55.83*	*-18005.00*
1993	*-19206.11*	*-2.43*	*NA*	*795.01*	*NA*	*88.20*	*546.72*	*93.14*	*397.17*	*-17288.31*

[307] *Latvijas Republikas Saeima, 2000. Meža likums (Law on Forests).*

Year	Biomass	DOM	SOM		Minerali-sation N_2O	Biomass burning	Drained organic soils		HWP	Total
			Mineral soils	Organic soils			N_2O	CH_4		
1994	-20923.32	-415.89	NA	795.01	NA	31.97	546.72	93.14	-98.00	-19970.38
1995	-19007.25	-394.17	NA	795.01	NA	97.94	546.72	93.14	-474.80	-18343.41
1996	-19203.79	-372.41	NA	794.68	NA	146.13	546.50	93.10	-686.37	-18682.16
1997	-15611.20	-350.11	NA	794.36	NA	100.56	546.28	93.06	-1567.11	-15994.17
1998	-13766.94	-329.67	NA	795.60	NA	77.38	546.05	93.03	-1968.56	-14553.12
1999	-8699.87	-510.53	NA	795.29	NA	267.58	545.83	92.99	-2303.07	-9811.78
2000	-12658.96	-479.74	NA	794.92	NA	226.71	545.61	92.95	-2427.42	-13905.93
2001	-13750.56	-439.71	NA	793.81	NA	66.32	544.75	92.80	-2276.70	-14969.28
2002	-12358.08	-400.96	NA	792.65	NA	353.83	543.88	92.66	-2312.34	-13288.35
2003	-11716.20	-362.39	NA	791.38	NA	122.93	543.02	92.51	-2284.02	-12812.77
2004	-8545.50	-422.91	NA	790.78	NA	100.05	542.16	92.36	-2162.56	-9605.62
2005	-7495.73	-379.82	NA	789.61	NA	28.27	541.29	92.21	-2207.09	-8631.25
2006	-10034.32	-337.26	NA	788.37	NA	494.99	540.43	92.07	-2247.61	-10703.34
2007	-9450.29	-295.51	NA	787.05	NA	49.47	539.57	91.92	-1332.73	-9610.53
2008	-11349.08	-253.26	NA	785.72	NA	62.54	538.70	91.77	-1009.66	-11133.26
2009	-4652.44	-3246.34	NA	777.43	NA	106.19	533.14	105.27	-1192.02	-7568.78
2010	-781.97	-3036.98	NA	775.75	NA	54.63	532.03	119.53	-1779.16	-4116.17
2011	-1348.52	-2828.49	NA	773.94	NA	25.40	530.93	133.78	-1991.17	-4704.14
2012	-3802.03	-2623.15	NA	772.07	NA	20.22	529.82	148.04	-1850.61	-6805.64
2013	-3842.68	-2418.59	NA	770.26	NA	39.47	528.71	162.29	-1864.42	-6624.96
2014	1523.10	-2190.30	NA	741.66	NA	105.71	509.05	196.42	-1824.10	-938.46
2015	-1932.69	-529.73	NA	740.85	NA	74.64	508.51	233.80	-1818.44	-2723.06
2016	-2831.45	-905.97	NA	740.09	NA	71.20	507.98	271.18	320.93	-1826.03
2017	-4141.94	-854.14	NA	739.33	NA	49.18	507.44	308.57	327.53	-3064.03
2018	-3892.96	-732.99	NA	738.57	NA	454.09	506.91	345.95	285.23	-2295.19
2019	-4603.34	-537.519	NA	728.45	NA	138.07	500.04	355.78	348.57	-3069.94
2020	-3826.81	322.971	NA	722.94	NA	56.44	496.17	366.15	303.39	-1558.75

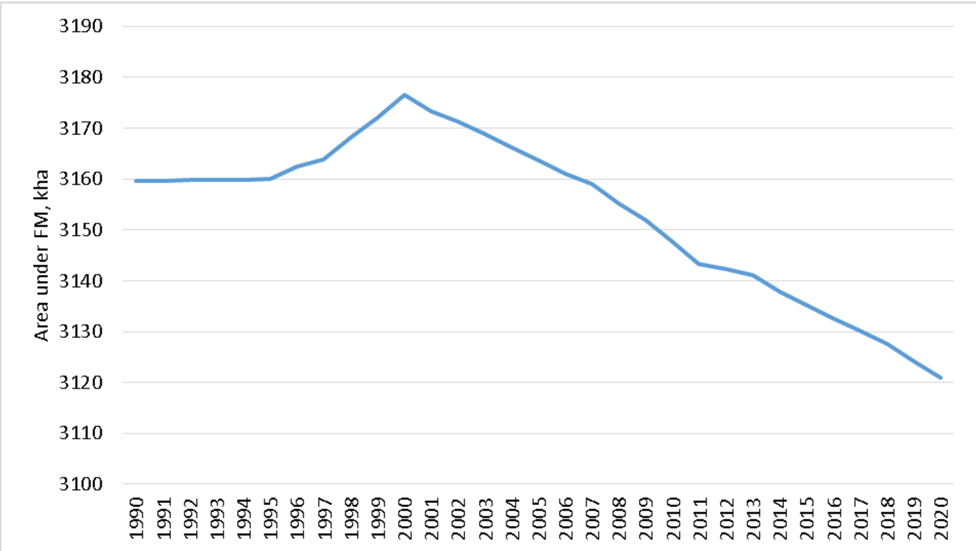

Figure 11.6 The area under FM for 1990 to 2020

The Law on Forests lays down provisions on management and utilization of forest. Afforested lands are also considered as subjects of the Law on Forests apart from reason of afforestation. Therefore all afforested lands are also considered managed. The purpose of the Law is to promote economically, ecologically and socially sustainable management and utilization of the forests in such a way that forests provide a sustainable satisfactory yield while biological diversity is being maintained.

11.5.2.1 Conversion of natural forest to planted forest

No emissions arising from the conversion of natural forests to planted forests are accounted for, because no such kind of activities takes place in Latvia in accordance with any supplementary methodological guidance developed by the IPCC. There is no official definition of "natural forests" in Latvia or by the IPCC.

11.5.2.2 Forest Management Reference Level (FMRL)

Latvia's forest management reference level is -16.302 Mt CO_2 eq. and -14.255 Mt CO_2 eq. (including HWP) as inscribed in the appendix to the annex to decision 2/CMP.7. The FMRL was constructed in 2011[308] and since then, several changes have been made to the applied data and methods.

Taking into account significant changes in data and methods since estimation of initial FMRL in 2011 and addressing recommendation by ERT in the Report of the technical assessment of the FMRL submission of Latvia submitted in 2011 to make a technical correction to the FMRL when final agreement on HWP estimation is reached, in 2021 Latvia has made a technical correction for the FMRL according the requirements of decision 2/CMP.7 and 2/CMP.8. and recommendations in the technical assessment report over Latvia`s FMRL submission. The results are described below.

Latvias FMRLcorr is constructed by the national Forest Growth Model (AGM) developed by LSFRI Silava. This forest research long-term prognosis model is developed as a simulation model. In modelling data from the NFI database was used. Changes to the forest stand in the programme are modelled on a forest element level where a collection of individuals of the same species, generation and level are considered a forest element. Changes in forest resources are modelled in five year periods. The process of existing tree stand modelling is deterministic, but renewing and harvesting are stohastic processes. In modelling the growing process of tree stands growing process models developed by LSFRI Silava were used. The process of forest resource prognosis consists of three stages: 1) creating a data table suitable for modelling; 2) defining a management scenario and criteria of suitable sectors; 3) modelling changes in forest resources for n periods in the future. The structure and calculation principles are described in details in Annex 5 and in the reports and scientific papers on the development and verification of AGM model (Lazdiņš et al., 2018[309]; Šņepsts et al., 2018[310]; Lazdiņš et al., 2019[311]; Lazdiņš et al., 2019[312]). For FMRL construction the historical period 2000-2008 has been used.

[308] *Submission of information on forest management reference levels by Latvia. Available: https://unfccc.int/topics/land-use/workstreams/land-use--land-use-change-and-forestry-lulucf/forest-management-reference-levels*
[309] *Lazdiņš, A., Lupiķis, A., Butlers, A., Bārdule, A., Kārkliņa, I. (2018). AGM model description (Draft No. 2018-01–1; Elaboration of Forest Reference Level for Latvia for the Period between 2021 and 2025, p. 98). LSFRI Silava.*
[310] *Šņepsts, G., Lazdiņš, A., Lazdiņa, D. (2018). Verification of AGM model (Draft No. 2018-05–1; Elaboration of Forest Reference Level for Latvia for the Period between 2021 and 2025, p. 19). LSFRI Silava.*
[311] *Lazdiņš, A., Šņepsts, G., Petaja, G., & Kārkliņa, I. (2019). Verification of applicability of forest growth model AGM in elaboration of forestry projections for National forest reference level. Proceedings of the 9th International Scientific Conference Rural Development 2019, 289–294, DOI: 10.15544/RD.2019.065*
[312] *Lazdiņš, A., Lupiķis, A., Butlers, A., Bārdule, A., Kārkliņa, I., Šņepsts, G., & Donis, J. (2019). Latvia's national forestry accounting plan and proposed forest reference level 2021-2025 (p. 200). LSFRI Silava.*

Policies and measures included into calculations of FMRLcorr are those implemented by 2009 and legislative provisions adopted by 2009. Into calculations of FMRLcorr, the last amendment of Forest Law dated on 14 November 2008 and Regulation No. 892 "Regulations regarding Tree Felling in Forest Lands" adopted 31 October 2006 is included. Thus, all the policies assumptions of the FMRL submission have kept unchanged.

Information on pools and gases estimated or omitted in the calculation of original FMRL and FMRLcorr is summarized in Table 11.9. FMRLcorr is -1472.89 Mt CO_2 eq. General information on elements (including exact harvesting rates, historical area and age class structure of forests) and methods used for the construction of FMRLcorr are summarized in Table 11.10.

Table 11.9 C pools and GHG sources included in the original FMRL and FMRLcorr

	Original FMRL[313]	FMRLcorr
Change in C pool included in the reference level		
Above-ground biomass	*Yes*	*Yes*
Below-ground biomass	*Yes*	*Yes*
Litter	*No*	*Yes*
Dead wood	*No*	*Yes*
Soil (mineral)	*No*	*Yes*
Soil (organic)	*Yes*	*Yes*
GHG sources included in the reference level		
Fertilization (N_2O)	*No*	*No*
Drainage of soils (N_2O)	*Yes*	*Yes*
Drainage of soils (CH_4)	*No*	*Yes*
Rewetting of soils (CH_4)	*No*	*Yes*
Liming (CO_2)	*No*	*No*
Biomass burning (CO_2)	*Yes*	*Yes*
Biomass burning (CH_4)	*Yes*	*Yes*
Biomass burning (CH_4)	*Yes*	*Yes*

The validation of the applied AGM was done during elaboration of the Forest reference level in 2018 by comparison of modelled balance of CO_2 emissions and removals in living biomass and field measurements based NFI data in 2000-2009, including data series for 2000-2003, which were extrapolated using NFI data and stand wise forest inventory data. The average accuracy of the model exceeds 95% and only in 2008, when the economy crisis striked, actual net CO_2 emissions are outside the uncertainty range of the modelled data. The accuracy of the modelled data significantly exceeds previously used EFISCEN and G4M models.

313 According to the Submission of Latvia on its forest management reference level (FMRL), submitted on 5 May 2011. Available: http://unfccc.int/files/meetings/ad_hoc_working_groups/kp/application/pdf/awgkp_latvia_fmrl_2011.pdf

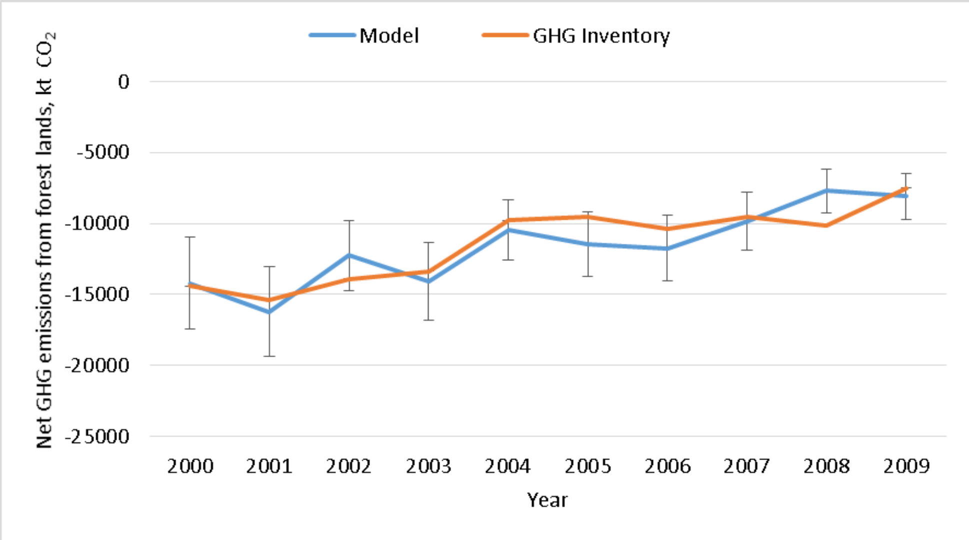

Figure 11.7 The validation results of the modelled and actual data on CO_2 emissions and removals in forest land in the reference period

11.5.2.3 Technical Corrections of FMRL

The main reasons for technical corrections of the original FMRL are summarized in Table 11.10. The Technical Correction of Latvia`s original FMRL is 14829.11 kt CO_2 eq., respectively estimated FMRL reduced by the specified value.

Table 11.10 The main reasons for technical corrections of the original FMRL

Element/method	Additions to /modification in the GHG inventory	FMRL technical correction	Submission of implementation	Description in NIR	Difference in average values of elements for 2000-2008			
					Element	Average value according to the National GHG Inventory Report 2009 submitted in 2011, unit	Average value according to the National GHG Inventory Report 2020 submitted in 2022, unit	Difference in average values, %
Area under FM	*Recalculation of the NFI data due to repeated measurement of borders of the NFI plots and their sectors.*	*Recalculated historical data on area under FM (Figure 11.6)*	*Repeatedly after the adoption of FMRL (in 2016, 2017, 2018)*	*6.4.2*	*Area under FM*	*3138.3 kha*	*3166.1 kha*	*+0.9%*
Forest characteristics	*Projection of harvest rate is calculated according to the propotion of growing stock accessible to regenerative felling and commercial thinning during the reference period (2000-2008).*	*Recalculated harvest projection (Figure 11.8 and Figure 11.9)*	*After the adoption of FMRL*	-	-	-	-	-
	Recalculated CSC in living above- and	*Updated figures on gross increment*	*Repeatedly after the adoption of*	-	*Annual gross increment of*	*7.37*	*8.16*	*+10.7%*

Element/method	Additions to /modification in the GHG inventory	FMRL technical correction	Submission of implementation	Description in NIR	Difference in average values of elements for 2000-2008			
					Element	Average value according to the National GHG Inventory Report 2009 submitted in 2011, unit	Average value according to the National GHG Inventory Report 2020 submitted in 2022, unit	Difference in average values, %
Forest characteristics	*below-ground biomass. Mortality was omitted in the FMRL calculation leading to significant overestimation of the net CO_2 removals in living biomass. Since the mortality is considered, the net CO_2 removals in living biomass significantly decreased.*	*(annual increment of living biomass) after completion of additional rounds of NFI cycles, species-specific wood density coefficients and BEFs.*	*FMRL (in 2013, 2014, 2017, 2018)*		*living biomass*	*$m^3\ ha^{-1}\ yr^{-1}$*	*$m^3\ ha^{-1}\ yr^{-1}$*	
					Net CSC (removals) in biomass under FM	*19335.0 kt $CO_2\ yr^{-1}$*	*10817.6 kt $CO_2\ yr^{-1}$*	*-44.0%*
New pool	*Inclusion and recalculation (due to completion of additional rounds of NFI cycles) of CSC in dead organic matter.*	*Updated figures on species specific mortality factors (annual mortality).*	*Repeatedly after the adoption of FMRL (in 2013, 2018)*	-	*Net CSC (removals) in dead wood*	*NO*	*363.7 kt $CO_2\ yr^{-1}$*	*+100%*

Element/method	Additions to /modification in the GHG inventory	FMRL technical correction	Submission of implementation	Description in NIR	Difference in average values of elements for 2000-2008			
					Element	Average value according to the National GHG Inventory Report 2009 submitted in 2011, unit	Average value according to the National GHG Inventory Report 2020 submitted in 2022, unit	Difference in average values, %
Historical harvesting rates	*Data source was changed from stand wise inventory to NFI (improved relationship characteristics between NFI data and stand wise inventory data developed by overlap splicing technique to recalculate historical harvesting rate).*	*Recalculated historical data (Table 6.11)*	*Repeatedly after the adoption of FMRL*	-	*Harvesting rate*	*9 858.8* *1000 m^3*	*13 275.1* *1000 m^3*	*+34.7%*
New method (2006 IPCC Guidelines)	*2006 IPCC Guidelines was implemented*	*Recalculation of GHG emissions from biomass burning (wildfires and controlled burning)*	*2015 (Latvia's national inventory report 1990-2013)*	*6.12*	*GHG emissions from biomass burning (wildfires and controlled burning)*	*69.7* *kt CO_2 eq. yr^{-1}*	*167.2* *kt CO_2 eq. yr^{-1}*	*+140.0%*

Element/method	Additions to /modification in the GHG inventory	FMRL technical correction	Submission of implementation	Description in NIR	Difference in average values of elements for 2000-2008			
					Element	Average value according to the National GHG Inventory Report 2009 submitted in 2011, unit	Average value according to the National GHG Inventory Report 2020 submitted in 2022, unit	Difference in average values, %
New EF for drained organic soils in forest land	*Implementation of country-specific CO_2 EF for drained organic soil (Lupikis and Lazdins, 2017)*	*Recalculation of CO_2 emissions from drained organic soils.*	*2018 (Latvia's national inventory report 1990-2016)*	*6.4.2*	*Net CSC (emissions) in organic soil*	*-291.3 kt C*	*-215.6 kt C*	*-26.0%*
New method and pools (IPCC Wetlands Supplement was implemented)	*IPCC Wetlands Supplement was implemented*	*Recalculation of GHG emissions from drained organic soil. GHG emissions from rewetted organic soils were included.*	*2015 (Latvia's national inventory report 1990-2013)*	*6.6.4*	*N_2O emissions from drained organic soils*	*0.40 kt N_2O*	*1.81 kt N_2O*	*+352.5%*
					CH_4 emissions from drained and rewetted organic soils	-	*3.69 kt CH_4*	*+100.0%*
Harvested wood products	*Recalculated data*	*Recalculated data on the production, import and export of the HWP in the reference period*	*Repeatedly after the adoption of FMRL*	-	*Net CSC (removals) in HWP*	*-1921.9* [314] *kt CO_2 yr^{-1}*	*-2028.9 kt CO_2 yr^{-1}*	*-5.6%*

[314] *According to the Submission of Latvia on its forest management reference level (FMRL), submitted on 5 May 2011. Available: http://unfccc.int/files/meetings/ad_hoc_working_groups/kp/application/pdf/awgkp_latvia_fmrl_2011.pdf*

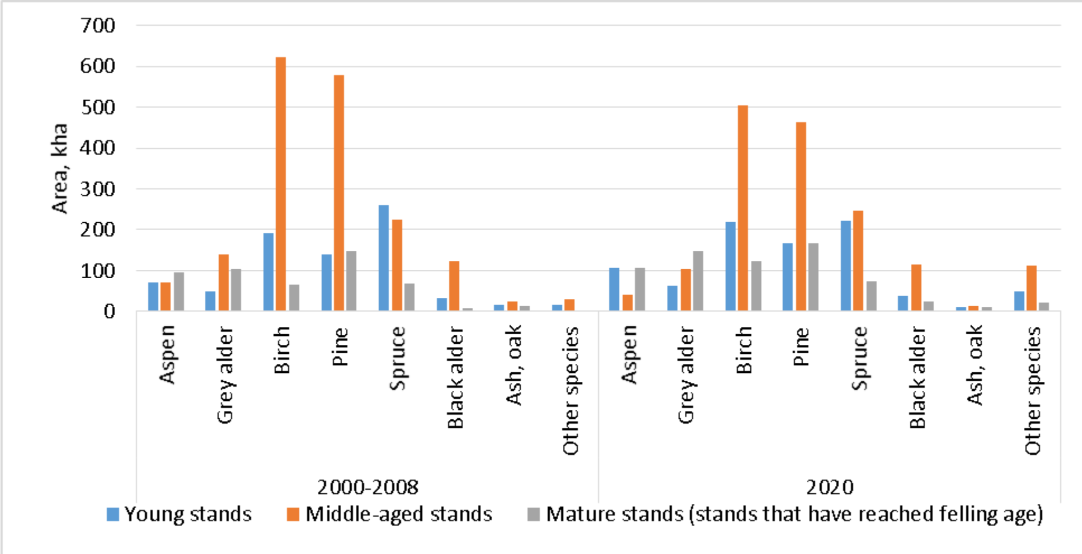

Figure 11.8 Historical data on age-class structure by tree species for 2000-2008 and for 2020

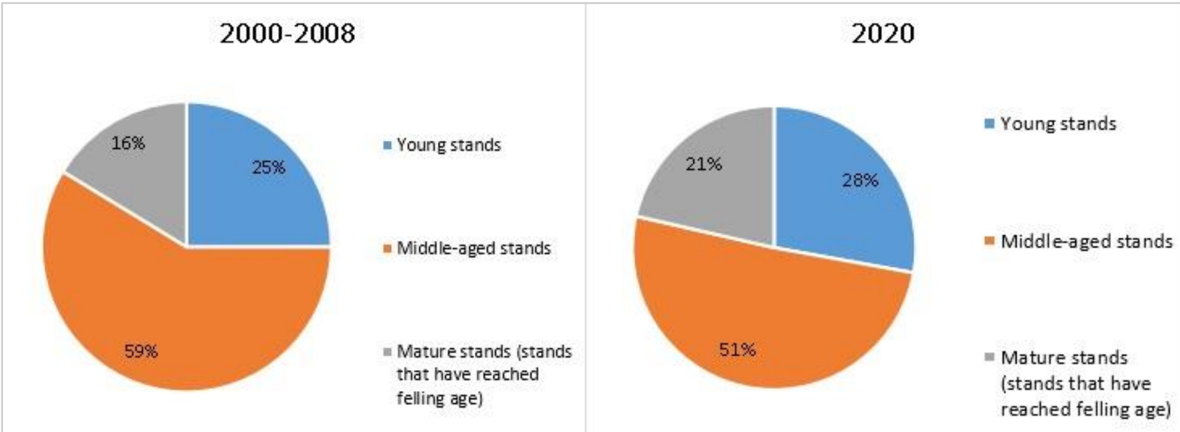

Figure 11.9 Share of young, middle-aged and mature stands (age-class structure) in forest land in 2000-2008 and in 2020

11.5.2.4 Information related to the natural disturbances provision under Article 3.4

Latvia does not intend to apply the Natural Disturbance provision, respectively, annual emissions resulting from natural disturbances and the subsequent removals during the commitment period in those areas are not estimated and not excluded from the accounting for forest management under Article 3, paragraph 4, of the Kyoto Protocol during the second commitment period.

11.5.2.5 Information on Harvested Wood Products under Article 3.4

Emissions from HWP originating from forests prior to the start of the second commitment period have been included in the reporting.

Emissions and removals resulting from changes in the HWP pool do not include imported HWP, irrespective of their origin. FAOSTAT data are used to identify share of imported HWP. Calculations are done according to the 2013 IPCC Kyoto Protocol Supplement and scientifically verified methodology[315].

Emissions from HWP originating from forests prior to the start of the 2nd commitment period have been calculated in the reference level in accordance with decision 2/CMP.7, annex, paragraph 16. The methodology for calculation of HWP is based on the 2013 IPCC Kyoto Protocol Supplement and earlier studies on the forest management reference level[316]. Half-lives are based on Table 2.8.2 of the IPCC KP Supplement of two years for paper, 25 years for wood panels and 35 years for sawn wood. Instant oxidation is considered for biomass originated in deforested areas.

Activity data for HWP used for estimation of the HWP pool removed from domestic forests, for domestic consumption and for export are obtained in FAOSTAT and verified by internal research data and expert judgements.

Detailed methodology of calculation of emissions from HWP including methods/approaches for HWP used for the construction of the FMRLcorr is provided in Chapter 6.11.2.

11.5.3 Information relating to Cropland Management, Grazing Land Management, Revegetation and Wetland Drainage and Rewetting if elected, for the base year

Not relevant.

[315] *Lazdiņš A., Strūve L. 2012. Contribution of harvested wood products to greenhouse gas emissions due to forest management in Latvia. In Mežzinātne. Special Issue. Abstracts for International Conferences Organized by LSFRI Silava in Cooperation with SNS and IUFRO, vol. 25 (58) (presented at the OSCAR 2012, Riga: LSFRI Silava, 2012), 79–82; Rüter S. 2011. Projection of Net-Emissions from Harvested Wood Products in European Countries, Hamburg.*

[316] *Rüter S. 2011. Projection of net emissions from harvested wood products in European Countries. Hamburg: Johann Heinrich von Thünen-Institute (vTI), 63 p, Work Report of the Institute of Wood Tech- nology and Wood Biology, Report No: 2011/1; Lazdiņš A., Strūve L. 2012. Contribution of harvested wood products to greenhouse gas emissions due to forest management in Latvia. In Mežzinātne. Special Issue. Abstracts for International Conferences Organized by LSFRI Silava in Cooperation with SNS and IUFRO, vol. 25 (58) (presented at the OSCAR 2012, Riga: LSFRI Silava, 2012), 79–82.*

11.6 *OTHER INFORMATION*

11.6.1 Key category analysis for Article 3.3 activities, forest management and any elected activities under Article 3.4

Key category analysis for KP LULUCF was performed according to the 2006 IPCC Guidelines. The results of the key category analysis for KP LULUCF activities for the inventory year 2020 are found in Table 11.11. Carbon stock change in living biomass, dead organic matter and organic soils under FM, D and AR, CSC in HWP, CO_2, N_2O and CH_4 emissions from drainage and rewetting of organic soils under FM, and N_2O emissions from N mineralization/immobilization associated with loss of soil organic matter under D are identified as key categories for the KP-LULUCF activities. UNFCCC inventory category associated activities under the KP are treated as a Key Categories when identified as key according to guidance included in Chapter 4, Volume 1, of the 2006 IPCC Guidelines.

Table 11.11 The key categories of KP LULUCF activities for the inventory year 2020

KP-LULUCF activities	Carbon pool or GHG source	Gas	Identification criteria
FM	*Carbon stock change in dead wood*	CO_2	*L1,L2,T1,T2*
FM	*Carbon stock change in living biomass*	CO_2	*L1,L2,T1,T2*
FM	*Carbon stock change in organic soils*	CO_2	*L1,L2,T1,T2*
FM	*Organic soils (drainage and rewetting)*	CO_2	*L1,L2*
FM	*Organic soils (drainage and rewetting)*	N_2O	*L1,L2,T1,T2*
FM	*Organic soils (drainage and rewetting)*	CH_4	*L1,L2,T1,T2*
FM	*Harvested wood products*	CO_2	*L1,L2,T1,T2*
AR	*Carbon stock change in living biomass*	CO_2	*L1,T1*
D	*Carbon stock change in dead organic matter (Cropland)*	CO_2	*L1*
D	*Carbon stock change in organic soils (Cropland)*	CO_2	*L1,L2,T1,T2*
D	*Carbon stock change in organic soils (Cropland)*	CO_2	*L1,L2,T1,T2*
D	*Carbon stock change in living biomass (Grassland)*	CO_2	*L1*
D	*Carbon stock change in dead organic matter (Grassland)*	CO_2	*L1,L2*
D	*Carbon stock change in dead organic matter (Settlements)*	CO_2	*L1*
D	*Carbon stock change in living biomass (Settlements)*	CO_2	*L1,L2,T2*
D	*Carbon stock change in mineral soil (Settlements)*	CO_2	*L1*
D	*Carbon stock change in organic soils (Settlements)*	CO_2	*L1,L2,T1,T2*
D	*Direct nitrous oxide (N_2O) emissions from nitrogen mineralization/ immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils (Settlements)*	N_2O	*L1,L2,T1,T2*

11.7 *INFORMATION RELATING TO ARTICLE 6*

There are no lands subject to Article 3.3 and Article 3.4 activities which are also subject to projects under Article 6.

12 INFORMATION ON ACCOUNTING OF KYOTO UNITS

12.1 *BACKGROUND INFORMATION*

Chapter 12 and 14 include Latvia's information on the Union Registry for Emissions Trading operated by the European Commission. The accounting on Kyoto units and the publicly available information is described in Chapter 12. Significant changes (if any) in the national registry are reported in Chapter 14.

The standard electronic format tables are included in the submission (see "RREG1_LV_2021_2_1" attached to the submission). The SEF tables include information on the AAU, ERU, CER, t-CER, l-CER and RMU in the Latvia's registry on 2021-12-31, information on transfers of the units in 2021 to and from other Parties of the Kyoto Protocol and carry over.

12.2 *SUMMARY OF INFORMATION REPORTED IN THE SEF TABLES*

According to decision 15/CMP.1, annex, part 1, section E each Party must include information on its aggregate holdings and transactions of Kyoto units in its annual report. The 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.

The SEF for 2021 was generated on 7 January 2022 with the Union registry version 13.5.2 r.ae6896a685d01adebff3c38ac72f91f2a7d1a953 build on 2021-12-01_11-37-43. Page ref. #517 07/01/2022 09:17:44 and the SEF application version 3.8.3, provided by the secretariat at 2018-01-26.

At the beginning of the 2021 there were 5 317 ERUs and 21 550 CERs held in entity holding accounts.

At the end of the 2021 there were 21 550 CERs and 5 317 ERUs held in the entity holding accounts.

The registry did not contain any t-CERs or l-CERs and no units were in t-CER and l-CER replacement accounts.

Latvia's CP2 assigned amount is 76 633 439 tonnes CO_2 eq.

Full details are available in the SEF tables.

In 2021, there were received the SEF comparison reports prepared by the international transaction log (ITL) administrator that provides information on the outcome of the comparison of data contained in the LV SEF tables with corresponding records contained in the ITL. There were not provided reports R2-R5 as there were no discrepancies in this report in 2021.

12.3 *DISCREPANCIES AND NOTIFICATIONS*

12.3.1 List of discrepant transactions

No discrepant transactions rejected and / or terminated with the response codes that are considered to be a discrepancy for the purpose of the reporting occurred in 2021 in Latvia's ETR.

No transactions in Latvia's ETR were cancelled or terminated.

12.3.2 List of CDM notifications

CDM notifications – reversal of storage notifications, non-certification notifications were not received in the reporting period 2021.

12.3.3 List of non-replacements

No non-replacement occurred during reporting period 2021.

12.3.4 List of invalid units

There weren't any invalid units in Latvia's ETR in the reporting period from 1st January 2021 to 31st December 2021.

12.3.5 Actions and changes to address discrepancies

There weren't any discrepant transactions that were not terminated and / or cancelled in Latvia's ETR during reporting period 2021.

12.4 *PUBLICLY ACCESSIBLE INFORMATION*

According to Article 44-48 of the decision 13CMP.1 Annex E the following information has to be publicly available:

- Article 45 – Information about the accounts opened in Latvia's Emission trading registry, account types, account holders and contact persons has been published the national administrator of Emission registry web page in file "Latvia's registry publicly accessible information".
- Article 46 – Information about Article 6 project against which the Party has issued ERUs.
- Article 47 – Information of the Kyoto Protocol units in the Latvia's Emission Trading registry opened accounts as well as transactions of Kyoto Protocol units is submitted in Standard Electronic Format.
- Article 48 - Legal entities authorized to participate in the mechanisms under Articles 6, 12 and 17 of the Kyoto Protocol. This information is provided in Annex 7.

The information required to be publicly accessible by the decisions 13/CMP/1 is available on the national administrator of Emission registry web page: https://videscentrs.lvgmc.lv/lapas/zinojums-par-klimatu (Submission under the UN Framework of Climate Change Convention Conference of the Parties decision 13/CMP.1 Annex E requirements)

As well as information on the Emission Registry of Latvia public webpage available:

https://unionregistry.ec.europa.eu/euregistry/LV/public/reports/publicReports.xhtml

The information on the accounts is also available on the European Commission webpage: http://ec.europa.eu/environment/ets/account.do;EUROPA_JSESSIONID=zyE_PpHqLkqmy0rOOeWALmfWfvpML4wVYw-l5j2-LwzuDy-fQcAX%21-198553537?languageCode=lv&account.registryCodes=LV&accountHolder=&search=Search&searchType=account&currentSortSettings

12.5 *CALCULATION OF THE COMMITMENT PERIOD RESERVE (CPR)*

Parties are required by the decision 11/CMP.1 under the Kyoto Protocol and paragraph 18 of the Decision 1/CMP.8 to establish and maintain a commitment period reserve as part of their responsibility to manage and account for their assigned amount. The commitment period reserve equals the lower of either 90% of a Party's assigned amount pursuant to Article 3(7bis), (8) and (8bis) or 100% of its most recently reviewed inventory, multiplied by 8.

Both methods are used for calculation of commitment period reserve.

1) 100% of most recently reviewed inventory, multiplied by 8:

CPR = 10,459,725 tonnes CO_2 eq * 8 = 83,677,798 tonnes CO_2 eq.

2) 90% of a Latvia`s assigned amount pursuant to Article 3(7bis), (8) and (8bis):

CPR = 76,633,439 tonnes CO_2 eq * 90% = 68,970,096 tonnes CO_2 eq.

The commitment period reserve equals the lower figure from both calculated, therefore Latvia`s commitment period reserve is 68,970,096 tonnes CO_2 eq.

12.6 *KP-LULUCF ACCOUNTING*

Latvia has chosen accounting of all KP-LULUCF activities regarding the Articles 3.3. (Aforestation, Reforestation and deforestation) and 3.4 (Forest Management) at the end of commitment period. Latvia has not elected any voluntary Kyoto Protocol LULUCF activities for the second commitment period (Table ES.3).

For the second commitment period, additions to the assigned amount of a Party resulting from forest management shall, in accordance with paragraph 13 of the annex to decision 2/CMP.7, not exceed 3.5 per cent of the national total emissions excluding LULUCF in the base year times eight.

Latvia`s Forest Management cap for the second commitment period of KP is reported in the "*Report on the review of the report to facilitate the calculation of the assigned amount for the second commitment period of the Kyoto Protocol of Latvia"*[317] and it is 7 394 541 t CO_2 eq. This value is fixed according to Article 12 of Decision 6/CMP.9.

[317] *Report on the review of the report to facilitate the calculation of the assigned amount for the second commitment period of the Kyoto Protocol of Latvia. Available: https://unfccc.int/sites/default/files/resource/docs/2017/irr/lva.pdf*

13 INFORMATION ON CHANGES IN NATIONAL SYSTEM

No changes have been made in national systems since the previous submission.

14 INFORMATION ON CHANGES IN NATIONAL REGISTRY

The following changes to the national registry of LV have occurred in 2021. Note, that the 2021 SIAR confirms that previous recommendations have been implemented and included in the annual report.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	*No changes since 2014.* *Jeļena Lazdāne-Mihalko* *National Administrator* *Latvian Environment, Geology and Meteorology Centre* *Address: Maskavas street 165, Riga, LV-1019* *Tel.: +371 67032015* *e-mail: Jelena.Lazdane@lvgmc.lv* *Aiva Puļķe* *National Administrator* *Latvian Environment, Geology and Meteorology Centre* *Address: Maskavas street 165, Riga, LV-1019* *Tel.: +371 67032015* *e-mail: Aiva.Pulke@lvgmc.lv*
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	*There has been 6 new EUCR releases (versions 12.4, 13.0.2, 13.2.1, 13.3.3 , 13.5.1 and 13.5.2) after version 11.5 (the production version at the time of the last Chapter 14 submission).* *No changes were applied to the database, whose model is provided in Annex A. No change was required to the application backup plan or to the disaster recovery plan.* *No change to the capacity of the national registry occurred during the reported period.*
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	*The changes that have been introduced with versions 12.4, 13.0.2, 13.2.1, 13.3.3, 13.5.1 and 13.5.2 compared with version 11.5 of the national registry are presented in Annex B.* *It is to be noted that 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 are carried out prior to the relevant major release of the version to Production (see Annex B).* *No other change in the registry's conformance to the technical standards occurred for the reported period.*
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	*No change of discrepancies procedures occurred during the reported period.*
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	*No changes regarding security were introduced.*
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 reported period.*
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	*No change to the registry internet address during the reported period.*
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	*No change of data integrity measures occurred during the reported period.*
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	*No change during the reported period.*

15 INFORMATION ON MINIMIZATION OF ADVERSE IMPACTS IN ACCORDANCE WITH ARTICLE 3, PARAGRAPH 14

Latvia reports the information on minimization of adverse impacts in accordance with Article 3, paragraph 14 in line with paragraphs 23-25 of the Annex to decision 15/CMP.1. Changes made since the last submission are underlined.

Parties included in Annex I that are in the position to do so, shall incorporate information on how they give priority, in implementing their commitments under Article 3, paragraph 14, to the following 6 actions, based on relevant methodologies referred to in paragraph 11 of decision 31/CMP.1.

(a) The progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse-gas-emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities.

Energy sector

1) Latvia is a country of high diversity of renewable energy sources. In 2020, the total consumption of renewable energy resources in Latvia was 74.2 petajoules (PJ), according to data of the Central Statistical Bureau (CSB). The decrease in renewable energy resources consumption in 2020 was influenced by the decrease in overall energy consumption[318]. The share of renewable energy sources in total structure of energy consumption has been increasing in recent years. Over ten years 2011–2020, renewable energy resources consumption in total energy consumption increased by 14.8%, and in 2020 was 42.4%[319]. By increasing the consumption of local energy resources, the energy dependence on imported energy resources decreased from 63.9% in 2005 to 44.0% in 2019[320].
2) Latvia has set one of the highest individual targets for the share of renewable energy by 2020 and 2030, respectively 40% and 50% of gross final energy consumption. In 2020, the actual share of renewable energy in gross final energy consumption exceeded Latvia's target totaling 42.13%[321] of gross inland energy consumption. This bring Latvia closer to its 2030 target.
3) „Sustainable Development Strategy of Latvia until 2030" is the long-term development planning document. Regarding to promotion of sustainable transport sector in Latvia, it is indicated therein that a sustainable transport infrastructure which ensures mobility inland and international reachability as well as the use of renewable energy such as electric motor technology, possibly also hydrogen engine development.

   Energy consumption in the transport sector has increased by 5.4% over five years (2016-2020), reaching 47.1 PJ in 2020. It accounts for about one third of Latvia's energy consumption and is almost entirely based on oil imports, as the share of electricity and biofuel in the transport sector is relatively insignificant. Diesel is the main source of energy used in transportation with a share of 69.3% of all fuels in 2020. Compared to

[318] CSB. Available: https://stat.gov.lv/lv/statistikas-temas/noz/energetika/preses-relizes/7127-atjaunigo-energoresursu-paterins-2020-gada?themeCode=EN
[319] CSB. Available: https://admin.stat.gov.lv/system/files/publication/2021-08/Nr_21_Latvijas_energobilance_2020_gada_%2821_00%29_LV.pdf
[320] CSB. Available: https://admin.stat.gov.lv/system/files/publication/2021-12/Nr_20_Vides_raditaji_Latvija_2020_%2821_00%29_LV_EN.pdf;
[321] CSB. Available: https://data.stat.gov.lv/pxweb/lv/OSP_PUB/START__NOZ__EN__ENA/ENA020/table/tableViewLayout1/;

2019, the consumption of diesel decreased by 6.9%. The share of LPG in transport has increased in recent years. The consumption of LPG in 2010 was 1,2 PJ but in 2020 – 1.8 PJ. Compared to 2019, the consumption of LPG has decreased by 9.6%. Consumption of petrol in the transport sector fell by 16.0% in five years, reaching 7.0 PJ in 2020, which is 3.8% less than in 2019. Electricity consumption in transport in 2020 was 339 TJ, which is 6.6% less than in 2019 (363 TJ). Compared to 2019, the consumption of electricity decreased in rail transport (by 7.4%) and pipeline transport (by 34.8%), but increased in road transport (by 2.1%)[322]. The share of renewable energy in the transport sector reached 4.73% in 2018 and 4.55% in 2019[323]. Although by 2020 this parameter must reach at least 10%, the share of renewable energy in the transport sector reached only 6.73%[324] in 2020.

Alternative Fuel Development Plan 2017-2020 was approved by the Cabinet of Ministers on 25 April 2017 (order Nr. 202) and amended on 16 April 2020 (order Nr. 189) aiming to identify the necessary research and analysis directions for the development of future policy on the introduction of alternative fuels in certain transport sectors to reduce greenhouse gas emissions. According to Cabinet Regulation No. 637 of November 3, 2015 "Specific Objective 4.4.1. “To develop electric vehicles charging infrastructure in Latvia”" it is planned to complete the Latvian national charging network by installing 139 charging stations by December 31, 2023. In 2021, the number of electric charging stations in the national network of electric vehicle charging stations (E-mobi) maintained by the Road Traffic Safety Directorate (CSDD) reached 141 units[325]. The number of registered electric cars (commercial vehicles and passenger cars) in Latvia at the end of 2021 were 2 215[326].

4) The National Energy and Climate Plan 2021-2030 (hereinafter - NECP), adopted on January 28, 2020, is a long-term energy and climate policy planning document, that defines the basic principles, goals and directions of action of the Latvian state energy and climate policy for the next ten years. The Plan was developed to ensure transition to low carbon economy by developing a balanced and effective energy policy based on market principles, promoting further development of the national economy and welfare of the society. The Plan covers objectives of all the dimensions of the Energy Union, as well as policies and measures required to reach them.

   NECP includes targets for all dimensions of the Energy Union where many numerical targets are set by EU legislation, such as the GHG reduction target, the share of energy from renewable sources in transport, the share of advanced biofuels and biogas in transport, interconnection targets or obligation, with specific conditions applicable to the purposes.

[322] *CSB. Available: https://stat.gov.lv/lv/statistikas-temas/noz/energetika/preses-relizes/7129-energoresursu-paterins-latvija-2020-gada?themeCode=EN*

[323] *CSB. Available: https://data.stat.gov.lv/pxweb/lv/OSP_PUB/START__NOZ__EN__ENA/ENA020/table/tableViewLayout1/;*

[324] *CSB. Available: https://data.stat.gov.lv/pxweb/lv/OSP_PUB/START__NOZ__EN__ENA/ENA020/table/tableViewLayout1/;*

[325] *CSDD. Available: http://www.e-transports.org/index.php/features-mainmenu-47/team/95-uzlades-punkti*

[326] *CSDD. Available: https://www.csdd.lv/cck?Itemid=327&collection=fails&file=doc_fails&id=1134&task=download&xi=4;*

Environmental taxes

Excise duty on Fuels

Articles 5 and 14 of the Law "On Excise Duties"[327] determine the rates of duty for mineral oils and their substitutes utilised for heat production. The actual rates are:

- fuel oil with the colorimetric index equal or above 2.0 and kinematic viscosity at 50°C equal or above 25 mm^2/s – 15.65 EUR/ton;
- kerosene, diesel (gas oil) and fuel oil (with the colorimetric index below 2.0 and kenematic viscosity at 50°C below 25 mm^2/s) as well as oil products and lubricants waste utilised as fuel for heat production – 60.00 EUR/ton;
- biodiesel (derived entirely from biomass) and paraffin-enriched diesel (derived from biomass) is taxed at a rate of EUR 330 per 1000 liters, if they are sold or used as fuel. Taxation rate of EUR 0 per 1000 liters is applied if relevant oil products are used as a combustion or in gas furnaces and in other equipment, not as fuel.

Articles 6^1 and 15^1 of the Law "On Excise Duties" determine the rates of duty for natural gas utilised for energy production. The taxation was in force 01.01.2010-31.08.2010 and has been re-introduced as of 01.07.2011. The differentiated rates are currently applied. The general rate is 1.65 EUR per 1 MWh (the highest calorific value). The reduced (33%, 0.55 EUR/1 MWh) rate is applied to natural gas utilised as fuel for industrial production processes as well as other processes related to production, for providing necessary climate conditions in production premises, for enterprises placed in industrial parks. The exemption is applied to natural gas utilised in agriculture sector for providing heat for greenhouses, industrial scale henhouses/sheds and incubators. The exemption from taxation is stated also for:

- natural gas utilised for other purposes (not as fuel or transport fuel) or utilised in two ways (including processes of chemical reduction, electrolytic and metallurgy processes);
- amount of natural gas used by the operator of natural gas transmission, storage and distribution system for the technological needs of natural gas supply (including losses during supply);
- natural gas utilised in mineralogy processes.

Law "On Excise Duties" establishes procedure by which duty shall be imposed. The Article 5,14 and 18 of the Law "On Excise Duties" determine the rates of duty for gasoline and diesel oil. The actual duties and their development are presented in Table 15.1.

Table 15.1 The 2016-2017, 2018-2019, 2020, and from 1 July 2021 duties for gasoline and diesel used in transport sector Duties (EUR per 1000 litres)

	2016-2017	2018-2019	2020	From 01.07.2021
Unleaded gasoline	*411.21*	*436*	*476*	*509*
Unleaded gasoline with 5% (volume) of ethanol produced from agriculture origin raw materials	*411.21*	*436*	*476*	*509*
Unleaded gasoline with 70-85% (volume) of ethanol produced from agriculture origin raw materials in Latvia or imported from EU member state	*123.36*	*131*	*30% from the base rate*	*360*

[327] *Law "On Excise Duties". Available: https://likumi.lv/ta/id/81066-par-akcizes-nodokli*

	2016-2017		2018-2019	2020	From 01.07.2021
Lead gasoline	*455.32*	*455.32*	*594*	*594*	
Diesel (gas oil);	*332.95*	*341*	*372*	*414*	
Diesel (gas oil) with any mix of biodiesel	*332.95*	*341*	*372*	*414*	
Pure biodiesel, produced in Latvia or imported from EU member state	*0*	*0*	*0*	*0*	*- (excluded from 01.02.2021)*
Oil gasses and other hydrocarbons (per 1000 kg)	*161*	*206*	*244*	*285*	

15% of the standard rate applies to the labeled diesel used in agriculture, logging, swamp processing, fish pond processing.

In accordance with the directions of the State Tax Policy Guidelines for 2021-2025 approved by the Cabinet of Ministers, it was planned to introduce a CO_2 component for oil products and natural gas in excise duty by linking with the emission allowance price (for example, initially EUR 25 per CO_2 t for oil products). Adjustments for excise duty on petroleum products should only be made if the CO_2 price increases by more than EUR 5 per CO_2 t, taking into account the CO_2 component calculated before. Unfortunately, no progress is being made in this direction, yet. Work on the State Tax Policy Guidelines for 2021-2025 in 2021 has been suspended due to other priorities.

Natural Resources Tax Law

The procedure of taxation applicable to coal, coke and lignite is prescribed by the *Natural Resources Tax Law*, Annex 9. The taxation on coal utilisation was introduced starting from the January 1st, 2007. The applied rates were doubled from 0.38 EUR GJ/t or 10,65 EUR per 1 ton if information of specific heating value is not available in 2019 to 0.76 EUR GJ/t or 21.3 EUR per 1 ton in 2020.

The exemption regarding coal utilised in electricity production and combined heat-power production has been withdrawn (starting from 2020).

Taxation applicable to the use of water for electricity production in hydropower plants (HPP) is prescribed by the *Natural Resources Tax Law*. This type of taxation has been introduced from 1 January 2014. In the period 01.01.2014-31.12.2016 this tax was applied to HPP with the capacity below 2 MW. From 01.01.2017 the tax is applied to all HPP. The current rate is EUR 0.00853 per 100 m^3 water flow through the hydrotechnical construction.

Extraction of local natural resources utilised for primary energy production. In relation to Latvia energy sector the tax rate for peat extraction may be considered, defined by Annex 1 of the *Natural Resource Tax Law*. The actual rate from the 01.01.2014 is EUR 0.55 per 1 ton of peat with moisture 40%. However, peat utilisation for energy production in Latvia is insignificant.

Taxation applicable to use of geological structures as underground natural gas storage. The procedure of taxation is prescribed in the *Natural Resources Tax Law*. The following tax rate are applied - EUR 0.0143 for pumped 100 m^3 of natural gas.

The taxation procedure of CO_2 emissions in combustion installations is also prescribed by the *Natural Resources Tax Law*. The subject of CO_2 taxation is CO_2 emissions from the polluting activities referred to Annex 2 the Law "On Pollution" for which a GHG emission permit is required and if the amount of the activity is below the limit defined for inclusion in EU Emissions Trading System. The tax rate per 1 ton of CO_2 emission has been slightly raised up from EUR 2.85 in 2014 up to EUR 4.5 in years 2017-2019. Starting from 2020 CO_2 tax has been doubled to EUR 9 per 1 CO_2 ton and increased to EUR 12 per 1 t CO_2 in 2021. The *Natural Resources Tax Law* also marks a further increase – in 2022 the CO_2 tax reaches EUR 15 per ton of CO_2. Installation operators that participate in the EU Emission Trading System or those using the renewable energy are excluded from this tax. The abolition of the CO_2 tax exemption for the use of peat for combustion plants which was in force until 2021 is recent achievement in phasing out fossil fuel subsidies.

Taxation on noxious air polluting emissions creates synergy effect with CO_2 taxation. The procedure of air polluting emissions taxation is prescribed by the *Natural Resources Tax Law*. The taxable are emissions of PM_{10} (75 EUR/ton), CO (7.83 EUR/ton), NH_3, H_2S and other non-organic compounds (18.50 EUR/ton), SO_2, NO_x, VOC, C_nH_m (85.37 EUR/ton), metals (Cd, Ni, Sn, Hg, Pb, Zn, Cr, As, Se, Cu) and their compounds recalculated for the relevant metal, V_2O_5 recalculated to vanadium (1138.30 EUR/ton).

Taxation applicable to electricity

The procedure is prescribed by the *Electricity Tax Law.* The actual rate is 1.01 EUR/MWh. According to this Law, electricity supplied to an end user, as well as electricity supplied for own consumption (exemption stated), shall be taxable. Taxpayers shall be both the entities who supply electricity to end users and have entered into contracts or otherwise agreed regarding the supply (selling) of electricity, and autonomous producers. The taxpayers shall be also end-users which purchase electricity in electricity spot exchange.

The Amendments of the *Electricity Tax Law*, that was in force from 01.01.2017 to 31.12.2020, had cancelled the most part of tax exemptions. According these Amendments only three exemptions are still in force:

- the carriage of goods and public carriage of passengers, including on rail transport and in public carriage of passengers in towns;
- household users;
- street lighting services.

Annual taxation of vehicles

The Law *„On the Vehicle Operation Tax and Company Car Tax"* established the annual taxation system for cars, that have been registered in Latvia after 01.01.2005 depending on engine size, maximal power of engine and full mass of vehicle. For cars, registered before 01.01.2005, tax rate continues to depend on the full mass of the car. Starting from 01.01.2017 the reform of cars annual taxation introduced the taxation based on CO_2 emissions specific values. The latest amendments of the Law, adopted in November 23, 2016, introduced cars annual taxation based on the specific CO2 emissions of the car. For the cars registered up to 31.12.2016 CO2 approach is applied starting from 2019 (thus, for the cars registered in the period 01.01.2009-31.12.2016 the "old approach" continued for years 2017 and 2018):

- environmental aspects: the tax is not applied to vehicles powered by an electric motor only (electric cars) and with a maximum CO_2 content of 50 g/km;
- social factors: the tax is not applied to one vehicle if the owner of the motorcycle or car is a handicapped person or a family with a handicapped child; 20% (up to 31.12.2015) and 50% (from 01.01.2016) tax rate reduction is applied to one car/family car, if the family has the status of multi-child family (three or more under-age children); state

services fulfilments - the taxation is not applied or reduced 50% tax rate is applied; the taxation is not applied to vehicles having sport vehicle or historical vehicle status;

- competitiveness of the agricultural economy: the reduced tax rate (25%) is applied to lorriesused in agriculture sector to ensure both production process and the transport of agricultural products.

An additional rate of EUR 300 for passenger cars with an engine capacity of more than 3500 cm^3 is also applied.

In 2020 amendments were introduced where the changes are mainly related to the transition from the European Driving Cycle (NEDC) to the Worldwide Harmonized Light Vehicle Test Procedure (WLTP). From 1 January 2021, for those vehicles for which only the WLTP emission figure is known, set new vehicle operating tax rates according to CO_2 emissions level. Adjustments also determined the procedure for calculation of the vehicle operating tax of a buses and trucks in accordance with the level of their engine emissions (EURO emissions level) and the number of axels.

(b) Removing subsidies associated with the use of environmentally unsound and unsafe Technologies.

As mentioned in section (a) several indirect subsidies in form of tax exemptions has been abolished: regarding coal utilisation in electricity production and combined heat-power production (from 2020) and peat exemption regarding CO_2 tax in combustion installations (from 2021).

(c) Cooperating in the technological development of non-energy uses of fossil fuels, and supporting developing country Parties to this end.

There were no collaborative studies or programs developed on capacity building and strengthening in developing country Parties.

(d) Cooperating in the development, diffusion, and transfer of less-greenhouse-gas-emitting advanced fossil-fuel technologies, and/or technologies, relating to fossil fuels, that capture and store greenhouse gases, and encouraging their wider use; and facilitating the participation of the least developed countries and other non-Annex I Parties in this effort.

There was no development, dissemination and transfer of low emissions technologies for fossil fuels and/or carbon capture and storage technologies to the developing country parties in 2020.

(e) Strengthening the capacity of developing country Parties referred to in Article 4, paragraphs 8 and 9, of the Convention to improve efficiency in upstream and downstream activities relating to fossil fuels, taking into consideration the need to improve the environmental efficiency of these activities.

There were no collaborative studies or programs developed on capacity building and strengthening in developing country Parties.

(f) Assisting developing country Parties which are highly dependent on the export and consumption of fossil fuels in diversifying their economies.

There have not been assistance projects in 2020 to diversify developing countries' economies.

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