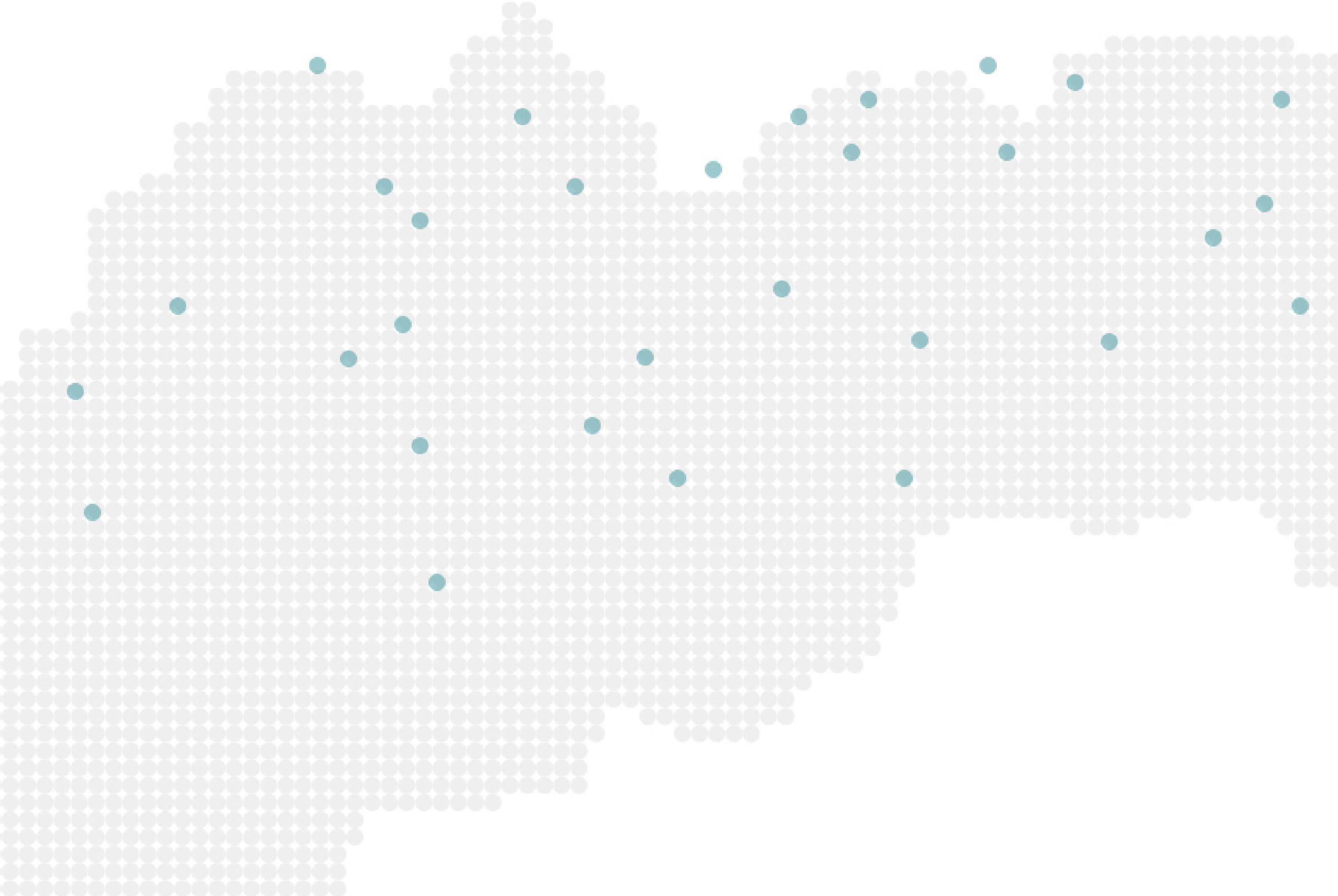
ODBOR
EMISIE
A BIOPALIVÁ



National Inventory Report 2024

SLOVAK REPUBLIC

Submission under the EU

Bratislava
June 2024

PREFACE

TITLE OF REPORT	NATIONAL GREENHOUSE GAS INVENTORY REPORT 1990 – 2022 UNDER THE EU
CONTACTS:	Compiled by Janka Szemesová Coordinator of the National Inventory System of the Slovak Republic
	Approved by Jozef Škultéty Head of the Climate Change Department of the Ministry of Environment of the Slovak Republic National Focal Point to the UNFCCC
ORGANISATION:	Slovak Hydrometeorological Institute
	Ministry of Environment of the Slovak Republic
ADDRESS:	Jeséniova 17, Bratislava
	Nám. Ľudovíta Štúra 1, Bratislava
EMAILS:	janka.szemesova@shmu.sk
	jozef.skultety@enviro.gov.sk
VERSION:	2. version
DATE OF SUBMISSION:	June, 2024

In 2024, the Slovak Republic is submitting report to the European Commission under the Article 26 (3) of the Regulation (EU) 2018/1999 and the Chapter III and Articles 8-24 of the Commission Implementing Regulation (EU) 2020/1208. The whole package of the National Inventory Report 2024 of the Slovak Republic comprises:

1. SVK NIR 2024 – Final sectoral chapters of Slovakia's National Greenhouse Gas Emission Inventory Report prepared using the UNFCCC reporting guidelines;
2. SVK_CRF_1990-2022 – CRF Tables version 2 (2024) generated using the CRF Reporter AR5 software, version 6.0.10 – AR5, accompanied by the simple xml file;
3. Tabular format specified in Articles 10-15, 17, 19-23 to the 2020/1208 Regulation.

The Slovakia inventory report as well as CRF tables can be downloaded from the following address: http://oeab.shmu.sk. GHG emissions are also published in publication Životné prostredie v SR (Chapter 1.3 Air, page 19) prepared by the Statistical Office of the Slovak Republic.

This version of the annual GHG emissions inventory is the first submission of the National Inventory Report 2024 of the Slovak Republic to the European Union under the Energy Governance. In addition, this is the fourth version of CRF tables generated as the official submission 2024 in the CRF Reporter 6.0.10 – AR5.

Submission is uploaded via the EIONET Central Data Repository tool of the EEA.

Major changes and corrections included in this SVK NIR 2024 are connected with the implementation of the IPCC 2019 Refinement and are focused on following issues:

- General: Harmonization of indirect emissions of the NOx, CO, NMVOC, SO_2 and NH_3 in line with the CLRTAP and NECD submissions reported in March 15, 2024 in all sectors (**Chapter ES.5**).
- General: Implementation of the ERT recommendations G.3, G.5 and G.6 from the final ARR 2022 (sent on 4th April 2023), in key sources and uncertainty analyses (**Chapters 1.2.8** and **1.2.9**, **Annex 1** and **Annex 3**).
- Energy: No major recalculations needed in this sector. According to the IPCC 2019 Guidelines, emissions from hydrogen production were reallocated from IPPU sector into energy category 1.A1.b. In addition, based on the new results from the Cenzus 2021 and specific survey in households, biomass consumption in the 1.A.4.b was corrected.
- Fugitive Emissions: This subcategory was recalculated based on the new classification and new emission factors included in the IPCC 2019 Refinement.
- IPPU: No major recalculations needed in this sector except f reallocation of emissions from hydrogen production into energy sector.
- Agriculture: Several recalculations focused on the major changes connected with the implementation of the IPCC 2019 Refinement.
- LULUCF: Minor recalculations in Cropland and HWP.
- Waste: Several recalculations in all categories connected with the implementation of the IPCC 2019 Refinement and the changes in activity data and methodologies.
- National Registry: Update of general information characteristics of the National Registry in the year 2023 and implementation of the ERT recommendations G.7 from the final ARR 2022 (sent on 4th April 2023) (**Chapter 14**).

More information on recalculations made in the GHG inventory preparation can be found in the sectoral chapters of this Report and the **Chapter 10**.

EXECUTIVE SUMMARY

ES.1. Background Information on Greenhouse Gas Inventories and Climate Change

Climate change is a key environmental, economic and social challenge globally and in Europe. On the one hand, most economic activities are contributing to climate change by emitting greenhouse gases or affecting carbon sinks (e.g. through land use change); on the other hand, all ecosystems, many economic activities as well as human health and well-being are sensitive to climate change.

Because the impact of the climate change differs in various regions of the world, its socio-economic and environmental impact always requires an active solution. Necessary political measures have to steam from detailed analysis of the current greenhouse gas (GHG) emissions in every sector, emission projections and impact assessment of adopted or planned policy measures. Such detailed analyses are good starting points for any policy reflected in national communication of a party prepared according to rules of the United Nations Framework Convention on Climate Change (UNFCCC).

Climate change, caused by increasing anthropogenic emissions of greenhouse gases, represents one of the most serious environmental threats for humankind. Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are the most important anthropogenic greenhouse gases with increasing concentration in atmosphere. The GHGs inventory includes also halogenated hydrocarbons (PFCs, HFCs) and SF_6, which are not controlled by the Montreal Protocol.

According to the WMO it is officially confirmed that 2023 is the warmest year on record, by a huge margin. The annual average global temperature approached 1.5° Celsius above pre-industrial levels – symbolic because the Paris Agreement on climate change aims to limit the long-term temperature increase (averaged over decades rather than an individual year like 2023) to no more than 1.5° Celsius above pre-industrial levels. Six leading international datasets used for monitoring global temperatures and consolidated by WMO show that the annual average global temperature was 1.45 ± 0.12 °C above pre-industrial levels (1850-1900) in 2023. Global temperatures in every month between June and December set new monthly records. July and August were the two hottest months on record. Long-term monitoring of global temperatures is just one indicator of climate and how it is changing. Other key indicators include atmospheric greenhouse gas concentrations, ocean heat and acidification, sea level, sea ice extent and glacier mass balance.

WMO's provisional State of the Global Climate in 2023 report, published on 30 November, showed that records were broken across the board. WMO will issue its final State of the Global Climate 2023 report in March 2024. This will include details on socio-economic impacts on food security, displacement and health.

The Paris Agreement seeks to hold the increase in the global average temperature to well below 2°C above pre-industrial levels while pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels. The Intergovernmental Panel on Climate Change says that climate-related risks for natural and human systems are higher for global warming of 1.5°C than at present, but lower than at 2°C. A study by WMO and the UK's Met Office last year predicted that there is a 66% likelihood that the annual average near-surface global temperature between 2023 and 2027 will be more than 1.5°C above pre-industrial levels for at least one year. This does not mean that we will permanently exceed the 1.5°C level specified in the Paris Agreement which refers to long-term warming over many years. The chance of temporarily exceeding 1.5°C has risen steadily since 2015, when it was close to zero. For the years between 2017 and 2021, there was a 10% chance of exceedance.[1]

The European Climate Law writes into law the goal set out in the European Green Deal for Europe's economy and society to become climate-neutral by 2050. The law also sets the intermediate target of reducing net greenhouse gas emissions by at least 55 % by 2030, compared to 1990 levels. Climate neutrality means achieving net zero greenhouse gas emissions for EU countries as a whole, mainly by cutting emissions, investing in green technologies and protecting the natural environment. The law aims to ensure that all EU policies contribute to this goal and that all sectors of the economy and society play their part. The Climate Law includes measures to keep track of progress and adjust our actions accordingly, based on existing systems such as the governance process for Member States' integrated national energy and climate plans, regular reports by the European Environment Agency, and the latest scientific evidence on climate change and its impacts. Slovakia is a part of these actions and agreed the climate neutrality until 2050 among the first countries in the EU (end of 2019).

During the year 2020, many countries were going through the worst economic contraction since the 1930s due to COVID-19 pandemic. Some economists believe it will be essentially V-shaped: first a steep fall, then a steep return to normal. In May 2020, the EU Commission proposed stimulus packages called "sustainable recovery" mostly address to investments into the buildings, transport, power and industry sectors. Aim of this plan is not only reduce emissions, but also create new jobs, make innovations and build circular economy.

On 14 July 2021, the European Commission adopted a series of legislative proposals setting out how it intends to achieve climate neutrality in the EU by 2050, including the intermediate target. The package proposes to revise several pieces of EU climate legislation, including the ETS directive, Effort Sharing Regulation, transport and land use legislation, setting out in real terms the ways in which the Commission intends to reach EU climate targets under the European Green Deal.

From 2021, the fourth EU ETS trading period has gone operational. Main change is the increase of linear reduction factor from 1.74% per annum to 2.2% per annum, which should bring at least 43% reduction within the EU ETS sectors by 2030. To achieve the ambitious reductions, several low carbon-funding mechanisms were introduced, in particular Innovation Fund (to support demonstration of innovative renewable energy and low-carbon innovation in industry, as well as carbon capture, use and storage) and a Modernisation Fund (to contribute to modernising the energy systems of 10 EU Member States with lower GDP).

[1] https://wmo.int/media/news/wmo-confirms-2023-smashes-global-temperature-record

ES.2. Summary of National Emission and Removal Trends

The GHG emissions presented in the National Inventory Report 2024 were updated and recalculated using the last updated methods based on the IPCC 2019 Refinement to the IPCC 2006 Guidelines for National Greenhouse Gas Inventories, national conditions and data published by the Statistical Office of the Slovak Republic.

Slovakia was reviewed in the UNFCCC centralised removed review during the week from 17th – 22th October 2022. As a result of the 2022 submission' review of Slovakia, "Provisional Main Findings of the ERT" was received in the end of review week. The report included several recommendations and findings in tables 1 and 2, in accordance with paragraph 84 of the annex to decision 13/CP.20. There was no Saturday Paper, but the resubmission in LULUCF and KP LULUCF sectors was required during the review week. Re-submission has impact on GHG total: in the base year 1990 – 1.3% and in 2020 – 4.1%, but only for emissions with LULUCF). Slovakia received final of the Annual Review Report 2022 and several improvements were already included in the 2023 submission. More information can be found in **Chapter 1.2**.

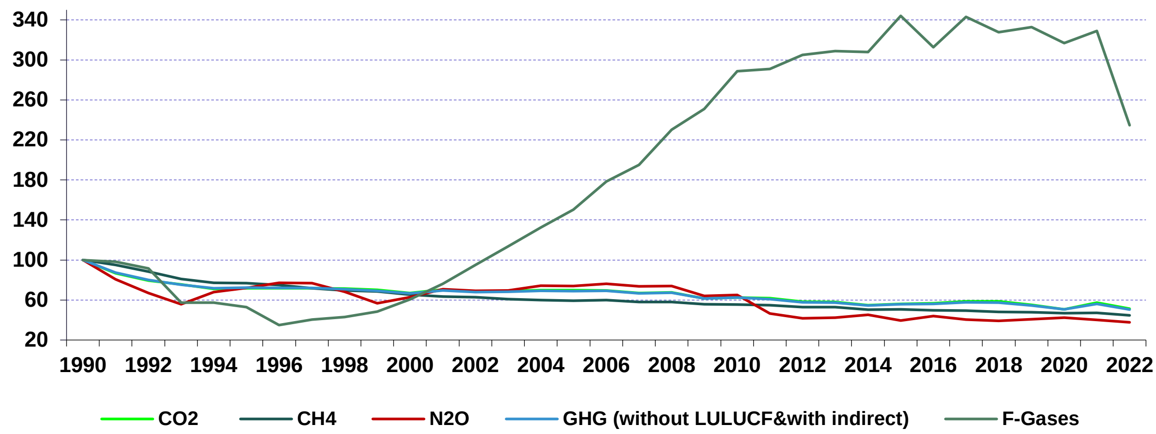
Total GHG emissions were 37 052.21 Gg of CO_2 eq. in 2022 (without LULUCF and with indirect emissions). This represents a reduction by 49.56% against the base year 1990. In comparison with 2021, the emissions decreased by 10%. The decrease in total emissions of 2022 compared to 2021 was due to decrease in the Energy and IPPU sectors.

The 2024 submission includes indirect CO_2 emissions in the solvents category (IPPU). This means, that indirect emissions were 39.50 Gg of CO_2 eq. in 2022. Indirect CO_2 emissions were estimated and reported for the time series 1990 – 2022.

The major changes in the 2024 national inventory of GHG emissions are caused by recalculations in the Fugitive Emissions, Agriculture, LULUCF and Waste sectors for the particular years or whole time series.

The emissions with LULUCF and with indirect emissions decreased in 2022 compared to 2021 by 12%. During period 1991 – 2022, the total greenhouse gas emissions in the Slovak Republic did not exceed the level of 1990. ***Tables ES.2*** and ***ES.3*** show the aggregated GHG emissions expressed in CO_2 equivalents and according to the gases in the period 1990 – 2022. ***Figure ES.1*** shows trend in the gases without LULUCF. The emissions of F-gases are only emissions from consumption HFCs, PFCs and SF_6 in industry only with the increasing trend since 1990 (despite decrease of PFCs gases from aluminium production).

Figure ES.1: *GHG emission trends compared with the base year (%) in the Slovak Republic*



GHG emissions in % to base years without LULUCF and indirect emissions; emissions are determined as of 15. 03. 2024

Slovakia decreased its emissions by around 20% between 2010 and 2022. The latest available GHG emission projections have demonstrated emissions decrease as an evidence of the successful implementation of the policies and measures and their effect on the improvement in energy intensity and industrial production efficiency. These projections were updated and reported during the year 2021 in line with the Low-Carbon Strategy of Slovak Republic (approved in February 2020 by the Government). New drivers and parameters reflecting the actual pandemic situation were projected. Actually, during the year 2024, a new emissions projection among the National Energy and Climate Plan are preparing and will be published in the First Biennial Transparency Report.

Reduction of emissions in Slovakia in past years was conjunction of different impacts starting from impressive industrial and technological restructuring connected with the fuel switching of fossil fuels from coal and oil to the natural gas (air pollution legislation since 1991 was the main driving force), economy restructuring towards the less energy intensive production (mostly in recent years) and also by temporary changes in production intensity (driven by global and EU markets). Transport (mostly the road transport), with continuously increasing emissions is an important exception. The continuous pressure is being made in formulating the effective strategy and policy to achieve further reduction of emissions in this sector too. For example, combination of regulatory and economic instruments (toll pay for freight vehicles based on their environmental characteristics in a combination with fuel and emission standards for new cars). The car tax system and the level of fuel taxation, which is close to the EU average, contribute to limit the increase of greenhouse gas emissions in the transport.

In Slovakia, the structural changes in the manufacturing industry towards less energy intensive industries such as machinery and automotive industry can explain why after 2009 the energy consumption did not pick up the same pace as prior to that year when led to a significant decrease in primary energy intensity (the GDP grew twice as fast as primary energy consumption). Therefore, the trend observed particularly in primary energy consumption is mainly due to other factors although some energy efficiency improvements did take place particularly during the period after the year 2012. The policy package still needs various improvements across the sectors including the sectoral mitigation targets particularly in transport, buildings, agriculture and waste. Preparation of the Act on Climate Change was in progress in Slovakia during 2022.

Although this optimistic trend recognised in previous years, it is visible since last 3 years, that the improvement of several indicators such as GHG per capita or GHG/GDP started slowed down and reached minimum level. GHG emissions level reached minimum in 2014 and trend is stabilised, fluctuated with increases in transport, households, waste and some industrial categories in the latest year, however, the year 2019 is the second lowest emissions' year since the base year (**Chapter 2**). Covid-19 pandemic situation occurred in 2020 in conjunction with the industrial changes in iron and steel production, transformation of electricity and heat production sectors and changes in fuels combustion caused by increasing prices led to the dramatically high decrease of the total emissions in 2020. However this optimistic development, the emission trend in 2021 increased back to the pre-pandemic level. Further reduction of emissions in 2022 was caused by the energy prices policy and due to economic reasons, several important industrial plants reduced or closed the operation. More information are in energy and IPPU sectoral chapters.

ES.3. Overview of Source and Sink Category

The emissions without LULUCF in 2022 and with indirect emissions are lower than in 2021 due to the essential decrease in Energy and IPPU sectors, mostly in energy and manufacturing industry, mineral production, chemical industry and metal industry.

The Energy sector (including transport) with the share of 69% was the main contributor to total GHG emissions in 2022. Transport with 21% share on total emissions contributes significantly to the GHG budget. In 2022, the transport in total emissions has increased by more than 3.4% in comparison with previous year 2021. In addition to fuel combustion in stationary sources of pollution, also the pollution from small sources of residential heating systems and fugitive methane emissions from transport, processing and distribution of oil and natural gas contribute significantly to the total GHG emissions. The increasing trend in transport is expected also in the next year due to increase in diesel oil.

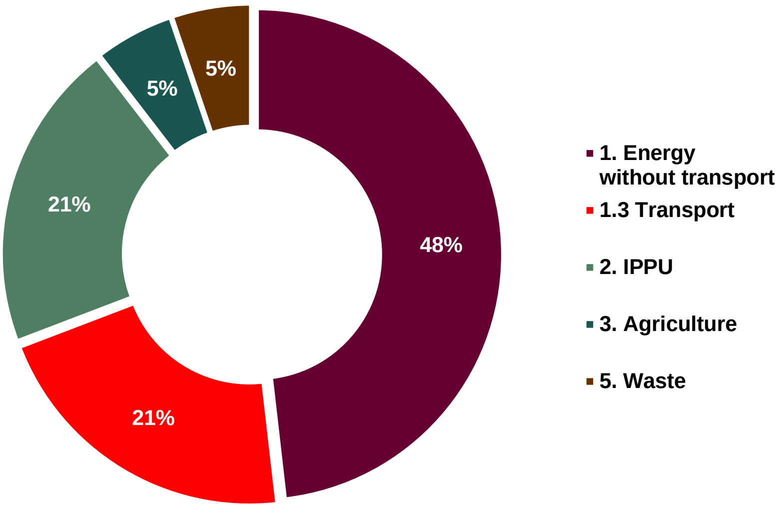
The Industrial Processes and Product Use sector was the second important sector in 2022 with its 21% share in total GHG emissions, producing mainly technological emissions from processing mineral products, chemical production and steel and iron production. The reduction of emissions from technological processes is very costly and there exist specific technical limits, therefore the emissions have not been changed since the reference year as significantly as for other categories. Mostly the production volume in industrial processes influences their level. The most growing emissions within the IPPU sector are HFCs and SF_6 emissions as result of industrial demand and use of these substances in construction, insulation of building, electro-technical and/or automobile industry.

In 2022, the share of the Agriculture sector on total GHG emissions was 5% and the trend in emissions is slightly decreasing since 1999. The most significant reduction of emissions from agriculture was achieved at the beginning of nineties as result of reduction in breeding livestock number together with restricted use of fertilizers.

The Waste sector contributed by 5% to total GHG emissions in 2022. Using of more exact methodology for the evaluation of methane emissions from solid waste disposal on sites and included also older layer into calculation resulted in continual increase of emissions by more than 100% compared to the base year 1990. Similar trend is expected to remain in future years, although the increase should not be so substantial as before. Volume of emissions from landfills depends, largely, on applied methodology to evaluate landfills and on the scale of implementation energy recovery of landfill gases by landfill operators.

The shares of individual sectors in total GHG emissions have not been changed significantly compared to the base year 1990. Nevertheless, increase in transport emissions in trend since 1990 and decreased share of stationary sources of pollution in the Energy sector are noticeable. Combustion of fossil fuels, which account for about 75% of the total CO_2 emissions in the Slovak Republic (without LULUCF), represent the most important anthropogenic source of CO_2 emissions (***Figure ES.2***, ***Table ES.4***).

Figure ES.2: *GHG emissions share by the sectors (%) in the Slovak Republic in 2022*



Aggregated GHG emissions without LULUCF and indirect emissions; emissions are determined as of 15. 03. 2024

Table ES.1: *Summary of the GHG emissions according to the gases and the sectors in 2022 and 2021*

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2022					
	Gg of CO_2 equivalents					
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
1. Energy	24 578.37	842.40	191.36	NO	NO	NO
2. Industrial Processes	6 908.01	15.02	111.05	480.86	5.91	15.38
3. Agriculture	60.84	1 129.70	743.88	NO	NO	NO
4. LULUCF	-7 316.72	45.85	45.13	NO	NO	NO
5. Waste	3.02	1724.87	202.03	NO	NO	NO
Memo Items - International Transport	*148.02*	*0.08*	*1.07*	*NO*	*NO*	*NO*
Total (excluding LULUCF)	31 550.24	3 712.00	1 248.32	480.86	5.91	15.38
Total (including LULUCF)	24 233.52	3 757.85	1 293.45	480.86	5.91	15.38

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2021					
	Gg of CO_2 equivalents					
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
1. Energy	26 777.94	999.19	203.03	NO	NO	NO
2. Industrial Processes	8 366.44	19.61	115.93	672.37	14.23	17.44
3. Agriculture	69.57	1 136.01	827.49	NO	NO	NO
4. LULUCF	-7 263.27	19.80	32.06	NO	NO	NO
5. Waste	2.04	1 762.89	178.28	NO	NO	NO
Memo Items - International Transport	*82.28*	*0.06*	*0.59*	*NO*	*NO*	*NO*
Total (excluding LULUCF)	35 216.00	3 917.71	1 324.73	672.37	14.23	17.44
Total (including LULUCF)	27 952.73	3 937.50	1 356.78	672.37	14.23	17.44

Table ES.2: *Summary of the GHG emissions according to the gases in 1990 – 2022*

GREENHOUSE GAS EMISSIONS	Base year 1990	1991	1992	1993	1994	1995	1996	1997
	Gg of CO_2 equivalents							
CO_2 emissions excluding net CO_2 from LULUCF	61 526.36	53 331.74	48 927.69	46 395.86	43 805.10	44 195.80	44 077.14	44 148.70
CO_2 emissions including net CO_2 from LULUCF	52 503.12	43 496.84	38 459.78	36 122.50	34 126.10	35 075.08	35 047.82	35 342.35
CH_4 emissions excluding CH_4 from LULUCF	8 314.12	7 893.44	7 342.52	6 729.83	6 402.39	6 398.64	6 239.34	5 970.51
CH_4 emissions including CH_4 from LULUCF	8 326.56	7 903.73	7 356.84	6 756.64	6 409.62	6 407.29	6 251.38	5 979.87
N_2O emissions excluding N_2O from LULUCF	3 313.10	2 677.63	2 216.50	1 849.83	2 252.44	2 390.56	2 561.18	2 541.23
N_2O emissions including N_2O from LULUCF	3 431.36	2 782.66	2 321.18	1 958.29	2 346.29	2 472.19	2 639.25	2 610.91
HFCs	NO	NO	NO	NO	0.20	12.38	26.31	38.33
PFCs	213.92	210.43	195.83	122.51	104.11	90.15	36.89	36.48
SF_6	0.06	0.04	0.04	0.09	18.16	10.47	11.51	11.83
Total (excluding LULUCF)	73 367.55	64 113.28	58 682.59	55 098.13	52 582.41	53 097.99	52 952.36	52 747.07
Total (including LULUCF)	64 475.03	54 393.70	48 333.68	44 960.03	43 004.48	44 067.56	44 013.15	44 019.77
Total (excluding LULUCF, including indirect emissions)	*73 455.32*	*64 199.80*	*58 768.01*	*55 182.38*	*52 665.58*	*53 180.07*	*53 033.33*	*52 826.91*
Total (including LULUCF, including indirect emissions)	*64 562.80*	*54 480.23*	*48 419.10*	*45 044.28*	*43 087.65*	*44 149.65*	*44 094.12*	*44 099.60*

GREENHOUSE GAS EMISSIONS	1998	1999	2000	2001	2002	2003	2004	2005
	Gg of CO_2 equivalents							
CO_2 emissions excluding net CO_2 from LULUCF	43 879.29	43 091.65	41 191.79	43 279.27	42 095.27	42 424.82	42 920.17	42 925.94
CO_2 emissions including net CO_2 from LULUCF	34 012.28	33 990.27	32 176.73	34 972.88	33 300.39	34 174.74	34 708.13	38 586.02
CH_4 emissions excluding CH_4 from LULUCF	5 785.99	5 684.99	5 434.78	5 278.22	5 209.32	5 060.57	4 981.35	4 919.28
CH_4 emissions including CH_4 from LULUCF	5 795.17	5 745.33	5 465.13	5 292.31	5 232.88	5 106.51	4 997.28	4 948.73
N_2O emissions excluding N_2O from LULUCF	2 256.90	1 881.24	2 082.59	2 348.13	2 286.77	2 299.92	2 463.20	2 448.86
N_2O emissions including N_2O from LULUCF	2 320.98	1 968.93	2 144.77	2 396.92	2 336.27	2 357.61	2 504.93	2 494.57
HFCs	50.73	71.82	98.20	130.29	167.96	201.17	240.28	277.09
PFCs	28.34	19.03	17.83	18.84	19.87	26.55	27.00	27.48
SF_6	13.04	13.03	13.44	13.74	15.23	15.52	15.91	16.89

GREENHOUSE GAS EMISSIONS	1998	1999	2000	2001	2002	2003	2004	2005
	Gg of CO_2 equivalents							
Total (excluding LULUCF)	52 014.27	50 761.76	48 838.64	51 068.49	49 794.42	50 028.55	50 647.91	50 615.55
Total (including LULUCF)	42 220.53	41 808.42	39 916.10	42 824.98	41 072.60	41 882.10	42 493.53	46 350.77
Total (excluding LULUCF, including indirect emissions)	*52 092.98*	*50 838.56*	*48 904.08*	*51 134.01*	*49 866.18*	*50 096.54*	*50 723.59*	*50 682.48*
Total (including LULUCF, including indirect emissions)	*42 299.24*	*41 885.22*	*39 981.55*	*42 890.50*	*41 144.36*	*41 950.09*	*42 569.21*	*46 417.70*

GREENHOUSE GAS EMISSIONS	2006	2007	2008	2009	2010	2011	2012	2013
	Gg of CO_2 equivalents							
CO_2 emissions excluding net CO_2 from LULUCF	42 751.31	41 154.07	41 551.01	37 799.53	38 462.08	38 045.88	35 963.34	35 623.26
CO_2 emissions including net CO_2 from LULUCF	35 336.67	34 169.89	35 680.21	32 144.81	33 702.59	32 917.60	29 696.22	28 637.92
CH_4 emissions excluding CH_4 from LULUCF	4 977.27	4 817.02	4 810.38	4 629.81	4 603.55	4 551.40	4 401.41	4 390.27
CH_4 emissions including CH_4 from LULUCF	4 995.88	4 847.65	4 829.59	4 658.17	4 625.99	4 578.34	4 452.96	4 407.35
N_2O emissions excluding N_2O from LULUCF	2 524.53	2 442.62	2 453.01	2 121.00	2 156.20	1 535.03	1 378.70	1 398.89
N_2O emissions including N_2O from LULUCF	2 562.15	2 484.55	2 486.36	2 158.13	2 188.89	1 570.04	1 427.25	1 430.04
HFCs	323.94	368.16	431.50	492.20	569.22	576.43	602.07	620.99
PFCs	40.96	31.39	41.43	24.50	28.27	24.63	28.62	17.02
SF_6	17.22	17.93	19.43	20.11	20.23	21.44	21.90	22.99
Total (excluding LULUCF)	50 635.23	48 831.19	49 306.76	45 087.15	45 839.56	44 754.81	42 396.04	42 073.43
Total (including LULUCF)	43 276.81	41 919.58	43 488.52	39 497.91	41 135.19	39 688.48	36 229.02	35 136.31
Total (excluding LULUCF, including indirect emissions)	*50 706.80*	*48 888.15*	*49 369.45*	*45 145.99*	*45 888.76*	*44 812.42*	*42 442.53*	*42 119.84*
Total (including LULUCF, including indirect emissions)	*43 348.38*	*41 976.54*	*43 551.22*	*39 556.75*	*41 184.39*	*39 746.09*	*36 275.51*	*35 182.73*

GREENHOUSE GAS EMISSIONS	2014	2015	2016	2017	2018	2019	2020	2021	2022
	Gg of CO_2 equivalents								
CO_2 emissions excluding net CO_2 from LULUCF	33 708.17	34 528.19	34 962.80	36 166.72	36 159.86	33 831.32	31 154.22	35 216.00	31 550.24
CO_2 emissions including net CO_2 from LULUCF	28 891.15	29 225.27	29 588.84	30 897.44	31 864.28	28 766.35	23 910.44	27 952.73	24 233.52
CH_4 emissions excluding CH_4 from LULUCF	4 188.90	4 210.78	4 134.48	4 115.98	4 004.37	3 968.27	3 900.32	3 917.71	3 712.00
CH_4 emissions including CH_4 from LULUCF	4 214.24	4 239.24	4 158.00	4 142.11	4 030.15	3 998.49	3 927.65	3 937.50	3 757.85
N_2O emissions excluding N_2O from LULUCF	1 497.84	1 311.07	1 459.77	1 337.48	1 300.15	1 353.63	1 398.87	1 324.73	1 248.32
N_2O emissions including N_2O from LULUCF	1 534.16	1 351.26	1 497.52	1 376.37	1 338.64	1 393.91	1 436.34	1 356.78	1 293.45
HFCs	626.14	704.84	647.95	710.19	675.62	688.69	646.65	672.37	480.86
PFCs	18.27	16.53	15.17	16.75	16.14	14.28	13.22	14.23	5.91
SF_6	14.60	14.75	6.00	7.30	9.68	9.14	17.73	17.44	15.38
Total (excluding LULUCF)	40 053.93	40 786.16	41 226.19	42 354.41	42 165.81	39 865.33	37 131.02	41 162.47	37 012.71
Total (including LULUCF)	35 298.58	35 551.89	35 913.48	37 150.17	37 934.50	34 870.85	29 952.03	33 951.05	29 786.97
Total (excluding LULUCF, including indirect emissions)	*40 103.47*	*40 842.50*	*41 278.70*	*42 401.89*	*42 218.93*	*39 910.63*	*37 176.89*	*41 206.13*	*37 052.21*
Total (including LULUCF, including indirect emissions)	*35 348.12*	*35 608.23*	*35 966.00*	*37 197.65*	*37 987.62*	*34 916.16*	*29 997.91*	*33 994.72*	*29 826.47*

Total aggregated GHG emissions, emissions are determined as of 15. 03. 2024, indirect emissions are reported in the 2024 submission.

Table ES.3: *Summary of the GHG emissions according to the sectors in 1990 – 2022*

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997
	Gg of CO_2 equivalents							
1. Energy	56 777.17	50 341.91	46 118.17	42 159.32	39 624.96	39 225.04	38 817.72	38 640.78
2. Industrial Processes	9 427.67	7 225.07	6 844.38	7 886.83	8 171.05	9 028.62	9 405.44	9 445.58
4. Agriculture	5 767.68	5 136.35	4 314.83	3 642.92	3 454.55	3 509.47	3 391.31	3 298.46
5. Land Use, Land-Use Change and Forestry	-8 892.53	-9 719.58	-10 348.91	-10 138.10	-9 577.92	-9 030.43	-8 939.21	-8 727.30
6. Waste	1 395.03	1 409.95	1 405.20	1 409.06	1 331.85	1 334.86	1 337.89	1 362.25

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1998	1999	2000	2001	2002	2003	2004	2005
	Gg of CO_2 equivalents							
1. Energy	38 129.26	37 375.92	36 476.86	38 381.71	36 092.42	36 919.28	36 426.18	36 885.68
2. Industrial Processes	9 555.64	9 171.96	8 191.62	8 381.92	9 315.95	8 872.47	10 099.17	9 585.07
4. Agriculture	2 940.34	2 806.38	2 731.71	2 838.82	2 831.67	2 663.01	2 509.94	2 534.66
5. Land Use, Land-Use Change and Forestry	-9 793.74	-8 953.34	-8 922.53	-8 243.52	-8 721.82	-8 146.45	-8 154.38	-4 264.77
6. Waste	1 389.03	1 407.50	1 438.45	1 466.05	1 554.38	1 573.80	1 612.63	1 610.14

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2006	2007	2008	2009	2010	2011	2012	2013
	Gg of CO_2 equivalents							
1. Energy	36 221.80	34 615.96	35 101.68	32 543.44	32 698.14	32 164.35	29 894.87	29 724.25
2. Industrial Processes	10 412.72	10 245.83	10 129.73	8 631.05	8 998.01	8 626.83	8 550.70	8 270.36
4. Agriculture	2 310.68	2 347.66	2 418.74	2 213.73	2 400.52	2 172.79	2 132.91	2 245.49
5. Land Use, Land-Use Change and Forestry	-7 358.41	-6 911.61	-5 818.24	-5 589.24	-4 704.36	-5 066.33	-6 167.02	-6 937.11
6. Waste	1 690.02	1 621.74	1 656.61	1 698.94	1 742.89	1 790.84	1 817.56	1 833.33

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2014	2015	2016	2017	2018	2019	2020	2021	2022
	Gg of CO_2 equivalents								
1. Energy	27 366.48	28 021.00	28 195.91	29 126.57	28 913.56	27 444.27	25 191.92	27 980.16	25 612.13
2. Industrial Processes	8 503.44	8 690.73	8 888.98	9 174.20	9 201.27	8 350.38	7 796.55	9 206.03	7 536.24
4. Agriculture	2 354.71	2 129.02	2 259.27	2 131.34	2 104.17	2 140.13	2 168.07	2 033.07	1 934.43
5. Land Use, Land-Use Change and Forestry	-4 755.36	-5 234.27	-5 312.70	-5 204.25	-4 231.31	-4 994.47	-7 178.98	-7 211.42	-7 225.74
6. Waste	1 829.31	1 945.41	1 882.02	1 922.30	1 946.82	1 930.55	1 974.48	1 943.21	1 929.92

Total aggregated GHG emissions, emissions are determined as of 15. 03. 2024, indirect emissions are reported in the 2024 submission.

ES.5. Indirect Emissions and Precursors of Greenhouse Gases

The Slovak Republic is providing here the estimate of CO, NOx, SO_2 and NMVOC emissions for the years 1990 – 2022 originally submitted under the NECD and the CLRTAP on February 15, 2024. The latest (March) data is included in CRF tables 1990 – 2022 generated by the CRF Reporter software v.6.0.10_AR5 as a part of annual GHG inventory submitted in March 15, 2024. According to the new rules for the reporting of the air pollutants recalling the Article 8(1) and the Annex I of the NECD, annual emission reporting requirements as referred to in the first subparagraph of the Article 8(1) for the years after the year 2017 was set for the emissions inventory in February, 15 and for the informative inventory reports (IIR) or emissions data resubmission in March, 15, respectively. Among others for example:

- In the Energy sector, emissions of NOx, NMVOC, SOx and CO in the categories 1.A.3.d.i.i and 1.A.4.b.i changed based on update of the activity data for fuel consumption.
- In the IPPU sector, emissions for historical years 1990 – 1999 from the category 2.H.2, changed as a result of the activity data update which resulted in recalculations of emissions of NMVOC.
- In the Agriculture sector, in categories 3.B.3, 3.B.1, 3.B.4 and 3.D.a.2.a emissions of NOx changed as a result of implementation of the IPCC 2019 Refinement and implementation of the 2023 EMEP/EEA Guidebook. In category 3.B.1, NMVOC emissions changed based on EU recommendation. In the category 3.B.4.h, NOx and NMVOC emissions changed due to implementation of a new methodology based on tier 1 method available in the 2023 EMEP/EEA Guidebook.
- In the Waste sector, emissions of NMVOC in the categories 5.A and 5.B.2 were recalculated due to an addition of the new activity data to the calculation based on the change in the EMEP/EEA GB version 2023.

These changes are resulted to the methodological changes in the NECD inventory and are reflected in the March 15, 2024 NECD submission and consequently provided in the GHG inventory submission 2024. According to the analyses, there are no larger inconsistencies (+/-5%) in the reporting under NECD (or CLRTAP) (submitted on 15/03/2024) and the GHG inventory (submitted on 15/03/2024). Due to differences in methodology, small inconsistencies occurred in the emissions from forest fires that are not included in the NECD inventory and emissions of NOx in manure management are not included directly in the GHG inventory (indirect N_2O emissions are calculated based on NOx emissions in the category 3.B.2 – Manure Management). More information can be found in **Chapter 10.1**.

Table ES.4: *Summary of the indirect GHG emissions according to the gases and the sectors in 2022*

EMISSIONS	TOTAL	ENERGY	INDUSTRY	AGRICULTURE	LULUCF	WASTE
	Gg					
NOx	55.10	41.97	5.27	6.43	1.05	0.39
CO	339.00	218.93	70.11	NO	37.28	12.67
NMVOC	83.12	50.23	25.60	5.92	0.64	0.72
SO_2	13.22	8.47	4.70	NO	0.03	0.01

Emissions of main pollutants are available in public databases:

- ŠÚ SR in the STATdat database.
- SHMÚ website – Air Emission Accounts data for the years 2008 – 2021 are available as the aggregates in format of separate PDF files for particular gases.

CHAPTER 1. INTRODUCTION

1.1. Background Information on Greenhouse Gas Inventories and Climate Change

1.1.1. Climate Change

The greenhouse effect of the atmosphere is similar to the effect that may be observed in greenhouses, however the function of glass in the atmosphere is taken over by the "greenhouse gases" (international abbreviation GHGs). Short wave solar radiation is transmitted freely through the greenhouse gases, falling to the earth's surface and heating it. Long wave (infrared) radiation, emitted by the earth's surface, is caught by these gases in the major way and partly reemitted towards the earth's surface. Because of this effect, the average temperature of the surface atmosphere is 33°C warmer than it would be without the greenhouse gases. Finally, this enables the life on our planet.

The most important greenhouse gas in the atmosphere is water vapour (H_2O), which is responsible for approximately two thirds of the total greenhouse effect. Its content in the atmosphere is not directly affected by human activity, in principle it is determined by the natural water cycle, expressed in a very simple way, as the difference between evaporation and precipitation. Carbon dioxide (CO_2) contributes to the greenhouse effect by 30%, methane (CH_4), nitrous oxide (N_2O) and ozone (O_3); all three together contribute by 3%. The group of synthetic (artificial) substances – chlorofluorocarbons (CFCs), their substitutes, hydrofluorocarbons (HCFCs, HFCs) and others such as fluorocarbons (PFCs) and SF_6, also belong to the greenhouse gases. There are other photochemical active gases as well, such as carbon monoxide (CO), oxides of nitrogen (NO_x) and non-methane organic compounds (NM VOC), which do not belong to the greenhouse gases, but contribute indirectly to the greenhouse effect of the atmosphere. They are registered together as the precursors of ozone in the atmosphere, as they influence the formation and disintegration of ozone in the atmosphere.

Despite setbacks from COVID-19, global greenhouse gas emissions increased in 2021. In 2021, greenhouse gas concentrations reached new highs, with globally averaged surface mole fractions for carbon dioxide (CO_2) at 415.7 ± 0.2 parts per million (ppm), methane (CH_4) at 1908 ± 2 parts per billion (ppb) and nitrous oxide (N2O) at 334.5 ± 0.1 ppb, respectively, 149%, 262% and 124% of pre-industrial (1 750) levels.

Carbon dioxide (CO_2) is a long-lived greenhouse gas that accumulates in the atmosphere. When CO_2 sources and sinks are in net balance, concentrations of CO_2 will have a small variability. That was the case over the 14 000 years that preceded the industrial era, which started around 1 750 AD. Emissions from burning fossil fuels and changing land uses have led to an increase in CO_2 in the atmosphere from the pre-industrial level of 280 parts per million (ppm) to current levels that are over 410 ppm (this means 410 CO_2 molecules per million of air molecules or 0.041% of all air molecules).

Methane (CH_4) is the second most important long-lived greenhouse gas and contributes about 17% of radiative forcing. Approximately 40% of methane is emitted into the atmosphere by natural sources (e.g., wetlands and termites), and about 60% comes from human activities like cattle breeding, rice agriculture, fossil fuel exploitation, landfills and biomass burning.

Nitrous Oxide (N_2O) is emitted into the atmosphere from both natural (about 60%) and anthropogenic sources (approximately 40%), including oceans, soil, biomass burning, fertilizer use, and various industrial processes. Nitrous oxide also plays an important role in the destruction of the stratospheric ozone layer, which protects us from the harmful ultraviolet rays of the sun. It accounts for about 6% of radiative forcing by long-lived greenhouse gases.

According to the global climatologic classifications, the Slovak Republic is located in the mild climate zone with mean monthly precipitation totals equally distributed over the whole year. The Atlantic Ocean affects more the western part of the country and the continental influence is more typical for the eastern part. The Mediterranean climate influences mainly the south of the central part of Slovakia by higher precipitation totals in autumn. A regular rotation of spring, summer, autumn and winter seasons is typical for the country. However, the overall increase of GHGs emissions concentration caused significant climatic changes in the temperature, water regime and extreme weather events in Slovakia.

Detail climatic measurements at several meteorological stations and more than 200 precipitation gauges since 1881 has enabled us to prepare the study on climate change and variability for the period of 1881 – 2022. It is also possible to separate natural causes of climate changes from those induced by enhanced atmospheric greenhouse effect (using global and regional climatic analyses).

Information on climate changes in Slovakia can be found in the Eight National Communication of the Slovak Republic and in the Fifth Biennial Report of Slovakia to the UNFCCC published in February 2023.

1.1.2. Greenhouse Gas Inventories

This National Inventory Report (NIR) of Slovakia for the submission to the EU, the UNFCCC and to the Kyoto Protocol includes data of the anthropogenic emissions by sources and removals by sinks of all greenhouse gases (GHGs) not controlled by the Montreal Protocol, i.e. carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), and sulphur hexafluoride (SF_6). Emissions of nitrogen trifluoride (NF_3) did not occurred in Slovakia and appropriate notation key was used in inventory.

Indirect CO_2 and N_2O emissions resulting from atmospheric oxidation of NH_3, CH_4 and NMVOC emissions from non-biogenic sources are also included in the inventory in the sectoral tables (IPPU and Agriculture). The indirect CO_2 emissions have been evaluated and included in the IPPU sector consistent with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (the IPCC 2006 GL) since the base year. Indirect N_2O emissions resulting from a deposition of nitrogen due to emissions of nitrogen oxides (NOx) and ammonia (NH_3) are estimated and indirect N_2O emissions from agricultural sources are included in the national total emissions consistent with the UNFCCC reporting guidelines in the Annex to Decision 24/CP.19 (UNFCCC 2013).

The SVK NIR 2024 includes also estimates of so-called indirect greenhouse gases and precursors (carbon monoxide (CO), nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO_2 meaning sulphur oxides and other sulphur emissions calculated as SO_2). Indirect greenhouse gases and sulphur dioxide do not have a direct warming effect, but influence on the formation or destruction of direct greenhouse gases, such as tropospheric ozone. These gases are not included in Annex A of the Kyoto Protocol, but are included in consistent way in the GHG inventory submission since the year 1990 (**Chapter ES.5**). The emissions and removals estimates are presented by gas and by category and refer to the latest inventory year unless otherwise specified. Full time series of the emissions and removals from 1990 to latest inventory year are included CRF tables, which are part of the inventory submission. In the NIR, the data is presented for a limited set of years consistent with the UNFCCC reporting guidelines.

The structure of this NIR follows the UNFCCC Reporting Guidelines. According to the emissions inventory submitted in March 15, 2024, the Slovak Republic total anthropogenic emissions of greenhouse gasses expressed as CO_2 equivalent decreased by more than 49% without LULUCF and with indirect emissions, compared to the base year 1990. This achievement is the result of impacts of several processes and factors, mainly:

- Recovery and investments after the Covid-19 pandemic impacts on transport, industry and services.
- Higher share of services on the GDP.

- Technological restructuring and change in structure of industries.
- Higher share of gaseous fuels on consumption of primary energy resources.
- Gradual decrease in energy consumption for certain energy intensive sectors.
- Impact of air protection legislation, which regulates directly or indirectly generation of greenhouse gas emissions.
- Global energy crises started in 2022 and increasing of fuel prices due to Ukraine war.
- Increase of energy efficiency and share of the renewable energy sources on final consumption.
- Phased-out one of three furnaces in the US Steel company (iron and steel producer) in June 2019 mostly caused decrease of EU ETS emissions in comparison with the ESD emissions (non-EU ETS). Re-introduction of the phased-out furnace took place in beginning of 2021, so the increase of emissions can be found in 2021 inventory. In 2022, further decrease in emissions of EU ETS occurred due to high fuel prices, several operators phased-out or reduced production. This, along with other factors, caused the changes in the share of allocated emissions in the EU ETS and the ESD/ESR; in the EU ETS (47%) and the ESD/ESRR (53%) (***Table 1.1***).
- Implementation of strict policies and measures in climate change and international agreements up to 2030 focused mostly on the EU ETS categories.
- Less intensive winter seasons, lower fuel consumption for heating.
- Higher share of biomass in the residential heating sector.

In May 2004, the Slovak Republic joined the European Union. Relevant European legislation has brought additional positive direct and indirect effects to the reduction of GHG emissions, mainly in the Energy sector. The introduction of emission trading system will allow the implementation of further reduction measures in all installations included in the EU ETS.

Table 1.1: *Total GHG emissions in the EU ETS and ESD/ESR for the years 2018 – 2022*

YEAR	2022	2021	2020	2019	2018
	Gg of CO_2 equivalents				
Total greenhouse gas emissions without LULUCF and with indirect emissions	37 052.2	41 206.1	37 176.9	39 910.6	42 218.9
Total verified EU ETS emissions	17 418.2	20 898.9	18 170.0	19 903.8	22 193.4
CO_2 emissions from 1.A.3.A civil aviation	1.5	1.3	0.9	1.8	2.9
Total verified ESD/ESR emissions	19 632.5	20 306.0	19 006.0	20 005.0	20 022.7

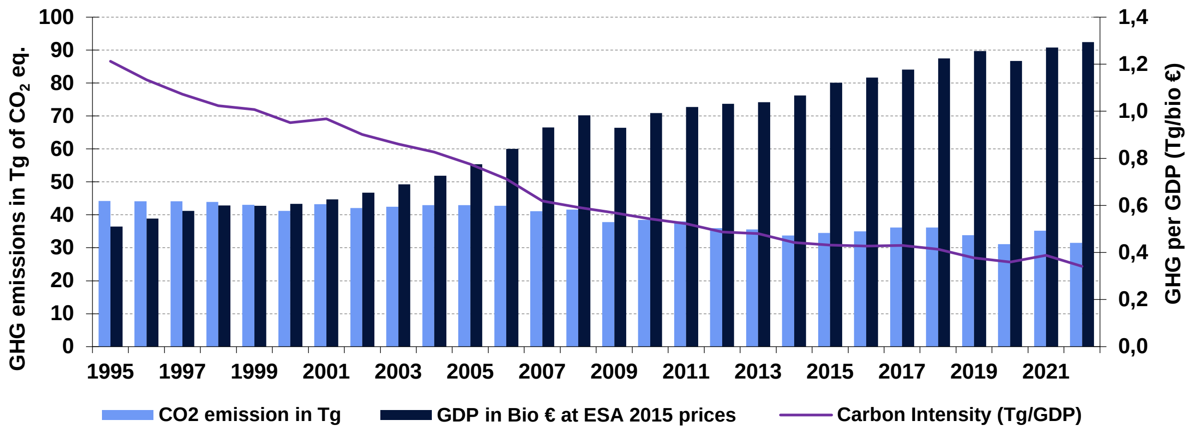
** preliminary data*

Table 1.2 and ***Figure 1.1*** show the most significant trend indicator of GDP and GHG emissions decoupling which was achieved in Slovakia in past years. In addition, development in the last inventory year (2022) is an evidence of continuation of decoupling process started in the 1997 and continuing after economic crises in 2009. With the recovery of economy, carbon emissions did not follow GDP growth. This is a signal of total reconstruction of Slovak economy and industry. It is also expected, that similar trend will continue in the future, while there are planned investments in energy saving and efficiency and step by step building a carbon neutral economy.

Table 1.2: *Decrease of carbon intensity per GDP in the Slovak Republic in 2007 – 2022*

YEAR	2007	2008	2009	2010	2011	2012	2013	2014
CO_2 **emission *in Tg***	41.15	41.55	37.80	38.46	38.05	35.96	35.62	33.71
GDP *in Bio* € at ESA 2015 prices	66.53	70.24	66.41	70.87	72.76	73.72	74.19	76.19
Carbon Intensity *in Tg/GDP*	0.62	0.59	0.57	0.54	0.52	0.49	0.48	0.44
YEAR	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
CO_2 **emission *in Tg***	34.53	34.96	36.17	36.16	33.83	31.15	35.22	31.55
GDP *in Bio* € at ESA 2015 prices	80.13	81.68	84.08	87.47	89.67	86.68	90.83	92.42
Carbon Intensity *in Tg/GDP*	0.43	0.43	0.43	0.41	0.38	0.36	0.39	0.34

Figure 1.1: *Comparison of CO_2 emissions per GDP (carbon intensity) in 1995 – 2022*



The Slovak Statistical Office, Dpt. of National Accounts. Within the revision of annual national accounts (base year 2015), year 2022 – preliminary.

1.1.3. International Agreements

International agreements under the UN:

United Nations Framework Convention on Climate Change (UNFCCC):

- Adopted on May 9, 1992 in New York
- Adopted by the Slovak Republic on May 19, 1993
- Ratified by the Slovak Republic on August 25, 1994
- Entry into force for the Slovak Republic on November 23, 1994

The aim of the Convention is to stabilize the atmospheric concentrations of greenhouse gases to a safe level that enables adapting of ecosystems and to prevent the dangerous consequences of the impact of anthropogenic activity.

Commitments:

- The level of emissions in 2020 must not exceed the level of 1990
- Prepare and annually submit greenhouse gas inventories
- Prepare and implement national mitigation programs
- Support sustainable management and cooperate in maintaining and increasing the number of captures of greenhouse gas emissions
- Take into account climate change in the appropriate extent within the relevant social, economic and environmental measures and actions

Kyoto Protocol (KP)

- Adopted on 11 December 1997 in Kyoto

- Adopted by the Slovak Republic on February 26, 1999
- Entered into force for the Slovak Republic on February 16, 2005
- Amendment to KP adopted on December 8, 2012 in Doha, Qatar

In a response to the significant increase in GHG emissions since 1992, legally binding agreement known as the Kyoto Protocol was adopted. Developed countries, listed in Annex I to the Convention, should reduce six GHGs emissions (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6) individually or together by 5.2% on average compared to the year 1990 during the first commitment period 2008 – 2012. The Kyoto Protocol also defined instruments for achieving the maximum reduction potential - such as joint fulfilment of obligations or emissions trading. Slovakia is committed to reducing emissions by 8%. Doha Amendment was negotiated to define a second binding (reduction) period (2013-2020) with the aim of reducing developed countries' emissions by 20% compared to the base year (mostly 1990, but negotiated separately for each side). Slovakia fulfilled the reduction targets for the first and the second commitment periods with a large difference in positive way. Currently, the GHG emissions without the LULUCF and without indirect emissions are almost 50% of the 1990 level.

Paris Agreement (PA)

- Adopted on 12 December 2015 in Paris
- Adopted by the Slovak Republic on April 22, 2016
- Ratified by the Slovak Republic on September 28, 2016
- Entered into force for the Slovak Republic on November 4, 2016

The Paris Agreement central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C. Monitoring, reporting and reducing emissions, including adaptation to climate change, is mandatory for all countries, not just those listed in Annex 1 to the Convention. Emissions reduction action plans, defined as nationally determined contributions (NDCs), set targets for reducing greenhouse gas emissions by 2025 or 2030, along with adaptation to the climate change. Countries should review and tighten their NDCs every 5 years to achieve carbon neutrality by 2050.

International agreements under the EU:

The European Union (EU) considers climate change as one of the four environmental priorities. On November 28, 2018, the European Commission presented its Long-Term Strategy for a prosperous, modern, competitive and climate-neutral economy by 2050. The Low-Carbon Development Strategy of the Slovak Republic until 2030 with a View to 2050 was adopted by the Government of the Slovak Republic by the Resolution No 104/2020. The European Commission launched the European Climate Pact in December 2020, an EU-wide initiative inviting people, communities and organisations to participate in climate action and build a greener Europe. As part of the European Green Deal, the Climate Pact offers a space for everyone to share information, debate and act on the climate crisis, and to be part of an ever-growing European climate movement. The Commission's proposal to cut greenhouse gas emissions by at least 55% by 2030 and 90% by 2040 sets Europe on a responsible path to become climate neutral by 2050.

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

The Regulation (EU) 2018/1999 together with Commission implementing Regulation EU) 2020/1208 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 integrated rules to ensure planning, monitoring and reporting of progress towards its 2030 climate and energy targets and its international commitments under the Paris Agreement have been adopted. The Regulation established a governance mechanism for the implementation of strategies and measures designed to meet the objectives and targets of the Energy

Union and the EU's long-term greenhouse gas emission commitments under the Paris Agreement, in particular the EU's ambition to achieve climate neutrality by 2030. Slovakia submitted the 2021 – 2030 draft plans under the Regulation on the Governance by the end of 2018 and final plans by the end of 2019. The Commission has assessed these both at EU and Member State level. The update of the national energy and climate plans is expected by the end of June 2023 in a draft form and by 30 June 2024 in a final form to reflect an increased ambition.

1.2. Description of the National Inventory Arrangements

1.2.1. Institutional, Legal and Procedurals Arrangements

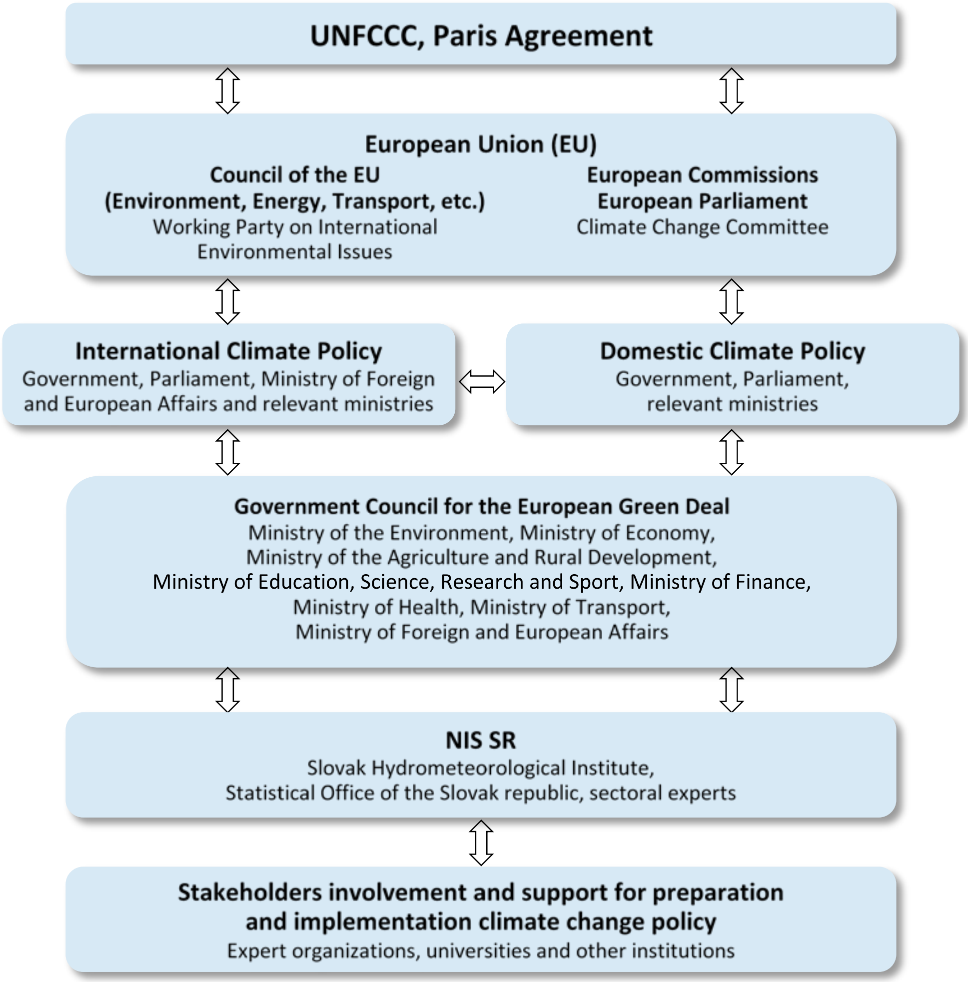
The Ministry of Environment of the Slovak Republic (MŽP SR) is responsible for development and implementation of national environmental policy including climate change and air protection objectives. It has the responsibility to develop strategies and further instruments of implementation, such as acts, regulatory measures, economic and market based instruments for cost efficient fulfilment of adopted goals. All ministries and other relevant bodies annotate both, the conceptual documents as well as legislative proposals. Following the commenting process, the proposed acts are negotiated in the Legislative Council of the Government, approved by the Government, and finally by the Slovak Parliament. The Ministry of Environment of the Slovak Republic is the main body to ensure conditions fulfilment and to monitor progress of the Slovak Republic for meeting all commitments and obligations of climate change and adaptation policy.

According to the Governmental Resolution No 821/2011 Coll. from 19th December 2011, minister of the Environment established the inter-ministerial High-Level Committee on Coordination of Climate Change Policy (HLC CoCCP) by Decision No 1/2012-8.1 from the January, 13th 2012. This Committee was created at the state secretary level and replaced previous coordinating body, i.e. the HLC CoCCP established in August 2008. Committee was chaired by the State Secretary of MŽP SR; other members were the state secretaries of the Ministry of Economy, Ministry of Agriculture and Rural Development, Ministry of Transport and Construction, Ministry of Education, Science, Research and Sport, Ministry of Health, Ministry of Finance, Ministry of Foreign Affairs and the Head of the Regulatory Office for the Network Industries. ***Figure 1.2*** provides in depth overview diagram showing the institutional arrangements concerning climate policy and its implementation.

Main objective of the HLC CoCCP was an effective coordination at developing and implementation of mitigation and adaptation policies and selection of appropriate measures to fulfil international obligations. An important output of its activities was also "Report on the Current State of Fulfilment of the International Climate Change Policy Commitments of the Slovak Republic" ("Správa o priebežnom stave plnenia prijatých medzinárodných záväzkov SR v oblasti politiky zmeny klímy"), regularly submitted to the Government, with aim to inform it on the basis of a detailed analysis of current progress on this issue. The first was in June 2012 and the latest was approved by the government in April 2024. This type of report will be published irregularly after 2019.

The role of HLC CoCCP has been replaced by Council of the Government of the Slovak Republic for the European Green Deal (CG EGD) which first session took place in April 20, 2021. CG EGD serves as expert, advisory, coordinating and initiative body of the Government of the Slovak Republic for matters relating to the European Green Deal as vision for achieving the sustainable development goals (i.e. national priorities for the implementation of the Agenda 2030 for sustainable development) and the transition to a carbon-neutral economy by 2050 and the related implementation of key policies and measures aimed at achieving climate and environmental goals and the continuing transformation of the economic, environmental, energy and social system of the Slovak Republic, including transformation of industry, agriculture, transport, tourism, manufacturing, non-productive, consumer and social areas. The CG EGD is chaired by minister for the Environment; other members are relevant ministers and representatives of state bodies and National Council of the Slovak Republic, local government authorities, self-government representatives and representatives of academy.

***Figure 1.2:** Institutional arrangements in climate change policy and its implementation*



The Ad-hoc Expert Group for preparing of the Adaptation Strategy of the Slovak Republic on Adverse Impacts of Climate Change and Ad-hoc Expert Group for preparing Low-Carbon Strategy of the SR were created under the HLC CoCCP in 2012. These expert groups include experts from other relevant ministries, academic, university positions, and other expert institutions. The Government Resolution No 148/2014 adopted the National Adaptation Strategy in March 26, 2014. The updated strategy has undergone the process of strategic environmental assessment under Act No 24/2006 Coll. On Environmental Impact Assessment. Strategy for the Adaptation of the Slovak Republic to Climate Change was updated and approved on October 17, 2018 by Government Resolution No 478/2018. The Climate Change Adaptation National Action Plan was supposed to be submitted to the Government by December 31, 2020. However, Government of the Slovak Republic prolonged submission by the end of August 2021. This Action Plan was approved on August 31, 2021 by Government Resolution No 476/2021.The preparation of the Climate Change Adaptation National Action Plan, which began in 2018, was under the auspices of the MŽP SR in cooperation with the Institute for forecasting of the Slovak Academy of Sciences. Based on qualitative and quantitative analyses, adaptation measures were prioritized in the Action Plan. The short-term measures for the period 2021 – 2023 and the medium-term for the period 2024 – 2027 were identified. The Action Plan contributes to a better reflection of adaptation measures in the 7 sectors – water protection, water management and water use, sustainable agriculture, adapted forestry, the natural environment and biodiversity, health and healthy population, adapted residential environment and technical, economic and social measures. Each of these 7 sectors has its specific goal, each of which has defined its basic principles and specific measures that define the tasks in a given sector. A total of 45 specific measures were identified and within them 169 tasks for the period of validity of the Action Plan until 2027. These measures and the related tasks are based on the updated National Adaptation Strategy. This Action Plan has undergone the process of strategic environmental assessment under Act No 24/2006 Coll. On Environmental Impact Assessment.

According to Government Resolution No 478/2018 – the first Information on the progress made in implementing adaptation measures on national level in the Slovak Republic shall be submitted to Government by 28. February 2023. This Information was approved by the Government Resolution No 110/2023. Following the Government Resolution No 476/2021 considering National Action Plan on Adaptation – the Information on short-term targets progress (of NAP) to the Government will be reported by 30. June 2024. The next planned revision of the National Adaptation Strategy taking into account new scientific knowledge on climate change is planned in 2025. According to Government Resolution No 478/2018 the next National Adaptation Strategy shall be submitted to the Government by 31. December 2025. National Adaptation Strategies, Action Plan, Government Resolutions and other data relevant to adaptation to climate change in Slovak Republic are available (in Slovak language) on the MŽP SR website.

On the EU level, according to the Regulation on the Governance of the Energy Union and Climate Action by 15 March 2021, and every two years thereafter, Member States shall report to the Commission information on their national climate change adaptation planning and strategies, outlining their implemented and planned actions to facilitate adaptation to climate change, including the information specified in Part 1 of Annex VIII and in accordance with the reporting requirements agreed upon under the UNFCCC and the Paris Agreement.

The Low-Carbon Development Strategy of the Slovak Republic until 2030 with a View to 2050 (LCDS), adopted in March 2020, aims to identify measures, including additional measures, to achieve climate neutrality in the Slovak Republic by 2050. The aim of the LCDS is to outline options for a comprehensive long-term (30-year) strategic roadmap for moving to a low-carbon economy, which will be completed by achieving climate neutrality by 2050. The LCDS identifies key policies and measures that will lead to achieving the headline target of the Paris Agreement – keeping the increase in global temperature this century to well below 2°C and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels. The LCDS aims to select and analyse cost-effective measures in terms of the scope of emission reductions and the economic and social impact. The measures envisaged in the near future, detailed, and modelled in the strategy under the WEM and WAM scenarios raised the fact that climate neutrality in Slovakia cannot be achieved by 2050 with them. Therefore, the strategy also includes additional measures (called NEUTRAL) which should move Slovakia closer to its goal by 2050. Whether this happens will be analysed in detail in the near future as part of the updating process. The implementation of the measures will require the active involvement of the relevant sectors, the interconnection and consolidation of the individual sectoral and crosscutting policies, and society-wide engagement. Consistent horizontal implementation of measures that are in harmony with the objective of achieving climate neutrality by the middle of this century and in line with this strategy is to be ensured by the Council of the Government of the Slovak Republic for the European Green Deal, the adoption of which is expected together with this Strategy.

Consistent horizontal implementation of measures in line with the objectives of climate neutrality by 2050 and in line with the LCDS is to be ensured by the Council of the Government of the Slovak Republic for the European Green Deal and Low-Carbon Transformation, adopted by the Government Resolution No 699 of November 4, 2020.

Thanks to the new approved environmental policy Greener Slovakia – Strategy of the Environmental Policy of the Slovak Republic until 2030 (the Envirostrategy 2030), Slovakia determined a way of how to face the biggest environmental challenges and address the most serious environmental problems. The Slovak Government approved the Envirostrategy 2030 on February 27, 2019.

Articles 4 and 12 of the UNFCCC require the Parties to the UNFCCC to develop, periodically update, publish, and make available to the Conference of the Parties their national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled under the Montreal Protocol. Moreover, the commitments require estimation of emissions and removals as a part of ensure that Parties are in compliance with emission limits, that they have a national system for estimation of sources and sinks of greenhouse gases, that they submit an inventory annually, and that they formulate national programs to improve the quality of emission factors, activity data, or methods. The obligation of the Slovak Republic to create and maintain the National Inventory System of the Slovak Republic (SVK NIS) which enables continual monitoring of greenhouse gases emissions is given by Article 5, paragraph 1 of the Kyoto Protocol.

Setting up the SVK NIS of emissions in compliance with the Kyoto Protocol requirements was framed with functions which it should fulfil according to the decision 19/CMP.1. The basic characteristics of the SVK NIS are as follows:

- To ensure linkages and co-operation among involved institutions, bodies and individuals to perform all activities for monitoring and estimation of GHG emissions from all sectors/categories according to the UNFCCC guidelines and relevant decisions and according to the approved IPCC methodologies. To enable using of all relevant data from national and international databases for preparing and improving GHG emission inventory.
- To define role and competencies of all involved stakeholders including the role of National Focal Point to the UNFCCC.
- To define and regularly implement quality assurance and quality control (QA/QC) process in two lines; both internally and externally by appropriate body.
- To ensure ongoing process of development capacities; financial, technical and expert sources in relation to QA/QC but also in relation to new tasks rising from the international process.

The National Inventory System of the Slovak Republic was established and officially announced by Decision of the Ministry of Environment of the Slovak Republic on 1st January 2007 in the official bulletin: Vestnik, Ministry of Environment, XV, 3, 2007. In agreement with paragraph 30(f) of Annex to Decision 19/CMP.1, which gives the definitions of all qualitative parameters for the SVK NIS, the description of quality assurance and quality control plan according to Article 5, paragraph 1 is also required. The revised report of the SVK NIS dated on November 2008 was focused on the changes in the institutional arrangement, quality assurance/quality control plan and planned improvements. The regular update of the SVK NIS with all qualitative and quantitative indicators is provided in the NIRs and was provided in the Eight National Communication of the SR on Climate Change, published in February 2023 and in the Fifth Biennial Report in 2023.

The role of responsible ministries in the national system

The MŽP SR is responsible for implementation of national environmental policy including climate change and air protection. It serves also as the National Focal Point to the UNFCCC.

District and regional environmental offices are decision-making bodies according to Act No 525/2003 Coll. These are located at eight regional and 46 district administration offices. The four inspectorates of the Slovak Environmental Inspection carry out inspection and enforcement activities. According to the Act No 146/2023 Coll. on Air Protection, competencies and decision-making process concerning large, medium and small pollution sources are given to regional and district levels and municipalities.

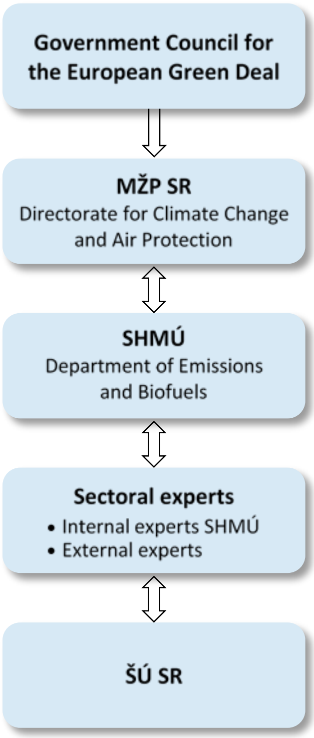
Act No 414/2012 Coll. on Emission Trading as amended is the legal instrument directly oriented towards the control of GHG emissions. According to this Act, competencies with respect to emission allowance trading are given to the MŽP SR and the regional and district environmental offices.

Slovak Hydrometeorological Institute as the single national entity

The Slovak Hydrometeorological Institute (SHMÚ) www.shmu.sk is authorised by the MŽP SR to provide environmental services, including annual GHG inventories according to the approved statute. The range of services, competencies, time schedule and financial budget are updated and agreed annually. All details of the SHMÚ activities are described in the Plan of Main Tasks. The plan, commented by all stakeholders is published after approval at the website of the SHMÚ. Deadline for the approval of this plan by the ministry is 31st December each year. In 2021, organisational changes occurred and the structure of SHMÚ was updated. Presented changes have no impact on the SVK NIS. Establishment of the Department of Emissions and Biofuels (OEaB) was based on organisational changes provided in January 2017. The OEaB has two main tasks: emission inventories and projections (GHG, NECD, and CRLTAP) and National System of Biofuels. The OEaB is also responsible for developing and maintaining the National Emission Information System (the NEIS) – the database of stationary sources to monitor the development of SO_2, NO_x, CO emissions at regional level and to fulfil reporting commitments under the national regulations and EU Directives. The NEIS software product is constructed as a multi-module system, corresponding fully to the requirements of current legislation. The NEIS database contains also some technical information about the sources like fuel consumption and use for the estimation of the sectoral approach. The Single National Entity is a part of the OEaB with the defined structure and overall responsibility for compilation and finalization of the inventory reports and their submission to the UNFCCC Secretariat and the European Commission according to the announcement. The SNE was officially appointed by the Decision of the Director General of the SHMÚ No 16/2011 in August 2011 and amended by the Decision of the Director General of the SHMÚ No 8/2012 in September 2012. The SNE coordinates the SVK NIS. It currently comprises nine full time experts working on inventory tasks and on biofuels. Composition of the SNE is the SVK NIS coordinator, the deputy SVK NIS coordinator and data manager, the energy and IPPU expert, transport expert, agricultural expert, two experts for NEIS database and two experts for emission projections. Permanent staff of the SNE is complemented to the SVK NIS by several institutions and external experts from relevant areas and sectors working on contracts updated as necessary and partly other experts of the OEaB (***Figure 1.3***).

On this figure is a structure of the SVK NIS, where the Committee on CCP is intergovernmental body responsible for implementation of climate change policy on cross-ministerial level. ***Table 1.3*** presents updated list of internal experts within SHMÚ and a list of external experts and institutions within the SVK NIS.

Figure 1.3: Structure and responsibilities of the SVK NIS



Responsibilities of expert organisations

Contracts with the external institutions and the sectoral experts are fully in a competence of the SNE after previous approval by the MŽP SR. The SNE is fulfilling inventory tasks fully in line with approved annual the Plan of Main Tasks and with financial resources allocated by the MŽP SR. To specify main objectives for given year, kick-off workshop with participation of the MŽP SR, SHMÚ and external co-operating bodies and experts is organised regularly, usually at the beginning of February each year. This workshop is also an official forum for closing and summing up outcomes from the previous year and preparing the activities, including the QA/QC plan and responsibilities for the current year. The main institutions involved in the compilation of the GHG inventory are:

- Ministry of Environment of the Slovak Republic;
- Slovak Hydrometeorological Institute;
- Statistical Office of the Slovak Republic;
- Slovak Technical University, Faculty of Chemical Engineering
- National Forest Centre – Ministry of Agriculture and Rural Development;
- Research Institute on Soil Protection Bratislava - Ministry of Agriculture and Rural Development.

Supporting institutions, founded by the Ministry of Environment to perform specific tasks linked to inventory activities, play an important role. These include the Slovak Hydrometeorological Institute, the Water Research Institute and the Slovak Environmental Agency. There are also other relevant subjects for data providing, which are listed in sectoral chapters (***Table 1.3***).

Table 1.3: *List of the sectoral experts in the SVK NIS*

INTERNAL EXPERTS - SHMÚ		
INSTITUTION	**NAME**	**RESPONSIBILITY**
Dept. of Emissions and Biofuels	Ms. Janka Szemesová	NIS coordinator
Dept. of Emissions and Biofuels	Ms. Alexandra Nadžadyová	Data manager of quality, Biofuels expert
Dept. of Emissions and Biofuels	Mr. Ján Horváth	Energy expert
Dept. of Emissions and Biofuels	Mr. Marcel Zemko Mr. Jozef Orečný Mr. Roman Mach	Emission projections experts, Buildings sector emissions
Dept. of Emissions and Biofuels	Ms. Michaela Câmpian Ms. Petra Kršáková	Other pollutant experts
Dept. of Emissions and Biofuels	Ms. Kristina Tonhauzer	Deputy of NIS coordinator and Agricultural expert
Dept. of Emissions and Biofuels	Ms. Monika Jalšovská	NEIS expert
Dept. of Emissions and Biofuels	Mr. Roman Mach	Uncertainty analyses, QA activity
Dept. of Water Quality	Ms. Lea Mrafková	GHG inventory in wastewater sector
Dept. of Climate Service	Mr. Peter Kajaba	Climatological data

EXTERNAL INSTITUTIONS/EXPERTS		
INSTITUTION	**NAME**	**RESPONSIBILITY**
Astraia	Mr. Ján Judák	Reference approach and fugitive emissions preparations
Ecosys Slovakia – company for environmental services in energy	Mr. Jiří Balajka	Consultations in energy and emission projections
National Forest Centre Zvolen	Mr. Ivan Barka Mr. Tibor Priwitzer Mr. Pavel Pavlenda	GHG inventory in Forest Land and KP LULUCF
Animal Production Research Centre	Ms. Zuzana Palkovičová Mr. Ondrej Pastierik Mr. Miroslav Záhradník	GHG inventory in agriculture – animal production
Research Institute on Soil Protection Bratislava National Agricultural and Food Institute	Mr. Michal Sviček Mr. Pavol Bezák Ms. Kristína Buchová	Data provider in agriculture sector – soils, LULUCF Cropland and fertilizers
Central Control and Testing Institute in Agriculture	Mr. Štefan Gáborík Ms. Maggioni-Brázová Ildikó	Data provider in the Agricultural sector – soil nutrition
Faculty of Chemical Technology of the Slovak Technical University Bratislava	Mr. Vladimir Danielik Mr. Juraj Labovský	GHG inventory in industrial processes and solvent use sectors and energy – sectoral approach Consultation in fuel balance Consultation for EU ETS
Faculty of Chemical Technology of the Slovak Technical University Bratislava	Mr. Igor Bodík	GHG inventory in waste – wastewater
Independent Expert	Mr. Marek Hrabčák	GHG inventory in waste – SWDS
Statistical Office of the Slovak Republic – Department of Cross-sectoral Statistics	Ms. Maria Lexová	Statistical data provider
Slovak Association for Cooling and Air Conditioning Technology		F-gases data provider

EXTERNAL INSTITUTIONS/EXPERTS		
INSTITUTION	**NAME**	**RESPONSIBILITY**
SPIRIT Information Systems – IT services, NEIS databases provider	Mr. Jozef Skákala	NEIS provider, consultation on the NACE classification of sources
ICZ Slovakia a.s.	Ms. Eva Vicenová	National Registry focal point
Ministry of Economy	Mr. Jozef Olexa	Data provider for renewables
Grassland and Mountain Agriculture Research Institute	Mr. Štefan Pollák	GHG inventory in Grassland

1.2.2. National Registry of the Slovak Republic

Slovakia operates its national registry in a consolidated manner with the EU Member States who are also Parties to Kyoto Protocol plus Iceland, Liechtenstein and Norway. The consolidated platform which implements the national registries in a consolidated manner (including national registry of Slovakia) is called Consolidated System of EU registries (CSEUR). The Slovak National Emission Registry was successfully connected to the International Transaction Log (ITL) with other EU countries in October 2008 and it has been fully operational since. More information related to the national registry is provided in **Chapter 12**. Changes in the national registry are reported in **Chapter 14** of this report.

Table 1.4: *Organization designated as registry system administrator of the Slovak Republic*

NAME OF THE INSTITUTION:	ICZ SLOVAKIA A.S.
Postal address:	Soblahovská 2050, 911 01 Trenčín, Slovakia
Phone & Fax number:	Phone: +421 32 6563 730, Fax: +421 32 6563 754
E-mail:	emisie@icz.sk
Web site address:	emisie.icz.sk
Contact person:	Eva Vicenová
Position:	Emission Registry Administrator
E-mail address:	eva.vicenova@icz.sk

1.2.3. Inventory Planning, Preparation and Management

The preparation of emission inventories within the SVK NIS for GHG emissions is decentralized according to the definition of Article 5.1 of the KP. The individual sectors are fully under the responsibilities of the external institutions and sectoral experts, who are authorized to evaluate the emission inventory within the delegated sectors. The preparation of the inventory includes three stages – inventory planning, preparation and management.

During the inventory planning are set up roles and responsibilities, specifying processes and resources according to internal and external QA/QC plans. These plans are updated and evaluated annually by the quality manager of the SVK NIS and approved by the MŽP SR. The inventory preparation process starts with the collection of activity data, emission factors and all relevant information needed for estimation of emissions, followed by choice of methods, data processing and then archiving.

For the inventory management, reliable data management to fulfil the data collecting and reporting requirements is necessary. The inventory management includes a control system for documents and data and for their archives.

1.2.4. Quality Assurance/Quality Control and Plans

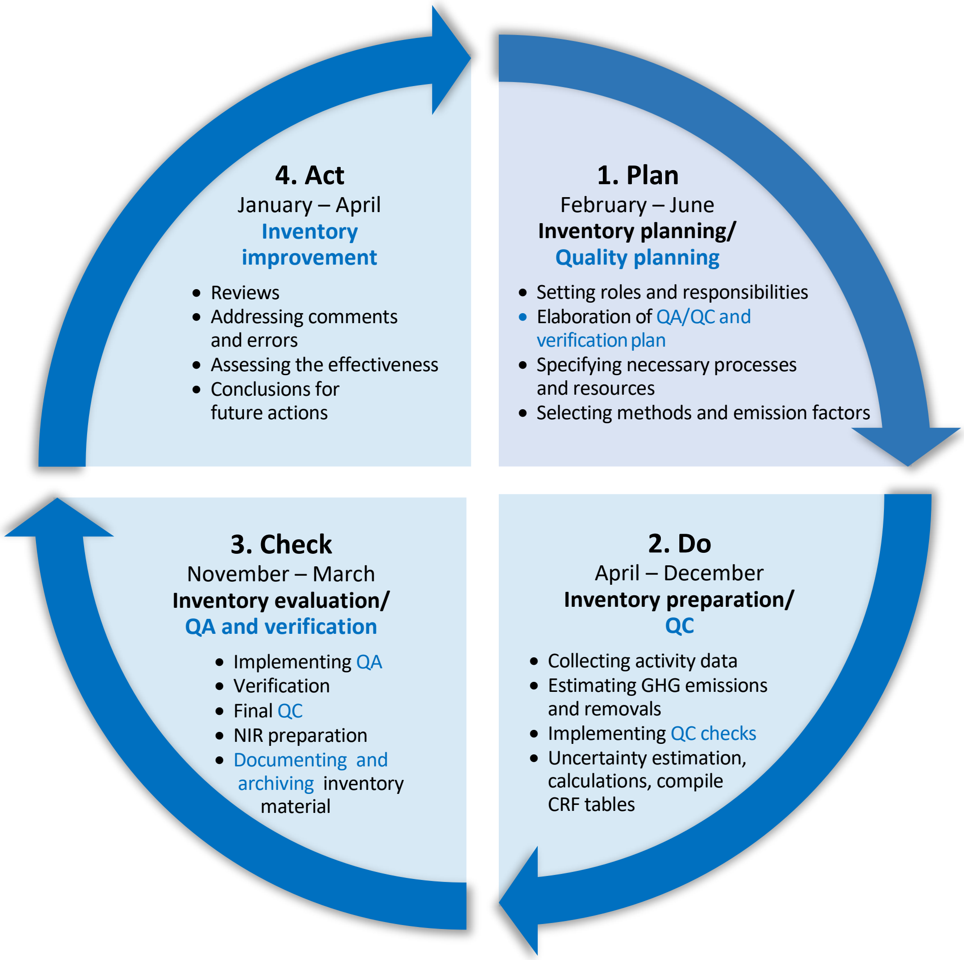
This section presents the quality management and inventory process. Category – specific QA/QC details with improvements and recommendations are discussed in the relevant sectoral chapters of this NIR.

Quality management

The Slovak Hydrometeorological Institute has built and introduced the quality management system (QMS) according to the requirements of EN ISO 9001:2008 standard of conformity. In the frame of introduction of the QMS for the SHMÚ as a global standard, the certification itself proceeds according to the partial processes inside of the SHMÚ structure. The process of Emission Inventories was the subject of internal and external audits during the March 2010 by the certification body ACERT, accredited by Slovak National Accreditation Service. The quality manager has completed several trainings regarding the QMS. The recertification process is taking place every two years.

The objective of the SVK NIS is to produce high-quality GHG inventories. In the context of GHG inventories, a high quality provides, that both the structures of the national system (i.e. all institutional, legal and procedural arrangements) for GHG emissions and removals and the inventory submissions (i.e. outputs, products) comply with the requirements, principles and elements arising from the UNFCCC in line with the MRV principles. The IPCC Guidelines for the GHG emissions inventory 2016 were fully implemented. The IPCC Guidelines Refinements 2019 were considered for possible utilisation in inventory where the methodology was missing in previous Guidelines. The starting point for accomplishing a high-quality GHG inventory is consideration of the expectations and requirements directed at the inventory. The quality requirements set for the annual inventories – transparency, consistency, comparability, completeness, accuracy, timeliness and continuous improvement – are fulfilled by implementing the QA/QC process consistently. ***Figure 1.4*** shows a model for the timeline steps provided in inventory process, QA/QC and verification procedures.

Figure 1.4: *PDCA cycle (Plan, Do, Check, Act)*



The SHMÚ implemented a policy of continuous training process for internal and external experts. Experts are trained during workshops of the SVK NIS, which are held two times per year. The minutes of the workshop and all relevant documents are available to the sectoral experts of the SVK NIS. The latest meeting was held on October 23-24, 2023[2] and the other ways of communication within the SVK NIS are via e-mail, phone call, visits and meetings.

The sectoral experts apply the QA/QC methodology according to the Quality Manual, collect data from providers and process emission inventory for a given sector – they provide partial reports with information on quality and reliability of data on activities and emissions. The quality manual including e.g. guidelines, QA/QC plans, templates and checklists is available to all experts of the SVK NIS via the Internet. The set of templates and checklists consists these documents:

- ✓ QA/QC Plan (external, internal)
- ✓ Matrix of Responsibility
- ✓ General QC
- ✓ Source Category-specific QC
- ✓ Quality Assurance
- ✓ Archive Document
- ✓ Improvement plan
- ✓ Recommendation list

All documents after filling out by experts are approved by responsible person of inventory system and then are archived. The data manager has the overall responsibility for documentation, formal contact with the sector experts and approval activities, taking over the sectoral reports and archiving them.

Inventory planning (PLAN)

The inventory planning stage includes the setting of quality objectives and elaboration of the QA/QC plans for the coming inventory preparation, compilation and reporting work. The setting of quality objectives is based on the inventory principles.

The quality objectives regarding all calculation sectors for inventory submissions are the following:

- ✓ Timeliness
- ✓ Completeness
- ✓ Consistency
- ✓ Comparability
- ✓ Accuracy
- ✓ Transparency
- ✓ Improvement

The quality objectives and the planned QC and QA activities regarding to all sectors are set in QA/QC plans (internal and external). In these documents, deadlines and responsibilities are descripted (included in **Annex 4** in ***Tables A4.1*** and ***A4.2***). These plans updates and evaluates the quality manager of the SVK NIS and following are approving by the MŽP SR.

[2] In the framework of the project EMISIE for the implementation of the IPCC 2019 Refinement

Quality control procedures (DO)

The experts perform the general and category-specific QC procedures during inventory preparation, calculation and compilation.

General quality control includes routine checks of correctness, completeness of data, identification of errors, deficiencies and documentation and archiving of the inventory material. The sectoral experts must adopt adequate procedures for development and modification of the spreadsheets to minimise emission calculation errors. Checks ensure compliance with the established procedures as well as allow detecting the remaining errors. Parameters, emission units and conversion factors used for the calculations must be clearly singled out and specified.

Category-specific QC includes reviews of the source categories, activity data and emission factors focusing on key categories and on categories where significant methodological changes or data revision have taken place. Experts fill QC forms during the compilation of inventory; results from QC activities are documented and archived.

Quality assurance (CHECK)

Quality assurance is performed after application QC checks concerning the finalised inventory. QA procedures include reviews and audits to assess the quality of inventory and the inventory preparation and reporting process, determine the conformity of the procedures taken and to identify areas where improvements could be made. These procedures ongoing on different levels, including basic reviews of the draft reports, general public review, external peer review, internal audit, EU and UNFCCC reviews.

With uploading to the SHMÚ website, printing and distribution of the final inventory document feedback from public is appreciated. The sectoral experts and the members of inventory team are participating in various seminars, meetings, conferences and sector-specific workshops during the year. The activities of inventory members and results of national inventory of GHG emissions are reported there. A broader range of researchers and practitioners in non-government organizations, industry and academia, trade associations as well as the public have the opportunity to contribute to the final documents. Comments received during these processes are reviewed and, as appropriate, incorporated into the reports or reflected in the inventory estimates.

Independent experts from the MŽP SR and the sectoral experts not directly involved into inventory cycle (except of above-mentioned activities) now perform QA. Each sector has a different reviewer:

GENERAL PART	Ms. Miroslava Dančová Mr. Mário Gnida	MŽP SR
ENERGY	Mr. Mário Gnida Ms. Katarína Nanášiová	MŽP SR Institute of Environmental Policy
TRANSPORT	Mr. Leoš Pelikán Ms. Zuzana Kačmárová	Centrum of Transport Research in Brno, Czech Republic[3]
IPPU	Mr. Jozef Škultéty	MŽP SR
AFOLU	Ms. Lenka Malatinská Ms. Hana Fratričová Ms. Kristína Buchová	MŽP SR MPaRV SR VÚPOP[4]
WASTE	Ms. Zuzana Jonáček Mr. Michal Patassi	SHMÚ MŽP SR

[3] In the framework of the Agreement on Mutual Cooperation signed in 2023

[4] Institute for Soil Protection

When checking the data quality of each sector, the SVK NIS coordinator, quality manager of the SVK NIS, data manager of the SVK NIS and other stakeholders must conduct the following general activities:

Checking: Check whether the data in the sectoral reports (calculations and documents) for each sector conform both to the general and specific procedures.

Documentation: Write down all verification results filling out a checklist, including conclusions and irregularities that have to be corrected. Such documentation helps to identify potential ways to improve the inventory as well as store evidence of the material that was checked and of the time when the check was performed.

Follow-up of corrective actions: All corrective actions necessary for documenting the activities carried out and the results achieved must be taken. If such check does not provide a clear clue concerning the steps to be taken, the quality control, bilateral discussion between expert and the SVK NIS coordinator will take place.

Data transference: All checked documents (including the final questionnaire and all annexes) shall be put into the project file and copies shall be forwarded to all the SVK NIS experts. Since the data quality supervision procedures must be observed all the time, it is not mandatory to conduct all checks annually during the inventory preparation. Certain activities, such as verification of the electronic data quality or project documentation for checking whether all documents have been provided, must be carried out every year or at least at set intervals. Some checks may be conducted only once (however, comprehensively) and then only from time to time.

Part of the QA procedures is bilateral cooperation with Czech Republic. The first meeting took place in July 2013 and since then is repeated every year. Team of GHG inventory experts from the SHMÚ and the Czech Hydrometeorological Institute (CHMI) met to exchange information and experience relating to the preparation of GHG inventory. In the last meeting, the experts from Slovakia, Czech Republic, Poland, Hungary and Austria attended. This last meeting with the Czech Hydrometeorological Institute (NIS CZ) took place in May 2023 in Prague (Czechia) and the next meeting is scheduled for June 2024.

In addition to the activities regarding the regional knowledge transferring in emissions inventories, the QA procedures focusing on introducing changes and improvements on national level are organised regularly. National experts, not directly involved in the SVK NIS, are invited to provide comments and discuss methodological issues.

Verification activities

Independent verification procedure was introduced since the inter-ministerial High Level Committee on Coordination of Climate Change Policy was established. The members of the Committee nominated experts involved in the verification and approval process for the selected parts of the emission inventory. The stakeholders (experts) are responsible for the official and legislative agreement of the presented results and ensure harmonisation within several international reporting.

Verification refers to the collection of activities and procedures that can be followed during the planning and development, or after the completion of an inventory, that can help to establish its reliability for the intended applications of that inventory. The used parameters and factors, the consistency of data is checked regularly. Completeness checks are undertaken, new and previous estimates are compared every time. The sector expert for uncertainty checks data entry into the database many times. If possible, activity data from different data sources are compared and thus verified. Comprehensive consistency checks between national energy statistics and IEA time series. Checking the results of the EU's internal review for the EU-28 (since 1. 2. 2020 EU-27), and analyse its relevance for Slovakia.

Confidential information is provided to the SVK NIS experts based on the bilateral agreements but cannot be reported on individual level (only aggregated) in emissions inventory.

Inventory improvement (ACT)

The main aim of the QA/QC process is continuous improvement of the quality of inventory. The outcomes and experiences from the annual reviews are the main sources for the preparation of recommendation lists and improvement plans based on this recommendation lists.

The recommendation lists and improvement plans are updated annually after the regular UNFCCC and/or EU compliance reviews take place. As the Slovakia is one of the Member States of the European Union, the separate review regime is undertaken under the EU Effort Sharing Regulation (ESR) in spring every year. These outcomes and recommendations are included in the improvement plan, too. Detailed recommendation lists and improvement plans are prepared by the sectors and delivered to the sectoral experts for consideration and prioritisation of planned activities for the next inventory cycle. These plans are including in **Annex 4**. According to the latest annual review on GHG emissions inventories 2022 (final ARR delivered on 4th April 2023), several ERT recommendations focused on general part of the inventory were implemented. These are connected with the key category analysis (G.5 and G.6) and uncertainty improvements (G.3), and CPR calculation and verification (G.7).

Prioritisation process is based on recommendations raised during the previous UNFCCC reviews. Prioritisation for improvements is given to those categories of the GHG emissions inventory, where higher uncertainty is a result of the assessment. The latest examples can be found in categories of swine in agriculture or in 1.B.2 of fugitive methane emissions. The underlying assumptions used for estimating uncertainties applied on EF and AD are mostly based on the default values provided in the IPCC 2006 GL and/or expert judgment. The prioritisations are performing on annual basis also by quantitative assessment of uncertainty assessment (UA) for the base year and the latest inventory year. This approach is a part of the annual QA/QC system since 2017 submission. According to the previously identified outcomes made for tabular comparison of the key categories and tier method used, it was recognised, that the tier 1 approach (fugitive emissions of methane, direct soil emissions) was used several key categories. These categories are selected as the high priority of important to move to higher tier method. During the last years, the prioritisation of the Improvement Plan was focused on the Energy sector and the harmonisation of different data sources for energy balance and implementation of the higher tiers for fugitive emissions based on the IPCC 2019 Refinement. The methodological tiers for significant categories (bases on the UA results) are continuously improving, also for example in the Agricultural sector (change methodology from tier 1 up to tier 2 for enteric fermentation and manure management in swine and in direct soil emissions). In the Waste sector, the high priority in this inventory was put on distribution of the sewage sludge and implementation of the QA/QC activities. The improvement of the uncertainties in the LULUCF sector finished in 2022 and are fully implemented in 2024 submission (**Chapter 6**).

1.2.5. Changes in the National Inventory Arrangements

During the preparation cycle of the GHG emissions inventory submitted in 2024, no significant changes in the arrangement or structure of the SVK NIS occurred. The SVK NIS is operational, functioning and fulfilling all main tasks and obligation in the line with the approved plans. However, several changes occurred during the year 2023. SVK NIS is continuing in the process of strengthening capacity among the national system in line with the improvement and prioritization plans. The uncertainties calculations were previously based on external cooperation, now (since the year 2021), an internal expert is responsible for all sectors across inventory. In addition, a new expert was involved in the cropland category to strengthen new calculations on land-based matrix and new expert was involved into agricultural team. During previous years, the several new institutions were involved in the inventory, aiming to focus on QA activities, new internal (SHMÚ) expert on emission projections and emissions estimation in household sector.

1.2.6. Inventory Preparation, and Data Collection, Processing and Storage and Archiving

The compilation of the emission inventory starts with the collection of activity data. A comprehensive description of the inventory preparation for GHG emissions is described in methodologies for the individual sectors. The methodologies are updated annually within the improvement plan and recommendation list and they are archived after formal approval at the web page of the SVK NIS and by the sectoral experts and the SVK NIS coordinator. The most important source of activity data is the Statistical Office of the Slovak Republic and the sectoral statistics of the relevant ministries. The NEIS database is also important reference source of data on fuels and other characteristics of stationary air pollution sources. The OEaB of the SHMÚ operates the NEIS. Other important sources are listed in ***Table 1.5*** below and full catalogue of activity data is listed in the NIS description.

Table 1.5: *List of important information sources for inventory preparation*

SECTOR	SOURCE OF INPUT DATA
ENERGY	Energy Statistics of the SR, NEIS, www.spp.sk, www.transpetrol.sk, EU ETS Reports, Reports of the EU ETS verifiers
INDUSTRIAL PROCESSES AND PRODUCT USE	Association of cement and lime producers, Association of refrigeration and air conditioning engineers, Association of paper producers; EU ETS Reports, Reports of the EU ETS verifiers, Association for coating and adhesives, solvent distributors, Research Institute for Crude Oil
AGRICULTURE	Green Report of the Ministry of Agriculture of the SR - Agriculture, Institute for Fertilisers Research, List of Livestock to the 31. 12. 2022, Crop yields data for crops and vegetables in 2022
LULUCF	Green Report of the Ministry of Agriculture of the SR - Forest, Cadastral Office
WASTE	Population (mid-year), Statistical Yearbook of Slovakia Table 3-3; Real Wage Index, Statistical Yearbook of Slovakia Table 1; Municipal Waste, industrial waste landfilled, Waste in the Slovak Republic in 2022; Database of disposal sites; Municipal Waste, industrial waste composted, industrial waste incinerated Waste in the Slovak Republic in 2019; Incinerators, Enviroportal; Generated, discharged BOD, COD, N, Environment in the SR (selected indicators in 2013 – 2022); Protein Consumption, Statistical Yearbook of Slovakia Table 5-8, State of Environment report 2022; Sludge, database of wastewater treatment plants, SHMÚ.

Collected input data are compared and checked with the international statistics (Eurostat, IAE, FAO and others). In some cases, the collected input data are compared with the results from models (e.g. in road transport it is COPERT model, model for the Waste sector, etc.).

Archiving of inventory documents and database is in the competence of the quality and data managers of the SVK NIS. Archiving of database is in the competence of the SVK NIS coordinator. Documents and emission inventories are archived at three levels. Official documents, methodologies and reports are archived and stored at the web page of the SVK NIS. The archiving is controlled by rules for archiving systems in organizations at the SHMÚ level. The documents needed for the quality management systems are archived in electronic form at the webpage of the SHMÚ (intranet). Documents required signature are printed and archived according to the archiving regulation of the Institute. Printed documents are archived in central archive of the SHMÚ and at the OEaB.

An archive system allows information to be easily reproduced, allows safeguards against data and information loss, and allows reproducibility of the estimates. The archive system includes relevant data sources and spreadsheets, reproduce the inventory and review all decisions about assumptions and methodologies. The archiving system checklist contains these archiving activities: documenting methods used, including those used to estimate uncertainty and data sources for each category; expert comments; revisions, changes in data inputs or methods and recalculation, also reason and source of changes; documenting the used software for calculation of emission. Each new inventory cycle benefits from effective data and documents management during development of the previous inventory.

Archived information includes all emission factors and activity data at the most detailed level, and documentation of how these factors and data have been generated and aggregated for the preparation of the inventory. This information also includes internal documentation on QA/QC procedures, external and internal reviews, documentation of annual key categories and key category identification, and planned inventory improvements and recommendations. All information on archiving is recorded in Archiving System. In addition, internal document about good practise in archiving were prepared. In this document, the exact way of archiving, procedures and steps is descripted.

1.2.7. Brief General Description of Methodologies and Data Sources Used

The methodologies used for the preparation of greenhouse gas inventory in the Slovak Republic are consistent with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006 GL). In line with the Quality Improvement Plans of the NIS SVK, methodologies and parameters have been implemented fully in accordance with the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories by the end of 2023 and therefore, this submission is fully in line with the IPCC 2019 Refinement. Detailed descriptions of used methodologies can be found as the sector specific ones in the following chapters of this Report. Regarding the tier approaches used in the SVK NIS, the detailed information can be found in CRF tables and sectoral chapters. The increasing tier of methodologies is one of the priorities mostly for key categories. This is also included in the improvement plan. In the view of provided recalculations, the higher tier method was implemented in the Agriculture, IPPU and Energy sectors.

Additional sources of activity data for the major sectors are as follows:

Energy:

The Statistical Office of the Slovak Republic:

- *Energ. P 2-01:* Yearly company statement on energy process of fuel enrichment.
- *Energ. P 3-01:* Yearly company statement on the consumption of fuels, electricity and heat for production of selected commodities.
- *Energ. P 4-01:* Yearly company statement on the production of heat and electricity.
- *Energ. P 5-01:* Yearly company statement of retail trade in solid fuels.
- *Energ. P 6-01:* Yearly company statement on sources and distribution of fuels.
- *Energ. P 1-01:* Yearly company statement of manufacture branches.

Transport:

Road transportation:

- *SLOVNAFT a. s. Bratislava*: Production and selling of gasoline and diesel fuel.
- *The Ministry of Economy of the Slovak republic:* Fuel sales of gasoline, diesel and biofuels.
- *SAPPO – Slovak association of petrochemical industry:* Gasoline, diesel and LPG selling data.
- *Slovak Gas Trading Company SPP Inc.:* Selling of compressed natural gas at gas stations.
- *SAD, a. s. Zvolen; ARRIVA Slovakia; DP Košice, a.s. Košice; DPB a.s. Bratislava; SAD Prievidza, a.s.:* CNG consumption data from bus transportation companies.
- *Presidium of the Police Force of the Slovak Republic, the Department of Documents and Registration of the Presidium:* Numbers of road vehicles for each year.

- *Ministry of Transport and Construction of the Slovak Republic:* Cumulative mileage data, odometers data.
- *Slovak Technical Control Stations:* Information on mileages.

Railways:

- *Železničná spoločnosť Slovensko, a. s.:* Fuel consumption data and selected operation capacity of combustion engine driven locomotives in personnel railway transport.
- *Železničná spoločnosť Cargo Slovakia, a. s.:* Fuel consumption data and selected operation capacity of combustion engine driven locomotives in railway freight service.
- *CER Slovakia a.* s.: Fuel consumption data and selected operation capacity of combustion engine driven locomotives in railway freight service.

Navigation:

- *Slovak navigation and harbours Inc. Bratislava & Norwardia*: Diesel oil selling data from custom storage to navigation companies in Slovak harbours.
- *Small companies from lakes and dams:* Fuel consumption data during the season.

Aviation:

- *EUROCONTROL:* Fuel consumption, LTO cycles and emissions.

IPPU:

- *Operators:* Manufacturers, importers, exporters and service, assembling organizations reported over by refrigerant.

Agriculture:

- *The Research Institute for Animal Production Nitra:* Expert guaranty of emission inventory
- *The Statistical Office of the Slovak Republic:* Number of the livestock, sowing areas, harvested areas, harvested yield.
- *The Breeding Services:* Detailed dividing of cattle and sheep
- *The Research Institute for Animal Production:* Animal production data.
- *The Central Controlling and Testing Institute in Agriculture:* Synthetic and organic fertilizers (sewage sludge, compost) applied to the soils, liming and urea application on soils, liming and urea application on the soil, pH of soils.

Waste:

- *COHEM SAŽP (Waste Management Centre of the Slovak Environmental Agency):* Industrial solid waste data.
- *ÚRSO – Regulatory Office for Network Industries:* Data on methane recovered from SWDSs.
- *ACE (the Association of Experts on Waste Water Treatment):* Data on sewage sludge management.
- *Duslo a. s.:* Data on ISW incineration.
- Websites of several companies and institutions are also used for the inventory: *OLO, KOSIT, Slovnaft, Duslo, NsP Prievidza, Fecupral, Ecorec.*

1.2.8. Brief Description of Key Categories

Key categories were assessed by Approach 1 by the level of emissions in years 1990 and 2022 and the trend in emissions for the year 2022 with and without LULUCF categories and those key categories have been chosen, whose cumulative contribution is less than 95%. The identification includes all reported greenhouse gases CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 and all IPCC source categories with LULUCF categories (in absolute values) performed with the detailed categorization. The detailed key categories were assessed and are listed in **Annex 1** of this Report.

In 2022, the Slovak Republic determined using the Approach 1 by the level assessment, 29 key categories with LULUCF and 25 key categories without LULUCF. In 2022, the Slovak Republic determined using the Approach 2 by the level assessment, 17 key categories with LULUCF and 20 key categories without LULUCF.

In 2022, the Slovak Republic determined using the Approach 1 by the trend assessment, 34 key categories with LULUCF and 29 key categories without LULUCF. In 2022, the Slovak Republic determined using the Approach 2 by the trend assessment, 19 key categories with LULUCF and 25 key categories without LULUCF.

List of key categories is almost identical for the base year 1990 and for the latest inventory year. The most important key categories are fuel combustion in energy sector for CO_2, road transport, forest land, direct N_2O emissions from agricultural soil or methane emissions from SWDS.

1.2.9. General Uncertainty Evaluation

The uncertainty assessment by the Approach 1 is enclosed in **Annex 3** to this report. Quantification of emissions uncertainty by level and trend assessment was calculated by using Approach 1 method published in the IPCC 2006 GL. The Approach 1 with the LULUCF estimated the 11.46% level uncertainty and the 5.54% trend uncertainty in 2022. Approach 1 without LULUCF estimated the 2.44% level uncertainty and the 1.13% trend uncertainty in 2022.

According to the previous recommendations, Slovakia is using hybrid combination of Approaches 1 and 2 in this submission for calculation of total uncertainty of the inventory (**Annex 3**). Uncertainty analyses performed by the Approach 1 in transport was carried out using Table 3.2 for uncertainty calculation and country specific uncertainties for activity data and emission factors were inserted into calculation table.

The Slovak Republic provided also Approach 2 for uncertainty analyses according to Chapter 3 of the IPCC 2006 GL for the complete Energy and Waste sectors for the year 2015 (latest results). The methodology and results were published and described in previous SVK NIR 2018.

Based on the latest Improvement Plan (**Chapter 1.2**), Monte Carlo calculation in the IPPU sector was updated in this submission and the results can be found in the **Chapter 4.2.1** of this Report.

Approach 2 in the Agriculture sector is provided in this submission. Uncertainty evaluation is based on Monte Carlo method. Results and methodology are descripted in the **Annex A.5.1** of this Report. Approach 2 in the LULUCF uncertainty analyses was updated in this submission, too. Uncertainty evaluation is based on Monte Carlo method. Results and methodology are descripted in the **Annex A.6.2** of this Report.

1.2.10. Completeness

Assessment of completeness is one of the elements of quality control procedure in the inventory preparation on the general and sectoral level. The completeness of the emission inventory is improving from year to year and the updates are regularly reported in the NIRs. The completeness checks for ensuring time series consistency is performed and the estimation is completed in recent inventory submission (2024). The improvements were performed in the previous inventory submissions such as estimation of GHG emissions for the agriculture and transport.

The list of categories reported by the notation keys is provided in CRF table 9. Whole overview of notation keys with detailed explanation is provided in ***Table A2.1*** with information on notation keys used for each sector was prepared. More information can be found in **Annex 2** of this Report. Information is divided to the sectors and categories. Several categories are reported as not occurring (NO) due to the not existence of the emission source or the source is out of threshold and measurement range. If the methodology does not exist in the IPCC Guidelines, the notation key not applicable (NA) was used. Several NE key categories have been reported in 2024 submission for 1990 – 2022.

Three reasons for not estimated (NE) categories are:

- no methodology is available;
- potential emissions/removals will under the threshold level of emissions in comparison to GHG emissions total;
- insufficient activity data (mostly for indirect GHG emissions like CO, SO_2 or NMVOC).

Table 1.6: *List of NEs in the 2024 submission*

GAS	SECTOR	CATEGORY	DESCRIPTION
CO_2	Energy	1.B Fugitive Emissions from Fuels/1.B.2 Oil and Natural Gas and Other Emissions from Energy Production/1.B.2.a Oil/1.B.2.a.4 Refining / Storage	Change of notation according to FCCC/ARR 2019 recommendation E.38; emissions are not estimated because the 2006 IPCC guidelines do not include methodologies to estimate these emissions.
CH_4	IPPU	2.C Metal Industry/2.C.1 Iron and Steel Production/2.C.1.b Pig Iron	Used methodology does not allow to distinguish the emissions
CH_4	IPPU	2.C Metal Industry/2.C.1 Iron and Steel Production/2.C.1.e Pellet	Used methodology does not allow to distinguish the emissions
CH_4	IPPU	2.D Non-energy Products from Fuels and Solvent Use/2.D.1 Lubricant Use	No methodology is provided neither in the IPCC 2006 GL not in IPCC 2019 Refinement.
N_2O	IPPU	2.D Non-energy Products from Fuels and Solvent Use/2.D.1 Lubricant Use	No methodology is provided neither in the IPCC 2006 GL not in IPCC 2019 Refinement.
CH_4	IPPU	2.D Non-energy Products from Fuels and Solvent Use/2.D.2 Paraffin Wax Use	No methodology is provided neither in the IPCC 2006 GL not in IPCC 2019 Refinement.
N_2O	IPPU	2.D Non-energy Products from Fuels and Solvent Use/2.D.2 Paraffin Wax Use	No methodology is provided neither in the IPCC 2006 GL not in IPCC 2019 Refinement.
CO_2	Agriculture	General	Indirect CO_2 emissions are not estimated in agriculture due to a lack of available methodology on atmospheric oxidation.
N_2O	Agriculture	General	Part of the indirect emissions of N_2O are included in the sectoral tables for manure management and agricultural soils indirect emissions from other than agricultural sources are not estimated.
N_2O	Agriculture	3.D Agricultural Soils/3.D.1 Direct N2O Emissions From Managed Soils/3.D.1.6 Cultivation of Organic Soils	The emissions are under the threshold of significance. See NIR Chapter Agriculture.

Categories included elsewhere (IE) are listed also in CRF table 9 with the explanations of reallocation.

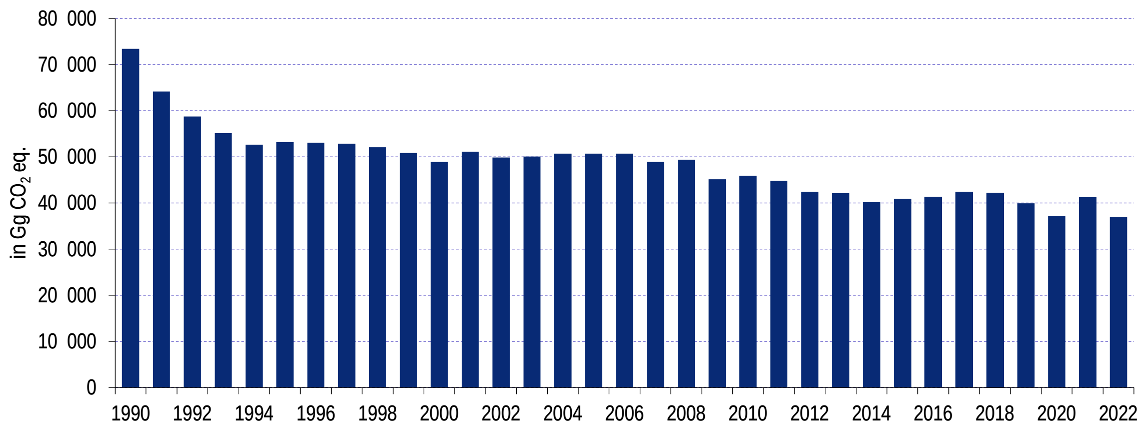
Both direct and indirect GHGs as well as precursor gases are covered by the inventory of the Slovak Republic. The geographic coverage is complete; the whole territory of the Slovak Republic is covered by the inventory.

CHAPTER 2. TRENDS IN GREENHOUSE GAS EMISSIONS

2.1. Description and Interpretation of Emission Trends for Aggregated GHG Emissions

The GHG emissions presented in the National Inventory Report 2024 were updated and converted by using the newest available methods, national conditions and data published by the Statistical Office of the Slovak Republic and other official statistical authorities. The improvements for the categories included in the Improvement Plan and prioritisation according to Recommendation Lists were implemented in this submission. Total GHG emissions were 37 052.21 Gg CO_2 eq. in 2022 (without LULUCF and with indirect emissions). This represents a reduction by more 49% in comparison with the reference (base) year 1990. In comparison with 2021, the emissions decreased by 10%. Total GHG emissions in the Slovak Republic decreased in 2022 in comparison with the previous year by almost 4 Tg, which was affected by the decrease in the Energy and IPPU sectors (mostly in the EU ETS sources) because of decreasing of industrial production in Slovakia. Total GHG emissions excluding the LULUCF sector have been decreasing continually from the base year and more stable trend in the recent years, dropped significantly in the years 2019 and 2020 due to special circumstances connected with the COVID-19 and other important changes made in Slovak economy. Then during the year 2021, emissions increased due to recovery of economy and afterwards due to Ukraine war, emissions decreased in 2022 affected by the increasing prices for fossil fuel. Significant changes in methodologies and emission factors are implemented in the frame of trying to keep consistency with the European Emission Trading System (EU ETS). ***Table 2.1*** shows the aggregated GHG emissions. In the period 1990 – 2022, the total greenhouse gas emissions in the Slovak Republic did not exceed the level of the base year 1990. ***Figure 2.1*** shows trends in the gases without LULUCF in relative expression.

Figure 2.1: *The aggregated GHG emission trends*



Aggregated GHG emissions without LULUCF and indirect emissions; emissions are determined as of 15. 03. 2024

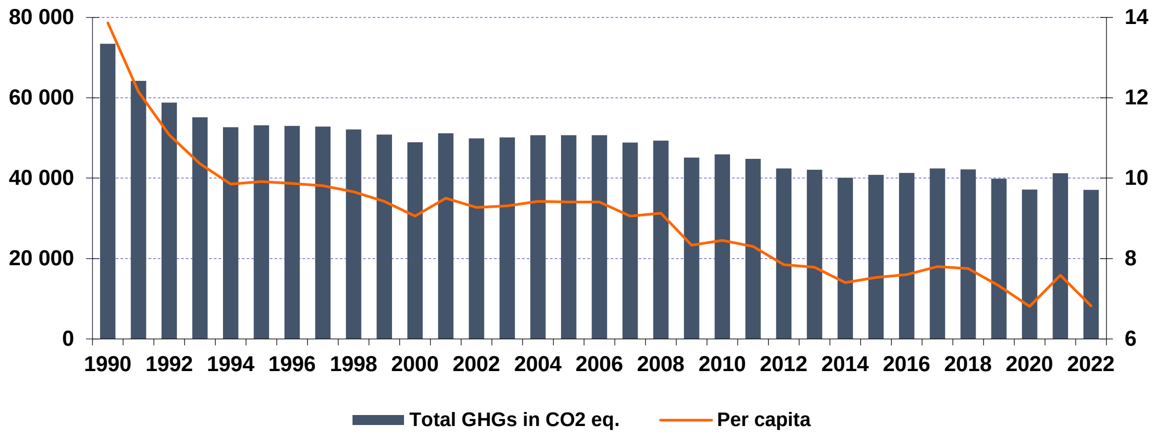
This important reduction of emissions has resulted above all from the strong although temporary decrease in economy activities, followed by restructuring of economy joined with implementing new and more effective technologies, reducing the share of the intensive energy industry and increasing share of services in GDP generation. Transport (mostly the road transport), with increasing emissions is an important exception.

Total anthropogenic greenhouse gas emissions by gases in the years 1990 – 2022 are depicted in ***Table ES.2*** in this Report.

Beside the basic macroeconomic indicators as GDP, GDP per capita, foreign and domestic trade development, inflation, employment, there are also mentioned the data on the amount of investment in environmental protection and activities in the area of science and research, without specifying their orientation. The economic crisis that began in 2008 has brought a significant weakening of the external demand, causing a decreasing dynamic of the Slovak export, manufacturing, labour market and total domestic demand. The debt crisis in the Eurozone that broke out in 2012 again caused a decline in external demand. Emission situation in Slovakia can be considered and evaluated separately. While the EU ETS sources/sectors is going to further reduction of their emissions, the emissions in the non-EU ETS sources (ESR sectors/sources) is mostly stabilised or negative. Regulations included in the EU ETS push sources via economical instruments (Modernisation Fond) into larger investments and reduction of CO_2 emissions. In addition, the Slovak economy introduced changes in energy industry and steel production (phase-out of the furnace in the U.S. Steel company) what have positive effect on emissions in the EU ETS part of inventory. On the other hand, non-EU ETS sources representing agriculture, small industry, transport, waste and other small sources have not effective mitigation measures in place and the sectors policies are not targeting emissions reduction in a sufficient way. Therefore, the Ministry of Environment prepared the new Climate Change legislation, what introduces the sectoral targets with the shared responsibility among the ministries and the private sectors.

The indicators can assess the current economic and emission situation in Slovakia. While the indicator of carbon intensity can be changed much more rapidly in the situation of a high economic growth, GHG per capita is a different case where you can get very impressive results even without any measures, just by higher population growth rate. However, this is not the case of the Slovak Republic right now. It will take much longer time to change numerator by the impact of new technologies implementation namely in combination with high dynamic of development in the energy intensive industries. However, the indicator reached the lowest level in 2020. This was caused by combination of above mentioned measures and special situation with COVID-19, Ukraine war and fuel prices policy in the last few years.

Figure 2.2: *Total GHG emissions in Gg of CO_2 eq. per capita in 1990 – 2022*



Aggregated GHG emissions without LULUCF and indirect emissions; emissions are determined as of 15. 03. 2024

2.2. Description and Interpretation of Emission Trends by Gas

Population of the Slovak Republic as of December 31, 2022 was 5 428 792 and has slightly decreasing. Average residential density is 110.7 inhabitants per km². The population is concentrated in towns in lowlands and the main basins. Mountain areas are randomly populated. Unemployment rate in the Slovak Republic was 5.9% at the end of 2023 (according to the national statistics), what is lower than the previous years. The capital Bratislava is the largest city in the Slovak Republic with the number of inhabitants 475 500.

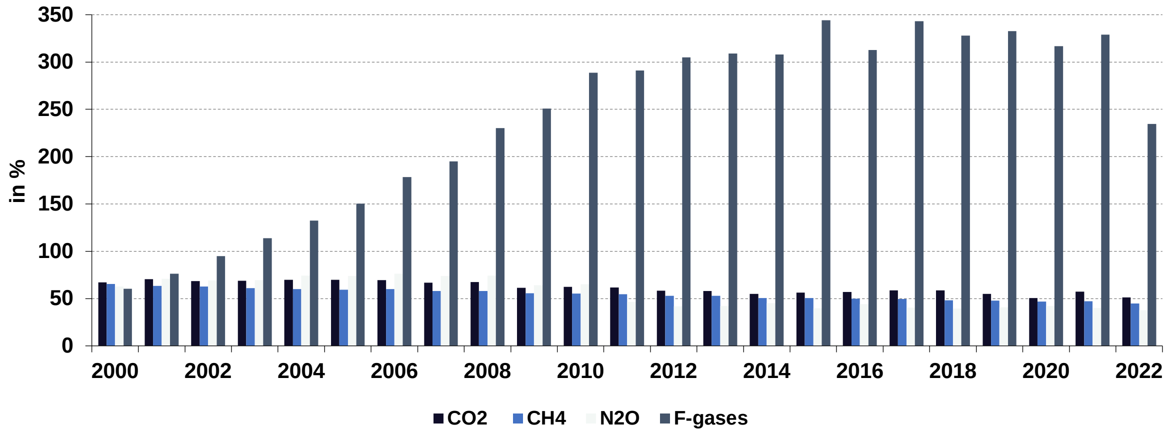
Total anthropogenic emissions of carbon dioxide excluding LULUCF and including indirect emissions have decreased by more than 48% in 2022 compared to the base year (1990). Nowadays the amount is 31 589.74 Gg of CO_2 without LULUCF and with indirect emissions. Compared to the previous inventory year 2021, emissions decreased by more than 10%. The reason for the decrease in CO_2 emissions in 2022 is caused by decreasing of CO_2 emissions in almost all energy and industry categories, except of transport. Mainly in energy industry, manufacturing industry and in metal industry. In 2022, CO_2 emissions including the LULUCF and including indirect emissions significantly decreased compared to the previous year and decreased by 53.80% compared to the base year.

Total anthropogenic emissions of methane without LULUCF and with indirect emissions decreased compared to the base year (1990) by more than 55% and currently the emissions are 3 712.00 Gg of CO_2 eq. In absolute value, CH_4 emissions were 132.57 Gg without LULUCF. Methane emissions from the LULUCF sector are 1.64 Gg of CH_4 caused by forest fires. These emissions, however negligible, are decreasing due to lower number of forest fires in Slovakia. Trend of methane emissions is affected by the implementation of new waste legislation and measures in fugitive emissions and agriculture. Compared to the previous inventory year 2021, the amount of emission is decreased by more than 5%, mostly due to declining emissions in energy and IPPU sectors.

Total anthropogenic emissions of N_2O without LULUCF decreased compared to the base year (1990) by more than 62% and currently the emissions are 1 248.32 Gg of CO_2 eq. Emissions of N_2O in absolute value were 4.71 Gg without LULUCF. Emissions of N_2O from the LULUCF sector are 0.17 Gg. Compared to the previous inventory year 2021, the emission decreased by almost 6%, the most invisible decrease occurred in energy, agricultural and waste sectors.

Total anthropogenic emissions of F-gases 502.15 Gg, from it 480.86 Gg of HFCs, 5.91 Gg of PFCs and 15.38 Gg of SF_6 in CO_2 eq. Emissions of HFCs decreased since 1995 due to the decrease in consumption and the replacement of PFCs and HFCs substances. Since that time, first decrease had occurred in the 2016 inventory year and repeated in 2018 and significant decrease continue in 2022. Decrease occurred in all F-gases and this is effect of implemented legislation of the EU in line with F-gases regulation (**Chapter 4**). Emissions' trend of PFCs has been decreasing and emissions of SF_6 has been slightly increasing due to the increasing consumption in industry. Decrease of F-gases emissions beginning in 2016 was caused by the biannual interval of servicing equipment. Despite this facts, emission of F-gases decreased compared to previous year 2021.

Figure 2.3: Emission trends by gas for the years 2000 – 2022 relative to the 1990 level (relative in %)

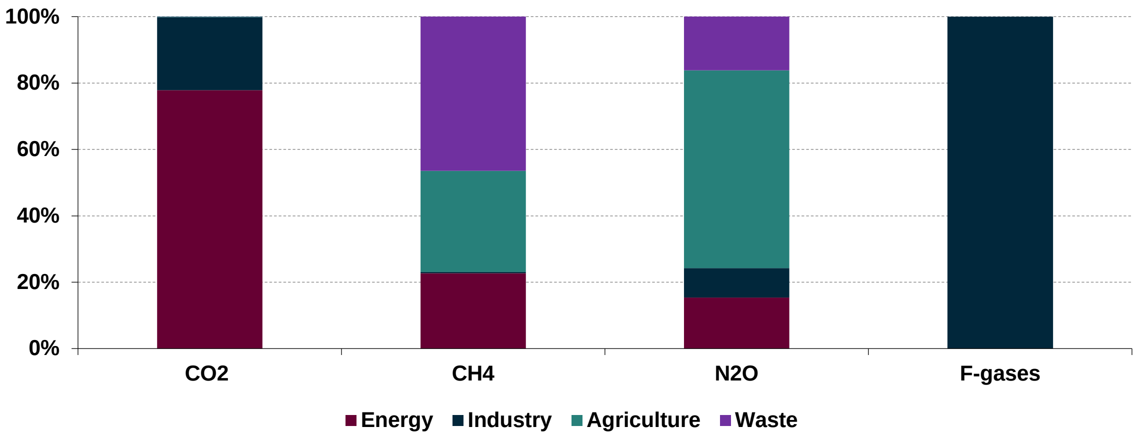


Aggregated GHG emissions without LULUCF and indirect emissions; emissions are determined as of 15. 03. 2024

2.3. Description and Interpretation of Emission Trends by Category

The major share of CO_2 emissions comes from the Energy sector (fuel combustion, transport) with the 77.9% share from the total carbon dioxide emissions in 2022 inventory, 21.9% of CO_2 is produced in the IPPU sector and negligible amount is produced in the Agriculture (0.2%) and the Waste (0.01%) sectors. The energy related CO_2 emissions from waste incineration are included in the Energy sector. The 46.5% of CH_4 emissions is produced in the Waste sector (SWDS), 22.7% of methane emissions is produced in the Energy sector and 30.4% in the Agriculture sector. Almost 59.6% of N_2O emissions is produced in the Agriculture sector (nitrogen from soils), 8.9% in the IPPU sector (nitric acid production), 16.2% in the Waste sector and 15.3% in the Energy sector. F-gases are produced exclusively in the IPPU.

Figure 2.4: Emission trends by gas in the sectors in 2022



Aggregated GHG emissions without LULUCF and indirect emissions; emissions are determined as of 15. 03. 2024

Aggregated GHG emissions from the Energy sector based on the sectoral approach (combustion) data in 2022 were estimated to be 25 612.13 Gg of CO_2 eq. including transport emissions (7 778.85 Gg of CO_2 eq.), which represent the decrease by 69% compared to the base year and decrease compare to previous year by 8.5%. Transport increased by 3.4% compared to 2021 and in comparison with the base year increased by more than 14%.

Total emissions from the IPPU sector were 7 536.24 Gg of CO_2 eq. in 2022, which was decreased by more than 20% compared to the base year and the decreased by 8% compared to the previous year. This sector covers also emissions from solvents use and indirect CO_2 emissions from solvents NMVOC emissions.

Emissions from the Agriculture sector were estimated to be 1 934.43 Gg of CO_2 eq. It is almost 67% decrease in comparison with the base year and the decrease compared to the previous year was 5%. The Agriculture sector is the sector with the most significant decrease compared to the base year 1990, because of the decreasing trend in cattle numbers and fertilisers use.

Emissions from the Waste sector were estimated to be 1 929.92 Gg of CO_2 eq. The decrease is less than 1% compared to the previous inventory year and the time series are stable for last years. Compared to the base year, the increase was more than 38%, because of increased methane emissions from solid waste disposal sites. The emissions from waste incineration with energy use are included into the Energy sector, categories 1.A.1.a, 1.A.2.f and 1.A.2.c.

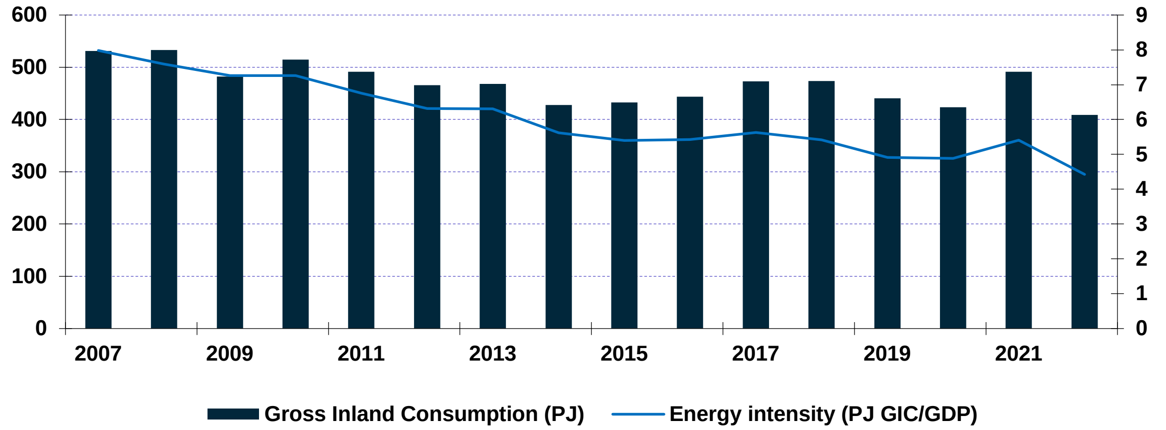
Structural changes in the Energy sector and the implementation of economic instruments have played an important role in achieving the status, when the trend of GHG emissions does not copy the fast GDP growth. In this context, the most important measure seems to be the adoption of the national legislation on air quality, which was approved in 1991 and it has initiated the positive trend in the reduction of the emissions of basic air pollutants and indirectly GHG emissions. At the same time, the consumption of primary energy resources as well as total energy has decreased.

Total anthropogenic greenhouse gas emissions by the sectors in the years 1990 – 2022 are depicted in ***Table ES.2*** in this Report.

According to the Joint Research Centre of the European Commission, the highest reduction in the energy intensity values during the 15-years period from 2000 to 2014 was found in the Slovak Republic, which has undergone a growth rate of 82.5%.[5] This positive development is the result of the successful restructuring of industry, the introduction of energy-efficient production processes in industry and effective energy-saving measures in household by superseding home appliances with more efficient variants (due to several support programmes focused on households). Energy intensity in 2022 decrease in comparison with the previous year, due to decrease of the GDP caused by the economic reasons and lower total inland energy consumption. The latest year development estimated the long-term trend in energy intensity per GDP and final decarbonisation of economy.

[5] Joint Research Centre: Energy Consumption and Energy Efficiency Trends in the EU-28 2000-2014 2016, p. 19.

Figure 2.5: The trend of energy intensity (right y axis) in the period 2007 – 2022 (estimated by the revised statistical approach NACErev.2)



Transport is a significant source of emissions in the Energy sector, with 28% share in total FEC (Final Energy Consumption) in the Slovak Republic. The proportion of transport is growing each year and the adopted policies and measures have no positive impact on increasing trend of emissions from transport. Emission balances in road transport are modelled according to method COPERT 5 version. GHG emissions from non-road transport are balanced by the use of EMEP/EEA 2023 methodology according to individual transport types (air, water and rail). The share of rail and water transports is decreasing from year to year, while the share of air transport increased rapidly in previous years, especially due to the increasing activity of low cost airlines, but the trend is stabilised recently. Slovak transport policy started to support railways and other alternative mode of transport (public, car sharing, etc.), but the effect of investments will be visible later.

Fugitive methane emissions from the extraction (only 0.4% share in total FEC) and distribution of fossil fuels were important, as the Slovak Republic is an important transit country regarding the transport of oil and natural gas from the former Soviet Union countries to Europe. Raw materials are transported through high-pressure pipelines and distribution network and they are pumped in pipeline compressors. During previous years, massive investments were introduced into transmission network to reduce fugitive emissions and losses. Further improvements were implemented by the specific distribution companies of oil and natural gas to the pipeline system (exploration, transit, distribution, etc.) in line with the international requirements. Side effect of these changes caused reducing fugitive emissions in this sector. New data and methodological approach for fugitive emissions from natural gas transmission was implemented into previous and current submissions.

The IPPU sector includes all GHG emissions generated from technological processes producing raw materials and products with the 28% share in total FEC in the Slovak Republic. Within the preparation of the GHG emission balance in the Slovak Republic, consistent emphasis is put on the analysis of individual technological processes and distinction between the emissions from fuel combustion in heat and energy production and the emissions from technological processes and production. Most important emission sources are balanced separately, emission and oxidation factors are re-evaluated, as well as other parameters entering the balancing equations and the results are compared with the verified emissions in the Slovak National Registry for CO_2 emissions. Fundamental emissions inventory in solvents is based on the balance of non-methane volatile organic compounds (NMVOC) according to EMEP/EEA 2023 methodology. Emissions are recalculated according to the stoichiometric coefficients to CO_2 emissions. Indirect emissions of CO_2 are estimated since the base year and allocated in the IPPU sector according to the IPCC 2006 GL.

The Agriculture sector with more than 1% share in total FEC in the Slovak Republic is the main source of methane and N_2O emissions in the GHG emissions balance in the Slovak Republic. The emissions balance is compiled annually based on the sectoral statistics and in recent years based on a new regionalisation of agricultural areas of the Slovak Republic. The Ministry of Agriculture of the Slovak Republic issues annual statistics "Green Report", part agriculture and food industry on a yearly basis. In recent year, the increasing trend of services and other (non-industrial) activities on GDP is visible. This has positive impact on the emissions. Slovakia is also providing to the EUROSTAT national accounts inventory of GHGs and pollutants according to the NECE rev.2 classification of economic activities. However, the methodology is different from the GHG inventory preparation, emissions trend shows interlinkages with the shift of GDP share of the economic sectors on total GDP of Slovakia.

The area of forest in the Slovak Republic covers 42% of the territory and wood harvesting is historically an important economic activity. Since 1990, sinks from the LULUCF sector have remained at the level of 8-10% of total GHG emissions, but in the recent years, sinks increased on 15% level of the total GHG emissions. Historically stable trend was disrupted in 2004 by a wind calamity in the High Tatras, which resulted in increased harvest of wood damaged by the calamity and pests and consequently in the decrease in total sinks to the half of former volumes. The lower harvest and better management of forest caused increasing of sinks in the last years.

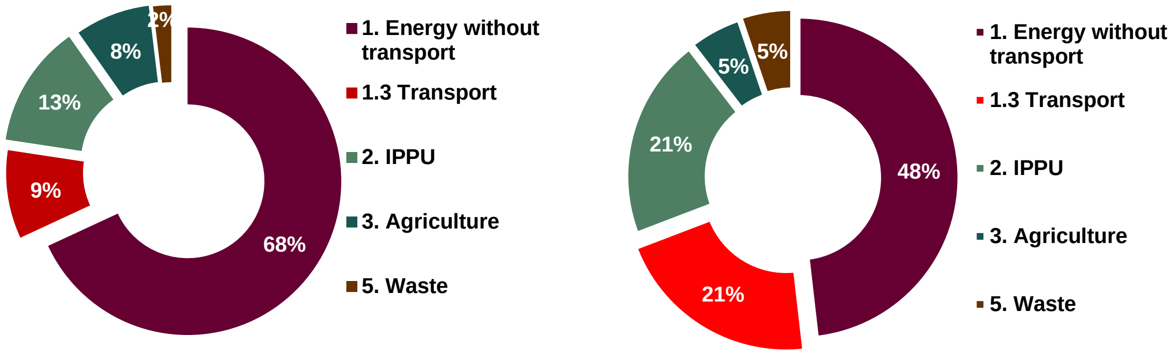
Several significant changes and re-evaluations of the applied methods have been carried out in the Waste sector, followed by recalculations in all categories of waste treatment. Methane emissions from solid waste disposal sites (SWDS) have the largest share on total emissions. Waste balance methodology has been revised and tier 2 approach FOD (First Order Decay) methodology has been used for the recalculations of the time series since 1950. The trend of methane emissions has been stabilised depending on the adopted legislation in municipal waste landfills, lower production of waste and higher share of recycling.

A more detailed description of the methodology as well as with the Monte Carlo uncertainty analysis is described in the references.[6] The disaggregation of emissions from municipal waste incineration into two groups, i.e. waste incineration with and without energy utilisation, was another important change with respect to the quality improvement of the emission inventory. The emissions from waste incineration with energy utilisation were reported under the Energy sector, sub-category 1.A.1.a (other fuels). The emissions from waste incineration without energy utilisation are reported within the Waste sector, but are negligible in the present year. The comparison of the 2022 sectors share with the base year is shown on following ***Figure 2.6***. The significant decrease is visible in the Energy and Agricultural sectors (without transport) and increase in the Waste and IPPU sectors and transport. Emissions from international aviation and shipping are excluded from the national totals and therefore not presented here.

International bunker emissions of the inventory are the sum of the aviation bunker and maritime bunker emissions. These emissions are reported as memo items; but excluded from national totals. Emissions of greenhouse gases from international aviation increased constantly between 1992 and 2008. Between 2009 and 2014, international bunker emissions decreased, partly reflecting the economic recession. Total GHG emissions from international transport felt on the level of 149.16 Gg of CO_2 equivalents in 2022 mostly due to dramatically decrease, practically stopping of air transport caused by Covid-19 pandemic situation in 2020-2021 and further recovery and increase of emissions in 2022. Emissions from international aviation have more than 95% share.

[6] Szemesová, J.; Gera, M.: Emission estimation of solid waste disposal sites according to the uncertainty analysis methodology, Bioclimatology and Natural Hazards, ISBN 978-80-228-17-60.

Figure 2.6: *The share of the individual sectors in total GHG emissions in 2022 (left) and 1990 (right)*



Aggregated GHG emissions without LULUCF and indirect emissions; emissions are determined as of 15. 03. 2024

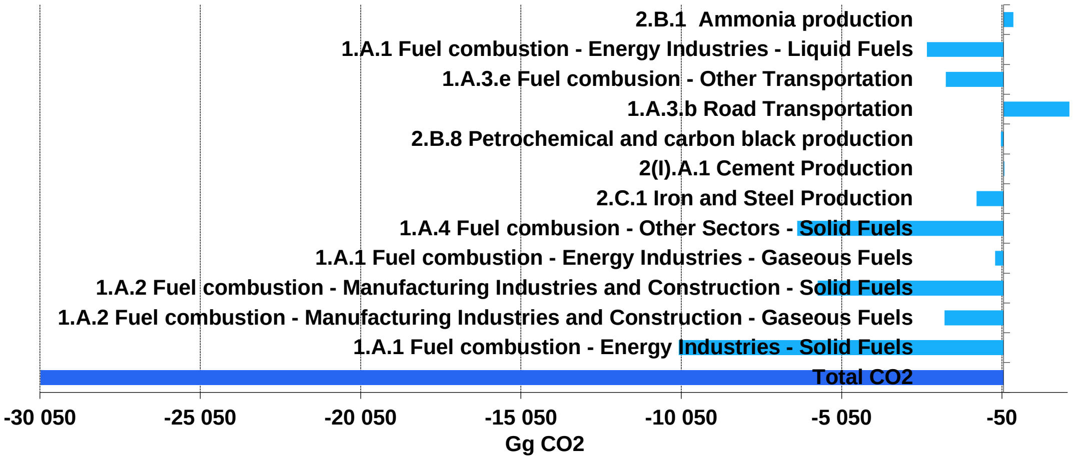
2.3.1. Change in Emissions from Key Categories

Key categories are defined as the sources or removals of emissions that have a significant impact on the inventory as a whole, in terms of the absolute level of emissions, the trend, or both. The Slovak Republic prepared key categories analysis for 2022 and 1990 emission sources in line with the IPCC 2006 GL by using Approach 1. The quantitative analyses include combined uncertainty (on emission factors and activity data) and recognized key categories by level assessment with and without the LULUCF sector (**Chapter 1.2.12** and **Annex 1** of this Report).

CO_2 emissions from the category 1.A.3.b - Road Transportation are the largest key source remains accounting for 24% of total CO_2 emissions without LULUCF in 2022. Between 1990 and 2022, CO_2 emissions in road transportation increased by 3.03 Mt of CO_2, which is 67% increase due to an increase in fossil fuel consumption (liquid) in this key category (***Figure 2.7***). Since 1990, the large increase in road transportation related CO_2 emissions was recognized. ***Figure 2.7*** shows that, solid fuels from the category 1.A.1 - Energy Industries, solid fuels is the key category without LULUCF (8.6%) with the largest decrease (79%; 10 Mt of CO_2) is between 1990 and 2022. The main explanatory factors of emissions decrease are in improvements in energy efficiency and (fossil) fuel switching from coal to gas. CO_2 emissions from the category 1.A.2 - Manufactured Industry, solid fuels in the Energy sector are the third largest key source in the Slovak Republic, accounting for 10.2% of total GHG emissions in 2022. Between 1990 and 2022, emissions from this category showed the decrease by 64%.

CO_2 emissions from fuels in the category 2.C.1 - Iron and Steel Production are the largest key category without LULUCF in the IPPU sector, accounting for 10.5% of total CO_2 emissions in 2022. Emissions decreased by 20% in the comparison with the base year. A shift from solid and liquid fuels to mainly natural gas took place and an increase of biomass and other fuels has been recorded.

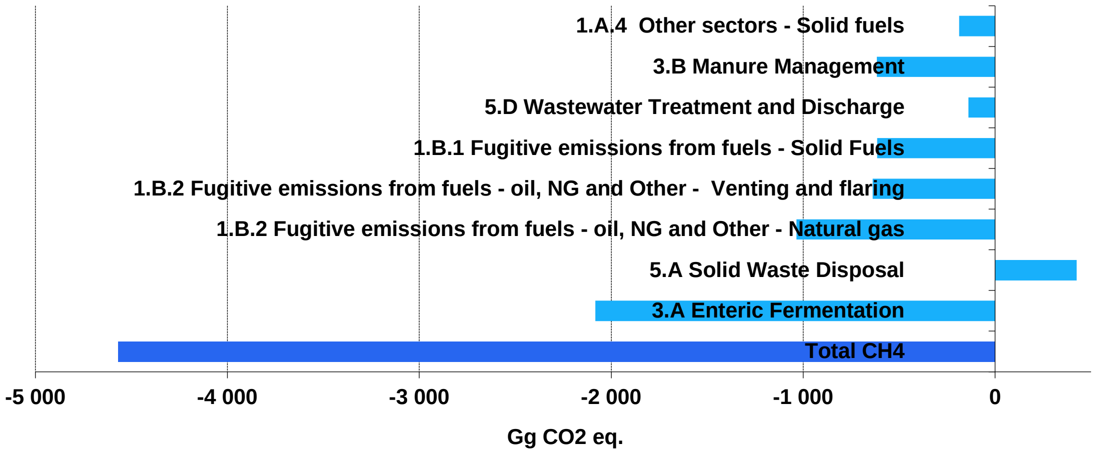
Figure 2.7: *Absolute change of CO_2 emissions by large key categories 1990 to 2022*



Aggregated GHG emissions without LULUCF and indirect emissions; emissions are determined as of 15. 03. 2024

Methane emissions account for almost 10% of total GHG emissions in 2022 and decreased by almost 55% since 1990 to 132.57 Gg CH_4 without LULUCF in 2022. The three largest key sources (5.A - Solid Waste Disposal at 32%, 3.A - Enteric Fermentation at 27% and 5.D - Wastewater Treatment at 7% of total CH_4 emissions in 2022) account for more than 67% of CH_4 emissions in 2022. ***Figure 2.8*** shows that the main reasons for declining CH_4 emissions were reductions in enteric fermentation mainly caused by the decreased of animal numbers and use reductions in fugitive emissions and coal mining. ***Figure 2.8*** shows significant decrease in the categories 3.A and 3.B and increase in 5.A caused by the change of IPCC methodology used for solid waste disposal sites which considers time layer since 1960. Slight increase occurred also in the category 5.B - Biological Treatment of Solid Waste, due to changing in waste management praxis in Slovakia.

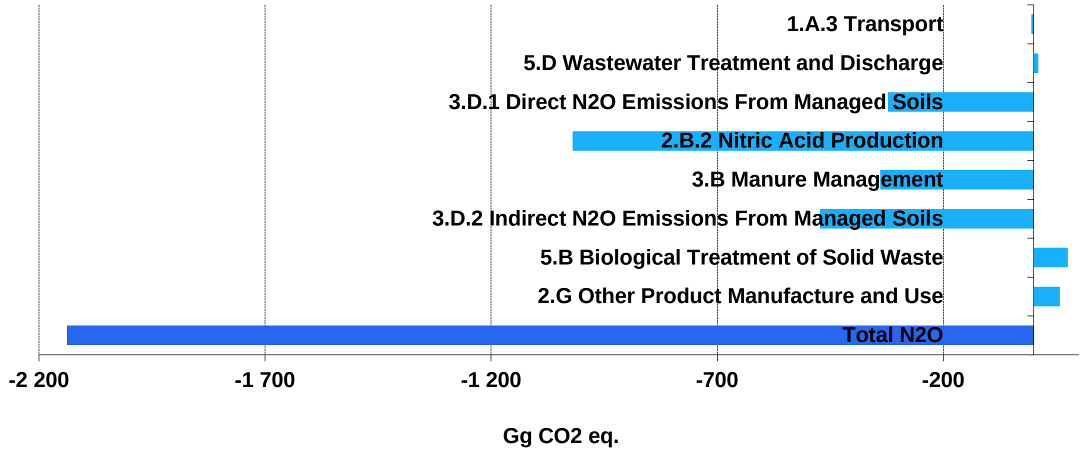
Figure 2.8: *Absolute change of CH_4 emissions by large key categories 1990 to 2022*



Aggregated GHG emissions without LULUCF and indirect emissions; emissions are determined as of 15. 03. 2024

N_2O emissions are responsible for 3% of total GHG emissions and decreased by 62% to 6.28 Gg of N_2O without LULUCF in 2022 (***Figure 2.9***). The three largest key sources causing this trend in agriculture are 3.D.1 - Direct N_2O Emissions from Managed Soils 35%, 3.D.2 - Indirect N_2O Emissions from Managed Soils at 9% and 3.B - Manure Management at 14% of total N_2O emissions in 2022. The main reason for large N_2O emission cuts were reduction measures in the nitric acid production and decreasing agricultural activities ***(Figure 2.9***). N_2O emissions increased in biological treatment of waste and other products manufactured categories. This increase was caused by increase of operationalise and production.

Figure 2.9: *Absolute change of N_2O emissions by large key categories 1990 to 2022*



Aggregated GHG emissions without LULUCF and indirect emissions; emissions are determined as of 15. 03. 2024

Fluorinated gas emissions account for 1.4% of total GHG emissions. In 2022, emissions were 502.15 Gg CO_2 eq., which was 235% above 1990 levels. The largest key source is 2.F.1 - Refrigeration and Air Conditioning and accounts for 96% of fluorinated gas emissions in 2022. HFC emissions from the consumption of halocarbons showed large increases between 1990 and 2022. The main reason for this is the phase-out of ozone-depleting substances such as chlorofluorocarbons under the Montreal Protocol and the replacement of these substances with HFCs (mainly in refrigeration, air conditioning, foam production and as aerosol propellants). On the other hand, PFC emissions decreased substantially since the base year. The decrease has started in 1996 and peaked in 1999 and 2001.

2.3.2. Main Reasons for Emission Changes in 2021 – 2022

Total GHG emissions in the Slovak Republic decreased by 10% in 2022 in comparison with the previous year, which was affected by the decrease in the Energy and IPPU sectors. Total GHG emissions excluding the LULUCF sector have decreased more than in 2020 (pandemic year). This decrease demonstrates the economic and industrial impact of the energy prices policy, restrictions against the import of fossil fuels and raw materials from Russian Federation and development of electricity prices for industry. Several industrial subjects phased-out or reduced production or transformed. There were several significant changes in methodologies and emission factors implemented in the latest submission, particularly in fugitive emissions, agriculture and waste sectors. More changes were connected with the implementation of the 2019 IPCC Refinement.

The main reason for emission changes in 2021 – 2022 were as follows:

- CO_2 emissions decrease in the Energy sector - category 1.A.1 – Energy Industry (0.9 Tg of CO_2) caused by decrease energy and heat production.
- CO_2 emissions decrease in the Energy sector - category 1.A.2 – Manufacturing Industry (0.9 Tg of CO_2) caused by decrease industrial production of heavy metals and chemistry.
- CO_2 emissions increase in the Energy sector - category 1.A.3 – Transport (0.4 Tg of CO_2) caused by increasing road transportation, mainly diesel-driven cars and transit.
- CO_2 emissions decrease in the IPPU sector – category 2.C – Iron and Steel Production (0.8 Tg of CO_2).

In addition, methane emissions decreased in the Energy sector - category 1.A.4 – Other Sectors (0.2 Tg of CH_4) and N_2O emissions increased in the Energy sector - category 1.A.4 – Other Sector (0.5 Tg of N_2O).

2.3.3. Key Drivers Affecting Emission Trends in LULUCF

The increasing trend of removals in forest land-use category is evident in the Slovak Republic since 1970. The increasing trend of removals cropland land-use category was recorded at the same time. Grassland areas decreased from 1980 to beginning of 1990 and since this year, decreasing trend of removals was recorded up to 2005. Since 2005, moderately downward trend has been taking place. Settlements land-use category has continual increasing trend during the whole period. This situation is mostly caused by development of transport infrastructure, industrial areas, municipal development and raising the standards and infrastructure in country and is very often connected with decreasing of the cropland and other land categories. Wetland represents 1.9% (94 kha) of the Slovak territory and it is considered constant, not involving any land use conversions. The LULUCF sector with net removals -7 225.74 Gg of CO_2 eq. in 2022 is very important sector and comprises from several key categories.

The major share from the LULUCF sector in 2022 represents removals in CO_2 with the contributions of the categories provided in the ***Table 2.1***. N_2O emissions from the disturbance associated with the land-use conversion to Cropland, Grassland, Settlements and Other Land were reported in this submission. In addition, removals from the harvested wood products were estimated in this submission. The emissions of other pollutants originate from forest fires and controlled burning of forest. The estimated amount of NOx emissions was 1.05 Gg and the estimated amount of CO emissions was 37.28 Gg in 2022 (***Table 2.1***).

Table 2.1: *Summary of total emissions and removals according to the categories in 2022*

CATEGORY	Net CO_2		CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	Gg		*Gg of CO_2 eq.*		*Gg*			
4. LULUCF	NO	-7 316.72	1.64	0.17	1.05	37.28	NO,NE,NA	0.01
A. Forest Land	NO	-6 643.65	1.64	0.09	1.05	37.28	NE,NA	NO
B. Cropland	NO	-649.74	NO	0.03	NO	NO	NO	NO
C. Grassland	NO	-36.24	NO	0.00	NO	NO	NO	NO
D. Wetlands	NO	NO	NO	NO	NO	NO	NO	NO
E. Settlements	90.50	80.39	NO	0.02	NO	NO	NO	NO
F. Other Land	76.66	76.37	NO	0.02	NO	NO	NO	NO
G. HWP	NO	-143.85	NO	NO	NO	NO	NO	NO
H. Other	NO	NO	NO	NO	NO	NO	NO	0.01

Aggregated GHG emissions without LULUCF and indirect emissions; emissions are determined as of 15. 03. 2024

2.3.4. Description and Interpretation of Emission Trends for Indirect GHG and SO_2

Information can be found in **Chapter ES.5** of this Report.

CHAPTER 3. ENERGY (CRF 1)

This Chapter was prepared using GWP_{100} taken from the 5th Assessment Report of the IPCC by the sectoral experts and institutions involved in the National Inventory System of the Slovak Republic:

INSTITUTE	CHAPTER	SECTORAL EXPERT
Faculty of Chemical and Food Technology, Slovak Technical University	Chapter 3.2 (except 3.2.8) Chapter 3.3	Juraj Labovský
Faculty of Chemical and Food Technology, Slovak Technical University	Chapter 3.4	Vladimír Danielik
Slovak Hydrometeorological Institute, Department of Emissions and Biofuels	Chapter 3.2.8 Chapters 3.5 & 3.6	Ján Horváth
External consultant	Chapter 3.5	Ján Judák

A significant decline in energy intensity was recorded in the previous years in Slovakia. The gross domestic energy consumption decreased by almost 16% since 2010. This decrease is associated with a decrease in solid and liquid fuels consumption for heating and with the significant decrease in natural gas consumption, while the electricity consumption is relatively stable. On the other hand, significant increase of biomass is visible. The share of different fuels on the primary energy consumption is as follow: natural gas 10.4%, nuclear fuel 69%, coal 7%, crude oil 4.2% and renewable sources (RES) more than 9.29% in 2022. Based on the National Energy Strategy up to 2030, an increase of nuclear and RES share on the total energy consumption is expected. A slight increase is projected in natural gas consumption in transport up to 2030 (transition fuel to zero-carbon 2050).

The most indicative decoupling trend in GHG emissions and GDP is visible directly in sector energy (fossil fuels consumption). The decrease in the consumption of solid fuels is 81% in comparison with the base year 1990. The consumption of liquid fuels decreased by 20% and the decline in gaseous fuels is 32%. By comparison, the consumption of biomass was 8 times higher in 2022 than in 1990. General trend in total consumption of fossil fuels is declining by 39% due to the increase in energy efficiency. ***Figure 3.1*** shows GHG emissions trend in Gg of CO_2 equivalents by categories for time series. Basic key categories 1.A.1 – Energy Industries, 1.A.2 – Manufacturing Industries and Construction and 1.A.4 – Other Sectors (services and households) have the most significant influence on the overall emission trends.

The Energy sector is the main contributor to overall GHG emissions with its share of 69% and 25 612.12 Gg of CO_2 eq. in 2022. Within this sector, ***Figure 3.2*** shows significant contributors (and key categories) to the emissions as follow: transport with its share of 30.3%, fuel combustion in the large (share 25%) and medium stationary sources of pollution (share 23%), pollution from small sources of residential heating systems (share 18.8%) and fugitive methane emissions from transmission/transport/distribution, processing and storage of oil and natural gas (share 2.7%).

Figure 3.1: *Trend in aggregated GHG emissions by categories in Gg of CO_2 eq. within the Energy sector in 1990 – 2022*

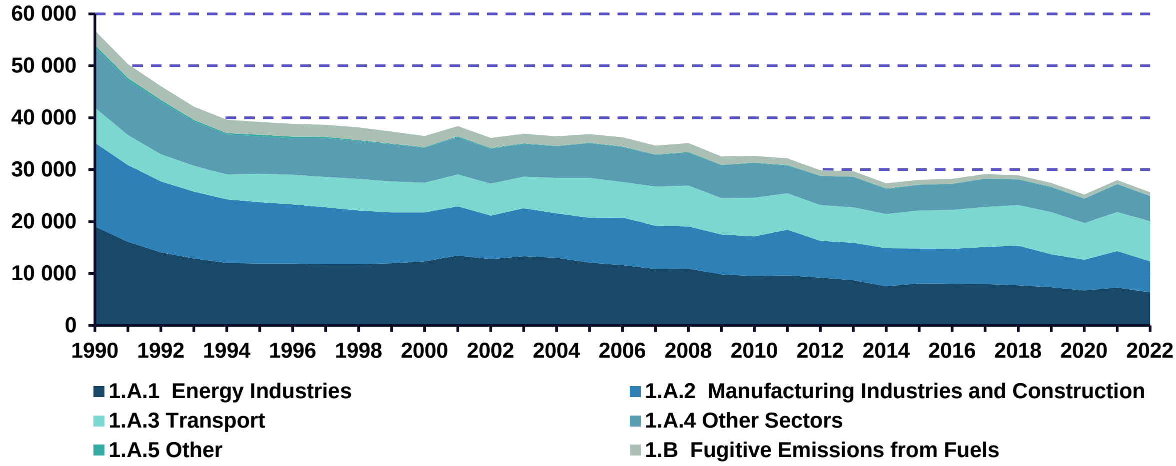


Figure 3.2: *The share of aggregated GHG emissions by categories within the Energy sector in 2022*

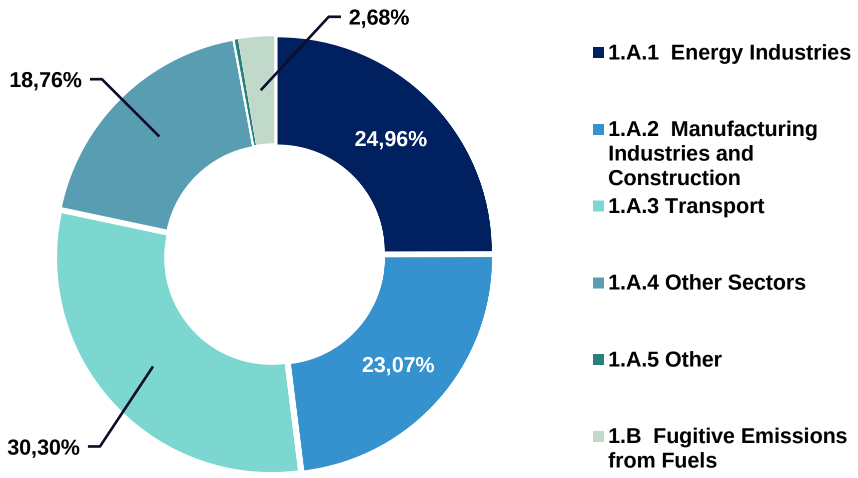


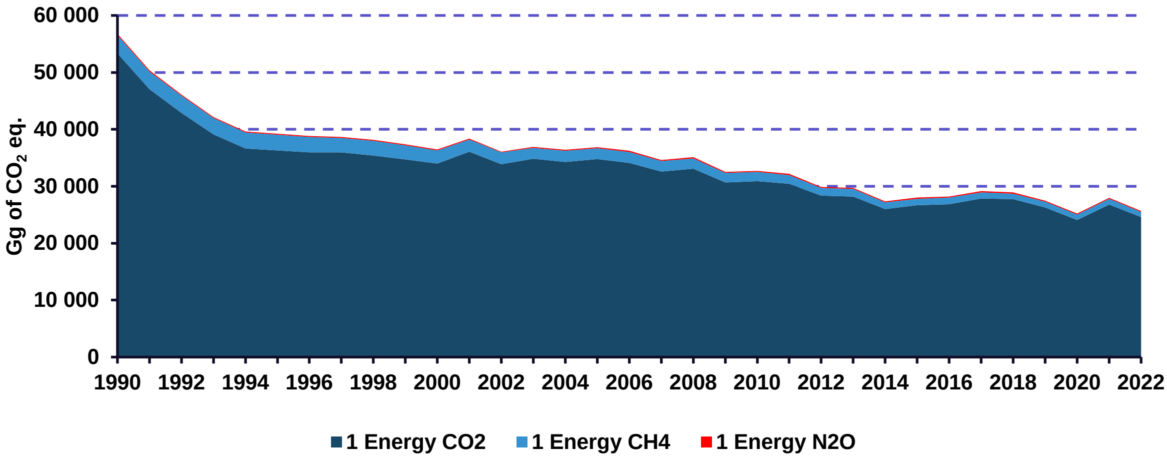
Table 3.1 and ***Figure 3.3*** show overall emissions trends since the base year 1990 according to gases and major categories. The majority of emissions is reported in the category 1.A – Fuels Combustion (more than 90% in all years) and major gas is carbon dioxide (more than 90% in all years). According to this analysis, prioritization in the inventory preparation and improvements is set for the key categories within 1.A (using higher tier approach in key categories) and mostly focused on CO_2 gas (developing country/plant specific EFs for CO_2).

Table 3.1: *GHG emissions by categories within the Energy sector in particular years*

YEAR	CO_2 EMISSIONS			CH_4 EMISSIONS			N_2O EMISSIONS		
	Energy	1.A	1.B	Energy	1.A	1.B	Energy	1.A	1.B
	Gg of CO_2 eq. /year								
1990	53 349.7	53 272.9	76.81	3 197.96	507.58	2 690.38	229.53	229.37	0.16
1995	36 704.8	36 236.5	76.31	2 756.15	312.42	2 443.72	156.09	155.89	0.20
2000	34 015.7	33 938.4	77.21	2 303.97	264.33	2 039.64	157.23	156.99	0.25
2005	34 807.6	34 662.2	145.34	1 889.69	358.43	1 531.26	188.42	187.26	1.15
2010	30 894.4	30 824.0	70.43	1 624.93	355.40	1 269.52	178.80	178.60	0.19
2011	30 422.5	30 348.2	74.38	1 557.68	334.43	1 223.25	184.14	183.91	0.23

YEAR	CO_2 EMISSIONS			CH_4 EMISSIONS			N_2O EMISSIONS		
	Energy	1.A	1.B	Energy	1.A	1.B	Energy	1.A	1.B
	Gg of CO_2 eq. /year								
2012	28 357.9	28 291.5	66.46	1 348.23	359.43	988.80	188.71	188.49	0.22
2013	28 186.2	28 115.7	70.51	1 343.04	345.26	997.77	195.03	194.80	0.22
2014	26 008.5	25 933.8	74.73	1 164.48	227.22	937.26	193.49	193.27	0.21
2015	26 695.8	26 622.9	72.98	1 116.22	304.93	811.29	208.94	208.72	0.23
2016	26 861.1	26 793.2	67.86	1 128.58	322.28	806.30	206.27	206.10	0.17
2017	27 835.3	27 760.2	75.12	1 081.63	312.60	769.03	209.60	209.38	0.22
2018	27 761.7	27 689.5	72.13	951.22	264.62	686.60	200.68	200.46	0.22
2019	26 275.4	26 205.6	69.80	976.01	271.08	704.93	192.84	192.64	0.20
2020	24 099.8	24 030.5	69.35	916.06	269.62	646.44	176.01	175.78	0.23
2021	26 777.9	26 714.8	63.13	999.19	327.91	671.28	203.03	202.81	0.21
2022	24 578.4	24 521.2	57.18	842.40	287.69	554.71	191.36	191.14	0.21

Figure 3.3: *Trend in aggregated emissions by gases within the Energy sector in 1990 – 2022 (Gg of CO_2 eq.)*



Sectoral approach based on bottom-up methodology is the most appropriate method for energy balance and for emissions estimation in the Slovak Republic. The sectoral approach is based on direct information from the large and medium stationary sources included in the EU ETS and completed with the statistical information provided by the Statistical Office of the Slovak Republic (ŠÚ SR) on the level of the statistical units (enterprises) – confidential data. Sectoral approach is compared with the reference approach based on top-down data published by the ŠÚ SR in the National Energy Balance (publicly available. The inter-annual fluctuation is very low and small discrepancies can occur in the fuel characteristics and using average parameters such as the calorific values or oxidation factors.

Fugitive GHG emissions in the period 1990 – 2022 were calculated based on the coal production from underground mines, obtained from the official statistical sources, mine companies (HBP, a.s., Baňa Dolina, a.s. a Baňa Čáry, a.s.), oil and NG transport companies, the ŠÚ SR and the Ministry of Economy of the Slovak Republic. A significant decrease in methane emissions in this category is visible in 2020, the situation was stabilised in 2021 while in 2022 further decrease was recorded. This is caused by the decrease of amount of coal mined and natural gas in transiting (therefore also fugitive emissions decreased inter-annual). This decrease was milder by methane emissions from abandoned mines.

The overview of categories according to the IPCC 2006 GL relevant for the Slovak Republic in the Energy sector is listed in ***Table 3.2***.

Table 3.2: *Reported emissions and tier approach in the Energy sector in 2022*

CATEGORY		DESCRIPTION / EMISSIONS / TIER					
1.A.1 Energy industries							
1.A.1.a	Public electricity and heat production	Electricity, combined heat and power generation, industrial and municipal waste incineration with energy use, cogeneration					
1.A.1.a.i	*Electricity generation*	CO_2	T2	CH_4	T1	N_2O	T1
1.A.1.a.ii	*Combined heat and power generation*	CO_2	T2	CH_4	T1	N_2O	T1
1.A.1.a.iii	*Heat plants*	CO_2	T2	CH_4	T1	N_2O	T1
1.A.1.a.iv	*Other (waste incineration, methane cogeneration)*	CO_2	T2	CH_4	T1	N_2O	T1
1.A.1.b	Petroleum refining	Refineries, petrochemical oil processing					
		CO_2	T3	CH_4	T1	N_2O	T1
1.A.1.c	Manufacture of solid fuels and other energy industries	Coke production, coal manufacturing					
1.A.1.c.i	*Manufacture of solid fuels*	CO_2	T2	CH_4	T1	N_2O	T1
1.A.1.c.ii	*Oil and gas extraction*	CO_2	T2	CH_4	T1	N_2O	T1
1.A.2 Manufacturing industries and construction							
1.A.2.a	Iron and steel	Iron, steel and ferroalloy production, manufacturing of iron ore					
		CO_2	T2	CH_4	T1	N_2O	T1
1.A.2.b	Non-ferrous metals	Non-ferrous metals production, casting					
		CO_2	T2	CH_4	T1	N_2O	T1
1.A.2.c	Chemicals	Chemical products manufacturing and production					
		CO_2	T2	CH_4	T1	N_2O	T1
1.A.2.d	Pulp, paper and print	Paper and pulp production, printing,					
		CO_2	T2	CH_4	T1	N_2O	T1
1.A.2.e	Food processing, beverages and tobacco	Food industry					
		CO_2	T2	CH_4	T1	N_2O	T1
1.A.2.f	Non-metallic minerals	Glass, cement, lime and magnesite production, brickworks, asphalt mixing plant, bating and electroplating					
		CO_2	T2	CH_4	T1	N_2O	T1
1.A.2.g	Other						
1.A.2.g.i	*Manufacturing of machinery*	CO_2	T2	CH_4	T1	N_2O	T1
1.A.2.g.ii	*Manufacturing of transport equipment*	CO_2	T2	CH_4	T1	N_2O	T1
1.A.2.g.iii	*Mining (excluding fuels) and quarrying*	CO_2	T2	CH_4	T1	N_2O	T1
1.A.2.g.iv	*Wood and wood products*	CO_2	T2	CH_4	T1	N_2O	T1
1.A.2.g.v	*Construction*	CO_2	T2	CH_4	T1	N_2O	T1
1.A.2.g.vi	*Textile and leather*	CO_2	T2	CH_4	T1	N_2O	T1
1.A.2.g.viii	*Other (industry not included above)*	CO_2	T2	CH_4	T1	N_2O	T1
1.A.3 Transport							
1.A.3.a	Civil aviation - domestic aviation	CO_2	T3	CH_4	T3	N_2O	T3
1.A.3.b	Road transport						
1.A.3.b.i	*Cars*	CO_2	T2	CH_4	T3	N_2O	T3
1.A.3.b.ii	*Light duty trucks*	CO_2	T2	CH_4	T3	N_2O	T3
1.A.3.b.iii	*Heavy duty trucks and buses*	CO_2	T2	CH_4	T3	N_2O	T3
1.A.3.b.iv	*Motorcycles*	CO_2	T2	CH_4	T3	N_2O	T3
1.A.3.b.v	*Other/Urea Based Catalysts*	CO_2	M	-	-	-	-
1.A.3.c	Railways	CO_2	T1	CH_4	T1	N_2O	T1
1.A.3.d	Domestic navigation - domestic shipping	CO_2	T1	CH_4	T1	N_2O	T1
1.A.3.e	Other transport						
1.A.3.e.i	*Pipeline transport*	CO_2	T2	CH_4	T1	N_2O	T1

CATEGORY		DESCRIPTION / EMISSIONS / TIER					
1.A.4 Other sectors							
1.A.4.a	Commercial/Institutional	Commercial and institutional building, hospitals, schools					
1.A.4.a.i	*Stationary combustion*	CO_2	T2	CH_4	T1	N_2O	T1
1.A.4.b	Residential	Sale fuels for households					
1.A.4.b.i	*Stationary combustion*	CO_2	T2	CH_4	T1	N_2O	T1
1.A.4.c	Agriculture/Forestry/Fishing	Farms and forest organizations, slaughters					
1.A.4.c.i	*Stationary*	CO_2	T2	CH_4	T1	N_2O	T1
1.A.4.c.ii	*Off-road vehicles and other machinery*	CO_2	T1	CH_4	T1	N_2O	T1
1.A.5 Other							
1.A.5.a	Stationary	Compress and petrol stations, paint shops, wastewater treatment plants, crematory					
		CO_2	T2	CH_4	T1	N_2O	T1
1.A.5.b	Mobile	Military aviation					
		CO_2	T1	CH_4	T1	N_2O	T1
1.B.1 Solid fuels							
1.B.1.a	Coal mining and handling	Underground mines for brown coal, brown coal processing					
1.B.1.a.1.i	*Underground mines - mining activities*	CO_2	T2	CH_4	T2	-	-
1.B.1.a.1.ii	*Post-mining activities*	-	-	CH_4	T1	-	-
1.B.1.a.1.iii	*Abandoned underground mines*	CO_2	T2	CH_4	T1	-	-
1.B.1.b	Solid fuel transformation	Charcoal production and coke production					
		CO_2	T1	CH_4	T1	N_2O	T1
1.B.2 Oil and natural gas and other emissions from energy production							
1.B.2.a	Oil						
1.B.2.a.2	*Production*	CO_2	T1	CH_4	T1	-	-
1.B.2.a.3	*Transport*	CO_2	T1	CH_4	T1	-	-
1.B.2.a.4	*Refining / Storage*	CO_2	T1	CH_4	T1	N_2O	T1
1.B.2.b	Natural gas						
1.B.2.b.2	*Production*	CO_2	T1	CH_4	T1	-	-
1.B.2.b.3	*Processing*	CO_2	T1	CH_4	T1	-	-
1.B.2.b.4	*Transmission and storage*	CO_2	T1	CH_4	T3	-	-
1.B.2.b.5	*Distribution*	CO_2	T1	CH_4	T1	-	-
1.B.2.b.6	*Other*	CO_2	T1	CH_4	T1	-	-
1.B.2.c	Venting and flaring						
1.B.2.c.1	Venting						
1.B.2.c.1.ii	*Gas*	CO_2	T1	CH_4	T3	-	-
1.B.2.c.2	Flaring						
1.B.2.c.2.i	*Oil*	-	-	-	-	N_2O	T1
1.B.2.c.2.ii	*Gas*	-	-	-	-	N_2O	T1
1.B.2.d	Other						
1.B.2.d	*Post-Meter Emissions - NG vehicles*	CO_2	T1	CH_4	T1	-	-
1.B.2.d	*Post-Meter Emissions - NG power plants*	CO_2	T1	CH_4	T1	-	-
1.B.2.d	*Post-Meter Emissions - NG appliances*	CO_2	T1	CH_4	T1	-	-

3.1. Overview of the Energy Sector

The Energy sector covers emissions from fossil fuels combustion (CRF 1.A) and fugitive emissions from mines, oil and natural gas (CRF 1.B). The inventory of emissions from fuel combustion includes direct GHG emissions (CO_2, CH_4, N_2O) and indirect GHG emissions (NOx, CO, NMVOCs), as well SO_2 emissions. Point sources, transport and other fuels combustion are included, too. The inventory of fugitive emissions from mines, oil and natural gas includes CO_2, CH_4, N_2O and NMVOCs emissions from brown coal mining, oil and natural gas refining and storage, the emissions from venting and flaring at oil refineries as well as, the emissions from natural gas transmission and distribution. The emissions from international bunkers (CO_2, CH_4, N_2O, SO_2 and indirect gases) and CO_2 emissions from biomass are included in memo items and not included into national total.

3.2. Fuel Combustion (CRF 1.A)

3.2.1. Overview of Fuel Combustion

Fossil fuels combustion for energy and heat production (including transport) is the most important source of GHG emissions in the Slovak Republic. The GHG emissions in this sector represent the major share of total GHGs emissions in CO_2 equivalents. It is especially category of public energy production for power and heat supply, industrial energy production for electricity and heat supply for technological processes, road transport and district heating – heat supply for the residential sector (block of flats and dwellings), public and services buildings and other objects of the non-productive sector.

Total aggregated emissions from fuel combustion, including transport, based on sectoral approach represented 25 000.02 Gg of CO_2 eq. in 2022.

This report uses the GWP 100 based on the IPCC Fifth Assessment Report for the year 2022. The difference between emission based on the GWP_{100} from the IPCC Fourth Assessment Report (AR4) and the IPCC Fifth Assessment Report (AR5)[1] are shown in the SVK NIR 2023.

Beginning a year 2014, a minor temporary increase in CO_2 emissions was observed. This increase can be attributed to the economic growth of Slovakia. However, since the year 2017, the emissions further decreasing and this trend is continuing until present inventory years. The increase in liquid fuels consumption is most notably in transport. The increase of biomass and other fuels (waste) consumption was notable. Emissions decreased more sharply in 2020 than in the previous period. There are several cumulative reasons for this decrease. Due to Covid-19 pandemic, a significant decrease in transport was observed. Similar decrease was observed in the category 1.A.4.a (services), especially in solid fuels. In addition, iron and steel production was significantly reduced. The main producer of iron and steel in Slovakia is the U. S. Steel, s. r. o. Košice, idled one of its three blast furnaces (June 2019 - January 2021). The inter-annual decrease in CO_2 emissions between 2018 and 2020 in fuel combustion was more than 13%. In the beginning of 2021, all furnaces in U. S. Steel, s. r. o. were put back into operation and the emissions returns to the values of 2018. Due to very high energy prices, low market demand and a sharp increase in steel imports, the steel production was significantly reduced in 2022. During the year 2022, up to two blast furnaces were gradually shut down. The reduction of CO_2 emission in the U. S. Steel, s. r. o. Košice was more than 1 650 kt CO_2, which represents a decrease more than 18% in comparison with previous year. Due to a small market size of Slovakia, the iron and steel production can significantly influenced the emission trend in overall.

On the other hand, notable increase of CO_2 emission was observed in services and in households in 2021. The increase of fuel consumption in households sector was caused by colder climatic conditions in 2021, which was also represented by increase of heating degree days across all regions. In 2022, the fuel consumption in services and households decreased and returned to the values before 2021.

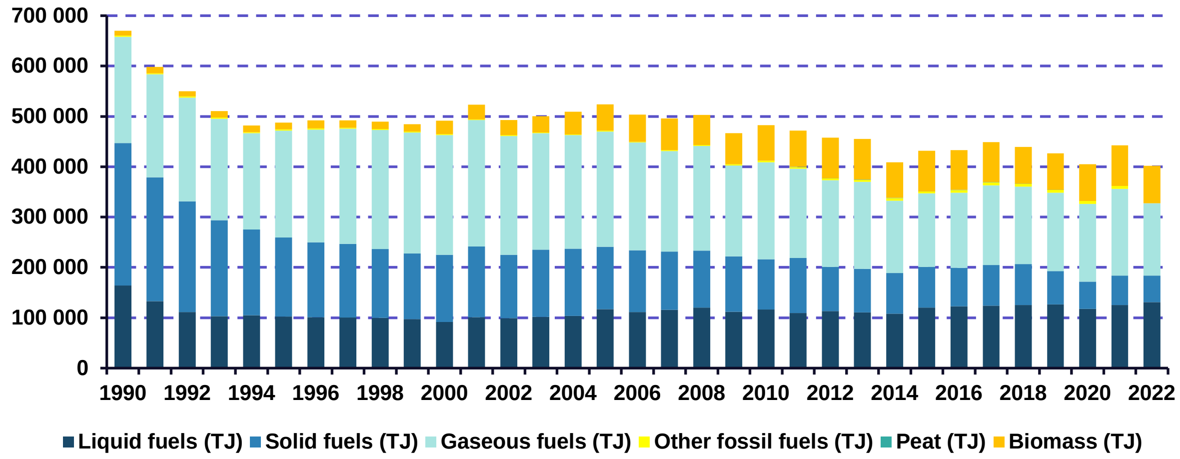
Significant reduction of natural gas consumption was caused by technical problems in a large-scale power plant in Malženice. After the general maintenance (April 2022), the operation of the power plant could not be resumed due to the damage and subsequent shutdown of the generator. The combined cycle power plant outage lasted almost 10 months and the reduction of natural gas consumption was more than 385 mil.m^3. This decrease led to a reduction of greenhouse gas emissions from gaseous fuels in Public electricity and heat production (CRF 1.A.1.a) at the level of 37%.

Table 3.3 shows trend in GHG emissions by categories within the sectoral approach in particular years indicated the significant decrease in emissions followed by decrease in fuel consumption and switch of fuel's share (increasing of gas and biomass, decreasing of liquid and solid fuels) which is showed on ***Figures 3.4*** and ***3.5***.

Table 3.3: *GHG emissions by categories in the 1.A - sectoral approach in particular years*

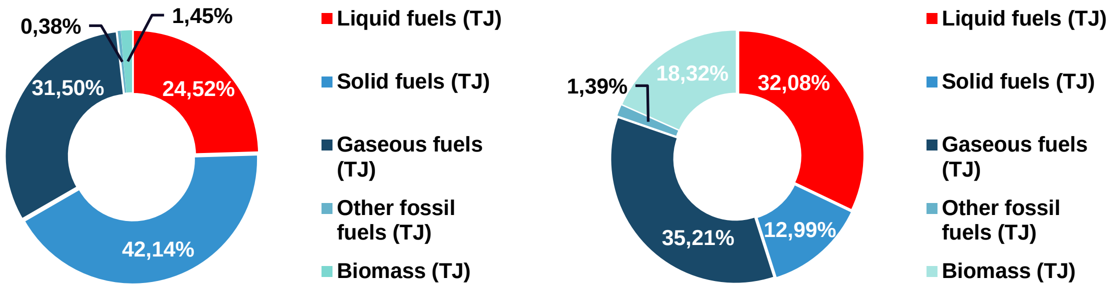
YEAR	1.A.1 ENERGY INDUSTRIES	1.A.2 MAN. INDUSTRIES AND CONST.	1.A.3 TRANSPORT	1.A.4 OTHER SECTORS	1.A.5 OTHER
	Gg of CO_2 eq./year				
1990	19 076.50	16 094.81	6 816.32	11 543.22	478.98
1995	11 917.42	11 809.02	5 490.92	7 208.06	279.39
2000	12 342.73	9 434.03	5 721.59	6 713.60	147.82
2005	12 125.38	8 576.38	7 693.08	6 717.37	95.72
2010	9 491.57	7 664.18	7 421.48	6 710.90	69.85
2015	8 076.34	6 768.99	7 293.40	4 944.54	63.93
2018	7 761.50	7 631.54	7 808.66	4 881.93	89.13
2019	7 378.25	6 327.49	8 123.05	4 775.36	83.68
2020	6 752.18	5 930.99	7 061.50	4 685.48	69.11
2021	7 308.61	7 032.32	7 522.68	5 316.63	64.06
2022	6 407.46	5 922.85	7 778.85	4 815.55	62.38

Figure 3.4: *Trend in fuels consumption within 1.A category in TJ in 1990 – 2022*



High-level dependency on import of primary energy sources (PES) is a limiting factor for the Energy sector in Slovakia and subsequently for the complete economic (mostly industrial) development of country. Net imports of PES are covered by almost 90% of the total energy demand.

Figure 3.5: *The share of fuels' consumption within category 1.A in 1990 and in 2022*



Energy Industries (CRF 1.A.1), Manufacturing Industries and Construction (CRF 1.A.2), Transport (CRF 1.A.3), Other Sectors (CRF 1.A.4) and Other (CRF 1.A.5) categories include emissions from fuel combustion in large and medium point sources (power plants, boilers and industrial plants with boilers and/or other combustion installations). Detailed emission trends by subcategories in particular years are presented in ***Table 3.4***.

Table 3.4: *GHG emissions by categories in the sectoral approach in particular years*

YEAR	1.A.1 ENERGY INDUSTRIES			1.A.2 MANUFACTURING INDUSTRIES AND CONSTRUCTION		
	1.A.1.a	1.A.1.b	1.A.1.c	1.A.2.a	1.A.2.b	1.A.2.c
	Gg of CO_2 eq./year					
1990	14 758.96	2 998.22	1 319.32	2 689.75	1 262.08	2 664.26
1995	8 403.78	2 209.76	1 303.87	2 454.39	534.68	3 067.04
2000	8 924.68	2 169.08	1 248.97	2 782.45	287.47	1 663.57
2005	8 677.58	2 098.93	1 348.87	3 397.87	188.47	875.43
2010	6 267.69	1 915.27	1 308.61	3 752.60	199.50	562.26
2015	4 969.16	1 817.08	1 290.11	2 874.94	139.23	484.56
2018	4 757.93	1 821.46	1 182.11	3 432.42	97.35	526.29
2019	4 469.70	1 735.06	1 173.48	2 448.92	101.75	473.68
2020	3 960.11	1 814.27	977.80	2 185.10	98.06	474.47
2021	4 382.71	1 841.78	1 084.11	3 170.55	116.65	476.70
2022	3 323.16	1 897.53	1 186.77	2 480.03	81.68	450.31

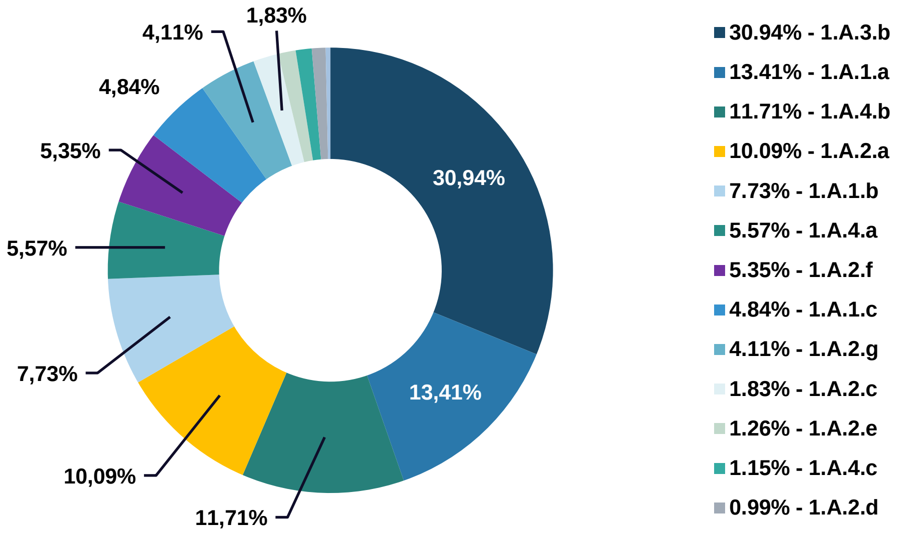
YEAR	1.A.2 MANUFACTURING INDUSTRIES AND CONSTRUCTION				1.A.3 TRANSPORT		
	1.A.2.d	1.A.2.e	1.A.2.f	1.A.2.g	1.A.3.a	1.A.3.b	1.A.3.c
	Gg of CO_2 eq./year						
1990	2 341.32	1 144.12	3 429.37	2 563.91	3.77	4 585.89	410.95
1995	1 215.04	761.49	1 838.65	1 937.72	2.68	4 112.70	220.30
2000	704.68	570.09	1 502.56	1 923.20	2.67	4 142.50	170.19
2005	547.82	436.90	1 390.07	1 739.82	7.85	6 240.52	115.43
2010	419.70	306.52	1 182.18	1 241.43	5.17	6 499.42	91.27
2015	499.68	329.64	1 248.30	1 192.64	3.68	7 005.14	93.72
2018	361.76	323.38	1 510.04	1 380.30	2.88	7 414.79	92.14
2019	450.62	345.82	1 461.37	1 045.33	1.84	7 628.26	90.06
2020	406.97	342.71	1 423.93	999.74	0.89	6 806.59	80.63
2021	313.10	321.78	1 439.37	1 194.15	1.30	7 303.17	91.28
2022	261.08	310.37	1 326.05	1 013.32	1.49	7 664.39	91.48

YEAR	1.A.3 TRANSPORT		1.A.4 OTHER SECTORS			1.A.5 OTHER	
	1.A.3.d	1.A.3.e	1.A.4.a	1.A.4.b	1.A.4.c	1.A.5.a	1.A.5.b
	Gg of CO_2 eq./year						
1990	0.02	1 815.69	4 166.56	7 220.89	155.78	407.24	71.73
1995	0.02	1 155.22	2 433.87	4 606.04	168.15	213.72	65.67
2000	0.02	1 406.20	1 570.15	4 771.32	372.13	130.58	17.24
2005	0.03	1 329.24	2 259.75	4 002.61	455.01	76.64	19.08
2010	0.33	825.29	2 571.84	3 732.13	406.93	54.08	15.78
2015	6.28	184.58	1 502.50	2 990.75	440.59	46.62	17.31
2018	2.58	296.26	1 471.12	3 028.65	364.01	76.48	12.65
2019	4.21	398.67	1 350.47	3 079.14	327.26	72.42	11.26
2020	5.40	167.99	1 164.60	3 133.55	363.97	58.01	11.10
2021	5.88	121.05	1 464.26	3 477.06	376.53	52.87	11.19
2022	5.35	16.14	1 374.86	3 132.97	320.64	53.74	8.64

The share of GHG emissions from stationary combustion (categories 1.A.1, 1.A.2, 1.A.4 and 1.A.5) to GHG emissions in Energy sector was 69.1% in 2022 (without transport). The share of solid fuels decreased from 42.14% in 1990 to 12.99% in 2022. By comparison, the consumption of biomass was 7.8 times higher in 2022 than in 1990. The share of biomass fuels increased from 1.45% in 1990 to 18.32% in 2022. General trend in total consumption of fuels is declining. Total consumption of fuels decreased by 39 % in comparison with base year (***Figure 3.5***). The highest share on GHG emissions has category 1.A.1.a - Public Electricity and Heat Production (13.41%), followed by 1.A.4.b - Residential (11.71%) and 1.A.2.a - Iron and Steel (10.09%) categories (***Figure 3.6***). The major share has category 1.A.3.b - Road transport (30.94%) which is the most important key category with one of the highest share on emissions in overall trend and in Energy sector. There is a significant decrease in CO_2 emissions in the category 1.A.2.c - Chemicals caused by the 99% decrease of solid fuels consumption. This decrease is significant and occurred in whole time series. However, the sharpest decrease occurred between 2001 and 2002. In 2001, there were only five plants in Slovakia, which used solid fuel as source of energy in chemical industry. In 2002, one of these plants stopped (significantly reduced) the production (ENERGETIKA, s. r. o. Strážske decreased by 355 Gg of CO_2 in solid fuels) and two others chemical plants reduced the production and also the consumption of solid fuels (CHEMES, a. s., HUMENNÉ decreased by 43 Gg of CO_2 in solid fuels, Duslo Šala, a. s. decreased by 43 Gg of CO_2 in solid fuels). In 2021, there was further significant decrease in the consumption of solid fuels. The main consumer of solid fuels (CHEMES, a. s) stopped the use of anthracite and residual fuel oil for heat production. In 2022, the consumption of solid fuels was practically the same as in the previous year.

A significant decrease can be observed also in categories 1.A.4.a - Services and 1.A.4.b - Households. This decrease is caused mainly by reduction of solid fuels combustion. The reduction of CO_2 emission from combustion of solid fuels is more than 98% percent in 1.A.4.a and 95% in 1.A.4.b in comparison with the base year. On the other hand, there is an increase of 68% in emission from natural gas in category 1.A.4.b in comparison with the base year.

Figure 3.6: The share of emissions in CO_2 eq. on different subcategories within 1.A in 2022



3.2.2. Uncertainty Analyses of the Fuel Combustion

According to the previous recommendations, Slovakia is using hybrid combination of Approaches 1 and 2 in this submission for calculation of total uncertainty of the inventory (**Annex 3** of this Report). Uncertainty analyses performed by the Approach 1 in the IPPU sector was carried out using Table 3.2 (IPCC 2006 GL) for uncertainty calculation and country specific uncertainties for activity data and emission factors were inserted into calculation table.

The Slovak Republic provided and published also Approach 2 for uncertainty analyses according to the Chapter 3 of the IPCC 2006 GL for the complete Energy and IPPU sectors for the year 2015. The methodology and results were described in previous SVK NIRs 2017 and 2018. The latest Monte Carlo simulation was performed in this sector for the year 2015. Due to capacity reasons and according to the QA/QC plan in this sector, new calculation of Monte Carlo uncertainty (approach 2) in the Energy sector and categories (including transport) will be performed in the next submission. For more information, please see the **Chapter 1.2** of this Report. Results of the Monte Carlo simulations were almost identical since this exercise was performed (since 2011).

CO_2 emissions from categories 1.A.1, 1.A.2, 1.A.3, 1.A.4 and 1.A.5 (liquid, solid and gaseous fuel combustion) are the most important key categories and they have a decisive effect on the management of level and trend uncertainties. The emission balance of other GHGs (CH_4, N_2O) from these categories was estimated by using the IPCC default methodology and default emission factors consistent with previous reporting.

AD, caloric value, EF and their uncertainties are available by the sectoral experts based on national circumstances. It helps to verify the correctness of aggregated uncertainty computation by Monte Carlo technique. EFs are expressed in t C/TJ. The changes and reallocations made in previous year are included to the current inventory. The new categories 1.A.2.g and 1.A.3.e are added to analysis. Contrary, the subcategory 1.A.5.b was removed from analyses.

From the background data structure, differences between Approach 1 and Approach 2 (based on the IPCC 2006 GL) are concentrated to the correlation among inputs parameters in this case, because formulas, which are applied in the Approach 2, use only multiplication and addition operation. In this time, Approach 2 is computed without correlation, therefore Approach 1 and Approach 2 are well comparable. Approach 2 offers more reliable statistical results and shows more information about statistical structure of analysed uncertainty.

3.2.3. Category-specific QA/QC and Verification Process

The sector specific QA/QC plan is based on the general QA/QC rules and activities in specific categories. Information used in the process of preparation GHG emissions inventory of the Energy sector was obtained from the different data sources:

- Statistical Office of the Slovak Republic, Department of Cross-Cutting Statistics (energy balance),
- National Emission Information System (database of all stationary emission sources),
- Emission Trading System (reports from operators and from verifiers),
- Questionnaires that were sent to the producers (in case of doubt).

More information on general QA/QC activities within the SVK NIS is included in the **Chapter 1.2** of this Report.

Emission balance in the Energy sector was prepared in the model taking into consideration also fuel balance in transport and IPPU. The sector specific QC activities were performed directly during calculation when checking several data sources for the emissions factors and other parameters. Activity data verification is processing with the cooperation of the ŠÚ SR and the NEIS experts including operators (or verifiers) in some cases. As it was already mentioned, the main source of activity data (and also NCVs and EFs) in current submission are verified EU ETS reports (plant level) and disaggregated data provided by the ŠÚ SR (enterprise level). New database system developed for fuels and emissions balance in the GHG inventory allows to perform several QC check more or less automatically.

In the category 1.A.1, more than 90% of emissions are cover by the EU ETS reports. The EU ETS activity data are compared against two independent sources: the NEIS database and disaggregated fuel consumptions provided by the ŠÚ SR. The Slovak Republic is providing information on the actual or estimated allocation of the verified emissions included in the EU ETS to the national GHG inventory Further details can be found in the ***Table 3.5***. The emission from EU ETS are balanced foe energy and IPPU sector.

Table 3.5: *Actual allocation of the verified emissions reported by installations and operators under Directive 2003/87/EC for the year 2022*

CATEGORY	GAS	GHG INVENTORY EMISSIONS	VERIFIED EMISSIONS UNDER DIRECTIVE 2003/87/EC	VERIFIED EMISSIONS/ INVENTORY EMISSIONS
		Gg of CO_2 or CO_2 eq.		*Ratio in %*
Greenhouse gas emissions (total emissions without LULUCF for GHG inventory and without emissions from 1A3a Civil aviation, total emissions from installations under Article 3h of Directive 2003/87/EC)	Total GHG	37 050.72	17 418.25	47.01%
CO_2 emissions (total CO_2 emissions without LULUCF for GHG inventory and without emissions from 1A3a Civil aviation, total emissions from installations under Article 3h of Directive 2003/87/EC)	CO_2	31 588.26	17 363.57	54.97%
1.A Fuel combustion activities, stationary combustion	CO_2	24 521.19	10 454.36	42.63%
1.A.1 Energy industries	CO_2	16 781.32	10 438.24	62.20%
1.A.2 Manufacturing industries and construction	CO_2	5 873.92	4 903.34	83.48%
1.A.3 Transport	CO_2	7 689.10	16.12	0.21%
1.A.4 Other sectors	CO_2	4 530.23	2.12	0.05%
1.B Fugitive emissions from fuels	CO_2	57.18	NO	NA
2.A Mineral products	CO_2	2 332.71	2 276.26	97.58%

CATEGORY	GAS	GHG INVENTORY EMISSIONS	VERIFIED EMISSIONS UNDER DIRECTIVE 2003/87/EC	VERIFIED EMISSIONS/ INVENTORY EMISSIONS
		Gg of CO_2 or CO_2 eq.		*Ratio in %*
2.B Chemical industry	CO_2	1 022.93	1 131.82	110.64%*
2.C Metal production	CO_2	3 501.26	3 501.13	100.00%
2.B Chemical industry (Nitric acid production)	N_2O	52.76	52.75	99.98%
3.C Metal production (Aluminium production)	PFCs	5.34	5.34	100.00%

* *Ratio verified emissions/inventory emissions is higher than 1, because downstream of CO_2 for urea production is reported in inventory.*

Based on analyses, total GHG emissions verified under the EU ETS represent 47% on the total GHG emissions (without LULUCF and domestic aviation) based on Mach 15, 2024 inventory submission. The share of the EU ETS emissions is comparable with the share of the EU ESR emissions in the Slovak Republic. This progress was analysed and the resulting outcomes refer to increasing of energy effectivity and decreasing of emissions in large point sources included in the EU ETS scheme. The number of installations fell under the threshold to be included into the scheme and therefore, the EU ESR emissions increased inter-annually.

Total CO_2 emissions verified under the EU ETS represent 54.97% on the total CO_2 emissions (without LULUCF and domestic aviation) based on Mach 15, 2024 inventory submission.

Total N_2O emissions verified under the EU ETS represent 4.03% on the total N_2O emissions (without LULUCF and domestic aviation) based on March 15, 2024 inventory submission.

Total PFCs emissions verified under the EU ETS represent 100% on the total PFCs emissions based on JMarch 15, 2024 inventory submission.

Basic QC procedures, which are performed for all recorded EU ETS data, can be distinguished in following categories:

- Comparison of aggregated site-specific data with the national statistics and/or EUROSTAT;
- Comparison of data across similar sites in individual CRF categories;
- Review significant changes in year-over-year estimates for individual plants, categories and subcategories;
- Comparison of direct measurements with estimates using a factor;
- Comparison of default factors to site or plant-level factors.

Information on activity data of the non-EU ETS sources obtained from the ŠÚ SR is compared and validated with the NEIS database. The NEIS database is referenced data set, not used directly for fuels and emissions balance in the national inventory, but considered in the QC process of activity data and other available parameters.

The QC activities directly provided during data collection in the NEIS database run at two levels. The first level is verification provided by the regional environmental offices according to the national law and the second level is provided by the SHMÚ, the Department of Emissions and Biofuels. The process of data verification in the NEIS database must be completed by the end of July year x-1.

The background documents are archived by the sectoral experts and in central archiving system of SVK NIS at SHMÚ.

In line with the national rules applied in the EU ETS, annual publication of emission factors and NCVs used in the sectoral and reference approach of the GHG emissions inventory is publicly available.

This procedure is a part of the QC activity applied particularly in this sector and checked by the verifiers and operators of ETS sources.

Also according to agreement with CDV (Centrum dopravního výskumu) from 2023, there is a QA/QC cross-check between Slovak and Czech in transport sector emissions estimation, including parameters and factors.

3.2.4. Category-specific Recalculations

Sectoral experts made revisions of the methodological approach and used activity data also in 2024 submission. After analysis, several improvements introduced in this submission led to recalculation or reallocation of data from several categories. This recalculation work is reaction on the implementation of the new ETF system and connected with the implementation of the 2019 IPCC Refinements.

In line with the Improvement and Prioritization Plan for 2024, and reflecting recommendations made during previous reviews and suggested experts' improvements, the following changes were implemented in 2024 submission.

Table 3.6: *Description of recalculation/reallocation implemented in 2024 submission*

RECOMME-NDATION NO.	CATEGORY	DESCRIPTION	REFERENCE
1.	1.A.1.b	Gaseous fuels reallocation from CRF category 2.B.10 to 1.A.1.b:	**Chapter 3.2.6**
2.	1.A.4.b	Recalculation of biomass consumption in the household sector	**Chapter 3.2.9**

Ad.1: Currently, grey hydrogen is produced in refinery Slovnaft. In a previous inventory, emissions have been reported in the category 2.B.10. According to the IPCC 2019 Refinement, refineries manufacture petroleum products for fuel and for non-energy uses, and produce hydrogen and other gases, intermediate products and basic chemicals. The CO_2 emissions from fuel consumed by the refinery for this activity are reported in Energy sector. This principle is maintained in the Guidelines even when some fuel use in the refinery is to support manufacture of chemicals for sale (for example, propylene or aromatics). In the IPCC 2019 Refinement, this principle is re-iterated within the new guidance presented for hydrogen production, which is a new IPPU source category; the emissions from hydrogen production within a refinery as an intermediate product, are primarily to support Energy sector activities, with emissions to be reported in the Energy sector.

Therefore, it was decided to reallocate the emission from the category 2.B.10 to 1.A.1.b. This reallocation will not affect the country's total emissions. To comparison of emissions in current and previous submission is summarized in following table.

Table 3.7: *Recalculations of the category 1.A.1.b for 1990 – 2021 and comparison of the submissions*

YEAR	SUBMISSION 2023				SUBMISSION 2024			
	ENERGY	CO_2	CH_4	N_2O	ENERGY	CO_2	CH_4	N_2O
	TJ	*Gg*			*TJ*	*Gg*		
1990	1 538.1	88.1	0.0015	0.0002	3 592.1	205.1	0.0036	0.0004
1991	1 815.1	103.1	0.0018	0.0002	4 237.1	240.1	0.0042	0.0004
1992	2 168.1	122.1	0.0022	0.0002	5 062.1	286.1	0.0051	0.0005
1993	2 465.1	139.1	0.0025	0.0002	5 757.1	324.1	0.0058	0.0006
1994	1 477.1	83.1	0.0015	0.0001	3 449.1	193.1	0.0034	0.0003
1995	2 349.1	131.1	0.0023	0.0002	5 486.1	307.1	0.0055	0.0005
1996	2 033.1	113.1	0.0020	0.0002	4 746.1	265.1	0.0047	0.0005
1997	2 213.1	123.1	0.0022	0.0002	5 167.1	287.1	0.0052	0.0005
1998	2 673.1	148.1	0.0027	0.0003	6 240.1	346.1	0.0062	0.0006
1999	2 717.1	151.1	0.0027	0.0003	6 344.1	351.1	0.0063	0.0006

YEAR	SUBMISSION 2023				SUBMISSION 2024			
	ENERGY	CO_2	CH_4	N_2O	ENERGY	CO_2	CH_4	N_2O
	TJ	*Gg*			*TJ*	*Gg*		
2000	3 189.1	176.1	0.0032	0.0003	7 445.1	410.1	0.0074	0.0007
2001	2 732.1	150.1	0.0027	0.0003	6 380.1	351.1	0.0064	0.0006
2002	4 287.1	236.1	0.0043	0.0004	10 009.1	550.1	0.0100	0.0010
2003	4 731.1	260.1	0.0047	0.0005	11 046.1	607.1	0.0110	0.0011
2004	5 183.1	284.1	0.0052	0.0005	12 101.1	664.1	0.0121	0.0012
2005	5 453.1	300.1	0.0055	0.0005	12 066.1	663.1	0.0121	0.0012
2006	5 328.1	293.1	0.0053	0.0005	11 731.1	645.1	0.0117	0.0012
2007	4 945.1	272.1	0.0049	0.0005	12 170.1	669.1	0.0122	0.0012
2008	4 856.1	266.1	0.0049	0.0005	12 052.1	660.1	0.0121	0.0012
2009	4 448.1	244.1	0.0044	0.0004	10 883.1	598.1	0.0109	0.0011
2010	4 908.1	270.1	0.0049	0.0005	10 614.1	585.1	0.0106	0.0011
2011	4 799.1	265.1	0.0048	0.0005	10 919.1	602.1	0.0109	0.0011
2012	4 315.1	238.1	0.0043	0.0004	10 779.1	595.1	0.0108	0.0011
2013	4 382.1	244.1	0.0044	0.0004	11 027.1	613.1	0.0110	0.0011
2014	4 468.1	249.1	0.0045	0.0004	10 804.1	602.1	0.0108	0.0011
2015	4 306.1	240.1	0.0043	0.0004	10 861.1	605.1	0.0109	0.0011
2016	4 214.1	235.1	0.0042	0.0004	11 085.1	618.1	0.0111	0.0011
2017	4 183.1	233.1	0.0042	0.0004	10 976.1	611.1	0.0110	0.0011
2018	4 470.1	249.1	0.0045	0.0004	10 450.1	582.1	0.0104	0.0010
2019	4 844.1	270.1	0.0048	0.0005	10 448.1	583.1	0.0104	0.0010
2020	3 946.1	220.1	0.0039	0.0004	9 443.1	527.1	0.0094	0.0009
2021	3 953.1	221.1	0.0040	0.0004	9 593.1	537.1	0.0096	0.0010

Ad.2: The mathematical model for estimating of biomass consumption in households has been improved. Recalculations were made in sector 1.A.4.b based on data from the new 2021 Census. The changes concerned the number of apartments connected to district heating system. This resulted in changes of biomass consumption for this sector. Detail information about the recalculation and comparison with previous data is provided in the **Chapter 3.2.9**.

3.2.5. Category-specific Improvements and Implementation of Recommendations

According to the draft ARR 2022 delivered on 28th February 2023, the ERT recommendation E.2 regarding the category 1.A.4 Other sectors – solid fuels – methane emissions to estimate and report CH_4 emissions from solid fuels for category 1.A.4 using at least a tier 2 methodology (in accordance with the 2006 IPCC Guidelines) if the emissions are identified as key. This issue is reflected below in this chapter and in the **Chapter 3.2.9**.

In addition, during the inventory preparation, following room for improvements was identified for future submissions:

- Households represent serious issue related to achievement of the reduction commitments for the $PM_{2.5}$ emissions of the Slovak Republic. Air pollution and high emissions burden are mainly caused by the individual combustion of solid fuels in households, which produces emissions of total suspended particles (TSP) and their fractions (PM_{10}, $PM_{2.5}$ and BC). This impacts also GHG emission inventory. Further cooperation with the Ministry of the Environment is in place; a new project LIFE for improvement of regional air quality requires also regional data on emissions from small sources. Therefore, additional statistical survey realised in 2022, improved emissions data on regional level, mostly included in biomass from households. More information can be find on website.

- Regarding the growing demand for better quality of emissions data and missing input data required for further improvement of methodology, balances and inventories, the Slovak Hydrometeorological Institute, Department of Emission and Biofuels applied for the EUROSTAT subvention for the road transport data collection. The grant project began in 2021 and finished in March 2023. The results were implemented in road transport. More information can be find on website.
- According to the ERT recommendation E.2 from the draft ARR 2022, the ERT identified room for improvement in moving to higher tier approach (tier 2) in CH_4 and N_2O emissions estimation for key fuels in energy. However, due to lack of information and absence of relevant study or report about types and numbers of combustion equipment in households and services (at most), this was not implemented, yet. More advanced and country specific EFs for non-CO_2 gases are essential for full implementation of higher tier. Moreover, in our Improvement Plan, an improvement in AD estimation has currently a higher priority. Moving to higher tier in category 1.A.4 is currently very difficult, as it covers large number of small sources. Category 1.A.4 covers two main sub-categories: households and services (agriculture is practically negligible). During last three years, several significant improvements in households' emissions inventory (1.A.4.b) were performed. These improvements were described and documented in previous submissions. Results were also published in several scientific journals and there is planning to be published also in future. This project was conducted together with the ŠÚ SR and the results were already implemented in the official statistical Energy Balance of the Slovak Republic. Statistical surveys in households were focused on the fuel consumption and energy balance in households with individual heating. This was used as inputs in mathematical model calculated fuels consumption in households. It was mainly focused on solid fuels and biomass; however, several improvements were performed also in other areas. The similar approach is planned to develop also for services, but this is budget related. The primary objective is to be able estimate the fuel consumption in buildings (non-residential). A relevant methodology to estimate the energy demand precisely and transparently and/or fuels consumption in non-residential buildings is the most essential. Therefore, according to the prioritization plan, the moving to higher tier method for CH_4 and N_2O emissions was postponed and improvement of activity data in the category 1.A.4.a was prioritized in the Improvement Plan.

3.2.6. Energy Industries (CRF 1.A.1)

The CRF category energy industries 1.A.1 consists of the following subcategories: Public Electricity and Heat Production (CRF 1.A.1.a), Petroleum Refining (CRF 1.A.1.b) and Manufacture of Solid Fuels and Other Energy Industries (CRF 1.A.1.c). These subcategories are further divided based on the IPCC 2006 GL.

Public electricity and heat production (1.A.1.a) - this allocates GHG emissions from power installations to produce electricity and heat and the combined heat-power installations (CHP). Total volume of fuels reported here was 59 470.93 TJ in 2022. The most significant gas reported here was carbon dioxide, which represented 3 286.28 Gg of CO_2 in 2022. Total CH_4 emissions were 0.49 Gg and total N_2O emissions were 0.087 Gg in 2022.

After significant decrease of emissions in years 2013 – 2014, trend was stabilized. Between 2018 and 2020 the decrease in CO_2 emissions was more than 5%. In 2022, a further significant decrease can be observed, when CO_2 emissions declined inter-annually by more than 30%. The decrease of solid fuels is continuous and visible in many facilities allocated in this category. Most important decrease in solid fuels was caused by thermal power plant in Vojany in year 2019, where the decrease of the semianthracite coal was more than 50%. The largest electricity producer in Slovakia (Slovenské elektrárne, a. s.) is undergoing the process of phase-out the coal consumption and replacing it with biomass. Similarly, one of the largest heat plants in Eastern Slovakia (TEKO, a. s.), reduced coal consumption in 2021 by more than 33% in comparison with year 2019 and more than 42% in comparison with year 2018. The decline in coal consumption in TEKO, a. s continued in 2022 and reached a value of 30% in comparison with year 2021.

On the other hand, natural gas consumption in this sector has a growing trend in last eight years. The sharp increase of natural gas consumption in 2019 was caused by ZSE Elektrárne, s. r. o. power plant, it operates the combined cycle power plant near Malženice city in the Western Slovakia and currently, it is the biggest combined cycle power plant in Slovakia. Technically, it is based on a joint shaft connecting a gas turbine with 284 MW of capacity and a steam turbine with 152 MW of capacity, jointly total of 430 MW. The power plant was put into operation in 2010 and put out of operation due to unfavourable conditions on energy markets in 2013. Since August 2018, the power plant has new owner and was put into operation, again. A significant change in trend occurred at the beginning of 2022. Reduction of natural gas consumption in Malženice was caused by technical problems. After the general maintenance (February - April 2022), the operation of the power plant could not be resumed due to the damage and subsequent shutdown of the generator. The combined cycle power plant outage lasted almost 10 months and the reduction of natural gas consumption was more than 385 mil. m^3. As a result of this shutdown, there was a decrease in greenhouse gases at the level of 37%.

GHG emissions in the category 1.A.1.a are disaggregated into subcategories (electricity generation, combined heat and power generation, heat plants and other). This reporting is based on information provided by the ŠÚ SR (modules ENERG 719 – ENERG 721).

The category 1.A.1.a.iv – Other includes two emission sources allocated in other fossil fuels:

- Cogeneration gas from mining activity for the years 2007 – 2014 (1.B.1.A - Coal Mining and Handling); (no CH_4 emissions from cogeneration occurred since 2015);
- Cogeneration of LFG from municipal solid waste incineration with energy use.

These gases are used for electricity and heat production and therefore are reported in Energy sector. Methane emissions from waste incineration with energy use are excluded from the category 5.C – Incineration and Open Burning of Waste.

Petroleum refining (1.A.1.b) - GHG emissions from the refineries are allocated in the category 1.A.1.b. Refineries process crude oil into a variety of hydrocarbon products. The biggest refinery Slovnaft, a. s. is the only petroleum refining company operating in Slovakia, processing approximately 5.39 million tons of crude oil in year 2022 (5.51 million tons of crude oil in 2021). This company is the most important supplier of petrol and diesel fuels in Slovakia (60% of market). Emissions from the petroleum refining, concern all combustion activities required to support the refining of petroleum products.

Within 1.A.1.b, the main emissions sources of fuel balance are oil, refinery gas and natural gas, which are used for heating and as sources of hydrogen for oil products processing (hydrocracking). Fuels are allocated to liquid and gaseous fuels categories. No solid fuel is combusted here.

Total volume of fuels allocated in 1.A.1.b expressed in energy units represented 27 552.01 TJ in 2022, practically identical to previous year (27 361.04 TJ in 2021). Total CO_2 emissions were 1 893.39 Gg. Total CH_4 emissions were 0.06 Gg and total N_2O emissions were 0.0095 Gg.

Manufacture of solid fuels and other energy industries (1.A.1.c) - Total volume of fuels allocated in the 1.A.1.c expressed in energy units represented 6 749.93 TJ in 2022. Total CO_2 emissions were 1 186.41 Gg in 2022. Total CH_4 emissions were 0.0068 Gg and total N_2O emissions were 0.0007 Gg.

Methodological issues – activity data

Tier 2 or/and tier 3 approaches are used for the majority of CO_2 combustion sources and country-specific emission factors are used for all fuels. CO_2 emissions estimation was performed based on the bottom-up approach. This is especially visible in the categories 1.A.1, 1.A.2 and 1.A.5 where emissions originated from the point sources (different approach is used in households and transport). For these sources, simple equations that combine activity data with emission factors are used.

The most important and essential methodological change in the sectoral approach was performed in 2013. Before year 2013, the primary source of activity data was the NEIS database.[1] Main reason for the mentioned modification was to increase the transparency of the sectoral approach.

The actual submission used activity data from verified reports of operators included in the EU ETS and individual statistical data of economical subjects in details (NACE rev.2 classification[2]) provided by the ŠÚ SR. The share of emission sources covered by the EU ETS in 1.A.1 is 89.7% and in 1.A.2 is 86.3%. The remaining sources allocated here are balanced by using ŠÚ SR data. After verification of the EU ETS reports by accredited verifiers, the EU ETS reports (in NIMs[3] formats) are released to the NIS expert team. In the first step, the EU ETS reports are processed and transferred into internal database system (see below) in May, year-1. Activity data are directly linked to the specific IPCC categories based on the NACE rev.2 classification (provided by the ŠÚ SR).

This approach is used also for proxy inventory for the year-1. As in May, the official data from the ŠÚ SR are not available; the EU ETS reports are validated against the ŠÚ SR and the NEIS data from previous year, to check the time series consistency and trends. After releasing official data from the ŠÚ SR and the NEIS (October – November, year-1), the validation procedure (focused on identification of gaps in data) is repeated and all potential issues are recorded and prepared for further analyses. The EU ETS reports are directly used to prepare the background for the sectoral approach in 1.A.1, 1.A.2, 1.A.4 and 1.A.5. The EU ETS reports incorporate at least two levels of verification. The EU ETS reports are verified by the accredited verifiers in accordance with the legislative requirements before submission to the competent authority (districts offices). There are only five plants, which used measurement-based approaches. Emissions from measured-based approach are not directly used in the GHG inventory due to ensure consistency of the methodology and emission factors across IPCC categories. Therefore, these operators are directly contacted to provide further details on fuels consumption, characteristics and other relevant inputs for emissions calculation. Emissions are calculated by the sectoral experts of the NIS. Calculated emissions can differ from the measurements, these differences are further analysed in the cooperation with the operators, verifiers and the Ministry of Environment of the Slovak Republic and used for emission inventory.

The activity data for the less energy efficient plant (not covered by the EU ETS = non-ETS) are obtained from the disaggregated energy balance data on plant level provided by the ŠÚ SR.[4] Official (verified) data from the ŠÚ SR are released to the SHMÚ in November year-1. These data are formed by several modules (Energ 719-721 and Energ 723-725). All modules are processed automatically and the information on fuels consumption is mapped to appropriate IPPC category. In similar manner, the fuel types used in individual modules are allocated to corresponding IPCC fuels' categories. This allows

[1] The NEIS is the database of stationary sources, which collects the data on air pollutants and fuels consumption from the large and medium sources of air pollution in the Slovak Republic. These data are available in consistent time series since 2000, when the system NEIS was put in operation.

[2] Pan-European classification system of economic activities

[3] NIMs – National Implementation Measures.

[4] These data are officially provided based on agreement between the MŽP SR, the SHMÚ and the ŠÚ SR.

emissions estimate for all non-ETS plants. Data is completed with the EU ETS data and used for the sectoral approach balance in the categories 1.A.1, 1.A.2, 1.A.4 and 1.A.5.

The emissions balance in the categories 1.A.1, 1.A.2, 1.A.4 and 1.A.5 is done by combination and summation of activity data from the EU ETS reports and the ŠÚ SR database provided on plant level. This procedure is performed automatically by the internal database system. This system contains unmodified information about the fuel consumption and allows comparison of data from different sources. All fuels are linked automatically to the corresponding IPCC fuels categories. Individual plants in database are allocated to specific IPPC category based on the NACE rev.2 classification. This allows disaggregation of emissions into individual IPPC categories without modifying the original dataset.

In chemical industry, petroleum industry and iron & steel production, the allocation procedure is more complicated, and it is performed manually (plant specific) in a collaboration with the IPPU experts (detailed information is provided in the **Chapter 4** of this Report and in the **Annexes 4**). The material and emissions data flows are too complicated to split of technological (IPPU) and combustion emissions (Energy sector). Therefore, models on plant level are included in the main database. Models are prepared by the IPPU and energy sectoral experts and their methodological description is provided in appendix of this NIR. The results of these models are presented in the form of simple input-output balance and the activity data from the EU ETS reports (or data from the ŠÚ SR) are replaced by the activity data calculated by the models. The background information for preparing models are obtained directly from the plant operators or the EU ETS verifiers. Data is validated against information from the standard databases and cross-checked by the energy and IPPU (or waste) experts. The cross checking is used to eliminate the issues with double counting, underestimated emissions or discrepancies with the IPCC 2006 GL. Based on the recent improvement in the EU ETS reporting, the comparisons were made for the apparent consumption of different fuels on plant (installation) level and for the allocation of production categories and harmonization with NACE rev.2 classification of installations.

For illustration, ***Table 3.8*** compares the share of GHG emissions in the individual IPPC categories based on the EU ETS data and the ŠÚ SR database. Very interesting is also comparison of the number of plants by the IPPC categories.

Table 3.8: *Distribution of CO_2 emissions estimated by a different type of source of activity in 2022*

CATEGORY	CO_2 EMISSIONS		NUMBER OF COMPANIES	
	EU ETS	ŠÚ SR	EU ETS	ŠÚ SR
	%		No.	
1.A.1 Energy Industries	86.9	13.1	29	197
1.A.2 Manufacturing Industries and Construction	83.5	16.5	51	1 864
1.A.4 Other Sectors	0.1	99.9	1	581
1.A.5 Other (Not specified elsewhere)	0.0	100.0	0	73

Based on the information provided in ***Table 3.8*** is visible, that the EU ETS share of CO_2 emissions in 1.A.1 is 86.9% and in 1.A.2 is 83.5%. Due to high "EU ETS CO_2 emissions" share, it is possible to compare the activity data between three independent sources (EU ETS, ŠÚ SR and NEIS).

For fuel combustion in 1.A.1.b - Petroleum Refining, a plant specific, tier 3, bottom-up approach was used. Activity data obtained directly from the Slovnaft, a. s. (data on the amount of fuel combusted in individual sources, plant specific emission factors) was used for calculation of GHG emissions and compared with the information provided by the ŠÚ SR and the NEIS database.

In 1.A.1.b, emission factors for liquid fuels are plant specific. The emissions estimation is based on the tier 3 while the material and energy balances are provided directly by operator. This information is formed by monthly consumption of individual fuel types and emissions sources used in each operation unit in refinery. The CO_2 EFs and NCVs are evaluated experimentally in the company's laboratory using the national standards. Certified measurements of emission factors for natural gas were provided by the

Slovak Gas Company (SPP, a. s.). The main sources of fuel balance are oil, refinery gases, petroleum coke and natural gas, which are used for heating and as sources of hydrogen for oil products processing. Consumptions provided by the ŠÚ SR, NEIS and operator correlated very well. Refinery gas, for which country specific NCV and EF are used, is a mixture of various gases of different quality. The main type of refinery gas used in Slovnaft, a. s. a source of energy is fuel gas H1 produced by mixing natural gas and waste gases from the technological operations in mixers. The refinery gas and the imported natural gas are blended (in blenders H1 and H2) and distributed through the refinery fuel system. Natural gas is used to stabilize the pressure and qualitative parameters of fuel gases. The next part of balanced gasses are fuel gases from local networks, especially from production units R5 (FG-R5) and RHC (FG-RHC) and waste gases from pressure swing adsorption (PSA-HPP and PSA-V-KHK). Emission factors of these gasses are based on the statistical evaluation of the chromatographic analyses performed every month. These analyses are performed in the laboratory of quality control of the refinery, accredited by STN EN ISO 17025:2005. Residual fuel oils are liquid distillation residues from refinery processes. Samples of the fuel are analysed in the quality control laboratory, which meets accreditation standards ISO/IEC 17 025. Based on the analysis, the NCV, sulphur content and nitrogen content are estimated. The analyses are performed every day enabling the estimation of monthly averages of qualitative parameters.

Moreover, information provided by operator is practically identical to information, which is background for the EU ETS. Therefore, there is good (practically absolute) correlation between emissions reported under the EU ETS and the national inventory. This approach was introduced in submission 2013 and slightly modified based on the recommendations provided by the ERT in previous reviews. The emissions originally allocated in the 1.A.1.b were split and reallocated into three new subcategories. Emissions from ethylene production were shifted into 2.B.8.b and emissions from hydrogen production into 2.B.10. The background for mentioned disaggregation is based on the consumption of fuels in individual units for production of plastics and units producing hydrogen. This information is provided directly by the operator. In 2024 submission, the emissions from hydrogen production were reallocated from category 2.B.10 to 1.A.1.b. The reason for reallocation was implementation of the IPCC 2019 Refinement, where the new guidance for hydrogen production is presented. Based on the used approach, the emissions from hydrogen production within a refinery as an intermediate product are primarily to support Energy sector activities and allocated here.

Greenhouse gas emissions were calculated for each emissions source by multiplying the fuel consumption (provided by the operator) by the respective emission factor. For calculation of CO_2 emissions, plant specific emission factors were used. CH_4 and N_2O emission factors were taken from the IPCC 2006 GL.

Municipal solid waste incineration with energy use in the category 1.A.1.a.iv

Municipal solid waste incineration with energy use is reported in 1.A.1.a.iv as other fuels. No emissions from the municipal solid waste incineration are reported in the category 5.C.1 Municipal Waste Incineration without energy use in the Waste sector because all incinerators of the MSW produce energy or heat in the Slovak Republic. Therefore, notation key "NO" is used in the 5.C.1. The MSW is combusted in two large stationary incinerators situated in Bratislava and Košice. Statistically negligible volume of MSW is incinerated outside of these two large plants. Industrial waste is incinerated mainly in cement and chemical industry, therefore these emissions are reported in the categories 1.A.2.f and 1.A.2.c.

Reasons for allocation of MSW incineration with energy use into 1.A.1.a.iv are as follow:

1. Consistency in time series;
2. Incinerators in Bratislava and Košice produce electricity for own consumption and also partly selling to public grid;
3. Bratislava incinerator is not producing heat for own consumption.

4. Incinerator in Košice is producing heat for heating plant TEKO Košice, which is allocated in the category 1.A.1.a.

Emission factors and NCVs

The country specific calorific values of the fuels are announced by the ŠÚ SR published in the Statistical Yearbook annually. The variations depend on fuel characteristics. If an operator used the plant specific calorific values, it is an obligation to provide supported measurements and inform relevant competent authority. The plant specific data and results of measurements can be found also in the EU ETS reports.

The NCVs taken from the ŠÚ SR and the EU ETS reports are used in inventory. These were calculated as country specific average (annual weighted average NCV):

- NCV of primary and secondary liquid fuels in the RA are the same as statistical values;
- NCV of primary and secondary solid fuels and natural gas applied in the RA are based on the analysis in accredited laboratories;
- NCV values of solid fuels used in the ŠÚ SR and the RA are not significantly different.

According to the direct information on the quantity of fuels combusted (in kt or mil. m^3) and their specific net calorific values, calculation of fuels consumption in energy unit (TJ) is provided. For fuel combustion and industrial processes, the following numerical data is reported in the EU ETS reports:

- mass or volume of fuels consumption;
- net calorific values of fuel;
- CO_2 emission factors;
- additional process material (carbonates).

Due to the high EU ETS emissions share in 1.A.1, the emission factors are estimated as weighted average of published emission factors for individual fuels in all installations allocated in this category. Averaged emission factors are subsequently used for estimation of CO_2 emission for plants, which are not covered by the EU ETS. CO_2 emission factors in refinery are plant specific (only one installation in 1.A.1.b).

The annual EU ETS reports are an important source of activity-specific and company specific data on CO_2 emissions, fuels and emission factors for major combustion sources (and industrial processes sources) in the national GHG emissions inventory. The EU ETS covers 103 sources with the total CO_2 emissions of 17 418 Gg in 2022.

For each fuel type, the default, country or plant specific emission factor is used and the corresponding emissions of CO_2, CH_4 and N_2O are calculated. The CO_2 emission factors are country or plant specific (and also IPCC category specific) derived from the national/plant fuel characteristics. Default carbon emission factors (t C/TJ) are estimated for individual fuel types based on the international methodologies (IPCC, OECD, IEA) and/or national measurements (expert judgment of the sectoral experts, EU ETS reports, industrial association's measurements, and scientific papers). Carbon emission factors are estimated from fuel composition and available average net calorific values of the most used fuels. Average country specific CO_2 emission factors have been used for natural gas, coal, brown coal according to the source of origin (Slovak, Ukraine, the Czech Republic), coke and coke gas since 2000. The revised emission factors depend on net calorific values and slightly vary from year to year and across to IPCC categories. The emission factors for natural gas and other important fuels are based on precise measurements and calculation published every month by the SPP, a. s., the Slovak Energy Industry, a. s., refinery plant Slovnaft, a. s. (liquid fuels), and the U. S. Steel, s. r. o. for iron and steel production. These EFs are in use for the installations under the EU ETS and for the reporting requirements of the MŽP SR. Carbon content per unit of energy is usually lower for light refined products, such as petrol, than for heavier products such as residual fuel oil.

For natural gas, the carbon emission factor depends on the composition of the gas (in its delivered state it is primarily methane, but it can also include small quantities of ethane, propane, butane, and heavier hydrocarbons). In the Slovak Republic, the emission factor for natural gas (mostly of the Russian origin) is based on precise measurements and calculations published every month by the SPP, a. s. since the year 2000. The same EFs for natural gas are used for the installations covered by the EU ETS annually to ensure consistency across country. The emission factors and composition of NG are published monthly online (***Tables 3.9 - 3.11***). Weighted averages are calculated based on monthly consumption announced by the SPP, a. s. Despite the fact, that the SPP, a. s. is in the present days not exclusive natural gas supplier (approximately 60% of market), the parameters of the NG are consistent in all consumers due to the common origin of natural gas distributed by the SPP, a. s. – Distribution. Natural gas used in the Slovak Republic is imported from Russia Federation and consists almost totally (>95%) of methane.

Table 3.9: *Composition of natural gas published on-line by the SPP, a. s. in 2022*

MONTH	CH_4	C_2H_6	C_3H_8	i-C_4H_{10}	n-C_4H_{10}	i-C_5H_{12}	n-C_5H_{12}	neo-C_5H_{12}	C_6H_{14}	CO_2	N_2
	mol %										
I.	94.2981	3.1006	0.6829	0.0965	0.1119	0.0269	0.0209	0.0019	0.0364	0.7250	0.8987
II.	94.4367	3.0900	0.6440	0.0931	0.1040	0.0252	0.0193	0.0019	0.0323	0.7035	0.8499
III.	94.6848	2.9620	0.6872	0.1029	0.1104	0.0255	0.0189	0.0015	0.0295	0.6042	0.7729
IV.	94.4315	3.0891	0.7207	0.1062	0.1141	0.0268	0.0201	0.0014	0.0327	0.6557	0.8016
V.	94.0502	3.2370	0.8927	0.1315	0.1423	0.0317	0.0236	0.0009	0.0335	0.6526	0.8037
VI.	93.0067	3.7582	1.0493	0.1521	0.1734	0.0399	0.0307	0.0012	0.0456	0.8815	0.8611
VII.	92.3647	4.1413	1.1977	0.1791	0.2042	0.0471	0.0365	0.0013	0.0543	0.9262	0.8473
VIII.	92.7202	3.8488	1.1272	0.1646	0.1934	0.0452	0.0353	0.0010	0.0567	0.9193	0.8879
IX.	92.6641	3.9460	1.1308	0.1624	0.1916	0.0424	0.0334	0.0008	0.0500	0.8886	0.8895
X.	92.8367	3.9511	1.0971	0.1616	0.1818	0.0401	0.0308	0.0008	0.0448	0.7948	0.8600
XI.	92.7545	3.8983	1.0259	0.1475	0.1702	0.0391	0.0305	0.0013	0.0486	0.9349	0.9489
XII.	92.5661	3.9674	0.9757	0.1370	0.1639	0.0392	0.0312	0.0016	0.0525	1.0611	1.0039

Table 3.10: *Overview of the EFs and NCVs for natural gas [15°C; 101.325 kPa] published on-line by the SPP, a. s. in 2022*

MONTH	RELATIVE DENSITY	DENSITY	NCV	COMBUSTION HEAT	WOBBE NUMBER	SULPHUR CONTENT	EF C
	mol %	$kg.m^{-3}$	$kWh.m^{-3}$	$kWh.m^{-3}$	$kWh.m^{-3}$	$mg.m^{-3}$	tCO_2/TJ
I.	0.5923	0.7259	9.700	10.748	13.97	0.0208	55.97
II.	0.5911	0.7244	9.695	10.744	13.97	0.0404	55.93
III.	0.5898	0.7228	9.710	10.760	14.01	0.0512	55.88
IV.	0.5916	0.725	9.721	10.771	14.00	0.0533	55.93
V.	0.5949	0.7291	9.771	10.825	14.04	0.0629	56.02
VI.	0.6028	0.7388	9.827	10.884	14.02	0.0323	56.29
VII.	0.6079	0.7450	9.894	10.956	14.05	0.0359	56.42
VIII.	0.6055	0.7421	9.854	10.912	14.02	0.0412	56.36
IX.	0.6054	0.7419	9.859	10.918	14.03	0.0469	56.35
X.	0.6036	0.7398	9.860	10.920	14.04	0.0469	56.28
XI.	0.6041	0.7404	9.820	10.876	13.99	0.0347	56.32
XII.	0.6053	0.7418	9.799	10.852	13.95	0.0256	56.38
AVERAGE	-	-	-	-	-	-	55.96

__Table 3.11:__ Overview of country or plant specific CO_2 EFs in t/TJ used in the category 1.A.1 in 2022

1.A.1.a	WEIGHTED CO_2 EFs	FUEL TYPE	C EFs	CO_2 EFs
Liquid	76.10	Gas/Diesel oil	20.35	74.61
		Residual fuel oil	21.17	77.62
		Liquefied petroleum gases	17.22	63.14
Solid	95.31	Anthracite	27.66	101.42
		Other bituminous coal	25.83	94.71
		Lignite	26.04	95.48
Gaseous	56.17	Natural gas	15.32	56.17
Biomass	107.86	Other biogas	14.90	54.59
		Sludge gas	14.90	54.59
		Other primary solid biomass	27.30	100.10
		Wood/Wood waste	30.50	111.83
1.A.1.b	**WEIGHTED CO_2 EFs**	**FUEL TYPE**	**C EFs**	**CO_2 EFs**
Liquid	74.29	Residual fuel oil	21.60	79.21
		Petroleum coke	29.53	108.29
		Refinery gas	15.26	55.98
Gaseous	56.17	Natural gas	15.32	56.17

1.A.1.c	WEIGHTED CO_2 EFs	FUEL TYPE	C EFs	CO_2 EFs
Liquid	63.97	Liquefied petroleum gases	17.22	63.14
		Gas/Diesel oil	20.35	74.61
Solid	193.37	Lignite	26.04	95.48
		Coke oven gas	11.74	43.05
		Blast furnace gas	75.05	278.18
Gaseous	56.17	Natural gas	15.32	56.17

Default CO_2 emission factors from the IPCC 2006 GL are used only for biomass, which almost invariably refers to wood, wood wastes and biogas. The actually used fuels-specific EFs are in ***Table 3.11***.

In addition to CO_2 emissions, the fuel combustion in stationary sources results in the CH_4, N_2O, NO_x, CO and NMVOCs emissions. Of these, CH_4, and N_2O account around 0.65% on the total GHG emissions (expressed in CO_2 eq.), in the Energy sector (CO_2: 6 366.07 Gg; CH_4: 15.55 Gg CO_2 eq.; N_2O: 25.84 Gg CO_2 eq.). These emissions are influenced by many factors, including fuel type, equipment design, and emissions control technology. Therefore, it is inherently more complex and more uncertain than CO_2 emissions estimation. The non-CO_2 EFs are default based on the IPCC 2006 GL.

Uncertainties and time-series consistency

According to the previous recommendations, Slovakia is using hybrid combination of the Approaches 1 and 2 in this submission for calculation of total uncertainty of the inventory (**Annex 3** of this Report). Uncertainty analyses performed by the Approach 1 in transport was carried out using Table 3.2 for uncertainty calculation and country specific uncertainties for activity data and emission factors were inserted into calculation table.

The Slovak Republic provided and published also Approach 2 for uncertainty analyses according to the Chapter 3 of the IPCC 2006 GL for the complete Energy and IPPU sectors for the inventory year 2015. The methodology and results were described in previous SVK NIRs 2017 and 2018. The latest Monte Carlo simulation was performed for the 2015 emissions inventory. Due to capacity reasons and according to the QA/QC plan in this sector, new calculation of Monte Carlo uncertainty (Approach 2) in the Energy sector and categories (including transport) will be performed in next submissions. For more information, please see the **Chapter 1.2** of this Report. Results of the Monte Carlo simulations were almost identical since this exercise was performed (since 2011).

Time series is consistent in all aspects (methodological approach, country specific EFs and oxidation factor used, fuel characteristics, etc.) to the detailed level of disaggregation (on plant specific level).

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

Category 1.A.2 includes CO_2 emissions allocated in: Iron and steel (1.A.2.a); Non-ferrous metals (1.A.2.b); Chemicals (1.A.2.c); Pulp, paper, and print (1.A.2.d); Food processing, beverages, and tobacco (1.A.2.e); Non-metallic minerals (1.A.2.f) and Other (1.A.2.g). Emissions include industrial emissions originating largely from energy and heat production in raw materials and semi-manufactured goods production. The emissions reported here are related to fuel combustion, only. Consumption of fuels used as feedstock and reduction medium is not included in this category as it is allocated in the IPPU sector.

Iron and steel (1.A.2.a) – the iron and steel industry is one of the most energy intensive industrial branches in the Slovak Republic. Total volume of fuels allocated in 1.A.2.a expressed in energy units represented 19 265.92 TJ in 2022.

The main iron and steel producer in the Slovak Republic - U. S. Steel, s. r. o. idled one of its three blast furnaces, whose total capacity is 4.5 million tonnes of raw iron a year, on June 2019. It did so in response to the situation on the European steel market which has been massively impacted by steel products imported into the European Union. The shutdown of the blast furnace led to a reduction in CO_2 emissions by more than 860 kt of CO_2 between years 2019 and 2018. In 2020, the decrease in emissions continued and total CO_2 emissions were at the level of 2 179 kt. From January 2021, iron production was resumed at all blast furnaces. As a result of the increase in iron production, there was an interannual increase in emissions at the level of 45% in 2021. Due to very high energy prices, low market demand and a sharp increase in steel imports, the steel production was significantly reduced in 2022. During the year 2022, up to two blast furnaces were gradually shut down. The reduction of CO_2 emissions was more than 1 650 kt CO_2, which represents a decrease of more than 18%. This sharp fluctuation is reflected in all categories, where the emissions from steel production are allocated (1.A.1.c, 1.A.2.a, 1.A.2.m and 2.C.1). One of the most significant companies in this category (OFZ, a. s. Oravský Podzámok), significantly reduced its production, too. The production was limited provisionally until the end of the year 2022 due to continued negative market conditions, in particular high electricity prices and low market prices for ferro-alloys. OFZ consumed large amount of biomass and there was a 50% decrease in biomass consumption in OFZ.

Total CO_2 emissions were 2 474.09 Gg. Total CH_4 emissions were 0.0902 Gg and total N_2O emissions were 0.0129 Gg.

Non-ferrous metals (1.A.2.b) – this source covers combustion-related emissions from non-ferrous metal industry. Total volume of fuels allocated in 1.A.2.b expressed in energy units was 2 569.57 TJ in 2022. There was also a significant decline in emissions in the CRF category 1.A.2.b. The most pronounced declines are seen for natural gas and coal. At the end of 2021, the Slovalco company (produced of aluminium), reduced production volume to 80% of their capacity, and a further reduction in production volume to 60% of capacity was achieved from February 2022. The production of primary foundry alloys was stopped. The complete closure of primary aluminium production after 70 years of production took place at the beginning of January 2023 with the shutdown of the last of the 226 pots. Consumption of liquid fuels is on the same level as in 2021. LPG consumption remained unchanged, however the consumption of residual fuel decreased practically to zero. The result of change in fuel mix caused a significant inter-annual change of IEFs.

Total CO_2 emissions were 78.94 Gg, total CH_4 emissions were 0.0434 Gg and total N_2O emissions were 0.0058 Gg.

Chemicals (1.A.2.c) – includes emissions from fuels combustion in chemical industry. Chemical industry produces several different products such as chemicals, plastics or solvents. Total volume of fuels expressed in energy units allocated in 1.A.2.c was 7 906.71 TJ in 2022, which is comparable with previous year. In 2015, significant reduction of natural gas consumption occurred, which was caused by the termination of operation of one company with relatively high share of fuels in the period between 2016 and 2020. Natural gas consumption was almost constant. In 2022, a moderate decrease of emissions from gaseous fuels can be observed.

There is a visible reduction in consumption of solid fuels. This trend is similar than in other categories, where solid fuels are replaced by natural gas and/or biomass. In year 2020, significant reduction in coal consumption occurred in the power plant Chemes, a. s., where the coal consumption decreases by more than 15%. In 2021, the major consumer of solid fuels (Chemes, a. s) stopped using anthracite and biomass. The solid fuels were replaced by natural gas. Therefore, the emissions from solid fuels decreased in 2022 practically to zero and the reduction of emissions is more than 99% in comparison with base year.

Total CO_2 emissions were 449.57 Gg, total CH_4 emissions were 0.01273 Gg and total N_2O emissions were 0.0015 Gg in 2022.

Pulp, paper and print (1.A.2.d) – includes emissions from fuel combustion in pulp, paper and print industry. Total volume of fuels allocated in 1.A.2.d expressed in energy units was 23 358.76 TJ in 2022 (practically identical to previous year). There was a visible decrease of inter-annual energy consumption between 2015 and 2016 (27 472.11 TJ in 2015 and 22 926.55 TJ in 2016). It was caused by decrease of fuels consumption in three major plants allocated here. In 2021, a significant interannual change in fuel mix occurred in this category. Major emissions producer (Bukoza Energo) cut coal consumption in half (decrease in coal consumption was more than 60 thousand tons). The reduction in coal consumption was compensated by an increase in biomass consumption (increase in biomass consumption was 10%). The result of the change in the fuel mix is 10% decrease in emissions. Similar trend is visible also in 2022. The inter-annual increase of emissions from biomass is 3.5% and decrease of emissions from solid fuels is 15%.

Total CO_2 emissions were 243.53 Gg, total CH_4 emissions were 0.1693 Gg and total N_2O emissions were 0.0483 Gg in 2022.

Food processing, beverage and tobacco (1.A.2.e) – total volume of fuels allocated in 1.A.2.e expressed in energy units represented 5 526.35 TJ in 2022. Total energy is comparable with previous year, however the fuels mix has been changed. One of the largest source in this category (Slovenské cukrovary) stopped producing heat from coal. The coal consumption drops to zero and the largest share in solid fuels represented coke consumption. The lignite was fully replaced with natural gas (therefore a significant increase in gaseous fuels is observed). Therefore, the inter-annual change of IEF is significant.

Total CO_2 emissions were 310.02 Gg, total CH_4 emissions were 0.0062 Gg and total N_2O emissions were 0.0007 Gg in 2022.

Non-metallic minerals (1.A.2.f) – total volume of fuels allocated in 1.A.2.f expressed in energy units represented 19 817.63 TJ in 2022. The fuels are allocated in solid, liquid, gaseous, other and biomass fuels.

Total CO_2 emissions were 1 310.35 Gg, total CH_4 emissions were 0.24 Gg and total N_2O emissions were 0.0334 Gg.

Other (1.A.2.g) - The remaining emissions from fuels combustion in manufacturing and industry were allocated in this category. Total volume of fuels expressed in energy units represented 18 238.02 TJ in 2022. The sharp decrease of emissions in this category started in 2020 and was caused by significant reduction of production in U. S. Steel, s. r. o. The decrease in natural gas consumption in comparison with previous year was more than 12%. The reduction of blast furnace gas was more than 32% and coke oven gas consumption decreased by more than 82%. During and after 2020, one of the furnaces was shut down, therefore the decrease in consumption of natural gas and coke oven gas continued. This decrease of solid fuels consumption is also reflected in the inter-annual fluctuation of implied emission factor of solid fuels. The reduction of coke oven gas consumption (with very low EF) caused increase of the share of coal (incinerated in other CRF categories). As the result of the decrease of the coke oven gas consumption, the IEF increase to value 94.81 t CO_2/TJ in 2020. In 2021, the production in U. S. Steel, s. r. o. was resumed and therefore the energy consumption and emissions increased significantly. In 2022, were two furnaces shut down, again. The shutdown of the furnaces also resulted in a significant decrease in emissions. In 2022, a significant increase in liquid fuels can be observed in sector 1.A.2.g.v. This increase was caused mainly by STRABAG company, where oil consumption increased by 300% compared to the previous year. Increased of oil consumption in this sector also caused a sharp increase of all IEFs.

Total CO_2 emissions were 1 007.41 Gg, total CH_4 emissions were 0.095 Gg and total N_2O emissions were 0.01222 Gg in 2022.

Based on the IPCC 2006 GL, this category was further split into 8 subcategories. The distribution of individual plants into subcategories was done based on the NACE rev.2 classification. The distribution of emissions along this category is ***Table 3.12***.

Table 3.12: *Disaggregation of CO_2 emissions across the subcategories of the 1.A.2.g in 2022*

SUBCATEGORY	CO_2 EMISSIONS	SHARE
	Gg/year	*%*
1.A.2.g.i Man. of machinery	154.87	15.37
1.A.2.g.ii Man. of transport equipment	173.32	17.2
1.A.2.g.iii Mining and quarrying	7.92	0.79
1.A.2.g.iv Wood and wood products	15.96	1.58
1.A.2.g.v Construction	42.96	4.26
1.A.2.g.vi Textile and leather	25.57	2.54
1.A.2.g.viii Other	586.81	58.25

Methodological issues – activity data

Detail description of the methodological issues and activity data used for estimation of emissions from fuel combustion is given in the **Chapter 3.2.6**.

Iron and steel (1.A.2.a) - in Slovakia, pig iron and steel are produced in iron and steel integrated plant and by the EAF. Iron and steel integrated production is a complex one with many energy-related installations (coke ovens, heating plant, etc.). To avoid double counting of the primary and secondary fuels from iron and steel industry, the revised estimation was prepared in previous years in cooperation with the IPPU experts. The estimation includes and compares information from the iron and steel industry based on the EU ETS reports of the biggest iron and steel company in the Slovak Republic (U. S. Steel, s. r. o.). Methodology for emissions estimation was prepared by the specific model developed according to the national circumstances to ensure higher quality of estimation, avoiding double counting and properly allocated emissions in the Energy and IPPU sectors. Description of model is provided in details in the **Annex 4.2** (Methodology for carbon balance of iron and steel production).

Emission factors and NCVs

Detail description of the emission factors and NCVs used for estimation of emissions from fuel combustion is given in the **Chapter 3.2.6**. Mainly country-specific or plant-specific emission factors are used in the category 1.A.2, although IPCC default emission factors are used for not key fuels. In the case of iron and steel integrated plant, all emission factors (NCVs and oxidation factors) are plant specific. Emission factors for anthracite, cooking coal, other bituminous coal and petroleum coke in the

1.A.2.a are also country specific (estimated as weighted average of sources allocated in this subcategory). The list of actually used EFs is presented in ***Table 3.13***.

Table 3.13: *Overview of country or plant specific CO_2 EFs in t/TJ in the category 1.A.2 in 2022*

1.A.2.a	WEIGHTED CO_2 EFs	FUEL TYPE	C EFs	CO_2 EFs
Liquid	70.60	Residual Fuel Oil	21.09	77.33
		Liquefied Petroleum Gases	17.22	63.14
Solid	139.17	Gas Coke	29.30	107.42
		Other Bituminous Coal	25.59	93.83
		Coke Oven Gas	11.77	43.16
		Blast Furnace Gas	75.05	275.18
Gaseous	56.17	Natural gas	15.32	56.17
Biomass	111.83	Wood/Wood Waste	30.50	111.83
1.A.2.b	**WEIGHTED CO_2 EFs**	**FUEL TYPE**	**C EFs**	**CO_2 EFs**
Liquid	66.09	Gas/Diesel Oil	20.22	74.14
		Residual Fuel Oil	21.09	77.33
		Liquefied Petroleum Gases	17.22	63.14
Solid	98.88	Other Bituminous Coal	25.72	94.31
		Gas Coke	29.30	107.42
Gaseous	56.17	Natural gas	15.32	56.17
Biomass	111.83	Wood/Wood Waste	30.50	111.83
1.A.2.c	**WEIGHTED CO_2 EFs**	**FUEL TYPE**	**C EFs**	**CO_2 EFs**
Liquid	63.90	Residual Fuel Oil	21.17	77.62
		Gas/Diesel Oil	20.22	74.14
		Liquefied Petroleum Gases	17.22	63.14
Solid	98.77	Anthracite	27.66	101.42
		Coking Coal	25.53	93.61
Gaseous	56.17	Natural gas	15.32	56.17
Biomass	138.58	Wood/Wood Waste	30.50	111.83
		Other Primary Solid Biomass	27.30	100.10
		Other Biogas	14.90	54.63
		Biogenic waste	39.00	143.00
1.A.2.d	**WEIGHTED CO_2 EFs**	**FUEL TYPE**	**C EFs**	**CO_2 EFs**
Liquid	71.71	Residual Fuel Oil	21.17	77.62
		Liquefied Petroleum Gases	17.22	63.14
Solid	99.10	Other Bituminous Coal	25.72	94.30
		Lignite	27.19	99.70
Gaseous	56.17	Natural gas	15.32	56.17
Biomass	98.39	Sulphite lyes (black liquor)	26.00	95.33
		Wood/Wood Waste	30.50	111.83
		Sludge Gas	14.90	54.63
		Other Primary Solid Biomass	27.30	100.10
1.A.2.e	**WEIGHTED CO_2 EFs**	**FUEL TYPE**	**C EFs**	**CO_2 EFs**
Liquid	63.23	Liquefied Petroleum Gases	17.22	63.14
		Gas/Diesel Oil	20.22	74.14
Solid	107.40	Anthracite	27.66	101.42
		Brown Coal Briquettes	26.61	97.57
		Gas Coke	29.30	107.42

Gaseous	56.17	Natural gas	15.32	56.17
Biomass	86.04	Other Primary Solid Biomass	27.30	100.10
		Sludge Gas	14.90	54.63
		Other Biogas	14.90	54.63
		Wood/Wood Waste	30.50	111.83
1.A.2.f	**WEIGHTED CO_2 EFs**	**FUEL TYPE**	**C EFs**	**CO_2 EFs**
Liquid	94.21	Residual Fuel Oil	21.18	77.66
		Petroleum Coke	27.26	99.95
		Liquefied Petroleum Gases	17.22	63.14
		Gas/Diesel Oil	20.35	74.62
Solid	97.77	Anthracite	27.66	101.42
		Other Bituminous Coal	25.72	94.30
		Lignite	27.19	99.70
		Gas Coke	29.30	107.42
Gaseous	56.17	Natural gas	15.32	56.17
Other	91.56	Municipal and Industrial Wastes	24.97	91.56
Biomass	91.69	Wood/Wood Waste	30.50	111.83
		Waste (biogenic)	24.97	91.56
1.A.2.g	**WEIGHTED CO_2 EFs**	**FUEL TYPE**	**C EFs**	**CO_2 EFs**
Liquid	66.29	Gas/Diesel Oil	20.22	74.14
		Liquefied Petroleum Gases	17.22	63.14
		Residual Fuel Oil	21.18	77.66
Solid	89.51	Blast Furnace Gas	75.05	275.18
		Coke oven Gas	11.77	43.16
		Lignite	27.19	99.70
		Other bituminous coal	25.72	94.30
Gaseous	56.17	Natural gas	15.32	56.17
Biomass	111.83	Other primary solid biomass	27.30	100.10
		Wood/Wood waste	30.50	111.83

Uncertainties and time-series consistency

Description of uncertainty is similar to the **Chapter 3.2.6** of this Report.

Time series is consistent in all aspects (methodological approach, country specific EFs and oxidation factor used, fuel characteristics, etc.) to the detailed level of disaggregation (on plant specific level).

3.2.8. Transport (CRF 1.A.3)

Transport has a very special position in the Energy sector, as it is not included in the EU ETS or other policies or measures, thus transport emissions are very difficult to regulate. The emissions balanced in the transport (1.A.3) include subcategories Domestic Aviation (1.A.3.a), Road transport (1.A.3.b), Railways (1.A.3.c), Domestic Navigation (1.A.3.d) and Pipeline transport (1.A.3.e.i). This report uses the GWP 100 based on IPCC Assessment report 5. The difference between emission based on GWP 100 IPCC Assessment report 4 (AR4) and 5 (AR5) are shown in the previous NIR 2023.

As mentioned in previous reports, there is still observed shift from public transport to individual passenger cars in Slovakia. After a decrease in fuel consumption and emissions in the pandemic year 2020, there can be observed again a rise, except of category of passenger car category. After a two-year decline in in the passenger cars category, the trend returned in 2022 to rise as well as the other road transport categories. Total aggregated GHG emissions in transport increased in 2022 against the base year by 14.12% and against the previous year increased by 3.41%. Road transport emissions rose by 67.13% in 2022 in comparison with the base year.

The emissions from road and non-road transport were calculated by using models, default methodologies and the consistent data series from 1990 – 2022 are presented in CRF Tables. Total GHG emissions in transport were 7 778.85 Gg of CO_2 eq. in 2022. The CO_2 emissions were 7 689.10 Gg, which represent 98.85% share on total transport emissions, the CH_4 emissions were 5.97 Gg of CO_2 eq. with the 0.08% share and N_2O emissions were 83.77 Gg of CO_2 eq. with the 1.08% share on total transport GHG emissions.

Within transport, the share of road transport was 98.53%, pipeline transport 0.21%, railways 1.17%, domestic aviation represents 0.02% and domestic navigation 0.07% (in CO_2 eq.). Total energy consumption was 113 067.15 TJ of fuels in 2022. Among fuels, the most important are liquid fuels (***Figure 3.7***) and gaseous fuels. No solid fuels were used in transport category. Category "other fossil fuels" represents the fossil part of biomass fuels. The time series of GHG emissions are presented in ***Table 3.14***.

Figure 3.7: *The share of fuels on different categories within transport in 2022*

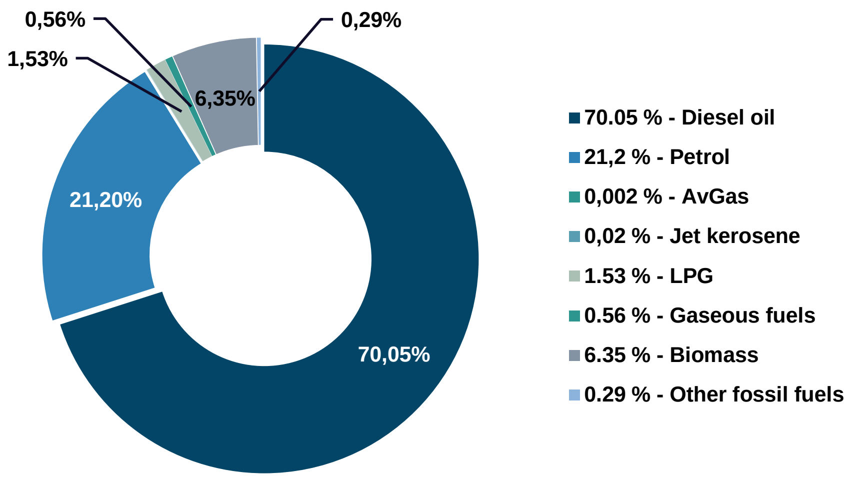


Table 3.14: *Fuel consumption and GHG emissions in transport by subcategories in particular years*

YEAR	1.A.3.a DOMESTIC AVIATION				1.A.3.b ROAD TRANSPORT			
	FUEL	CO_2	CH_4	N_2O	FUEL	CO_2	CH_4	N_2O
	TJ	*Gg/year*			*TJ*	*Gg/year*		
1990	51.48	3.74	0.000070	0.000102	61 027.37	4 503.02	1.1654	0.1895
1995	36.57	2.66	0.000050	0.000072	54 601.91	4 033.64	1.2323	0.1681
2000	36.50	2.65	0.000050	0.000072	56 107.97	4 077.90	0.9199	0.1466
2005	107.14	7.79	0.000158	0.000212	84 295.59	6 159.74	1.0570	0.1932
2010	70.59	5.13	0.000095	0.000140	92 325.43	6 435.39	0.7401	0.1634
2015	50.31	3.66	0.000069	0.000099	99 466.88	6 930.96	0.3213	0.2460
2016	49.00	3.56	0.000065	0.000097	102 047.46	7 063.70	0.2264	0.2502
2017	46.96	3.42	0.000066	0.000093	104 097.00	7 182.73	0.2995	0.2659
2018	39.21	2.85	0.000054	0.000078	106 593.35	7 338.01	0.2028	0.2683
2019	25.15	1.83	0.000040	0.000050	109 199.25	7 549.99	0.2029	0.2739
2020	12.17	0.88	0.000017	0.000024	98 361.62	6 743.79	0.1694	0.2191
2021	17.82	1.29	0.000025	0.000035	105 503.74	7 226.19	0.1854	0.2709
2022	20.47	1.48	0.000027	0.000040	111 494.34	7 583.91	0.2076	0.2818

YEAR	1.A.3.c RAILWAYS				1.A.3.d DOMESTIC NAVIGATION			
	FUEL	CO_2	CH_4	N_2O	FUEL	CO_2	CH_4	N_2O
	TJ	*Gg/year*			*TJ*	*Gg/year*		
1990	5 024.14	372.29	0.0209	0.1437	0.30	0.02	0.0000021	0.0000006
1995	2 693.37	199.58	0.0112	0.0770	0.27	0.02	0.0000019	0.0000005
2000	2 080.68	154.18	0.0086	0.0595	0.33	0.02	0.0000023	0.0000007
2005	1 411.21	104.57	0.0059	0.0404	0.47	0.03	0.0000033	0.0000009
2010	1 162.77	82.32	0.0048	0.0333	4.49	0.33	0.0000339	0.0000090
2015	1 220.28	84.33	0.0051	0.0349	83.94	6.22	0.0005895	0.0001679
2016	1 250.91	86.53	0.0052	0.0358	64.24	4.76	0.0004522	0.0001285
2017	1 222.54	84.35	0.0051	0.0350	63.32	4.69	0.0004458	0.0001262
2018	1 197.06	82.93	0.0050	0.0342	34.53	2.56	0.0002446	0.0000691
2019	1 174.06	81.02	0.0049	0.0336	56.36	4.17	0.0003974	0.0001127
2020	1 052.53	72.53	0.0044	0.0301	72.25	5.35	0.0005058	0.0000144
2021	1 186.31	82.15	0.0049	0.0339	78.25	5.82	0.0005477	0.0001565
2022	1 193.84	82.29	0.0050	0.0341	71.45	5.29	0.0005002	0.0001429

YEAR	1.A.3.e.i PIPELINE TRANSPORT			
	FUEL	CO_2	CH_4	N_2O
	TJ	*Gg/year*		
1990	31 844.87	1 813.95	0.0318	0.0032
1995	20 644.81	1 154.10	0.0206	0.0021
2000	25 523.75	1 404.81	0.0255	0.0026
2005	24 168.60	1 327.92	0.0242	0.0024
2010	1 4961.55	824.47	0.0150	0.0015
2015	3 309.18	184.40	0.0033	0.0003
2016	5 351.33	298.41	0.0054	0.0005
2017	5 730.92	319.11	0.0057	0.0006
2018	5 315.65	295.17	0.0053	0.0005
2019	7 141.84	398.28	0.0071	0.0007
2020	3 009.14	167.83	0.0030	0.0003
2021	2 160.94	120.93	0.0022	0.0002
2022	287.05	16.12	0.0003	0.00003

To estimate CO_2 emissions, country-specific (CS) data were used. The data used to calculate country-specific CO_2 emission factors (EF) included the fuel Net Calorific Value (NCV) and the H:C and O:C ratio for specific fuels. This EF was subsequently applied to every transport sector where these fuels were used. The calculated CS EF is summarized in ***Table 3.15***.

Table 3.15: *CO_2 country-specific emission factors for selected fuels for the year 2022*

FUEL	PETROL	DIESEL OIL	BIO-ETHANOL	BIO-DIESEL
	t/TJ	*t/TJ*	*t/TJ*	*t/TJ*
Emission factor	69.144	74.083	69.895	69.941

Domestic aviation (CRF 1.A.3.a) - The inventory evaluation of GHG emissions in domestic aviation was performed for all GHGs, precursors and air pollutants. In the absence of national data on the exact numbers of domestic LTO cycles for the years 1990 – 2004 (only total national + international numbers of LTO cycles are available), summary information from the EUROCONTROL database was used. According to the recommendations of the ERT during previous reviews and following the IPCC 2006 GL, the emissions estimation was based on the fuel sold to national and international civil flights (tier 1 approach as it is not a key category for the Slovak Republic) for the years 1990 – 2004. The Slovak airports, except for the airport in Žilina, where exercises with light aircrafts of the Žilina University predominate, are managed by themselves as separate company. Other smaller civil airports (Nitra, Prievidza, Ružomberok and Lučenec) are operated by aero clubs with predomination of sport flights. Described approach is maintained for a time series 1990 – 2004. For the time series 2005 – 2022, EUROCONTROL data on the number of flights, fuels consumption and share of domestic and international flights was used.

The fuels consumption in domestic aviation decreased in 2022 compared to the base year 1990 by 60.2%. The total jet kerosene consumption was 18.22 TJ and the consumption of aviation gasoline (AvGas) was 2.26 TJ allocated in domestic aviation in 2022 (***Table 3.16***). Total GHG emissions from domestic aviation were 1.49 Gg of CO_2 eq. in 2022. There was a visible increase of emissions in years 2002 – 2008 (***Figure 3.10***). In 2002, air transport was positively affected by the entry of low-cost companies to the Slovak market, like SkyEurope Airlines, Seagle Air and Danube Wings, but this also caused an increase in emissions. The time series is influenced by the fact, that the Slovak Republic has no official national airlines since the Slovak Airlines are out of business since 2007, SkyEurope since 2009 and close distance of other big international airports in Vienna and Budapest.

Table 3.16: *The fuels consumption and GHG emissions for national flights in particular years*

YEAR	AVIATION GASOLINE				JET KEROSENE			
	CONSUMPTION	EMISSIONS			CONSUMPTION	EMISSIONS		
	TJ	*t* CO_2	*t* CH_4	*t* N_2O	*TJ*	*t* CO_2	*t* CH_4	*t* N_2O
1990	3.35	236.99	0.002	0.007	48.13	3 501.22	0.068	0.095
1995	2.22	156.82	0.001	0.004	34.36	2 499.39	0.049	0.068
2000	2.56	180.67	0.002	0.005	33.94	2 469.37	0.048	0.067
2005	0.95	67.23	0.001	0.002	106.19	7 725.42	0.158	0.210
2010	1.85	130.64	0.001	0.004	68.75	5 001.21	0.094	0.136
2015	2.11	149.27	0.001	0.004	48.20	3 506.73	0.068	0.095
2016	1.68	116.63	0.001	0.003	47.32	3 442.59	0.064	0.094
2017	1.97	138.78	0.001	0.004	44.99	3 281.18	0.065	0.089
2018	2.32	163.68	0.001	0.005	36.89	2 690.19	0.053	0.073
2019	1.99	140.17	0.001	0.004	23.16	1 689.13	0.039	0.046
2020	1.59	110.14	0.001	0.003	10.58	769.74	0.016	0.021
2021	1.50	104.19	0.001	0.003	16.31	1 186.75	0.025	0.032
2022	2.26	156.35	0.001	0.004	18.22	1 325.12	0.026	0.036

Road transport (CRF 1.A.3.b) - Short distance passenger transport is an important part of road transport. It is the most exploited type of transport in the Slovak Republic due to a high density and quality of road network and interconnection of all municipalities. In recent years, road transport has expanded significantly in the transport of goods and persons. In 2022, the transport network included 545 km of highways, 317 km of motorways and 3 337 km of the category 1st class roads. Total road network represented 18 156 km of roads in the Slovak Republic[5] in 2022. Road transport is the most important and key category with the highest share of emissions and continually increasing trend in fuels consumption within transport. This increase was however interrupted by the COVID pandemic and Slovakia observed a temporary major decrease of fuel consumption and GHG emissions in 2020. After that it is again observed rise in fuel consumption and emissions from 2021. Total aggregated emissions from road transport reached 7 664.39 Gg of CO_2 eq. in 2022. The increase in emissions compared to 2021 is 4.95%, and increase compared to the base year is 67.13%. The major share of emissions belongs to heavy duty vehicles and passenger cars (***Table 3.14***). Total blended CO_2 emissions were

[5] Slovak Road Database 2022

8 139.01 Gg in 2022. These blended emissions include also emissions from lube oil from two-stroke petrol passenger cars. After separation of biomass content, the final CO_2 balance for fossil part of fuels was 7 583.91 Gg. Biomass content in fuels increased in 2018 compared to the previous year mainly to introduction of E10 petrol and subsequently decrease because of COVID-19, emissions actually represent 529.92 Gg of bio-CO_2. The most of the emissions come from the city traffic (***Table 3.18***).

Table 3.17: *Overview of total GHG emissions according to the type of vehicles in 2022*

CATEGORY OF ROAD VEHICLE	Emissions			CATEGORY OF ROAD VEHICLE	Emissions		
	CO_2	CH_4	N_2O		CO_2	CH_4	N_2O
	t/year	*kg/year*			*t/year*	*t/year*	
Passenger Cars	4 867 151	138 270	128 043	Diesel N1-III	599 178	899	15 378
Petrol Mini	2 862	188	28	Heavy Duty Trucks	2 001 947	30 521	117 602
Petrol Small	832 031	65 999	10 444	Petrol >3,5 t	17	4	0
Petrol Medium	614 626	39 696	7 417	Rigid <=7,5 t	153 192	4 085	6 187
Petrol Large-SUV-Executive	115 262	4 621	799	Rigid 7,5 - 12 t	175 780	2 739	5 452
2-Stroke	38	13	0	Rigid 12 - 14 t	42 077	631	2 117
Petrol Hybrid Mini	46	4	1	Rigid 14 - 20 t	64 543	1 942	2 661
Petrol Hybrid Small	7 441	617	83	Rigid 20 - 26 t	6 100	262	187
Petrol Hybrid Medium	45 995	3 805	524	Rigid 26 - 28 t	786	18	31
Petrol Hybrid Large-SUV-Executive	16 462	1 324	182	Rigid 28 - 32 t	650	29	30
Petrol PHEV Small	955	70	9	Rigid >32 t	709	21	27
Petrol PHEV Medium	3 063	200	27	Articulated 14 - 20 t	1 557 911	20 786	100 904
Petrol PHEV Large-SUV-Executive	1 495	82	11	Articulated 20 - 28 t	183	5	6
Diesel Mini	200	1	14	Buses	328 915	22 262	10 449
Diesel Small	41 331	142	1 412	Urban Buses Midi <=15 t	23 707	202	904
Diesel Medium	2 322 337	6 850	86 839	Urban Buses Standard 15 - 18 t	20 844	107	611
Diesel Large-SUV-Executive	692 196	1 550	17 866	Urban Buses Articulated >18 t	2 726	11	53
Diesel PHEV Large-SUV-Executive	208	0	8	Coaches Standard <=18 t	259 504	2 716	8 701
LPG Bifuel Mini	33	2	1	Coaches Articulated >18 t	4 839	21	169
LPG Bifuel Small	87 711	6 507	1 087	Diesel Hybrid	614	2	12
LPG Bifuel Medium	63 287	4 452	1 013	Urban Biodiesel Buses	0	0	0
LPG Bifuel Large-SUV-Executive	14 790	955	238	L-Category	23 112	12 210	409
CNG Bifuel Mini	23	6	0	Mopeds 2-stroke <50 cm^3	23	36	0
CNG Bifuel Small	3 335	875	28	Mopeds 4-stroke <50 cm^3	1 058	630	18
CNG Bifuel Medium	1 332	288	9	Motorcycles 2-stroke >50 cm^3	87	124	2

CATEGORY OF ROAD VEHICLE	Emissions			CATEGORY OF ROAD VEHICLE	Emissions		
	CO_2	CH_4	N_2O		CO_2	CH_4	N_2O
	t/year	*kg/year*			*t/year*	*t/year*	
CNG Bifuel Large-SUV-Executive	92	23	1	Motorcycles 4-stroke <250 cm³	2 344	2 613	86
Light Commercial Vehicles	917 889	4 310	23 195	Motorcycles 4-stroke 250 - 750 cm³	8 879	5 581	139
Petrol N1-I	26 319	1 712	332	Motorcycles 4-stroke >750 cm³	10 706	3 224	164
Petrol N1-II	17 919	645	222	Quad & ATVs	3	1	0
Petrol N1-III	3 251	136	63	Micro-car	11	1	0
Diesel N1-I	26 545	156	1 018	**National Total**	**8 139 014**	**207 573**	**279 699**
Diesel N1-II	244 678	762	6 183				

Table 3.18: *Results from COPERT model in distribution for driving mode (CO_2 emissions are from blended fuels with bio-component) in 2022*

TRAFFIC	***CO_2***	***CH_4***	***N_2O***
	t/year		
Urban	3 593 607	136.71	118.01
Rural	3 219 690	52.58	122.81
Highway	1 325 717	18.29	38.87
TOTAL	8 139 014	207.57	279.70

Railways (CRF 1.A.3.c) - Railways are the second largest source of emissions in transport, despite the decreasing character of this transport mode. Railways and rail transport are slowly modernised in Slovakia with the support of the EU funds. Improved quality and ecology of rail transport and the increase in passengers' number are the results of this modernisation. Modernisation of rail infrastructure results in an increase of operational speed to 160 km/h and increase of safety. According to the Annual Report of Slovak Railways[6] in 2022, the length of managed railways was 3 626 km of which the length of electric railways was 1 585 km. Total emissions from railways transport reached 91.48 Gg of CO_2 eq. in 2022 and they increased by 0.22% compared to 2021 (***Table 3.19***) and decreased several times compared to the base year. The decrease of fuels consumption compared to the base year was caused by the improvements of technical parameters. Rising of passenger transport on railways, partly caused by governmental measure[7] led to emissions increase, while cargo is fluctuating without visible trend.

Table 3.19: *Overview of fuels consumption and GHG emissions in railways in particular years*

YEAR	TOTAL CONSUMPTION	CO_2	CH_4	N_2O
	TJ	*Gg/year*		
1990	5 024.137	372.289	0.021	0.144
1995	2 693.369	199.579	0.011	0.077
2000	2 080.683	154.179	0.009	0.060
2005	1 411.206	104.570	0.006	0.040
2010	1 162.771	82.320	0.005	0.033
2015	1 220.277	84.332	0.005	0.035
2016	1 250.911	86.533	0.005	0.036
2017	1 222.536	84.352	0.005	0.035

6 Annual Report of Slovak Railway 2022, p. 14

7 Since 2013, social measure was introduced – free railways for students and retired on lower categories of trains.

YEAR	TOTAL CONSUMPTION	CO_2	CH_4	N_2O
	TJ	*Gg/year*		
2018	1 197.061	82.933	0.005	0.034
2019	1 174.056	81.024	0.005	0.034
2020	1 052.530	72.532	0.004	0.030
2021	1 186.310	82.150	0.005	0.034
2022	1 193.836	82.294	0.005	0.034

Domestic navigation (CRF 1.A.3.d) - The major share of emissions from shipping in Slovakia are realized as transit on Danube River. Due to international character of this river, emissions are included in the subcategory 1.D.1.b - Memo Items/International Bunkers/International Navigations (**Chapter 3.8**). Based on the information from the State Navigation Administration (the SNA), there are several movements realized between the Bratislava, Komárno and Štúrovo ports on the Slovak territory (national transport). Usually ships do not stop their operation on the Slovak territory, but the transit continues to Austria or Hungary. However, the part of GHG emissions from the movements between the ports on Slovak Territory is included in the national emissions inventory. Detailed information was based on statistics made by the SNA and the Slovak Shipping and Ports Company. The share of "national fuel consumption" is available since 2005. Inland shipping transport on small lakes for tourist purposes was not included in the 2020 report as those were not operating during the COVID-19 pandemic. In 2021 only a few restored their activity.

Total aggregated emissions from inland shipping excluding international navigations (on Danube River) reached 5.35 Gg of CO_2 eq. in 2022. After a decrease in 2018, an increase is observed from 2019 despite of COVID pandemic and no tourist tours on lakes (***Table. 3.20***).

Table 3.20: *Overview of fuels consumption and GHG emissions in domestic navigation in particular years*

YEAR	TOTAL CONSUMPTION	CO_2	CH_4	N_2O
	TJ	*Gg/year*		
1990	0.303	0.022	0.000002	0.000001
1995	0.274	0.020	0.000002	0.000001
2000	0.328	0.024	0.000002	0.000001
2005	0.468	0.035	0.000003	0.000001
2010	4.488	0.327	0.000031	0.000009
2015	83.942	6.215	0.000587	0.000168
2016	64.239	4.757	0.000452	0.000128
2017	63.324	4.689	0.000445	0.000126
2018	34.530	2.556	0.000244	0.000069
2019	56.361	4.172	0.000397	0.000113
2020	72.251	5.350	0.000506	0.000145
2021	78.250	5.823	0.000548	0.000157
2022	71.451	5.293	0.000500	0.000143

Pipeline transport (CRF 1.A.3.e.i) – Total fuels in 1.A.3.e.i expressed in energy units represented 287.05 TJ and total GHG emissions represented 16.14 Gg of CO_2 eq. in 2022. The share of this category on total transport emissions significantly decreased to 0.21% in 2022. This significant decrease is caused by war in Ukraine and lower transport of natural gas from east to west. The fuel consumption and GHG emissions are shown in ***Table 3.14***.

Methodological issues

Domestic aviation (1.A.3.a) – Domestic Aviation is not a key category. The airport traffic in Slovakia is determined only by the origin of airlines. It means, that there is no direct information about the number of domestic and international flights in statistics. Tier 1 approach for emission estimation in domestic aviation, both for aviation gasoline and jet kerosene was used for time series 1990 – 2004. Tier 1 approach is based on fuel sold on the airports. For this period, only total number of LTO cycles is known, therefore average disaggregation of activities between national and international aviation was judged. The expert judgment of share of national and international aviation activities for the period 1990 – 2004 was improved based on the known real numbers for time series 2005 – 2021 based on tier 3. Then the time series 1990 – 2004 was revised using constant share for national and international flights. Real share of national and international activities for the period 2005 – 2022 was taken from the EUROCONTROL (***Table 3.21***).

Table 3.21: *The share of fuel consumption in domestic aviation and international bunkers for the period 1990 – 2004*

FUELS	DOMESTIC AVIATION		INTERNATIONAL BUNKERS	
	PREVIOUS ESTIMATE	REVISED ESTIMATE	PREVIOUS ESTIMATE	REVISED ESTIMATE
AVIATION GASOLINE	90%	30%	10%	70%
JET KEROSENE	10%	5%	90%	95%

The implied emission factors applied in previous submissions for the years 1990 – 2004 were not in the IPCC range, therefore the new EFs for all GHG gases were calculated as average from the available EUROCONTROL data for years 2005 – 2018 and used from 2019 onwards for the years 1990 – 2004. These average EFs are EUROCONTROL based and were used since 2004 back to the base year to maintain consistency in the time-series. Activity data for the years 1990 – 1993 are not available and were estimated as expert judgment according to real LTO cycles in this period. For the period 1994 – 2004, activity data were directly provided by the airports on annual basis. Due to the time series consistency, the net calorific values from the EUROCONTROL data were used to convert obtained activity data.

From the year 2005 onwards, Slovakia decided to use directly the EUROCONTROL data. The decision was based on analysis of the national data and data obtained from the EUROCONTROL. Results showed that EUROCONTROL data are more consistent and accurate in line with the QA/QC rules. EUROCONTROL data used tier 3 applying the Advanced Emissions Model (AEM).

Following data were taken from the EUROCONTROL (***Tables 3.22*** and ***3.23***):

- fuel consumption of aviation gasoline for domestic flights;
- fuel consumption of aviation gasoline for international flights;
- fuel consumption of jet kerosene for domestic flights;
- fuel consumption of jet kerosene for international flights;
- CO_2, CH_4, N_2O emissions for all subcategories;
- NCVs calculated from fuel consumption.

Table 3.22: *Average EFs for the GHG emissions used in domestic civil aviation according to tier 1 based on fuel consumption*

PARAMETER	**EMISSIONS FACTORS**	
	INTERNATIONAL FLIGHTS	**NATIONAL FLIGHTS**
Emissions	Jet kerosene	
	kg/TJ of fuel	
CO_2	72 748	72 748
CH_4	0.707	1.343
N_2O	1.977	1.977
Emissions	Aviation gasoline	
CO_2	6 959	6 959
CH_4	0.541	0.572
N_2O	1.953	1.953

Table 3.23: *Average NCVs for the GHG emissions used in domestic civil aviation according to tier 1 based on fuel consumption*

NCVs		
Aviation Gasoline	*TJ/Gg*	44.00
Jet Kerosene	*TJ/Gg*	43.30

Road transport (1.A.3.b) – COPERT model 5 (v.5.5) was used for estimation of road transport emissions. The model distinguishes vehicle categories and emission factors reflecting the recent development and research. These data are not available before 2000. The methodology is often referred to the name of program (methodology "COPERT"). The model is based on the fuel approach, what is used for the CO_2 emissions estimation (tier 2). The fuel consumption and other variables such as H/C and O/C ratio and carbon content in fuels is used in this approach. According to the previous ERT recommendation, the country specific H/C ratio and NCVs were used in model calculation. Slovakia is analysing composition of fuels sold by the majority of companies on the market, representing 3 different refineries on regular basis. Delivering actual and most recent data on fuels' composition is crucial for correct country-specific EFs estimation. The H/C and O/C ratio of the fuels was analysed by the Research Institute for Crude Oil and Hydrocarbon Gases (VÚRUP) in 2022 (***Tables 3.24*** and ***3.25***). According to measured data and previous information provided by the Slovnaft refinery, the H/C ratio rose between 2015 and 2017 only by 0.26%. The NCVs of the fuels were obtained from the Statistical Office of the Slovak Republic and are shown in ***Table 3.26*** for the years 1990 – 2022.

Table 3.24*: Results of the H/C ratio analyses of fuel types and lube oil in 2022*

FUEL	**PETROL**	**DIESEL OIL**	**LPG**	**CNG**	**BIO-ETHANOL**	**BIO-DIESEL**	**LUBE OIL**
H/C Ratio	1.872	1.946	2.589	3.900	3.000	1.857	2.080

Table 3.25: *Results of the O/C analyses of fuel types and lube oil in 2022*

FUEL	**PETROL**	**DIESEL OIL**	**LPG**	**CNG**	**BIO-ETHANOL**	**BIO-DIESEL**	**LUBE OIL**
O/C Ratio	0.028	0.005	NA	NA	0.500	0.110	NA

NA=oxygen is not present

Table 3.26: Net calorific values (NCVs) for the fuel type obtained by the ŠÚ SR for particular years

YEAR	PETROL BLENDED	DIESEL OIL BLENDED	LPG	CNG	BIO-ETHANOL	ETBE	ESTERS
	TJ/Gg						
1990	43.206	42.511	NO	NO	NO	NO	NO
1995	43.388	42.076	46.000	NO	NO	NO	NO
2000	43.316	42.588	46.000	48.814	NO	NO	NO
2005	43.800	42.208	46.000	48.767	NO	NO	NO
2010	43.728	42.218	46.000	48.948	27.000	36.000	37.000
2011	43.780	42.206	46.000	48.923	27.000	36.000	37.000
2012	43.740	42.206	46.000	48.802	27.000	36.000	37.000
2013	43.952	42.043	46.000	48.753	27.000	36.000	37.800
2014	43.905	42.043	46.000	48.597	27.000	36.000	38.450
2015	43.909	42.143	46.000	48.760	27.000	36.000	39.265
2016	43.908	42.136	46.000	48.800	27.000	36.000	39.486
2017	43.899	42.127	46.000	48.800	27.000	36.200	39.699
2018	43.774	42.695	46.564	48.000	28.800	36.000	37.300
2019	43.934	42.600	46.000	48.800	27.000	36.000	39.867
2020	43.932	42.086	46.000	48.780	27.000	36.000	39.807
2021	43.928	42.087	46.000	48.070	27.000	36.000	39.646
2022	43.924	42.108	46.000	48.004	27.336	36.000	39.987

Statistically recorded fuel consumption and fuel consumption calculated through COPERT 5 model are equal, except of fossil petrol. There is a statistically insignificant difference on the level up to 2%. This is caused by highly complicated calculation and due to drastically shorten the time needed for calculation. The new version added new vehicle categories for the CH_4 and N_2O emissions estimation, with the disaggregation into 5 basic categories and 375 subcategories. Further disaggregation was applied according to the operation of road vehicles in the urban, rural and highway driving mode. In COPERT 5, buses were divided into 2 subcategories (urban and coaches) and seven weight categories. Heavy-duty vehicles are divided into 2 basic categories (rigid and articulated). Rigid vehicles are further divided by weight into 8 and articulated into six subcategories. EMEP/EEA methodology used technical parameters of different vehicle types and country-specific characteristics, such as the composition of car fleet, the age, operation and fuels or climate conditions.

Model estimates emissions from the following input data:

- total fuel consumption,
- composition of vehicle fleet,
- driving mode,
- driving speed,
- emission factors,
- annual mileage.

Information about the vehicle fleet is based on database IS EVO (Information System for Vehicle Evidence) operated by the Police Presidium of the Slovak Republic.

The EFs values for CH_4 and N_2O in COPERT 5 model are defined separately for the different types of fuels, types of vehicles, different technological level of vehicles, driving mode and season as these emissions are depended on ambient and vehicle temperature. In case of CH_4 emissions, the balance is based on the average speed and drive mode for certain vehicles´ group. The emission factors for pollutants such as CO_2, SO_2, N_2O, NH_3, PM and partially also CH_4 can be obtained by the simple formula of driving mode and consumed fuel. Emission factors are then calculated automatically by the model based on the input parameters such as the average speed, the quality of fuels, the age of vehicles, the weight of vehicles and the volume of cylinders.

Accurate and actual data on distance-based values and parameter values are necessary to run the COPERT 5 model (***Table 3.27***). Therefore, new input data on mileages was requested from the Technical Inspection (odometers) and the IS EVO (from the Police Department). As the unique key for binding data from these two registries, VIN number (Vehicle Identification Number) was used. Using MS Access, the average annual mileages were calculated. Further data, needed for calculation were: the first registration of vehicle, vehicle type, engine volume, weight, emission category and data from odometer. At least that many years as are between two technical controls were needed.

The average annual mileages including consistency with fuel consumption were also used for identifying distribution of vehicles to their appropriate COPERT category. The Traffic Census of Slovakia conducted in every five years (2000, 2005, 2010 and 2015[8]) was the main source for activity data such as intensity on urban, rural and highways.

Table 3.27: *Overview of input data used in the COPERT 5 model in 2022*

CATEGORY OF ROAD VEHICLE	ACTIVITY DATA		CATEGORY OF ROAD VEHICLE	ACTIVITY DATA	
	No.	*km/veh.*		*No.*	*km/veh.*
Passenger Cars	2 523 199	1 564 173	Diesel N1-II	74 057	133 311
Petrol Mini	155	1 076	Diesel N1-III	145 177	123 351
Petrol Small	7 318	23 590	Heavy Duty Trucks	77 034	1 693 908
Petrol Medium	822 316	51 625	Petrol >3,5 t	108	346
Petrol Large-SUV-Executive	396 600	71 866	Rigid <=7,5 t	24 645	161 758
Petrol 2-Stroke	47 161	68 106	Rigid 7,5 - 12 t	14 014	204 115
Petrol Hybrid Mini	50	22 952	Rigid 12 - 14 t	3 823	143 335
Petrol Hybrid Small	6 835	49 234	Rigid 14 - 20 t	5 293	125 528
Petrol Hybrid Medium	27 450	60 548	Rigid 20 - 26 t	1 235	64 843
Petrol Hybrid Large-SUV-Executive	9 233	65 219	Rigid 26 - 28 t	58	159 652
Petrol PHEV Small	873	26 505	Rigid 28 - 32 t	211	107 467
Petrol PHEV Medium	2 081	41 793	Rigid >32 t	165	109 942
Petrol PHEV Large-SUV-Executive	977	40 670	Articulated 14 - 20 t	27 462	444 216
Diesel Mini	394	13 006	Articulated 20 - 28 t	20	172 706
Diesel Small	25 347	71 636	Buses	8 159	1 390 237
Diesel Medium	919 254	160 646	Urban Buses Midi <=15 t	736	206 538
Diesel Large-SUV-Executive	207 248	116 224	Urban Buses Standard 15 - 18 t	392	226 720
Diesel PHEV Large-SUV-Executive	72	44 902	Urban Buses Articulated >18 t	41	164 467
LPG Mini	21	9 989	Coaches Articulated >18 t	36	377 011
LPG Small	23 560	161 987	Coaches Standard <=18 t	6 668	259 162
LPG Medium	19 646	161 184	Diesel Hybrid	16	51 345
LPG Large-SUV-Executive	4 989	146 381	Urban CNG Buses	270	104 994
CNG Mini	14	10 651	L-Category	165 156	43 875
CNG Small	1 060	58 350	Mopeds 2-stroke <50 cm³	1 071	3 819
CNG Medium	489	64 496	Mopeds 4-stroke <50 cm³	27 275	3 920

[8] Data were published in 2016

CATEGORY OF ROAD VEHICLE	ACTIVITY DATA		CATEGORY OF ROAD VEHICLE	ACTIVITY DATA	
	No.	*km/veh.*		*No.*	*km/veh.*
CNG Large-SUV-Executive	56	21 538	Motorcycles 2-stroke >50 cm^3	2 633	5 732
Light Commercial Vehicles	272 527	574 153	Motorcycles 4-stroke <250 cm^3	47 667	4 898
Petrol N1-I	24 607	66 245	Motorcycles 4-stroke 250 - 750 cm^3	48 000	8 073
Petrol N1-II	9 152	72 557	Motorcycles 4-stroke >750 cm^3	38 377	11 403
Petrol N1-III	1 971	62 073	Quad & ATVs	59	1 293
Diesel N1-I	17 563	116 616	Micro-car	74	4 737

CO_2 correction factor was introduced into the COPERT model in 2018. According to the EMEP/EEA air pollutant emission inventory Guidebook 2023, the CO_2 emissions of new passenger cars registered in Europe are monitored in order to meet the objectives of Regulation EC 443/2009. Empirical models have been constructed to check how well measured in-use fuel consumption of passenger cars can be predicted based on independent variables. The set of models based on type-approval fuel consumption, require vehicle mass and capacity to predict real-world fuel consumption. Moreover, this set of models does not distinguish between vehicle types and it is ideal to predict consumption of new car registrations because both vehicle mass and type-approval CO_2 are readily available from the CO_2 monitoring database. A regression model has been developed considering the registration year as an additional variable to the currently used variables (mass and capacity of vehicle). The average mass, engine capacity and type-approval CO_2 values per passenger car category are required as user input to enable the CO_2 correction option. The mean FC_{Sample} is calculated as the average fuel consumption of the vehicle sample used in developing COPERT emission factors over the three parts (Urban, Rural and Highway) of the Common Artemis Driving Cycles (CADC). The sum of fuel consumption of the three CADC parts was used, each weighted by a 1/3 factor. It is noted that this 'average' fuel consumption was computed using actual vehicle performance (measurements), not COPERT emission factors. The correction factor is then calculated as: Correction= $FC_{In\ use}/FC_{Sample}$.

This correction coefficient is then used to calculate the modified fuel consumption and respective CO_2 emission factors for hot emissions only and the introduction was possible only from the year 2010 as there are no data available for previous years.

Regarding non-CO_2 emissions, the values used for setting and calculating the emission factors and the corresponding emissions in the COPERT model were verified and discussed in the previous years. The results of a comparative assessment for CH_4 and N_2O emissions showed, that the emissions inventory of Slovakia is comparable with other European countries and therefore the use of emission factors in the COPERT model are fully in agreement with the Middle European (Slovakia) national circumstances. The IEFs used in COPERT model are regularly updated and verified (***Table 3.28***) in a more advance versions of model. Methane IEFs are gradually decreasing for all vehicle categories, including light-duty vehicles owing to changes in the vehicle fleet. Newer vehicles are emitting fewer hydrocarbon pollutants, to which oxidation catalysts contribute. Methane behaves just like other hydrocarbons, so it declines, resulting in a decline in total emissions and also in IEFs. The emissions of N_2O are slowly increasing for light-duty vehicles (diesel) owing to NO_X reduction devices (SCR and EGS/DPF system).

***Table 3.28:** Overview of CH_4 and N_2O IEFs for the road vehicle categories in 2022*

CATEGORY OF ROAD VEHICLE	EMISSION FACTORS		CATEGORY OF ROAD VEHICLE	EMISSION FACTORS	
	CH_4	N_2O		CH_4	N_2O
	mg/km			*mg/km*	
Passenger Cars	5.05	4.68	Diesel N1-II	0.81	6.57
Petrol Mini	9.36	1.41	Diesel N1-III	0.39	6.64
Petrol Small	12.89	2.04	Heavy Duty Trucks	8.00	30.84
Petrol Medium	12.25	2.29	Petrol >3,5 t	109.90	6.00
Petrol Large-SUV-Executive	12.31	2.13	Rigid <=7,5 t	9.29	14.07
2-Stroke	79.58	0.00	Rigid 7,5 - 12 t	8.24	16.39
Petrol Hybrid Mini	9.32	1.27	Rigid 12 - 14 t	8.46	28.36
Petrol Hybrid Small	9.32	1.25	Rigid 14 - 20 t	19.51	26.75
Petrol Hybrid Medium	9.32	1.28	Rigid 20 - 26 t	34.60	24.67
Petrol Hybrid Large-SUV-Executive	9.32	1.28	Rigid 26 - 28 t	17.18	29.44
Petrol PHEV Small	6.82	0.93	Rigid 28 - 32 t	38.40	39.82
Petrol PHEV Medium	6.82	0.94	Rigid >32 t	24.66	32.22
Petrol PHEV Large-SUV-Executive	6.82	0.95	Articulated 14 - 20 t	7.28	35.32
Diesel Mini	0.40	6.66	Articulated 20 - 28 t	19.10	20.92
Diesel Small	0.63	6.29	Buses	58.11	27.28
Diesel Medium	0.49	6.26	Urban Buses Midi <=15 t	5.33	23.83
Diesel Large-SUV-Executive	0.54	6.26	Urban Buses Standard 15 - 18 t	4.21	24.15
Diesel PHEV Large-SUV-Executive	0.02	4.87	Urban Buses Articulated >18 t	4.17	20.55
LPG Mini	10.60	2.93	Coaches Articulated >18 t	9.26	29.68
LPG Small	12.50	2.09	Coaches Standard <=18 t	4.41	35.36
LPG Medium	12.50	2.84	Diesel Hybrid	8.40	28.69
LPG Large-SUV-Executive	12.70	3.17	Urban CNG Buses	1 036.09	0.00
CNG Mini	39.92	0.99	L-Category	57.10	1.91
CNG Small	44.61	1.42	Mopeds 2-stroke <50 cm³	103.81	1.00
CNG Medium	44.17	1.39	Mopeds 4-stroke <50 cm³	34.79	1.00
CNG Large-SUV-Executive	40.29	1.37	Motorcycles 2-stroke >50 cm³	124.50	2.00
Light Commercial Vehicles	1.18	6.34	Motorcycles 4-stroke <250 cm³	60.92	2.00
Petrol N1-I	10.87	2.11	Motorcycles 4-stroke 250 - 750 cm³	80.54	2.00
Petrol N1-II	9.30	3.20	Motorcycles 4-stroke >750 cm³	39.29	2.00
Petrol N1-III	10.96	5.07	Quad & ATVs	53.82	2.00
Diesel N1-I	0.96	6.28	Micro-car	4.94	0.90

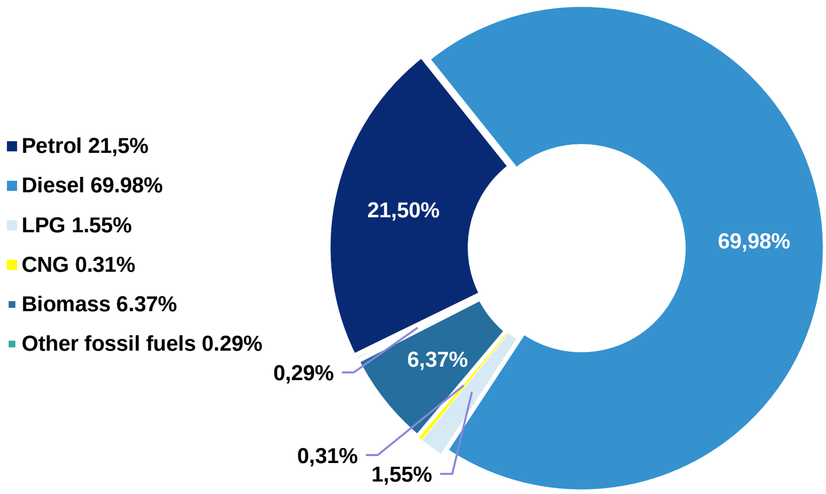
Input parameters for CNG buses are known only since 2000. Before the year 2000, CNG consumption in transport was negligible. The consumption of CNG as fuel can be used neither for a diesel engine nor for a petrol engine without modifications. The CNG buses have completely different combustion and after-treatment technology despite using the same fuel as CNG passenger cars. Hence, their emissions performance may vary significantly. Therefore, CNG buses also need to fulfil specific emissions standards (Euro II, Euro III, etc.). Due to the low NO_x and PM performance compared to diesel oil, an additional emissions standard has been set for CNG vehicles, known as the standard for Enhanced Environmental Vehicles (EEV). The emission limits imposed for EEV are even below Euro V and usually

EEVs are benefited from taxation waivers and free entrance to low emissions zones. New stoichiometry buses are able to fulfil the EEV requirements, while older buses were usually registered as Euro II, Euro III, Euro IV or Euro V.

The statistical consumptions of petrol, diesel oil and biofuels were received from data reported under the Fuel Quality Directive art. 7a by SHMU and cross-checked according to data received from the Ministry of Economy (MH SR). According to the latest QA/QC these consumptions are the most accurate (**Chapter 3.2.8**). Data about LPG distribution and sale were obtained from the Slovak Association of Petrochemical Industry (SAPPO). CNG consumption were obtained directly from transport companies for city and regional bus transport that operate CNG fuelled vehicles and the Financial Administration of the Slovak Republic (FR SR). All documents are available in Slovak language and they are official. Share of diesel oil represents 69.98%, followed by petrol with 21.50% share, then LPG (1.55%), CNG (0.31%), biomass (6.37%) and other fossil fuels (fossil part of biofuels) (0.29%) in 2022 (***Figure 3.8***).

The blending of biomass in liquid fuels was considered and the bio-emissions are calculated since 2007 (first year of using blended fuels in transport in Slovakia). Fuel quality is provided by the MH SR in terms of implementing Directive No 2009/29/EC and the Directive No 2009/30/EC on the replacement of fossil fuels with bio-component. The share of biomass in liquid fuels in transport was calculated as bio-component percentage. In ETBE as bio-component is considered only in 37% by mass in calculation of total bio-components in fuel. From the biomass (biodiesel) is also subtracted the 5.34% fossil methanol part and all emissions from the bio-parts of biofuels are reported as biomass emissions, and the fossil part is reported in its associated fossil fuel (ETBE – petrol; FAME – diesel). Fossil part of FAME was calculated as national average according to data from the report under Fuel Quality Directive Art. 7(a) (***Table 3.29***).

Figure 3.8: *Share of fuels on total consumption in road transport in 2022*



Requirements for the quality of motor fuels containing bio-component must be at the level of the specifications listed in the STN EN 228:2004 and STN EN 590:2004, respectively. The quality of blending in bio-liquid fuels must meet the requirements specified in the STN EN 14 214, STN EN 15 376.

Table 3.29: *Estimated activity data and share of biomass for the time series 2007 – 2022*

YEAR	PETROL		DIESEL OIL	
	BIOMASS SHARE (ENERGY)	BIOMASS CONSUMPTION	BIOMASS SHARE (ENERGY)	BIOMASS CONSUMPTION
	%	*TJ*	*%*	*TJ*
2007	2.30%	652.26	4.09%	2 677.29
2008	1.23%	358.17	4.77%	2 795.75
2009	2.58%	706.72	5.14%	3 090.30
2010	2.95%	779.13	5.28%	3 577.88
2011	2.97%	715.87	6.05%	3 741.68
2012	2.94%	710.56	5.79%	3 846.12
2013	3.21%	726.60	6.43%	4 107.36
2014	3.88%	859.33	5.65%	3 766.08
2015	3.33%	747.87	5.74%	4 342.97
2016	3.10%	725.62	6.68%	5 158.95
2017	4.06%	943.49	6.92%	5 464.18
2018	4.52%	1 018.32	6.97%	5 697.80
2019	4.46%	1 042.07	6.45%	5 371.36
2020	6.20%	1 390.40	7.27%	5 401.90
2021	6.20%	1 419.47	6.96%	5 617.89
2022	6.04%	1645.29	6.95%	5 779.55

Table 3.30: *National fossil carbon content in biofuels in 2022*

FEEDSTOCK	VOLUME	C FOSSIL PART	CARBON CONTENT	*g FOSSIL CO_2/g FAME*
	m^3	%	%	
Rapeseed	76 757.10	5.30%	75.50%	0.147
Palm oil	188.72	5.50%	71.80%	0.145
Sunflower seed	10 291.44	5.30%	77.20%	0.150
Used cooking oil*	52 278.82	5.40%	74.40%	0.147
NATIONAL AVERAGE	-	5.34%	75.21%	0.147

**for used cooking oil are no data of carbon content available, thus data for lard were used*

The CO_2 emissions from urea-based catalysts were estimated using COPERT 5 model for categories “heavy duty trucks Euro V and EURO VI” and “passenger cars diesel Euro 6 a, b, c, d-temp and d”. These vehicles occurred in Slovakia since 2010 and therefore, time series 2010 – 2021 were reported in this submission. As the number of vehicles with the SCR technology is equal to heavy duty vehicle in Euro VI category, the default value in COPERT model was used. In line with the UNFCCC Reporting Guidelines (these emissions are not energy-related), these emissions are allocated in the IPPU sector category 2.D.3 (**Chapter 4.5**).

Railways (1.A.3.c) – GHG emissions from railways were estimated from diesel oil consumed by the operation of diesel traction and using the simple tier 1 according to the IPCC 2006 GL. According to the key category analysis, this source is not key category in 2024 submission. The IPCC default emission factors were used, except for CO_2 were country-specific emission factor was used (***Table 3.15***). According to the previous UNFCCC recommendation, the country specific NCVs were used in calculations for time series and therefore the fuel consumptions (and subsequently GHG emissions). The NCVs of blended diesel oil and esters are shown in ***Table 3.28***.

The consumption of diesel oil for the motor traction in the Slovak Republic is obtained from the Railways Company, a. s. (ZSSK) annually. It is assumed that the consumption of diesel oil in motor traction of railways transport is equal to the diesel oil sold for the railways. The mobile sources of pollution in the railways transport include vehicles of motor traction of ZSSK. This motor traction is divided into 2 basic groups of vehicles: motor locomotives (Traction 70) and motor wagons (Traction 80). The motor traction has been operated by four depots in the organizational structure of ZSSK since 2002 (Bratislava, Zvolen, Žilina and Košice).

In terms of implementing Directive No 2009/29/EC and Directive No. 2009/30/EC on replacement of fossil fuels with biofuels emissions from biomass are calculated and reported since 2007. The share of biomass in diesel oil was calculated as bio-component percentage, by weight of the total weight of the fuel (***Table 3.30***).

Domestic navigation (1.A.3.d) – Domestic navigation includes emissions from national shipping between ports on Danube River on Slovak territory and domestic shipping on lakes and dams for touristic purposes. According to the key category analysis, this source is not key category in 2024 submission.

Shipping between Slovak ports on Danube River: The Slovak Shipping and Ports Company is providing detailed information on diesel oil consumption on the Danube River. The consumption is allocated between national and international companies. The total fuels sold to international companies is reported in the Memo Items (1.D.1.b) and total fuels sold to national companies (Slovak Water Management Enterprise) is reported in the Domestic Navigation (1.A.3.d). This activity represents movements of ships between Slovak ports (Bratislava, Komárno and Štúrovo). This approach was introduced in 2005 and the reallocation of fuels led to the reallocation between subcategories 1.A.3.d and 1.D.1.b.

Shipping on lakes: The State Navigation Administration was officially requested to check availability of information about the shipping activity in the Slovak Republic except the Danube River movements. Only total number of ships and boats operated outside of the Danube River is registered, but without information about their activity or fuel consumption. Based on expert research three other relevant shipping routes occur in Slovakia, however in limited extent:

- River – basin of the Váh (Piešťany, Trenčín, Liptovská Mara dam);
- The tributary River of the Váh (Oravská Priehrada dam);
- River – basin of the Bodrog (Zemplínska Šírava dam).

While the public and tourist shipping activities in the Slovak Republic are not very frequent and have expanded only in the recent years (due increase of tourism), it was necessary to propose an appropriate methodological approach for emissions estimation. Chosen activity data were:

- The number of trips per year - is limited by the daily schedule of trips mostly in summer months (May-October);
- The duration of trips (in hours) - can differ according to the type of trips (mostly short or long tours);
- The technical parameters of the most populated ships – the country specific technical parameters of vessels can be found on the webpage. The engines are mostly with 100 kilowatts power, which is a common type of engine used in non-road mechanisms, or in agricultural machinery (type Zetor). The engines run mostly on diesel oil;
- The average consumption of diesel oil in litres per hour - based on technical description of the engines it is 12 litres of diesel oil per hour of work. The consumption of diesel oil in tons was calculated using average density of diesel oil (0.83 kg/dm^3).
- During the pandemic year 2020 there was no traffic on lakes observed, thus no petrol and biofuels consumption was observed. Therefore notation keys "NO" were used.

The GHG emissions are calculated multiplying fuel consumption by diesel motor boats with emission factor. The country specific NCVs, obtained from the ŠÚ SR, were used to convert the fuels consumption in energy units. The NCV for diesel oil is shown in ***Table 3.27***. The emission factors are taken from the IPCC 2006 GL and GHG emissions were recalculated for the whole time series. The default emission factors used in categories 1.A.3.d and 1.D.1.b are identical (***Table 3.31***). Activity data for domestic navigation are shown in ***Tables 3.31*** and ***3.33***.

Table 3.31: *The emission factors used in GHG inventory for navigation in 2022*

PARAMETER	EMISSIONS FACTORS	
EMISSIONS	DOMESTIC NAVIGATION	INTERNATIONAL NAVIGATION
	kg/TJ of fuel	
CO_2	74 082.64	74 082.64
CH_4	7	7
N_2O	2	2

Table 3.32: *Total fuels consumption (petrol + diesel) in domestic navigation in particular years*

YEAR	FUEL CONSUMPTION	
	TJ	*t*
1990	0.30	7.14
1995	0.27	6.51
2000	0.33	7.70
2005	0.47	11.08
2007	4.52	94.85
2008	4.79	99.38
2009	4.40	90.73
2010	4.49	104.49
2011	11.27	265.31
2012	14.96	352.35
2013	46.01	1 092.89
2014	59.11	1 403.26
2015	83.94	1 990.22
2016	64.24	1 524.12
2017	63.32	1 506.80
2018	34.53	819.41
2019	56.36	1 337.89
2020	72.25	1 716.75
2021	78.25	1 859.18
2022	71.45	1 690.20

Table 3.33: *Diesel oil sold by shipping companies and allocation to the categories 1.A.3.d and 1.D.1.b*

YEAR	SHIPPING COMPANIES	SALE OF DIESEL OIL		
		NATIONAL	INTERNATIONAL	**TOTAL**
		1.A.3.d	1.D.1.b	1.A.3.d + 1.D.1.b
		t/year		
2005	Slovak Shipping and Ports (Danube)	1.3	128.7	130
	International shipping companies	-	84	84
	Total	1.3	212.7	214
2010	Slovak Shipping and Ports (Danube)	91.8	9 087.20	9 179.00
	International shipping companies	0	1 363.00	1 363.00
	Total	91.8	10 450.20	10 542.00
2015	Slovak Shipping and Ports (Danube)	1 981.80	5 945.40	7 927.20
	Slovak Water Management Enterprise	NO	-	NO
	Other companies	0.5	47.5	48
	International shipping companies	-	1 016.00	1 016.00
	Total	1 982.30	7 008.90	8 991.20

YEAR	SHIPPING COMPANIES	SALE OF DIESEL OIL		
		NATIONAL	INTERNATIONAL	**TOTAL**
		1.A.3.d	1.D.1.b	1.A.3.d + 1.D.1.b
		t/year		
2016	Slovak Shipping and Ports (Danube)	1 515.10	4 545.40	6 060.50
	Slovak Water Management Enterprise	-	NO	NO
	Other companies	2	189	191
	International shipping companies	-	1 272.00	1 272.00
	Total	1 517.00	6 006.50	7 523.50
2017	Slovak Shipping and Ports (Danube)	1 492.90	4 478.70	5 971.60
	Slovak Water Management Enterprise	-	NO	NO
	Other companies	2.4	236.6	239
	Morsevo (Komárno)	NO	1 034.00	1 034.00
	International shipping companies	-	168.5	168.5
	Total	1 495.30	5 917.80	7 413.10
2018	Slovak Shipping and Ports (Danube)	3 239.00	809.75	2 429.25
	Slovak Water Management Enterprise	-	NO	NO
	Other companies	232	2.32	229.68
	Morsevo (Komárno)	824	NO	824
	International shipping companies	-	NO	NO
	Total	4 295.00	812.07	3 482.93
2019	Slovak Shipping and Ports (Danube)	1 327.00	3 981.00	5 308.00
	Slovak Water Management Enterprise	NO	-	NO
	Other companies	3.26	322.74	326
	International shipping companies	-	760	760
	Morsevo (Komárno)	NO	NO	NO
	Total	1 330.26	5 063.74	6 394.00
2020	Slovak Shipping and Ports (Danube)	1 555.75	4 667.25	6 223.00
	Slovak Water Management Enterprise	NO	-	NO
	Other companies	161	NO	161
	International shipping companies	-	94	94
	Morsevo (Komárno)	NO	NO	NO
	Total	1 716.75	4 761.25	6 478.00
2021	Slovak Shipping and Ports (Danube)	1 764.25	5 292.75	7 057.00
	Slovak Water Management Enterprise	0	0	0
	Other companies	95	0	95
	International shipping companies	0	165	165
	TaM Terminal (Komárno)[9]	NO	NO	NO
	Total	1 859.25	5 457.75	7 317.00
2022	Slovak Shipping and Ports (Danube)	1 569.25	4 707.75	6 277.00
	Slovak Water Management Enterprise	0	0	0
	Other companies	120	0	120
	International shipping companies	0	855	855
	TaM Terminal (Komárno) [9]	0	0	0
	Total	1 689.25	5 562.75	7 252.00

[9] Previously Morsevo

Slovakia reconstructed the time series for petrol fuel consumption as appropriate till 2008. Slovakia used expert judgement with the combination of statistical yearly income of the company, which operates the ships, and the yearly number of tourists in the region to estimate petrol consumption. Outcomes of this calculation are presented in ***Table 3.34***. During the data investigation it was found out that the company started the operation of these ships only in the year 2008 and after the COVID pandemic there is no information about further operation.

Table 3.34: *Outcomes of the petrol consumption reconstruction and emission estimation for the years 2008 – 2022*

YEAR	FOSSIL PETROL				BIO-PETROL			
	Energy	CO_2	CH_4	N_2O	Energy	CO_2	CH_4	N_2O
	TJ	*t*			*TJ*	*t*		
2008	0.0339	2.3486	0.0017	0.0001	0.0003	0.0218	0.00002	0.000001
2009	0.0389	2.6972	0.0019	0.0001	0.0008	0.0524	0.00004	0.000002
2010	0.0566	3.9244	0.0028	0.0001	0.0013	0.0880	0.00006	0.000003
2011	0.0508	3.5175	0.0025	0.0001	0.0012	0.0859	0.00006	0.000002
2012	0.0629	4.3602	0.0031	0.0001	0.0016	0.1107	0.00008	0.000003
2013	0.0549	3.8077	0.0027	0.0001	0.0015	0.1060	0.00008	0.000003
2014	0.0928	6.4306	0.0046	0.0002	0.0041	0.2810	0.00020	0.000008
2015	0.0428	2.9678	0.0021	0.0001	0.0017	0.1150	0.00008	0.000003
2016	0.0573	3.9742	0.0029	0.0001	0.0021	0.1428	0.00010	0.000004
2017	0.0573	3.9736	0.0029	0.0001	0.0021	0.1427	0.00010	0.000004
2018	0.0639	4.4253	0.0032	0.0001	0.0027	0.1882	0.00014	0.000005
2019	0.0636	4.4602	0.0032	0.0001	0.0029	0.1892	0.00014	0.000005
2020	NO	NO	NO	NO	NO	NO	NO	NO
2021	NO	NO	NO	NO	NO	NO	NO	NO
2022	NO	NO	NO	NO	NO	NO	NO	NO

Pipeline transport (1.A.3.e.i) - The consumption of natural gas used for energy to drive turbines in pipeline system were obtained from the NEIS database. Tier 2 approach and the country specific emission factor was used for CO_2 emissions estimation in pipeline. The emission factor for NG combustion is 56.17 t (CO_2)/TJ in 2022.

Uncertainties and time-series consistency

According to the previous recommendations, Slovakia is using hybrid combination of Approaches 1 and 2 in this submission for calculation of total uncertainty of the inventory (**Annex 3** of this Report). Uncertainty analyses performed by the Approach 1 in transport was carried out using Table 3.2 for uncertainty calculation and country specific uncertainties for activity data and emission factors were inserted into calculation table.

The Slovak Republic provided and published also Approach 2 for uncertainty analyses according to the Chapter 3 of the IPCC 2006 GL for the complete Energy (including transport) and the IPPU sectors for the year 2015. The methodology and results were described in previous SVK NIR 2017 and 2018. The latest Monte Carlo simulation was performed for the 2015 emissions inventory. Due to capacity reasons and according to the QA/QC plan in this sector, new calculation of Monte Carlo uncertainty (Approach 2) in the Energy sector and categories (including Transport) will be performed in the next submissions. For more information, please see the **Chapter 1.2** of this Report. Results of the Monte Carlo simulations were almost identical since this exercise was performed (since 2011).

Increasing quality of the emissions inventory from transport depends closely on the reduction and removal of the following uncertainties:

- The uncertainties joint with the COPERT methodology;

- The uncertainties joint with the collection, preparation and application of the input data.

The quality of calculated results by the COPERT 5 has been influenced significantly by the uncertainty of the following statistic information:

- Statistic information about consumption of the fuels;
- Allocation of total number of vehicles among all the categories according to the methodology;
- The average annual mileage;
- The average speed in the traffic mode;
- The average temperatures;
- The beta-factor.

COPERT 5 requires the determination of CH_4 emission factors and the calculation of CH_4 emissions accumulated, respectively, in order to determine:

- Data on the numbers of road vehicles in the Slovak Republic in current year, divided into categories prescribed by the methodology;
- Data on average monthly temperatures in current year;
- The average speed of vehicle categories in city, road and highway driving modes;
- The annual mileage – will take place between categories of vehicles, divided into urban, rural and highway traffic.

Domestic aviation (1.A.3.a) – Trend in aviation transport for the years after 2008 is decreasing. The period 2004 – 2008 was influenced by the boom of low-cost airlines and advantage of Bratislava airport with the lower charges in comparison with the big international airports in the neighbouring countries. After this period, aviation transport decreased back on the 2003 level and the trend is very stable. The aviation regarding the national circumstances is not very important transport mode in Slovakia. The airports Bratislava, Košice and Poprad are the busiest airports. Other airports have only local character for hobby and sport flights.

Road transport (1.A.3.b) – Using of COPERT version 5 for whole time series (since 1990) is limited by availability of input data. Development in model structure and complexity does not allow to use the more advance versions before 2000. Trend in the CO_2 and N_2O emissions from road transport corresponds with the consumption of the liquid fuels. Emission factors are annually updated based on national data. The variability is caused by changes in inputs for vehicle fleet, fuel consumption and emission factors. Until 2008, trend of petrol consumption has fluctuated and after 2008, the trend is stable due to the improvement in fuel consumption and implementation of renewable directive. In 2015 and 2016 the consumption increased and afterwards stabilized again. The trend of diesel oil consumption was increasing since 1990, but it is more stable in the recent years with temporary decrease in 2020. This was caused by the variation of fuel price in transit, the development of construction, commercial, industrial activities, economic development and, of course, by the trend of increasing numbers of new cars within the commercial market of the Slovak Republic, which significantly determines the development of the emissions from transport. In addition, the decrease of N_2O is caused by significantly lower N_2O EF for LPG passenger cars in category EURO 3 and newer. Cars in these category from year 2016 prevail in vehicle fleet. Significant decrease of CNG consumption is caused by change of vehicle fleet and decrease of CNG consumption in the biggest public transport providers (Public

Transport Companies in Bratislava and Košice cities and Zvolen Bus-intercity Company).[10] CNG and older diesel oil buses are slowly replaced by electric and EURO 6 diesel buses.

Decrease of methane emissions in the category 1.A.3.b.i (passenger diesel cars) is caused by significantly lower CH_4 EF for passenger cars in category EURO 3 and newer.

The elimination of negative influences of road transport continues with the increase of LPG, CNG and electric vehicles (mostly passenger cars and buses).

Railways (1.A.3.c) – Methodology, activity data and used emission factors for diesel oil are consistent for the whole time series. The blending of biomass in liquid fuels used in railways transport was considered since 2007.

Domestic navigation (1.A.3.d) – Emissions from domestic navigation represent emissions from shipping on lakes for the period 1990 – 2022 and emissions from shipping on lakes and movements between national ports on Danube River for the years 1990 – 2022. In 2022 there were no movements on lakes. The time series consistency was improved in previous submissions. Based on the expert judgement from the Slovak Shipping and Ports Company, before the year 2005, only negligible fuels were sold for national shipping on the Danube River. The variability in consumption is because of neighbourhood of bigger ports in Vienna and Budapest and different prices and taxation of fuels used in shipping activities.

Pipeline transport (1.A.3.e.i) – Methodology, activity data and used emission factors for natural gas are consistent in the time series and energy-related categories (natural gas used in energy combustion).

Category-specific QA/QC and verification process

Category specific QA/QC is based on the general QA/QC plan described in the **Chapter 1.2** of this Report. The emissions inventory in transport categories were prepared by the sectoral expert. Variety of input data sources and databases led to inconsistencies in transport fuel consumption occurrence in the last years. Therefore, in agreement with our Improvement Plan in Transport, the extensive analyses of the available statistical information in liquid fuels in transport began in the 2017. Results are summarized in the next paragraphs.

Source specific comparison of fuel statistics - QA/QC procedures for the transport follow basic rules and activities of QA/QC as defined in the IPCC 2006 GL. The QC checks were done during the CRF and NIR compilation, general QC questionnaire was filled in and is archived. Also according to agreement with CDV (Centrum dopravního výskumu) from 2023, there is a QA/QC cross-check between Slovak and Czech Transport sector emission estimation.

Due to frequent questions for data consistency between the IEA statistics and the national inventory, the data sources were investigated. Comparison of activity data and their sources is also crucial for evaluation of consistency in reporting. Petrol, diesel oil and biofuels consumption are key activity data in transport, thus the comparison was focused on these statistical data across several sources.

Datasets for this analysis are the years 2014 – 2021:

- Statistical Office of the Slovak Republic (ŠÚ SR) inserts data also from the Administration of State Material Reserves of the Slovak Republic (ŠHR SR);
- Ministry of Economy of the Slovak Republic (MH SR);
- Finance Administration of the Slovak Republic (FR SR);
- Ministry of Environment of the Slovak Republic (MŽP SR).

[10] Companies do not have English equivalent names

Each source has specific forms or questionnaires, CN codes and different reporting rules, methodologies and dates of publication or collection. Different institutions further process these data. The ŠÚ SR used import/export and production data, the FR SR used data from taxes on sales of products of crude oil and from taxes on sales of biofuels.[11,12]

***Table 3.35:** Crude oil and crude oil products data flow and utilisation (final user is the SHMÚ)*

ORIGIN OF DATA	PRIMARY USER	SECONDARY USER
Import-export data (ŠÚ SR - Depart. of Foreign Trade)	Statistical Office of Slovak Republic (Depart. of Energy Statistics)	EUROSTAT
Data regarding production and sales (companies)		Slovak Hydrometeorological Institute
Data from taxes on sales of biofuels	Financial administration of Slovak Republic	Ministry of Economy
Data from taxes on sales of products of crude oil		SK - BIO[13]
Confirmation (certificate) of the sustainability of biofuels	Slovak Hydrometeorological Institute (according to Art. 7a of Directive 98/70/EC)	European Environmental Agency
Data on production and sales (companies)	Slovak State Material Reserves	International Energy Agency (data on crude oil and crude oil products)
		EUROSTAT (natural gas)
Data of fuel sales on gas stations (NEIS)	Ministry of Environment (according to Art. 8 of Directive 98/70/EC)	European Environmental Agency

As it is shown in ***Table 3.35*** and on ***Figure 3.9***, discrepancies occurred between major data sources-providers. During discussions with the main authorities, several information was collected by the sectoral experts, which were further analysed:

- Each authority reports different data in different forms for different institutions or requirements (***Table 3.35***);
- The conversion factors (e.g. density) differ throughout all data suppliers not only between authorities and companies, but also for each delivered supply has own characteristics;
- Dates of collection for tax reports and reports to the ŠÚ SR differ.

***Table 3.36:** Results of the comparison of fuels consumption according to different sources*

DATA SOURCE	ŠÚ SR			FR SR		
YEAR	Petrol	Diesel Oil	Biofuels	Petrol	Diesel Oil	Biofuels
	kt					
2014	529.0	1 315.0	167.0	508.6	1 619.7	-
2015	550.0	1 259.0	182.0	516.6	1 743.0	-
2016	581.0	1 442.0	163.0	533.3	1 841.7	-
2017	620.0	1 905.0	176.0	540.0	1 914.0	-
2018	579.0	1 879.0	174.0	544.6	1 978.2	-
2019	562.0	1 952.0	183.0	546.4	2 003.6	-
2020	531.0	1 796.0	187.0	524.5	1 860.0	-
2021	541.0	1 889.0	195.0	541.6	1 958.8	-
2022	515.0	1819.0	206.0	570.5	2 010.7	-

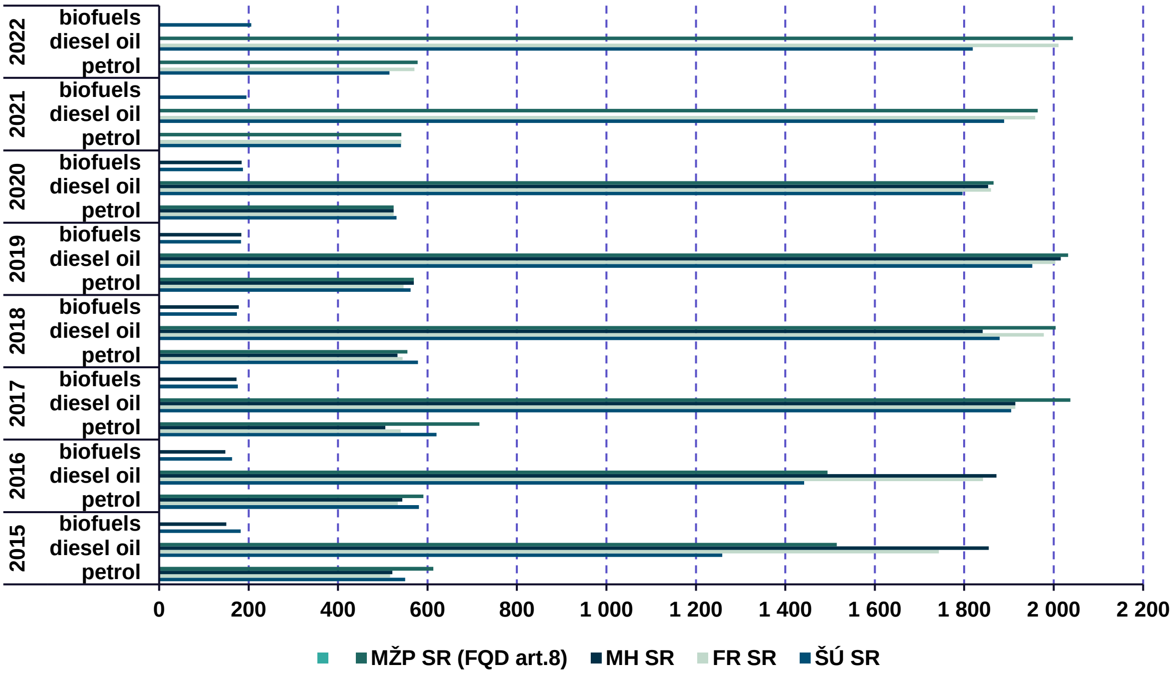
[11] Council Directive (EU) 2015/652 laying down calculation methods and reporting requirements pursuant to Directive 98/70/EC of the European Parliament and of the Council relating to the quality of petrol and diesel fuels

[12] Act 309/2009 Coll. on the Promotion of renewable energy sources and high-efficiency cogeneration and on amendments to certain acts as amended, http://www.minzp.sk/en/areas/renewable-energy-sources/biofuels-bioliquids/

[13] SK-BIO is the national register for biofuels and bioliquids

DATA SOURCE	MH SR[14]			MŽP SR (FQD ART.8)		
YEAR	Petrol	Diesel Oil	Biofuels	Petrol	Diesel Oil	Biofuels
	kt					
2014	517.2	1 639.0	138.9	664.9	1 507.4	-
2015	521.5	1 854.8	149.9	613.1	1 514.8	-
2016	543.8	1 872.3	147.9	591.0	1 494.6	-
2017	506.0	1 914.0	173.0	715.7	2 037.0	-
2018	532.7	1 841.6	178.0	555.0	2 004.6	-
2019	569.0	2 016.0	184.0	532.0	1 893.0	-
2020	524.0	1 853.5	184.9	524.5	1 865.5	-
2021	-	-	-	541.7	1 964.1	-
2022	-	-	-	578.2	2 042.7	-

Figure 3.9: *Results of fuels consumption comparison according to different sources (kt)*



The main outcome of this analysis is harmonisation of fuels consumption in country on the most possible level and lowering the differences in reporting by different subjects to 2.8% for fossil fuels and 2% for biofuels in 2022. Full consistency of data on national level is not possible. This is due to different legislation that each authority is required to fulfil (e.g. statistical reporting to EU institutions, tax collection, etc.).[15]

Domestic aviation (1.A.3.a) – Since 2011, the agreement of the European Commission (EC) and the EUROCONTROL is in place. Based on this agreement, annual comparison of aviation fuel consumption and emissions data with AEM model calculations is prepared. The comparison of the EUROCONTROL

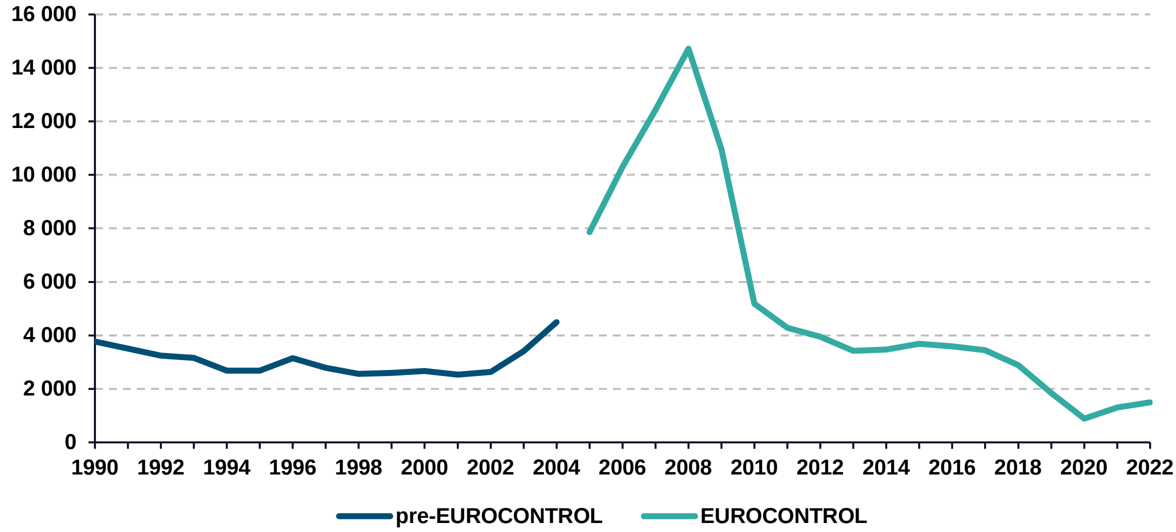
[14] From 2021 Ministry of Economy is not publishing these data

[15] Regulation (EC) 1099/2008 of the European Parliament and of the Council, Act No. 268/2017, which amend Act No. 98/2004 Coll. on the Excise Duty on mineral oil as amended, which amends Act No. 309/2009 Coll. on the Promotion of renewable energy sources and high-efficiency cogeneration and on amendments to certain acts as amended (only § 14a), https://www.financnasprava.sk/en/businesses/taxes-businesses/excise-duties-businesses#TaxRatesMineralOil

and the UNFCCC aviation data is provided on the level of individual EU Member State (EU MS). The information and data evaluated are part of the QA/QC activities in aviation. The EC works towards making data from the EUROCONTROL available to the EU MS on a regular basis, for quality check, however this information is not possible to make public available. Consistent time series (***Figure 3.10***) is maintained by using calculated average EFs from EUROCONTROL. The methodology is explained in the **Chapter 3.2.8**.

The verification process is also based on cross-checking of input data from the Slovak airports and the comparison with the sectoral statistical indicators (ŠÚ SR). The background documents are archived by the sectoral experts in the central archiving system at the SHMÚ. The quality manager of the NIS has responsibility for the verification, approval and archiving.

Figure 3.10: *Demonstration of time-series consistency between pre-EUROCONTROL methodology and EUROCONTROL methodology*



Road transport (1.A.3.b) – QC activities ensuring the quality standards for the preparation of the emissions inventory in the road transport are based on the cooperation of several experts and institutions. The activity data and input parameters provided from the different data sources are collected and then checked for the basic quality criteria (consistency, transparency, etc.) and archived by the sectoral experts. The process of verification is based on cross-checking of input data from the ŠÚ SR and the comparison with the fuel balance from the COPERT. The background documents are archived by the sectoral experts and in central archiving system of SNE at SHMÚ.

Other/Urea based catalysts (1.A.3.b.v allocated in 2.D.3) – The COPERT 5 model was used for these emissions estimation and information of category specific QA/QC and verification are described in section road transport.

Railways (1.A.3.c) – Verification process is based on cross-checking of the input data on fuel consumption from the Railways Company, a. s. and the ŠÚ SR. The preliminary results of emissions inventory are sent to other subjects (MŽP SR) for valuation and QA activities. The QC verification process includes the comparison of statistical and calculated data on fuel consumption.

Domestic navigation (1.A.3.d) – Verification of activity data on fuels sold for shipping activities was performed by the sectoral expert and compared with the statistical information from requested institutions and companies as mentioned in this chapter above. New survey among small companies and municipalities operating touristic boats and ships on lakes and dams in Slovakia was made during the year 2020. These data were used to estimate the emissions from domestic shipping in 2019.

Pipeline transport (1.A.3.e.i) – Information of category specific QA/QC and verification are described in section for fugitive emissions 1.B.

Scrap Subsidy Program (SSP)

In 2009, a Scrap Subsidy Program was launched in Slovakia to support the exchange of old passenger cars (PC) for new cars – in that time (EURO 4). During two phases of this program, 44 200 vehicles were handed over for scrapping and 39 275 of EURO 4 vehicles were bought. This caused a decrease of the number of passenger cars in all categories in the frame of the SSP (4 475 cars older than 10 years). After the analyses made by the SHMÚ, it can be seen (***Table 3.37***), that most of deregistered cars were in EURO 1 emission category or older categories.

Through deeper analysis (***Table 3.38***) it was discovered, that reduction of registered cars wasn´t present in all emission categories (EURO). Despite of the rules of the SSP supported only new vehicles, purchases of 10 years old cars and older (outside of this program) were occurred. This concerns two categories:

1. Conventional diesel passenger cars;
2. EURO 2 passenger cars (petrol and diesel oil).

An inter-annual increase of 14 365 passenger cars in the category of conventional diesel PC was recorded (instead of decrease). Similar situation was recorded also in the category EURO 2 PC (diesel and petrol), where the number of passenger cars rose by 16 653. These anomalies probably reduced the potentially positive impact of the SSP. The insufficient rules and control of the SSP started up and accelerated the annual rise of new registration of passenger cars with a small positive impact on air quality and climate change in Slovakia.

On the other hand, the SSP was possibly one of the factors causing decrease of fuel consumption (FC) in year 2009. Exact effect cannot be calculated as exact data from the SSP are missing. However, a small positive effect on GHG emissions and air pollutants is visible. The main positive outcomes of the SSP are:

- The SSP caused fuel consumption decrease;
- The SSP has moderate effect on air quality.

On the other hand, negative outcomes are also important:

- The SSP failed in an intention to decrease a number of pre-EURO 4 vehicles;
- The SSP accelerate registration of additional vehicles (not only new or modern one);
- The SSP has no significant effect on GHG emissions.

Table 3.37: *Number of scrapped passenger cars by age (according to the Automotive Industry Association statistics) in 2009*

AGE OF SCRAPPED CARS	EMISSION CATEGORY	TOTAL NUMBER OF SCRAPPED/ DEREGISTERED VEHICLES	SHARE OF SCRAPPED VEHICLES ON THE TOTAL FLEET
10-15 years	EURO 1 and EURO 2	7 366	-
15-20 years	ECE 1504 and EURO 1	9 684	55.8%
20-25 years	ECE 1503 and ECE 1504	17 310	54.6%
>25 years	pre-ECE till ECE 1503	9 840	23.8%
New registrations	EURO 4	39 275	-

Table 3.38: *Yearly change (2008 – 2009) in number of passenger cars by emission category (according to the Police Dpt. statistics)*

TYPE	TOTAL NUMBER OF PC IN 2008	TOTAL NUMBER OF PC IN 2009	DIFFERENCE	AVERAGE MILEAGE IN 2008	AVERAGE MILEAGE IN 2009	DIFFERENCE
Conventional	38 908	53 273	14 365	10 240.11	8 024.19	-2 215.92
PRE ECE	86 778	73 350	-13 428	3 415.64	3 300.58	-115.05
ECE 15/00-01	93 514	79 725	-13 789	3 080.74	2 976.97	-103.77
ECE 15/02	94 546	80 701	-13 845	4 312.89	4 167.62	-145.27
ECE 15/03	110 107	95 425	-14 682	5 028.18	4 858.81	-169.37
ECE 15/04	153 137	136 141	-16 996	6 087.41	5 882.36	-205.05
Euro 1	195 607	195 263	-344	9 660.12	8 227.15	-1 432.97
Euro 2	321 717	338 370	16 653	11 555.38	9 811.85	-1 743.52
Average			-5 258			-766.37

Category-specific recalculations

This chapter describes the recalculations of emissions. In the NIR 2024, there were no category specific recalculations made.

Category-specific improvements and implementation of recommendations

In the preliminary findings under the UNFCCC, there were no recommendations for the transport sector.

3.2.9. Other Sectors (CRF 1.A.4)

The source category 1.A.4 Other Sectors includes stationary combustion in agriculture, forestry, The source category 1.A.4 Other Sectors includes stationary combustion in agriculture, forestry, commercial and institutional and households.

Commercial/Institutional (1.A.4.a) – total volume of fuels in 1.A.4.a expressed in energy units represented 24 381.47 TJ in 2022. Total CO_2 emissions were 1 365.02 Gg, total CH_4 emissions were 0.2954 Gg and total N_2O emissions were 0.0059 Gg in 2022.

Residential (1.A.4.b) – total volume of fuels in 1.A.4.b expressed in energy units represented 74 097.79 TJ in 2022. Total CO_2 emissions were 2 869.42 Gg, total CH_4 emissions were 8.3944 Gg and total N_2O emissions were 0.1076 Gg in 2022.

Agriculture, forestry and fisheries (1.A.4.c) – total volume of fuels in 1.A.4.c expressed in energy units represented 5 518.04 TJ in 2022. Total CO_2 emissions were 295.79 Gg, total CH_4 emissions were 0.1440 Gg and total N_2O emissions were 0.0786 Gg in 2022. The fuels are allocated in solid, liquid, gaseous and biomass fuels categories.

All non-road mobile machinery is also reported in this category. Agricultural machinery (tractors, harvesters, etc.), forestry machinery, industry machinery (forklifts, excavators, etc.) and residential machinery (hedge cutters, garden shredders, etc.) are included in the category 1.A.4.c.ii. The data collected by questionnaires in households in the frame of the project "Quality Improvement of Air Emission Accounts and Extension of Provided Time-series" were used for estimation of emissions from residential machinery the first time in 2018 inventory. In addition, liquid fuels used in residential machinery (hobby, gardens, cleaning) were collected and reported in the 1.A.4.c.ii.

Methodological issues, activity data, emission factors and NCVs

A description of general methodologies used for GHG emissions estimation from fuel combustion is given in the **Chapters 3.2.6** and **3.2.7**.

Activity data (emission factors and NCVs) are collected from several sources (in agreement with the other energy categories):

- Annual energy balance (publication Energy,[16] published by the ŠÚ SR, annually);
- Disaggregated data provided by the ŠÚ SR (restricted from public, provided only for the SNE);
- The NEIS Central database;
- Results from project, surveys and research.

The Residential category is the key emissions source and represents 7.7% share on the total GHG emissions in the year 2022. Category 1.A.4.b balanced mostly gaseous (natural gas), solid (coal) and biomass (wood) fuels. Whereas the gaseous fuels consumption is consistent and accurate due to statistics made directly by the natural gas suppliers on distribution network, solid fuels and biomass statistics were not fully covered by the ŠÚ SR. Direct regular statistics is missing. Due to these reasons, several inconsistencies between fuels consumption reported in this category were recorded and commented in the previous submissions. Therefore, in 2018, the Project Grant "Quality Improvement of Air Emission Accounts and Extension of Provided Time series" launched by the European Commission – EUROSTAT was successfully finished. Results were published online in several partial reports and on the international conferences. The Project Grant was carried out in cooperation with the Statistical Office of the Slovak Republic and concluded in December 2022. Outcomes and Final Report will be available after validation from the EUROSTAT in 2023. Cooperation with the Statistical Office of the Slovak Republic continued and resulted in to the second more complex statistical survey in households, with primary solid fuels heating. This activity, together with help and interest of other relevant national authorities, confirmed and improved previous estimation of solid fuels and biomass consumption in households.

In addition, in the frame of the project LIFE IP – Improvement of air quality supported by the European Union, the OEaB experts have prepared a report that describes the structured distribution of small sources of pollution (available only in Slovak language). The main task of the analysis presented in this annual report was to obtain information on the regional distribution of boiler types in Slovakia. In addition, precise estimates of the consumption of solid fuels at the regional level, especially biomass (firewood), were developed. The input data were obtained on the basis of an extensive third statistical survey carried out in 2022 in cooperation with the Statistical Office of the Slovak Republic. The statistical sample was chosen in order to streamline the results and thus allow for a more even distribution of small combustion sources at the regional level. The results presented in this report will serve to identify and select regions where modernization of boilers is needed and will help direct the decision-making process of allocating funds in the form of subsidies.

In previous inventory, data on solid fuels and biomass (wood) energy consumption in households collected and evaluated in a frame of this Project Grant were used and updated. Statistical data and time series were corrected based on improved methodology and inputs were also provided to the ŠÚ SR for energy balance. According to the information provided by the ŠÚ SR, revision of households' energy statistics to the EUROSTAT was reported for the year 2018 and expected revision will be provided to EUROSTAT also for time series in this year. Revision was focused on solid fuels and biomass (non-fossil fuels) consumption since the year 2012. With this revision, consistency in the reporting data in households was improved. In 2022, third survey focused on households with individual heating with solid fuels took place. New results are available in 2024 inventory submission for biomass and solid fuels consumption.

[16] Energy 2022, Statistical Office of Slovak Republic (2023) ISBN: 978-80-8121-918-4

Methodology introduced by new background data further corrected and improved the energy and emissions balance considering the effect of regional-climatological data. The principle of new methodological approach was supported by statistical survey and further estimation of “total energy demand for heating and hot water preparation” in households, calculated using data from questionnaires and climatological data in different regions. In principle, average value of “energy demand” is a parameter on heating demand (including preparation of hot water) for 1 m^2 of housing area for 1 year. Total housing area, energy effectivity of houses and climatological factors in regional scaling were taking into consideration for the calculation of total energy demand for heating in houses without central heating system.

Table 3.39: *Overview of the country or plant specific CO_2 EFs in t/TJ the category 1.A.4 in 2022*

1.A.4.a	WEIGHTED CO_2 EFs	FUEL TYPE	C EFs	CO_2 EFs
Liquid	67.65	Liquefied Petroleum Gases	17.22	63.14
		Gas/Diesel Oil	20.22	74.14
		Residual Fuel Oil	21.09	77.33
Solid	102.76	Lignite	27.23	100.21
		Brown coal briquettes	26.61	97.57
		Other Bituminous Coal	25.69	94.19
		Gas Coke	29.60	108.53
Gaseous	56.17	Natural gas	15.32	56.17
Biomass	75.04	Wood/Wood waste	30.50	111.83
		Sludge gas	14.90	54.63
1.A.4.b	**WEIGHTED CO_2 EFs**	**FUEL TYPE**	**C EFs**	**CO_2 EFs**
Liquid	63.14	Liquefied Petroleum Gases	63.14	63.14
Solid	97.58	Other Bituminous Coal	25.69	94.19
		Lignite	27.23	100.21
		Brown coal briquettes	26.61	97.57
		Gas Coke	29.60	108.53
Gaseous	56.17	Natural gas	15.32	56.17
Biomass	111.83	Wood/Wood waste	30.50	111.83
1.A.4.c	**WEIGHTED CO_2 EFs**	**FUEL TYPE**	**C EFs**	**CO_2 EFs**
Liquid	73.65	Liquefied petroleum gases	17.22	63.14
		Gas/Diesel oil	20.22	74.14
		Diesel oil	20.20	74.08
		Petrol	18.86	69.14
Solid	97.37	Lignite	27.23	100.21
		Gas coke	29.60	108.53
		Other bituminous coal	25.69	94.19
		Brown coal briquettes	26.61	97.57
Gaseous	56.17	Natural gas	15.32	56.17
Biomass	72.00	Other biogas	14.90	54.63
		Wood/Wood waste	30.50	111.83
		Other primary Solid biomass	27.30	100.10

Uncertainties and time-series consistency

Description of uncertainty is similar to the **Chapter 3.2.6** of this Report.

Time series is consistent in all aspects (methodological approach, country specific EFs and oxidation factor used, fuel characteristics, etc.) to the detailed level of disaggregation (on plant specific level).

Category-specific recalculations

Recalculations were made in sector 1.A.4.b based on data from new 2021 Census. The changes concerned the number of apartments connected to district heating system. This resulted in changes of fuel consumption for this sector. Based on the available data, we previously assumed a declining trend in the share of households connected to district heating. However, the data from the Census 2021 confirmed a stable to slightly increasing trend. This affected the calculation of biomass consumption in households, leading to a reduction in the fuel (biomass) consumption for heating in residences. This recalculation affected biomass consumption in the years 2012 to 2022, the base year was not affected. The comparison of original data and recalculated is summarized in following table.

Table 3.40: *Comparison of recalculated data in 2023 and 2024 submissions*

YEAR	SUBMISSION 2023				SUBMISSION 2024			
	ENERGY	CO_2	CH_4	N_2O	ENERGY	CO_2	CH_4	N_2O
	TJ	*Gg*			*TJ*	*Gg*		
2012	32 968.5	3 687.0	9.8906	0.1319	32 651.1	3 651.5	9.7953	0.1306
2013	30 717.1	3 435.2	9.2151	0.1229	30 098.1	3 366.0	9.0294	0.1204
2014	17 452.7	1 951.8	5.2358	0.0698	16 677.6	1 865.1	5.0033	0.0667
2015	26 260.4	2 936.8	7.8781	0.1050	25 129.4	2 810.3	7.5388	0.1005
2016	29 407.7	3 288.8	8.8223	0.1176	27 932.7	3 123.8	8.3798	0.1117
2017	27 856.5	3 115.3	8.3570	0.1114	26 004.7	2 908.2	7.8014	0.1040
2018	22 156.3	2 477.8	6.6469	0.0886	20 237.5	2 263.2	6.0712	0.0809
2019	23 925.2	2 675.6	7.1776	0.0957	21 970.1	2 457.0	6.5910	0.0879
2020	24 677.1	2 759.7	7.4031	0.0987	22 207.5	2 483.5	6.6623	0.0888
2021	28 681.5	3 207.6	8.6045	0.1147	28 811.3	3 222.1	8.6434	0.1152
2022					24 834.9	2 777.4	7.4505	0.0993

Category-specific improvements and implementation of recommendations

Improvements are implemented in line with the Improvement and Prioritization Plan for the year 2024. Further improvements in the category 1.A.1.4.a are not planned in the near future.

3.2.10. Non-Specified (CRF 1.A.5)

Emissions reported in this category arising from the military aviation and from fuel combustion in stationary sources that are not specified elsewhere. Total volume of fuels in the 1.A.5 expressed in energy units represented 1 524.54 TJ in 2022.

Total CO_2 emissions were 61.85 Gg, total CH_4 emissions were 0.0107 Gg and total N_2O emissions were 0.0009 Gg in 2022.

Methodological issues, activity data, emission factors and NCVs

A description of the general methodology, activity data, EFs and NCVs used for estimation of emissions from fuels combustion is given in the **Chapters 3.2.6** of this Report.

In 1.A.5.a, the main source of activity data is provided by the ŠÚ SR (disaggregated data – information on fuels consumption at the level of individual subjects). The sources allocated here are not included in the EU ETS. Total volume of fuels in the 1.A.5.a expressed in energy units represented 1 408.63 TJ in 2022. Total CO_2 emissions were 53.42 Gg, total CH_4 emissions were 0.0097 Gg and total N_2O emissions were 0.0002 Gg in 2022.

The jet kerosene, petrol and diesel oil from military usage is reported in the 1.A.5.b. GHG emissions from military aviation, i.e. jet kerosene consumption, are estimated since 1990 and military petrol and diesel oil are estimated since 2016. Data for military petrol and military diesel oil before 2016 were statistically estimated by the sectoral experts using linear regression back to basic year 1990 based on years 2016 – 2019. The information is directly provided by the Ministry of Defence of the Slovak Republic. Also fuels used for military machinery do not have a biofuel part. The methodology is comparable with the methodology used for the emissions estimation of civil aviation, based on fuel consumption in military service multiplied by the default emission factor for jet kerosene. ***Table 3.41*** provides overview of the weighted average emission factors and fuels in the category 1.A.5 for 2022.

Table 3.41: *Overview of the country or plant specific CO_2 EFs in t/TJ in the category 1.A.5 in 2022*

1.A.5	WEIGHTED CO_2 EFs	FUEL TYPE	C EFs	CO_2 EFs
Liquid	71.26	Liquefied petroleum gases	17.22	63.14
		Residual fuel oil	21.09	77.33
		Diesel oil	20.20	74.08
		Jet kerosene	19.84	72.75
		Petrol	18.86	69.14
Solid	97.69	Gas coke	29.60	108.53
		Lignite	27.23	100.21
		Other bituminous coal	25.69	94.19
Gaseous	56.17	Natural gas	15.32	56.17
Biomass	55.75	Sludge gas	14.90	54.63
		Other biogas	14.90	54.63
		Other primary solid biomass	27.30	100.10
		Wood/Wood waste	30.50	111.83

Uncertainties and time-series consistency

Description of uncertainty is similar to the **Chapter 3.2.6** of this Report. Time series is consistent in all aspects (methodological approach, country specific EFs and oxidation factor used, fuel characteristics, etc.) to the detailed level of disaggregation (on plant specific level).

Category-specific recalculations

No recalculations were implemented in this submission.

Category-specific improvements and implementation of recommendations

Improvements are implemented in line with the Improvement and Prioritization Plan for the year 2024, no specific improvement is planned for the next submission.

3.3. Comparison of the Sectoral Approach with the Reference Approach (CRF 1.AC)

The data gathered and processed by the Statistical Office of the Slovak Republic (the annual energy statistics balance) is the background for the reference approach. Therefore, the data provided in the reference approach is consistent with official energy balance data. The reference approach balance includes emissions from fuel combustion differentiated according to the gaseous, liquid, solid and biomass categories and different sectors.

The reference approach is based on the top-down methodology and is characteristic of minimum requirements on input data. The reference approach provides only aggregated estimates of emissions by fuel type distinguishing between primary and secondary fuels. The aggregated nature of the reference approach means that stationary combustion cannot be distinguished from the mobile combustion. The method is applied also as the quickest control and verification method. It is necessary to mention, that this approach does not include fugitive emissions, i.e. uncontrolled emissions from mining and post-mining activities, from transport and other use of fuels (technological use).

The methodology for reference approach estimation is consistent during time series across of the main types of fuels and followed the methodology provided in the IPCC 2006 GL.

The official frame contract was signed between the Statistical Office of the Slovak Republic and the Ministry of Environment to ensure direct cooperation with the National Inventory System (SHMÚ). Frame contract specifies major responsibilities in providing information about energy balance and any changes or recalculations directly to the ŠÚ SR. A close cooperation of the NIS and the ŠÚ SR ensures consistency and transparency in reporting. The cooperation on the official level and the ongoing discussions on removing any discrepancy between the several statistical systems of energy data (NEIS, ŠÚ SR or EU ETS) is in place. A bottom-up methodology was used for the emissions balance in the sectoral approach. More information is provided in the **Chapter 3.2** of this report.

Based on the actual data provided in the 2024 submission, time series consistency was improved leading to increase of transparency reported in this area (***Figure 3.11***). A difference between CO_2 emissions allocated in reference and in sectoral approaches is less than 2% for last seven years. In 2022, the difference in CO_2 emissions was 0.60% and difference in the total energy consumption was -0.25%.

The reference and sectoral approach were estimated on fully independent data sets, whereby obtained differences in CO_2 emissions are not significant. Based on the IPCC methodology, reference approach in apparent consumption of fuels was estimated after consideration of carbon stored in iron and steel and in chemical industry and refinery. Due to the different methodology used by the ŠÚ SR, not all fuels used as technological input in production are also reported in the statistical questionnaires in this way. This is a case of natural gas used in ammonia production (allocated in the IPPU sector, but in the statistical questionnaire allocated in the Energy sector), or coking coal used as reducing agent in steel production (allocated in the IPPU, but in the statistical questionnaire allocated in the Energy sector).

These reallocations were considered in the apparent consumption and the results are provided in ***Tables 3.42 - 3.47***. However, due to differences in methodological approaches used in the national inventory for the sectoral approach and used in the statistical energy balance, in some years the differences are higher than required according to the QA/QC process. After thorough analyses of these years (2011, 2015, 2017), the results show the major inconsistencies in other and liquid fuels.

One of the reasons for the reference and sectoral approach discrepancies during time series is used source of activity data. The RA is based on national fuel delivery statistics, the bottom-up approach is based on fuel consumptions (EU ETS reports and disaggregated energy balance data). However, the main reason is the effect of emission factors (and/or calorific values) in the reference approach of liquid fuels. This is enhanced by the fact that all volume of used crude oil which is processed in the Slovak Republic is imported. Practically all resulting CO_2 emissions from combustion of the liquid fuels reported in the reference approach is from the import, export and stock changes of crude oil.

A small variation in the average net calorific value used (which is difficult to determine), has a large influence on the total CO_2 emissions. Similar situation is also in calorific values and emission factors of naphtha, lubricants and bitumen, which are used to estimate the fraction of carbon stored. To visualize the importance of correct estimation of EF and NCV of crude oil (and/or other liquid fuels) following ***Table 3.42*** summarize the effect of the uncertainty in the estimation of these parameters.

Table 3.42: *Effect of the uncertainty in the estimation of NCVs and EFs and its impact on the RA-SA difference*

NCVs AND EFs DIFFERENCE	%	-5%	-2%	-1%	0%	1%	2%	5%
NCVs	*TJ/kt*	44.100	42.840	42.420	42.000	41.580	41.160	39.900
EFs	*t C/TJ*	21.006	20.406	20.206	20.005	19.805	19.605	19.005
Apparent consumption	*PJ*	246	239	236	234	232	229	222
Net CO_2 emissions	*Gg*	20 902	9 472	5 873	2377	-1 016	-4 307	-13 583
Emission difference (liquid fuels)	*%*	23.19	10.82	6.77	2.77	-1.20	-5.12	-16.65

In the first row, the uncertainty of estimated EFs and NCVs of crude oil is depicted. Following rows show the actual values of NCVs and EFs which were used to compare the difference between RA and SA. The increase of the actual values of NCVs and EFs by 5% causes increase of the RA-SA difference up to 25%. It is also important to underline, that the uncertainty of few percent in the case of liquid fuels is often occurred. Several steps to increase the quality of the NCVs and EFs estimation were performed, however the uncertainty of these estimates was over 2% in every case. Therefore, in current submission, the EFs were left unchanged (IPCC default) and the NCVs were adopted from the ŠÚ SR. The consumption of crude oil is not included in the sectoral approach, therefore the problems mentioned here does not affect the inventory. It means, that the bottom-up approach is more accurate. Based on the results of performed analysis it is not expected the decrease of the RA-SA difference in liquid fuels below 2% in all years of time series. Significantly better situation is in solid and gaseous fuels.

Further significant difference is visible in the case of waste. Based on our research, the main source of the difference is caused by data processing methodology of the ŠÚ SR on waste incinerated. An incorrect categorization of municipal and industrial waste in the energy balance provided by the ŠÚ SR was identified. Moreover, the estimation of composition (biogenic/fossil part) of waste in the SA is based on information provided directly by the operators. Several meetings are organized with the experts from the ŠÚ SR on this issue.

In 2022 submission, the largest difference (in relative values) was in peat consumption. The primary reason of this difference is absence of peat as a fuel in Energy balance provided by the ŠÚ SR. Based on the EU ETS reports, there is just one company, which used peat as fuel (based on the EU ETS reports). Due to reference approach is prepared strictly based on information included in the energy balance provided by the ŠÚ SR, where peat is not included (mentioned company reports the fuel type in energy balance as briquettes), the difference occurred in this fuel. This issue cannot be improved and harmonised due to statistical rules of 3 or more data sources, therefore peat consumption in official statistics is zero, however published in the EU ETS. After 2020, there was no peat consumption reported in sectoral approach (the last company also stopped using peat as a fuel).

In 2022, the emissions decrease in most categories of Energy sector. The largest decrease was caused by the gradual shutdown of two blast furnaces in the company U. S. Steel, s. r. o. (inter-annual decrease of 1 655 kt CO_2). Due to technical problems in a large-scale power plant in Malženice, significant reduction of natural gas consumption occurred (inter-annual decrease of 755 kt CO_2). For three years in a row, a continuous increase in fuel consumption in the transport sector can be observed (inter-annual increase of 256 kt CO_2).

Figure 3.11: *Difference between the reference and sectoral approaches CO_2 emissions (in Gg) in 1990 – 2022*

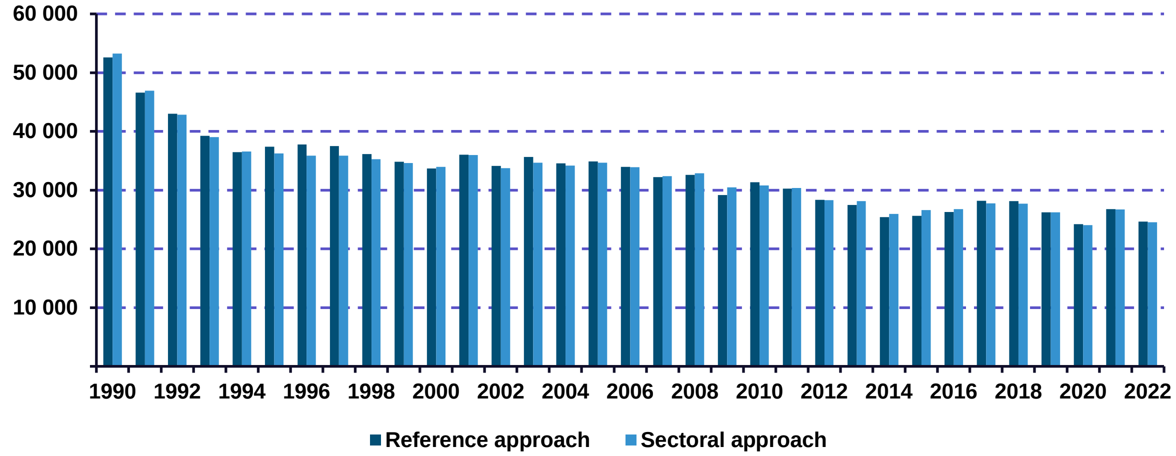


Table 3.43: *The comparison of the RA and the SA in total fuels consumption and CO_2 emissions in 1990 – 2022*

YEAR	RA	SA	APPARENT ENERGY CONSUMPTION	ENERGY CONSUMPTION DIFFERENCE	RA	SA	EMISSIONS DIFFERENCE
	PJ			%	Gg of CO_2		%
1990	753	660	652	-1.28	52 572	53 273	-1.32
1991	659	586	586	0.02	46 616	46 952	-0.72
1992	625	540	539	-0.02	43 007	42 838	0.39
1993	587	498	495	-0.48	39 263	39 038	0.58
1994	562	469	460	-1.90	36 461	36 566	-0.29
1995	591	474	487	2.64	37 395	36 236	3.20
1996	600	476	493	3.62	37 776	35 883	5.27
1997	600	477	494	3.51	37 524	35 858	4.65
1998	583	475	477	0.31	36 135	35 293	2.39
1999	566	470	461	-1.84	34 848	34 625	0.64
2000	546	464	455	-2.00	33 699	33 938	-0.70
2001	577	494	494	-0.13	36 043	35 974	0.19
2002	560	463	458	-1.02	34 107	33 760	1.03
2003	565	468	466	-0.47	35 643	34 683	2.77
2004	555	464	447	-3.74	34 551	34 154	1.16
2005	567	471	464	-1.63	34 861	34 662	0.57
2006	551	450	441	-1.93	33 974	33 921	0.16
2007	531	433	423	-2.37	32 233	32 395	-0.50
2008	533	443	431	-2.83	32 592	32 867	-0.84
2009	482	405	383	-5.52	29 175	30 484	-4.29
2010	514	412	413	0.21	31 331	30 824	1.64
2011	492	400	393	-1.68	30 235	30 348	-0.37
2012	466	377	370	-2.03	28 361	28 291	0.24
2013	468	375	366	-2.32	27 489	28 116	-2.23
2014	428	338	330	-2.48	25 431	25 934	-1.94
2015	433	351	337	-4.13	25 641	26 623	-3.69
2016	443	354	345	-2.58	26 292	26 793	-1.87
2017	473	369	373	1.01	28 208	27 760	1.61
2018	474	366	368	0.59	28 105	27 690	1.50

YEAR	RA	SA	APPARENT ENERGY CONSUMPTION	ENERGY CONSUMPTION DIFFERENCE	RA	SA	EMISSIONS DIFFERENCE
	PJ			*%*	*Gg of CO_2*		*%*
2019	441	354	352	-0.52	26 213	26 206	0.03
2020	423	332	333	0.32	24 199	24 031	0.70
2021	472	362	361	-0.30	26 771	26 715	0.21
2022	424	333	332	-0.31	24 655	24 521	0.54

Table 3.44: *The comparison of the RA and the SA in liquid fuels consumption and CO_2 emissions*

YEAR	RA	SA	APPARENT ENERGY CONSUMPTION	ENERGY CONSUMPTION DIFFERENCE	RA	SA	EMISSIONS DIFFERENCE
	PJ			*%*	*Gg of CO_2*		*%*
1990	197	164	155	-5.71	11 628	12 252	-5.09
1995	145	103	109	6.30	8 084	7 662	5.51
2000	122	92	89	-2.53	6 769	6 769	0.00
2005	139	117	107	-8.34	8 333	8 651	-3.68
2010	144	117	114	-2.20	8 729	8 542	2.18
2015	129	120	108	-10.35	7 952	8 803	-9.67
2018	158	125	130	3.72	9 733	9 202	5.77
2019	150	126	127	0.66	9 495	9 300	2.09
2020	150	118	119	1.42	8 861	8 622	2.77
2021	156	125	123	-1.76	9 165	9 218	-0.57
2022	160	131	130	-0.67	9 697	9 585	1.18

Table 3.45: *The comparison of the RA and the SA in solid fuels consumption and CO_2 emissions in particular years*

YEAR	RA	SA	APPARENT ENERGY CONSUMPTION	ENERGY CONSUMPTION DIFFERENCE	RA	SA	DIFFERENCE
	PJ			*%*	*Gg of CO_2*		*%*
1990	342	282	287	1.66	29 866	28 958	3.14
1995	226	157	170	8.15	17 796	16 564	7.44
2000	179	134	135	0.85	14 125	13 921	1.47
2005	178	124	123	-0.86	13 556	13 263	2.21
2010	159	100	99	-0.60	11 492	11 383	0.96
2015	137	81	80	-1.06	9 257	9 331	-0.80
2018	139	81	82	0.11	9 436	9 406	0.32
2019	114	66	65	-1.96	7 541	7 687	-1.90
2020	97	54	54	-1.07	6 237	6 303	-1.05
2021	118	59	59	-0.35	7 350	7 350	-0.01
2022	100	53	53	-0.57	6 352	6 375	-0.36

Table 3.46: *The comparison of the RA and the SA in gaseous fuels consumption and CO_2 emissions in particular years*

YEAR	RA	SA	APPARENT ENERGY CONSUMPTION	ENERGY CONSUMPTION DIFFERENCE	RA	SA	DIFFERENCE
	PJ			*%*	*Gg of CO_2*		*%*
1990	214	211	210	-0.65	11 062	11 827	-6.47
1995	221	212	207	-2.41	11 472	11 814	-2.90
2000	244	237	230	-2.87	12 748	13 070	-2.46
2005	247	229	232	1.17	12 805	12 614	1.52
2010	210	193	198	2.78	10 974	10 640	3.14
2015	162	146	144	-1.08	8 043	8 131	-1.09
2018	171	154	152	-1.10	8 474	8 569	-1.10
2019	171	156	155	-0.71	8 630	8 691	-0.70
2020	171	154	154	-0.11	8 575	8 583	-0.09
2021	191	172	173	0.65	9 692	9 629	0.65
2022	159	144	145	0.74	8 123	8 064	0.74

Table 3.47: *The comparison of the RA and the SA in other fossil fuels consumption and CO_2 emissions in particular years*

YEAR	RA	SA	APPARENT ENERGY CONSUMPTION	ENERGY CONSUMPTION DIFFERENCE	RA	SA	DIFFERENCE
	PJ			*%*	*Gg of CO_2*		*%*
1990	0.18	2.55	0.18	-92.97	16	236	-93.18
1995	0.48	2.10	0.48	-77.35	43	197	-78.34
2000	0.64	1.91	0.64	-66.61	57	180	-68.12
2005	1.89	1.43	1.89	31.59	168	135	24.79
2010	1.53	2.86	1.53	-46.66	136	259	-47.43
2015	4.40	3.91	4.39	12.31	389	342	14.02
2018	4.68	5.48	4.68	-14.59	461	504	-8.50
2019	5.42	5.66	5.42	-4.29	546	524	4.22
2020	5.87	5.72	5.87	2.61	526	522	0.83
2021	6.03	5.82	6.03	3.74	565	518	9.05
2022	5.26	5.67	4.95	-12.60	482	498	-3.26

3.4. Feedstocks and Non-energy Use of Fuels (CRF 1.AD)

Using the IPCC 2006 GL, the quantity of carbon excluded from the RA (carbon used for ammonia production, petrochemicals production, carbide production, hydrogen production, iron and steel production, ferroalloys production, aluminium production as well as non-energy using of lubricants) was estimated. Total carbon excluded from the RA was 1 661.23 Gg in 2022, which represented 6 091.15 Gg of CO_2. The emissions from the carbon excluded are reported in respective categories in the IPPU sector.

The major share of carbon excluded represents the carbon from coking coal, both in fuel consumption and in amount of carbon (51.3% and 50.5%, respectively) The other significant source of carbon excluded is using of natural gas (15.9% in fuel consumption and 13.5% in quantity of carbon). Details on the share in fuel units and carbon units are presented on ***Figures 3.12*** and ***3.13***. The CO_2 emissions excluded from the RA are presented on ***Figure 3.14*** for the whole time series 1990 – 2022.

Figure 3.12: The share of different fuels consumption for feedstock and non-energy use in 2022

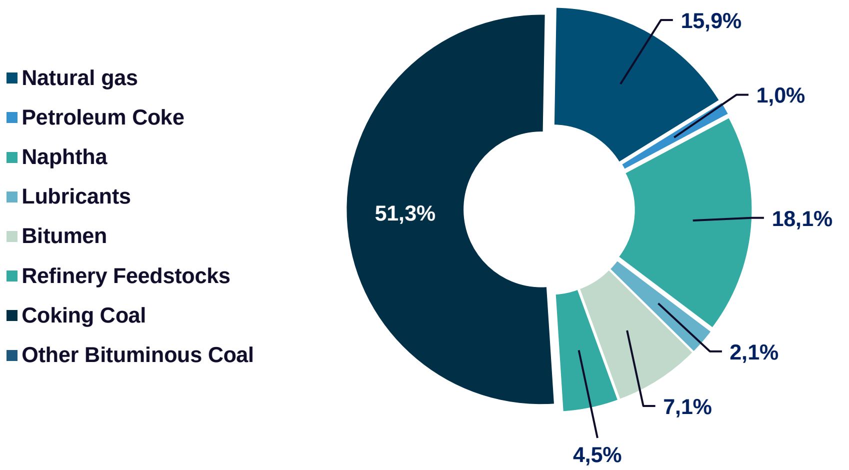


Figure 3.13: The share of carbon for feedstock and non-energy use in 2022

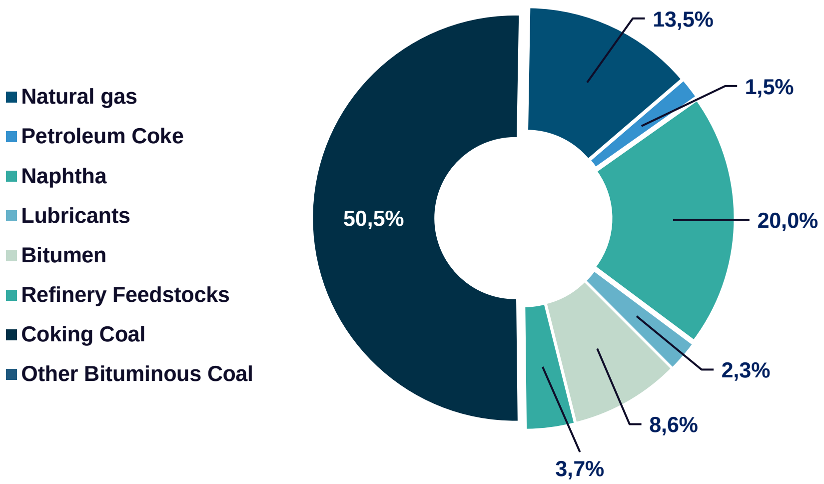
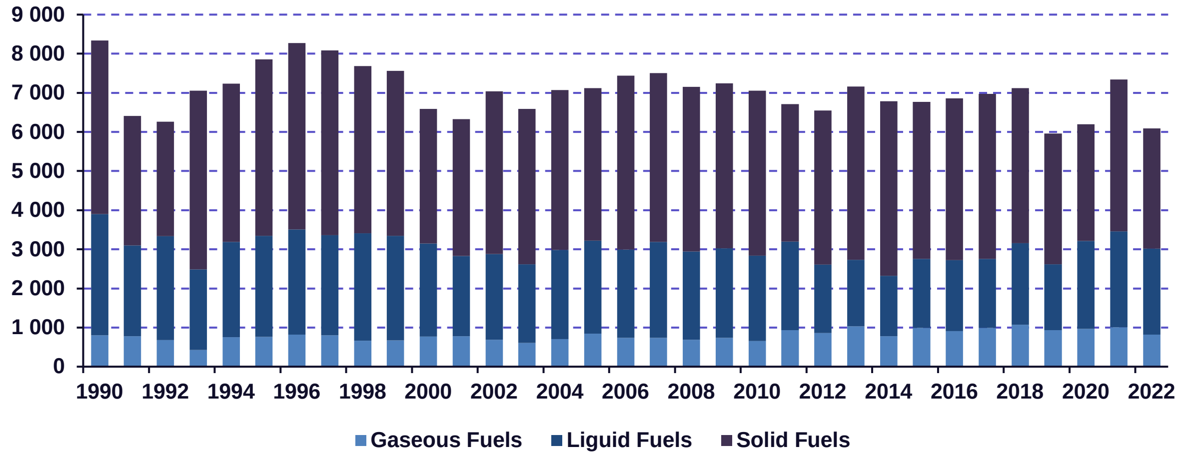


Figure 3.14: The CO_2 emissions (Gg) according to the fuels excluded from the RA in 1990 – 2022



Liquid fuels (petroleum coke, naphtha, and refinery feedstocks), solid fuels (coking coal, other bituminous coal) and gaseous fuels (natural gas) are used as feedstock in Slovakia. Lubricants and bitumen (liquid fuels) are used for non-energy purposes. The respective amounts of mentioned fuels are allocated in the IPPU sector and emissions are included there. The allocation of the fuels excluded from the RA and included in the IPPU sector is presented in ***Tables 3.48*** and ***3.49***.

Table 3.48: *The allocation of fuels excluded from the RA in the IPPU sector*

FUEL	USED AND REPORTED IN CATEGORIES
Natural gas	2.B.1 Ammonia production 2.B.8 Petrochemicals 2.B.10 Hydrogen production 2.C.1 Iron and steel production
Petroleum Coke	2.C.3 Aluminium production
Naphtha	2.B.8 Petrochemicals
Lubricants	2.D.1 Lubricants
Bitumen	2.D.3 Solvents use
Refinery feedstock	2.B.8 Petrochemicals
Coking coal	2.B.5 Carbide production 2.C.1 Iron and steel production 2.C.2 Ferroalloys production
Other bituminous coal	2.B.5 Carbide production 2.C.1 Iron and steel production 2.C.2 Ferroalloys production

The plant-specific (where available) and country-specific NCVs and EFs are used for estimation the volume of carbon excluded and respective CO_2 emissions excluded from the RA.

Natural gas, petroleum coke, naphtha, lubricants, refinery feedstock, coking coal and other bituminous coal were balanced as feedstock and non-energy use of fuels. The quantities of the fuels and carbon used for non-energy purposes were provided directly by the plant operators or by the ŠÚ SR. The results are presented in ***Table 3.49***.

Table 3.49: *Total volume of carbon in different fuels excluded from the RA in particular years*

YEAR	Natural Gas	Petroleum Coke	Naphtha	Lubricants	Bitumen	Refinery Feedstock	Coking Coal	Other Bituminous Coal
	kt							
1990	250.61	NO	296.25	65.54	418.77	65.58	1 209.70	IE
1995	254.92	NO	362.98	65.54	199.63	76.18	1 231.99	IE
2000	274.56	37.94	395.73	65.54	83.40	65.80	937.52	IE
2005	329.10	66.86	347.70	39.49	126.88	67.55	1 025.05	37.72
2010	263.78	65.44	338.98	16.90	112.07	63.64	1 111.31	37.91
2011	345.90	58.88	333.75	25.27	130.46	69.99	919.05	38.59
2012	331.44	59.02	216.90	36.99	114.05	50.60	972.18	103.11
2013	382.35	58.29	229.11	44.37	82.46	48.34	1 137.30	71.98
2014	308.83	62.11	197.85	36.27	86.39	37.60	1 102.47	116.29
2015	370.41	59.68	198.40	36.64	129.79	55.39	1 058.04	37.64
2016	351.55	64.46	208.34	36.04	133.40	53.57	1 022.86	104.30
2017	373.22	62.38	222.59	38.83	101.68	55.26	987.03	164.52
2018	382.34	62.33	278.41	39.41	128.81	61.32	902.15	178.42
2019	338.96	59.50	264.18	32.22	51.23	54.02	880.33	30.88
2020	347.89	53.37	353.79	26.02	119.10	60.63	740.50	72.85
2021	361.81	60.88	383.68	29.46	126.95	67.35	973.54	84.38
2022	223.45	24.74	331.76	38.41	142.58	62.01	838.27	NO

IE - included in coking coal

3.5. Fugitive Emissions from Fuels (CRF 1.B)

3.5.1. Overview of Fugitive Emissions from Fuels

Fugitive emissions from the categories 1.B.1 - Solid Fuel and 1.B.2 - Oil and Natural Gas are important sources of methane emissions in the national GHGs inventory. Fugitive methane emissions from charcoal production and coke production are included in the category 1.B.1.b – Solid Fuel Transformation. This report uses the GWP 100 based on IPCC Assessment report 5 for the year 2022. The difference between emission based on GWP 100 IPCC Assessment report 4 (AR4) and 5 (AR5[1]) are summarized in previous SVK NIR 2023.

In 2022, total aggregated fugitive emissions in the category 1.B represented 687.16 Gg of CO_2 eq. Overview of the total GHG emissions reported in the category 1.B is provided in ***Table 3.1*** and tier used is provided in ***Table 3.2***. Methane emissions from abandoned underground mines (category 1.B.1.a.1.iii) are reported in the inventory since 2015. ***Tables 3.50*** and ***3.51*** summarize emissions according to the most significant categories within 1.B in particular years. GHG emissions from the activities occurring in the category 1.B.2.a.5 – Distribution of Oil Products are not estimated because of the 2006 IPCC Guidelines and also 2019 Refinement to the 2006 IPCC Guidelines do not include methodologies to estimate them, therefore the notation key “NE” is used here.

The trend is steadily decreasing as an outcome of introduction of new technologies, methodologies and closing the coal mines. Fugitive emissions from the transport and distribution of fossil fuels (oil and natural gas) are significant because Slovakia is an important transit country for oil and natural gas from East-European countries to the European Union. Raw materials are transported through high-pressure pipelines and distribution network and they are pumped by pipeline compressors (1.A.3.e.i). Trend in fugitive emissions from the transport and distribution of oil and natural gas in the Slovak Republic was stabilized and since 2000 slightly decreased. The increase in the past was caused by the expansion of the distribution system for natural gas and growth of its consumption. Since 2000, fugitive emissions from oil have decreased due to the decrease in production and distribution.

Table 3.50: *GHG emissions by categories within the 1.B.1 - Solid Fuels in particular years*

YEAR	1.B.1.a Coal Mining and Handling					1.B.1.b Solid Fuel Transformation		
	1.B.1.a.1.i		1.B.1.a.1.ii	1.B.1.a.1.iii				
	CO_2	CH_4	CH_4	CO_2	CH_4	CO_2	CH_4	N_2O
	Gg							
1990	19.03	25.14	2.09	0.73	1.05	NO	0.11	NO
1995	21.54	27.44	2.27	0.45	0.62	4.71	0.21	0.0002
2000	21.51	26.62	2.20	0.36	0.48	7.85	0.28	0.0004
2005	20.78	14.66	1.51	1.61	1.25	75.36	2.02	0.0038
2010	19.74	13.89	1.43	1.91	1.49	4.74	0.20	0.0002
2015	19.51	11.32	1.17	1.91	1.22	6.28	0.24	0.0003
2016	18.62	10.85	1.11	2.25	1.44	2.27	0.13	0.0001
2017	21.40	9.29	1.11	3.33	1.62	6.28	0.23	0.0003
2018	18.64	7.34	0.91	4.31	1.91	6.44	0.24	0.0003
2019	17.89	8.13	0.86	3.69	1.86	6.28	0.23	0.0003
2020	12.26	5.75	0.59	3.49	1.81	5.97	0.21	0.0003
2021	13.43	6.17	0.65	3.60	1.83	6.28	0.24	0.0003
2022	10.72	6.17	0.52	3.49	2.18	6.28	0.24	0.0003

Table 3.51: *GHG emissions by categories within the 1.B.2 - Oil and NG and other emissions from energy production in particular years*

YEAR	1.B.2.a OIL			1.B.2.b Natural gas		1.B.2.c Venting and Flaring			
						1.B.2.c.1.ii Gas		1.B.2.c.2.i Oil	1.B.2.c.2.ii Gas
	CO_2	CH_4	N_2O	CO_2	CH_4	CO_2	CH_4	N_2O	N_2O
	Gg							*kg*	
1990	39.69	0.47	0.0005	17.12	42.34	0.23	23.55	49.00	29.75
1995	33.58	0.44	0.0004	15.79	34.27	0.23	20.62	49.75	23.05
2000	34.49	0.39	0.0005	12.77	24.91	0.21	16.50	39.53	11.59
2005	34.15	0.32	0.0005	13.20	18.86	0.23	14.83	20.77	9.85
2010	32.49	0.26	0.0005	11.28	10.60	0.20	10.51	8.77	6.14
2015	35.27	0.26	0.0005	9.77	5.99	0.17	1.87	6.42	5.74
2016	33.95	0.25	0.0005	10.53	6.10	0.19	1.98	5.60	5.94
2017	32.77	0.24	0.0005	11.08	6.31	0.20	1.73	3.87	5.89
2018	32.16	0.23	0.0005	10.34	5.46	0.19	1.44	3.44	5.68
2019	30.09	0.21	0.0004	11.57	5.20	0.21	1.65	2.91	4.96
2020	37.76	0.25	0.0006	9.63	5.39	0.18	2.00	1.40	4.37
2021	32.43	0.23	0.0005	7.21	6.28	0.13	1.37	3.05	4.38
2022	31.69	0.22	0.0005	4.86	5.40	0.08	0.79	1.43	3.73

3.5.2. Uncertainties and Time-series Consistency

The Approach 1 of uncertainty analysis was performed according to the IPCC 2006 GL. Approach 2 uncertainty estimation was not performed due to lack of input data. Availability of inputs is the most facing issue in these categories. The amount of methane from underground mining is naturally fluctuating. The direct measurements of the CH_4 emissions from the ventilated air are with the ±20% of accuracy depending on the measurement's installation. The repeatability of the measurements increases the accuracy up to ±5%. For the continual measurements during 2 weeks, the uncertainty is in the range of ±10-15%.

The emissions inventory of fugitive methane emissions from fuels were revised in the previous years, the chosen emission factors for underground coal mining and handling correspond to the national circumstances in the Slovak mining industry. The important reason for this opinion is an occurrence of brown coal underground mines with mainly non-gaseous system in deep shafts. In addition, new emission factors (IPCC 2006 GL, Table 4.2.4) were used for the entire time series. The methodology in these categories is consistent during time series and across the main types of fuels.

3.5.3. Category-specific QA/QC and Verification Process

The verification process in the category 1.B.1 is based on cross-checking of input data from the mining companies and the comparison with the sectoral statistical indicators from the Ministry of Economy of the Slovak Republic and the ŠÚ SR. More information can be find in the **Chapter 3.5.6** (***Figure 3.15***).

The verification process in the category 1.B.2 is based on cross-checking the input data from the supplier companies Nafta, a. s. (oil), Transpetrol, a. s. (oil), Eustream, a. s. (natural gas) and the SPP - Distribution, a. s. (natural gas) with the statistics from the Ministry of Economy of the Slovak Republic and the Statistical Office of the Slovak Republic (ŠÚ SR).

For the inventory preparation and verification of currently used methodology, the fugitive emissions from NG were estimated also with the use of data provided directly by (bottom-up approach):

- Eustream, a. s.; as the company responsible for the transmission and storage of the NG and venting (categories 1.B.2.b.4 and 1.B.2.c.1.ii);

- Slovenský plynárenský priemysel – distribúcia a.s (SPP-Distribution, a. s.); as the in-country distributor of natural gas (NG) reported in the category distribution of NG (1.B.2.b.5);
- Nafta, a. s.; as the exclusive company responsible for oil and NG production in Slovakia.

In this submission, further information on the status of implementation of recommendation is providing. Slovakia after cross-check of activity data, changed reported data from statistical data to plant based data. Each company, except of Transpetrol, a. s., is providing the activity data (production, processing and transport) and also with directly measured emissions of CH_4. Slovakia used these data to recalculate time-series for most of the fugitive emissions categories.

Further improvements are expected to be implemented into NG distribution category (1.B.2.b.5) but these data are not fully verified and will be reported in the next submissions. The SPP-Distribution, a. s., as the second large contributor to the emissions in this category, provided fugitive emissions from distribution of natural gas. These emissions are considered as difference between distribution input and real consumption (output). The difference is reported as distribution losses, but there is a high uncertainty caused by real consumption measurement inaccuracy. In addition, the SPP-Distribution, a. s. sent in a beginning of the year 2021 methodological background document to support measured data on natural gas losses during transfer and distribution. This document is not translated in English, but there is a description of distribution losses and fugitive emissions from pipeline system, type of measurements made in a company and uncertainty assessment. Also in 2023 should be approved new MRV on the EU level. This will be published as a directive and will harmonize the calculation of fugitive emissions from natural gas distribution across EU. This calculation will be published in 2023 – 2024 as CEN/ISO standard. After that the Slovak Republic will report fugitive emissions from natural gas distribution according to the new regulations and calculations.

In addition, improvements in the CO_2 emissions estimation based on direct measurements of the content of natural gas are planned for next submissions.

The background documents are archived by the sectoral experts and in the central archiving system of the SNE at the SHMÚ.

3.5.4. Category-specific Recalculations

This chapter describes the recalculations of emissions from fugitive emissions and its subcategories with respect to the previous submission caused by implementation of the 2019 Refinements to the 2006 IPCC Guidelines (2019 RF), most of the categories were recalculated. The list of recalculations is provided in this chapter.

Revision of activity data – Based on the 2019 RF methodology, Slovakia revised all activity data for each fugitive emissions subsectors and added new activity to the subsector 1.B.1.b Solid fuel transformation. The added activity was coke production. For the category 1.B.2.b three new activity data sources were identified according to the 2019RF: Post-Meter emissions from natural gas for appliances, CNG vehicles and industrial plants.

Revision of methodology – Based on the 2019 RF methodology, new emission factors were implemented across the whole sector. Venting and flaring emission factors were unified with the appropriate fugitive emissions EF. This resulted in major decrease of emissions in the subsector 1.B.2.c and relocation of emissions causing usage of notation key “IE”. Also new subsector for fugitive emissions from natural gas were introduced – Post-Meter fugitive emissions from natural gas. These emission had to be due reporting software restrictions reported as 1.B.2.d Other.

CO_2 recalculations in 1.B - ***Table 3.52*** shows the recalculations of CO_2 emissions for categories of 1.B – Fugitive emissions. Recalculations of CO_2 emissions in 1990 – 2021 are due to implementation of new methodologies, activity data and updated emission factors.

Table 3.52: *Differences in CO_2 emissions between previous submission and current submission caused by recalculations*

YEAR	1.B	1.B.1.a	1.B.1.b	1.B.2.a	1.B.2.b	1.B.2.c	1.B.2.d
	Gg						
1990	52.63	0.75	NO	39.67	16.54	-4.34	0.01
1991	44.43	0.61	NO	32.83	14.86	-3.88	0.01
1992	39.95	0.56	NO	28.36	14.38	-3.36	0.01
1993	43.83	0.50	4.71	28.01	14.09	-3.49	0.01
1994	47.24	0.46	4.71	31.14	14.55	-3.63	0.01
1995	49.89	0.45	4.71	33.56	15.25	-4.08	0.01
1996	50.05	0.43	4.71	33.92	14.85	-3.87	0.01
1997	49.64	0.42	4.71	34.02	13.98	-3.50	0.01
1998	50.88	0.39	4.71	34.57	14.46	-3.25	0.01
1999	52.30	0.39	6.28	34.71	14.26	-3.35	0.01
2000	52.03	0.36	7.85	34.47	12.28	-2.94	0.01
2001	53.68	0.37	9.42	34.63	12.09	-2.85	0.01
2002	108.78	0.38	64.37	35.19	11.50	-2.67	0.01
2003	116.54	0.69	70.65	34.97	12.65	-2.43	0.01
2004	119.76	1.64	72.22	35.12	12.83	-2.06	0.01
2005	122.10	1.61	75.36	34.13	12.70	-1.71	0.01
2006	177.45	2.29	130.31	34.25	12.27	-1.73	0.06
2007	180.00	2.11	131.88	36.09	11.40	-1.53	0.06
2008	180.98	1.94	133.45	35.01	11.57	-1.05	0.06
2009	170.67	1.93	125.60	34.02	9.99	-0.93	0.06
2010	49.23	1.91	4.74	32.49	10.88	-0.85	0.06
2011	54.34	1.61	6.64	35.74	11.27	-0.98	0.06
2012	47.44	1.50	6.75	32.10	7.93	-0.90	0.06
2013	50.90	1.48	6.28	34.79	9.08	-0.78	0.06
2014	47.06	2.19	6.59	30.94	8.07	-0.79	0.06
2015	52.19	1.91	6.28	35.26	9.45	-0.77	0.06
2016	48.03	2.25	2.27	33.94	10.20	-0.69	0.06
2017	52.42	3.33	6.28	32.77	10.73	-0.75	0.06
2018	52.40	4.31	6.44	32.16	10.00	-0.57	0.06
2019	50.72	3.69	6.28	30.08	11.24	-0.63	0.06
2020	56.18	3.49	5.97	37.76	9.30	-0.39	0.06
2021	48.84	3.60	6.28	32.42	6.87	-0.38	0.06

CH_4 recalculations in 1.B - ***Table 3.53*** shows the recalculations of CH_4 emissions for categories of 1.B – Fugitive emissions. Recalculations of CH_4 emissions in 1990 – 2021 are due to implementation of new methodologies, activity data and updated emission factors.

Table 3.53: *Differences in CH_4 emissions between previous submission and current submission caused by recalculations*

YEAR	1.B	1.B.1.a	1.B.1.b	1.B.2.a	1.B.2.b	1.B.2.c	1.B.2.d
	Gg						
1990	0.55	1.08	NO	-0.12	-1.80	-0.055	1.33
1991	0.10	0.87	NO	-0.11	-2.00	-0.054	1.28
1992	-0.06	0.79	NO	-0.09	-2.14	-0.046	1.32
1993	-0.08	0.72	0.13	-0.09	-2.15	-0.050	1.36
1994	0.05	0.66	0.13	-0.10	-1.92	-0.051	1.33
1995	0.00	0.62	0.12	-0.11	-1.98	-0.056	1.41
1996	-0.28	0.58	0.12	-0.11	-2.24	-0.054	1.42
1997	-0.43	0.55	0.12	-0.10	-2.39	-0.048	1.45
1998	-0.57	0.52	0.10	-0.10	-2.52	-0.045	1.47
1999	-0.78	0.50	0.12	-0.11	-2.71	-0.050	1.48
2000	-0.80	0.48	0.13	-0.10	-2.74	-0.044	1.48
2001	-0.93	0.46	0.14	-0.10	-2.93	-0.041	1.53
2002	-0.62	0.44	0.51	-0.10	-2.87	-0.039	1.44
2003	-0.16	0.62	0.55	-0.09	-2.62	-0.032	1.41
2004	0.56	1.39	0.56	-0.09	-2.60	-0.029	1.33
2005	-0.11	1.25	0.58	-0.08	-3.07	-0.023	1.24
2006	6.99	1.91	0.94	-0.08	-2.72	-0.021	6.96
2007	7.20	1.99	0.95	-0.08	-2.58	-0.021	6.94
2008	7.10	1.84	0.96	-0.08	-2.65	-0.014	7.05
2009	7.30	1.67	0.90	-0.07	-2.11	-0.011	6.93
2010	6.46	1.52	0.11	-0.07	-2.05	-0.010	6.97
2011	6.45	1.48	0.12	-0.08	-2.11	-0.011	7.04
2012	6.51	1.39	0.12	-0.07	-1.93	-0.008	7.01
2013	6.53	1.36	0.11	-0.07	-1.88	-0.008	7.02
2014	7.01	1.29	0.12	-0.06	-1.21	-0.009	6.89
2015	6.90	0.96	0.12	-0.07	-1.00	-0.009	6.90
2016	6.92	1.01	0.09	-0.07	-1.03	-0.008	6.93
2017	7.03	1.12	0.11	-0.07	-1.08	-0.006	6.95
2018	6.87	1.07	0.12	-0.06	-1.24	-0.005	7.00
2019	6.74	1.14	0.11	-0.06	-1.49	-0.005	7.04
2020	6.61	1.12	0.09	-0.07	-1.61	-0.003	7.08
2021	7.02	1.05	0.12	-0.06	-1.29	-0.004	7.21

N_2O recalculations in 1.B - ***Table 3.54*** shows the recalculations of N_2O emissions for categories of 1.B – Fugitive emissions. Recalculations of N_2O emissions in 1990 – 2021 are due to implementation of new methodologies, activity data and updated emission factors.

Table 3.54: *Differences in N_2O emissions between previous submission and current submission caused by recalculations*

YEAR	1.B	1.B.1.b	1.B.2.a	1.B.2.c
	kg			
1990	552.76	NO	541.24	11.52
1991	449.35	NO	440.61	8.74
1992	388.47	NO	380.81	7.66
1993	619.72	240.00	372.39	7.33
1994	666.52	240.00	418.43	8.09
1995	699.11	240.00	449.66	9.45

YEAR	1.B	1.B.1.b	1.B.2.a	1.B.2.c
	kg			
1996	705.70	240.00	456.97	8.73
1997	711.35	240.00	463.36	7.99
1998	721.41	240.00	474.15	7.26
1999	798.78	320.00	472.32	6.45
2000	878.86	400.00	473.45	5.40
2001	964.18	480.00	478.41	5.77
2002	3 773.96	3 280.00	488.68	5.28
2003	4 098.25	3 600.00	492.07	6.17
2004	4 181.64	3 680.00	497.03	4.61
2005	4 331.04	3 840.00	487.03	4.02
2006	7 135.68	6 640.00	490.77	4.91
2007	7 241.61	6 720.00	518.09	3.53
2008	7 311.37	6 800.00	508.69	2.68
2009	6 898.51	6 400.00	495.90	2.61
2010	717.81	241.60	474.41	1.80
2011	860.93	338.40	521.22	1.32
2012	813.62	344.00	469.71	-0.10
2013	831.73	320.00	510.78	0.95
2014	789.68	336.00	454.14	-0.46
2015	838.25	320.00	518.04	0.20
2016	615.88	115.76	499.21	0.91
2017	801.66	320.00	483.46	-1.80
2018	803.17	328.00	474.80	0.36
2019	762.60	320.00	444.48	-1.88
2020	863.80	304.00	560.10	-0.30
2021	800.62	320.00	479.11	1.51

3.5.5. Category-specific Improvements and Implemented Recommendations

In this report the 2019 Refinements to the 2006 IPCC Guidelines were implemented.

3.5.6. Solid Fuels (CRF 1.B.1)

Coal mining and handling (CRF 1.B.1.a) – 868.51 kt of brown coal was mined from underground mines in the Slovak Republic in 2022, mostly for domestic consumption (energy industry and households). Total methane emissions from the underground coal mining were estimated to be 8.88 Gg (6.17 Gg of CH_4 from mining activities, 0.52 Gg of CH_4 from post-mining activity and 2.18 Gg from abandoned mines) in 2022. Total CO_2 emissions from the underground coal mining were estimated to be 14.21 Gg in 2022.

Table 3.55: *Overview of fugitive emissions from mining and post-mining activities in particular years*

YEAR	Brown coal produced	CH_4 emissions from mining	CH_4 recovery from mining	CH_4 emissions from post-mining	CH_4 emissions from abandoned mines	Total CH_4 emissions	CO_2 emissions from mining
	kt	*Gg*					
1990	3 456.00	25.143	NO	2.086	1.046	28.275	19.030
1995	3 759.10	27.437	NO	2.267	0.617	30.321	21.542
2000	3 649.30	26.620	NO	2.201	0.478	29.299	21.513

YEAR	Brown coal produced	CH_4 emissions from mining	CH_4 recovery from mining	CH_4 emissions from post-mining	CH_4 emissions from abandoned mines	Total CH_4 emissions	CO_2 emissions from mining
	kt	*Gg*					
2005	2 511.20	13.340	NO	1.514	1.250	17.423	20.781
2010	2 377.53	13.894	NO	1.434	1.487	16.814	19.740
2015	1 939.33	11.324	NO	1.169	1.225	13.719	19.513
2016	1 847.13	10.845	NO	1.114	1.443	13.402	18.617
2017	1 834.00	9.286	NO	1.106	1.618	12.010	21.398
2018	1 502.00	7.342	NO	0.906	1.908	10.156	18.642
2019	1 431.00	8.126	NO	0.863	1.855	10.844	17.891
2020	980.00	5.750	NO	0.591	1.806	8.146	12.261
2021	1 074.00	6.172	NO	0.648	1.826	8.646	13.430
2022	868.51	6.172	NO	0.524	2.180	8.876	14.214

Solid fuel transformation (CRF 1.B.1.b) – total CO_2 eq. emissions from this category were 12.87 kt in 2022. Fugitive methane emissions from charcoal production and coke production in the Slovak Republic is reported in this category. Charcoal production is reported in the FAO database since 1993. The production of wood charcoal is included in this category and CH_4 emissions were estimated for the years 1993 – 2022. Total volume of wood charcoal produced in Slovakia was 4 kt in 2022. Total CH_4 emissions were 0.12 Gg in 2022. According to the new 2019 RF methodology it is possible to estimate also CO_2 and N_2O emission, as well as CH_4 emissions from coke production. CO_2 emissions from coke production are already included in the carbon balance in 1.A.1.c. Total coke production was 1 450 kt in 2022 and producing 0.07 kt of CH_4 emissions in 2022.

Methodological issues

Coal mining and handling (CRF 1.B.1.a) – Total emissions from fugitive sources in coal mining industry can be calculated by the following formula:

CH_4 = underground mining emissions + post-mining activity emissions - recovery or flared methane with cogeneration + emissions from abandoned mines

According to the 2019 Refinements to the 2006 IPCC GL (2019 RF), tier 2 and the country specific EFs were used. The amount of mined brown coal (in the raw form) is the primary activity data. For the calculation of fugitive methane emissions from mining activities the emission factors from the following source were used:

- International Energy Agency - CIAB Global Methane and the Coal Industry. Emission factors based on the International Energy Agency CIAB methodology were assigned according to the depth of the mines for mining within 6 a 13 m^3 CH_4/t and 0.9 m^3 CH_4/t for post-mining activity.

For comparison reasons, fugitive emissions were estimated based on the EFs from different source:

- IPCC 2006 Guidelines for National Greenhouse Gas Inventories (IPCC 2006 GL) and also 2019 Refinements to the 2006 IPCC GL, Volume 2: Energy Chapter 4: Fugitive Emissions: 4.1 fugitive emissions from mining, processing, storage and transport of coal. According to the Refinements, the emission factor is identical for all mines without depth differentiation with the values of 10 m^3 CH_4/t for coal mining and 0.9 m^3 CH_4/t for post-mining activities.

- Measurements of EF CH_4 as specified by the mines operator - HBP, a.s. The emission factors estimated by the HBP, a.s. mine operator on the base of measured concentration values of the methane in the air ventilation was assigned for one single mine according to the suggestion of the operator. These emission factors are underestimated.

The emission factors for post-mining activities were used from the IPCC 2019 RF (for mining without drainage with known gas amount). In the coal after mining is present 30% of gas and 10% of gas for mines with pre-drainage. Overview of emission factors is presented in ***Table 3.56***.

Based on the national circumstances and in accordance with the conservative principle of the IPCC 2006 GL, it was decided to calculate fugitive methane emissions in the period 1990 – 2021 on the base of coal production from underground mines obtained from the official sources and emission factors according to the methodology IEA-CIAB Global Methane and the Coal Industry selected for the depth of the mines (***Table 3.56,*** point 2).

Table 3.56: *Coal production, characteristics of mines and the emission factors for mining and post-mining in single mines in the Slovak Republic in 2022*

MINE	COAL PRODUCTION	DEPTH OF MINE	EF CH_4					
			1. 2019 RF		2. IEA - CIAB		3. HPB, a.s.	
			Mining	Post-mining	Mining	Post-mining	Mining	Post-mining
	t/year	*m*	*m^3/t*					
Mine Nováky	751 650	200	10	0.9	6	0.9	0.92	0.39
Mine Nováky 6th logging place	NO	200	10	0.9	6	0.9	4.17	0.46
Mine Cigeľ	NO	500	10	0.9	13	0.9	0.00	0.00
Mine Cigeľ 7th logging place	NO	500	10	0.9	13	0.9	4.17	0.46
Mine Handlová	NO	500-1500	10	0.9	13	0.9	0.00	0.00
Mine Handlová east shaft	NO	500-1500	10	0.9	13	0.9	4.17	0.46
Mine Dolina	NO	600	10	0.9	13	0.9	0.02	0.01
Mine Čáry	116 860	400	10	0.9	13	0.9	0.02	0.01

The fugitive methane emissions were partly used for electricity and heat cogeneration between 2007 and 2014 in the east shaft of mine Handlová and did not occur after 2015. Using emission factors according to the depth of mine (IEA-CIAB), the appropriate EF is estimated for each mine and the total emissions from mining are summarised. The average CH_4 EF for mining activities was 4.65 kg/t in 2022.

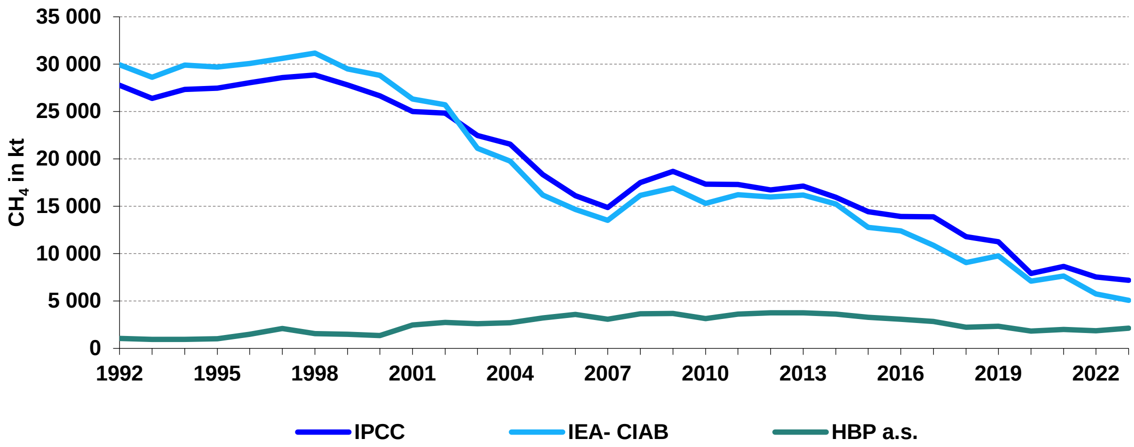
Five localities of underground mines operated by two companies are in the Slovak Republic. Data of coal production from the underground mines were obtained from official sources (MH SR, ŠÚ SR) and directly from the companies: Hornonitrianske bane Prievidza (HBP) and previously also from Baňa Dolina Veľký Krtíš (BD). According to the Regulation of the Slovak Office of Mines No 21/1988 Coll., mines are differentiated based on gas release as follows:

- HBP, a.s. Prievidza:
  - Mine Cigeľ – non-gaseous (closed in July 2017)
  - Mine Cigeľ 7th logging place - gaseous,
  - Mine Handlová – gaseous,
  - Mine Nováky – gaseous,
  - Mine Čáry Holíč – gaseous;
- Baňa Dolina Veľký Krtíš – gaseous (closed).

Figure 3.15 shows the comparison of trends in estimated CH_4 emissions in the Slovak Republic in the years 1990 – 2020 according to different emission factors (IPCC 2006 GL, IEA-CIAB methodology and EF(CH_4) measured by HBP, a.s. Prievidza). In a case of emissions calculation with use of the IPCC emission factors, the trend of CH_4 fugitive emissions is declining in accordance with the reduction of coal mining in the Slovak Republic (tier 1). The application of EF (CH_4) specified by the mine operator

(HBP, a. s.) shows the increasing trend of fugitive emissions CH_4 in contradiction with the decrease in coal mining activity. It is due to the move of coal mining to the parts of mines with coal containing more gas. Using these plant specific emission factors is not in accordance with the good practice, because measurements are not certified and they are not carried out continuously and on more sites. The emissions can be underestimated.

Figure 3.15: *Comparison of CH_4 (t) emissions trends in the Slovak Republic in years 1992 – 2022*



CH_4 emissions from post-mining activities are presented in mined coal and released into the atmosphere during the manipulation and storage of coal. The measurements of these emissions are not carried out so the emissions are estimated with the default emission factors based on coal mined. It is assumed, that 25-40% of CH_4 is present in the coal. It is recommended to use the emission factor 30% for the mines without drainage and the emission factor 10% for the pre-drainage mines. The average emission factor used for the emissions estimation from post-mining activities based on the IEA-CIAB methodology is 0.9 m^3/t (0.603 kg/t) in 2022.

CO_2 emissions estimation from coal mining is based on expert judgement provided by the Department of Ventilation and Drainage of the HBP, a. s. company. Annual quantities of mining winds and average CO_2 concentration are measured as part of the safety protocols. This is an approximation with respect to the accuracy of the measuring instruments for measuring the mining air. The mine Čáry has the same depth as the mines of the HBP, a. s. company, therefore the same EFs were used. There is no production registered in other mines in 2022.

Table 3.57: *Overview of CO_2 emission factors for single mines in the Slovak Republic in 2022*

MINE	COAL PRODUCTION	EF	EMISSIONS CO_2
	t/year	*t CO_2/t*	*t/year*
Mine Nováky	751 650	0.0125351	9 281
Mine Čáry	116 860	0.012340	1 442
TOTAL	865 510	0.012509	10 723

Solid Fuel Transformation (CRF 1.B.1.b) – fugitive emission from solid fuel transformation have been calculated by the IPCC tier 1 default approach with using 2019 Refinements to the 2006 IPCC Guidelines. This category includes fugitive emissions from charcoal, biochar and coke production. The GHG emissions from charcoal and coke combustion are included in the Energy sector, where the activity data represents the quantity of production excluding export.

Production of charcoal and coke in Slovakia were obtained from the official FAO statistic for charcoal and the Statistical office of the Slovak Republic for coke. A higher production of charcoal was recognised in years 2002 – 2009. This issue was also consulted with the Ministry of Agriculture of the Slovak Republic (responsible for FAOSTAT) but it was not possible to reconstruct the reasons of this trend.

CO_2 emissions occur only in charcoal production and are considered as biomass origin, thus should be reported as memo items. CO_2 emissions from coke production are based on the carbon content are balanced and reported in the Energy sector under the EU ETS. There is no biochar production in Slovakia.

Table 3.58: *Charcoal and coke production and fugitive emissions in particular years*

YEAR	Charcoal production	Coke production	CO_2 emissions	CH_4 emissions	N_2O emissions
	Gg/year	*Gg/year*	*Gg/year*	*Gg/year*	Gg/year
1990	0.00	2 340.00	0.00	0.11	0.0000
1995	3.00	1 854.00	4.71	0.21	0.0002
2000	5.00	1 596.92	7.85	0.28	0.0004
2005	48.00	1 740.00	75.36	2.02	0.0038
2010	3.02	1 550.01	4.74	0.20	0.0002
2011	4.23	1 520.01	6.64	0.24	0.0003
2012	4.30	1 470.01	6.75	0.25	0.0003
2013	4.00	1 440.01	6.28	0.23	0.0003
2014	4.20	1 470.01	6.59	0.24	0.0003
2015	4.00	1 530.01	6.28	0.24	0.0003
2016	1.45	1 540.01	2.27	0.13	0.0001
2017	4.00	1 490.01	6.28	0.23	0.0003
2018	4.10	1 500.01	6.44	0.24	0.0003
2019	4.00	1 320.01	6.28	0.23	0.0003
2020	3.80	1 110.00	5.97	0.21	0.0003
2021	4.00	1 626.00	6.28	0.24	0.0003
2022	4.00	1 450.00	6.28	0.23	0.0003

Source specific recalculations

Recalculations are described in the Chapter 3.5.4.

3.5.7. Oil and Natural Gas and Other Emissions from Energy Production (CRF 1.B.2)

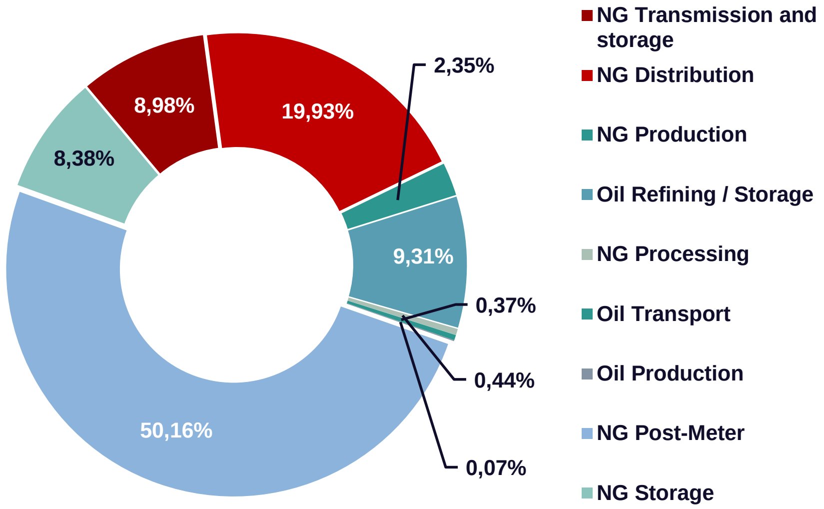
The production of oil and natural gas from domestic sources is negligible in the Slovak Republic and the major share of these stocks comes from import. Fugitive methane emissions from natural gas distribution and venting are key categories in level assessment. Total CH_4 emissions represented 374.63 Gg of CO_2 eq. (13.38 Gg of CH_4) in 2022. Total CO_2 emissions were 36.69 Gg in 2022. Total N_2O emissions were 4.75 kg in 2022. The major share of emissions belongs to the NG post meter emissions (50.16%), NG distribution (19.93%) and transmission and storage (8.98%). Production of natural gas has stabilised in 2022 and represented 2.35% from the total fugitive emissions from oil and NG activities.

Total fugitive GHG emissions from oil activities (1.B.2.a) were 37.98 Gg of CO_2 eq. (31.69 t of CO_2 and 0.22 t of CH_4) in 2022. Total GHG emissions are decreasing continuously due to decrease in production and storage.

Table 3.59: Trend in fugitive emissions from oil activities in particular years

YEAR	1.B.2.a OIL									
	1.B.2.a.2 Production			1.B.2.a.3 Transport			1.B.2.a.4 Refining/Storage			
	Production	Emissions		Transfer	Emissions		Refining/ Storage	Emissions		
	kt	t CO_2	t CH_4	kt	t CO_2	t CH_4	kt	kt CO_2	t CH_4	t N_2O
1990	73.14	3 290.43	212.83	13 581.00	6.65	73.34	6 221.14	36.39	186.63	0.54
1995	74.25	3 340.37	216.06	13 581.00	6.14	67.66	5 168.47	30.24	155.05	0.45
2000	59.00	2 654.41	171.69	9 300.00	4.56	50.22	5 442.00	31.84	163.26	0.47
2005	31.00	1 394.69	90.21	10 662.34	5.22	57.58	5 598.00	32.75	167.94	0.49
2010	13.08	588.60	38.07	10 075.33	4.94	54.41	5 453.00	31.90	163.59	0.47
2015	9.59	431.27	27.90	9 932.04	4.87	53.63	5 954.53	34.83	178.64	0.52
2016	8.36	376.03	24.32	9 171.32	4.49	49.53	5 738.02	33.57	172.14	0.50
2017	5.78	259.82	16.81	9 582.25	4.70	51.74	5 557.00	32.51	166.71	0.48
2018	5.14	231.25	14.96	9 460.16	4.64	51.08	5 457.49	31.93	163.72	0.47
2019	4.34	195.12	12.62	8 997.64	4.41	48.59	5 109.01	29.89	153.27	0.44
2020	2.09	94.03	6.08	9 974.83	4.89	53.86	6 437.93	37.66	193.14	0.56
2021	4.56	205.02	13.26	8 819.00	4.32	47.62	5 507.00	32.22	165.21	0.48
2022	2.14	96.14	6.22	9 595.06	4.70	51.81	5 400.00	31.59	162.00	0.47

Figure 3.16: The share of individual activities in fugitive emissions of oil and natural gas in 2022



Total fugitive GHG emissions from natural gas activities (1.B.2.b) were 156.02 Gg of CO_2 eq. (4.86 Gg of CO_2 and 5.40 Gg of CH_4) in 2022. Despite the expansion of the distribution system, the trend of the fugitive emissions from distribution of the natural gas in the Slovak Republic is decreasing in line with the decrease of natural gas transit.

Table 3.60: Trend in fugitive emissions from NG activities in particular years

YEAR	1.B.2.b NATURAL GAS								
	1.B.2.b.2 Production			1.B.2.b.3 Processing			1.B.2.b.4 Transmission and storage		
	Product.	Emissions		Process.	Emissions		Transfer	Emissions	
	mil m³	*t* CO_2	*t* CH_4	*mil m³*	*t* CO_2	*t* CH_4	*mil m³*	*t* CO_2	*t* CH_4
1990	444.00	1 753.80	2 548.56	444.00	4 195.80	333.00	73 600.00	11 040.00	35 328.00
1995	344.00	1 358.80	1 974.56	344.00	3 250.80	258.00	73 600.00	11 040.00	27 968.45
2000	173.00	683.35	993.02	173.00	1 634.85	129.75	68 600.00	10 290.00	19 208.84
2005	147.00	580.65	843.78	147.00	1 389.15	110.25	73 900.00	11 085.00	13 303.35
2010	94.03	361.99	526.04	94.03	866.03	68.73	65 302.00	9 795.30	5 225.75
2015	84.57	338.22	491.49	84.57	809.16	64.22	55 800.00	8 370.00	1 392.80
2016	87.89	350.33	509.09	87.89	838.14	66.52	60 600.00	9 090.00	1 450.61
2017	87.29	347.29	504.67	87.29	830.86	65.94	64 200.00	9 630.00	1 465.26
2018	84.15	334.76	486.46	84.15	800.88	63.56	59 700.00	8 955.00	866.75
2019	73.60	292.57	425.15	73.60	699.94	55.55	69 060.00	10 359.00	809.90
2020	65.26	257.87	374.73	65.26	616.93	48.96	56 980.00	8 547.00	1 059.67
2021	65.33	258.07	375.02	65.33	617.40	49.00	40 362.00	6 054.24	1 197.89
2022	55.61	219.66	319.21	55.61	525.52	41.71	25 772.86	3 865.93	1 110.91

YEAR	1.B.2.b NATURAL GAS					
	1.B.2.b.5 Distribution			1.B.2.b.6 Other		
	Distribution	Emissions		Storage	Emissions	
	mil m³	*t* CO_2	*t* CH_4	*mil m³*	*t* CO_2	*t* CH_4
1990	6 666.00	133.32	4 132.92	1.00	0.04	0.29
1995	6 485.00	129.70	4 020.70	159.40	6.38	46.23
2000	7 136.00	142.72	4 424.32	524.30	20.97	152.05
2005	7 399.00	147.98	4 587.38	50.00	2.00	14.50
2010	6 098.00	121.96	3 780.76	3 435.21	137.41	996.21
2015	4 639.00	92.78	2 876.18	4 017.26	160.69	1 165.01
2016	4 716.00	94.32	2 923.92	3 969.67	158.79	1 151.20
2017	4 901.25	98.02	3 038.77	4 246.87	169.87	1 231.59
2018	4 777.99	95.56	2 962.35	3 724.15	148.97	1 080.00
2019	4 841.46	96.83	3 001.70	3 129.80	125.19	907.64
2020	5 003.88	100.08	3 102.40	2 783.82	111.35	807.31
2021	5 471.00	109.42	3 392.02	4 368.00	174.72	1 266.72
2022	4 463.69	89.27	2 767.49	3 997.00	159.88	1 159.13

Total fugitive GHG emissions from flaring and venting activities (1.B.2.c) were 0.21 Gg of CO_2 eq. (0.21 Gg of CO_2 and 3.73 kg of N_2O) in 2022 (***Table 3.61***). Major emission decrease is caused by change in the Tier 1 methodology and emissions factors. According to the 2019 RF in most categories are now in the emissions factors also included emissions from venting and flaring of oil and natural gas. Separately are reported only directly measured emission (Tier 3) and emissions with no new emission factors.

Table 3.61: Trend in fugitive emissions from venting and flaring activities in particular years

YEAR	1.B.2.c.1 VENTING		1.B.2.c.2 Flaring	1.B.2.c.2 Flaring
	1.B.2.c.1.ii Gas		1.B.2.c.2.i Oil	1.B.2.c.2.ii Gas
	CO_2 (t)	CH_4 (t)	N_2O (t)	N_2O (t)
1990	228.16	23 552.00	0.049	0.030
1995	228.16	20 624.96	0.048	0.023
2000	212.66	16 495.62	0.040	0.012
2005	229.09	14 831.10	0.021	0.010
2010	202.44	10 508.53	0.009	0.006
2015	172.98	1 868.81	0.006	0.006
2016	187.86	1 984.26	0.006	0.006
2017	199.02	1 731.17	0.004	0.006
2018	185.07	1 442.56	0.003	0.006
2019	214.09	1 648.17	0.003	0.005
2020	176.64	2 003.84	0.001	0.004
2021	125.12	1 373.36	0.003	0.004
2022	79.90	790.46	0.001	0.004

The 2019 RF also introduced sources of fugitive emissions. These sources are poste-meter emissions from using CNG vehicles, appliances in households and services and fugitive emissions from industrial plants, where natural gas is combusted. The share of these emissions on the total fugitive emissions from oil and natural gas was 47% (195.24 CO_2 eq.). Overview of these emissions is summarized in the following table.

Table 3.62: Trend in fugitive emissions from other activities in particular years

YEAR	1.B.2.d Other (Poste-meter emissions)								
	CNG cars	*CO_2*	*CH_4*	*Appliance*	*CO_2*	*CH_4*	*Industrial plants*	*CO_2*	*CH_4*
	No.	*tons*		*No.*	*tons*		*mil. m^3*	*tons*	
1990	NO	NO	NO	NE	NE	NE	3 319.38	10.95	1 327.75
1995	NO	NO	NO	NE	NE	NE	3 528.17	11.64	1 411.27
2000	40	0.0001	0.12	NE	NE	NE	3 692.88	12.19	1 477.15
2005	158	0.0004	0.47	NE	NE	NE	3 097.17	10.22	1 238.87
2010	289	0.0007	0.87	1 496 033	49.37	5 984.13	2 453.04	8.10	981.22
2015	1 398	0.0032	4.19	1 510 532	49.85	6 042.13	2 136.90	7.05	854.76
2016	1 541	0.0035	4.62	1 514 666	49.98	6 058.66	2 165.34	7.15	866.13
2017	1 750	0.0040	5.25	1 514 262	49.97	6 057.05	2 214.59	7.31	885.84
2018	1 980	0.0046	5.94	1 519 409	50.14	6 077.64	2 279.11	7.52	911.64
2019	2 063	0.0047	6.19	1 522 827	50.25	6 091.31	2 365.51	7.81	946.20
2020	2 095	0.0048	6.29	1 527 512	50.41	6 110.05	2 416.83	7.98	966.73
2021	2 146	0.0049	6.44	1 529 546	50.48	6 118.18	2 707.13	8.93	1 082.85
2022	2 218	0.0051	6.65	1 532 244	50.56	6 128.98	2 087.94	6.89	835.18

Methodological issues

The fugitive emissions from oil and natural gas in the Slovak Republic were calculated according to the 2019 Refinements to the IPCC 2006 GL using default tier 1 approach.

Emissions from NG transition and storage (fugitive and venting) were calculated using the OGMP 2.0 methodology (Oil and Gas Methane Partnership) on tier 4 approach, which is complementary with the IPCC tier 3 approach. Combination of direct measurements and modelling was used. The calculation were made by Eustream, a. s. and afterwards analysed and verified by the national expert. Throughout description of the methodology is available in Slovak language. This data provided the base for recalculation of the whole time-series of NG transmission. Trend analysis and calculation was used to back-recalculated emissions to the base year 1990. Since the year 2013, direct emissions measurements based on the data from the Eustream, a. s. company are reported. These data are in line with official reports of the company to the other national or international organisations.

Eustream, a. s. uses plant specific methodology for emissions estimation as fugitive emissions from compressors, accidents and planned repairs. Specific compressor stations and transmission system is described on the webpage of Eustream, a.s.[17] (according to the ERT recommendation E.6 based on the draft SVK ARR 2022 delivered on 28th February 2023). To monitor each of these possibilities infrared cameras are used.

Despite the expansion of the distribution system, the trend in fugitive CH4 emissions from distribution of natural gas in the Slovak Republic is decreasing. This decrease is caused by the decrease of natural gas transit. When comparing the methods used for fugitive methane emissions estimation, it is clear that disaggregation of the gas and oil industry in the major categories and subcategories, according to the principles of "good practice" is important. Emissions balance is prepared separately for each subcategory. Considering that the oil and natural gas industry is well developed in the Slovak Republic.

Source specific recalculations

Recalculations are described in the Chapter 3.5.4.

3.6. International Bunker Fuels (CRF 1.D.1)

International bunkers category includes emissions from the International Aviation (1.D.1.a) and International Navigation (1.D.1.b). These emissions are excluded from the national totals. This report uses the GWP 100 based on IPCC Assessment report 5 for the year 2022. The difference between emission based on GWP 100 IPCC Assessment report 4 (AR4) and 5 (AR5) are shown in previous SVK NIR 2023.

3.6.1. International Aviation (1.D.1.a)

Since 1990 to 2004, the Slovak Republic has been estimating the emissions from the international aviation based on the information provided by the airports about LTO cycles and fuel consumption. The expert approach was used for processing of activity data and disaggregation of fuels into national and international flights in the previous submissions. In this submission, the share was intended as constant value for the years 1990 – 2004 based on trend in years 2005 – 2021. Based on the national circumstances (size of country), the international aviation occurs more frequently than the national aviation. EUROCONTROL data was used in this submission for time series 2005 – 2022, data on the emissions, fuel consumption and division of domestic and international flights.

The GHG emissions estimation was performed based on the fuels sold at the Slovak airports (Bratislava, Košice, Poprad, Sliač, and Žilina) in the period 1990 – 2004. In 2022, the emissions in the international civil aviation represented 131.57 Gg of CO_2 eq. The decrease of emissions after 2008 is explained by the recession of economy and cancelling of many regular flights operated by the foreign companies at Bratislava airport. In recent years, the international aviation begins its rise back to pre-2008 emissions

[17] Eustream, a. s. transmission system: https://www.eustream.sk/en/transmission-system/grid-information-map-transmission-network/mapa-prepravneho-systemu/

as Bratislava and Košice are a base for low-cost companies (WizzAir, Ryanair, Flydubai, and Eurowings) as well as Austrian Airlines. The major decrease of emissions in 2020 is caused by the COVID pandemic and cancelation of many regular flights. Methodology for emissions estimation in this category is consistent with the methodology used in the domestic aviation and is described in the **Chapter 3.2.8** of this Report.

The Slovak Republic has used a tier 1 based on fuel sold, both for aviation gasoline and jet kerosene for 1990 – 2004. In the previous submissions, there were used expert judgment on the sharing of domestic and international flights. According to previous recommendations, the share between domestic and international aviation for the years 1990 – 2004 was estimated by using the trend for the years 2005 – 2021 from the available EUROCONTROL data. The changes are shown in **Chapter 3.2.8**. The emission factors of all gases were changed for jet kerosene and aviation gasoline and information is provided in the **Chapter 3.2.8** of this Report.

New EUROCONTROL data published in 2022 were used for emissions' estimation of aviation transport for time series 2005 – 2020. The decision follows an analysis of the national data and data obtained from EUROCONTROL and approved by the Ministry of Transport and Construction of the Slovak Republic. Aggregated national fuel and emissions balance was calculated using a tier 3 applying the Advanced Emissions Model (AEM) by EUROCONTROL.

Considering comparison between the EUROCONTROL results and national data on fuel consumption, emissions and implied emission factors, the following data were considered (taken from EUROCONTROL results) more accurate and reliable for 2024 inventory preparation:

- calorific values for fuels;
- fuel consumption of aviation gasoline for domestic flights;
- fuel consumption of aviation gasoline for international flights;
- jet kerosene for domestic flights;
- jet kerosene for international flights;
- CO_2, CH_4 and N_2O emissions for all subcategories.

The overview of the international aviation fuels consumption according to the type (aviation gasoline and jet kerosene) is presented in ***Table 3.63***. For the period 1994 – 2004, data were obtained directly from the airports´ statistics on annual basis. For the period 1990 – 1993, data were based on expert judgment according to the real LTO cycles in this period. To ensure consistency over time series, NCVs of fuels were used from EUROCONTROL data. Total consumption of jet kerosene was 1 793.50 TJ and total consumption of aviation gasoline was 1.72 TJ in international flights in 2022.

Table 3.63: *Fuels consumption and GHG emissions in international flights in particular years*

YEAR	AVIATION GASOLINE				JET KEROSENE			
	CONSUMPTION	EMISSIONS			CONSUMPTION	EMISSIONS		
	TJ	t CO_2	t CH_4	t N_2O	TJ	t CO_2	t CH_4	t N_2O
1990	7.82	552.964	0.004	0.016	914.43	66 523.27	0.632	1.808
1995	5.18	365.913	0.002	0.010	652.78	47 488.40	0.451	1.290
2000	5.96	421.562	0.003	0.012	644.94	46 918.05	0.446	1.275
2005	1.93	136.798	0.001	0.004	1 914.83	139 300.37	1.350	3.785
2010	2.09	147.709	0.001	0.004	1 814.71	132 016.84	1.269	3.588
2015	2.19	154.854	0.001	0.004	1 982.76	144 242.52	1.334	3.920
2016	3.64	253.476	0.002	0.007	2 113.08	153 722.75	1.493	4.177
2017	1.80	127.088	0.001	0.003	2 260.82	164 889.54	1.581	4.481
2018	1.87	131.574	0.001	0.004	2 527.74	184 357.20	1.777	5.009
2019	1.56	109.722	0.001	0.003	2 543.38	185 497.54	1.795	5.041
2020	1.16	80.152	0.001	0.002	750.40	54 590.51	0.574	1.483

YEAR	AVIATION GASOLINE				JET KEROSENE			
	CONSUMPTION	EMISSIONS			CONSUMPTION	EMISSIONS		
	TJ	*t CO_2*	*t CH_4*	*t N_2O*	*TJ*	*t CO_2*	*t CH_4*	*t N_2O*
2021	1.94	134.390	0.001	0.004	894.18	65 050.29	0.666	1.768
2022	1.72	119.177	0.001	0.003	1 793.50	130 474.11	1.269	3.546

Source specific recalculations

In the NIR 2024 there were no category specific recalculations made.

3.6.2. International Navigation (CRF 1.D.1.b)

GHG emissions inventory in international navigation transport includes CO_2, CH_4 and N_2O emissions from shipping activities in the Danube River. The consumption of diesel oil is determined indirectly by available statistical data on shipping activities of transit in the Slovak part of the Danube River during the year and the technical parameters of the Danube traction vessels. Total aggregated emissions from inland shipping included in international navigation reached 17.59 Gg of CO_2 eq. in 2022. The decrease is significant in comparison with the base year but the inter-annual fluctuations are visible also in recent years. The Slovak Republic used tier 1 approach based on the IPCC 2006 GL. The emissions of greenhouse gases are calculated from the consumed fuel by diesel motor boats multiplied by emission factor. The country specific NCVs were used to convert the quantity of fuel consumption in energy units. The NCVs for diesel fuel blended are shown in the **Chapter 3.2.8** of this Report. The emission factors were taken from the IPCC 2006 GL and GHG emissions were recalculated for time series. Emission factors used in category 1.A.3.d and 1.D.1.b are identical and shown in ***Table 3.64***.

Table 3.64: *The default emission factors in kg/TJ used in navigation for time series*

PARAMETER	EMISSIONS FACTORS	
	DOMESTIC NAVIGATION	INTERNATIONAL NAVIGATION
EMISSIONS	*kg/TJ*	
CO_2	74 082	74 082
CH_4	7	7
N_2O	2	2

The Slovak Shipping and Ports Company provided detailed information on diesel oil consumption on the Danube River. The consumption is allocated between national and international companies. It was assumed that total fuel sold to international companies is reported in the memo items category (1.D.1.b) and total fuel sold to national companies (Slovak Water Management Enterprise) is reported in the domestic navigation (1.A.3.d). This activity represents movements of ships between Slovak ports (Bratislava, Devín and Komárno cities). This approach was introduced in 2005 and the reallocation of fuels led to the reallocation between categories 1.A.3.d and 1.D.1.b. The GHG emissions from diesel oil sold to international transport in the important Slovak ports Bratislava and Komárno were balanced is shows in ***Table 3.65***.

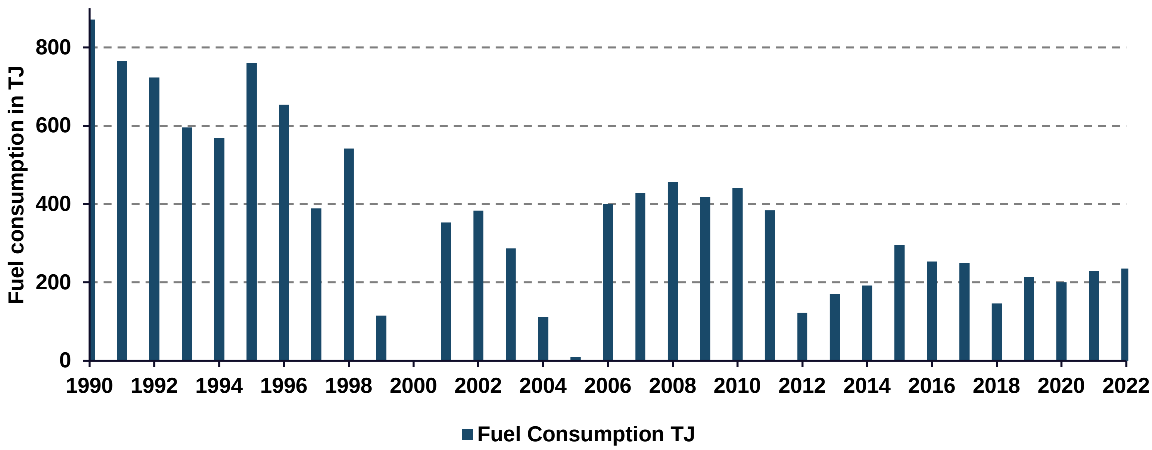
Table 3.65: *GHG emissions balance of diesel oil sold for shipping companies in particular years*

YEAR	CONSUMPTION		EMISSIONS			
	t/year	*TJ*	*t of CO_2*	*t of CH_4*	*t of N_2O*	*t of CO_2 eq.*
1990	20 500.00	871.48	64 576.6	6.10	1.74	65 209.25
1995	18 066.00	760.14	56 326.7	5.32	1.52	56 878.60
2000	NO	NO	NO	NO	NO	NO
2005	212.70	8.98	665.2	0.06	0.02	671.76
2010	10 450.21	441.19	32 692.0	3.09	0.88	33 012.26
2015	7 008.90	295.38	21 887.4	2.07	0.59	22 101.80
2016	6 006.47	253.08	18 753.9	1.77	0.51	18 937.59

YEAR	CONSUMPTION		EMISSIONS			
	t/year	*TJ*	*t of CO_2*	*t of CH_4*	*t of N_2O*	*t of CO_2 eq.*
2017	5 917.84	249.30	18 473.2	1.75	0.50	18 654.19
2018	3 482.93	146.67	10 868.4	1.03	0.29	10 974.93
2019	5 063.74	213.24	15 793.7	1.49	0.42	15 948.49
2020	4 761.25	200.38	14 838.70	1.40	0.40	14 984.18
2021	5 457.75	229.70	17 093.03	1.61	0.46	17 259.80
2022	5 562.75	235.17	17 421.88	1.65	0.47	17 592.61

The sources of activity data for the period 1994 – 2022 are the Slovak Shipping and Ports Company in Bratislava, the State Shipping Administration and other international shipping companies operated in Slovakia in accordance with the annually provided statistical information in water transport. The activity data for the period 1990 – 1993 are not statistically documented so the expert judgment was performed on the base of the shipping traffic on the Danube River. The emissions for the year 2000 were estimated to be negligible, because of increasing prices of diesel oil in the Slovak Republic and decreasing prices of fuels in the neighbouring countries (market discrepancies).

Figure 3.17: *Overview of diesel l oil consumption (TJ) for shipping transport in 1990 – 2022*



Source specific recalculations

In the NIR 2024, there were no category specific recalculations made.

CHAPTER 4. IPPU (CRF 2)

This Chapter was prepared using GWP_{100} taken from the 5th Assessment Report of the IPCC by the sectoral experts and institutions involved in the National Inventory System of the Slovak Republic:

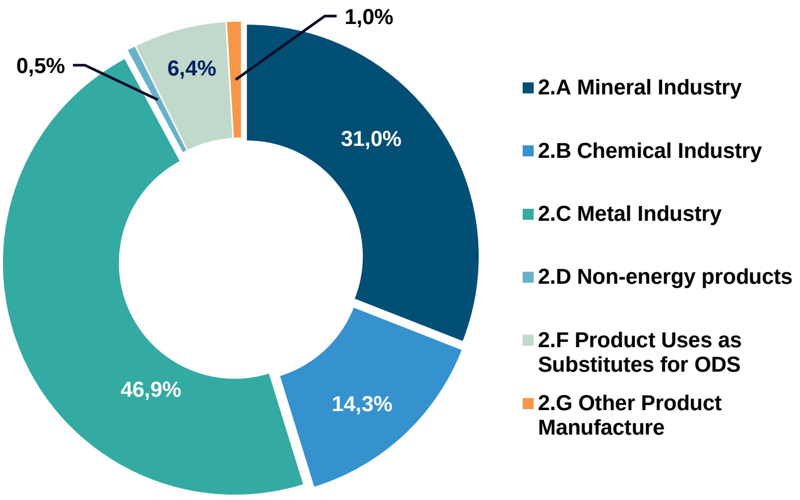
INSTITUTE	CHAPTER	SECTORAL EXPERT
Faculty of Chemical and Food Technology, Slovak Technical University	All chapters	Vladimir Danielik
Faculty of Chemical and Food Technology, Slovak Technical University	2.D – NMVOC inventory	Vladimir Danielik
Slovak Hydrometeorological Institute, Department of Emissions and Biofuels	2.D.3 – Urea Based Catalysts	Ján Horváth

4.1. Overview of the Sector

The Industrial processes and product use sector includes all GHG emissions generated from the technological processes producing raw materials and products. Within the preparation of the GHG emissions balance in the Slovak Republic, consistent methodology is put on the analysis of individual technological processes and disaggregation between the fuel combustion emissions (in heat and energy production) and emissions from the technological processes and industrial production. In this submission, 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories was fully implemented. Most important emission sources (installations) are balanced separately, and details are explained in **Annexes 4.1-4.2** to this Chapter. Emission and oxidation factors were determined, as well as other parameters entering the balancing equations and the results are compared with the verified emissions provided in the EU ETS reports.

In 2022, total aggregated GHG net emissions from the sector of industrial processes and product use were 7 536.24 Gg of CO_2 eq. and they decreased compared with the previous year by approximately 12%. The decrease is largely due to the decreased production of iron and steel. Compared to the base year 1990 the emissions are lower by 20%. CO_2 is the most important gas with the share of 91.7%, followed by F-gases (6.7%) and N_2O emissions (1.5%) shares. The most important emission sources are categories of metal production (46.9%), mineral products (31.0%), chemical industry (14.3%) and substituents for ODS (6.4%). Other product manufacture and non-energy products categories shares 1.0% and 0.5%, respectively (***Figure 4.1***). The most important source of N_2O emissions are categories Nitric Acid Production and N_2O from Product Use, which share almost the total amount of N_2O emissions with the ratio near to 1:1.

Figure 4.1: The share on emissions of individual categories in the IPPU sector in 2022



The IPPU sector covers emissions from the technological processes in mineral products industry (CRF 2.A), in chemical industry (CRF 2.B), in metal production (CRF 2.C), in non-energy products from fuels and solvent use (CRF 2.D), in electronics industry (CRF 2.E), in product uses as substitutes for ODS (CRF 2.F) and in other product manufacture (CRF 2.G). The emissions inventory of technological processes includes direct greenhouse gas emissions (CO_2, CH_4, N_2O, halocarbons and SF_6) and indirect greenhouse gas emissions (NO_x, CO, NMVOCs). List of GHG gases reported in individual categories in 2022 is presented in ***Table 4.1***.

Table 4.1: GHG gases reported in the IPPU sector according to the CRF categories in 2022

CATEGORY (CODE AND NAME)	METHODOLOGY/TIER	GHG GASES REPORTED
2.A.1 Cement Production	T2	CO_2
2.A.2 Lime Production	T2	CO_2
2.A.3 Glass Production	T3	CO_2
2.A.4.a Ceramics	T3	CO_2
2.A.4.b Other Uses od Soda Ash	NO	NO
2.A.4.c Non Metallurgical Magnesia Production	T3	CO_2
2.A.4.d Other - Limestone for Desulphurization	T3	CO_2
2.A.5 Other	NO	NO
2.B.1 Ammonia Production	T3	CO_2, CH_4, N_2O
2.B.2 Nitric Acid Production	T3	N_2O
2.B.3 Adipic Acid Production	NO	NO
2.B.4 Caprolactam, Glyoxal and Glyoxylic Acid Production	NO	NO
2.B.5 Carbide Production	T2	CO_2
2.B.6 Titanium Dioxide Production	NO	NO
2.B.7 Soda Ash Production	NO	NO
2.B.8.a Methanol	NO	NO
2.B.8.b Ethylene	T2	CO_2
2.B.8.c Ethylene Dichloride and Vinyl Chloride Monomer	T2	CO_2
2.B.8.d Ethylene Oxide	NO	NO
2.B.8.e Acrylonitrile	NO	NO
2.B.8.f Carbon Black	NO	NO
2.B.9 Fluorochemical Production	NO	NO
2.B.10 Other - Hydrogen Production	NO	NO
2.C.1 Iron and Steel Production	T2, T3, T1	CO_2, CH_4, N_2O

CATEGORY (CODE AND NAME)	METHODOLOGY/TIER	GHG GASES REPORTED
2.C.2 Ferroalloys Production	T3, T2	CO_2, CH_4
2.C.3 Aluminium Production	T3, T2, T1	CO_2, PFCs
2.C.4 Magnesium Production	NO	NO
2.C.5 Lead Production	T1	CO_2
2.C.6 Zinc Production – not occurring since 2015	T1	CO_2
2.C.7 Other	NO	NO
2.D.1 Lubricant Use	T1	CO_2
2.D.2 Paraffin Wax Use	T1	CO_2
2.D.3 Solvent Use	T2	CO_2
2.D.4 Other	NO	NO
2.E.1 Integrated Circuit or Semiconductor	NO	NO
2.E.2 TFT Flat Panel Display	NO	NO
2.E.3 Photovoltaics	NO	NO
2.E.4 Heat Transfer Fluid	NO	NO
2.E.5 Other	NO	NO
2.F.1 Refrigeration and Air Conditioning	T2	HFCs: 23, 32, 125, 134a, 143a, 152a PFCs: 116
2.F.2 Foam Blowing Agents	T2	HFCs: 134a, 245fa, 365mfc, 227ea
2.F.3 Fire Protection	T1a	HFCs: 134a, 227ea, 236fa
2.F.4 Aerosols	T1a	HFCs: 134a, 227ea
2.F.5 Solvents	NO	NO
2.F.6 Other Applications	NO	NO
2.G.1 Electrical Equipment	T3	SF_6
2.G.2 SF_6 and PFCs from Other Product Uses	NO	NO
2.G.3 N_2O from Product Uses	T1	N_2O
2.G.4 Other	NO	NO
2.H.1 Pulp and Paper Industry	NO	NO
2.H.2 Food and Beverages Industry	NO	NO
2.H.3 Other	NO	NO

4.2. Overall Trends in Industrial Processes

Overall trends from numbers provided by the Statistical Office of the Slovak Republic were updated. Energy intensity of industrial processes in the Slovak Republic decreased significantly in comparison with the base year 1990. Between 2005 and 2022, substantial energy savings were made, while the sharp GDP growth was recorded in Slovakia. A decrease in the final energy consumption by 12% was accompanied by an increase in the energy productivity. However, the energy productivity of the **IPPU sector** in Slovakia is still relatively lower in comparison with the EU average. This has been caused by the historical structure of industrial production.

The internal structure of the Slovak industry underwent further changes after accession to the EU. The importance of mining and distribution of electricity, gas and water on production of value added has been significantly reduced and nowadays it is comparable with other developed countries. The gross value-added of total industry in GDP of the Slovak Republic increased from 12 Bio Euro in 2005 to 18 Bio Euro in 2022.

The most important indicator is decrease in fuels, electricity and heat consumption in industry in 2021 in comparison with 2005. On the other hand, the increase of renewable energy sources in industry is dominant in recent years. The overview of emission trends in gases and categories is provided in ***Tables 4.2*** and ***4.3*** and ***Figures 4.2*** and ***4.3***.

Table 4.2: *GHG emissions according to the individual gases in the IPPU sector in particular years*

YEAR	CO_2 Emissions	CH_4 Emissions	N_2O Emissions	HFC, PFC and SF_6
	Gg of CO_2 eq.			
1990	8 111.12	14.13	1 088.43	213.98
1995	7 825.13	12.78	1 077.71	113.00
2000	7 124.79	14.29	923.06	129.47
2005	8 072.99	17.32	1 173.30	321.46
2010	7 519.11	18.20	842.99	617.72
2011	7 561.32	16.85	426.16	622.50
2012	7 542.59	17.85	337.68	652.59
2013	7 365.56	18.48	225.32	661.00
2014	7 623.64	19.42	201.36	659.02
2015	7 749.89	18.41	186.31	736.12
2016	8 029.65	19.10	171.11	669.12
2017	8 263.20	19.80	156.96	734.24
2018	8 322.93	19.43	157.47	701.44
2019	7 482.55	15.42	140.31	712.10
2020	6 978.23	13.99	126.73	677.60
2021	8 366.44	19.61	115.93	704.04
2022	6 908.01	15.02	111.05	502.15

Table 4.3: *GHG emissions according to the categories in the IPPU sector in particular years*

YEAR	2.A	2.B	2.C	2.D	2.E	2.F	2.G
	Gg of CO_2 eq.						
1990	2 714.02	1 833.81	4 814.71	50.49	NO	NO	14.64
1995	2 070.94	2 137.46	4 720.38	50.49	NO	12.38	36.96
2000	2 230.10	2 045.76	3 735.14	50.49	NO	99.48	30.66
2005	2 532.96	2 219.40	4 434.35	30.17	NO	277.49	90.70
2010	1 941.18	1 761.92	4 619.47	16.94	NO	569.22	89.29
2011	2 359.34	1 586.68	3 994.19	23.90	NO	576.43	86.28
2012	2 116.99	1 265.40	4 432.75	33.55	NO	602.07	99.94
2013	2 030.23	1 216.56	4 229.79	41.10	NO	620.99	131.68
2014	2 181.08	995.33	4 578.94	36.17	NO	626.14	85.77
2015	2 151.36	1 144.04	4 579.71	35.46	NO	704.84	75.32
2016	2 183.45	1 073.85	4 878.50	37.49	NO	647.95	67.74
2017	2 277.13	1 144.35	4 933.31	39.96	NO	710.19	69.26
2018	2 279.54	1 353.00	4 781.31	40.32	NO	675.62	71.48
2019	2 284.96	1 175.92	4 098.19	34.96	NO	688.69	67.68
2020	2 218.73	1 198.98	3 626.61	29.85	NO	646.65	75.74
2021	2 335.45	1 269.22	4 820.21	33.81	NO	672.41	74.92
2022	2 332.71	1 076.42	3 533.08	40.77	NO	480.89	72.38

Figure 4.2: Trend of emissions in the IPPU sector according to individual gases in 1990 – 2022

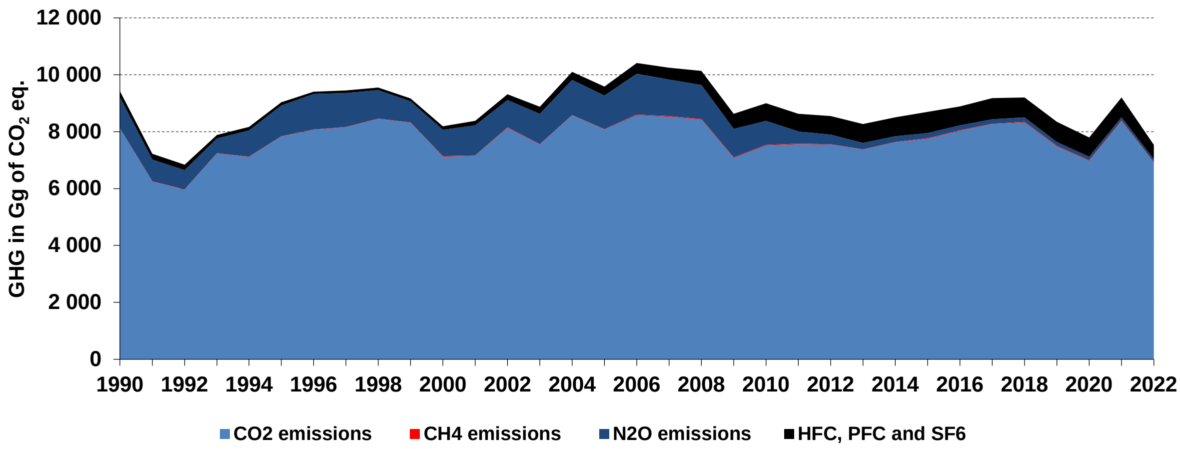
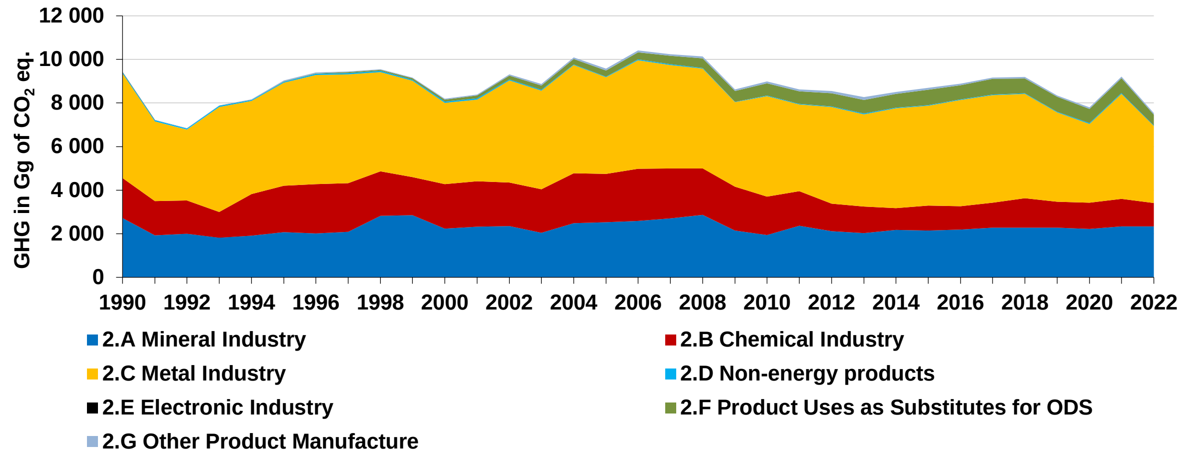


Figure 4.3: Trend of emissions in the IPPU sector according to the categories in 1990 – 2022



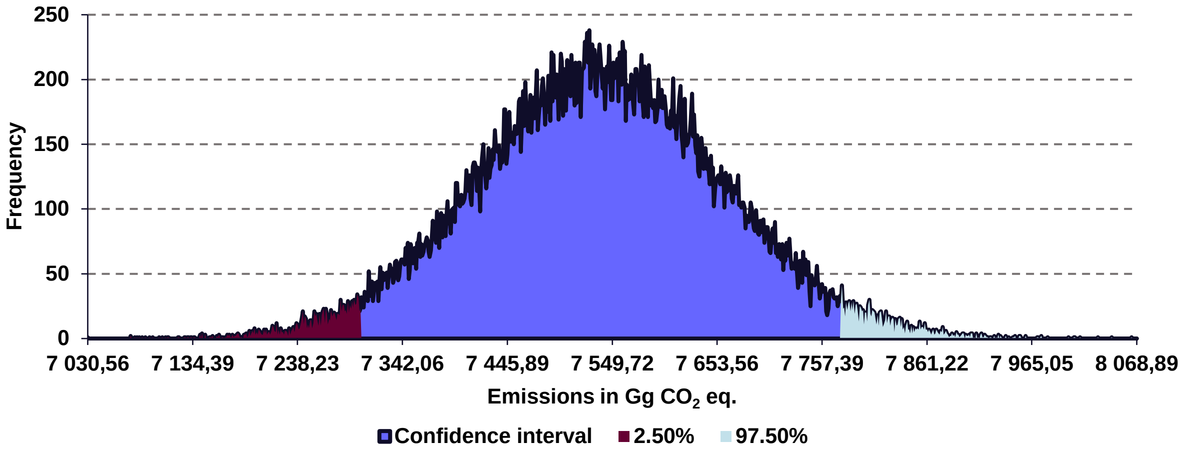
4.3. Uncertainty Analyses

According to the previous recommendations, Slovakia is using hybrid combination of Approaches 1 and 2 in this submission for calculation of total uncertainty of the inventory (**Annex 3** of this Report). Uncertainty analyses performed by the Approach 1 in the IPPU sector were carried out using Table 3.2 for uncertainty calculation and country specific uncertainties for activity data and emission factors were inserted into calculation table.

The Slovak Republic provided and published also Approach 2 for uncertainty analyses according to the Chapter 3 of the IPCC 2006 GL for the complete Energy and IPPU sectors for the year 2015. The methodology and results were described in previous SVK NIR 2017 and 2018. Due to the implementation of 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, uncertainty analyses of the IPPU sector were made in this submission using the Monte Carlo simulation.

Aggregated uncertainty is computed from partial uncertainties. Every category is computed from disaggregated data. The data are split by emission factors or by technological processes. Computed uncertainties are aggregated consecutively to the total uncertainty. The results of every category are generated from 60 000 trials, with random number generator of random numbers for adequate PDF. From theory and knowledge, it is known, that the direct computation of aggregated uncertainty is difficult in many cases. For this reason, a statistical approach has been chosen and the Monte Carlo method is used. It induces the construction of PDF for all input parameters. In some cases, the absence of direct measurement was solved by expert contributions. Mean value and confidence interval have the background usually in measured data or in empirical relations. On the other hand, uncertainty shapes of input parameters are based on following data: (i) uncertainty of data from the EU ETS reports are taken from the criteria presented in the EU ETS reports (uncertainty of scales, of laboratory analysis, *etc.*); (ii) uncertainty of data that are not covered by the EU ETS reports was assumed as default values from the IPCC 2006 GL; (iii) uncertainties of HFCs in 2.F category and SF_6 in 2.G category were estimated by the sectoral expert for IPPU based on input data provided by the Ministry of the Environment of the Slovak Republic.[1] The results for the IPPU sector and its subsectors following the mentioned assumptions can be seen can be seen in the text below.

Figure 4.4: *Probability density function for IPPU sector (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
7 535.86	7 536.53	120.91	7 030.56	8 068.89	-3.13%	3.18%

Several uncertainties for EFs are country specific and were used in the overall tier 2 uncertainty preparation. The average mean value of GHG emissions for the Industrial Processes and Product Use sector obtained by the Monte Carlo simulation is 7 536.53 Gg of CO_2 eq. in 2022, which is in excellent agreement with the emission estimates reported in the sector (7 536.24 Gg CO_2 eq.). The overall uncertainty was estimated to be 3.15%. Confidence interval (95%) is represented by the relative values to the mean: (-3.13%; +3.18%).

4.4. Sector-specific QA/QC and Verification Processes

The sector-specific QA/QC plan is based on the general QA/QC rules and activities in specific categories. Information used in the process of preparation GHG emissions inventory of the IPPU sector was obtained from the different data sources:

- Statistical Office of the Slovak Republic, Department of Cross-Cutting Statistics (energy balance),
- National Emission Information System (database of all stationary emission sources),
- Emission Trading System (reports from operators and from verifiers),

[1] Based on the Annex III of the Implementing Regulation 749/2014/EU on structure, format and review information pursuant to Regulation (EU) 525/2013, Article 7 (1) (m) (ii)

- Slovak Association for Cooling and Air-conditioning Technology (SZCHKT),
- Questionnaires that were sent to the producers (in case of any doubt).

More information on general QA/QC activities within the National Inventory System of the Slovak Republic is included in the **Chapter 1** of this Report.

Input data from producers (providers) are collected by the SNE in cooperation with the sectoral experts and the Slovak University of Technology in Bratislava (Faculty of Chemical and Food Technology). Complete input data related to the production and the quality of products from the previous year is available at the beginning of October (year X+1). The sectoral experts in the cooperation with the Slovak University of Technology in Bratislava (Faculty of Chemical and Food Technology) check and compare obtained information from different data sources during the sectoral inventory preparation in October and November (year X+1). Following QC activities are provided during data collection step:

- comparison with the information provided by the Statistical Office of the Slovak Republic,
- comparison with the information provided by the different associations of producers (if existent),
- comparison with the available information in EU ETS reports (if existent).

Further QC activities during the sectoral inventory preparation:

- outliers checking with developed automated tool,
- comparison of IEFs with the IPCC default EFs and IEFs of neighbouring countries (where available).

Any discrepancies are directly discussed with subject or data providers. Draft of the sectoral GHG emissions inventory is prepared in the middle of November (year X+1). Quality assurance activities are performed on the draft of the sectoral inventory and the sectoral report. The draft is cross-checked with the independent expert not participating on inventory preparation step from the Slovak University of Technology (independent review) and other experts involved in the NIS SR. The independent review is then finished at the end of November and forwarded to the uncertainty analyses. During the application of Monte Carlo model for the uncertainty analyses, the methodology, EFs and other parameters are verified again (mathematically). The final sectoral inventory is prepared at the end of December and it is approved by the NIS coordinator during the January (year X+2). All original data and protocols are archived at the SHMÚ and in the computers and back-up server of national experts involved in the inventory process.

Cement Production - Activity data provided by the Slovak Association of Cement Producers and from the EU ETS reports were verified with the statistical information. Based on the information provided in the EU ETS reports it follows that CO_2 emission was 1489.40 Gg. All sources reported in this category are included in the EU ETS. The emissions reported in the national inventory were nearly the same (higher by 0.03%). The difference is caused by rounding.

Lime Production - Activity data provided by the Slovak Association of Lime Producers and from the EU ETS reports were verified with the statistical information. Sugar plants are not included in official statistics. If any discrepancies occur, the small occasional producers are identified and included in the inventory. Other possible activity data source is the NEIS database. Data there were recorded according to the category of products. In 2022, there were 3 plants included in "others" (2 sugar plants, 1 other plant – production of secondary aluminium). When comparing CO_2 emissions reported in the EU ETS reports and inventory emissions of EU ETS plants, the difference is about 0.8% (higher emissions are in GHG inventory). The difference is caused by rounding of CaO and MgO contents in lime.

Glass Production - All sources reported in this category are included in the EU ETS and final emissions are the same as in the GHG inventory.

Ceramics - The EU ETS covers all operators reported in this category. CO_2 emissions reported in the EU ETS reports and in the GHG inventory are the same.

Magnesia Production - All sources reported in this category are included in the EU ETS. CO_2 emissions reported in the EU ETS reports were 229.43 Gg in 2022 and are nearly the same as in the GHG inventory (+0.0006 Gg).

Other Carbonates - All sources reported in this category are included in the EU ETS, however, part of them is not calculated but measured. CO_2 emissions calculated in the EU ETS reports were 33.91 Gg in 2022. In the GHG inventory, CO_2 emissions were calculated to be 50.33 Gg, which is in accordance with the EU ETS reports when also measured emissions are considered.

Ammonia Production - All sources reported in this category are included in the EU ETS. As ammonia production is one of the largest CO_2 emissions sources and key category (in the **IPPU sector**), a significant attention was paid to validation of activity data and procedures used for the estimation of CO_2 emission in this sector. Basic information on ammonia production and natural gas consumption are provided directly from producer.

Due the subtracting of CO_2 used for urea production, additional QA/QC exercise was performed. Amount of 112.59 Gg of CO_2 was used for the urea production. The CO_2 emissions from the urea consumption were 66.69 Gg in Slovakia (DeNOx technologies and using as fertilizers). The difference between these two values (45.90 Gg) is caused by the exporting of urea, because the rest of urea was exported. Based on the data provided by producer approximately 55.91 kt of urea was used for the production of AdBlue (catalyst for vehicles); from which 42.11 kt was exported. This export represents the value of CO_2 as follows: 30.74 kt. Based on the data from the Statistical Office of the Slovak Republic, the urea was exported also under the commodity codes: (i) 31021010, “Urea containing more than 45% by weight of nitrogen on the dry anhydrous product”; (ii) 31028000, "Mixtures of urea and ammonium nitrate in aqueous or ammoniacal solution". Because urea contains 46% of nitrogen, it is clear, that the commodity code 31021010 represents pure urea and export-import difference can be easily calculated from the export and import data. Calculated in this way, the difference between import and export of urea was 62.14 kt of nitrogen in favour of *import*, which represents *98.61 Gg of “imported” CO_2*. Balance of the urea exported/imported under the commodity code 31028000 is much more difficult to estimate. The content of urea in products reported under commodity code 3102800 can varying. According to the announcement of the Ministry of Finance 555/2002 Z. z., the fertilizers with the different content of urea can be used. The nitrogen originating from the urea can be in the range (11-51) %. Because of import data are reported as kilograms of nitrogen, the amount of urea imported to Slovakia was calculated using this range. It follows, that the amount of urea import into Slovakia under the commodity code 31028000 was in the range (1-04-4.84) kt (4.37 kt of nitrogen). According to the data provided by the Slovak fertilizer producer, the fertilizer DAM-390 represents more than 98% export of this commodity. It is the mixture of ammonium nitrate and urea containing 29-30% of N, from which 15.5% of N origins from urea and the rest is from AN. To ensure conservative principle, it can be assumed that 50% of nitrogen origins from urea. Thus, the exported urea under this commodity code represents value 158.34 kt. It results from the balance that the difference between import and export of urea under commodity code 31028000 was (153.50 – 157.29) kt in favour of export, which represents (112.05 – 114.82) Gg of “exported” CO_2. Balancing of CO_2 from the export/import of urea gives the range (44.18 – 46.95) Gg of “totally exported” CO_2 from Slovakia. Comparing with the value of “missing” CO_2 from the balance of production and use (45.90 Gg) it can be concluded that subtracting of CO_2 used for urea production was made in a correct way. The production/use/import/export balance of urea for the time series 2010 – 2022 is presented in the **Annex 4.3**. Data before 2010 are not available.

Nitric Acid Production - Activity data are from the EU ETS reports and information provided by the operators in questionnaires (requested by the SNE) were compared with the measurement’s protocols on N_2O concentration in output gases. All sources reported in this category are included in the EU ETS.

Carbide Production - The EU ETS report contains only CO_2 emissions from CaC_2 production no data about using of calcium carbide. Therefore, no comparison with EU ETS can be made, information provided in the separate questionnaires are used.

Ethylene Production - Activity data from the EU ETS reports and information provided by the operators in questionnaires (requested by the SNE) were compared. All sources reported in this category are included in the EU ETS.

Ethylene Dichloride and Vinyl Chloride Monomer - Activity data are from the EU ETS reports and information provided by the operators in questionnaires (requested by the SNE) are compared. All sources reported in this category are included in the EU ETS.

Iron and Steel Production - Specific QA/QC procedure was made for the integrated iron and steel company that represents the biggest source of CO_2 emissions in the **IPPU sector**. The comparison of two independent emission estimations was evaluated. The EU ETS reports contain information on CO_2 emissions. These results were compared with the results obtained by the carbon balance prepared and presented in the **Chapter 4.9.1** and in the **Annex 4.1** of this Report. The difference between CO_2 emissions calculated from these two sources is 0.08% in 2022.

Ferroalloys Production - Activity data are compared with the information from the ŠÚ SR (ferroalloy production). Another source used for verification is the U.S. Geological Survey. Data for the period 1990 – 2011 were available and were compared with the results of the national GHG emissions inventory. The consistency of time series was verified.

Aluminium Production - Activity data and emissions were verified with the theoretical thermodynamic calculation provided at the Slovak University of Technology, Faculty of Chemical and Food Technology together with comparison with the EU ETS report. All sources of aluminium production in Slovakia are covered with the EU ETS.

Lead Production - This production is not covered by the EU ETS, therefore data was provided directly by the operators.

Non-Energy Products from Fuels and Solvents Use - This category is not covered by the EU ETS, the data were obtained from the special questionnaires of the ŠÚ SR. Due to the lack of appropriate statistical information and methodological advises in the IPCC 2006 GL, inputs were taken directly from the estimations of the NMVOC emissions reported under the CLRTAP submission (see **Chapter ES.5**). Total NMVOC emissions from solvent use, road paving with asphalt, asphalt roofing and asphalt blowing were estimated in the frame of the National Program for Emissions Reduction of Non-Methane Volatile Organic Compounds in the Slovak Republic.

QA/QC activities and verification process for F-gases is provided in the **Chapter 4.12.6** of this Report.

4.5. Sector-specific Recalculations

Several recalculations were made in IPPU sector in this submission due to the implementation of 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Recalculations and reallocations made in IPPU sector were provided and implemented in the line with the Improvement and Prioritization Plan reflecting recommendations made during previous reviews and expert improvement.

NUMBER/ RECOMME-NDATION	CATEGORY	DESCRIPTION	REFERENCE
1	2.B.2	Recalculation of the time series 1990-1999 with the EF for atmospheric plant	**Chapter 4.8.2**
2	2.B.10	Reallocation of the hydrogen production into Energy sector	**Chapter 4.8.9**
3	2.C.1	Newly calculated CH_4 and N_2O emissions	**Chapter 4.9.1**

4	2.C.3	Recalculation of PFC emissions from high-voltage anode effect and incorporating of PFC emissions from low-voltage anode effect	**Chapter 4.9.3**
5	2.F.1	Reallocation of HFC-152a from 2.F.1.c to 2.F.1.f (heat pump) and correction of PFC c-C_4F_8 to C_2F_6 (PFC-116)	**Chapter 4.12.9**

Ad 1: Recalculation focused on the N_2O emissions from nitric acid production have been done for the time series 1990-1999. Implementation of 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories resulted in the recalculation of N_2O emissions from atmospheric nitric acid plant. From comparison of 2006 IPCC Guidance and 2019 IPCC Refinement it followed that EF increased by 11.1% (from 4.5 kg/t to 5 kg/t). Because the technological line of the atmospheric plant was old, we used for it the emissions factor 13.0 kg N_2O/1 t of HNO_3 according to the recommendation of the ERT review in past years. Therefore, we adopted the increase of this emission factor by 11.1%. The increase was adopted for historical data 1990-1999 when the nitric acid was produced also in the atmospheric plant. In 2000, the atmospheric plant was closed, so no other recalculation was necessary since 2000. The impact of the recalculation is presented in the ***Table 4.4.***

Table 4.4: *The comparison of N_2O emissions estimates from nitric acid production for the time series 1990 – 1999*

YEAR	SUBMISSION 2023		SUBMISSION 2024		Changes in 2.B.2
	Nitric acid production	Total N_2O emissions	Nitric acid production	Total N_2O emissions	
	kt	*t*	*kt*	*t*	*%*
1990	400.54	3 830.65	400.54	4 047.73	5.67%
1991	301.83	2 682.28	301.83	2 792.21	4.10%
1992	278.44	2 404.47	278.44	2 487.51	3.45%
1993	233.62	1 878.50	233.62	1 911.70	1.77%
1994	360.82	3 290.65	360.82	3 444.17	4.67%
1995	398.80	3 760.47	398.80	3 962.54	5.37%
1996	446.78	4 371.61	446.78	4 639.68	6.13%
1997	421.33	4 134.88	421.33	4 390.92	6.19%
1998	377.35	3 536.24	377.35	3 721.68	5.24%
1999	306.51	2 654.86	306.51	2 716.48	2.32%

Ad 2: Recalculation focused on the CO_2, CH_4 and N_2O emissions from hydrogen production have been done for the whole time series. Implementation of 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories resulted in the reallocation of the hydrogen production into the Energy sector: *"Refineries manufacture petroleum products for fuel and for non-energy uses, and in doing so produce hydrogen and other gases, intermediate products and basic chemicals. The CO_2 emissions from fuel consumed by the refinery for this activity are reported as Energy Sector emissions. This principle is maintained in the Guidelines even when some fuel use in the refinery is to support manufacture of chemicals for sale (for example, propylene or aromatics). In the 2019 Refinement, this principle is re-iterated within the new guidance presented for hydrogen production, which is a new IPPU source category; the emissions from hydrogen production within a refinery as an intermediate product are primarily to support Energy sector activities, with emissions to be reported in the Energy sector."* (Vol. 3 – Introduction, Chapter 1.3.3, page 1.12). Therefore, the reallocation was made, the impact is shown in the ***Table 4.5.***

Table 4.5: *The comparison of emissions estimates from hydrogen production for the whole time series*

YEAR	SUBMISSION 2023		SUBMISSION 2024		Changes in 2.B.10
	CO_2 emissions	Total emissions	CO_2 emissions	Total emissions	
	Gg CO_2 eq.				*%*
1990	116.99	117.10	NO	NO	-100%
1991	137.37	137.50	NO	NO	-100%
1992	163.46	163.62	NO	NO	-100%
1993	185.19	185.37	NO	NO	-100%
1994	110.56	110.67	NO	NO	-100%
1995	175.33	175.50	NO	NO	-100%
1996	151.28	151.43	NO	NO	-100%
1997	164.27	164.43	NO	NO	-100%
1998	197.99	198.18	NO	NO	-100%
1999	200.91	201.11	NO	NO	-100%
2000	234.28	234.51	NO	NO	-100%
2001	200.55	200.75	NO	NO	-100%
2002	314.45	314.76	NO	NO	-100%
2003	346.86	347.20	NO	NO	-100%
2004	379.52	379.90	NO	NO	-100%
2005	363.37	363.73	NO	NO	-100%
2006	352.26	352.61	NO	NO	-100%
2007	397.01	397.40	NO	NO	-100%
2008	393.99	394.38	NO	NO	-100%
2009	353.71	354.06	NO	NO	-100%
2010	314.45	314.76	NO	NO	-100%
2011	337.31	337.64	NO	NO	-100%
2012	357.06	357.41	NO	NO	-100%
2013	369.29	369.65	NO	NO	-100%
2014	353.04	353.39	NO	NO	-100%
2015	365.29	365.65	NO	NO	-100%
2016	383.16	383.53	NO	NO	-100%
2017	378.24	378.61	NO	NO	-100%
2018	332.95	333.28	NO	NO	-100%
2019	312.50	312.80	NO	NO	-100%
2020	306.64	306.94	NO	NO	-100%
2021	315.63	315.94	NO	NO	-100%

Ad 3: Recalculation focused on the CH_4 and N_2O emissions from iron and steel production have been done for the whole time series. Implementation of 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories resulted in the calculation of CH_4 and N_2O emissions estimates. Details about the calculation can be found in the **Chapter 4.9.1**. Due to the fact that the recent CRF Reporter does not allow to report N_2O emissions in 2.C.1 category, N_2O emissions are reported in artificially created 2.C.7 category. In this report, however, they are referenced as a part of 2.C.1 category. The impact of the recalculation is presented in the ***Table 4.6.***

Table 4.6: *The comparison of net emissions estimates from iron and steel production for the whole time series*

YEAR	SUBMISSION 2023		SUBMISSION 2024		Changes in 2.C.1
	CO_2 emissions	Total emissions	CO_2 emissions	Total emissions	
	Gg CO_2 eq.				%
1990	4 167.97	4 167.97	4 167.97	4 182.73	0.35%
1991	3 033.79	3 033.79	3 033.79	3 046.90	0.43%
1992	2 657.66	2 657.66	2 657.66	2 669.89	0.46%
1993	4 355.36	4 355.36	4 355.36	4 368.63	0.30%
1994	3 834.15	3 834.15	3 834.15	3 847.95	0.36%
1995	4 322.63	4 322.63	4 322.63	4 335.91	0.31%
1996	4 552.01	4 552.01	4 552.01	4 564.11	0.27%
1997	4 565.28	4 565.28	4 565.28	4 578.00	0.28%
1998	4 093.29	4 093.29	4 093.29	4 106.13	0.31%
1999	3 985.68	3 985.68	3 985.68	3 999.85	0.36%
2000	3 344.72	3 344.72	3 344.72	3 359.30	0.44%
2001	3 375.50	3 375.50	3 375.50	3 391.04	0.46%
2002	4 147.04	4 147.04	4 147.04	4 164.04	0.41%
2003	3 974.88	3 974.88	3 974.88	3 993.04	0.46%
2004	4 291.21	4 291.21	4 291.21	4 309.53	0.43%
2005	3 907.36	3 907.36	3 907.36	3 924.83	0.45%
2006	4 405.47	4 405.47	4 405.47	4 425.41	0.45%
2007	4 161.42	4 161.42	4 161.42	4 181.15	0.47%
2008	4 013.73	4 013.73	4 013.73	4 031.17	0.43%
2009	3 496.89	3 496.89	3 496.89	3 511.91	0.43%
2010	4 089.57	4 089.57	4 089.57	4 107.71	0.44%
2011	3 488.82	3 488.82	3 488.82	3 505.23	0.47%
2012	3 860.47	3 860.47	3 860.47	3 878.02	0.45%
2013	3 763.30	3 763.30	3 763.30	3 781.27	0.48%
2014	4 051.40	4 051.40	4 051.40	4 070.30	0.47%
2015	4 028.13	4 028.13	4 028.13	4 045.76	0.44%
2016	4 334.99	4 334.99	4 334.99	4 353.72	0.43%
2017	4 328.02	4 328.02	4 328.02	4 346.99	0.44%
2018	4 187.82	4 187.82	4 187.82	4 206.59	0.45%
2019	3 554.28	3 554.28	3 554.28	3 569.05	0.42%
2020	3 145.82	3 145.82	3 145.82	3 159.09	0.42%
2021	4 274.88	4 274.88	4 274.88	4 294.18	0.45%

Ad 4: Recalculation focused on the PFC emissions from aluminium production have been done for the whole time series. Implementation of 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories resulted in the recalculation of CF_4 and C_2F_6 emissions estimates due to the change of default parameters of the anode effect. Moreover, newly introduced so-called low-voltage anode effect and resulting CF_4 emissions were incorporated into the inventory, as well. Details about the calculation can be found in the **Chapter 4.9.3**. The impact of the recalculation is presented in the ***Table 4.7.***

Table 4.7: The comparison of net emissions estimates from aluminium production for the whole time series

YEAR	SUBMISSION 2023			SUBMISSION 2024			2023/2024	
	CO_2 emissions	PFC emissions	Total emissions	CO_2 emissions	PFC emissions	Total emissions	Changes in PFC	Changes in total
	Gg CO_2 eq.						%	
1990	121.32	283.05	404.37	121.32	213.92	335.24	-24.4%	-17.1%
1991	119.34	278.43	397.77	119.34	210.43	329.77	-24.4%	-17.1%
1992	111.06	259.11	370.17	111.06	195.83	306.89	-24.4%	-17.1%
1993	69.48	162.10	231.58	69.48	122.51	191.99	-24.4%	-17.1%
1994	59.04	137.74	196.78	59.04	104.11	163.15	-24.4%	-17.1%
1995	58.68	119.24	177.92	58.68	90.15	148.83	-24.4%	-16.4%
1996	179.11	36.62	215.73	179.11	36.89	215.99	0.7%	0.1%
1997	177.16	35.50	212.66	177.16	35.87	213.03	1.0%	0.2%
1998	173.64	24.15	197.79	173.64	26.32	199.96	9.0%	1.1%
1999	175.57	12.06	187.63	175.57	16.46	192.03	36.5%	2.3%
2000	176.56	12.13	188.69	176.56	16.56	193.11	36.5%	2.3%
2001	176.96	12.16	189.12	176.96	16.59	193.55	36.5%	2.3%
2002	176.56	12.13	188.69	176.56	16.56	193.11	36.5%	2.3%
2003	179.46	22.19	201.65	179.46	24.96	204.42	12.5%	1.4%
2004	252.25	20.55	272.80	252.25	26.31	278.56	28.0%	2.1%
2005	254.22	21.33	275.55	254.22	27.09	281.31	27.0%	2.1%
2006	240.35	38.09	278.44	240.35	40.86	281.21	7.3%	1.0%
2007	237.43	26.46	263.89	237.43	31.39	268.83	18.7%	1.9%
2008	243.64	38.45	282.09	243.64	41.43	285.08	7.8%	1.1%
2009	225.12	18.89	244.01	225.12	24.50	249.62	29.7%	2.3%
2010	263.47	22.49	285.96	263.47	28.27	291.75	25.7%	2.0%
2011	261.28	18.08	279.36	261.28	24.63	285.90	36.2%	2.3%
2012	259.52	23.08	282.59	259.52	28.62	288.14	24.0%	2.0%
2013	265.24	8.82	274.06	265.24	17.02	282.26	92.9%	3.0%
2014	266.00	10.02	276.02	266.00	18.27	284.27	82.3%	3.0%
2015	276.33	7.65	283.98	276.33	16.53	292.86	116.1%	3.1%
2016	271.41	5.84	277.25	271.41	15.17	286.59	160.0%	3.4%
2017	274.01	7.75	281.76	274.01	16.75	290.76	116.0%	3.2%
2018	275.53	7.00	282.53	275.53	16.14	291.66	130.6%	3.2%
2019	274.71	4.67	279.38	274.71	14.28	288.99	205.9%	3.4%
2020	238.71	5.04	243.75	238.71	13.22	251.93	162.1%	3.4%
2021	258.68	5.34	264.02	258.68	14.19	272.87	165.6%	3.4%

Ad 5: Recalculation is described in the **Chapters 4.12.7** and **4.12.9**. The impact of the recalculation is negligible.

The impact of the recalculations Ad.1 – Ad.5 on the total emissions in the IPPU sector is presented in the ***Table 4.8.***

Table 4.8: *The impact of the above-mentioned recalculations on the IPPU sector for the whole time series*

YEAR	SUBMISSION 2023		SUBMISSION 2024		2023/2024	
	CO_2 emissions	Total emissions	CO_2 emissions	Total emissions	CO_2 emissions	Total emissions
	Gg CO_2 eq.				%	
1990	8 228.11	9 541.61	8 111.12	9 427.67	-1.42%	-1.19%
1991	6 383.77	7 388.32	6 246.40	7 225.07	-2.15%	-2.21%
1992	6 125.39	7 037.04	5 961.93	6 844.38	-2.67%	-2.74%
1993	7 414.62	8 089.71	7 229.43	7 886.83	-2.50%	-2.51%
1994	7 217.68	8 260.88	7 107.12	8 171.05	-1.53%	-1.09%
1995	8 000.46	9 166.38	7 825.13	9 028.62	-2.19%	-1.50%
1996	8 211.33	9 473.47	8 060.05	9 405.44	-1.84%	-0.72%
1997	8 323.21	9 529.07	8 158.94	9 445.58	-1.97%	-0.88%
1998	8 643.42	9 689.67	8 445.43	9 555.64	-2.29%	-1.38%
1999	8 515.16	9 338.17	8 314.25	9 171.96	-2.36%	-1.78%
2000	7 359.07	8 407.12	7 124.79	8 191.62	-3.18%	-2.56%
2001	7 351.98	8 562.69	7 151.43	8 381.92	-2.73%	-2.11%
2002	8 449.17	9 609.29	8 134.72	9 315.95	-3.72%	-3.05%
2003	7 892.85	9 198.75	7 545.99	8 872.47	-4.39%	-3.55%
2004	8 946.34	10 454.99	8 566.82	10 099.17	-4.24%	-3.40%
2005	8 436.36	9 925.57	8 072.99	9 585.07	-4.31%	-3.43%
2006	8 937.65	10 742.63	8 585.39	10 412.72	-3.94%	-3.07%
2007	8 924.58	10 618.57	8 527.57	10 245.83	-4.45%	-3.51%
2008	8 822.00	10 503.70	8 428.01	10 129.73	-4.47%	-3.56%
2009	7 433.02	8 964.47	7 079.31	8 631.05	-4.76%	-3.72%
2010	7 833.56	9 288.85	7 519.11	8 998.01	-4.01%	-3.13%
2011	7 898.63	8 941.52	7 561.32	8 626.83	-4.27%	-3.52%
2012	7 899.65	8 885.02	7 542.59	8 550.70	-4.52%	-3.76%
2013	7 734.85	8 613.85	7 365.56	8 270.36	-4.77%	-3.99%
2014	7 976.68	8 829.68	7 623.64	8 503.44	-4.43%	-3.69%
2015	8 115.18	9 029.86	7 749.89	8 690.73	-4.50%	-3.76%
2016	8 412.80	9 244.45	8 029.65	8 888.98	-4.55%	-3.85%
2017	8 641.44	9 524.85	8 263.20	9 174.20	-4.38%	-3.68%
2018	8 655.88	9 506.64	8 322.93	9 201.27	-3.85%	-3.21%
2019	7 795.05	8 638.80	7 482.55	8 350.38	-4.01%	-3.34%
2020	7 284.87	8 082.04	6 978.23	7 796.55	-4.21%	-3.53%
2021	8 682.07	9 493.81	8 366.44	9 206.03	-3.64%	-3.03%

4.6. Sector-specific Improvements and Implementation of Recommendations

2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories was fully implemented during the inventory preparation. No other improvements have been done; all issues raised by UNFCCC review were implemented in the previous 2023 submission.

The study of CO_2 captured during the use of lime for sugar production is ongoing and it is planned to incorporate it in the future submissions.

4.7. Mineral Products (CRF 2.A)

4.7.1. Source-category Description

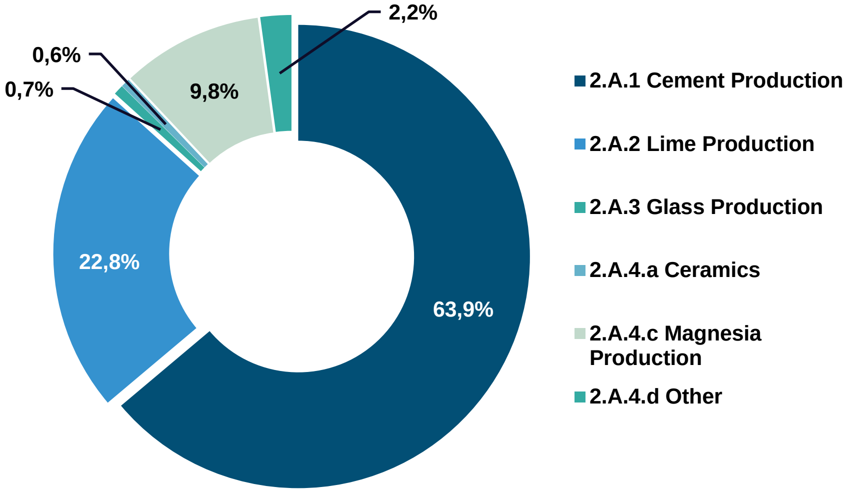
The major share of CO_2 emissions comes from the production and transformation of mineral products. Total emissions were 2 332.71 Gg of CO_2 in 2022 (only CO_2 emissions are reported in this category), almost the same as in previous year 2021. Compared to 1990, the decrease in mineral production is approximately 14%. Major trend behind the decrease in mineral production is decrease in demand of products.

The major share of emissions in this category belongs to cement production (63.9%), lime production (22.8%) and dead burned magnesia production (9.8%). The ceramics production shared 0.6% and glass production 0.7%. The rest of emissions (2.2%) are reported in other category. Emissions in 2.A.4.b are not occurring.

Table 4.9: *CO_2 emissions in the category 2.A by subcategories in particular years*

YEAR	2.A.1 Cement Production	2.A.2 Lime Production	2.A.3 Glass Production	2.A.4.a Ceramics	2.A.4.c Magnesia Production	2.A.4.d Other
	Gg					
1990	1 464.50	794.92	7.88	14.79	431.94	NO
1995	1 154.63	593.23	18.01	11.04	294.03	NO
2000	1 190.45	556.73	22.82	10.36	409.82	39.92
2005	1 256.40	711.96	33.04	13.06	476.01	42.49
2010	859.92	651.88	13.15	12.75	376.35	27.13
2011	1 261.79	672.41	11.83	11.65	363.83	37.83
2012	1 095.93	632.00	11.46	12.93	318.04	46.65
2013	1 135.27	560.14	13.22	14.94	279.56	27.10
2014	1 266.76	570.80	12.26	12.99	278.33	39.94
2015	1 308.57	534.30	11.93	14.24	247.76	34.56
2016	1 340.95	521.62	14.83	17.65	220.19	68.21
2017	1 367.05	507.78	15.20	20.82	291.28	75.00
2018	1 346.68	522.65	16.02	21.29	304.39	68.51
2019	1 404.27	489.24	18.16	21.52	295.15	56.62
2020	1 443.15	430.65	18.39	16.45	263.63	46.47
2021	1 452.93	539.96	19.70	16.07	257.70	49.10
2022	1 489.72	532.42	16.33	14.47	229.43	50.33

Figure 4.5: *The share of CO_2 emissions on individual categories in the 2.A in 2022*



4.7.2. Cement Production (CRF 2.A.1)

Cement production plants in the Slovak Republic (four plants), where cement clinker is produced, are included into the EU ETS. Therefore, input data are directly taken from the EU ETS reports and from the reports of verifiers. Presented parameters are weighted averages. Total CO_2 emissions from cement clinker production were 1 489.72 Gg in 2022 and higher by 3% than in previous year. In comparison with the base year 1990, the CO_2 emissions in this category increased by 2%. The reason of the rising trend is the increasing need for construction purposes.

Table 4.10: *Activity data and CO_2 emissions in the category 2.A.1 in particular years*

YEAR	Cement Clink Production	CaO Content	MgO Content	Correction Factor	CO_2 Emissions	IEF (CO_2)
	kt				*Gg*	*t/t*
1990	2 835.75	64.60%*	NE	1.0184	1 464.50	0.5164
1995	2 235.75	64.60%*	NE	1.0184	1 154.63	0.5164
2000	2 313.71	64.36%*	NE	1.0184	1 190.45	0.5145
2005	2 352.68	64.31%	1.79%	1.0184	1 256.40	0.5340
2010	1 653.59	66.07%	2.60%	0.9506	859.92	0.5200
2011	2 433.86	67.13%	1.50%	0.9541	1 261.79	0.5184
2012	2 126.12	65.25%	1.86%	0.9680	1 095.93	0.5155
2013	2 161.32	65.53%	2.52%	0.9693	1 135.27	0.5253
2014	2 415.34	66.00%	2.23%	0.9668	1 266.76	0.5245
2015	2 506.12	65.70%	2.58%	0.9600	1 308.57	0.5221
2016	2 599.39	64.84%	2.36%	0.9647	1 340.95	0.5159
2017	2 698.82	64.83%	2.50%	0.9447	1 367.05	0.5065
2018	2 695.74	64.84%	2.39%	0.9336	1 346.68	0.4996
2019	2 854.64	65.11%	2.33%	0.9168	1 404.27	0.4919
2020	2 944.94	65.31%	2.28%	0.9116	1 443.15	0.4900
2021	2 937.74	65.45%	2.52%	0.9137	1 452.93	0.4946
2022	3 041.27	65.33%	2.56%	0.9058	1 489.72	0.4898

** Aggregated CaO content = CaO Content + 1.092/0.785×MgO content*

Methodological issues

Cement is produced by a high temperature reaction of calcium oxide (CaO) with silica (SiO_2) and with alumina (Al_2O_3). A source of calcium oxide is limestone ($CaCO_3$). As the cement clink is produced at the temperature of 1 450°C the reaction produces carbon dioxide. The other emissions originate from impurities in the raw material (SO_2). Based on the information provided by the EU ETS verifiers, tier 2 method according to the IPCC 2006 GL has been applied since 2002 based on plant specific information. The calculations provided by the producers in the EU ETS reports balanced CO_2 emissions based on cement clinker production and CaO and MgO contents. The data required for calculation of CO_2 emissions are summarized in ***Table 4.11*** (C = confidential, but available for the sectoral experts).

Table 4.11: *Input data used for the CO_2 emissions estimation in the category 2.A.1 in 2022*

PLANT/OPERATOR	CEMENT CLINK	CaO CONTENT	MgO CONTENT	CKD	COMPOSITION FACTOR	CO_2
	kt	*%*	*%*			*Gg*
Cemmac	C	65.70%	1.74%	1.0082	0.9597	190.05
VSH (CRH)	C	64.59%	4.11%	1.0199	0.6582	271.63
CRH – Portland	C	65.68%	2.44%	1.0261	0.9488	582.59
CRH – white	C	68.08%	2.25%	1.0048	1.0000	78.65
Považská cementáreň	C	64.81%	1.60%	1.0000	1.0000	366.80
TOTAL	3 041.27	65.33%	2.56%	1.0155	0.8920	1 489.72

Based on availability of information, the plant specific emission factors were used since 2002. The annual estimation of overall EFs is expressed as weighted average and is based on the specific contents of CaO and MgO in cement clinker in each producer and varies over the years. The implied CO_2 emission factor was 0.4898 t CO_2/t of cement clink in 2022 (correction factor is also included in this value). Correction factor consists of CKD (Cement Kiln Dust) and so-called composition factor that represents the amounts of non-carbonate origin of CaO and MgO (using of ground granulated blast-furnace slag). All these data are plant specific.

$$Corr. factor = CKD * Composition\ Factor$$

$$Composition\ Factor = \frac{(0.785 * \%CaO_c + 1.092 * \%MgO_c) * m_c - (0.785 * \%CaO_s + 1.092 * \%MgO_s) * m_s}{(0.785 * \%CaO_c + 1.092 * \%MgO_c) * m_c}$$

where: $\%CaO_c$ is the fraction of CaO in cement clinker produced; $\%MgO_c$ is the fraction of MgO in cement clinker produced; m_c is the mass of cement clinker produced; $\%CaO_s$ is the fraction of CaO in slag entering; $\%MgO_s$ is the fraction of MgO in slag entering; m_s is the mass of slag entering. However, the factor is directly known from the EU ETS reports of the plants.

Uncertainties and time-series consistency

According to the ERT recommendation I.1 of ARR 2022, in the period 1990 – 1999 the average aggregated CaO content in the cement clinker was assumed to be very close to the default IPCC value from the IPCC 1996 GL (64.6%). The using of this aggregated CaO content is based on the average value of the CaO content in 2000 – 2003 (64.36% in 2000; 63.90% in 2001; 64.50% in 2022 and 65.70% in 2003). The weighted average value is 64.62%, which is very close to that IPCC value. Therefore, the value (64.6%) was also assumed as country specific. In 2003, one plant with the lowest CaO content was closed for reconstruction. It was reopened in 2004 and the cement clinker with higher content of CaO is produced there since that time. This is the reason of higher aggregated CaO content and IEF since 2002 and therefore the years since 2004 were not considered for calculation of the average value. Another plant was renovated and did not produce cement clink in 2010. It resulted in decrease of emissions in 2010 and thereafter-significant increase in 2011 after its reopening.

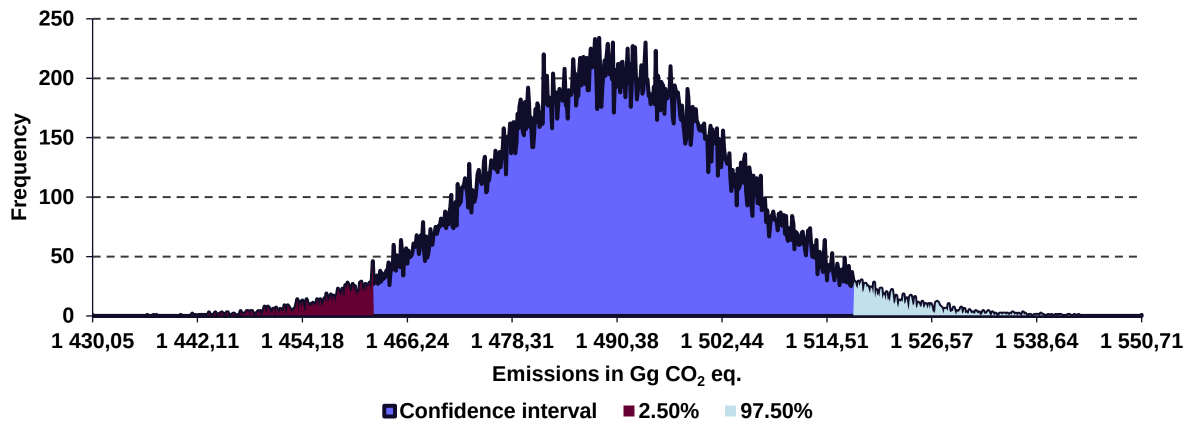
In the period 1990 – 2004, the contents of MgO are not explicitly known. It was included in the CaO content based on stoichiometry; therefore we call it as aggregated CaO content.

Ground granulated blast-furnace slag has been also used as raw material since 2009, which results in additional increase of CaO and MgO contents (non-carbonate origin) in the cement clinker. Therefore, we use the correction factor instead of CKD factor in the calculation. Correction factor is CKD multiplied by the so called "Composition Factor". CKD and Composition factors are plant specific, and they are known since 2008. Because of conservative approach, the highest value of the CKD (1.0184; the value close to the default CKD) was used for time series before 2008. For this time series, Composition factor was assumed to be 1, no correction for slag was made.

There were totally five cement sites in 1990 – 1996 in Slovakia. In 1997, one of them finished production of cement clinker. In 2003 and 2010, one of the other four cement sites did not produce cement clinker. During the period 1990 – 2022, no changes in technologies were made in plants; only the changes in composition of the clinker and use of raw materials (slag) occurred.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. Country specific value of cement clink mass uncertainty (1.5%) and country specific value of uncertainty of cement clink composition (2%) were used in uncertainty analyses by Monte Carlo method for this category. The uncertainty of CKD factor was assumed to be 5% with the lower limiting value of CKD (1). Similarly, the uncertainty of the composition factor was assumed to be 5% with the upper limiting value of the factor (1). The overall uncertainty of CO_2 emissions was calculated to be 1.86%.

Figure 4.6: *Probability density function for 2.A.1 (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
1 489.67	1 489.77	14.09	1 430.05	1 550.71	-1.84%	1.86%

4.7.3. Lime Production (CRF 2.A.2)

From a chemical point of view, lime is calcium oxide (CaO). It is produced by a thermal decomposition of limestone at the temperatures of 1 040 – 1 300°C. Carbon dioxide is produced according to the same reaction scheme as shown above in the case of cement production. Only CO_2 emissions are reported in this category. Total CO_2 emissions from lime production decreased by 1% when compared with the previous year and were 532.42 Gg in 2022. The decrease in emissions by 33% is achieved when compared with the base year.

Table 4.12: *Activity data and CO_2 emissions in the category 2.A.2 in particular years*

YEAR	Lime Production	CO_2 Emissions	CaO Content
	kt	*Gg*	
1990	1 076.00	794.92	91.20%
1995	803.00	593.23	91.20%
2000	753.59	556.73	91.20%

YEAR	Lime Production	CO_2 Emissions	CaO Content	MgO Content	"HYPOTHETIC" CaO Content
	kt	*Gg*			
2001	815.96	602.80	90.56%	0.47%	91.20%
2005	913.08	711.96	89.55%	4.72%	96.12%
2010	822.36	651.88	86.95%	7.72%	97.70%
2011	856.05	672.41	85.94%	7.82%	96.82%
2012	797.33	632.00	78.32%	13.96%	97.74%
2013	716.54	560.14	87.39%	6.40%	96.30%
2014	727.63	570.80	86.81%	7.26%	-
2015	680.20	534.30	87.34%	6.93%	-
2016	663.02	521.62	86.17%	7.49%	-
2017	640.06	507.78	87.47%	7.46%	-
2018	668.99	522.65	86.87%	6.95%	-
2019	634.58	489.24	87.28%	6.21%	-
2020	554.22	430.65	87.78%	6.49%	-
2021	696.12	539.96	74.33%	15.66%	-
2022	688.95	532.42	87.66%	6.56%	-

"Hypothetic" CaO content = CaO Content + 1.092/0.785×MgO content

Methodological issues

Table 4.12 shows "hypothetic" CaO content and includes stoichiometric data on the CaO and MgO contents. This approach was used due to no availability of distinguished data for the period 1900 – 2000. In that period, the same content of CaO in the lime is assumed (91.2%). This value is based on the data available for 2001 and 2002 and on all the data available in the period 1990 – 2000. The average content of CaO in lime was (91.2% ± 0.2%) in the period 1990 – 2002. "Hypothetic CaO content" is not presented in ***Table 4.12*** since 2014 because it is not necessary to report for recent years. Tier 2 according to the IPCC 2006 GL was used for the whole time series with the combination of plant specific activity data and emission factors estimated for each plant. Calculation is based on data provided by the producers of lime in questionnaires and in the EU ETS reports (produced lime and CaO and MgO contents). Data required and used for CO_2 emissions estimation are summarized in ***Table 4.13***.

Based on availability of information, the plant specific emission factors have been used since 2001. The annual estimation of national EFs varies over the years. Calculation of EFs is based on weighted average based on purity of lime in individual production unit. The implied CO_2 emission factor is 0.773 t CO_2/t of lime in 2022 (correction factor is included in the IEF). Correction factor presented in ***Table 4.13*** represents LKD (Lime Kiln Dust) as introduced in the IPCC 2006 GL. Data necessary for determination of correction factor were provided by the plant operators. When LKD was not provided by operator, default value (1.02) was used. Total quantity of produced lime in Slovakia was 688.95 kt in 2022. Activity data used for inventory are summarized in ***Table 4.13*** Large and medium producers provided activity data in their EU ETS reports or reports from verifiers, small plants like sugar producers provided activity data based on questionnaires to the SNE.

Table 4.13: Activity data necessary for the estimation of CO_2 emissions in the category 2.A.2 in 2022

Plant	Lime Production	CaO Content	MgO Content	LKD	CO_2 Emissions
	kt				*Gg*
Calmit	C	92.51%	0.87%	1.0053	94.17
Dolvap Varín	C	88.24%	10.26%	1.0000	100.42
Carmeuse	C	85.30%	7.78%	1.0266	301.82
Others*	C	92.50%	2.00%	1.0200	36.00
TOTAL	688.95	87.66%	6.56%	1.0171	532.42

*C = confidential, *aggregated data from small plants not covered by the EU ETS as sugar producers*

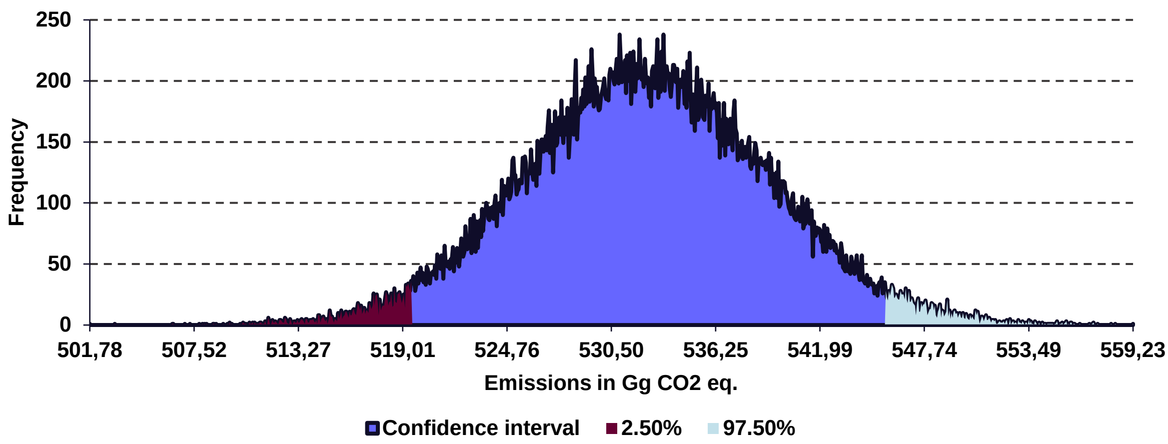
Uncertainties and time-series consistency

Time series consistency is assured by using the "hypothetic" CaO content during the period 1990 – 2000 as explained in detail above. This content is compared with the data presented in 2001 and 2002. Dolomitic lime production started in one plant in 2003 and the CaO content is not comparable since this year. Because of the dolomitic lime production, the overall IEF has increased since that time, as well. Lime produced by sugar producers is included in inventory as "others". The country specific LKD factor estimated in 2013 was used for the rest of the time series before 2013 because no other data on LKD were available. In 2014 and 2015, the country specific LKD factor was very close to the factor reported in 2015; therefore, no recalculation of the historical data was necessary.

In Slovakia, lime is produced by three lime producers that are included in the EU ETS system and four other producers (sugar plants, pulp and paper and the other plant – production of secondary aluminium) that are not included in the EU ETS. It can be assumed that CO_2, which is evolved during the lime production in sugar plants, is back captured there. However, because of no detailed data about back capturing of CO_2 in the lime and due to the ensuring of conservatism, no capturing of CO_2 is reported in the inventory. The CO_2 emissions from lime production by the pulp and paper industry are not estimated because of the use of the Kraft chemical recovery process, which results in biogenic CO_2 emissions originating from biomass input.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. Country specific value of lime mass uncertainty (1.5%) and default value of uncertainty in CaO and MgO contents in lime (2%) were used in uncertainty analyses by Monte Carlo method for this category. The uncertainty of LKD factor was assumed to be 5% with the lower limiting value of the LKD (1). For the sugar plants, and the plant produced the secondary aluminium, the uncertainties of CaO and MgO contents and LKD factor were assumed to be 10%. Based on calculation, the overall uncertainty of CO_2 emissions was calculated to be 2.45%.

Figure 4.7: Probability density function for 2.A.2 (t of CO_2 eq.)



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
532.34	532.40	6.66	501.78	559.23	-2.42%	2.47%

4.7.4. Glass Production (CRF 2.A.3)

Basic raw material for glass production is silica (SiO_2). Limestone ($CaCO_3$), dolomite ($CaMg(CO_3)_2$), soda ash (Na_2CO_3), potash (K_2CO_3), Pb_3O_4, Al_2O_3, and colouring agents are used in glass production process. NMVOC and CO are the most important emissions, but they are not reported in this category (notation key "IE" was used). These emissions are allocated in 1.A.2.f. Only CO_2 emissions were estimated in this category and were 16.34 kt in 2022.

Methodological issues

CO_2 emissions from used carbonates were calculated by tier 3 method on the stoichiometry principle according to the IPCC 2006 GL. The calcination fraction was assumed one. Based on availability of information, the plant specific emission factors were used since 2004. The annual estimation of national EFs varies over the years. According to the ERT recommendation I.3 of the ARR 2022, calculation of EFs is based on weighted average based of used carbonates and CO_2 emissions in individual production unit. Implied emission factor was 0.421 t/t of used carbonates mixture or 0.029 t/t of glass produced in 2022. This value is much lower than the default factor (using tier 1) used in the IPCC 2006 GL. It is caused by using alternative additions to raw materials as calumite (blast furnace granulated slag), colemanite ($CaB_3O_4(OH)_3 \cdot H_2O$) or clay as well as by using different amounts of recycled glass. However, it should be mentioned that due to the using of higher tier (tier 3), the amount of recycled glass is not necessary to follow. The main reason of such low IEF is the production of glass fibers at which the above mentioned non-carbonate raw materials are used (IEF = 0.014 t / t of glass fiber). For the inventory, the production of glass fibers is included in white glass production with the share ca 40%. The other glass producers report the IEF (0.11 – 0.12) t / t of glass, which is in accordance with tier 1 IEF.

Glass production based on direct information from producers was as follows: 566.84 kt of white glass in 2022. No leaded glass or green glass was produced in 2022. $SrCO_3$ and Li_2CO_3 were not used for glass production. Total amounts of used carbonates were 38.76 kt in 2022 and time series (***Table 4.14***).

Table 4.14: *Total amounts of used carbonates and CO_2 emissions in particular years*

YEAR	$CaCO_3$	K_2CO_3	Na_2CO_3	$BaCO_3$	$MgCO_3$	$SrCO_3$	Li_2CO_3	Total	CO_2
	kt								*Gg*
1990	17.91	a)	a)	a)	a)	a)	a)	17.91	7.880
1995	40.93	a)	a)	a)	a)	a)	a)	40.93	18.007
2000	51.87	a)	a)	a)	a)	a)	a)	51.87	22.821
2005	55.45	2.75	16.00	0.89	1.76	0.01	0.01	76.87	33.038
2010	15.89	0.48	13.62	1.52	0.01	NO	NO	31.52	13.145
2011	15.17	0.31	11.49	0.01	0.54	NO	NO	27.52	11.825
2012	14.75	0.03	11.45	0.01	0.39	NO	NO	26.63	11.456
2013	15.31	0.72	14.24	0.56	0.43	NO	NO	31.26	13.224
2014	14.22	0.64	13.29	0.48	0.34	NO	NO	28.97	12.262
2015	14.83	0.46	11.92	0.46	0.44	NO	NO	28.11	11.931
2016	17.64	0.57	15.55	0.70	0.53	NO	NO	34.99	14.828
2017	17.74	0.66	16.03	0.74	0.69	NO	NO	35.86	15.195
2018	17.70	0.76	17.99	0.78	0.67	NO	NO	37.90	16.020
2019	19.94	0.71	20.91	0.86	0.55	NO	NO	42.98	18.160
2020	20.19	0.65	21.27	0.74	0.59	NO	NO	43.44	18.389
2021	22.14	0.76	21.98	0.90	0.75	NO	NO	46.53	19.697
2022	19.11	0.72	17.93	0.88	0.12	NO	NO	38.76	16.335

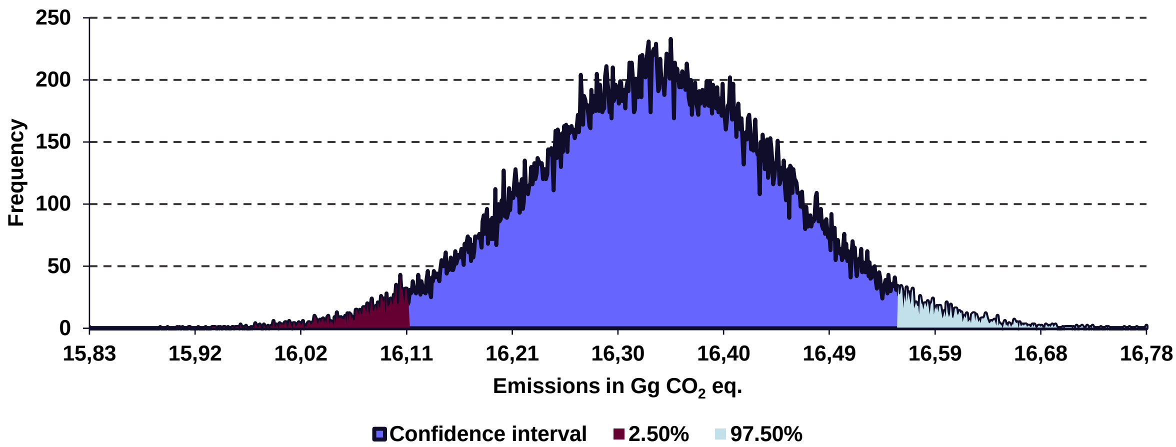
a) Carbonates are included in the form of calcium carbonate (based on stoichiometry).

Uncertainties and time-series consistency

There were several operators producing glass (from 3 to 7) in Slovakia during the time series 1990 – 2020. Detailed statistics of used carbonates is available only after the year 2003 and therefore methodology used in GHG inventory is based on total carbonates (in the form of calcium carbonate) calculated based on stoichiometry. This calculation was provided by reverse method, it means, that the specific averages CO_2 EFs per 1 t of each type of glass was known for every producer (except for one plant, where the same EFs was used as for the similar type of glass production). Therefore, the CO_2 emissions are known and only one ("aggregated") carbonate can be calculated from that data. The plant specific EFs are commercially confidential and they will be available during review process on request of the ERT. New production of lead glass started in 2000 and ended in 2002. Similarly, new production of lead glass started in 2003 and ended in 2006. Both productions were small. The increase in emissions since 2005 is caused by change of one big plant owner (resulting in increase of production and emissions). Other plants were closed in 2008 and 2012. Since 2008, colemanite and calumite slag are widely used in the biggest glass plant in order to replace carbonates, which resulted in significant emissions decrease. Since 2009, emissions from glass production have been almost stable.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. Country specific value of used carbonates uncertainty (2.5%) is used in uncertainty analyses by Monte Carlo method for this category. Based on calculation, the overall uncertainty of CO_2 emissions was calculated to be 1.33%.

Figure 4.8: *Probability density function for 2.A.3 (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
16.34	16.34	0.12	15.83	16.72	-1.35%	1.33%

4.7.5. Other Process Uses of Carbonates – Ceramics (CRF 2.A.4.a)

Ceramics includes the production of bricks and roof tiles, vitrified clay pipes, refractory products, expanded clay products, wall and floor tiles, table and ornamental ware (household ceramics), sanitary ware, technical ceramics, and inorganic bonded abrasives. Process-related CO_2 emissions reported from ceramics result from the calcination of carbonates in the clay, as well as from addition of additives. CO_2 emissions from ceramics production were 14.47 Gg CO_2 in 2022.

Methodological issues

CO_2 emissions from the used carbonates were calculated by tier 3 method according to the IPCC 2006 GL based on principle of the stoichiometry. The calcination fraction assumed to be one. Based on available information, plant specific emission factors were used since 1990. The annual estimation of country specific EF is expressed as weighted average and is based on the stoichiometry of carbonates and CO_2. Implied emission factor calculated in 2022 was 0.49 t/t of used carbonates mixture. This approach was used for all years.

Fraction of carbonates in raw materials is determined analytically in each plant. Based on the analysis, amounts of used $CaCO_3$ and $MgCO_3$ are obtained. Total amounts of used carbonates were 29.58 kt in 2022 and time series is presented in ***Table 4.15***.

Table 4.15: *Total used carbonates and CO_2 emissions the category 2.A.4.a in particular years*

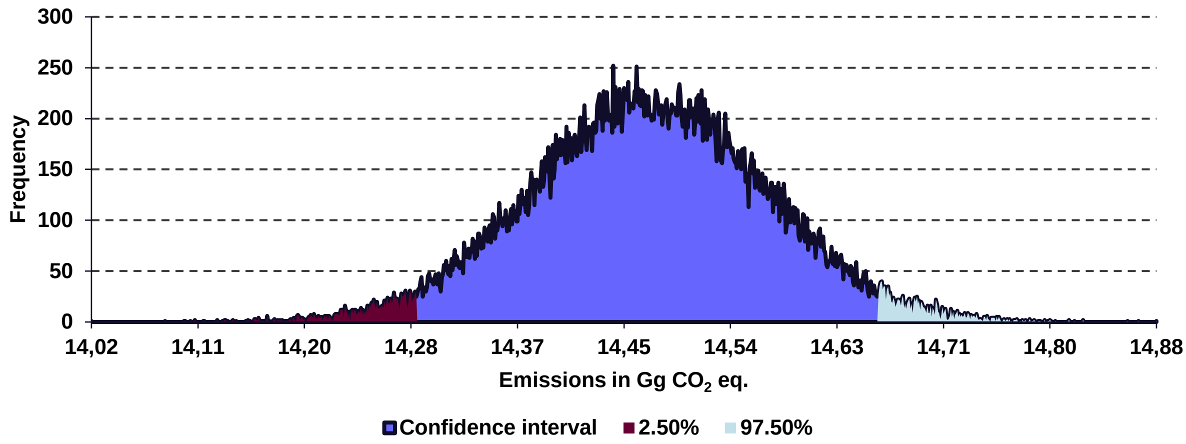
YEAR	$CaCO_3$	$MgCO_3$	Total Carbonates	CO_2 Emissions
	kt			*Gg*
1990	25.41	6.92	32.33	14.79
1995	17.19	6.66	23.85	11.04
2000	15.79	6.54	22.33	10.36
2005	21.80	6.64	28.44	13.06
2010	18.95	8.46	27.41	12.75
2011	16.61	8.32	24.93	11.65
2012	19.06	8.71	27.77	12.93
2013	22.76	9.43	32.19	14.94
2014	19.64	8.33	27.97	12.99
2015	21.83	8.88	30.71	14.24
2016	29.20	9.20	38.40	17.65
2017	34.82	10.53	45.35	20.82
2018	33.55	12.50	46.05	21.29
2019	35.65	11.18	46.83	21.52
2020	23.62	11.59	35.22	16.45
2021	17.30	16.20	33.50	16.07
2022	11.83	17.75	29.58	14.47

Uncertainties and time-series consistency

The same tier approach is used for period 1990 – 2022. The presented data are obtained directly from producers. The missing data for some ceramics producers was interpolated or extrapolated for the periods 1990 – 1991 and 1993 – 1995 on the level of individual producer with the consideration of economic aspects of construction industry in Slovakia (it served as limiting conditions of interpolation or extrapolation methods) as it was described in previous submissions (SVK NIR 2014). Several (14) plants were reported in this category during time series, recently only five of them report CO_2 emissions. The others were closed. New owner came into the market and bought three existing plants in 2007. The high increase in CO_2 emissions is caused by significant increase in production in those plants. However, in 2009, one plant was closed due to the economic reasons and decrease in production occurred in the other plants.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. Default value of used carbonates uncertainty (2.5%) was used in uncertainty analyses by Monte Carlo method for this category. Based on calculation, the overall uncertainty of CO_2 emissions was calculated to be 1.29%.

Figure 4.9: Probability density function for 2.A.4.a (t of CO_2 eq.)



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
14.47	14.47	0.10	14.02	14.88	-1.29%	1.29%

4.7.6. Other Process Uses of Carbonates – Other Uses of Soda Ash (CRF 2.A.4.b)

Soda ash is used in a variety of applications, including, glass production, soaps and detergents, flue gas desulphurization, chemicals, pulp and paper and other common consumer products. Using of soda ash (where is applicable in Slovakia) is reported in the category where it is consumed (see category 2.A.3 Glass Production). In Slovakia, soda ash is used in glass industry, only. No plants using soda ash for the other possible applications are present in Slovakia except of flue gas desulphurization. For flue gas desulphurization only calcium carbonate is used in Slovakia.

4.7.7. Other Process Uses of Carbonates – Non-Metallurgical Magnesia Production (CRF 2.A.4.c)

Magnesite clinker for refractory materials is produced in Slovakia. According to the IPCC 2006 GL production of dead burned magnesia for refractory materials is reported in this category. Carbon dioxide is produced by thermal decomposition of magnesite. This chemical reaction scheme of the thermal decomposition is $MgCO_3 = MgO + CO_2$. Total CO_2 emissions from magnesite production were 229.43 Gg in 2022 and decreased by ca 11% when compared with the year 2021. The decrease is due to the decrease in the production of magnesite clinker. When compared to 1990, the decrease is approximately 47%. It was caused by closing of one plant during the monitored time series and occasional closing of magnesite clinker production in others (in this case, the plant produced the refractory materials from stocked or bought magnesite clinker).

Methodological issues

Magnesite raw materials used in the Slovak Republic contain small amounts of $CaCO_3$ and $FeCO_3$. Emissions are calculated on the stoichiometric base (CO_2 and respective carbonate). The amounts of magnesite raw materials and emissions of CO_2 in the period of 1990 – 2022 are summarized in ***Table 4.16***. CH_4 and N_2O emissions are not occurring and therefore notation key "NO" was used for time series.

CO_2 emission factors used for emissions estimation in this category are as follows: 0.44 t/t $CaCO_3$, 0.522 t/t $MgCO_3$ and 0.38 t/t $FeCO_3$. Total consumption of magnesite raw materials in the Slovak Republic was 476.47 kt in 2022. The composition of raw materials is summarized in ***Table 4.16***. It should be noted that $CaCO_3$ and $FeCO_3$ contents are included in $MgCO_3$ content on the basis of stoichiometry for the years before 1999, due to lack of input data.

***Table 4.16:** Consumption and composition of magnesite raw materials and CO_2 emissions in the category 2.A.4.c in particular years*

YEAR	Raw Materials Used	$MgCO_3$ Content	$CaCO_3$ Content	$FeCO_3$ Content	CO_2 Emissions	EF
	kt				*Gg*	*t/t*
1990	887.74	0.9321	*	*	431.94	0.487
1995	604.32	0.9321	*	*	294.03	0.487
2000	850.57	0.8850	0.0324	0.0147	409.82	0.482
2005	988.58	0.8804	0.0382	0.0135	476.01	0.482
2010	820.32	0.8424	0.0400	0.0038	376.35	0.459
2011	724.27	0.9193	0.0444	0.0077	363.83	0.502
2012	634.97	0.9090	0.0436	0.0189	318.04	0.501
2013	603.38	0.8418	0.0489	0.0063	279.56	0.463
2014	590.33	0.8210	0.0452	0.0606	278.33	0.471
2015	550.04	0.8063	0.0299	0.0432	247.76	0.450
2016	462.81	0.8462	0.0383	0.0453	220.19	0.476
2017	622.44	0.8260	0.0475	0.0418	291.28	0.468
2018	657.28	0.8168	0.0477	0.0415	304.39	0.463
2019	634.89	0.8178	0.0498	0.0423	295.15	0.465
2020	560.73	0.8261	0.0533	0.0407	263.63	0.470
2021	549.84	0.8180	0.0560	0.0448	257.70	0.469
2022	476.47	0.8294	0.0666	0.0508	229.43	0.482

**carbonates reported in $MgCO_3$ on the basis of stoichiometry*

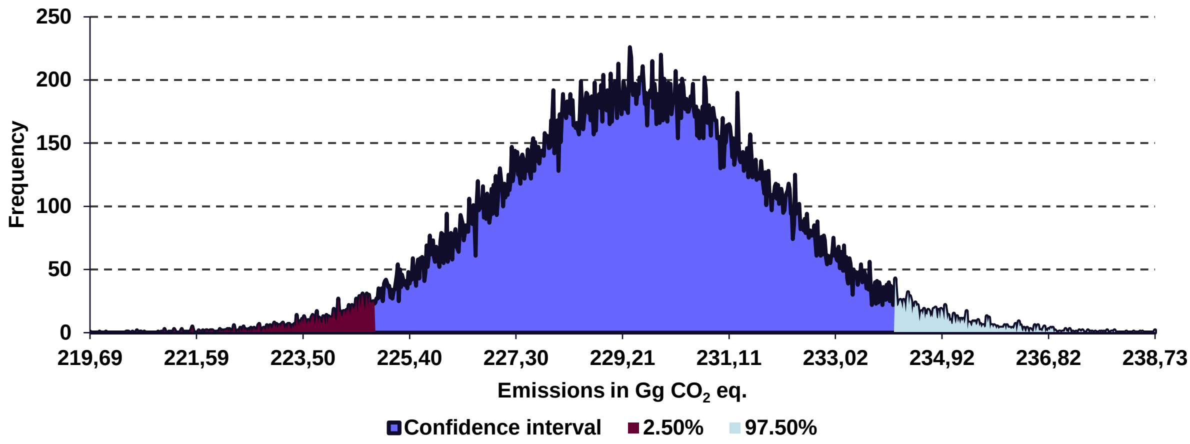
Uncertainties and time-series consistency

There were six plants producing magnesite clinker in Slovakia in 1990 – 2020. One of them ended its production in 1991. New plant entered into market in 2004; in 2007, it finished its production. Another new plant entered into market also in 2004; in 2009, it finished its production. This second operator has had very limited production of clinker. Another one stopped its production of magnesite clinker for years 1992 – 1994. Two plants continuously produced magnesite clinker since 1990. These two plants have one owner.

The same tier approach is used for the whole period 1990 – 2020. Because of the lack of input data on the consumption of magnesite raw materials and their composition before 2008, the data on the production of magnesite clinker and its composition were used to reconstruct the time series before 2008. More details on this procedure were described in the **Annex 4.1** of the SVK NIR 2016. However, only activity data on raw materials for the time series 1990 – 2007 were reconstructed (approximated data), while the CO_2 emissions are exactly calculated from the magnesite clinker production and its composition. Therefore, the comparison of the IEF changes is not possible between years.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. Default value of magnesite raw materials uncertainty (1.5%) and country specific value of $MgCO_3$, $CaCO_3$ and $FeCO_3$ contents uncertainty (2.0%) were used in uncertainty analyses by Monte Carlo method for this category. Based on calculation, the overall uncertainty of CO_2 emissions was 2.02%.

Figure 4.10: *Probability density function for 2.A.4.c (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
229.44	229.43	2.38	219.69	238.73	-2.02%	2.03%

4.7.8. Other Process Uses of Carbonates – Other (CRF 2.A.4.d)

Carbon dioxide is produced at thermal and chemical decomposition of limestone or other carbonates. The maximum values of the CO_2 emission factors based on the stoichiometry are 440 kg CO_2 per ton of consumed $CaCO_3$ and 522 kg CO_2 per ton of consumed $MgCO_3$, which are also recommended by the IPCC 2006 GL. The CO_2 emissions estimated in this category are based on limestone consumed in desulphurization process of coal.

Methodological issues

Limestone used in Slovakia often contains a small amount of $MgCO_3$. CO_2 emissions are estimated using the balance of carbonates according to the IPCC 2006 GL and the plant specific emission factors. The amount of consumed carbonates according to the different sources and CO_2 emissions in the period 1990 – 2022 are summarized in ***Table 4.17***.

Based on availability, the plant specific emission factors have been used since 2004. The annual estimation of EFs is expressed as weighted average and is based on the stoichiometry of limestone and dolomite in the mixtures in each producer. Therefore, the IEF varies over the years. Implied emission factor in 2022 was 0.442 t/t of used carbonates mixture.

Total amount of carbonates used at desulphurization was 113.95 kt in 2022, the activity data are summarized in ***Table 4.17***. The consumption increased significantly in 2016, the consumption of limestone reached the highest level since start of using of the desulphurization technology. The probable reason of the increased using of limestone is the new emission limits for SO_2 since January 1st, 2016. Consumption of limestone increased approximately two times in the power plant using brown coal. This trend continued also in 2018. In 2019, this trend was interrupted, the consumption of brown coal decreased. Total CO_2 emissions estimated in this category were 50.33 Gg in 2022.

Table 4.17: *Total used carbonates and CO_2 emissions in the category 2.A.4.d in particular years*

YEAR	Desulphurization ($CaCO_3$)	Desulphurization ($MgCO_3$)	Total Carbonates	CO_2 Emissions
	kt			*Gg*
1990	NO	NO	NO	NO
1995	NO	NO	NO	NO
2000	88.86	1.58	90.44	39.92

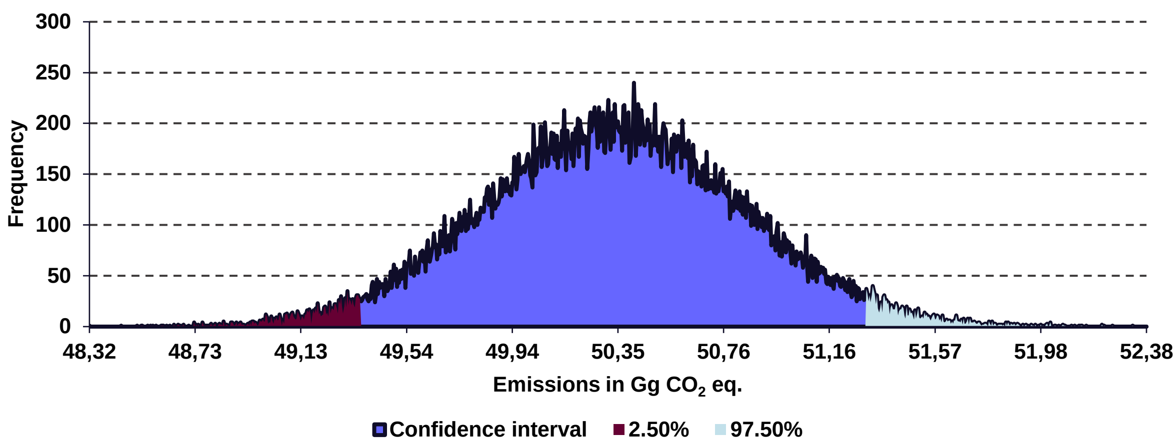
YEAR	Desulphurization ($CaCO_3$)	Desulphurization ($MgCO_3$)	Total Carbonates	CO_2 Emissions
		kt		*Gg*
2005	94.52	1.73	96.25	42.49
2010	60.49	0.99	61.48	27.13
2011	84.46	1.28	85.74	37.83
2012	103.83	1.84	105.67	46.65
2013	59.84	1.48	61.32	27.10
2014	88.39	2.01	90.40	39.94
2015	76.95	1.35	78.30	34.56
2016	150.09	4.16	154.25	68.21
2017	166.50	3.34	169.84	75.00
2018	150.99	3.97	154.96	68.51
2019	125.39	2.78	128.17	56.62
2020	103.23	2.01	105.24	46.47
2021	109.13	2.09	111.21	49.10
2022	111.60	2.35	113.95	50.33

Uncertainties and time-series consistency

The same tier approach is used for period 1996 – 2020. Before 1996, no desulphurization technology was used in Slovakia. Data presented in ***Table 4.17*** were obtained directly from producers. The decrease in consumption of limestone for desulphurization in 2010 was caused by using of 15 654 t stock lime bought from lime producer for desulphurization. It represents (using back calculation to carbonates) approximately 25.55 kt of $CaCO_3$ and 0.17 kt of $MgCO_3$. Emissions from that lime consumption were already allocated and reported in 2.A.2 in 2010. In 2012, no using of stock lime was reported and therefore emissions are higher than in previous years. In 2013 emissions decreased again (by 42%) due non-use of the desulphurization process in one plant. In 2014, the desulphurization process was again used in that plant. Since 1990, there have been seven plants with desulphurization technology. The significant increase in limestone consumption in 2016 is a result of the new emission limits for SO_2 since January 1st, 2016. Consumption of limestone increased approximately two times in the power plant using brown coal.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. Country specific value of their composition uncertainty in $CaCO_3$ and $MgCO_3$ (2.5%) were used in uncertainty analyses by Monte Carlo method for this category. Based on calculation, the overall uncertainty of CO_2 emissions was calculated to be 1.93%.

Figure 4.11: *Probability density function for 2.A.4.d (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
50.33	50.33	0.50	48.32	52.38	-1.93%	1.93%

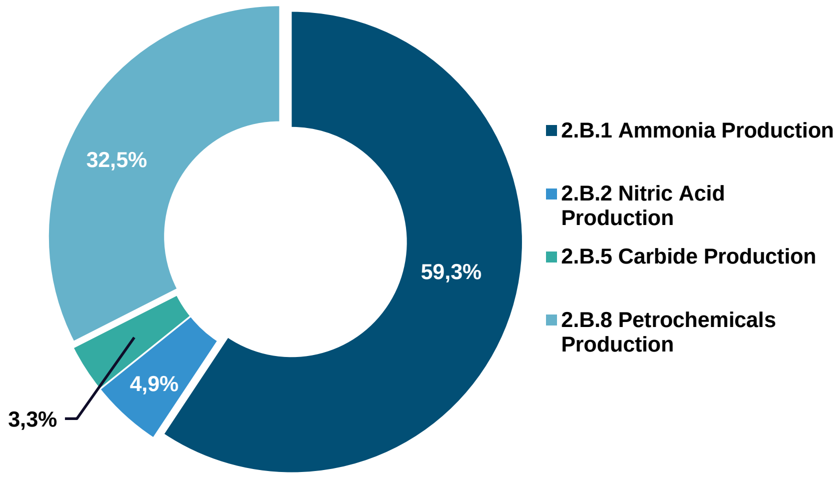
4.8. Chemical Industry (CRF 2.B)

Production of ammonia is the major source of CO_2 emissions and nitric acid production is the major source of N_2O emissions in this category. Total GHG emissions reported in this category were 1 076.42 Gg of CO_2 eq. in 2022. The decrease of emissions in the comparison with the previous year is approximately 15% and decrease by 41% in the comparison with the base year. The decrease is caused by significantly lower production of ammonia. The significant decrease in emissions was reported in nitric acid production where using of secondary YARA catalyst fully reflected this situation since 2011. In 2013, also the last producer of nitric acid started using of this secondary catalyst. Decrease of emissions in calcium carbide production is caused by decrease in production and change of raw material. Within category, major share (59.3%) in emissions belongs to ammonia production, 32.5% belongs to petrochemicals production, and 4.9% belongs to nitric acid production and 3.3% to carbide production. The hydrogen production (other) was reallocated into Energy sector according to the IPCC 2019 Refinement.

Table 4.18: *Emissions in the category 2.B according to the subcategories in particular years*

YEAR	2.B.1 Ammonia Production	2.B.2 Nitric Acid Production	2.B.5 Carbide Production	2.B.8 Petrochem. Production	2.B.10 Other
	Gg of CO_2 eq.				
1990	332.36	1 072.65	0.00	428.80	NO
1995	488.47	1 050.07	139.01	459.91	NO
2000	521.73	904.61	156.73	462.68	NO
2005	573.24	1 098.05	176.72	371.40	NO
2010	388.06	772.56	197.56	403.75	NO
2011	578.73	359.93	222.28	425.75	NO
2012	546.68	258.20	141.26	319.26	NO
2013	675.35	115.08	95.35	330.79	NO
2014	530.30	128.66	85.76	250.60	NO
2015	639.45	124.30	48.47	331.82	NO
2016	564.58	107.89	63.16	338.22	NO
2017	633.80	93.35	59.35	357.84	NO
2018	791.47	93.85	68.26	399.41	NO
2019	689.15	80.58	62.05	344.14	NO
2020	703.96	67.54	45.83	381.66	NO
2021	769.53	56.64	47.57	395.49	NO
2022	638.54	52.76	35.49	349.63	NO

Figure 4.12: *The share in CO_2 emissions of individual subcategories in 2.B in 2022*



4.8.1. Ammonia Production (CRF 2.B.1)

Ammonia is made from nitrogen and hydrogen by fine-tuned versions of the process developed by Haber and Bosch $N_2 + 3H_2 = 2NH_3$. In principle, the reaction between hydrogen and nitrogen is easy. However, to get a respectable yield of ammonia in a chemical plant a catalyst and extreme pressures up to 600 atmospheres and temperature of 400°C are needed. The results of ammonia production in Slovakia are summarized in ***Table 4.19***.

Methodological issues

Tier 3 method according to the IPCC 2006 GL was applied in the emissions estimation of the category 2.B.1 and the plant specific emission factors were used for whole time series. The information on ammonia production and natural gas consumption for its production was provided directly by the operators. The measured values of natural gas consumption provided by the operator were used for CO_2 emissions estimation and calculated according to the relationship:

$$E(CO_2) = FR \cdot CF \cdot CCF \cdot OF \cdot \frac{44}{12} - R(CO_2)$$

where: FR is total consumption of natural gas for ammonia production in Nm^3; CF is conversion factor in MJ/m^3 (35.202 in 2022); CCF is content of carbon in the fuel in t/TJ (15.312 in 2022) and OF is oxidation factor of the fuel (1). It should be noted, that parameters (NCV, EF) used for natural gas are plant specific. $R(CO_2)$ represents the amount of carbon dioxide that is recovered and used for urea production. In Slovakia, urea is produced and respective amounts of CO_2 are subtracted from the calculated emissions. Due the subtracting of CO_2 from urea production, the import/export of urea is yearly monitored. Emissions from the use of urea are reported in the Agriculture sector, category 3.H Urea application and in 2.D.3 Other (using of urea in urea-based catalytic converters). The use of urea in catalytic converters for NO_x emissions in cars is calculated by the COPERT 5 model (**Chapter 3**). The use of urea in industrial plants is annually monitored by questionnaires that are sent to the operators at which the decrease of NO_x emissions occurred. QA/QC on the use of urea, its export/import comparison is described in the **Chapter 4.4** and **Annex 4.3.**

The implied emission factor is 1.38 t CO_2 per 1 t of ammonia produced in 2022 after subtracting of CO_2 used for urea production. Without subtracting of CO_2 used for urea production the implied emission factor is 1.62 t CO_2 per 1 t of ammonia The methane and N_2O emission factors are IPCC default: 1 kg/TJ of natural gas (CH_4) and 0.1 kg/TJ of natural gas (N_2O). Results are provided in ***Tables 4.19*** and

4.20. Production of ammonia decreased by 20% in 2022 when compared with 2021 and it is a key category in level and trend assessment. The producer supplied the data on the total consumption of natural gas for the ammonia production in 2022 that are necessary for the calculation of emissions. The presented data are based on direct measurements in plant. In 2019, new, very modern, ammonia technological line started, which resulted in lower CO_2 emission.

Table 4.19: *Ammonia production and GHG emissions in particular years*

YEAR	Ammonia Production	CO_2 Emissions*	CH_4 Emissions	N_2O Emissions	NG Consumption	
	kt	*Gg*	*t*		*mil. m³*	*TJ*
1990	360.00	616.97	10.83	1.08	322.54	10 827.83
1995	383.80	654.14	11.70	1.17	343.87	11 698.41
2000	403.00	683.85	12.36	1.24	361.07	12 359.46
2005	426.35	721.40	13.06	1.31	381.99	13 064.02
2010	233.56	484.65	8.75	0.88	254.31	8 753.49
2011	455.48	779.42	14.07	1.41	407.74	14 070.98
2012	377.30	717.42	12.92	1.29	373.90	12 922.60
2013	474.91	888.08	15.98	1.60	461.25	15 979.72
2014	346.27	660.68	11.86	1.19	340.71	11 856.72
2015	476.94	884.82	15.88	1.59	454.27	15 878.88
2016	403.96	787.01	14.10	1.41	401.92	14 103.50
2017	458.88	873.80	15.70	1.57	449.16	15 700.36
2018	516.74	1 028.79	18.47	1.85	529.40	18 474.44
2019	491.95	822.68	14.77	1.48	422.85	14 770.06
2020	545.23	883.52	15.86	1.59	452.87	15 856.94
2021	580.51	930.46	16.64	1.66	475.90	16 638.42
2022	462.12	750.41	13.37	1.34	379.70	13 366.19

** CO_2 emissions without consideration of urea production*

Table 4.20: *Urea production, CO_2 used for the production and resulting CO_2 emissions in particular years*

YEAR	Urea Production	CO_2 Consumed	Net CO_2 Emissions*	IEF
	kt	*Gg*		*t/t*
1990	C	285.20	331.77	0.922
1995	C	166.31	487.83	1.271
2000	C	162.79	521.06	1.293
2005	C	148.87	572.52	1.343
2010	C	97.07	387.58	1.659
2011	C	201.46	577.96	1.269
2012	C	171.45	545.98	1.447
2013	C	213.60	674.48	1.420
2014	C	131.03	529.65	1.530
2015	C	246.24	638.58	1.339
2016	C	223.20	563.81	1.396
2017	C	240.86	632.94	1.379
2018	C	238.32	790.46	1.530
2019	C	134.34	688.35	1.400
2020	C	180.42	703.09	1.290
2021	C	161.83	768.62	1.324
2022	C	112.59	637.81	1.380

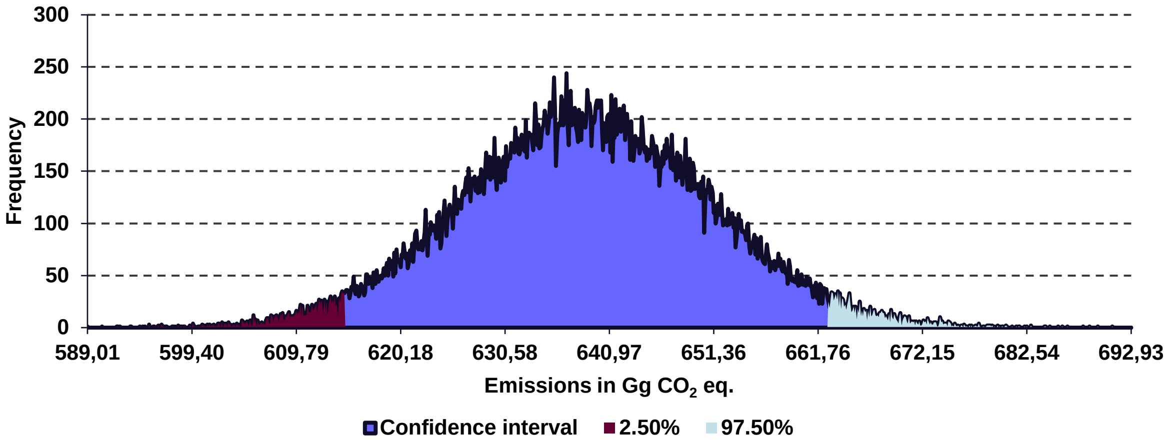
**CO_2 emissions with consideration of urea production, C = confidential (available in NIS archive)*

Uncertainties and time-series consistency

Consistent tier 3 method is used for the whole period 1990 – 2020. Higher emission factor in 2010 was caused by malfunctions in plant. The ammonia was not produced for 3.5 months in 2010. The emissions were higher as usual at the new start of the production. In 2011, the EF decreased to the values of the same level as before the malfunction. The reason of the increased production of ammonia is the new production line that was put in the operation during the year 2018. Since 2019, the new (modern) production line is fully operational. The investments in its construction amounted to 310 million €. Nowadays, the Agrofert Group in Šala has the most modern and the most ecological ammonia production technology not only in Slovakia, but also in Europe. It resulted in the decrease of the CO_2 emissions and IEF from the technological step (decrease by ca 15%).

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. The uncertainty estimation used several input parameters such as fuel consumption (*FR*), content of Carbon in fuel (*CCF*), the amount of carbon dioxide that is recovered and used for urea production (*R*), their emission factors and their default uncertainties according to the IPCC 2006 GL. The production process generates CO_2 emissions and CH_4 and N_2O emissions that were also included into the uncertainty calculation. Based on calculation, the overall uncertainty of CO_2 emissions (in eq.) was calculated to be 3.78%.

Figure 4.13: *Probability density function for 2.B.1 (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
638.54	638.58	12.30	589.01	692.93	-3.76%	3.78%

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

Globally, nitric acid production consumes about 20% of all produced ammonia. Nitric acid production in the Slovak Republic is an important source of N_2O emissions and a key category in level and trend assessment. Total nitric acid production decreased by ca 18% in 2022 when compared to 2021. However, the N_2O emissions decreased by 7% in 2022 when compared with 2021. Typical characteristic of the used technology (with secondary YARA catalyst) is that emissions are low but fluctuate in a certain degree. Thus, continuous monitoring of emissions is necessary.

Methodological issues

Since 2005, N_2O and NO_x emissions are continuously monitored by the nitric acid producers with medium-pressure and high-pressure plant. Since 2013, the monitoring is running also in the third (the last) plant. Nitric acid is produced in three industrial plants situated in Slovakia owned by one provider since 2012. Nitric acid is produced by using two technologies: two medium-pressure plants and one high-pressure plant. The N_2O emissions are directly measured during these processes. According to this, the emission factors were estimated annually, based on certified measurements in this plant.

- Atmospheric-pressure EFs: Production in atmospheric plant ended in 1999. The emission factor 4.5 kg N_2O/1 t of HNO_3 was recommended for this type of technology in 2006 IPCC Guidelines. In 2019 IPCC Refinement the emission factor was changed to 5.0 kg N_2O/1 t of HNO_3; which mean the increase by 11.1%. Because the technological line of the atmospheric plant was old we used for it the emissions factor 13.0 kg N_2O/1 t of HNO_3 according the recommendation of the ERT review. We adopted the increase of emission factor by 11.1% also for this value. Thus, the recalculation of the historical data was done, that is presented in **Chapter 4.5**, ***Table 4.4.***

- Medium-pressure EFs: Two medium pressure plants produce nitric acid in Slovakia. One of them directly measured N_2O emissions in 2005 – 2010 (reg. No SNAS 230/S-189). Results are provided in ***Table 4.21***.

Table 4.21: *Measured EFs in medium pressure nitric acid plant in 2005 – 2010*

YEAR	2005	2006	2007	2008	2009	2010
	kg/t					
EF N_2O	7.3	10.33	10.33	7.6	7.5	7.5

The malfunction in 2006 – 2007 resulted in higher N_2O emission factors. The average value of the emission factor (7.5 kg/1 t of HNO_3) calculated based on presented period (except 2006 and 2007 values) was used as EF in medium pressure plant for the period 1990 – 2004. The same value was also measured before the technological change, which took place in 2010. In September 2010, the producer started to use the technology with secondary YARA catalyst and use of continuous emission monitoring system. It resulted in significant decrease of N_2O emissions.

The same EF was also used for the other medium-pressure plant in the Slovak Republic. The used medium-pressure technologies are very similar. The later medium-pressure plant changed owner at the end of the year 2012, and the plant was modernized in the same way as the other plant (secondary catalyst and continuously monitoring of N_2O emissions).

- High-pressure EFs: The high-pressure plant started its production in 1999. The N_2O emission factor in high-pressure plant was directly measured in 2006 and 2007 (9.02 kg N_2O/1 t of HNO_3). This value was then used for the whole time series for the high-pressure technology. It is very close to the IPCC default value (9 kg/t). In September 2010, the producer introduced the technology with secondary YARA catalyst and continuous emission monitoring system. It resulted in significant decrease of N_2O emissions.

The detailed information on N_2O emission factors from the nitric acid production in 2022 is presented in ***Table 4.22***. The overall EF = 0.380 kg N_2O/t of HNO_3 in 2022 was estimated as weighted average. N_2O emissions were 199.09 t in 2022. The detailed results are in ***Tables 4.22*** and ***4.23***.

Table 4.22: *Detailed information on measured N_2O concentrations and EFs in 2022*

PLANT	N_2O Concertation	Weighted Average EF
	ppm	*kg/t*
Medium Pressure Plant 1	117.05	0.390
Medium Pressure Plant 2	28.97	0.118
High Pressure Plant	129.72	0.425

***Table 4.23:** Estimated N_2O emissions and IEFs (N_2O) in particular years*

YEAR	HNO_3 Production	EF N_2O	N_2O Atmospheric	N_2O Medium Pressure	N_2O High Pressure	TOTAL N_2O Emissions
	kt	*kg/t HNO_3*	*t*			
1990	400.54	10.106	2 170.86	1 876.88	NO	4 310.94
1995	398.80	9.936	2 020.78	1 941.77	NO	4 250.00
2000	407.22	8.383	NO	1 256.58	2 157.06	3 413.64
2005	497.68	8.326	NO	1 584.29	2 559.28	4 143.57
2010	510.97	5.706	NO	1 393.18	1 522.15	2 915.33
2011	593.75	2.288	NO	739.54	618.68	1 358.22
2012	550.51	1.770	NO	587.81	386.52	974.33
2013	611.65	0.710	NO	136.50	297.76	434.26
2014	580.09	0.837	NO	156.40	329.13	485.53
2015	634.31	0.740	NO	95.27	373.80	469.07
2016	568.55	0.716	NO	71.69	335.45	407.14
2017	646.23	0.545	NO	118.87	233.42	352.28
2018	575.32	0.616	NO	127.84	226.32	354.16
2019	571.27	0.532	NO	120.23	183.86	304.09
2020	580.24	0.439	NO	125.42	129.44	254.85
2021	636.32	0.336	NO	87.29	126.42	213.72
2022	523.76	0.380	NO	77.18	121.91	199.09

Uncertainties and time-series consistency

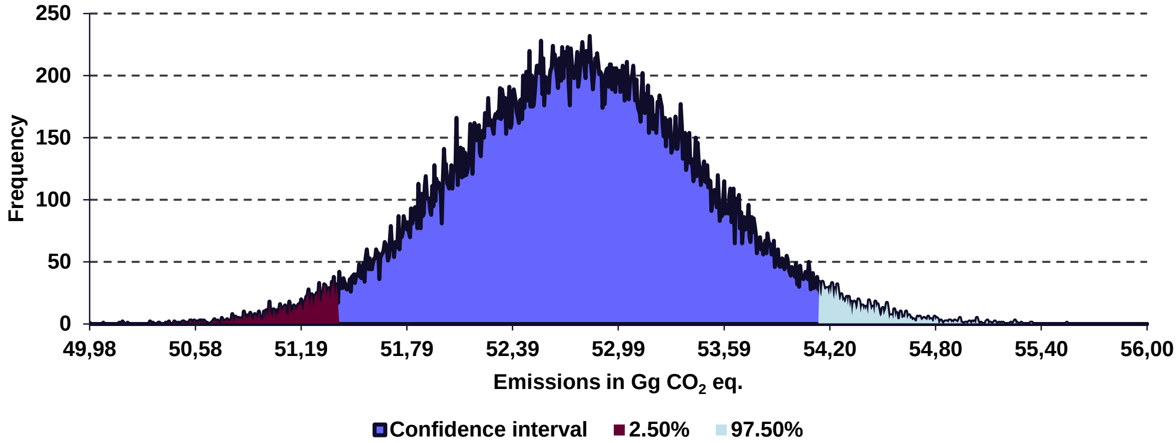
There is only one owner, which has been operating several nitric acid production plants in Slovakia since 2012. Nitric acid is produced in two medium- and one high-pressure plants. Until 1999, also atmospheric-pressure plant had been operated in Slovakia. The plant specific emission factors are used for medium and high-pressure technologies since 1990.

The emission factors for medium-pressure plant are based on the measured data in 2005, 2008, 2009 and 2010. The average value (7.5 kg/1 t of HNO_3) of EF is used for other years of time series except the years 2006 and 2007. According to the N_2O emissions measured in 2006 and 2007, the EF was 10.332 kg/1 t of HNO_3 (malfunction in the plant). The emission factor for high-pressure plant was measured to be 9.02 kg/1 t of HNO_3 which is in good agreement with the IPCC default EF for this type of technology (9 kg/1 t of HNO_3). The same value was used in 1990 – 2010, when the high-pressure production of nitric acid occurred.

In September 2010, technology was changed in medium- and high-pressure technologies by one producer. The secondary YARA catalyst was introduced, which resulted in significant decrease of N_2O emissions since 2010. The second plant was using un-modified technology and EF equalled 7.5 kg/1 t of HNO_3. At the end of 2012, the second medium-pressure plant was bought by the new owner (already owned the second plant). The plant was modernized in the same way as the other (secondary catalyst and continuously monitoring of N_2O emissions) and emission factor was improved. In the end of 2020, there was another modernization of the one of the medium-pressure plants. During the modernization, the number of catalyst layers was increased that resulted in another decrease of N_2O emissions. The decrease was fully evident in 2021.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. Uncertainty values on the GHG concentration in gas output (2%), output gas flow (3%) and operating hours (0.5%) were taken from the used gas output certificates analysis. Based on calculation, the overall uncertainty of CO_2 emissions (in eq.) was calculated to be 2.59%.

Figure 4.14: *Probability density function for 2.B.2 (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
52.76	52.76	0.70	49.98	56.00	-2.57%	2.60%

4.8.3. Adipic Acid Production (CRF 2.B.3)

Adipic acid is not produced in the Slovak Republic therefore notation key “NO” was used.

4.8.4. Caprolactam, Glyoxal and Glyoxylic Acid (CRF 2.B.4)

None of these products are produced in the Slovak Republic therefore notation key “NO” was used.

4.8.5. Carbide Production (CRF 2.B.5)

Silicon carbide (CRF 2.B.5.a)

Silicon carbide is not produced in the Slovak Republic therefore notation key “NO” was used.

Calcium carbide (CRF 2.B.5.b)

Calcium carbide (the correct chemical name of this compound is calcium acetylide) is produced by the reaction of CaO and coke in submerged arc furnace. The final CO_2 emissions balance is influenced by export of carbide, use of carbide in Slovakia and use of limestone. Total CO_2 emissions reached 35.49 Gg of CO_2 in 2022 and decreased by 25% in comparison with 2021. It corresponds to the decrease of the production. Since 2015, the calcinated anthracite is used instead of other bituminous coal.

Methodological issues

Carbon balance of all input-output flows was used. The method is similar to tier 3 method according to the IPCC 2006 GL with the combination of country specific emission factors and NCVs. These EFs are updated annually. The CO_2 emissions are calculated from the coal consumption (reduction step), limestone use, and products use. Limestone has not been used since 2011. The CO_2 emissions from reduction step are calculated in the following way: CO_2 emissions = (Σ(consumption of coal x NCV x EF(C))-(carbide production × C content in carbide)) x 44/12.

Acetylene is produced in the plant not only for welding application. A part of produced acetylene can be used to produce the vinyl chloride monomer. When this occurs, the CO_2 emissions from this production are reported in 2.B.8.c (ethylene dichloride and vinyl chloride monomer (VCM)). The calcium carbide for acetylene production for welding application was calculated by conservative approach, as follows: Calcium carbide for welding = import + production – export – calcium carbide for VCM.

Results of CO_2 emissions from non-exported production are summarized in ***Table 4.24*** (C = confidential data are available in the SNE archive).

Table 4.24: *Estimated CO_2 emissions, carbide production and export in particular years*

YEAR	Carbide Prod.	Carbide Export-Import	Carbide for VCM Prod.	$CaCO_3$ Consum.	Coking Coal Consum.	Other Bitumi-nous Coal Consum.	IEF CO_2	CO_2
	kt						*t/t*	*Gg*
1990	NO	NO	NO	NO	NO	NO	NO	NO
1995	84.30	C	C	131.63	66.61	7.14	1.65	139.01
2000	88.82	C	C	138.68	70.26	7.44	1.76	156.73
2005	97.03	C	C	151.50	76.73	8.15	1.82	176.72
2010	98.26	C	C	158.17	77.69	8.28	2.01	197.56
2011	107.40	C	C	172.89	84.89	9.07	2.07	222.28
2012	100.48	C	C	NO	79.44	8.46	1.41	141.26
2013	81.79	C	C	NO	60.93	6.16	1.17	95.35
2014	74.30	C	C	NO	57.99	4.34	1.15	85.76
2015	56.18	C	C	NO	41.05	3.55*	0.86	48.47
2016	67.95	C	C	NO	48.01	4.50*	0.93	63.16
2017	71.64	C	C	NO	47.82	5.08*	0.83	59.35
2018	70.15	C	C	NO	48.30	4.79*	0.97	68.26
2019	60.47	C	NO	NO	45.90	3.49*	1.03	62.05
2020	47.61	C	NO	NO	38.07	1.65*	0.96	45.83
2021	48.48	C	NO	NO	39.01	1.47	0.98	47.57
2022	36.12	32.70	NO	NO	27.97	1.83	0.98	35.49

** calcinated anthracite*

Implied CO_2 emission factors of carbide production are updated annually based on the annual values of the NCV and EFs of used fuels and carbon content in the products (calcium carbide). Implied CO_2 emission factor in 2021 was 0.88 t CO_2/t of produced CaC_2 (only from technological process, no acetylene production is included). When the acetylene production for welding application is included in formula, the IEF increased to the value 0.98 t CO_2/t of produced CaC_2.

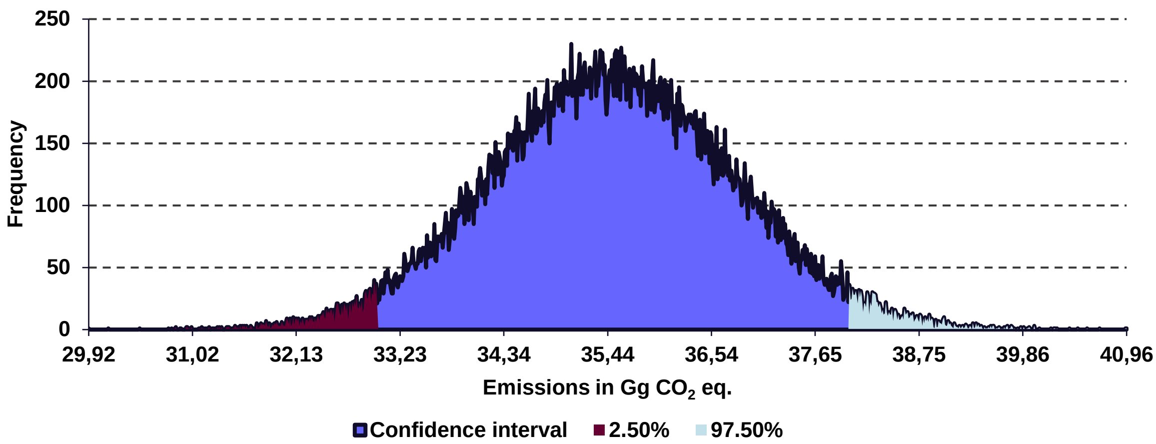
According to the direct information provided by the producers, a part of produced calcium carbide was exported from the Slovak Republic and another part of calcium carbide was used for acetylene and following vinyl chloride production (not in 2022). No calcium carbide was imported to Slovakia in 2022. The rest of produced calcium carbide was used for acetylene production for welding applications (conservative approach). No production of CaO occurred in 2022. The CaO was bought from the lime producers and approximately 40% of CaO was imported from neighbouring countries. Therefore, no CO_2 emissions from CaO preparation (limestone decomposition step) were allocated in this category. Since 2015, calcinated anthracite is used for the production of Søderberg anodes. The content of carbon in this type of material is declared min. 95%, for ensuring conservatism the assumption of 100% content of carbon is used for the calculation of emission estimates.

Uncertainties and time-series consistency

The production of calcium carbide in Slovakia started in 1992. Since that year, consistent methodology and tier method has been used for the whole time series for emissions estimation. Fluctuations and outliers in emission trend (1998, 2002, 2011 – 2020) and emission factors were caused by differences in exported volume of final calcium carbide and utilization of CaC_2 for acetylene and following VCM production (***Table 4.24***). The CaO production finished in 2011. In the present, the CaO is produced by the lime producers and bought for carbide production.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. Default values of calcium carbide production and export uncertainty (1.5%), country specific values for fuels used uncertainty (1.5%), the net calorific values and carbon content in the fuels (2.0%) except of the carbon content in calcinated anthracite (5.0%), the value for carbide in use (1.5%) and the value of respective EFs uncertainty (10%) based on methodology for emissions estimation were used in uncertainty analyses by Monte Carlo method for this category. Based on calculation, the overall uncertainty of CO_2 emissions was calculated to be 7.08%.

Figure 4.15: *Probability density function for 2.B.5.b (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
35.48	35.48	1.29	29.92	40.96	-7.03%	7.12%

4.8.6. Titanium Dioxide Production (CRF 2.B.6)

Titanium dioxide is not produced in the Slovak Republic and “NO” notation key was used.

4.8.7. Soda Ash Production (CRF 2.B.7)

Soda ash is not produced in the Slovak Republic and “NO” notation key was used.

4.8.8. Petrochemical and Carbon Black Production (CRF 2.B.8)

Methanol (CRF 2.B.8.a), ethylene oxide (CRF 2.B.8.d), acrylonitrile (CRF 2.B.8.e) and carbon black (CRF 2.B.8.f) are not produced in the Slovak Republic and “NO” notation keys were used.

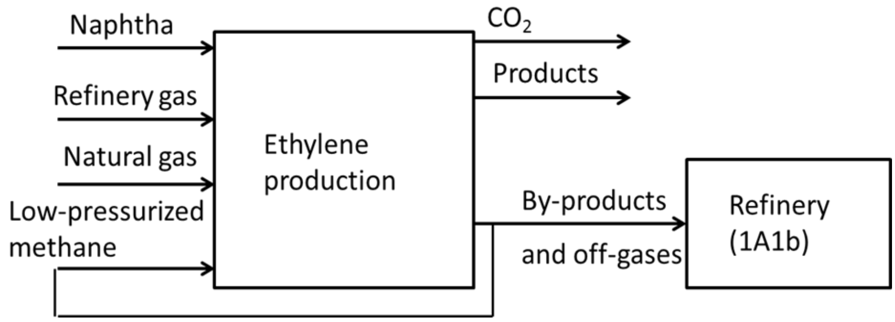
Ethylene (CRF 2.B.8.b)

Ethylene is produced by steam cracking of naphtha in the Slovak Republic. Natural gas, refinery gas and low-pressurized methane are used as the other feedstock in the process. Propylene is a valuable co-product of the process. The other by-products and off-gases are transferred into refinery and they are reported in 1.A.1.b. Total CO_2 emissions from ethylene production were 345.20 Gg in 2022, which is lower by 12% compared with previous year. The decrease is caused by decreasing the production.

Methodological issues

Carbon balance approach (tier 2), as described in the IPCC 2006 GL, was used. All feedstock (naphtha, natural gas, refinery gas and low-pressurized methane) and all products (ethylene, propylene, and other chemicals – by-products) are balanced (***Figure 4.16***). Methane emissions do not occur when using approach described in the IPCC 2006 GL.

Figure 4.16: *Scheme of carbon material balance used in for 2.B.8.b*



Input streams as naphtha and refinery gas originates in the refinery. During the reaction in the ethylene unit, a refinery gas with high content of methane is formed. This methane is separated from the refinery gas and creates an inner loop in the process. The rest of the refinery gas (after separating of methane) is going into refinery and it represents an input stream for emission estimates in the Energy sector (1.A.1.b category). In refinery, other chemicals as butadiene *etc.* are separated and off-gases are burned. The burning of off-gases is reported in the Energy sector (1.A.1.b category). The data "Carbon in other chemicals" presented in ***Table 4.25*** represents carbon outgoing from ethylene unit (due to many the other produced chemicals, total carbon content is reported). From this amount, the low pressurized methane is separated, while the rest is going into refinery. On the other hand, another stream of refinery gas is outgoing from refinery and it represents the input stream in the ethylene unit.

The total amount of carbon excluded from reference approach is the difference between carbon contained in input flows (naphtha, excess refinery gas, natural gas) and carbon in off-gases going to the refinery. Part of it is stored in products (ethylene and propylene) and the rest is evolved as CO_2 emissions This approach (including the inner loop into the calculation) is chosen because of comparability with the EU ETS report where the emission estimates are calculated based on the fuel combustion. The methodology used was also published in the paper by Eva Krtková et. al.[2]).

Ethylene is produced by one operator in Slovakia and therefore the NCVs and emission factors of all feedstock were provided directly (EU ETS reports). Total production of ethylene and propylene was provided by the plant operator. Detailed data are presented in ***Table 4.25***.

Table 4.25: *Activity data and related CO_2 emissions from ethylene and propylene production in particular years*

YEAR	Naphtha	Natural Gas	Refinery Gas	Low-Pressurized CH_4
	Inputs in TJ			
1990	14 867.6	3 074.8	4 366.1	0.0
1995	19 271.2	1 714.1	5 071.7	1 306.4
2000	21 625.6	1 419.9	4 380.5	2 357.3
2005	17 440.0	959.5	4 497.4	1 031.8
2010	17 004.0	1 610.6	4 237.1	1 244.2
2011	16 742.4	1 532.7	4 062.2	1 126.2
2012	10 900.0	1 487.9	2 928.5	612.1
2013	11 510.4	1 707.9	3 124.8	907.5

[2] Eva Krtková, Vladimir Danielik, Janka Szemesová, Klára Tarczay, Gábor Kis-Kovács and Vladimír Neužil, Non-Energy Use of Fuels in the Greenhouse Gas Emission Reporting, Atmosphere 2019, 10, 406; DOI: https://www.mdpi.com/2073-4433/10/7

YEAR	Naphtha	Natural Gas	Refinery Gas	Low-Pressurized CH_4
	Inputs in TJ			
2014	11 264.0	1 319.6	2 522.0	584.2
2015	14 916.0	1 123.8	3 707.6	1 079.9
2016	10 472.0	1 150.2	3 584.5	1 250.4
2017	11 176.0	1 290.4	3 702.3	1 363.0
2018	13 948.0	1 355.5	4 105.8	1 718.6
2019	13 244.0	1 182.9	3 624.6	1 432.9
2020	17 732.0	909.9	4 081.9	2 004.0
2021	19 184.0	728.6	4 533.3	1 968.7
2022	16 588.0	535.6	4 156.6	1 700.7

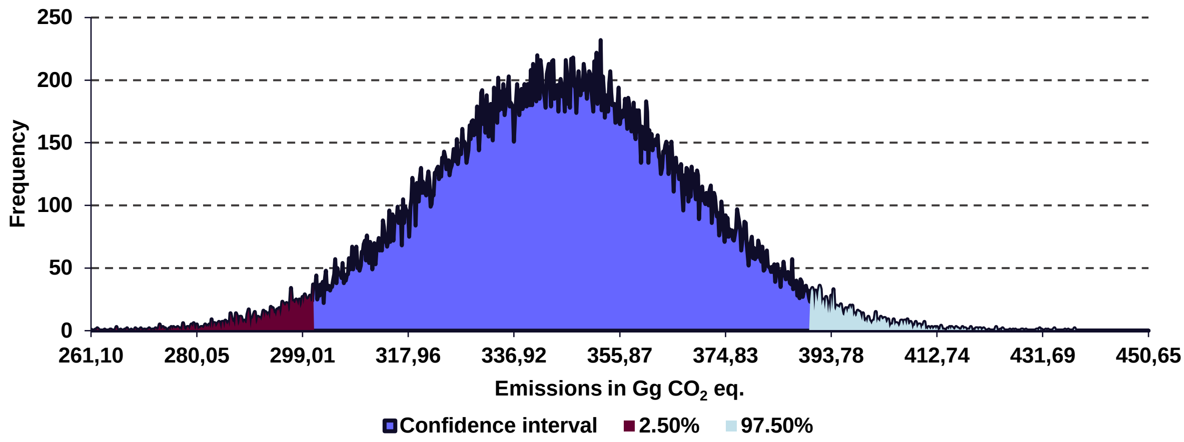
YEAR	Ethylene Production	Propylene Production	Carbon In Other Chem.	CO_2 Emissions	IEF (CO_2)
	Outputs in kt			*Gg*	*t/t*
1990	216.5	98.6	27.3	416.80	1.925
1995	200.3	93.3	133.9	447.80	2.236
2000	207.4	92.9	175.5	449.28	2.166
2005	202.5	91.9	96.8	357.33	1.765
2010	197.0	93.0	91.8	391.16	1.986
2011	194.0	96.0	86.6	411.73	2.122
2012	128.0	68.0	50.2	306.42	2.394
2013	145.5	71.7	44.3	322.24	2.215
2014	102.8	55.2	90.1	243.55	2.369
2015	137.0	67.0	123.7	323.91	2.364
2016	146.0	71.0	23.7	328.16	2.248
2017	176.0	84.0	0.9	348.90	1.982
2018	198.0	98.0	25.6	391.74	1.978
2019	169.5	81.9	49.7	340.24	2.008
2020	207.9	153.9	44.9	379.68	1.826
2021	213.6	165.5	59.1	391.28	1.832
2022	169.3	217.6	0.4	345.20	2.039

Uncertainties and time-series consistency

Consistent methodology based on tier 2 method was used for the whole-time series since 1990. Fluctuations and outliers in emission trend were caused by the different amounts of other chemicals produced in process and by the different share of fuels (naphtha, NG, refinery gas, low-pressured methane). Fluctuations in IEF are caused by relating of the IEF to the production of ethylene only, while there is a varied share of the different products produced during the time series. Sensitivity of time series is caused by the limited number of operators produced in Slovakia and their actual activity. The corresponding volume of natural gas and other fuels presented in ***Table 4.25*** were subtracted from 1.A.2.c in the Energy sector.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. Country specific values of different fuels' uncertainty, country specific values for fuels NCV and EFs uncertainty (2.0%) and calculated value for ethylene and propylene production uncertainty (1.5%) based on methodology for emissions estimation described above were used in this uncertainty analyses by Monte Carlo method. Based on calculation, the overall uncertainty of CO_2 emissions was 12.91%.

Figure 4.17: *Probability density function for 2.B.8.b (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
345.25	345.29	22.76	261.10	450.65	-12.84%	12.91%

Ethylene Dichloride and Vinyl Chloride Monomer (CRF 2.B.8.c)

Ethylene dichloride (EDC) is produced by direct chlorination process in the Slovak Republic. Cracking of ethylene dichloride results in vinyl chloride monomer (VCM) and HCl. The HCl is consumed in the reaction with acetylene that results in another amount of vinyl chloride monomer. This amount of consumed acetylene is not reported in 2.B.5.b (calcium carbide production) to avoid double counting. Total CO_2 emissions from ethylene dichloride and vinyl chloride monomer production were estimated in this category for whole time series. The emissions were 4.43 Gg in 2022 and increased by ca 5% in comparison with the previous year 2021.

Methodological issues

Tier 2 approach and carbon balance approach, as described in IPCC 2006 GL was used. The used approach is described on the following scheme (***Figure 4.18***).

Ethylene dichloride and vinyl chloride monomer is produced by one operator in Slovakia. All streams (inputs) shown on ***Figure 4.18*** were taken into account with respective emission factors and contents of carbon (plant specific data). These parameters were updated annually.

Total production of vinyl chloride monomer and the production of ethylene dichloride (a part of it that is a final product, not intermediate for VCM) were delivered directly by the plant operator. Information on streams inputs and outputs material balance are summarized in ***Table 4.26***.

Figure 4.18: *Carbon material balance used in emissions estimation of the category 2.B.8.c*

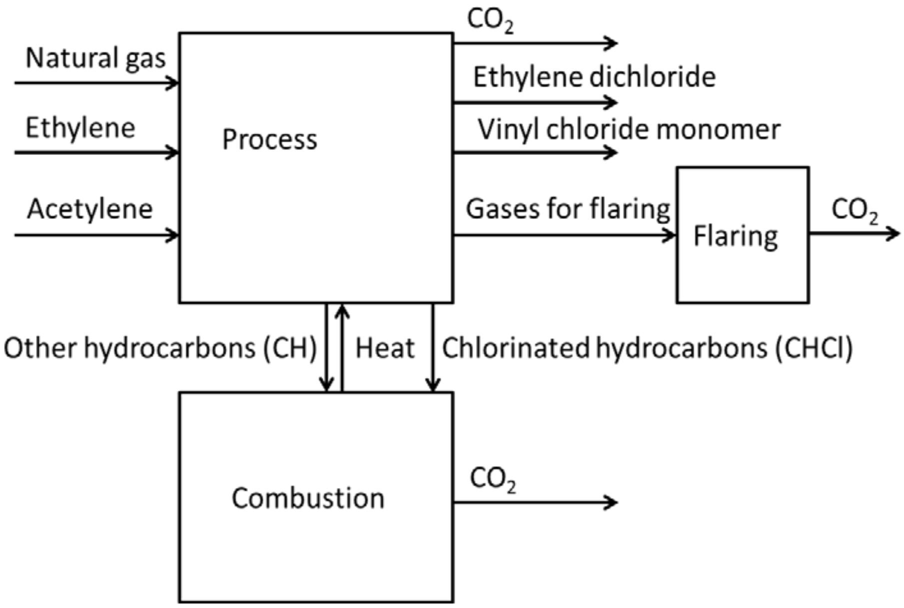


Table 4.26: *Activity data and related CO_2 emissions from the EDC and VCM production in particular years*

YEAR	Natural Gas Consumption	Ethylene Consumption	Acetylene Consumption	EDC Production*	VCM Production
	1 000 m³	*kt*			
1990	5 084	10.320	14.313	NO	55.536
1995	4 935	17.356	8.177	NO	56.159
2000	5 302	21.003	9.471	NO	66.963
2005	5 850	18.807	9.166	NO	61.568
2010	5 272	17.448	5.743	0.893	50.085
2011	5 872	19.294	5.772	1.150	53.928
2012	5 475	18.149	2.587	0.712	44.300
2013	3 548	11.915	3.462	0.666	33.059
2014	3 013	10.148	3.068	1.172	28.185
2015	3 174	10.816	3.486	-0.158	31.127
2016	4 694	11.762	6.357	1.571	39.484
2017	3 505	10.612	5.703	0.305	35.193
2018	4 030	8.970	2.810	0.502	26.295
2019	405	6.933	NO	0.348	12.957
2020	626	3.203	NO	-0.323	6.770
2021	1 754	7.132	NO	0.688	14.828
2022	1 539	7.415	NO	0.436	15.167

YEAR	Gas for Flaring	CHCl**	CH***	Proc. CO_2	Combust. CO_2	Flaring CO_2	Total CO_2	IEF (CO_2)
	1 000 m³	*kt*		*Gg*				*t/t VMC*
1990	43.9	1.587	0.282	10.382	1.449	0.173	12.004	0.2161
1995	50.7	2.042	0.284	10.045	1.866	0.199	12.110	0.2156
2000	53.4	2.104	0.265	11.264	1.922	0.210	13.396	0.2000
2005	44.8	2.397	0.268	11.704	2.190	0.176	14.070	0.2285
2010	45.3	1.862	0.271	10.703	1.701	0.178	12.583	0.2512
2011	51.9	2.114	0.269	11.883	1.932	0.204	14.019	0.2600

YEAR	Gas for Flaring	CHCl**	CH***	Proc. CO_2	Combust. CO_2	Flaring CO_2	Total CO_2	IEF (CO_2)
	1 000 m³	*kt*		*Gg*				*t/t VMC*
2012	50.5	1.621	0.297	11.160	1.481	0.198	12.839	0.2898
2013	50.2	0.936	0.206	7.491	0.855	0.197	8.543	0.2584
2014	24.8	0.903	0.234	6.194	0.769	0.097	7.051	0.2502
2015	24.0	0.778	0.269	7.103	0.714	0.094	7.911	0.2541
2016	99.2	1.095	0.426	8.629	1.041	0.390	10.061	0.2548
2017	128.2	1.315	0.536	7.170	1.269	0.504	8.942	0.2541
2018	132.5	0.852	0.288	6.374	0.521	0.777	7.672	0.2918
2019	58.2	0.639	0.078	3.193	0.229	0.478	3.900	0.3010
2020	110.5	0.323	0.048	1.293	0.435	0.248	1.975	0.2918
2021	202.7	0.561	0.087	2.982	0.797	0.434	4.214	0.2842
2022	143.6	0.666	0.117	3.335	0.565	0.526	4.425	0.2918

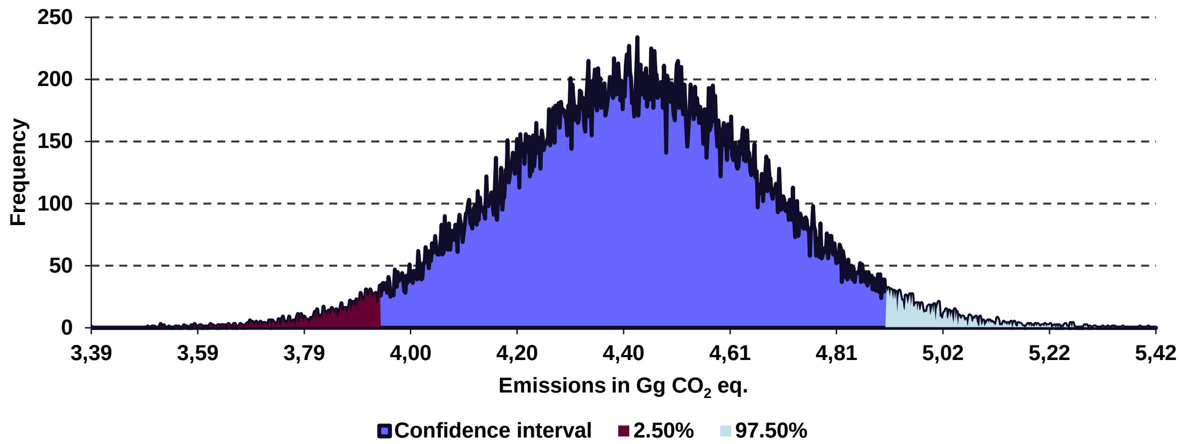
**production of EDC that is used as a product, not an intermediate to VCM; **chlorinated hydrocarbons; ***other hydrocarbons*

Uncertainties and time-series consistency

Consistent methodology and tier method are used for the whole time series since the base year. Fluctuations and outliers in emissions and IEFs are caused by different amounts of vinyl chloride monomer produced by two methods (from ethylene and/or acetylene). Sensitivity of time series are caused also by the limited number of operators produced in Slovakia and their actual activity or production capacity. The respective amounts of natural gas were subtracted from 1.A.2.c of the Energy sector. It should be mentioned that the negative value of EDC production in 2015 and in 2020 means the using of stocked or bought amount of EDC. Not enough EDC was produced in the plant in those years for the purpose of VCM production.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. Country specific values of different inputs (fuels) uncertainty, country specific values for fuels NCV and EFs uncertainty (2.0%), value for VCM and EDC production, acetylene and ethylene consumption uncertainty (1.5%) based on methodology for emissions estimation described above were used in this uncertainty analyses by Monte Carlo method. Based on calculation, the overall uncertainty of CO_2 emissions was 10.93%.

Figure 4.19: *Probability density function for 2.B.8.c (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
4.24	4.24	0.25	3.39	5,42	-10.93%	10.92%

4.8.9. Hydrogen Production (CRF 2.B.10)

In this submission, 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories was fully implemented. In Vol. 3 – Introduction, Chapter 1.3.3, page 1.12 it is stated: "*Refineries manufacture petroleum products for fuel and for non-energy uses, and in doing so produce hydrogen and other gases, intermediate products and basic chemicals. The CO_2 emissions from fuel consumed by the refinery for this activity are reported as Energy Sector emissions. This principle is maintained in the Guidelines even when some fuel use in the refinery is to support manufacture of chemicals for sale (for example, propylene or aromatics). In the 2019 Refinement, this principle is re-iterated within the new guidance presented for hydrogen production, which is a new IPPU source category; the emissions from hydrogen production within a refinery as an intermediate product are primarily to support Energy sector activities, with emissions to be reported in the Energy sector.*"

Until now, the hydrogen production in refinery was included in this category. Based on the above cited paragraph, the hydrogen production is allocated into Energy sector and "NO" notation key is used.

4.9. Metal Production (CRF 2.C)

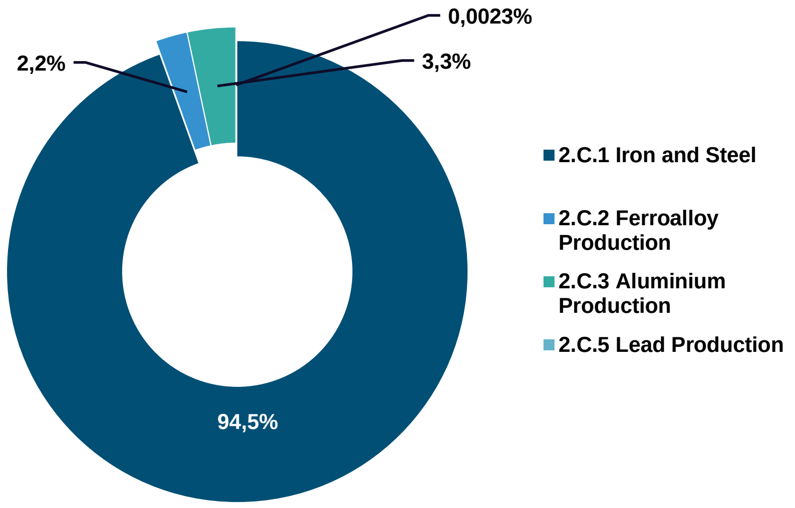
This category produces emissions of CO_2, CH_4 and PFCs emissions (Aluminium Production). Total emissions were 3 533.08 Gg of CO_2 eq. in 2022; the decrease was 27% when compared with 2021 due the significant decrease of all productions. Even the aluminium production finished. Comparing with the base year, the emissions are lower by 26%. However, more efficient production results in significantly higher iron and steel production at the same emission production. According to the IPCC 2006 GL, also zinc and lead production are reported in 2.C.5 Lead Production and 2.C.6 Zinc Production.

Table 4.27: *Emissions in the category Metal Production 2.C in particular years*

YEAR	2.C.1 Iron and Steel	2.C.2 Ferroalloy Production	2.C.3 Aluminium Production	2.C.5 Lead Production	2.C.6 Zinc Production
	Gg of CO_2 eq.				
1990	4 182.73	296.74	335.24	NO	NO
1995	4 335.91	235.64	148.83	NO	NO
2000	3 359.30	182.72	193.11	NO	NO
2005	3 391.04	166.09	193.55	NO	NO
2010	4 164.04	334.79	193.11	NO	NO
2011	3 993.04	329.55	204.42	0.01	NO
2012	4 309.53	372.33	278.56	0.04	0.02
2013	3 924.83	228.22	281.31	0.05	0.01
2014	4 425.41	276.20	281.21	0.06	0.01
2015	4 181.15	301.64	268.83	0.06	NO
2016	4 031.17	263.42	285.08	0.06	NO
2017	3 511.91	115.67	249.62	0.06	NO
2018	4 107.71	220.01	291.75	0.01	NO
2019	3 505.23	203.04	285.90	0.01	NO
2020	3 878.02	266.53	288.14	0.03	NO
2021	3 781.27	166.19	282.26	0.03	NO
2022	4 070.29	224.30	284.27	0.08	NO

The major share of emissions (94.5%) belongs to the iron and steel production, 2.2% belongs to the ferroalloy production and 3.3% to the aluminium production. Other subcategories are not significant in emission share within the category 2.C.

Figure 4.20: *The share in GHG emissions in the category 2.C by subcategories in 2022*

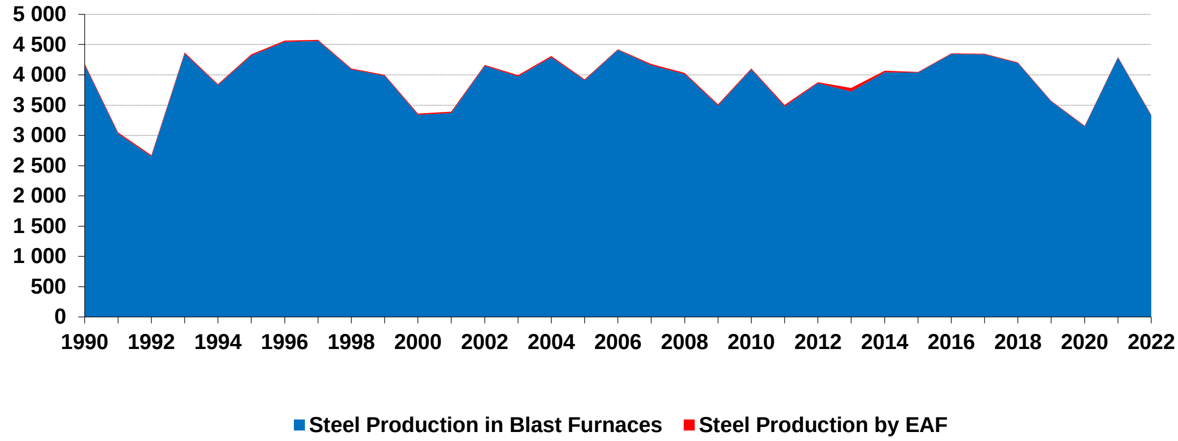


4.9.1. Iron and Steel Production (CRF 2.C.1)

Total CO_2 emissions in this category were 3 339.31 Gg in 2022, lower by 22% when compared with the year 2021. The reason of such decrease is the significant decrease in production due to the economic reasons. Comparing the base year, the decrease was 20%. Pig iron is produced by the reduction process of iron ore with coke in a blast furnace. The major emissions emitted from this process are CO_2 emissions. Limestone is added as an agent for slag formation. Pig iron contains about 4% of carbon and a part of this carbon is oxidized in the next step. This process is accompanied by the CO emissions release. The most of CO is burned to CO_2. Iron ore was processed to pig iron. Category iron and steel production includes following processes: (i) steel production (2.C.1.a), (ii) pig iron production (2.C.1.b), (iii) sinter production (2.C.1.d) and (iv) steel production in electric arc furnaces (EAF) (2.C.1.f). Major sources of technological CO_2 emissions are pig iron and steel production in blast furnaces. Due to the difficult disaggregation between emissions originated from pig iron and from steel production, total CO_2 emissions from total production processes were allocated directly in steel production category. Therefore, the notation key “IE” was used in the other categories. The CO_2 emissions from the EAF steel production are reported separately in 2.C.1.f.

Implementation of 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories resulted in changes in the inventory: (i) methane emissions from sinter and coke production. Due to the technological scheme of the process (***Figure A4.1.1*** in the **Annex 4.1** of this Report) we report the methane emission from coke production in IPPU sector instead of Energy sector; (ii) nitrous oxide emissions from the flaring of blast furnace gas and converter gas. The methane and nitrous oxide emissions were estimated back to the 1990. However, based on the new available data we plan reconsider the technological scheme to differentiate the fuels and emissions between IPPU and Energy sector in more details. The result will be reported in the next submission.

Figure 4.21: *Emission trend in the category 2.C.1 according to type of production in 1990 – 2022*



Methodological issues

Pig iron and steel are produced mainly in blast furnaces and by the EAF processes. Technological emissions from pig iron (2.C.1.b), steel (2.C.1.a) and emissions from coke electrodes used by the EAF steel production (2.C.1.f) are included in this category. Due to application of tier 2 method, methane emissions were not balanced until now.

The plant with blast furnaces is one complex with many energy-related installations (coke ovens, heating plant, manufacturing of steel products, etc.). After direct discussion with the plant operators, simplified scheme of the plant in order to carbon balance was proposed (***Figure A4.1.1*** in the **Annex 4.1** of this Report).

All streams were calculated based on the plant specific conversion units and carbon EFs or based on carbon content oi iron ore and steel. Carbon balance of iron and steel production is described in full details in the **Annex 4.1**. The used method corresponds to tier 2 for CO_2 as described in the IPCC 2006 GL. Methane emissions from sinter and coke production are calculated using Tier 1 method and reported in 2.C.1.a. No data for higher Tier are available. Nitrous oxide emissions from blast furnace gas and converter gas flaring are calculated using Tier 1 method, as well. No data for higher Tier are available. However, CRF Tables (CRF Reporter) are not prepared for reporting of N_2O emissions from iron and steel production, Therefore, they are reported separately in artificially created category 2.C.7.i Iron and Steel – N_2O.

The CO_2 emissions were calculated by using following equation:

$$E(steelBF) = (\sum(massofCininputstream_i) - \sum(massofCinoutputstream_i)) \cdot \frac{44}{12}$$

$$E(steelEAF) = EF(steelinEAF) \cdot massofSteelproducedinEAF$$

$$TotalEmissions = \sum_i E(i)$$

The methane emissions were calculated using the equation:

$$TotalEmissions = QuantityOfSinterProduced \cdot EF(sinter) + QuantityOfCokeProduced \cdot EF(sinter)$$

where *EF(sinter)* = 0.07 kg/t and *EF(coke)* = 0.089 kg/t.

The N_2O emissions were calculated using the equation:

$$TotalEmissions = BFGflared \cdot EF(BFG) + ConverterGasFlared \cdot EF(converter)$$

where *EF(BFG)* = 5.6×10^{-7} t/ TJ and *EF(converter)* = 4.0×10^{-7} t/ TJ.

EFs of CO_2 are estimated annually on plant level, what is equal to country specific level in this case. Inter-annual fluctuations in emission factors are caused by two basic technological situations:

-different volume of iron scrap is added to the charge in steel making process,

-different amounts of gas fuels are produced in blast furnaces.

The average content of carbon in iron ore was 3.377 kg/t, in pig iron it was 18.45 kg/t and 0.834 kg/t in steel (data supplied directly) in 2022. Emission factors and other parameters are summarized in ***Tables 4.28-4.30***. The CO_2 emissions from the EAF process are estimated based on carbon balance, where all material flows are considered. Methane and nitrous oxide emissions for the whole time series are summarized in ***Tables 4.31-4.32.***

Iron and steel is produced by several plants (U.S.Steel Košice, a. s., UNEX Prakovce, Metalurg, Slovakia Steel Mills and by Ironworks Železiarne Podbrezová, a. s.). The manufacturer of iron and steel in blast furnaces (integrated production of iron and steel) produced pig iron (part of which was sold and not processed to steel) and 3 197.69 kt of steel in 2022 (decrease by 20% when compared with 2021). Total production of steel produced by the EAF technology was 365.53 kt in 2022. The plant UNEX Prakovce did not produce steel since 2013. New plant, Slovakia Steel Mills, started their production by the EAF technology in 2013. However, due to the sanctions to the Russian Federation, its production decreased and, in the end of 2014 the production was stopped. Since 2019, only one plant using EAF technology is in operation. Activity data on produced pig iron, what is sold to customers and not processed to steel are presented in 2.C.1.b. These data are presented without emissions because these emissions are balanced together with steel production and allocated in the 2.C.1.a.

Table 4.28: *Activity data, emission factors and CO_2 emissions in integrated iron and steel production in 2005 – 2022 that are reported in 2.C.1.a subcategory*

YEAR	Coal Cons.	Coke	NG Cons.	CG Output	BFG Output	Steel Prod.	Limestone Used	CO_2	IEF (CO_2)
	kt		*mil. M³*	*kt*				*Gg*	*t/t*
2005	2 594.52	-20.00	30.67	626.30	3 622.84	4 238.12	829.34	3 893.90	0.919
2006	2 853.64	179.00	37.68	670.28	4 665.12	4 836.49	781.85	4 391.72	0.908
2007	2 960.17	-147.00	26.31	682.77	3 838.94	4 784.81	606.74	4 140.88	0.865
2008	2 867.21	-152.00	22.11	668.56	3 693.60	4 229.40	464.33	3 992.89	0.944
2009	2 455.88	-85.00	20.27	592.13	3 378.26	3 642.28	518.34	3 479.24	0.955
2010	2 516.80	327.63	36.14	657.13	4 227.88	4 401.78	640.47	4 071.97	0.925
2011	2 503.00	-27.00	41.18	645.28	4 025.42	3 961.02	600.73	3 461.85	0.874
2012	2 709.17	-22.00	24.89	618.32	4 135.38	4 236.19	622.03	3 842.85	0.907
2013	2 482.48	-13.97	22.25	591.42	3 867.60	4 344.25	820.30	3 708.94	0.854
2014	2 606.36	74.98	20.13	604.21	3 958.03	4 439.48	973.80	4 024.91	0.907
2015	2 641.87	-29.98	20.18	657.42	3 586.84	4 310.94	800.39	4 018.99	0.932
2016	2 626.27	99.39	23.31	649.04	3 703.90	4 599.44	942.05	4 326.18	0.941
2017	2 650.44	150.69	19.37	784.45	3 894.35	4 712.96	961.71	4 319.01	0.916
2018	2 637.44	176.76	20.67	792.90	4 097.63	4 641.84	957.39	4 177.19	0.900
2019	2 279.01	28.15	21.04	549.83	3 018.73	3 608.95	749.44	3 543.54	0.982
2020	1 914.80	92.42	17.15	477.18	2 687.21	3 119.01	650.71	3 136.29	1.006
2021	2 677.74	108.19	18.60	578.35	4 002.59	4 560.37	963.27	4 264.48	0.935
2022	2 313.60	-41.41	18.08	538.54	3 197.69	3 558.10	767.63	3 313.75	0.931

CG = coking gas, BFG = blast furnace gas, con. = consumption, prod. = production

Table 4.29: *Production and CO_2 emissions in steel industry in 1990 – 2004*

YEAR	Steel Production	Limestone Used	CO_2 Emissions	IEF (CO_2)
	kt		*Gg*	*t/t*
1990	3 561.50	615.78	4 149.82	1.165
1991	3 163.40	540.44	3 015.13	0.953
1992	2 952.40	501.77	2 639.86	0.894
1993	3 205.40	555.13	4 337.65	1.353

YEAR	Steel Production	Limestone Used	CO_2 Emissions	IEF (CO_2)
	kt		*Gg*	*t/t*
1994	3 330.40	581.39	3 815.70	1.146
1995	3 207.40	562.16	4 304.41	1.342
1996	2 920.00	508.61	4 533.89	1.553
1997	3 072.30	542.47	4 547.00	1.480
1998	3 100.00	541.86	4 075.07	1.315
1999	3 420.00	527.61	3 967.28	1.160
2000	3 519.99	713.79	3 326.23	0.945
2001	3 751.85	660.08	3 356.97	0.895
2002	4 103.20	575.05	4 129.07	1.006
2003	4 382.92	608.29	3 956.26	0.903
2004	4 421.14	1 154.75	4 273.53	0.967

Table 4.30: *Activity data, emission factors (below) and CO_2 emissions in individual plants with EAF steel production in particular years*

YEAR	ŽELEZIARNE PODBREZOVÁ			SLOVAKIA STEEL MILLS			METALURG STEEL		
	Steel by EAF	Carbon	CO_2	Steel by EAF	Carbon	CO_2	Steel by EAF	Carbon	CO_2
			Gg			*Gg*			*Gg*
1990	C	3.81	13.97	NO	NO	NO	C	1.10	4.02
1995	C	3.88	14.22	NO	NO	NO	C	1.04	3.83
2000	C	3.88	14.22	NO	NO	NO	C	1.12	4.10
2005	C	3.41	12.49	NO	NO	NO	C	0.24	0.89
2010	C	4.47	16.37	NO	NO	NO	C	0.34	1.23
2011	C	7.06	25.88	NO	NO	NO	C	0.30	1.09
2012	C	4.64	17.00	NO	NO	NO	C	0.17	0.62
2013	C	3.97	14.55	C	10.85	39.80	C	0.00	0.01
2014	C	3.00	11.01	C	4.21	15.43	C	0.01	0.05
2015	C	2.49	9.14	NO	NO	NO	NO	NO	NO
2016	C	2.39	8.78	NO	NO	NO	C	0.01	0.04
2017	C	2.38	8.73	NO	NO	NO	C	0.08	0.28
2018	C	2.83	10.35	NO	NO	NO	C	0.08	0.28
2019	C	2.93	10.74	NO	NO	NO	NO	NO	NO
2020	C	2.60	9.53	NO	NO	NO	NO	NO	NO
2021	C	2.84	10.41	NO	NO	NO	NO	NO	NO
2022	C	2.82	10.35	NO	NO	NO	NO	NO	NO

YEAR	UNEX, PRAKOVCE		TOTAL		
	Steel by EAF	CO_2	Steel by EAF	CO_2	IEF
	kt	*Gg*	*kt*	*Gg*	*t/t*
1990	C	0.16	310.73	18.15	0.0584
1995	C	0.16	314.64	18.21	0.0579
2000	C	0.17	316.36	18.49	0.0584
2005	C	0.08	356.90	13.46	0.0377
2010	NO	NO	331.25	17.60	0.0531
2011	NO	NO	374.22	26.97	0.0721
2012	NO	NO	372.40	17.62	0.0473
2013	NO	NO	711.34	54.36	0.0764
2014	NO	NO	527.85	26.49	0.0502
2015	NO	NO	315.05	9.14	0.0290

YEAR	UNEX, PRAKOVCE		TOTAL		
	Steel by EAF	CO_2	Steel by EAF	CO_2	IEF
	kt	*Gg*	*kt*	*Gg*	*t/t*
2016	NO	NO	293.80	8.82	0.0300
2017	NO	NO	356.80	9.01	0.0253
2018	NO	NO	380.30	10.63	0.0280
2019	NO	NO	327.78	10.74	0.0328
2020	NO	NO	279.95	9.53	0.0341
2021	NO	NO	370.29	10.41	0.0281
2022	NO	NO	365.53	10.35	0.0283

Table 4.31: *Activity data and CH_4 emissions from integrated iron and steel plant*

YEAR	SINTER		COKE		TOTAL
	Production	CH_4 emission	Production	CH_4 emission	CH_4 emission
	kt				
1990	5 532.13	0.3872	1 199.29	0.1067	0.4940
1991	4 913.90	0.3440	1 065.27	0.0948	0.4388
1992	4 586.19	0.3210	994.23	0.0885	0.4095
1993	4 978.99	0.3485	1 079.38	0.0961	0.4446
1994	5 173.30	0.3621	1 121.50	0.0998	0.4619
1995	4 981.95	0.3487	1 080.02	0.0961	0.4449
1996	4 535.41	0.3175	983.22	0.0875	0.4050
1997	4 771.96	0.3340	1 034.50	0.0921	0.4261
1998	4 815.26	0.3371	1 043.89	0.0929	0.4300
1999	5 312.49	0.3719	1 151.68	0.1025	0.4744
2000	5 468.23	0.3828	1 185.44	0.1055	0.4883
2001	5 828.42	0.4080	1 263.52	0.1125	0.5204
2002	6 374.24	0.4462	1 381.85	0.1230	0.5692
2003	6 808.94	0.4766	1 476.09	0.1314	0.6080
2004	6 868.35	0.4808	1 488.97	0.1325	0.6133
2005	6 552.13	0.4586	1 420.42	0.1264	0.5851
2006	7 477.21	0.5234	1 620.96	0.1443	0.6677
2007	7 397.32	0.5178	1 603.64	0.1427	0.6605
2008	6 538.65	0.4577	1 417.49	0.1262	0.5839
2009	5 630.97	0.3942	1 220.72	0.1086	0.5028
2010	6 805.16	0.4764	1 475.27	0.1313	0.6077
2011	6 153.96	0.4308	1 334.10	0.1187	0.5495
2012	6 581.34	0.4607	1 426.75	0.1270	0.5877
2013	6 737.70	0.4716	1 460.64	0.1300	0.6016
2014	7 182.50	0.5028	1 446.66	0.1288	0.6315
2015	6 562.73	0.4594	1 504.28	0.1339	0.5933
2016	7 070.81	0.4950	1 512.39	0.1346	0.6296
2017	7 179.50	0.5026	1 472.05	0.1310	0.6336
2018	7 006.23	0.4904	1 483.81	0.1321	0.6225
2019	5 466.96	0.3827	1 306.39	0.1163	0.4990
2020	4 970.97	0.3480	1 110.74	0.0989	0.4468
2021	7 205.65	0.5044	1 524.99	0.1357	0.6401
2022	5 520.99	0.3865	1 385.53	0.1233	0.5098

Table 4.32: *Activity data and N_2O emissions from integrated iron and steel plant*

YEAR	BLAST FURNACE GAS		CONVERTER GAS		TOTAL
	Quantity flared	N_2O emission	Quantity flared	N_2O emission	N_2O emission
	TJ	*t*	*TJ*	*t*	*t*
1990	5 385.42	3.0158	1 148.60	0.4594	3.4753
1991	4 783.58	2.6788	1 020.21	0.4081	3.0869
1992	4 464.57	2.5002	952.16	0.3809	2.8810
1993	4 846.94	2.7143	1 033.75	0.4135	3.1278
1994	5 036.11	2.8202	1 074.07	0.4296	3.2498
1995	4 849.83	2.7159	1 034.40	0.4138	3.1297
1996	4 415.13	2.4725	941.71	0.3767	2.8492
1997	4 645.41	2.6014	990.83	0.3963	2.9978
1998	4 687.56	2.6250	999.76	0.3999	3.0249
1999	5 171.60	2.8961	1 102.96	0.4412	3.3373
2000	5 323.22	2.9810	1 135.21	0.4541	3.4351
2001	5 673.85	3.1774	1 209.99	0.4840	3.6614
2002	6 205.19	3.4749	1 323.30	0.5293	4.0042
2003	6 628.37	3.7119	1 413.51	0.5654	4.2773
2004	6 686.20	3.7443	1 425.84	0.5703	4.3146
2005	6 378.37	3.5719	1 366.81	0.5467	4.1186
2006	7 278.92	4.0762	1 559.79	0.6239	4.7001
2007	7 201.14	4.0326	1 543.12	0.6172	4.6499
2008	6 365.24	3.5645	1 364.00	0.5456	4.1101
2009	5 481.64	3.0697	1 174.65	0.4699	3.5396
2010	6 624.68	3.7098	1 419.59	0.5678	4.2777
2011	5 990.75	3.3548	1 277.44	0.5110	3.8658
2012	6 406.80	3.5878	1 366.19	0.5465	4.1343
2013	6 559.02	3.6730	1 401.04	0.5604	4.2335
2014	7 090.73	3.9708	1 508.14	0.6033	4.5741
2015	5 865.68	3.2848	1 398.03	0.5592	3.8440
2016	6 220.81	3.4837	1 646.25	0.6585	4.1422
2017	7 241.34	4.0552	1 514.47	0.6058	4.6609
2018	8 001.10	4.4806	1 365.17	0.5461	5.0267
2019	4 739.26	2.6540	880.65	0.3523	3.0062
2020	4 433.78	2.4829	979.78	0.3919	2.8748
2021	8 022.07	4.4924	1 753.80	0.7015	5.1939
2022	5 414.26	3.0320	1 288.12	0.5152	3.5472

Uncertainties and time-series consistency

Iron and Steel Production is the significant source of GHG emissions and key category in level and trend assessment, therefore important attention was paid on time series consistency. However, there are several comments to be mentioned:

Iron and Steel Production in blast furnaces: Natural gas was also used for heating of blast furnaces since 2000. Therefore, the IEF (CO_2) decreased from that year. The detailed data for country specific methodology described above are directly available for period 2005 – 2022. The older data (1990 – 2004) has been recalculated in previous submissions by using alternative recalculation techniques (surrogate method). The recalculation was based on the combined driver based on the mass of produced steel and pig iron and the total amount of coking coal used in the plant. Where available, the mass and composition of iron scraps, the mass and composition of iron ore and the mass of pig iron that was not processed to steel were considered to ensure the reliable results. This way of extrapolation

provided more consistent data (see comparison of IEF for the boundary years 2003 – 2007). The EU ETS reports are available since 2005, but no disaggregated data on fuel consumption or CO_2 emissions to the very bottom level are presented in these reports. The methodology used by plant operator in the EU ETS report is based on total mass balance and was used for comparison during QA/QC process.
The methane and nitrous oxide emissions estimates are reported for the first time in this submission. Detailed activity data are available since 2014. For the period 1990 – 2013, the surrogate method for extrapolation was used. Several drivers were tested. As the best ones, the following driver were used: (i) driver for the sinter production: the ratio of the sinter produced to the quantity of steel and pig iron produced. The uncertainty of the driver is 2.4%; (ii) driver for the coke production: the ratio of the coke produced to the quantity of steel and pig iron produced. The uncertainty of the driver is 5.0%; (iii) driver for the BFG: the ratio of the BFG flared to the quantity of steel and pig iron produced. The uncertainty of the driver is 1.9%; (iv) driver for the converter gas flaring: the ratio of the converter gas flaring to the quantity of steel produced. The uncertainty of the driver is 6.1%.

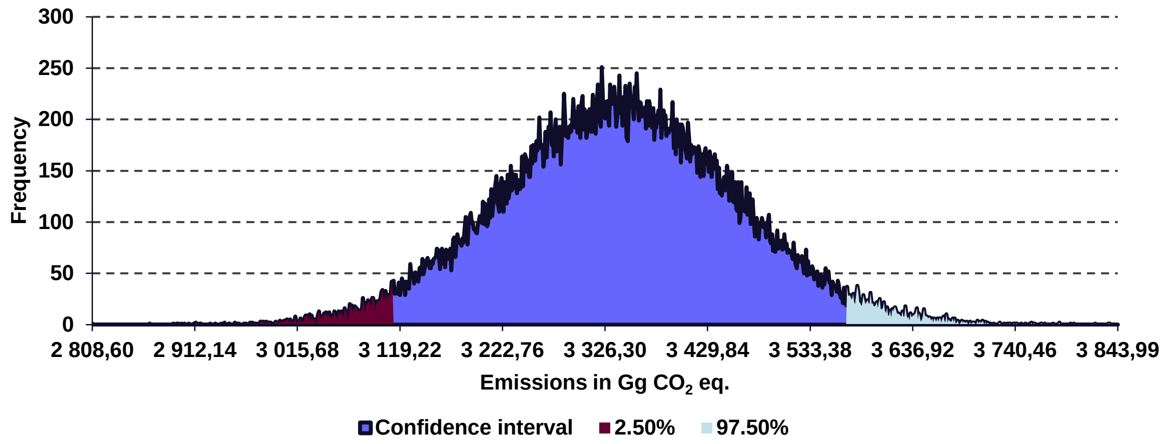
EAF Steel Production: Emissions estimation is based on the available country specific data and following assumptions

- Železiarne Podbrezová: the EU ETS reports are available since 2005. According to the questionnaires sent back by the producer for the period 2000 – 2004, the average value of carbon (in all material inputs) for production is 13.4 kg / 1 t of produced steel.
- Metalurg Steel: the EU ETS reports are available since 2005. Until 2006, the CO_2 emission factor was 0.165 t / 1 t of produced steel. This approach was based on the carbon balance made directly by the plant. Since 2007, direct consumption of carbon is available. From the data directly reported in the period 2007 – 2011, carbon consumption was extrapolated using driver method (steel production) back to 1990. The EF (CO_2) = 0.165 t/t was verified during this exercise. In 2015, the plant did not produce steel. Since 2019, the plant does not produce steel, as well.
- UNEX Prakovce: The plant is not included in the EU ETS. The default CO_2 emission factor was used (0.08 t/t) for produced steel. The plant did not produced the steel since 2010.
- Slovakia Steel Mills: the EU ETS report with detailed data is available since the start of the production (2013). The production in 2013 was high due to export to the Russian Federation (the RF). In 2014, after economic sanctions put on the RF, the export and subsequently production significantly decreased, too (production from 394 kt in 2013 to 177 kt in 2014 and CO_2 decreased from 40 Gg in 2013 to 15 Gg in 2014). This plant was closed in the end of 2014.

The above-mentioned assumptions were used for the CO_2 emissions estimation in the period 1990 – 1999, as well. Wide range of the EFs for the EAF steel production is based on the content of carbon in the scraps. One of the plants is using low carbon scraps (<0.1% of C). On the other hand, the other plant is using high carbon iron scraps (about 4% of C). Content of carbon in produced steel is approximately 1%. The unequal carbon content results in significantly different EFs.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. Compatible methodology to energy sector was used for uncertainty analyses in this category. Estimation is based on materials properties, activity data uncertainty was assumed to be 1.5%, uncertainties of NCVs and carbon contents were assumed to be 2%. Uncertainties of emission factors of CH_4 and N_2O were chosen in accordance with 2019 IPCC Refinement to be 400%. Based on calculation, the overall uncertainty of CO_2 emissions was calculated to be 6.84%.

__Figure 4.22:__ Probability density function for 2.C.1 (t of CO_2 eq.)



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
3 339.05	3 339.40	116.49	2 808.61	3 844.00	-6.78%	6.91%

4.9.2. Ferroalloys Production (CRF 2.C.2)

Ferroalloys are produced by the reduction reaction of iron ore and added metal and/or metalloid (Si) oxides in arc furnaces and submerged arc furnaces. Processing CO_2 and CH_4 (only from FeSi alloys) emissions from ferroalloys production were 75.98 Gg of CO_2 and 13.33 t of CH_4 in 2022. The decrease is by 70% when compared to the year 2021; which is accordance with the decrease of the production. According to the IPCC 2006 GL, also limestone used for the production was included in this estimation.

Methodological issues

The CO_2 emissions estimation is based on the carbon material balance (tier 2 approach) described in the IPCC 2006 GL:

CO_2 emissions = (C in coal materials + C in raw materials + C in carbonates – C in products) * 44/12

The methane emissions were calculated based on operation specific emission factors (tier 2). The production of FeSi started in 1998. Further information is provided in ***Tables 4.33-4.35***.

Plant specific emission factors are estimated annually (based on carbon balance). Methane emission factor is based on the operational specific default value 1.3 kg CH_4/1 t of FeSi ferroalloys for whole time series (IPCC 2006 GL). Information on activity data was taken directly from producers of ferroalloys provided in questionnaires and they are summarized in ***Table 4.33***.

__Table 4.33:__ Activity data used for carbon balance and CO_2 emissions in ferroalloys production in 2022

Carbon in "Raw Materials"	Carbon in Coals	Limestone Consumed	Carbon in Products	CO_2 Emissions
t				Gg
887.6	21 029.3	NO	1 194.8	75.981

__Table 4.34:__ Activity data, CO_2 and CH_4 emissions in ferroalloys production in 1990 – 2001

YEAR	FERROALLOYS				$CaCO_3$ Used	Total CO_2	EF (CO_2)	Total CH_4
	Based on Cr	Based on Mn	Based on Si	Total				
	kt						t/t	t
1990	53.000	116.000	NO	169.000	73.853	296.739	1.756	NO
1991	52.000	113.000	NO	165.000	72.105	289.618	1.755	NO

YEAR	FERROALLOYS				$CaCO_3$ Used	Total CO_2	EF (CO_2)	Total CH_4
	Based on Cr	Based on Mn	Based on Si	Total				
	kt						t/t	t
1992	50.000	110.000	NO	160.000	69.920	281.004	1.756	NO
1993	47.000	103.000	NO	150.000	65.550	263.394	1.756	NO
1994	34.000	111.300	NO	145.300	63.496	259.567	1.786	NO
1995	45.000	89.800	NO	134.800	58.908	235.642	1.748	NO
1996	46.000	84.000	NO	130.000	56.810	226.252	1.740	NO
1997	42.000	78.000	NO	120.000	52.440	209.025	1.742	NO
1998	44.000	81.000	8.666	133.666	58.412	246.984	1.848	11.27
1999	46.700	56.300	13.205	116.205	50.782	220.040	1.894	17.17
2000	17.658	69.458	7.611	94.727	41.396	182.446	1.926	9.89
2001	12.140	69.380	5.200	86.720	37.897	165.901	1.913	6.76

Table 4.35: *Activity data, CO_2 and CH_4 emissions in ferroalloys production in 2002 – 2022*

YEAR	$FeSi_{75}$	$FeSi_{65}$	$FeSi_{45}$	FeSiMn	FeMnC	FeCr	FeSiCa	Total
	kt							
2002	31.208	NO	NO	62.084	56.297	3.521	364	153.474
2003	41.539	NO	NO	52.773	43.434	1.654	1.155	140.555
2004	34.684	NO	NO	64.842	66.959	1.634	1.137	169.256
2005	13.943	1.710	859	47.843	43.458	894	11	108.718
2006	12.319	2.473	1.363	59.128	59.391	NO	NO	134.674
2007	8.417	112	NO	71.587	74.065	NO	NO	154.181
2008	9.510	941	393	59.940	61.194	NO	NO	131.978
2009	4.241	118	278	32.102	20.976	NO	NO	57.715
2010	16.274	9.519	626	34.960	35.449	NO	NO	96.828
2011	22.079	7.174	1.039	25.023	18.180	NO	4.066	77.561
2012	24.658	3.614	201	50.089	12.862	NO	10.168	101.592
2013	30.952	1.761	365	26.794	2.119	NO	3.685	65.676
2014	37.530	1.206	559	29.642	17.554	NO	4.735	91.226
2015	35.761	1.497	929	27.063	25.373	NO	4.898	95.521
2016	27.943	1.799	1.114	35.736	35.589	NO	4.086	106.267
2017	43.117	1.307	210	40.069	42.115	NO	2.661	129.479
2018	39.129	1.543	3.429	37.225	32.364	NO	NO	113.689
2019	27.566	808	1.060	49.897	26.187	NO	NO	105.518
2020	27.679	0.812	1.066	33.812	24.045	NO	1.182	88.596
2021	32.797	0.849	1.145	48.590	30.929	NO	1.478	115.788
2022	10.007	0.250	0.365	15.242	9.106	NO	0.458	35.428

YEAR	$CaCO_3$ Used	Total CO_2	EF (CO_2)	Total CH_4
	kt		t/t	t
2002	67.068	333.657	2.174	40.57
2003	61.423	328.038	2.334	54.00
2004	73.965	371.066	2.192	45.09
2005	47.510	227.646	2.094	20.35
2006	58.853	275.660	2.047	19.23
2007	67.377	301.324	1.954	11.09
2008	57.674	263.043	1.993	13.59
2009	25.221	115.512	2.001	5.67

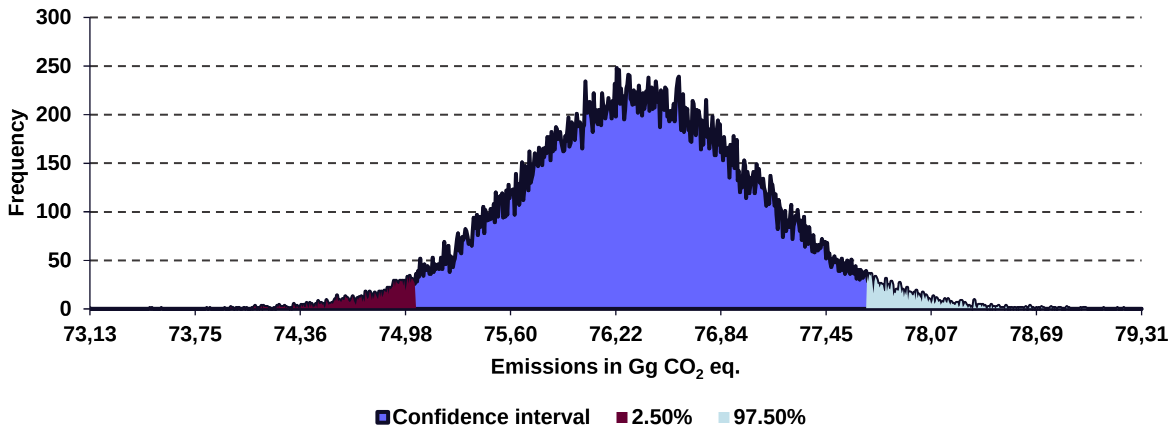
YEAR	CaCO$_3$ Used	Total CO$_2$	EF (CO$_2$)	Total CH$_4$
	kt		t/t	t
2010	42.314	219.069	2.262	33.53
2011	33.894	201.979	2.604	38.03
2012	44.396	265.502	2.613	36.75
2013	28.713	165.003	2.512	42.53
2014	41.893	222.894	2.443	50.36
2015	6.428	239.671	2.509	48.43
2016	4.824	237.053	2.482	38.66
2017	4.344	293.887	3.077	57.75
2018	323	281.565	2.948	52.87
2019	NO	239.101	2.503	36.89
2020	NO	214.524	2.421	37.04
2021	NO	251.900	2.843	43.74
2022	NO	75.981	2.145	13.33

Uncertainties and time-series consistency

Carbon balance for CO_2 emissions (and EFs) estimation is used since 2002. Before 2002, a different aggregation of production data is available. EFs in the period 1990 – 2001 are constant and were calculated from available data (1.684 t/t of ferroalloys based on Mn, 1.3 t/t of ferroalloys based on Cr and 3.194 t/t of ferroalloys based on Si). In previous submissions (period 1990 – 2001) verification of emissions calculation was made as follows: (i) the activity data for the period 2002 – 2010 were aggregated in the same way as data available for the years 1900 – 2001; (ii) CO_2 emissions for the period 2002 – 2010 were calculated using the emission factors reported above and compared with the carbon balance method. The difference between these estimations did not exceed 0.6%. Significant increase in emissions since 2002 is caused by the change of the new plant owner´s plans and the new market situation. The using of calcium carbonate in the plant ended during 2018.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. Following input parameters were applied for the uncertainty analyses in this category: carbon content in materials and products (2.0%), mass of raw materials and products (1.5%). Additionally, not only CO_2, but also CH_4 emissions from FeSi were included in calculation. The default value of CH_4 emission factor uncertainty was used (10%). The overall uncertainty is 1.74%.

Figure 4.23: *Probability density function for 2.C.2 (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
76.35	76.35	0.68	73.13	79.31	-1.72%	1.76%

4.9.3. Aluminium Production (CRF 2.C.3)

Aluminium is produced by the electrolysis of alumina dissolved in cryolite-based melt (t = 950°C). The main additives to cryolite (Na_3AlF_6) are aluminium fluoride (AlF_3) and CaF_2. In Slovakia, the plants for aluminium production use a modern technology where the majority of HF and other fluorides escaped from the electrolytic cells is absorbed and adsorbed on alumina. Alumina is used subsequently in the electrolytic process. The anodes are made from graphite. So-called pre-baked anodes for aluminium production are made in separate plants. Due to this technology, emissions are much lower than in the Søderberg process. The release of CF_4 and C_2F_6 emissions can occur at a special technological disturbance (the anode effect). Because of the progress in process control, this irregularity occurs only (1-2) times in a month. Implementation of IPCC 2019 Refinement resulted in the dividing of PFC emission into two sources: (i) high-voltage anode effect (HVAE) that corresponds to the "common" anode effect as described above; (ii) low-voltage anode effect (LVAE) that was not described in IPCC 2006 Guidance, however, it is described in IPCC 2019 Refinement as a new source of PFC emission.

In the middle of 2022, the aluminium plant was closed due to the high prices of electrical energy. Therefore, the production and emissions decreased very rapidly in this category.

Methodological issues

Tier 3 in combination with tier 2 method based on plant specific emission factors and activity data was applied since 2004 in CO_2 and HVAE PFCs emissions estimation. According to the information from producers, 28 555 t of graphite anodes were used with the sulphur and ash contents 1.37% and 0.16%, respectively, in 2022. The CO_2 emissions from electrolysis were estimated based on the IPCC 2006 GL multiplying the volume of used anodes by carbon content and 44/12 (103.10 Gg CO_2 in 2022). The CO_2 emissions from pitch volatiles combustion and from bake furnace packing material were calculated by the tier 3 method (eq. 4.22 and 4.23 of the IPCC 2006 GL, Volume 3, Chapter 4) and were as follows: 4.60 Gg and 3.75 Gg, respectively. Before 1996, default EF (CO_2) = 1.8 t/t for Søderberg process had been used. Since that year, the CO_2 emission factors are evaluated annually in agreement with the tier 3 method described in the IPCC 2006 GL.

The total PFC emissions were 0.87 t (5.88 Gg of CO_2 eq.) in 2022. The HVAE PFC emission was calculated according to the Slope method (tier 2) with default values of Slope coefficient and ratio of CF_4/C_2F_6. According to the data from the plant operator, the number of anode effects per pot day equals to 0.052 and their average duration was 0.55 min in 2022. On the other hand, the LVAE PFC emissions was calculated using Tier 1 method (with EF(CF_4) = 0.009 kg / t of aluminium). There is not methodology for tier 2, and tier 3 requires specific measurements that were not realized in the plant.

For the aluminium electrolysis, the consumption of graphite in electrolysis was 28 555 t and from 39 603 t of "green" anodes 37 995 t of anodes was produced. SF_6 is not used in aluminium castings in the Slovak Republic.

Table 4.36: *CO_2 emissions and EFs in aluminium production in particular years*

YEAR	Aluminium Production	CO_2 (Electrolysis)	CO_2 (Anode Production)	Total CO_2	EF per Aluminium
	kt			*Gg*	*t/t*
1990	67.40	121.32	NE	121.32	1.8000
1995	32.60	58.68	NE	58.68	1.8000
2000	109.81	160.33	16.23	176.56	1.6078
2005	159.20	230.69	23.53	254.22	1.5968
2010	163.00	239.38	24.09	263.47	1.6164
2011	162.84	237.21	24.07	261.28	1.6045
2012	160.66	235.77	23.75	259.52	1.6153
2013	163.30	241.10	24.14	265.24	1.6243
2014	167.67	246.07	19.93	266.00	1.5865

YEAR	Aluminium Production	CO_2 (Electrolysis)	CO_2 (Anode Production)	Total CO_2	EF per Aluminium
	kt			Gg	t/t
2015	171.33	253.74	22.59	276.33	1.6129
2016	173.64	257.08	14.34	271.41	1.5631
2017	173.49	257.97	16.04	274.01	1.5794
2018	173.72	256.20	19.33	275.53	1.5860
2019	174.79	256.20	18.51	274.71	1.5716
2020	151.87	223.24	15.47	238.71	1.5717
2021	164.00	241.54	17.14	258.68	1.5773
2022	71.93	103.10	8.35	111.45	1.5493

Table 4.37: *PFC emissions and EFs in aluminium production in particular years*

YEAR	HVAE CF_4	EF per Aluminium	HVAE C_2F_6	EF per Aluminium	LVAE CF_4	Total PFC
	t	kg/t	t	kg/t	t	Gg CO_2 eq.
1990	28.15	0.4176	2.42	0.0359	0.07	28.15
1995	11.86	0.3637	1.02	0.0313	0.03	90.15
2000	1.30	0.0118	0.13	0.0011	0.99	16.56
2005	2.28	0.0143	0.22	0.0014	1.43	27.09
2010	2.41	0.0148	0.23	0.0014	1.47	28.27
2011	1.93	0.0119	0.19	0.0012	1.47	24.63
2012	2.47	0.0154	0.24	0.0015	1.45	28.62
2013	0.94	0.0058	0.09	0.0006	1.47	17.02
2014	1.07	0.0064	0.10	0.0006	1.51	18.27
2015	0.82	0.0048	0.08	0.0005	1.54	16.53
2016	0.62	0.0036	0.06	0.0003	1.56	15.17
2017	0.83	0.0048	0.08	0.0005	1.56	16.75
2018	0.75	0.0043	0.07	0.0004	1.56	16.14
2019	0.50	0.0029	0.05	0.0003	1.57	14.28
2020	0.54	0.0036	0.05	0.0003	1.37	13.22
2021	0.57	0.0035	0.06	0.0003	1.48	14.19
2022	0.21	0.0029	0.02	0.0003	0.65	5.88

Uncertainties and time-series consistency

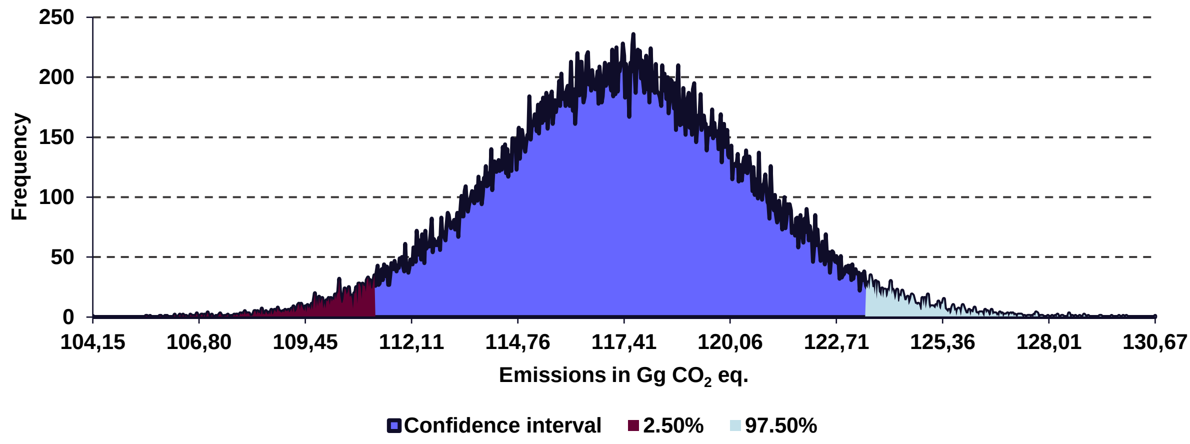
The technology was changed from Søderberg to prebaked technology in 1996. It results in significant decrease of CO_2 and PFC emissions. The CO_2 emissions were calculated by using the tier 1 method in the period 1990 – 1995 due to lack of detailed data. Due to the changes in ownership of the plant (and new producing policy), higher tier method can be implemented since 1996. Input data necessary for tier 3 method are available since 2005. Average CO_2 emission factor calculated from years 2005 and 2010 – 2012 was used also for years 1996 – 2004 (emission factors based on the years 2006 – 2009 could not be used due to technological reasons. Background data about it were made available and accepted by the ERT during in-country review in 2012). According to the questionnaire sent by producer, the significant progress in control of the electrolysis was achieved in 2009 (this information is confidential but was provided together with the reasoning of the IEF (CO_2) decrease during the in-country review in 2012). The improvements in production resulted also in decrease of PFC emissions after 2009. Further improvement in better performance controlling process of electrolysis cells continues until now. The CO_2 emissions from pitch volatiles combustion and from bake furnace packing material were calculated in 2013 for the first time (according to the IPCC 2006 GL) and the resulting implied emission factor per produced aluminium was estimated. This IEF was also used for the time series 1996

– 2012. This IEF is almost without change also for next years and recalculation of the time series 1996 – 2012 is not necessary.

In this submission, the new source of PFC emission was adopted from IPCC 2019 Refinement. The emissions reported so far represented emissions from HVAE as it is now defined in IPCC 2019 Refinement. They were recalculated using new default coefficients of the Slope method. New source of PFC emission from LVAE was calculated using the default emission factors for the corresponding technologies used.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. The uncertainties in the mass of used materials and products (1.5%), the consumption of anodes (3.0%), contents of sulphur and ash in anodes (5.0%) were used. For the calculation of PFC emission estimates plant specific uncertainties for AE frequency (5.0%) and AE duration (2.0%), together with the default uncertainties for the slope (45.0%) and C_2F_6/CF_4 ratio (35.0%) and default emission factor for LVAE (100%) for the respective technology were used. Based on calculation, the overall uncertainty was calculated to be 5.23%.

Figure 4.24: *Probability density function for 2.C.3 (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
117.32	117.32	3.13	104.15	130.67	-5.24%	5.21%

4.9.4. Magnesium Production (CRF 2.C.4)

This production does not occur in the Slovak Republic, therefore the notation key "NO" for time series was used.

4.9.5. Lead Production (CRF 2.C.5)

Lead is produced only from secondary raw materials in Slovakia. This production started in Imperial Smelt Furnaces in 2011 and is not significant. The CO_2 emission was 80.00 t in 2022.

Methodological issues

This category is not key category and therefore tier 1 method based on the IPCC 2006 GL was used for whole time series.

Default EF (0.2 t/t) for CO_2 emissions from treatment of secondary raw materials was used for whole time series. According to the direct information from the plant operator, 400 t of lead was produced from the secondary raw materials in 2022.

Table 4.38: The overview of activity data and CO_2 emissions from lead production in 1990 – 2022

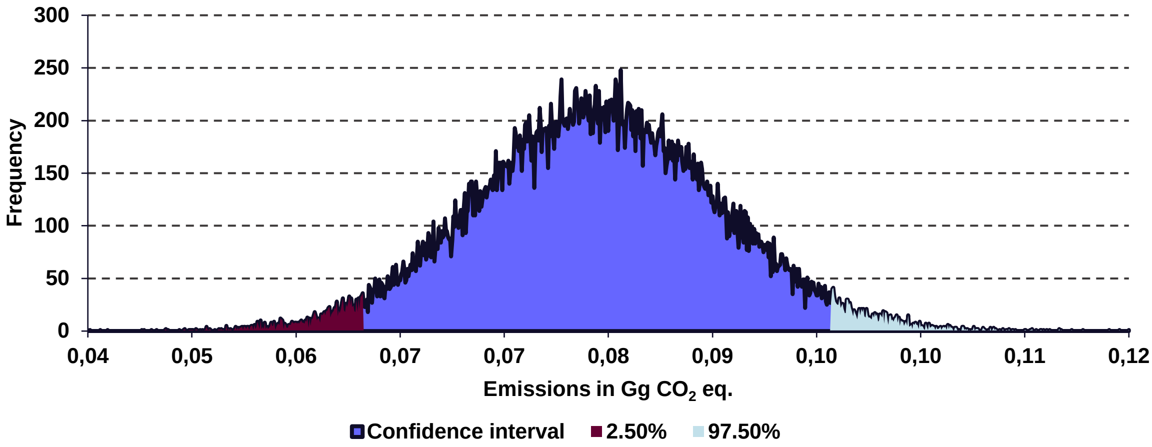
YEAR	Lead Production from Secondary Materials	CO_2 Emissions	IEF (CO_2)
	t		t/t
1990-2010	NO	NO	NA
2011	49.81	9.96	0.2
2012	203.63	40.73	0.2
2013	261.10	52.22	0.2
2014	292.70	58.54	0.2
2015	323.12	64.62	0.2
2016	292.05	58.41	0.2
2017	303.83	60.77	0.2
2018	47.60	9.52	0.2
2019	66.00	13.20	0.2
2020	125.00	25.00	0.2
2021	155.00	31.00	0.2
2022	400.00	80.00	0.2

Uncertainties and time-series consistency

Tier 1 method according to the IPCC 2006 GL is used in whole time series.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. The uncertainties in the mass of produced lead (1.5%) and EF (20%) were used in uncertainty analyses by Monte Carlo method. Based on calculation, the overall uncertainty of CO_2 emissions in eq. was calculated to be 20.20%.

Figure 4.25: Probability density function for 2.C.5 (t of CO_2 eq.)



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
0.080	0.080	0.009	0.045	0.117	-20.19%	20.29%

4.9.6. Zinc Production (CRF 2.C.6)

Zinc is produced by pyrometallurgical process involving the use of an Imperial Smelting Furnace, which allows the simultaneous treatment of lead and zinc concentrates in Slovakia and is not significant. This production started in 2012. Since 2015, the production was not occurring.

Methodological issues

This category is not key category and therefore tier 1 method based on the IPCC 2006 GL was used for whole time series.

Default EF (0.43 t/t) for CO_2 emissions from pyrometallurgical process was used for whole time series. According to the direct information from the plant operator, no zinc was produced in 2022.

***Table 4.39:** The overview of activity data and CO_2 emissions from zinc production in 1990 – 2022*

YEAR	Zinc Production (Pyrometallurgical - ISF)	CO_2 Emissions	IEF (CO_2)
	t		*t/t*
1990 – 2011	NO	NO	NA
2012	43.90	18.88	0.43
2013	31.45	13.52	0.43
2014	23.94	10.29	0.43
2015 – 2022	NO	NO	NA

4.10. Non-energy Products from Fuels and Solvent Use (CRF 2.D)

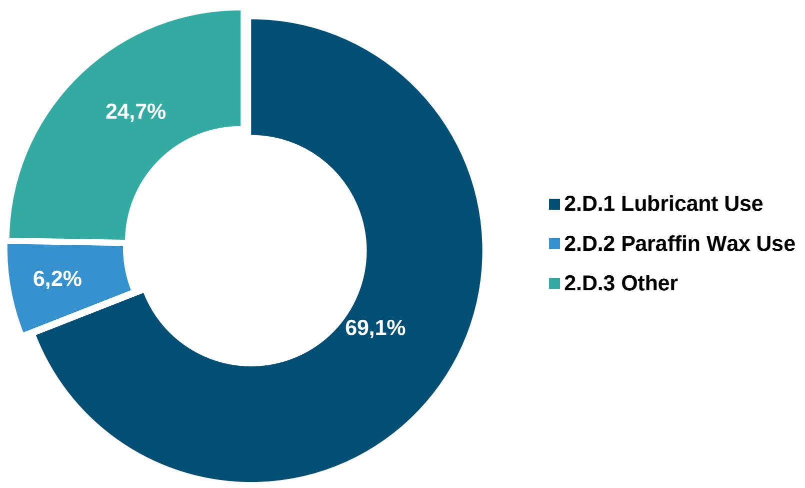
This category produces emissions of CO_2 and NMVOC. Based on known composition of NMVOC emissions, indirect (potential) CO_2 emissions were calculated in this submission, too. Direct CO_2 emissions were 40.77 Gg in 2022 and increased by approximately 20% compared with the previous year. When comparing with the base year, the decrease was 19% mostly caused by the decrease use of lubricants.

***Table 4.40:** Emissions in the category 2.D according to subcategories in particular years*

YEAR	2.D.1 Lubricant Use	2.D.2 Paraffin Wax Use	2.D.3 Other
	Gg of CO_2 eq.		
1990	48.02	2.46	NO
1995	48.02	2.46	NO
2000	48.02	2.46	NO
2005	28.94	1.23	NO
2010	12.39	2.54	2.01
2011	18.52	1.90	3.48
2012	27.11	2.52	3.93
2013	32.51	2.54	6.05
2014	26.58	3.17	6.42
2015	26.85	2.54	6.07
2016	26.40	2.54	8.55
2017	28.46	2.52	8.98
2018	28.88	1.90	9.54
2019	23.61	2.54	8.81
2020	19.05	2.54	8.26
2021	21.58	2.54	9.70
2022	28.15	2.54	10.08

The major share (69.1%) in emissions belongs to the lubricant use category, 24.7% belongs to the other used (urea use) and 6.2% to the paraffin wax use.

Figure 4.26: *The share of GHG emissions in individual subcategories of the 2.D in 2022*



In 2021 submission, recalculations were focused on the NMVOC emissions from solvent use have been prepared since the base year 1990. Also, harmonization between the GHG a CLRTAP inventories continuing and the completion of the QA/QC process of NMVOC emissions in 2.D.3 categories was finished in 2020 and presented in 2021 submission. The results are summarised in the **Annex 4.4** of NIR 2022. Moreover, CO_2 emissions resulted from the NMVOC emissions are indirect and are reported according to the document "Conclusions and recommendations from the 17th meeting of greenhouse gas inventory lead reviewers". No recalculation was made in this submission regarding the indirect CO_2 emissions.

4.10.1 Lubricant Use (CRF 2.D.1)

Lubricants are mostly used in industry and transport. The CO_2 emissions estimated in Slovakia from this category were 28.15 Gg in 2022.

Methodological issues

This category is not key category and therefore tier 1 method based on the IPCC 2006 GL was used for whole time series.

Default carbon content (20 t CO_2/TJ) and ODU (Oxidized During Use) factor (0.2) according to the IPCC 2006 GL was used.

Activity data of non-energy use of lubricants are available from the Statistical Office of the Slovak Republic. Total volume of lubricants for non-energy use in Slovakia was 1 920.7 TJ in 2022. Due to technical reasons, the activity data in this category are presented in CRF Tables in kilotons units.

Due to lack of relevant statistics, data for the time series 1990 – 2001 were approximated by the Statistical Office of the Slovak Republic.

Table 4.41: *The overview of activity data and CO_2 emissions in lubricant non-energy use in particular years*

YEAR	Lubricant Use	Lubricants Use	CO_2 Emissions
	kt	*TJ*	*Gg*
1990	78	3 276.8	48.024
1995	78	3 276.8	48.024
2000	78	3 276.8	48.024

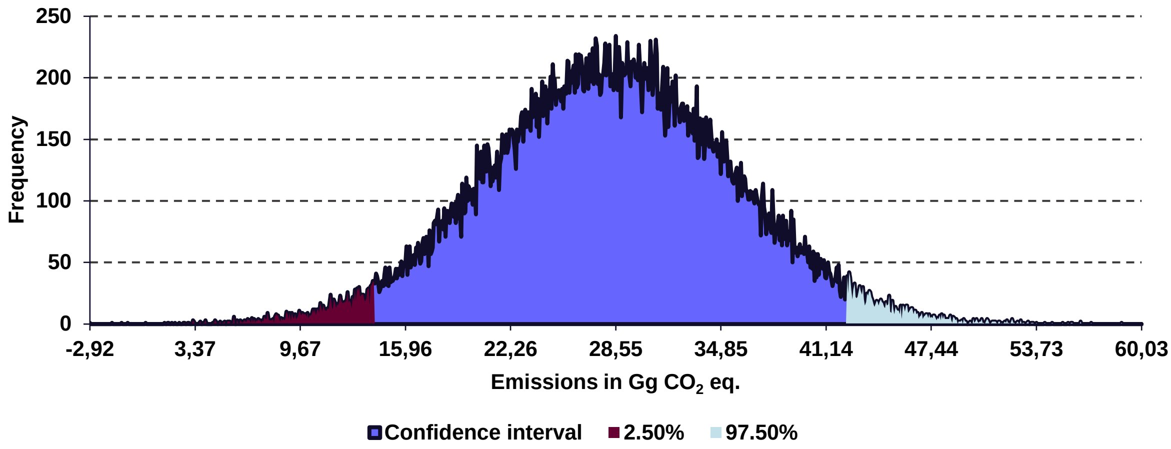
YEAR	Lubricant Use	Lubricants Use	CO_2 Emissions
	kt	TJ	Gg
2005	47	1 974.5	28.938
2010	20	845.2	12.388
2011	30	1 263.5	18.517
2012	44	1 849.5	27.106
2013	53	2 218.4	32.513
2014	44	1 813.4	26.577
2015	45	1 831.8	26.847
2016	46	1 801.5	26.402
2017	47	1 941.5	28.455
2018	47	1 970.4	28.878
2019	39	1 611.1	23.612
2020	31	1 300.0	19.053
2021	35	1 472.5	21.581
2022	46	1 920.7	28.150

Uncertainties and time-series consistency

Tier 1 method according to the IPCC 2006 GL is used in whole time series.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. The uncertainties in the mass of used lubricants (3%), NCV uncertainty (2%), carbon content in lubricants uncertainty (3%) and ODU uncertainty (50%) were used in uncertainty analyses by Monte Carlo method for this category. Based on calculation, the overall uncertainty of CO_2 emissions in eq. was calculated to be 50.23%.

Figure 4.27: *Probability density function for 2.D.1 (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
28.17	28.19	7.23	2.92	60.03	-50.08%	50.36%

4.10.2. Paraffin Wax Use (CRF 2.D.2)

Paraffin waxes are mostly derived by combustion of waxes derivate of paraffin (e.g. candles). The CO_2 emissions estimated in Slovakia from this category were 2.54 Gg in 2022.

Methodological issues

This category is not key category and therefore tier 1 method based on the IPCC 2006 GL was used for whole time series. Default carbon content (20 t CO_2/TJ) and ODU factor (0.2) according to the IPCC 2006 GL was used. Activity data on non-energy use of paraffin wax in Slovakia are available from the Statistical Office of the Slovak Republic. Total volume of paraffin wax for non-energy use in Slovakia was 173.2 TJ (4 kt) in 2022. No paraffin wax was reported in the years 2004 and 2006 (based on the statistical data). Due to lack of relevant statistics, data for the time series 1990 – 2002 were approximated by the Statistical Office of the Slovak Republic.

Table 4.42: *The overview of activity data and CO_2 emissions in paraffin wax non-energy use in particular years*

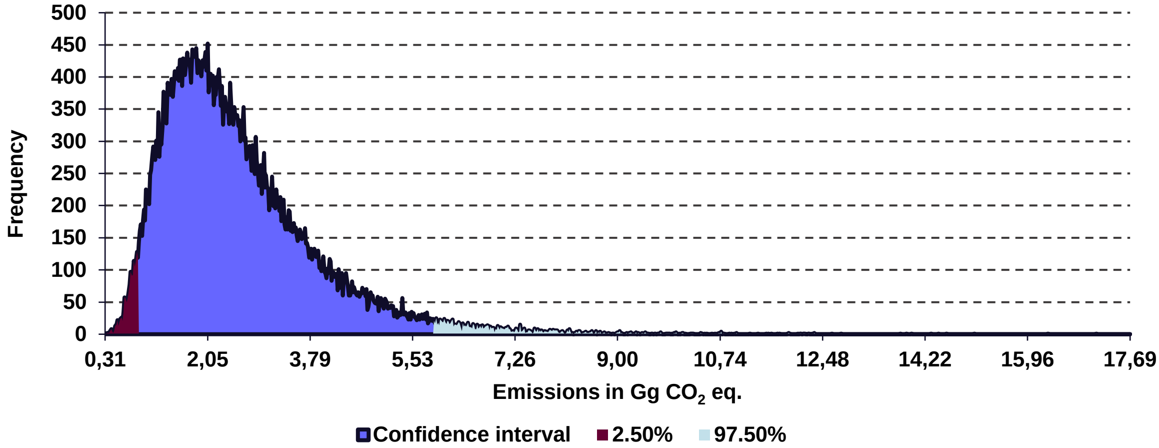
YEAR	Paraffin Wax Use	Paraffin Wax Use	CO_2 Emissions
	kt	*TJ*	*Gg*
1990	4	168.04	2.46
1995	4	168.04	2.46
2000	4	168.04	2.46
2005	2	84.02	1.23
2010	4	173.20	2.54
2011	3	129.90	1.90
2012	4	172.00	2.52
2013	4	173.20	2.54
2014	5	216.50	3.17
2015	4	173.20	2.54
2016	4	173.20	2.54
2017	4	172.00	2.52
2018	3	129.90	1.90
2019	4	173.20	2.54
2020	4	173.20	2.54
2021	4	173.20	2.54
2022	4	173.20	2.54

Uncertainties and time-series consistency

Tier 1 method according to the IPCC 2006 GL is used in whole time series.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. The uncertainty in the mass of used paraffin wax was assumed in the absolute value to be 0.5 kt. This approach was chosen due to the reporting of the wax mass in the rounded whole numbers in statistical data. Because low amount of wax, the rounding can significantly influence the total mass of paraffin wax. Based on this, it was assumed that the value from statistics should be (4±0.5) kt, which represents the uncertainty 12.5%. The NCV uncertainty (2.5%), carbon content in paraffin uncertainty (5%) and ODU uncertainty (100%) were used in uncertainty analyses by Monte Carlo method for this category. Based on calculation, the overall uncertainty of CO_2 emissions in eq. was calculated to be 101.25%.

Figure 4.28: *Probability density function for 2.D.2 (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
2.26	2.55	1.32	0.31	17.69	-65.76%	130.24%

4.10.3. Other (CRF 2.D.3)

This category includes potential CO_2 and NMVOC emissions from solvent use, road paving with asphalt. CO_2 emissions were calculated from solvent use, where composition of NMVOC emissions is known. It should be noted that CO_2 emissions represent only potential emissions originate from the oxidation of NMVOC emissions. Total NMVOC emissions from solvent use, road paving with asphalt and asphalt roofing were estimated in the frame of the National Program for Emission Reduction of Non-Methane Volatile Organic Compounds in the Slovak Republic.

Collection of available input data of solvents used in industry was the most challenging step in inventory preparation. Official statistical information in this area was insufficient, so it was decided directly requested producers, importers, distributors and users of solvents and other products. This inventory was prepared in the consistency with the CLRTAP inventory. During last several submissions, the CLRTAP inventory was recalculated in several 2.D.3 subcategories. The results of the recalculation were always adopted in GHG inventory, which resulted in the recalculation of NMVOC and CO_2 emissions in 2.D.3 category since the base year. In 2020, the thorough QA/QC process focused on the harmonisation of the CLRTAP (NECD) and the GHG inventories for the 2.D.3 categories was finished, and the recalculation was necessary in previous submission. More information about the comparison of changes among submissions and detailed activity data can be found in the **Annex 4.4** of NIR 2022 and detailed information is presented in the CLRTAP submission 2022. The respective indirect CO_2 were calculated on the basis of stoichiometry of NMVOC emissions.

Urea used in catalytic converters is reported in this category. The use of urea in catalytic converters can occur in vehicles and in industrial plants. The CO_2 emissions from urea based catalysts were estimated using COPERT 5 model. The fuel consumption of diesel oil corresponding heavy duty trucks and passenger cars with SCR are included in the category 1.A.3.b.

The use of urea in industrial plants is reported in Slovakia since 2016. This possible use of urea is annually monitored by questionnaires that are sent to the operators. The only NO_x reduction method used in Slovakia before 2016 occurred in the ammonia plant where ammonia is used for reduction purposes and no CO_2 emissions occur at this method. Since 2016, due the new emission limits for NO_x, seven plants started using the DeNOx technologies. Three of them are using the ammonia, the rest are using the urea.

Total direct GHG emissions in this category were 10.08 Gg of CO_2 eq. in 2022. Total NMVOC emissions were 17.89 kt. ***Table 4.38*** summarizes CO_2 and NMVOC emissions for particular years of time series.

Table 4.43: *CO_2 and NMVOC emissions (Gg) in 2.D.3 in particular years*

YEAR	NMVOC Emissions	Indirect CO_2 Emissions	Direct CO_2 Emissions
	kt	*Gg*	
1990	38.495	87.769	NO
1995	35.824	82.085	NO
2000	29.601	65.444	NO
2005	30.732	66.929	NO
2010	22.416	49.201	2.012
2011	26.146	57.615	3.484
2012	21.197	46.484	3.925
2013	21.088	46.413	6.052
2014	22.502	49.541	6.421
2015	25.643	56.344	6.073
2016	23.925	52.517	8.549
2017	21.725	47.481	8.981
2018	24.154	53.114	9.539
2019	20.547	45.301	8.807
2020	20.851	45.875	8.258
2021	19.886	43.666	9.695
2022	17.890	39.505	10.077

Methodological issues

In the CLRTAP inventory, 2.D.3 category consists of following subcategories:

- 2.D.3.a Domestic solvent use including fungicides
- 2.D.3.b Road paving with asphalt
- 2.D.3.c Asphalt roofing
- 2.D.3.d Coating application
- 2.D.3.e Degreasing
- 2.D.3.f Dry cleaning
- 2.D.3.g Chemical products
- 2.D.3.h Printing
- 2.D.3.i Other solvent use

In the GHG inventory, all categories except of 2.D.3.b and 2.D.3.c are reported under 2.D.3 Other – Solvent Use. Categories 2.D.3.b and 2.D.3.c are reported separately in 2.D.3 Other – Road paving with asphalt and 2.D.3 Other – Asphalt roofing.

During the QA/QC process performed in last years, a great effort was made to identify the chemical compounds in NMVOC emissions. 97 chemical compounds were identified. Due to this large number, the list of the chemical compounds is not presented in the report, however, it is available to the ERT. Carbon content in the chemical compounds was calculated based on the stoichiometry of the molecule. For the others NMVOC emissions the carbon content was assumed to be the default value (0.6). The identification of large number of chemical compounds in the NMVOC emissions, made the CO_2 emissions estimate more accurate than in the previous submissions where only several groups of the chemicals were reported. CO_2 emissions were calculated for each subcategory separately (2.D.3.a – 2.D.3.i) since the year 2000. Extrapolation by the trend was used for the years 1990 – 1999 for each category, as well. The results are presented in ***Tables 4.43-4.44***. Detailed data are presented in the **Annex 4.4** of NIR 2022.

The CO_2 emissions from urea based catalysts from cars were estimated using COPERT 5 model for vehicle category “Heavy duty trucks Euro V 2008 Standards” and “Passenger cars Diesel PC Euro 6 up to 2016” for the years 2010 – 2022. As the number of vehicles with SCR technology is not known, the default value in COPERT model 5 was used. The urea based catalysts were not used before 2010. More information is included in the Chapter 3 of this Report. The CO_2 emissions from urea based catalysts in industry were calculated from the amount of used urea in industrial DeNOx technologies. Activity data on the urea use were reported in the CRF reporter as the sum of the urea used for industrial DeNOx technologies and of its use in vehicles. However, the concentration of urea solution in cars is assumed to be 32% in COPERT 5 model, while the concentration of the urea in industrial DeNOx technologies is usually 40%. Therefore, the consumption of urea from use in vehicles was estimated by reverse calculation from the CO_2 emissions in the term of the pure urea and summed with the pure urea (calculated from the 40% solution) from industrial technologies. In the NIR, the activity data on the urea use are reported separately according to the ERT recommendation I.5 based on the ARR 2022. The CO_2 emissions from urea based catalysts are presented in ***Table 4.46***.

Table 4.44: *NMVOC and CO_2 emissions in solvent use category in particular years*

YEAR	NMVOC Emissions	Indirect CO_2 Emissions
	kt	*Gg*
1990	38.386	87.512
1995	35.771	81.961
2000	29.575	65.382
2005	30.708	66.874
2010	22.399	49.164
2011	26.125	57.570
2012	21.179	46.446
2013	21.070	46.373
2014	22.486	49.504
2015	25.622	56.297
2016	23.904	52.471
2017	21.705	47.436
2018	24.132	53.066
2019	20.529	45.261
2020	20.834	45.837
2021	19.863	43.615
2022	17.867	39.454

Table 4.45: *NMVOC and CO_2 emissions from asphalt using in particular years*

YEAR	Road Paving with Asphalt	Asphalt Roofing	Road Paving with Asphalt	Asphalt Roofing	Road Paving with Asphalt	Asphalt Roofing
	Asphalt use in kt		*NMVOC in t*		*Indirect CO_2 in t*	
1990	366.8	130.2	62.355	46.717	154.994	102.777
1995	171.0	65.9	29.067	23.659	72.251	52.051
2000	52.5	46.5	10.363	16.323	25.760	35.910
2005	113.0	32.3	19.138	5.773	42.103	12.701
2010	102.4	25.3	14.373	2.402	31.620	5.285
2011	121.0	28.1	18.230	2.411	40.105	5.304
2012	102.3	27.6	14.870	2.340	32.715	5.147
2013	86.0	41.0	15.197	2.907	33.434	6.396
2014	79.2	59.4	13.746	2.635	30.242	5.797

YEAR	Road Paving with Asphalt	Asphalt Roofing	Road Paving with Asphalt	Asphalt Roofing	Road Paving with Asphalt	Asphalt Roofing
	Asphalt use in kt		*NMVOC in t*		*Indirect CO_2 in t*	
2015	147.3	37.9	20.067	0.973	44.147	2.141
2016	150.8	66.4	18.942	1.959	41.672	4.310
2017	115.0	50.6	18.737	1.290	41.221	2.838
2018	146.0	68.5	19.933	2.096	43.852	4.611
2019	132.5	63.7	16.455	1.900	36.201	4.180
2020	132.9	65.0	15.082	2.186	33.180	4.810
2021	154.8	79.0	20.829	2.229	45.823	4.904
2022	163.1	59.4	20.953	2.114	46.096	4.652

Table 4.46: *CO_2 emissions originating from the use of urea in catalytic converters in 2010 – 2022*

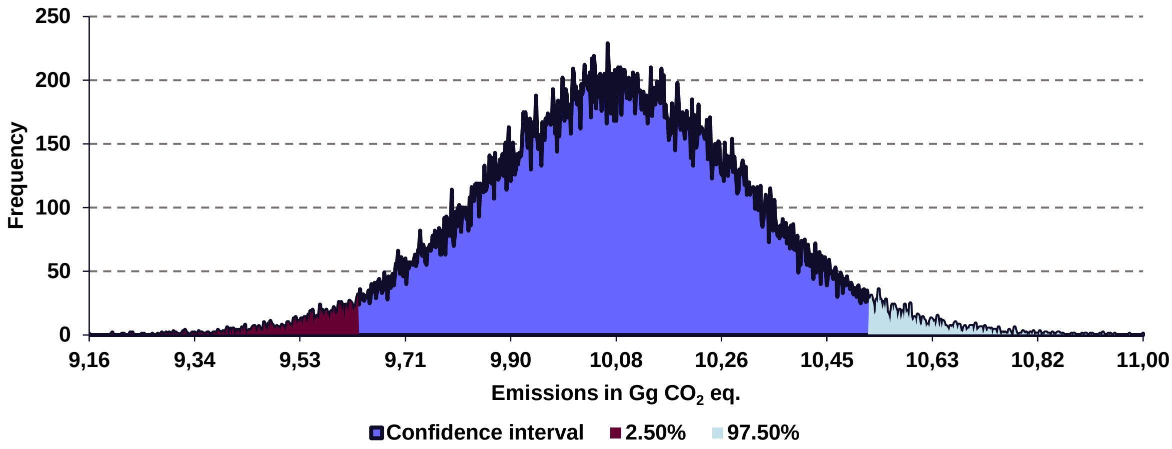
YEAR	Urea Consumption in Industry	CO_2 Emissions in Industry	Urea Consumption in Cars	CO_2 Emissions in Cars	Total CO_2 Emissions
	t				
2010	NO	NO	2 745.8	2 012.2	2 012.2
2011	NO	NO	4 753.6	3 483.5	3 483.5
2012	NO	NO	5 356.5	3 925.3	3 925.3
2013	NO	NO	8 258.0	6 051.6	6 051.6
2014	NO	NO	8 761.6	6 420.6	6 420.6
2015	NO	NO	8 287.0	6 072.8	6 072.8
2016	2 227.8	1 632.6	9 437.8	6 916.2	8 549.2
2017	2 271.0	1 664.2	9 984.5	7 316.8	8 981.0
2018	1 997.8	1 464.0	11 019.1	8 075.0	9 539.0
2019	732.4	536.7	11 150.7	8 171.4	8 807.1
2020	1 568.8	1 149.6	9 700.4	7 108.6	8 258.2
2021	1 661.1	1 217.3	11 569.1	8 478.0	9 695.3
2022	1 623.0	1 189.4	12 127.5	8 887.2	10 076.6

Uncertainties and time-series consistency

Consistent methodology and tier method was used for the whole time series in all subcategories mentioned in this chapter. The detailed data are available since 2000. The extrapolation was used for the rest of the time series. The extrapolation was based on the average IEF of CO_2 per 1 t of NMVOC from the years 2000 – 2005.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. The uncertainty of AD was assumed to be 1.5% with the carbon content uncertainty 2% for the urea consumption in industrial plants. Due to the using of the COPERT 5 model for the CO_2 emission estimates from transport, the uncertainty of this value was assumed to be 5.0%. The uncertainty of CO_2 emissions (in eq.) is 4.42%.

Figure 4.29: *Probability density function for 2.D.3 (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
10.08	10.08	0.23	9.16	11.00	-4.43%	4.41%

4.11. Electronic Industry (CRF 2.E)

No halocarbons, SF_6 or NF_3 were used in the Slovak Republic in 1990 – 2022 in this category, therefore notation key "NO" was used in all 2.E categories.

4.12. Product Uses as Substitutes for ODS (CRF 2.F)

4.12.1. Source Category Description

F-gases notion means the emissions of substances that, because of their effects, can be added to the greenhouse gases group. However, before COP3 in Kyoto F-gases were not considered in the GHG emissions inventory or GHG emission projections.

At the present, following gases are included into inventory submission of the Slovak Republic:

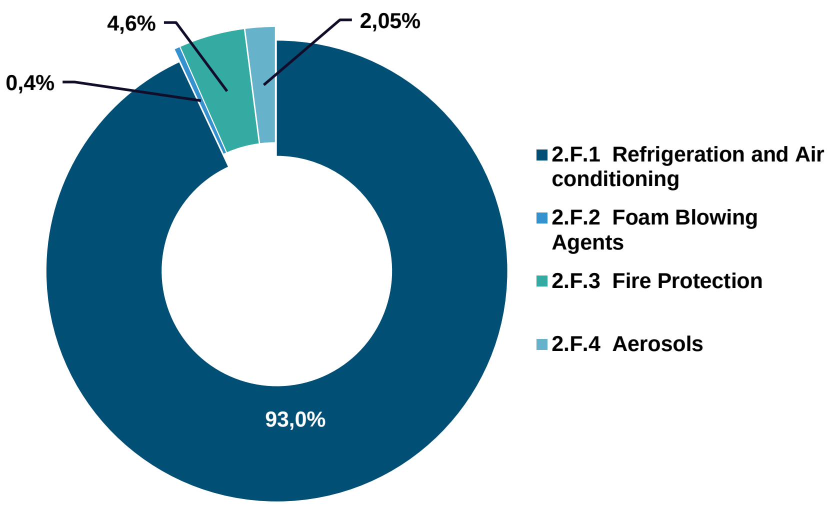
- HFCs – hydrofluorocarbons (23, 32, 125, 134a, 152a, 143a, 227ea, 236fa, 245fa, 365mfc);
- SF_6 – sulphur hexafluoride;
- PFCs – per fluorocarbons (CF_4 for the period 1997 – 2005; C_2F_6).

The PFC emissions (CF_4 and C_2F_6) from metal production are reported in 2.C.3 – Aluminium Production. The inventory of F-gases is complicated due to a high number of substances. These gases are components of different mixtures and are used in more than 15 different applications. Each application has its own development of consumption and emissions trend. To ensure environmental integrity, the post-2012 agreement includes additional fluorinated gases (NF_3, hydrofluoroethers and perfluoropolyethers) with lower GWPs. There are two additional HFCs gases already reported in the Slovak inventory under memo items: HFC 245fa and HFC 365mfc. These gases are used in industry as foam agent (polyurethane-foam blowing agent – PU closed cell foam and integral PU-foam) with the highest consumption as PU spray foam for roof insulation.

Table 4.47: The overview of actual HFCs and PFCs emissions in particular years

YEAR	2.F.1	2.F.2	2.F.3	2.F.4	2.F.5	2.F.6	Total 2.F
	Gg CO_2 eq.						
1990	NO	NO	NO	NO	NO	NO	NO
1995	10.202	NO	2.179	NO	NO	NO	12.381
2000	82.192	5.597	7.988	2.425	1.274	NO	99.475
2005	252.913	4.803	13.196	6.182	0.398	NO	277.491
2010	543.084	2.114	16.908	7.116	NO	NO	569.222
2011	548.226	2.182	18.403	7.624	NO	NO	576.434
2012	574.144	2.542	17.684	7.704	NO	NO	602.074
2013	593.363	2.142	17.391	8.098	NO	NO	620.993
2014	598.021	1.985	17.728	8.406	NO	NO	626.139
2015	674.550	1.800	19.427	9.058	NO	NO	704.835
2016	615.631	1.790	21.279	9.253	NO	NO	647.952
2017	679.098	1.781	20.991	8.325	NO	NO	710.194
2018	645.605	1.772	20.141	8.103	NO	NO	675.621
2019	656.458	1.763	22.155	8.310	NO	NO	688.686
2020	615.045	1.754	21.546	8.303	NO	NO	646.649
2021	642.666	1.745	19.130	8.832	NO	NO	672.373
2022	447.340	1.737	21.931	9.852	NO	NO	480.860

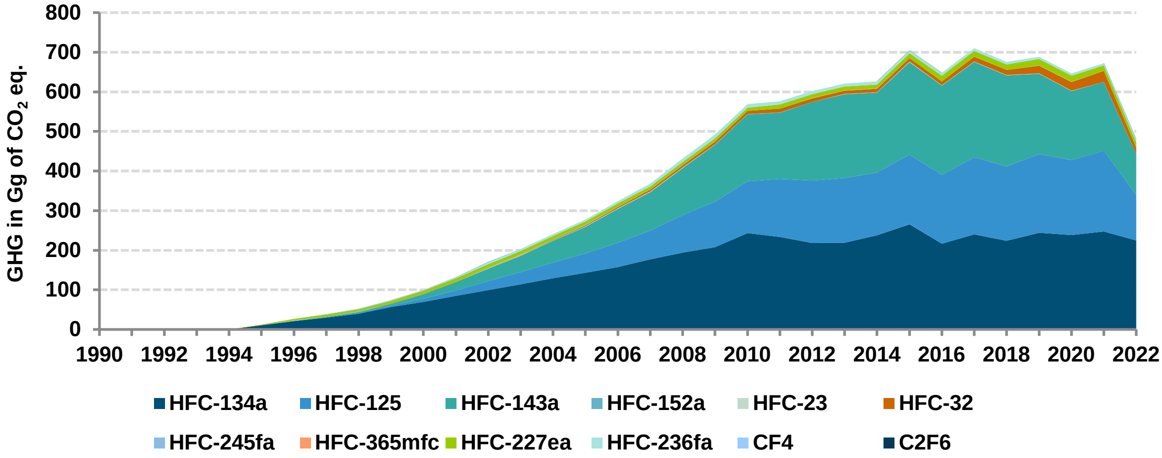
Figure 4.30: *The share of emissions in the 2.F category according to the subcategories in 2022*



Total actual HFCs and PFCs emissions reported in the category 2.F Product uses as substitutes for ODS were 480.86 Gg of CO_2 eq. in 2022 and they decreased by 28% compared to the previous year. The decrease corresponds to the decrease of emissions in 2.F.1 category. The reasons for such high decrease are discussed in the respective categories.

The decrease was expected due the Regulation (EU) No 517/2014 of the European parliament and of the Council on fluorinated greenhouse gases. However, due to the decommissioning of the equipment with the high GWP gases, only small decrease occurred in several last years. Total trend in several last years (since 2017) fluctuated but was slowly decreasing.

Figure 4.31: *Trend in individual F-gases in 1990 – 2022*



Generally, increasing trend is visible since the base year and is caused by supplying HCFCs gases by the HFCs up to 2010. However, the emissions of F-gases were approximately constant since 2010 because of the almost complete replacement of HDFCs gases. Another reason of the change in trend is the use of HFC-134a in mobile air conditioners (ACs). Coolant R134a showed continuing increasing trend mainly because of rising uses of cars with ACs. This trend stopped in 2010. It was caused by smaller purchases of cars in Slovakia since 2010, which resulted in a smaller bank of HFC-134a in Slovakia. Also HFO-1234yf is used in an increased extent in new cars; while in 2016 the ratio of HFO-1234yf and HFC-134a was ca 1:1, in 2022 the ratio is ca 9:1.

4.12.2. Activity Data

Before year 2009, the activity data had been collected via paper questionnaires addressed to the 250 potential suppliers, users and consumers of the substances based on the description of the substances with GWP (global warming potential). These potential consumers of the substances were requested annually by the letter authorized by the Ministry of Environment. Provided data enabled to determine the rate of emissions and new filling by using the method of approximation. In case of any uncertainty, received data were verified by the provider and they were summarized in tables according to the way of use. Since the year 2009, input data are reported through the new electronic system that includes also a servicing of the installed equipment (more than 1 200 operators report data). Tables used since 1990 were used also in the latest inventory years for data storage and archiving in order to retain the continuity of observing trends.

The implemented electronic system consists of:

- Annual reporting of F-gases (new charges and leakages) by certified companies;
- Annual reporting of F-gases imported in bulks by certified companies;
- Annual reporting of F-gases in products by importers, exporters, producers by companies.

All operators dealing with the F-gases have access to this electronic system based on certification. Advantages of electronic data logging and reporting are in the possibilities of automatic analysis, fault detection and comparison of, fast access to the full history of leak checks and various forms of output. Service engineers get quick survey of the customers, cooling circuits, details of all maintenance work and repairs, refrigerants in store, refrigerants added, recovered, reclaimed, and disposed of it. Value added of electronic logbook is indirect detection of refrigerant leak. The fault detection classifier estimates the probability of refrigerant leak. Electronic way of the data records enables summarizing, reporting and analysing important data in a chosen period.

This system is based on the activities of the Slovak Association for Cooling and Air-conditioning Technology (SZ CHKT) and started its operation in the year 2009. The Slovak Association for Cooling and Air-conditioning Technology (the "Notified Body") is the body officially authorized by the Ministry of Environment to certify companies and organizations for the activities in this area. The electronically led documentation has developed from the previous paper form. Evaluated data were collected from the service organizations. Details on the electronic system and method of data collection are presented in the Annex 4.2 of this Report.

The Slovak Republic reports emissions of HFCs and PFCs gases (use of substances) in the IPPU sector in the following subcategories:

- 2.F.1 Refrigeration and air conditioning
- 2.F.2 Foam blowing agents
- 2.F.3 Fire protection
- 2.F.4 Aerosols

In the following subcategories are emissions not reported in 2019 and the notation key "NO" was used:

- 2.F.5 Solvents – no gases occur in this category since 2006;
- 2.F.6 Other application – no gases occur in this category.

4.12.3. Emission Factors

Emission factors were evaluated in each category for each individual product (or using of gas) to ensure the best available accuracy of inventory. EFs are described in each category.

4.12.4. Methods

The actual emission estimation of time series was performed mainly by tier 2 method that accounts for the time lag between the consumption and the emissions. Detailed description of methodology is provided in the subcategories.

4.12.5. Uncertainties and Time-series Consistency

A consistent time series of the HFCs import-export exists since 1995 and is well documented, based on questionnaires. In previous submissions, the data on banks were not consistent because of use of extrapolation in 2010. The recalculation of banks was made according to the discussion with the ERT during six weeks' period after in-country review in 2012. In that submission, this extrapolation was useful in order to differentiate the banks among different subcategories. The differentiation was based on the 2010 share of HFCs gases. Data gathered from 2010 onwards on refrigerant use by subcategories support this disaggregation. Therefore, the disaggregation was accepted by the ERT as a final one and further step, removal of inconsistency of bank data, followed. The inconsistency was caused by the two types of formula used for bank calculation. In the 2015 submission, the bank data were recalculated by the same formula (previously used only for data since 2010) for the whole time series. The reported emissions are also influenced by the recalculation of the disposal emissions in last reporting years. A new, consistent method for the estimation of retiring equipment was used in 2015 submission. The main change in 2016 submission was the recalculation of reported recovery (in CRF reporter). In previous submissions, the recovery represented the amount of HFCs and PFCs that was recovered and recycled from the disposed systems and could be used again. Since 2016 submission, the recovery represents amount that was recovered, recycled, and destroyed from disposed systems. Emissions were not influenced by this correction. In 2017 submission, the recalculation of operational emissions has been done in 2.F.1 category. This recalculation considered the possibility of no servicing of equipment few years before its decommissioning. Details are presented in 2.F.1 category.

Monte Carlo method for the uncertainty analyses was implemented for F-gases for the first time in 2016 submission. The IPCC default values for uncertainty of activity data and emission factors were used. The results of the simulation are presented in respective subcategories.

4.12.6. Source-Specific QA/QC and Verification

Slovakia has a unique reporting system of F-gases in bulks and in products. Due to the reporting system includes all F-gases, the QA/QC of 2.G category is included here, as well. Data processing system and verification is done automatically. The advantages of the system are as follows:

- historical development of reported data in numbers and graphs during the reported years are available,
- reported numbers from importers (wholesalers) of F-gases and reported numbers from service companies are compared,
- Notified Body has access to historical development in all monitored categories and compares it with ex-post and ex-ante projections up to 2030.

This data processing system allows calculating the emissions by top-down approach. However, the differentiation of the reported data into subcategories is rather limited (mainly in 2.F.1 - Refrigeration and air conditioning).

The new internet reporting system Leaklog has been running since 2009 on the legal basis (Act No 286/2009 Coll. and its amendment No 314/2009 Coll.). Increased publicity from the Ministry of Environment and increased number of inspections from the Slovak Inspection of Environment has increased knowledge of the companies to get data that are more accurate. This system allows estimating the emissions by the bottom-up approach with differentiating among subcategories (see the **Annex 4.2** for more details). These two sets of data are supplementary to each other and allow comparing the total amounts of F-gases consumed in Slovakia. Data from these two reporting systems are compared annually.

Refrigeration and Air Conditioning - Verification is a part of electronic database system.

Fire Extinguishers - The information on fillings and recycling of already used fire extinguishers is realized with the cooperation of the Association of the Fire Extinguishers Producers in the Slovak Republic based on the Regulation of the Ministry of Environment of the Slovak Republic No 314/2009 Coll. The Association is obliged to provide information from all members. The sector-specific QA/QC activities were performed as described in the **Chapter 4.2** of the Report and results are verified by the top-down approach. Verification is a part of electronic database system.

N_2O from Product Uses - Due to the lack of appropriate statistical information and methodological advises in this category, inputs were taken directly from the questionnaires sent to distributors of N_2O liquid gas in the Slovak Republic.

4.12.7. Source-Specific Recalculations

In this submission, the recalculation with the negligible impact on the total emissions was done. In 2014 and 2016, installing of few new devices was included into 2.F.1.c, however, emissions from their service were included in 2.F.1.f. Therefore, the reallocation of these devices from 2.F.1.c to 2.F.1.f have been done with no change in emissions in 2.F.1 category. In this submission, the presence of PFC gas c-C_4F_8 in the inventory was checked. It was found out that the reporting of this gas was a mistake, it was part of the bled R508B, where PFC-116 (C_2F_6) is present. Therefore, the gas was changed to the correct one, change in emissions was negligible (+0.005 Gg CO_2 eq.), originating only from the difference in GWP.

4.12.8. Source-Specific Planned Improvements

No improvements are planned.

4.12.9. Refrigeration and Air Conditioning Equipment (CRF 2.F.1)

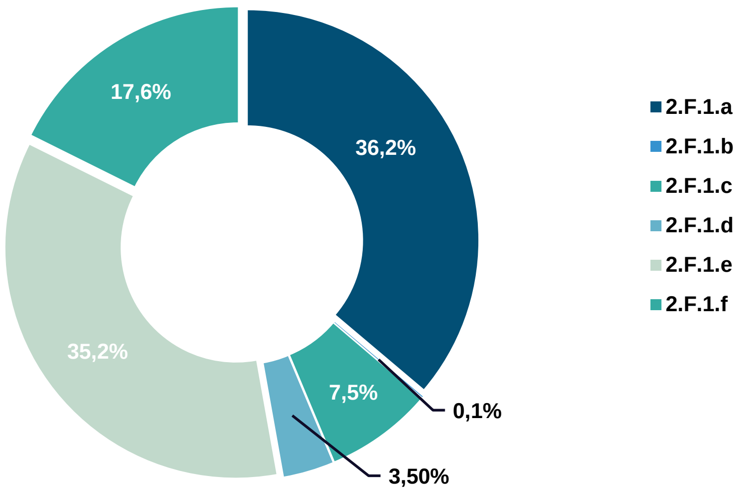
The emissions originating from refrigeration and AC equipment represent more than 95% of emissions from the 2.F category. Therefore, these emissions are significant source. Total actual emissions of HFCs were 447.37 Gg of CO_2 eq. in 2022 and they decreased by 30% in comparison with the previous year. The decrease due the Regulation (EU) No 517/2014 of the European parliament and of the Council on fluorinated greenhouse gases was expected. The expectations are caused by several reasons. One of them is end of using of new R404A gas with GWP 3940 (only recovered gas can be used since now). Another reason is using of new replacements of R404A, R410A, R134a with low GWP blends (in Slovakia new gases R448A, R449A, R454B, R454C, R513A, R514A, R1234yf, R1234ze were introduced into the market). However, the decommissioning of the old equipment disrupts this expectation in several past years. In this submission, expectations about the reduction of emissions were fully met. When compared with the previous year, the reduction in emissions was ca 195 Gg CO_2 eq. At verifying of this decrease, synergistic effect of several facts was determined: (i) significant increase of recovery, mainly R404A and R410A blends. The increased recovery corresponds to the decrease in emissions by ca 80 Gg CO_2 eq.; (ii) reduction in usage of the blend with high GWP (R404A, R410A, R407C and R134a) and their replacement with the blends with low GWP. This reduction corresponds to the decrease in emissions by ca 90 Gg CO_2 eq.; (iii) decrease in decommissioning of devices in categories 2.F.1a, 2.F.1.d and 2.F.1.f that corresponds to the decrease in emissions by 13 Gg CO_2 eq. Totally, it corresponds to the decrease in emissions by 183 Gg CO_2 eq.; which is in very solid agreement with the actual decrease of 195 Gg CO_2 eq.

It can be also seen that the small decreasing trend (with fluctuations) occurs since 2017.

The emissions of NF_3 and SF_6 are not occurring in this category. The following gases and subcategories are reported in 2.F.1:

- HFC-23, HFC-32, HFC-125, HFC-134a, HFC-143a, HFC-152a and C_2F_6 in 2.F.1.a - Commercial refrigeration.
- HFC-134a in 2.F.1.b - Domestic refrigeration.
- HFC-32, HFC-125, HFC-134a and HFC-143a in 2.F.1.c - Industrial refrigeration.
- HFC-32, HFC-125, HFC-134a and HFC-143a in 2.F.1.d - Transport refrigeration.
- HFC-134a in 2.F.1.e - Mobile AC.
- HFC-32, HFC-125, HFC-134a and HFC-143a in 2.F.1.f - Stationary AC.

Figure 4.32: *The share of individual subcategories within the category 2.F.1 in 2022*



The products designed for coolants R22, R134a and R404A were usually imported up to the year 1998. Only in 1999, the indications of import of products containing coolants R407C and R410A are emerging. When the Act No. 76/1998 on the Protection of the Ozone Layer of the Earth entered into force on April 1, 1998, the use of the alternative coolants started. Consumption of alternative coolants R401A and R409A in order to supply R22 started to decrease in the year 2002. Coolants R407C and R410A show the increase since 1999. Coolant R134a shows continuing increasing trend mainly because of rising use of cars with AC; the increasing trend stopped in 2010. It is caused by smaller purchases of cars in Slovakia and lower amount of gas in AC since then, which results in smaller bank of HFC-134a in Slovakia. General increasing trend of HFCs emissions visible since the base year has been caused by supplying HCFCs gases by the HFCs. However, because of the almost complete replacement of HCFCs gases, the F-gases emissions were approximately constant since 2010. Rising trend since 2014 is caused by increased decommissioning of refrigerant units, while the decreasing trend since 2016 is caused by increased using of HFCs with lower GWP. Servicing of the MACs with HFC-134a is lower than in previous years, therefore the operational emissions decreased. On the other hand, the servicing with HFO-1234YF increased.

The decreased in 2018 was followed after a peak in 2017. This can be explained by the decreasing of share of mixtures containing major share of HFC-134a and HFC-125 increasing of the share of mixtures with a higher HFC-32 content. This is mostly visible in subcategory 2.F.1.f. In 2022, the replacement of HFC-404A with the blends HFC-448A and HFC-452A occurred in an increased extent. Also the replacement of HFC-410A with HFC-452B was more significant than in the previous year. The replacement of HFC-134a with the HFC-513A blend is negligible, but using of R1234yf, R1234ze is of increased importance. The use of natural refrigerants is of increased importance in this submission, as well.

Approximately 36% of total F-gases emissions (in CO_2 eq.) are allocated in 2.F.1.a – Commercial Refrigeration followed by 2.F.1.e – Mobile AC (35%) in 2022 (***Figure 4.33***). This relates to the high share of automotive industry in last years in Slovakia. About 18% emissions are allocated in 2.F.1.f – Stationary AC, 7% in 2.F.1c, 4% in 2.F.1.d and below 1% in 2.F.1.b – Domestic Refrigeration. Time series of F-gases consumption in the category 2.F.1 is summarized in the following ***Tables 4.48-4.54***.

Figure 4.33: *The share of individual F-gases in the category 2.F.1 in 2022*

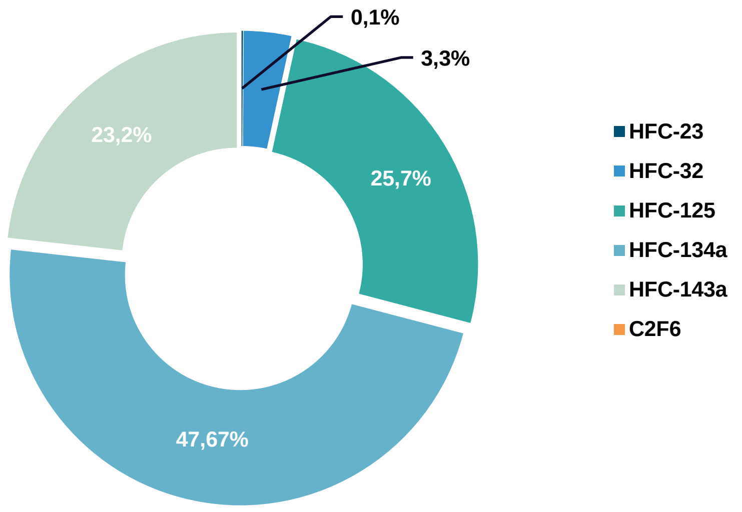


Table 4.48: *Aggregated data on HFCs use in the subcategory 2.F.1.a in particular years*

YEAR	New Fillings	New Addition to Bank	Bank	Retired Equip.	Emissions From: New Fillings	Emissions From: Bank	Emissions From: Disposal	Recovery	Total
	Gg CO_2 eq.								
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	2.304	4.056	4.056	NO	0.023	0.767	NO	NO	0.790
2000	34.303	59.940	121.623	NO	0.343	17.941	NO	NO	18.284
2005	84.295	110.225	625.353	3.130	0.843	89.274	2.381	0.749	92.497
2010	117.202	136.799	1338.124	35.500	1.172	200.687	29.086	6.415	230.945
2011	84.876	135.435	1401.600	53.453	0.849	185.001	43.892	9.562	229.741
2012	72.657	141.886	1454.765	67.925	0.727	204.650	55.846	12.079	261.222
2013	78.970	153.151	1504.833	80.128	0.790	214.583	65.974	14.154	281.347
2014	100.696	91.000	1484.649	86.239	1.007	212.735	68.497	17.742	282.242
2015	111.966	104.003	1463.439	97.401	1.120	236.280	82.012	15.389	319.419
2016	101.551	120.448	1449.254	102.160	1.016	227.965	73.842	28.318	302.829
2017	70.463	78.876	1373.565	120.336	0.705	216.399	111.025	9.311	328.139
2018	50.753	47.398	1247.467	139.448	0.508	194.369	125.379	14.069	320.266
2019	40.706	39.999	1120.365	134.361	0.407	179.086	125.335	9.026	304.864
2020	12.383	32.743	985.480	137.959	0.124	139.440	119.734	18.225	259.327
2021	4.900	20.181	854.497	123.962	0.049	153.227	107.159	16.803	260.478
2022	14.468	16.530	732.367	113.386	0.145	117.009	44.635	68.751	161.815

Table 4.49: *Aggregated data on PFCs use in the subcategory 2.F.1.a in particular years*

YEAR	New Fillings	New Addition to Bank	Bank	Retired Equip.	Emissions From: New Fillings	Emissions From: Bank	Emissions From: Disposal	Recovery	Total
	Gg CO_2 eq.								
1990-2018	NO	NO	NO	NO	NO	NO	NO	NO	NO
2019	NO	0.707	0.707	NO	NO	NO	NO	NO	NO
2020	NO	NO	0.707	NO	NO	NO	NO	NO	NO
2021	NO	NO	0.707	NO	NO	0.036	NO	NO	0.036
2022	NO	NO	0.707	NO	NO	0.029	NO	NO	0.029

Table 4.50: *Aggregated data on HFCs use in the sub-category 2.F.1.b in particular years*

YEAR	New Fillings	New Addition to Bank	Bank	Retired Equip.	Emissions From:			Recovery	Total
					New Fillings	Bank	Disposal		
	Gg CO_2 eq.								
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	NO	NO	NO	NO	NO	NO	NO	NO	NO
2000	13.130	12.998	56.741	NO	0.131	0.284	NO	NO	0.415
2005	1.586	1.359	74.942	NO	0.016	0.375	NO	NO	0.391
2010	NO	0.189	69.975	4.290	NO	0.350	2.574	1.716	2.924
2011	NO	5.779	64.386	8.814	NO	0.322	5.288	3.526	5.610
2012	NO	9.566	59.364	11.414	NO	0.297	6.848	4.565	7.145
2013	NO	12.486	54.848	13.363	NO	0.274	8.018	5.345	8.292
2014	NO	1.661	43.933	9.842	NO	0.220	4.468	5.374	4.688
2015	NO	0.018	36.211	6.016	NO	0.181	4.314	1.703	4.495
2016	NO	NO	31.576	3.708	NO	0.158	2.610	1.097	2.768
2017	NO	NO	29.038	2.030	NO	0.145	1.441	0.589	1.587
2018	NO	NO	27.106	1.546	NO	0.136	1.283	0.263	1.418
2019	NO	NO	25.990	0.893	NO	0.130	0.850	0.043	0.980
2020	NO	NO	25.179	0.649	NO	0.126	0.598	0.051	0.724
2021	NO	NO	24.655	0.419	NO	0.123	0.383	0.037	0.506
2022	NO	NO	24.438	0.173	NO	0.122	0.140	0.033	0.262

Table 4.51: *Aggregated data on HFCs using in the sub-category 2.F.1.c in particular years*

YEAR	New Fillings	New Addition to Bank	Bank	Retired Equip.	Emissions From:			Recovery	Total
					New Fillings	Bank	Disposal		
	Gg CO_2 eq.								
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	3.423	0.655	0.655	NO	0.034	0.097	NO	NO	0.131
2000	39.834	8.680	17.306	NO	0.398	2.278	NO	NO	2.676
2005	96.958	16.088	91.300	NO	0.970	11.776	NO	NO	12.746
2010	134.340	13.730	203.361	0.105	1.343	25.980	0.064	0.041	27.387
2011	145.366	142.015	344.924	0.323	1.454	32.488	0.218	0.105	34.160
2012	91.984	73.893	418.077	0.517	0.920	53.625	0.366	0.152	54.910
2013	83.479	54.283	471.121	0.894	0.835	56.148	0.665	0.229	57.647
2014	51.382	53.585	522.659	1.380	0.514	46.648	0.965	0.415	48.126
2015	48.774	51.768	570.689	2.664	0.488	53.420	2.203	0.461	56.111
2016	47.303	51.108	615.858	4.295	0.473	54.831	3.105	1.190	58.408
2017	47.643	49.815	657.014	6.575	0.476	59.532	6.040	0.535	66.049
2018	54.514	91.715	737.732	8.334	0.545	49.106	7.500	0.834	57.151
2019	20.907	60.144	784.263	10.654	0.209	44.038	9.978	0.676	54.225
2020	6.014	14.431	783.419	11.839	0.060	43.186	10.305	1.534	53.552
2021	4.294	18.233	784.433	13.744	0.043	46.431	11.905	1.839	58.380
2022	42.621	87.606	853.999	13.898	0.426	27.610	5.310	8.588	33.346

Table 4.52: Aggregated data on HFCs using in the sub-category 2.F.1.d in particular years

YEAR	New Fillings	New Addition to Bank	Bank	Retired Equip.	Emissions From:			Recovery	Total
					New Fillings	Bank	Disposal		
	Gg CO_2 eq.								
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	NO	1.156	1.156	NO	NO	0.243	NO	NO	0.243
2000	2.843	4.299	12.348	NO	0.028	2.180	NO	NO	2.208
2005	6.676	9.527	47.177	0.703	0.067	7.039	0.447	0.256	7.552
2010	10.582	12.772	93.762	3.282	0.106	14.595	2.504	0.778	17.205
2011	13.192	18.099	103.691	3.714	0.132	14.301	2.830	0.884	17.263
2012	11.283	15.449	109.836	4.194	0.113	15.786	3.207	0.987	19.106
2013	5.267	6.388	105.809	4.718	0.053	15.363	3.627	1.091	19.043
2014	1.759	1.752	95.709	5.503	0.018	12.500	3.967	1.535	16.485
2015	4.888	4.888	87.149	5.889	0.049	22.433	4.770	1.119	27.252
2016	3.423	9.424	81.880	6.811	0.034	23.584	4.823	1.988	28.442
2017	2.857	6.204	72.189	8.308	0.029	20.874	7.368	0.939	28.271
2018	3.628	4.491	61.170	7.458	0.036	20.187	6.575	0.883	26.798
2019	1.191	2.074	48.603	7.718	0.012	20.197	7.209	0.509	27.418
2020	0.611	1.285	37.754	8.387	0.006	14.870	7.355	1.032	22.231
2021	NO	0.352	30.799	5.459	NO	17.994	4.748	0.711	22.742
2022	3.249	3.249	29.395	2.035	0.032	14.818	0.821	1.214	15.672

Table 4.53: Aggregated data on HFCs using in the sub-category 2.F.1.e in particular years

YEAR	New Fillings	New Addition to Bank	Bank	Retired Equip.	Emissions From:			Recovery	Total
					New Fillings	Bank	Disposal		
	Gg CO_2 eq.								
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	21.479	59.207	59.207	NO	0.215	6.477	NO	NO	6.692
2000	64.437	76.822	386.615	NO	0.644	42.296	NO	NO	42.940
2005	107.395	116.232	896.882	NO	1.074	98.119	NO	NO	99.193
2010	240.630	116.719	1314.360	30.053	2.406	165.772	18.032	12.021	186.211
2011	275.132	130.330	1376.452	31.323	2.751	149.845	18.794	12.529	171.390
2012	398.192	69.680	1372.319	32.362	3.982	136.871	19.417	12.945	160.271
2013	412.867	56.810	1346.229	36.903	4.129	131.095	22.142	14.761	157.365
2014	324.723	56.633	1311.294	41.455	3.247	150.464	18.820	22.634	172.532
2015	484.940	67.508	1279.104	45.971	4.849	154.210	32.961	13.010	192.021
2016	404.641	31.178	1203.225	50.536	4.046	105.939	35.578	14.959	145.563
2017	196.198	24.065	1114.561	53.803	1.962	124.123	38.200	15.603	164.285
2018	260.464	12.165	1008.764	56.810	2.605	106.876	47.152	9.658	156.633
2019	225.507	22.569	909.850	58.914	2.255	107.765	56.057	2.857	166.076
2020	159.243	16.684	801.903	61.017	1.592	105.410	56.202	4.814	163.205
2021	93.142	9.800	686.895	63.492	0.931	106.809	57.965	5.528	165.706
2022	79.969	8.516	576.428	63.157	0.800	105.530	50.984	12.173	157.313

Table 4.54: Aggregated data on HFCs using in the sub-category 2.F.1.f in particular years

YEAR	New Fillings	New Addition to Bank	Bank	Retired Equip.	Emissions From: New Fillings	Emissions From: Bank	Emissions From: Disposal	Recovery	Total
	Gg CO_2 eq.								
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	12.711	12.711	12.711	NO	0.127	2.219	NO	NO	2.346
2000	32.330	21.297	94.095	NO	0.323	15.345	NO	NO	15.669
2005	71.963	37.700	268.953	NO	0.720	39.815	NO	NO	40.535
2010	107.306	37.149	515.882	11.465	1.073	70.306	7.034	4.431	78.413
2011	106.682	101.112	601.346	12.017	1.067	81.501	7.493	4.524	90.061
2012	121.818	114.980	698.620	13.234	1.218	61.773	8.498	4.736	71.489
2013	90.259	81.340	758.645	15.809	0.903	58.391	10.374	5.435	69.668
2014	46.751	86.929	819.165	19.962	0.468	61.813	11.667	8.295	73.948
2015	98.800	131.979	919.897	24.080	0.988	56.564	17.700	6.380	75.252
2016	54.706	95.748	980.302	27.495	0.548	59.031	18.041	9.454	77.620
2017	251.464	177.959	1119.831	29.843	2.515	64.252	24.001	5.842	90.768
2018	95.527	142.743	1219.699	32.944	0.955	55.477	26.907	6.037	83.339
2019	65.819	78.825	1251.088	35.751	0.658	70.266	31.971	3.780	102.896
2020	53.862	50.168	1245.502	43.697	0.539	77.947	37.520	6.177	116.006
2021	703.689	124.957	1307.739	49.773	7.037	86.083	41.734	8.039	134.854
2022	107.113	81.197	1327.107	46.686	1.071	59.878	17.983	28.703	78.932

Methodological issues

The IPCC 2006 GL describe two tiers for estimating emissions. The bottom-up approach takes into account the time lag between consumption and emissions explicitly through emission factors. The top-down approach, the time lag is taking into account implicitly, by tracking the amount of virgin chemicals consumed in a year that replaces emissions from the previous year.

The web reporting system used in Slovakia allows calculating emissions in both approaches. The bottom-up approach is combined with the top-down approach. The procedure is as follows:

1. Using the bottom-up approach (tier 2a) from the Logbook Leaklog;
2. Calculation of the total consumptions of individual gases in Slovakia based on the Leaklog (tier 2a);
3. Calculation of the total consumption of individual gases in Slovakia according to the top-down approach (tier 2b);
4. Comparison of the total consumptions calculated by these two approaches;
5. If differences above 2% occur, the data for bottom-up approach are corrected as follows (expert judgement based on the QA activity introduced in 2011):

   R134a: Difference is added to leakage from mobile AC,

   R404A: Difference is added between new charge/recharge 0.2/0.8,

   R407C: Difference is added to new charge of stationary AC,

   R410A: Difference is added to leakage from industrial refrigeration and stationary AC 0.1/0.9.
6. If differences below 2% occur, the data for bottom-up approach are corrected proportionally according to the operational emissions.
7. Calculation of emission estimates by the bottom-up approach using the corrected data.

In 2022, no significant corrections were necessary, the differences between top-down and bottom-up approaches were up to 2%. Following formulas (tier 2b, top-down approach) based on the structure of the reporting systems were used:

Emissions = Annual Sales of New Refrigerant – Total Charge of New Equipment + Disposal Emissions

where *Annual Sales* and *Total Charge of New Equipment* are calculated by formulas presented in the IPCC 2006 Guidelines, Chapter 3, p. 7.54 (not simplified formulas).

Following formulas (tier 2a, bottom-up approach) based on the structure of the reporting systems were used: Emissions = Emissions from new fillings + Operational emissions + Disposal emissions

where: *Emissions from new fillings* represent 1% (EF) of the new charges filled in Slovakia (*Chemicals to Charge Domestically Manufactured and Assembled Equipment + Chemical to Charge Equipment that is not Factory-Charged*).

Operational emissions: The approach described in IPCC 2006 GL assumes that servicing of equipment restocks the bank of single chemical and thus the amount of gas used for servicing represents the operational emissions. Slovakia adopted this assumption with a modification. The servicing of equipment restocks the bank of chemical and its amount used at servicing equals to the emissions. However, equipment that is few years before decommissioning is not serviced and bank is not restock at this equipment. Therefore, the operational emissions are composed from two terms in this submission: (i) data from servicing of equipment; (ii) emissions from non-serviced equipment few years before its decommissioning. The first term in the operational emissions represents the consumption of gases for servicing and container management (these data are reported in Leaklog). It is assumed that the chemical used for servicing restocks the emissions from the bank and thus the bank of the chemical remains constant. The second term in operational emissions represents emissions from non-serviced equipment few years before its decommissioning. These emissions decrease the amount of chemical in equipment and the equipment contains only a part of the chemical at its decommissioning. The emissions are calculated by using product life factor that are presented in ***Table 4.55***. The product life factors, number of years when the equipment is not serviced and fraction of gas remaining at the decommissioning of equipment presented in ***Table 4.55*** are consistent and they are based on the default factors presented in IPCC 2006 GL. These emissions do not restore the bank of the chemical and are subtracted from the bank.

Table 4.55: *Product life factor of not serviced equipment; number of years, when the equipment is not serviced and ratio of initial charge that is remaining at decommissioning of equipment*

Category	Product Life Factor	Years Before Retirement	Initial Charge Remaining at Retirement
2.F.1.a	10%	2	80%
2.F.1.b	0.5%*	12-15*	80%*
2.F.1.c	20%	1	80%
2.F.1.d	25%	2	50%
2.F.1.e	16.67%	3	50%
2.F.1.f	10%	2	80%

** Default IPCC 2006 GL values*

Disposal emissions represent the emissions from the retired equipment. Since 2014, the recycling companies report the data about recovery of gases in database Leaklog. There is available amount of gas that is recovered, reused and destroyed in recycling factories. All these terms are covered in CRF term “recovery”. The amount of recovered gas is known and comparison with the amount of gas in decommissioned equipment can be made. The fractions of gases that are recovered from disposed equipment in 2022 are presented in ***Table 4.56***. Differentiating of the gases among the subcategories is not possible, only total data for each gas is available. Therefore, the same fraction of recovered gas is assumed in all categories. The annual data of the recovery ratio of the individual gases for whole time series is presented in ***Table 4.57***. For years before 2013, the average value of the years 2014 and 2015 is assumed.

Table 4.56: *Comparison of amount of gases in retired units and amount of recovered gases in 2022*

F-GAS	Amount in Retired Equipment	Recovery Amount	Ratio
	t		
HFC-23	0.017	NO	-
HFC-32	13.345	9.611	72.02%
HFC-125	23.697	16.314	68.85%
HFC-134a	59.976	11.560	19.27%
HFC-143a	16.042	9.627	60.01%
HFC-152a	NO	NO	-

Table 4.57: *Aggregated data on HFCs recovery ratio (%) in the category 2.F.1. in particular years*

YEAR	HFC-23	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-152a
	%					
2013 and before	-	55.0	25.0	40.0	13.0	-
2014	-	68.2	27.3	54.6	15.6	-
2015	-	43.7	22.7	28.3	11.9	-
2016	-	49.5	34.6	29.6	24.4	-
2017	-	29.8	12.6	29.0	3.9	-
2018	-	30.5	16.0	17.0	6.3	
2019	-	17.5	11.1	4.9	4.0	-
2020	-	15.9	15.9	7.9	11.7	-
2021	-	17.0	18.1	8.7	11.1	-
2022	-	72.0	68.9	19.3	60.0	

For the consistency of operational emissions, it is necessary to follow the bank of chemical. The bank is calculated as follows:

$Bank_{in\ year\ t}$ = $Bank_{in\ year\ t-1}$ + New additions to bank – Chemical in retired equipment – Operational emissions from non-serviced equipment

Where: New additions to bank = Chemicals to Charge Domestically Manufactured and Assembled Equipment + Chemicals to Charge Equipment that is not Factory-Charged + Chemicals Contained in Imported Equipment Already Charged – Chemicals Contained in Exported Equipment Already Charged.

It should be mentioned that due to the last two terms in the above relationship the using of the data about new fillings from CRF reporter is not possible for the calculation of the bank (stock). Calculation of the bank has to contain data that includes import and export of already filled equipment.

Emissions factor from the filling chemicals into new equipment (product manufacturing factor) is assumed 1% (based on the producers' data) for all categories and gases in the 2.F.1.

Operational emission factor (product life factor) is calculated annually based on the reported operational emissions and the respective bank.

Disposal emission factor (disposal loss factor) is based on the data of recycling companies. The fractions of gases that are recovered from disposed equipment are presented in ***Table 4.57***. The average value of the years 2014 and 2015 is assumed since 2013 and back to base year 2013.

Activity data were collected via web reporting system and treated as described above and in the **Annex 4.2** of this Report.

2.F.1.a – Commercial Refrigeration: This category includes emissions from manufacturing, assembly, installation of small refrigeration equipment mostly for export ("stand-alone" commercial application including also some equipment for domestic refrigeration) and emissions from refrigeration in supermarkets and other commercial refrigeration. Only one company manufactures smaller “stand-alone” equipment for commercial and refrigeration (fridges, freezers) with the HFC R-134a and R-404A as cooling agents. This equipment is mostly exported. Data on F-gas consumption are reported through web reporter. Emissions from commercial refrigeration manufacturing, assembly, installation are estimated to equal 1%. No detailed figure on the installed equipment is available. Data on consumption for new systems and refilling were provided by the main service companies through web reporting; the stocks were calculated accordingly. Used refrigerants R-32, R-404A, R-410A, R-134a, R-600A, R-407C, R-717, R-723, R-449A, R-290, R-513A, R-452A, R-507, R-508B, R-407F, R-407H, R-417A, R-448A, R-407A, C_5H_{12}, R-1234yf, R-23, CO_2, R-1234ze, R-422D, R-437A, R-22, R-143a. Lifetime of equipment was assumed 9-12 years. Nameplate capacity of retired equipment was calculated as follows:

Retired equipment$_{\text{in year t}}$ = New addition to stock$_{\text{in year t-12}}$ / 4 + New addition to stock$_{\text{in year t-11}}$ / 4 + New addition to stock$_{\text{in year t-10}}$ / 4 + New addition to stock$_{\text{in year t-9}}$ / 4

The fraction of the gas that remained in the retired equipment is presented in ***Table 4.55*** and the recovered fraction is presented in ***Table 4.57***.

2.F.1.b – Domestic Refrigeration: Partially also the HFC-134a is used for domestic use as refrigerant in refrigerators (fridges and freezers). HFC-134a as refrigerant was introduced by industry at the end of 1995 as replacement of CFC-12. In the following years (starting in 1999) it was gradually replaced by R600a (isobutane). Charging of refrigerators with R134a was stopped by the end of 2006. The calculation of operational emissions is different in this category. The domestic refrigeration units are not serviced usually. Therefore, we used the default product life factor (0.5%) and it is assumed that the emissions decrease the bank of the chemical. Lifetime of domestic refrigeration equipment was assumed 12-15 years.

Nameplate capacity of retired equipment was calculated as follows:

Retired equipment$_{\text{in year t}}$ = New addition to stock$_{\text{in year t-15}}$ / 4 + New addition to stock$_{\text{in year t-14}}$ / 4 + New addition to stock$_{\text{in year t-13}}$ / 4 + New addition to stock$_{\text{in year t-12}}$ / 4

The fraction of the gas that remained in the retired equipment is presented in ***Table 4.55*** and the recovered fraction is presented in ***Table 4.57***.

2.F.1.c – Industrial Refrigeration: In industrial refrigeration, refrigerants are used for production process, e.g. in chemical industry to keep definite process temperatures or in food industry for cooling/freezing partly inosculating with commercial refrigeration. In contrast to commercial refrigeration, in the **IPPU sector** not only HFC/HCFC refrigerants play the significant role, but also NH_3 and CO_2, as well. The refrigeration systems are normally maintained by service companies. Refrigerants are R-134a, R-513A, R-404A, R-407C, R-452A, R-32, R-410A, R-449A, R-1234yf, R-22, R-407A, R-417A, R-422A, R-448A, R-143A, R-407H, R-507, R-152a, R-407F, R-600A, CO_2, R-290, R-425A, R-452B, R-401A, R-170, R-50, R-23, R-1234ze, R-514A, R-515B. Lifetime of equipment was assumed 15-19 years. Nameplate capacity of retired equipment was calculated as follows:

Retired equipment$_{\text{in year t}}$ = New addition to stock$_{\text{in year t-19}}$ / 5 + New addition to stock$_{\text{in year t-18}}$ / 5 + New addition to stock$_{\text{in year t-17}}$ / 5 + New addition to stock$_{\text{in year t-16}}$ / 5 + New addition to stock$_{\text{in year t-15}}$ / 5

The fraction of the gas that remained in the retired equipment is presented in ***Table 4.55*** and the recovered fraction is presented in ***Table 4.57***.

2.F.1.d – Transport Refrigeration: This group includes refrigerated road vehicles. Recently used refrigerants are: R-134a, R-600A, R-404A, R-143a, R-123, CO_2, R-452A, R-32, R-410A, R-449A, R-1234yf, R-507, R-407C, R-448A, R-290, R-124, R-417A, R-422D. Manufacturing of refrigeration units takes place in Slovakia only in very small scale. Emissions occur mainly from stock and from disposal.

Lifetime of equipment was assumed 8-9 years. Nameplate capacity of retired equipment was calculated as follows:

Retired equipment$_{\text{in year t}}$ = New addition to stock$_{\text{in year t-9}}$ / 2 + New addition to stock$_{\text{in year t-8}}$ / 2

The fraction of the gas that remained in the retired equipment is presented in ***Table 4.55*** and the recovered fraction is presented in ***Table 4.57***.

2.F.1.e – Mobile AC: Mobile air conditioning includes passenger cars, trucks, busses, agricultural machines, rail and manufacturing of vehicles for construction sites. The use of R-134a for mobile air conditioning started in 1995. New charges filled into vehicles are taken from the automobile producers in Slovakia. New additions to stock are calculated from the registrations of vehicles in Slovakia and compared with the records of official manufacturers and importers of cars. The following time series of the share of cars with MAC is assumed: (i) in years 1995 – 1999, 70% of registered cars contained MAC; (ii) in 2000 – 2003, 80% of registered cars contained MAC; (iii) in 2004 – 2011, 90% of registered cars contained MAC; (iv) 100% of registered cars contained MAC since 2012. The presented shares are based on the data of car manufacturers in Slovakia. We assume that the share is a typical one and it is applied to the rest of cars.

In 2022, 86 520 new vehicles were registered in Slovakia. In these vehicles, the average charge was assumed 0.063 kg of HFC-134a per one new car in 2022. The average charge is based on the data from car manufacturers in Slovakia (number of produced cars; consumption of HFC-134a and HFO-1234yf necessary to fill them. In 2022, the average charge was 0.621 kg while the share of HFC-134a was 10.1%). We assume that a similar average charge can be used for cars that are not produced in Slovakia. The number of imported and registered second-hand vehicles was 17 455 pcs. HFC-134a charge in these vehicles was assumed to be as in new registered vehicles. The time series of the HFC load into new vehicles is presented in ***Table 4.58***.

Table 4.58: *Loads of HFCs into new vehicles*

YEAR	Number of Produced Vehicles	Amount of HFC-134a Used In New Vehicles	Amount of HFC-1234yf Used in New Vehicles	Fraction of HFC-134a From Total HFC Use	Average HFC Load per One Vehicle	Average HFC-134a Load per One Vehicle
	No	*t*	*t*		*kg*	*kg*
2016	1 095 191	310.517	354.577	0.4669	0.607	0.284
2017	1 266 289	150.15	386.606	0.2797	0.424	0.119
2018	1 093 215	199.95	532	0.2732	0.67	0.183
2019	1 122 067	173.113	461.324	0.2729	0.565	0.154
2020	990 598	122.211	444.738	0.2156	0.572	0.123
2021	1 000 030	71.648	508.351	0.1235	0.580	0.072
2022	970 275	61.128	541.71	0.1014	0.621	0.063

Lifetime of equipment was assumed 12-15 years. Nameplate capacity of retired equipment was calculated as follows:

Retired equipment$_{\text{in year t}}$ = New addition to stock$_{\text{in year t-15}}$ / 4 + New addition to stock$_{\text{in year t-14}}$ / 4 + New addition to stock$_{\text{in year t-13}}$ / 4 + New addition to stock$_{\text{in year t-12}}$ / 4

The fraction of the gas that remained in the retired equipment is presented in ***Table 4.55*** and the recovered fraction is presented in ***Table 4.57***.

2.F.1.f – Stationary AC: This category includes stationary air conditions, room air conditions and heat pumps. Plants for waste heat recovery are included in this category, as well (we are not able to distinguish between them and heat pumps). Stationary air conditions include large equipment >20 kW. Data on consumption for new systems and refilling are provided by service organizations since 2009 via web reporting, the stocks are calculated accordingly. Room air conditions are in the contrast with the stationary AC (a comparable sector in terms of HFCs consumption for new and refilling). Room AC systems include small mobile and compact equipment to be installed at windows or walls, fixed split- and multisplit systems up to 20 kW and larger Variable Refrigerant Flow (VRF) or Multi Air Conditioning systems. Small equipment, split- and multisplit systems and VRF systems are imported already charged with refrigerant. The installation of heat pumps with the HFCs started in Slovakia mainly in the 2004. Heat pumps are manufactured in Slovakia and imported, as well. Used F-gases in this subcategory are: R-407C, R-32, R-134a, R-410A, R-1234yf, R-449A, R-404A, R-407H, R-507, CO_2, R-417A, R-290, R-600A, R-407A, R-437A, R-448A, R-452A, R-401A, R-513A, R-23, R-22, R-143a, R-422D, R-422A, R-407F, R-405A, R-454B, R-452B, R-424A. Lifetime of air conditioning equipment and heat pumps was assumed 12-15 years. Nameplate capacity of retired equipment was calculated as follows:

Retired equipment$_{\text{in year t}}$ = New addition to stock$_{\text{in year t-15}}$ / 4 + New addition to stock$_{\text{in year t-14}}$ / 4 + New addition to stock$_{\text{in year t-13}}$ / 4 + New addition to stock$_{\text{in year t-12}}$ / 4

The fraction of the gas that remained in the retired equipment is presented in ***Table 4.55*** and the recovered fraction is presented in ***Table 4.57***.

Uncertainties and time-series consistency

A consistent time series of HFCs import-export exists since 1995 and is well documented. In previous submissions, the data on banks were not consistent because of use of extrapolation in 2010. The recalculation of banks was made according to the discussion with the ERT during six weeks' period after in-country review in 2012. In that submission, this extrapolation was useful in order to differentiate the banks among different subcategories. The inconsistency was caused by two types of formula used for bank calculation. In the 2015 submission, the inconsistent bank data were corrected, the bank data were recalculated by the same formula (as presented above) in the whole time series.

In 2017 submission, the bank data were recalculated again. The reason of recalculation was new way of operational emission estimation. It was assumed that equipment few years before its decommissioning is not serviced and the operational emission from this equipment has to be subtract from the bank. New product life factors were estimated based on this assumption. Product life factors for the time series 1990 – 2009 were assumed average of product life factors in the period 2010 – 2013 (outliers were excluded from the average). The used product life factors are presented in ***Table 4.59*** and they are within the range presented in the IPCC 2006 GL. The reported emissions are also influenced by the recalculation of the disposal emissions in last reporting years. Amounts of HFCs in retiring equipment were calculated consistently according to the previous presented formulas for all subcategories.

The changes in trend in new fillings in 2.F.1.e are caused by manufacturers of cars. Three factories exist in Slovakia. One of them has been producing cars since 1995, the others since 2006. Since 2015 submission the new fillings emissions are calculated from the data provided by the car producers (HFCs used for new fillings) for the years since 2009. For the rest of the time series the new fillings were estimated based on car production. The following time series of the share of cars with MAC is assumed: (i) in years 1995 – 1999, 70% of registered cars contained MAC; (ii) in 2000 – 2003, 80% of registered cars contained MAC; (iii) in 2004 – 2011, 90% of registered cars contained MAC; (iv) 100% of registered cars contained MAC since 2012.

The emissions in the category 2.F.1.f have stable trend since 2012 (inter-annual changes are up to 5%). The decrease in 2.F.1.a in 2011 was caused by the economic situation on the market and decrease in use of R404A in that year from service. The decrease in 2.F.1.c in 2014 is caused by decrease in service of units containing R404A and by starting to use units with the mixtures containing R152a with lower GWP.

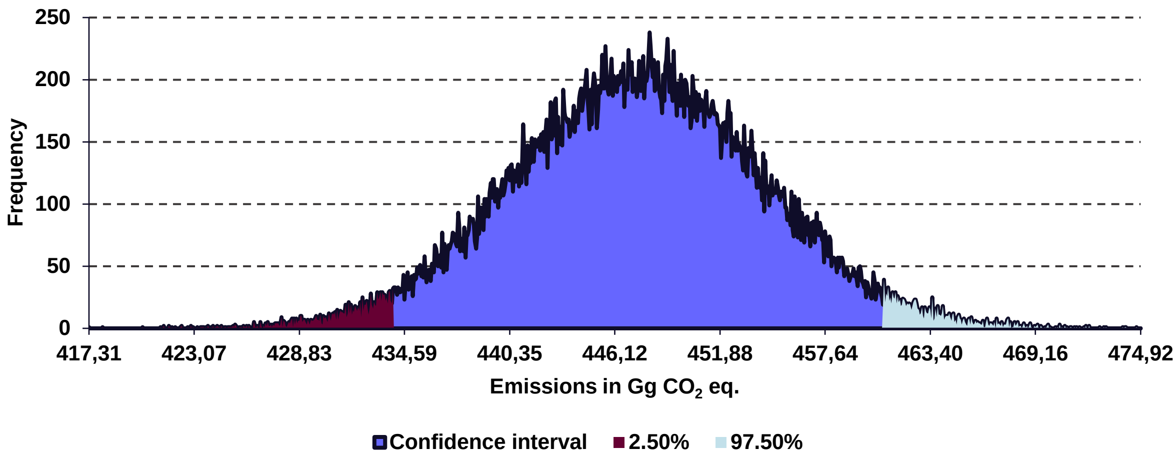
Generally, the decrease due the Regulation (EU) No 517/2014 of the European parliament and of the Council on fluorinated greenhouse gases is expected. The expectations are caused by several reasons. One of them is end of using of new R404A gas with GWP 3940 (only recovered gas can be used since now). Another reason is using of new replacements of R404A, R410A, R134a with low GWP blends (in Slovakia new gases R448A, R449A, R454B, R454C, R513A, R514A, R1234yf, R1234ze were introduced into the market). However, the decommissioning of the old equipment disrupts this expectation in several past years. In this submission, expectations about the reduction of emissions were fully met. In this submission, when compared with the previous year, the reduction in emissions was ca 195 Gg CO_2 eq. At verifying of this decrease, synergistic effect of several facts was determined: (i) significant increase of recovery, mainly R404A and R410A blends. The increased recovery corresponds to the decrease in emissions by ca 80 Gg CO_2 eq.; (ii) reduction in usage of the blend with high GWP (R404A, R410A, R407C and R134a) and their replacement with the blends with low GWP. This reduction corresponds to the decrease in emissions by ca 90 Gg CO_2 eq.; (iii) decrease in decommissioning of devices in categories 2.F.1a, 2.F.1.d and 2.F.1.f that corresponds to the decrease in emissions by 13 Gg CO_2 eq. Totally, it corresponds to the decrease in emissions by 183 Gg CO_2 eq.; which is in very solid agreement with the actual decrease of 195 Gg CO_2 eq.

Table 4.59: *Product life factors of individual gases in the category 2.F.1 in 1990 – 2009*

CATEGORY	HFC-125	HFC-134a	HFC-143a	HFC-152a	HFC-23	HFC-32
	%					
2.F.1.a	14.20	19.20	13.93	22.30	10	NO
2.F.1.b	NO	0.50	NO	NO	NO	NO
2.F.1.c	12.46	15.00	12.92	NO	NO	9.72
2.F.1.d	12.59	21.04	12.28	NO	NO	12.95
2.F.1.e	NO	10.94	NO	NO	NO	NO
2.F.1.f	12.97	17.48	8.61	NO	NO	9.62

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. The uncertainties of data taken from the database Leaklog were assumed to be 2%. Uncertainties of data calculated from the decommissioning were assumed to be 10% while the uncertainty of EF from new fillings was assumed as default value (100%). The overall uncertainty in CO_2 eq. emissions is 2.99%. It was computed by Monte Carlo simulation.

Figure 4.34: *Probability density function for 2.F.1 (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
447.39	447.36	6.83	417.31	474.92	-2.99%	3.00%

4.12.10. Foam Blowing (CRF 2.F.2)

This category is not significant and includes F-gases used in industry as follow:

- PU foam appliances (transferred from blowing agent R141b directly to cyclopentane in 1998).
- Injected PU foams in commercial cooling (started in 1999 and transferred from blowing agent R134a to water in 2007).
- Sprayed PU foams for roofs (transferred directly from ODS to HFC245fa and 365mfc in 2002).
- PU panels for containers, store rooms, *etc.* Big importers imported only panels with hydrocarbons, water blowing agents; smaller importers (in opened market) imported panels with R134a from 1999 up to 2007. In the main application areas of PU hard foam (rigid foam insulating panels, flexibly coated; rigidly faced sandwich panels) hydrocarbons and CO_2 are usually used as blowing agent. In the area of PU insulating foam for pipes HFC-245fa and HFC-365mfc cover a small share of the market whilst CO_2 and pentane are dominating.

Total HFCs emissions in this category were 1.74 Gg CO_2 eq. in 2022 (***Table 4.60***).

Methodological issues

HFCs emissions from open cells are not occurring in Slovakia. For closed cells, the blowing agents remain longer in foam; the half life time is calculated with >20 years and depends on the panel's thickness. According to the IPCC 2006 GL, product life of the used cells should be 50 years except of injected foams where product life is 15 years. These values are used in the calculation of emissions estimates. Emissions estimates are calculated based on first-year emissions and annual losses as described in the IPCC 2006 GL (emissions from decommissioning do not occur in Slovakia, yet).

Bank of used HFCs is monitored since the first year of their use as follows: Bank in year t = Bank in year t-1 + New fillings in year t-1 – Emissions from new fillings in year t-1 – Emissions from bank in year t-1 – Decommissioned equipment in year t

The relationship for bank is different from that used for refrigeration category because no servicing occurs for foams.

Emission factors are based on the data provided by producers. First-year loses are assumed to be 10%, annual losses 0.5%. These values are the same or close to the default values according to the IPCC 2006 GL. Activity data were collected via the web reporting system as described in the **Annex 4.2** of this Report. Import-export of bulk chemicals and products were collected in order to obtain annual sales data, which were then assumed be equal to new fillings. It was decided to use conservative approach for the first-year emissions from all new fillings occurred in Slovakia. In 2014, the using of HFC-227ea was reported for the first time in Slovakia.

Table 4.60: *Aggregated data on HFCs using in the category 2.F.2 in particular years*

YEAR	New Fillings	Bank	Disposal	New Fillings			Bank	Disposal
				New Fillings	Bank	Disposal		
	Gg CO_2 eq.							
1990	NO	NO	NO	NO	NO	NO	NO	NO
1995	NO	NO	NO	NO	NO	NO	NO	NO
2000	53.560	48.204	NO	5.356	0.241	NO	NO	5.597
2005	34.282	274.942	NO	3.428	1.375	NO	NO	4.803
2010	3.656	349.693	NO	0.366	1.748	NO	NO	2.114
2011	4.257	351.236	NO	0.426	1.756	NO	NO	2.182
2012	7.752	353.311	NO	0.775	1.767	NO	NO	2.542
2013	3.489	358.521	NO	0.349	1.793	NO	NO	2.142

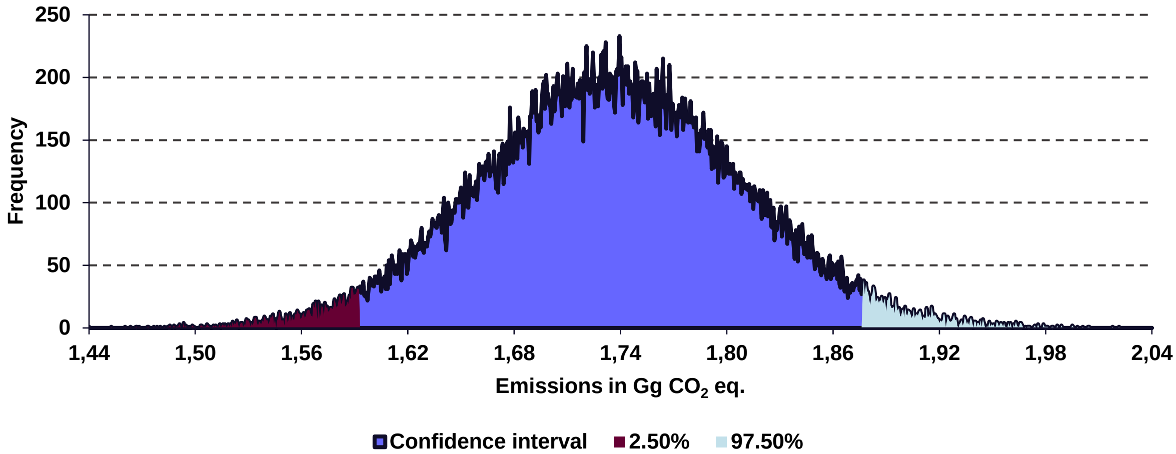
YEAR	New Fillings	Bank	Disposal	New Fillings			Bank	Disposal
				New Fillings	Bank	Disposal		
	Gg CO_2 eq.							
2014	1.853	359.869	NO	0.185	1.799	NO	NO	1.985
2015	0.012	359.737	NO	0.001	1.799	NO	NO	1.800
2016	NO	357.949	NO	NO	1.790	NO	NO	1.790
2017	NO	356.159	NO	NO	1.781	NO	NO	1.781
2018	NO	354.378	NO	NO	1.772	NO	NO	1.772
2019	NO	352.606	NO	NO	1.763	NO	NO	1.763
2020	NO	350.843	NO	NO	1.754	NO	NO	1.754
2021	NO	349.089	NO	NO	1.745	NO	NO	1.745
2022	NO	347.344	NO	NO	1.737	NO	NO	1.737

Uncertainties and time-series consistency

A consistent time series of HFCs import-export exists since the first years of HFCs using in foams and is well documented (the collection of data started in 1995 by using questionnaires – before the start of using of HFCs in foams). The same method was used for the whole time series. The decrease in emissions (and new fillings) in 2008 was caused by replacing of blowing agent R134a with water in new injected PU foams in 2007.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. The uncertainties of data taken from the database Leaklog were assumed to be 2%. Uncertainties of data calculated from the decommissioning were assumed to be 5% while the uncertainties of EFs were assumed to be default ones: from new fillings 10%; product life factor (10%), disposal factor (15%). The overall uncertainty in CO_2 eq. emissions is 8.21%. It was computed by Monte Carlo simulation.

Figure 4.35: *Probability density function for 2.F.2 (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
1.74	1.74	0.08	1.44	2.04	-8.19%	8.22%

4.12.11. Fire Protection (CRF 2.F.3)

This category is not significant and includes F-gases used in the following industry:

- HFC134a used as fluid in operating systems since 1994 in very little amount;

- HFC227ea (*FM 200*) is used as extinguishing media and suitable alternative for halon H1301 in fixed extinguishing systems since 2004. After 1993, halons are not imported into Slovakia;
- HFC 236fa (*FE36*) started to be used for portable extinguishing systems since the year 2000;
- PFCs extinguishing media are not imported into Slovakia. PFC 410 and PFC 614 have been never used in stabile extinguishing equipment.

Prices of new extinguishing medias are quite high (approx. 40 Euro/kg), so the consumption and emissions are minimal. Stationary fire protection systems for flooding indoor spaces mainly use inert gases at present. Formerly used ozone layer depleting halons have been replaced in some cases by HFCs. HFC-227ea in the fire extinguishers was firstly introduced on the Slovak market in 1994. F-gases for firefighting are imported in cylinders and filled in fixed installed systems.

Total HFCs emissions in this category were 21.93 Gg CO_2 eq. in 2022.

Methodological issues

Annual sales of single HFC gases are calculated based on import – export of bulk chemicals and products. Detailed data on consumption for new equipment, the stock in existing fixed flooding systems, annual losses (refilling) and recovered F-gases from disposal were obtained directly from the fire protection companies. Stabile extinguishing systems (flooding a streaming systems) used to protect electronic equipment have pressure vessels with lifetime from 10-12 years (given by the producer). After this time, extinguishing media are recovered, recycled and used again. In systems with working pressure 25 or 40 bar, the lifetime of pressure vessels is supposed to be at least up to 25 years.

HFC emissions occur from filling in fixed systems, from the bank (*in case of false alarm, fire, leakage, accidents etc.*) and from disposal. Test flooding, in former times an important source of emissions, have not taken place since 2000. The product manufacturing emission factor for filling of fixed systems is 1%. The emissions from bank are equalized with the company reports for refilling of losses. The product life factor from bank is 5% based on this assumption. Both factors were consulted with the fire protection companies and are in agreement with references. Used product life factor was used as a country specific one and it is slightly higher than the default value provided in the IPCC 2006 GL for installed flooding systems (1-3% per year). Emissions from disposal are reported since 2016.

Activity data were collected via web reporting system as described the **Annex 4.2** of this Report. Import-export of bulk chemicals and products data were collected in order to obtain annual sales data (which are equal to new fillings + service). Detailed data on consumption for the new equipment, the stock in existing fixed flooding systems, annual losses (refilling) and recovered F-gases from disposal were obtained directly from the fire protection companies and the Association of the Fire Extinguishers Producers in the Slovak Republic. These data served as tools for differentiating of annual sales data into new fillings and operational emissions (from bank).

***Table 4.61:** Aggregated data on HFCs used in the category 2.F.3 in particular years*

YEAR	New Fillings	Bank	Disposal	New Fillings	Bank			Disposal	New Fillings
					New Fillings	Bank	Disposal		
	Gg CO_2 eq.								
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	33.812	33.668	36.823	NO	0.338	1.841	NO	NO	2.179
2000	31.270	31.152	153.507	NO	0.313	7.675	NO	NO	7.988
2005	19.098	19.034	260.099	NO	0.191	13.005	NO	NO	13.196
2010	15.527	15.152	335.054	NO	0.155	16.753	NO	NO	16.908
2011	41.793	41.548	359.694	NO	0.418	17.985	NO	NO	18.403
2012	10.737	10.241	351.533	NO	0.107	17.577	NO	NO	17.684

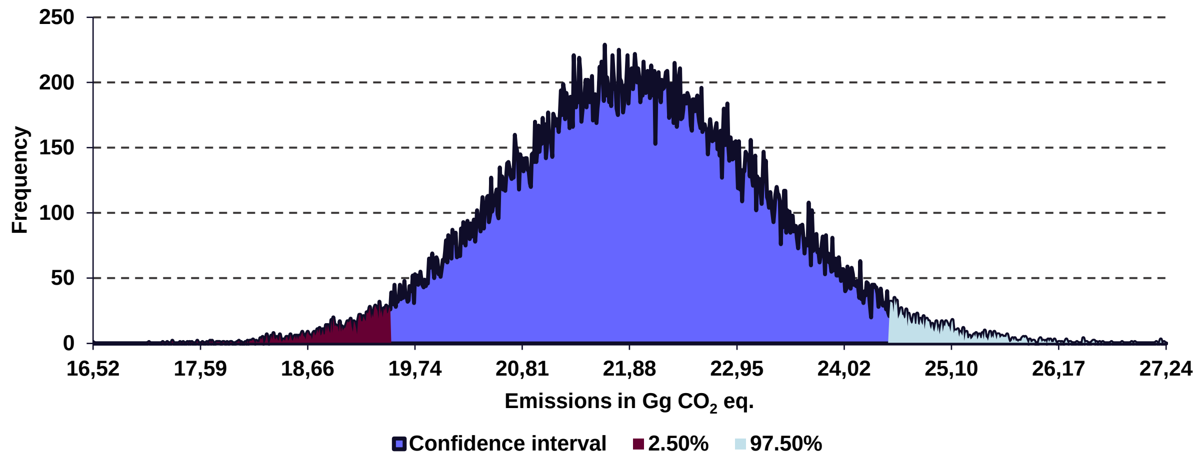
YEAR	New Fillings	Bank	Disposal	New Fillings	Bank			Disposal	New Fillings
					New Fillings	Bank	Disposal		
	Gg CO_2 eq.								
2013	12.047	11.565	345.414	NO	0.120	17.271	NO	NO	17.391
2014	21.318	22.274	350.296	NO	0.213	17.515	NO	NO	17.728
2015	39.530	48.071	380.639	NO	0.395	19.032	NO	NO	19.427
2016	27.211	27.084	379.918	6.702	0.272	18.996	2.011	4.692	21.279
2017	31.536	16.428	367.488	7.672	0.315	18.374	2.302	5.370	20.991
2018	20.062	12.044	351.243	7.680	0.201	17.562	2.378	5.302	20.141
2019	34.131	28.065	340.927	16.495	0.341	17.046	4.767	11.728	22.155
2020	24.564	8.086	324.752	5.499	0.246	16.238	5.063	0.436	21.546
2021	27.038	5.425	309.165	3.623	0.270	15.458	3.402	0.221	19.130
2022	22.708	7.610	290.536	8.408	0.227	14.527	7.177	1.231	21.931

Uncertainties and time-series consistency

A consistent time series of HFCs import-export data exists since 1995 and is well documented by using questionnaires. The same method was used for the whole time series. The increasing trend (since 1994) in actual emissions from HFC-227ea and HFC-236fa was stabilized and emissions are approximately at the same level. The purchase of new fire extinguishers depends mostly on the building of new server rooms.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. The uncertainties of data taken from the database Leaklog were assumed to be 2%. Uncertainties of data calculated from the decommissioning were assumed to be 10% while the uncertainties of EFs were assumed to be default ones: from new fillings 15%; product life factor (20%), recovery (10%). The overall uncertainty in CO_2 eq. emissions is 11.38%. It was computed by Monte Carlo simulation.

Figure 4.36: *Probability density function for 2.F.3 (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
21.92	21.94	1.27	16.52	27.24	-11.14%	14.54%

4.12.12. Aerosols (CRF 2.F.4)

The producers of aerosols in Slovakia changed directly from ODS to mechanical principles and use of hydrocarbons and dimethyl ether in 1990. The group of aerosols gases includes medical aerosols, i.e. Metered Dose Inhalers (MDIs), only. The HFC-134a and HFC227ea are used as propellant for such aerosols in Slovakia. However, since 2015, HFC-134a occurs only in Slovakia. Total HFCs emissions in this category are not significant and were 9.85 Gg of CO_2 eq. in 2022. The production of MDI does not occur in Slovakia.

Methodological issues

Aerosol emissions are considered prompt because all the initial charge escapes within the first two years after manufacture, typically six months after sale for most sub-applications (due to the short expiration time). It is assumed that the initial charge escapes approximately during two years. Therefore, the total amount of aerosol initially charged in product containers prior to sale in actual year and year before were taken into consideration in emissions estimation.

The production of MDI does not occur in Slovakia. The initial charge (new fillings, import to Slovakia) escapes during two years. This calculation of emission estimates corresponds to the equation:

$Emissions_{in\ year\ t}$ = $Initial\ charge_{in\ year\ t-1}$ * (1-EF) + $Initial\ charge_{in\ year\ t}$ * EF

In a similar way a bank of chemicals is calculated:

$Bank_{in\ year\ t}$ = $Initial\ charge_{in\ year\ t-1}$ * (1-EF) + $Initial\ charge_{in\ year\ t}$ * (1-EF)

EF is the same in both equation and equals to 0.5.

The basic philosophy of the calculation of bank is that the bank refers to the amount of gas that is not released as an emission in the previous and current year. In order to increase transparency, the numerical exercise is provided.

The content of HFC-134a in sold MDI in 2017 and 2018 were 6.175 t and 6.292 t, respectively. For emission calculation in 2018 the following way is used:

1. Due the fact that EF=0.5, the half of the amount sold in 2017 was used in 2017 and this amount is not of interest for 2018 calculation.
2. The rest of the gas sold and not used in 2017 was moved to bank of chemicals (3.087 t).
3. Emission calculation for 2018: the term *Initial charge*$_{in\ year\ t-1}$ ** (1-EF)* in the equation represents the gas that was moved to the bank in 2017 (3.087 t). The term *Initial charge*$_{in\ year\ t}$ ** EF* in the equation represents the gas that was used in 2018 (the half of the gas sold in 2018: 3.146 t).
4. Bank calculation for 2018: the term *Initial charge*$_{in\ year\ t-1}$ ** (1-EF)* in the equation represents the gas that was moved to the bank in 2017 (3.087 t). The rest of the gas that was sold in 2018 (and not used this year) is also added to the bank (3.146 t) and will be used for emission calculation in 2019.
5. It should be noted that the same numbers for emissions and bank are due the fact that EF=0.5. E.g. if we assume that EF=0.6 the values for emissions and bank will not be the same.

The State Institute for Drug Control of Slovakia is in the position to provide activity relevant data for emissions estimation. The activity data represents the number of containers with aerosols imported to Slovakia. The State Institute for Drug Control (ŠÚKL) provided this data on behalf of the Act No 286/2010 Coll. Data are available since 2000. Based on the statement of the ŠÚKL experts, no MDIs had been imported to Slovakia before the year 2000.

Table 4.62: *Aggregated data on HFCs using in the category 2.F.4 in particular years*

YEAR	Filled Into New Products	Bank	Emissions From:		Total Emissions
			New Fillings	Bank	
	Gg CO_2 eq.				
1990	NO	NO	NO	NO	NO
1995	NO	NO	NO	NO	NO

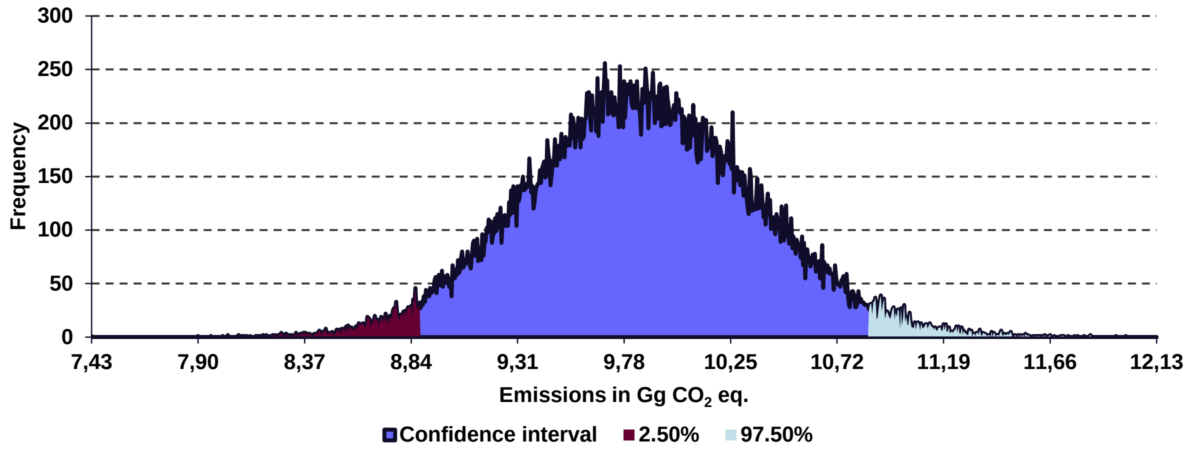
YEAR	Filled Into New Products	Bank	Emissions From:		Total Emissions
			New Fillings	Bank	
	Gg CO_2 eq.				
2000	NO	2.425	NO	2.425	2.425
2005	NO	6.182	NO	6.182	6.182
2010	NO	7.116	NO	7.116	7.116
2011	NO	7.624	NO	7.624	7.624
2012	NO	7.704	NO	7.704	7.704
2013	NO	8.098	NO	8.098	8.098
2014	NO	8.406	NO	8.406	8.406
2015	NO	9.058	NO	9.058	9.058
2016	NO	9.253	NO	9.253	9.253
2017	NO	8.325	NO	8.325	8.325
2018	NO	8.103	NO	8.103	8.103
2019	NO	8.310	NO	8.310	8.310
2020	NO	8.303	NO	8.303	8.303
2021	NO	8.832	NO	8.832	8.832
2022	NO	9.852	NO	9.852	9.852

Uncertainties and time-series consistency

A consistent time series of HFCs import-export data exists since the first years of MDIs use (2000) and is well documented. The same method for emissions estimation is used for the whole time series. HFC-134a is used since 2000. MDIs containing HFC-227ea are imported into Slovakia since 2008 and ended in 2015.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. The uncertainty of MDI sales for previous and actual year was assumed to be 10%. The uncertainty of emissions in CO_2 eq. is 10.04%. It was computed by Monte Carlo simulation.

Figure 4.37: *Probability density function for 2.F.4 (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
9.84	9.85	0.50	7.43	12.13	-9.82%	10.22%

4.12.13. Solvents (CRF 2.F.5)

The HFCs emissions are not occurring in this category, recently. There is no import of F-solvents to Slovakia because they are rather expensive. SP-255, which contains distilled oil and methyl acetate, is used as a flushing material. The solvents L113 and S316 used in Slovakia are not obliged to include in the emissions inventory. The solvents with HFCs are not used in cleaning machines for flushing refrigeration circuits. The emissions of PFC14 (CF_4) in solvents were estimated for the years 1997 – 2006 and then PFC14 was replaced with the SF_6 gas. No PFCs or SF_6 emissions were occurring in this category in 2022. Used amount of SF_6 is negligible (below 0.2 t/year). In the production process, the SF_6 is used for Si wafers etching after previous operation (Si wafers cutting on chips). Technological process can be described as follows:

- Si wafers are put into chamber of plasma equipment and after that air is exhausted from chamber for required vacuum,
- etching process starts with high-frequency burning SF_6 what cause etching of Si wafers surface,
- SF_6 and remains after etching process are exhausted from plasma equipment,
- these by-products go into special washing tank with NaOH where HF is neutralized.

According to the measuring of the semiconductor producer Semicron Vrbové, SF_6 emissions during etching are not emitted into atmosphere. Therefore, notation key “NO” is used for time series. PFC14 emissions from the solvents use are reported for the period 1997 – 2006.

Table 4.63: *PFC14 emissions in the category 2.F.5 in 1997 – 2006*

YEAR	Filled Into New Products	Bank	Emissions From:		Total Emissions
			New Fillings	Bank	
	Gg CO_2 eq.				
1997	NO	0.610	NO	0.610	0.610
1998	NO	2.021	NO	2.021	2.021
1999	NO	2.563	NO	2.563	2.563
2000	NO	1.274	NO	1.274	1.274
2001	NO	2.244	NO	2.244	2.244
2002	NO	3.315	NO	3.315	3.315
2003	NO	1.591	NO	1.591	1.591
2004	NO	0.696	NO	0.696	0.696
2005	NO	0.398	NO	0.398	0.398
2006	NO	0.099	NO	0.099	0.099

Emissions are considered prompt. It was considered that the new fillings escape during two years. Therefore, the total amount of PFC114 used in actual year and year before was used for emissions estimation. Due to this fact (the rest of the previous year’s new fillings has to escape in the next year), the emission factor from bank is 100% (the bank is calculated in the same way as described in the Chapter 4.12.12). The emission calculation corresponds to the equation:

$Emissions_{in\ year\ t} = New\ fillings_{in\ year\ t-1} * (1-EF) + New\ fillings_{in\ year\ t} * EF$, where EF=0.5.

4.12.14. Other Applications (CRF 2.F.6)

Emissions in this category are not occurring for the time series 1990 – 2022.

4.13. Other Product Manufacture (CRF 2.G)

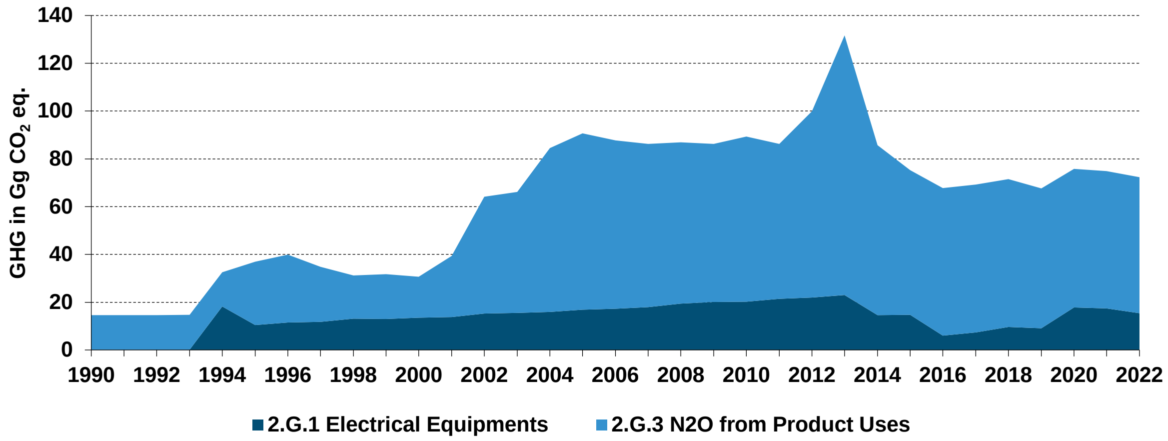
4.13.1. Source Category Description

Emissions of SF_6 from the high voltage switchgears and emissions of N_2O from use for anaesthesia and in food industry (aerosol cans) are reported in this category. Total emissions in CO_2 eq. were 72.38 Gg in 2022, decreased by 3% in comparison with the previous year. The decrease is caused by decreased service emissions of electrical equipment. Comparing with the base year, the increase is nearly 500%. This increase is mostly caused by the increase in N_2O emissions from aerosol cans. Emissions from SF_6 from other product use (2.G.2) are included in 2.G.1 electrical equipment.

Table 4.64: *Emissions in the category 2.G according to the subcategories in particular years*

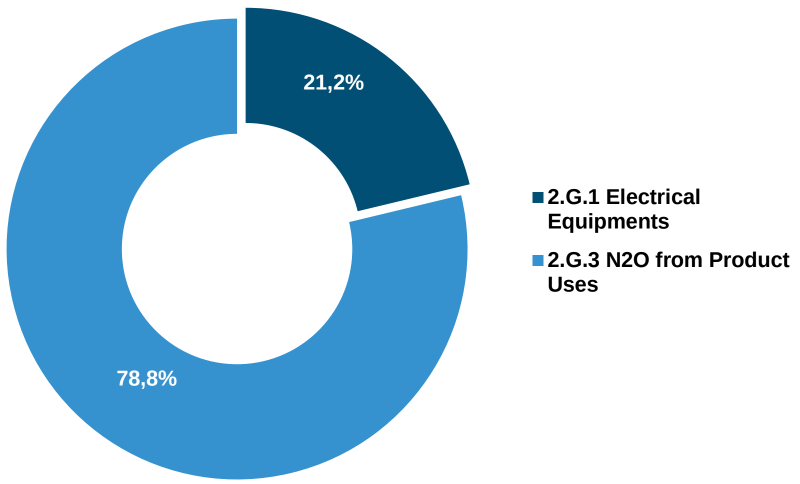
YEAR	2.G.1 Electrical Equipment	2.G.2 SF_6 and PFCs from Other Product Use	2.G.3 N_2O from Product Use
	Gg of CO_2 eq.		
1990	0.06	IE	14.58
1995	10.47	IE	26.50
2000	13.44	IE	17.21
2005	16.89	IE	73.82
2010	20.23	IE	69.06
2011	21.44	IE	64.84
2012	21.90	IE	78.04
2013	22.99	IE	108.69
2014	14.60	IE	71.17
2015	14.75	IE	60.57
2016	6.00	IE	61.75
2017	7.30	IE	61.96
2018	9.68	IE	61.80
2019	9.14	IE	58.54
2020	17.73	IE	58.01
2021	17.44	IE	57.48
2022	15.38	IE	57.00

Figure 4.38: *The trend of individual subcategories in the category 2.G in 1990 – 2022*



The major share (78.8%) in emissions belongs to the N_2O emissions from the product use, 21.2% belongs to SF_6 emissions from electrical equipment.

Figure 4.39: *The share in GHG emissions on individual categories of the 2.G in 2022*



4.13.2. Electrical Equipment (CRF 2.G.1)

Emissions of SF_6 from the thermal insulation of windows and from the high voltage switchgears are reported in this category. The Nitrasklo Ltd. company for windows used SF_6 since 1994 for anti-noise and thermal isolation. It was mixed with argon in the rate 30:70. Due the more effective production, consumption decreased. It was filled in close cycles without emissions from production. Consumption of SF_6 in Nitrasklo Ltd. continually decreased and it was phased out in the year 2002. Amount of stored gas annually in windows in the Slovak Republic was 10 kg from 80 kg filled into windows annually (70 kg were exported in windows). For the stock of gas remaining inside, an annual leakage rate is 1%. SF_6 emissions from window insulation are very negligible when compared to the emissions from electrical equipment (approx. 0.09% of total SF_6 emissions. Since the production of windows stopped in 2002, we considered it unfeasible to report disaggregated emissions. Data on windows are reported together with the emissions from isolating gas in high voltage switchers.

Most of the SF_6 is used as insulation media in high and low voltage electric equipment because of higher safety level and enable to reduce dimension of equipment. SF_6 is used as an arc quenching and insulating gas in high-voltage (>36 kV [110–380 kV]) and medium-voltage (1–36 kV) switchgear and control gear. The equipment – mainly Gas-Insulates Systems, GIS – has not been manufactured during the report period in Slovakia, but has been completely imported. High-voltage GIS (HV GIS) operate with a high operating pressure (up to seven bar) and large gas quantities. They are imported with a transport filling and are filled up on site. The systems are “closed for life” and have to be replenished in their lifetime. Emissions from operating HV systems are higher than emissions from the medium-voltage GIS (MV GIS). These operate with lower overpressure and small gas quantities of only some kg per system. They are already charged with SF_6 when imported and are hermetically closed (“sealed for life”).

Total actual emissions of SF_6 were 15.38 Gg CO_2 eq. (0.654 t SF_6) in 2022 (***Table 4.65***). In 2013, old equipment started to be disposed. Servicing of the electrical equipment was lower than in previous years, therefore the operational emissions decreased. It was verified by top-down approach (balance of annual sales etc. of SF_6).

Table 4.65: *SF_6 emissions in the category 2.G.1 in particular years*

YEAR	New Fillings	New Addition to Bank	Bank	Retired Equip.	Emissions from: New Fillings	Emissions from: Bank	Emissions from: Disposal	Recovery	Total
	Gg CO_2 eq.								
1990	3.008	3.008	3.008	NO	0.030	0.030	NO	NO	0.060
1995	72.122	63.008	974.526	NO	0.721	9.745	NO	NO	10.466
2000	54.779	42.307	1 289.668	NO	0.548	12.897	NO	NO	13.444
2005	88.595	73.329	1 600.124	NO	0.886	16.001	NO	NO	16.887
2010	69.584	50.520	1 957.101	NO	0.696	19.531	NO	NO	20.227
2011	102.319	82.751	2 039.852	NO	1.023	20.417	NO	NO	21.440
2012	85.164	64.768	2 104.620	NO	0.852	21.044	NO	NO	21.896
2013	64.390	49.350	2 143.160	10.810	0.644	22.161	0.184	10.626	22.988
2014	47.215	62.731	2 068.376	137.515	0.472	11.793	2.338	135.177	14.603
2015	121.035	152.786	2 210.024	11.138	1.210	13.354	0.189	10.949	14.753
2016	6.705	165.196	2 357.065	18.154	0.067	5.621	0.309	17.846	5.997
2017	17.631	86.571	2 433.818	9.818	0.176	6.957	0.167	9.651	7.300
2018	40.361	74.491	2 485.782	22.527	0.404	8.883	0.394	22.132	9.681
2019	9.338	46.841	2 511.102	21.521	0.093	8.680	0.364	21.157	9.137
2020	4.196	38.688	2 536.423	13.367	0.042	17.455	0.233	13.134	17.729
2021	NO	47.888	2 575.092	9.219	NO	17.283	0.155	9.064	17.438
2022	14.558	22.674	2 568.187	29.579	0.146	14.707	0.524	29.055	15.377

Methodological issues

The IPCC 2006 GL describe two general approaches for estimating emissions, which occur during the year mass-balance (top-down) and emission-factor (bottom-up) approach, respectively. The bottom-up approach takes into account the time lag between consumption and emissions explicitly by the emission factors. The top-down approach takes the time lag into account implicitly, by tracking the amount of virgin chemical consumed in a year that replaces emissions from the previous year.

The web reporting system allows calculating emissions in both approaches. The bottom-up approach in a combination with the top-down approach was used. The procedure is as follows:

1. Using the bottom-up approach from the Logbook Leaklog (described in the **Annex 4.2**);
2. Calculation of the total consumption of SF_6 in Slovakia based on the Leaklog;
3. Calculation of the total consumption of SF_6 in Slovakia according to the top-down approach;
4. Comparison of calculated results by different approaches;
5. If differences occur, the data in bottom-up approach are corrected by correction of operational emissions (no correction was necessary in 2022);
6. Calculation of emission estimates by the bottom-up approach using the corrected data.

For the top-down approach, the following formula based on the structure of the reporting systems was used:

Emissions = Annual sales of SF_6 – Total charge of new equipment + Disposal emissions

where: *Annual sales* and *Total charge of new equipment* are calculated by formulas presented in the IPCC 2006 Guidelines, Chapter 3, p. 7.54 (not simplified formulas). This formula corresponds to the formula described in Chapter 3, p. 8.14.

For bottom-up approach, the following formulas are used:

Emissions = Emissions from new fillings + Operational emissions + Disposal emissions where: *Emissions from new fillings* represent 1% (EF) of the new charges filled in Slovakia (*SF_6 to Charge domestically manufactured and Assembled equipment + SF_6 to Charge equipment that is not Factory-Charged*).

Operational emissions represent the consumption of gases for servicing (these data are reported in Leaklog). It is assumed that the SF_6 used for servicing restocks the emissions from the bank and thus the bank of the chemical remains constant.

Disposal emissions represent the emissions from the retired equipment.

For the consistency of operational emissions, the bank of SF_6 is necessary to follow. The bank is calculated as follows:

$Bank_{in\ year\ t} = Bank_{in\ year\ t-1}$ + New additions to bank – SF_6 in retired equipment

where: *New additions to bank = SF_6 to Charge Domestically Manufactured and Assembled Equipment + SF_6 to Charge Equipment that is not Factory-Charged + SF_6 Contained in Imported Equipment Already Charged – SF_6 Contained in Exported Equipment Already Charged.*

Emission factors from the filling SF_6 into new equipment (product manufacturing factor) is assumed 1% (based on the producers' data). Operational emission factor (product life factor) is calculated yearly based on the reported operational emissions and the respective bank.

Disposal emission factor (disposal loss factor) is based on the survey of recycling factories. It follows that 98.2% of SF_6 is recovered for repeated used or destroyed (in 2022, 0.063 t was destroyed). Thus, the disposal loss factor is 1.8%. The activity data are collected together with the other F-gases data as described in the category 2.F and in the **Annex 4.2** of this Report. Amount of SF_6 in disposed systems was taken directly from recycling factories.

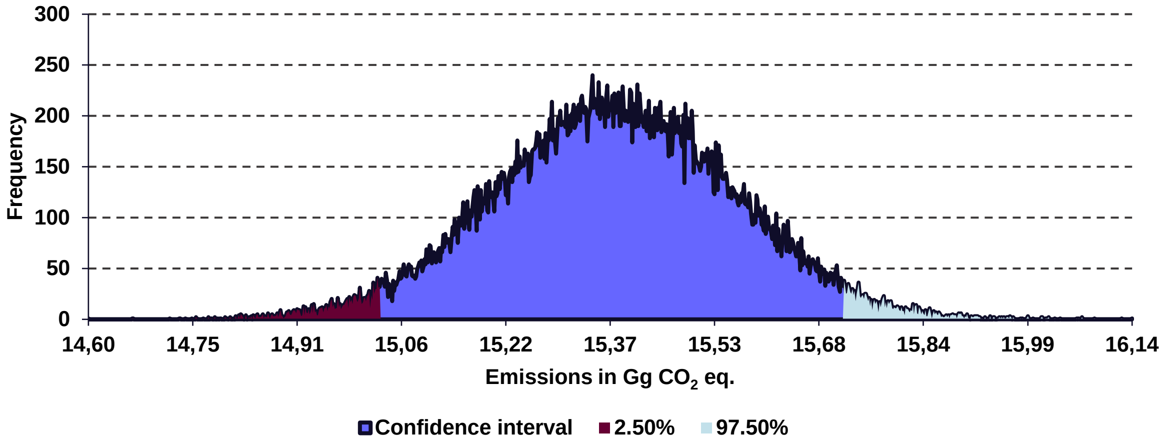
Uncertainties and time-series consistency

A consistent time series of SF_6 import-export data exists since 1993 and is well documented. Data were collected in questionnaires. In previous submissions, the data on banks were not consistent because of use of extrapolation in 2010. The inconsistency was caused by two types of formula used for bank calculation. In the 2015 submission, the inconsistent bank data were corrected, the bank data were recalculated by the same formula (as presented above) in the whole time series. Product life factor for the time series 1990 – 2009 was assumed average of product life factors of 2010 – 2014 (1%). Product life factor is higher than the default value (0.2%) provided in the IPCC 2006 GL.

In 1994, the owner of the Slovak electrical power system began with the modernization of grids and transformer stations. Therefore, the sharp increase in SF_6 emissions is visible in 1994.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. The uncertainties of data taken from the database Leaklog were assumed to be 2%. Uncertainties of data calculated from the decommissioning were assumed to be 20% while the uncertainty of EF from new fillings was assumed as default value (100%). The overall uncertainty in CO_2 eq. emissions is 2.25%. It was computed by Monte Carlo simulation.

Figure 4.40: *Probability density function for 2.G.1 (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
15.38	15.38	0.18	14.60	16.14	-2.26%	2.21%

4.13.3. Use of SF_6 and PFCs in Other Products (CRF 2.G.2)

SF_6 can be used as an extinguishing medium in electronics, protection against explosion, isolation, sterilization, detection gas, alloying of Al and Mg and in tobacco production. SF_6 gas is rather expensive and therefore it was never used as an extinguishing medium in industry in Slovakia. Shoes and tires with F-gas cushions are not manufactured or imported to Slovakia for the time series 1990 – 2022. Emissions from in windows insulation are reported in 2.G.1.

4.13.4. N_2O from product uses (CRF 2.G.3)

Medicine (anaesthesia) and food industry (aerosol cans) N_2O emissions are reported in this category in 2020. There is also the consumption of N_2O for analytical purposes, but the gas is burned after use, so this source is not included into inventory. Total N_2O emissions from aerosol cans were 195.6 t and total N_2O emissions from anaesthesia were 19.5 t in 2022.

Methodological issues

The methodology is based on the default tier 1 due to less significant of this category (it is not a key category). The final N_2O emissions from these sources are equal to the consumed gas in medicine and food industry in the reporting year. The time series was reconstructed based on the statistical data on production. The N_2O emissions according to the categories are summarized in ***Table 4.66***.

Table 4.66: *N_2O emissions from product use in particular years*

YEAR	Total N_2O		
	2.G	2.G.3.a Medical Application (Anaesthesia)	2.G.3.b Other (Aerosol Cans)
	Gg		
1990	0.0550	0.0550	NO
1995	0.1000	0.1000	NO
2000	0.0650	0.0650	NO
2005	0.2785	0.0656	0.2129
2010	0.2606	0.0528	0.2078
2011	0.2447	0.0490	0.1957
2012	0.2945	0.0445	0.2500
2013	0.4102	0.0190	0.3912
2014	0.2686	0.0176	0.2510

YEAR	Total N_2O		
	2.G	2.G.3.a Medical Application (Anaesthesia)	2.G.3.b Other (Aerosol Cans)
	Gg		
2015	0.2285	0.0275	0.2010
2016	0.2330	0.0190	0.2140
2017	0.2338	0.0178	0.2160
2018	0.2332	0.0182	0.2150
2019	0.2209	0.0186	0.2023
2020	0.2189	0.0198	0.1991
2021	0.2169	0.0196	0.1973
2022	0.2151	0.0195	0.1956

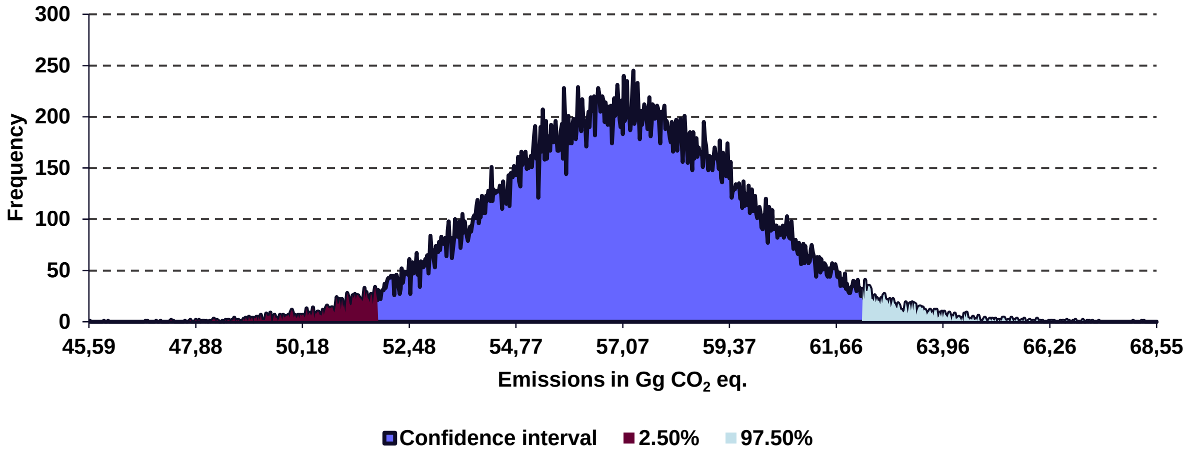
Used N_2O EFs in medicine and food industry are based on approximation, that emissions are equal to consumed gas (EF = 1 t/t). It is assumed that all gas is evaporated into the atmosphere in the reporting year. This assumption is in line with the IPCC 2006 GL for medical applications and aerosol cans in food industry. The activity data in the category 2.G.3 come from the distributors of N_2O liquid gas – Messer-Tatragas, Linde, Air Products and SIAD companies. The disaggregation of gas utilization is based on direct information from the gas distributors.

Uncertainties and time-series consistency

Consistent methodology and tier method were used for the whole time series.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. Activity data uncertainty (10%) was used for the uncertainty analyses in 2.G.3 according to the individual sources. The overall uncertainty is 9.14%.

Figure 4.41: *Probability density function for 2.G.2 (t of CO_2 eq.)*



Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
57.00	57.00	2.66	45.59	68.55	-9.14%	9.14%

4.14. Other Production (CRF 2.H)

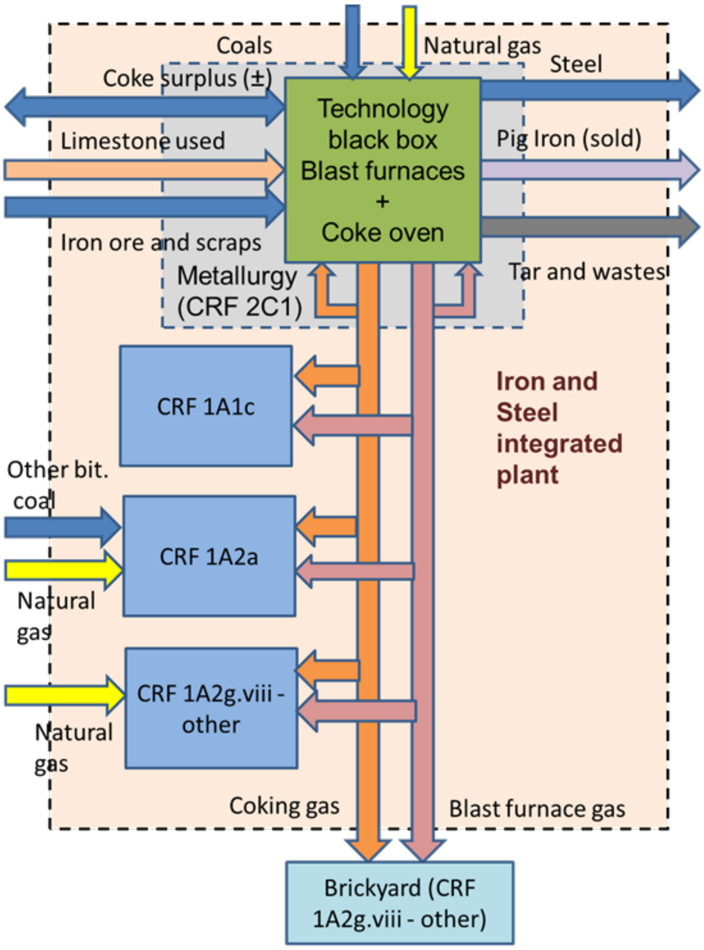
The NMVOC emissions mainly from food industry were reported in this category in 2022. Total emissions of NMVOC were 3 336 t and are consistent with the CLRTAP inventory. No GHG emissions occurred in the time series 1990 – 2022.

Annex 4.1. CO_2 Reference Approach and Comparison with the Sectoral Approach, and Relevant Information on the National Energy Balance

A4.1.1 Methodology for Carbon Balance of Iron and Steel Production

The country specific methodology is implemented in the inventory (see Chapter 4.9.1 of this Report). Pig iron and steel are produced in iron and steel integrated plant and by the EAF method. Iron and steel integrated production is a complex with many energy-related installations (coke ovens, heating plant, etc.). Several available data for integrated iron and steel can be found in: (i) questionnaires provided by the producers (data on raw materials, pig iron and steel produced and limestone used); (ii) the NEIS database (detailed data on fuels used and their flows); (iii) the EU ETS reports (data on total carbon balance of all inputs and outputs). The EU ETS reports were used during QA/QC process to verify estimates. The allocation of sources into IPCC subcategories cannot be provided based on data available in the EU ETS reports. In order to prepare carbon balance, the simplified scheme of the plant was proposed (***Figure A4.1.1***). Occasional sale of produced pig iron was considered, too. In some cases, parts of coking gas and blast furnace gas were sold to the nearby brickyard plant, which was also considered during estimation. Total carbon balance was calculated according to the proposals depicted in the Scheme. All the streams were estimated using plant specific conversion units and carbon EFs taken from the category 1.A.2.a of the Energy sector or based on carbon content in materials.

Figure A4.1.1: *The simplified distribution scheme of the complex plant for pig iron and steel production*



Carbon balance consists of four steps: (1) balance of 2.C.1, (2) balance of 1.A.1.c, (3) balance of 1.A.2.a and (4) balance of 1.A.2.g.viii - Other.

Table A4.1.1: *Balance of the category 2.C.1 in 2022*

STREAM	AD	NCV	EF (C)	CARBON
	kt; mil. m³	*TJ /m.u.*	*t/TJ; mass fraction*	*kt*
Coking coal	2 313.60	29.405	25.554	1 738.48
Anthracite	0.00	0.000	0.000	0.00
Coke surplus	-41.41	27.182	29.680	-33.40
Natural gas	18.08	35.209	15.321	9.75
Tar and wastes	-1 593.56	NA	0.045	-72.00
Coking gas	-538.54	16.850	11.774	-106.84
Blast furnace gas	-3 197.69	3.090	75.053	-741.59
Iron ore	5 986.50	NA	3.377E-03	20.22
Steel	-3 558.10	NA	8.340E-04	-2.97
Pig iron sold	-6.59	NA	1.845E-03	-0.01
Limestone used	767.63	NA	1.201E-01	92.19
TOTAL	903.82			

CO_2 emissions estimation in the 2.C.1 is based on the carbon balance (from that plant) and represents the value 3 313.75 Gg (total carbon × 44/12).

Table A4.1.2: *Balance of the category 1.A.1.c in 2022*

STREAM	AD	NCV	EF (C)	CARBON
	kt; mil. m³	*TJ /m.u.*	*t/TJ; mass fraction*	*kt*
Natural gas	0.235	35.209	15.32	0.13
Coking gas	123.03	16.85	11.77	24.41
Blast furnace gas	1 232.44	3.09	75.05	285.82
TOTAL	310.36			

CO_2 emissions estimation in 1.A.1.c is based on the carbon balance (from that plant, not total 1.A.1.c) and represents the value 1 137.97 Gg (total carbon × 44/12).

Table A4.1.3: *Balance of the category 1.A.2.a in 2022*

STREAM	AD	NCV	EF (C)	CARBON
	kt; mil. m³	*TJ /m.u.*	*t/TJ; mass fraction*	*kt*
Other bituminous coal	276.85	26.823	25.588	190.01
Natural gas	8.35	35.209	15.321	4.50
Coking gas	237.72	16.850	11.774	47.16
Blast furnace gas	1 723.74	3.090	75.053	399.76
TOTAL	641.44			

CO_2 emissions estimation in 1.A.2.a is based on the carbon balance (from that plant, not total 1.A.2.a) and represents the value 2 351.94 Gg (total carbon × 44/12).

Table A4.1.4: *Balance of 1.A.2.g.viii – Other in 2022*

STREAM	AD	NCV	EF (C)	CARBON
	kt; mil. m³	*TJ /m.u.*	*t/TJ; mass fraction*	*kt*
Natural gas	91.09	35.209	15.321	49.13
Coking gas	177.54	16.850	11.774	35.22
Blast furnace gas	241.52	3.090	75.053	56.01
TOTAL	140.37			

CO_2 emissions estimation in 1.A.2.g.viii - Other is based on the carbon balance (from that plant, not total 1.A.2.g.viii - Other) and represents the value 514.69 Gg (total carbon × 44/12).

The output from the plant was 0.236 mil. m^3 of coking gas and 0 mil. m^3 of blast furnace gas in 2022. In the years, when output is reported from the iron and steel plant, it means, that gases are sold to nearby brickyard and they are balanced in the category 1.A.2.g.viii - Other.

Carbon balance presented in this Annex is only from the integrated iron and steel plant. The CO_2 emissions estimation presented here is allocated in the categories 2.C.1, 1.A.1.c, 1.A.2.a and 1.A.2.g.viii - Other. The presented Energy sector includes also other productions or technologies in Slovakia. Therefore, total CO_2 emissions calculated via this approach will be lower than those presented in each individual CRF table. In comparison with the verified CO_2 emissions under the EU ETS, the emissions estimated for the integrated iron and steel plant by using this country specific input-output approach differ by 0.08%: (i) NIR: 7 322.50 Gg CO_2; (ii) EU ETS: 7 316.76 Gg CO_2. It should be noted that in both values compared the CO_2 from desulphurization and DENOX applications are included (3.46 and 0.69 Gg CO_2, respectively).

Annex 4.2. Methodology of Acquisition and Data Processing on F-gases Consumption in the Categories 2.F, 2.G.1 and 2.G.2

Fluorinated greenhouse gases (F-gases) are used in numerous applications and include three types of gases: HFCs, PFCs and SF_6. F-gases emissions are mainly released from refrigeration and air conditioning equipment, foams, aerosols, solvents, fire protection equipment, from halocarbon production, from certain industrial processes in semiconductor and non-ferrous metal industry and from equipment for transmission of electricity during manufacture, use and at disposal.

Due to their relatively high global warming potentials, F-gases are addressed by international conventions such as the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol (with post-2012 amendment), as well as by policies at the European and at national levels. The EU committed to reduce overall greenhouse gas emissions by 20% compared to the base year 1990 during the second commitment period 2013 – 2020.

The EU policy targets are based on further reduction of halocarbon refrigerant usage, on the substantially decreased leakage percentage and energetically efficient operation of air conditioning systems, heat pumps and refrigeration installations. Success of the EU Regulation No. 517/2014 depends on effective measures. This new regulation, which replaces the first EU Regulation No. 842/2006 was applied from 1st January 2015, strengthens the existing measures and introduces a number of far-reaching changes. By 2030, it will cut the EU's F-gas emissions by two-thirds compared with 2014 levels. Described solutions are based on data recorded in the log-book according to EN 378 Regulation (EC) No 1516/2007. Advantages of electronic data logging and reporting are shown on the possibilities of automatic analysis, fault detection and comparison of, fast access to the full history of leak checks and various forms of output. Value added of electronic logbook is indirect detection of refrigerant leak. The fault detection classifier estimates the probability of refrigerant leak.

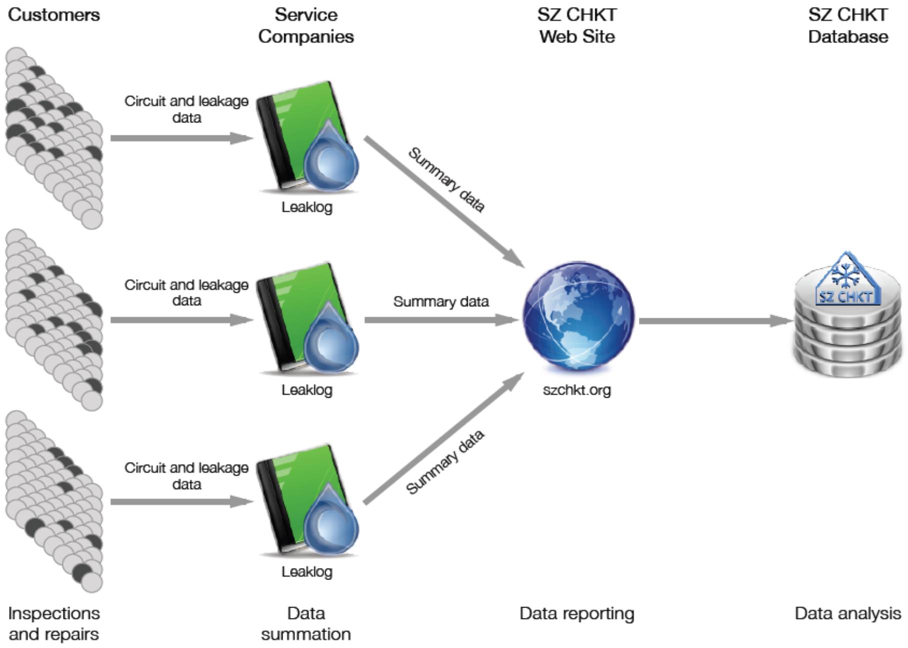
In the year 2003, Slovakia started software with access to the processing and data assessment. This software system is based on the activities of the Slovak Association for Cooling and Air-conditioning Technology (SZCHKT). The electronically led documentations have been developed from the previous paper questionnaires. Evaluated data were collected from the service organizations and customers. The backward running contact with inventoried companies enabled cooperation that is more effective. The companies can find their data reported in the previous years in the questionnaires. It enables the mutual control of the used data. Next step was data processing in Access database.

Database of original data was processed in following tables:

01 Adresy organizacii s pohybom latok	01 Addresses of companies with move of substances
02 Kody druhu importu a exportu latok	02 Code of the type of import and export
03 Latky HFC SF6 PFC	03 Substances
04 Zlozky zmesi latok	04 Components of the substances (mixtures)
05 Druh latky	05 Type of substance
06 Emisne koeficienty podla pouzitia latky	06 Emission factors
07 Roky	07 Inventory years
08 Pohyby latok za rok	

Database was prepared for processing according to the suggested algorithm. This way of data reporting was the only one used up to the end of the year 2009. In 2009, a new internet reporting system Leaklog started. This system is based on the activities of the Slovak Association for Cooling and Air-conditioning Technology (SZCHKT) and is available. The SZCHKT is the "Notified Body", the body officially authorized by the Ministry of Environment to certified companies and organizations for the activities in this area. Evaluated data are collected from the service organizations.

Figure A4.2.1: *System of data transfer from customer to Notified Body*



The reporting and data processing system consists of:

- Annual reporting of F-gases (new charges and leakages) by certified companies;
- Annual reporting of F-gases imported in bulks by certified companies;
- Annual reporting of F-gases in products by importers, exporters, producers by companies.

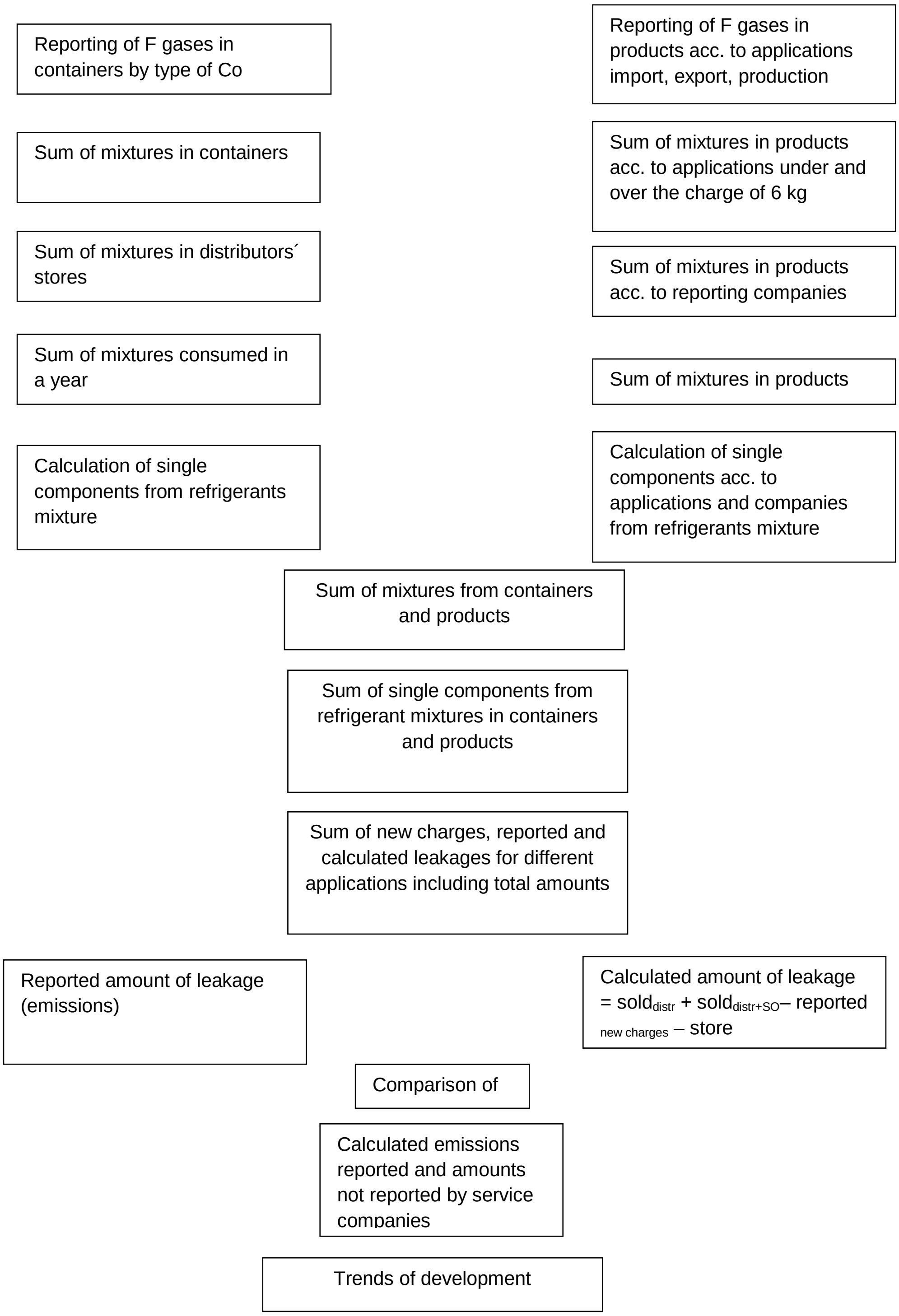
All companies dealing with the F-gases have access to the electronic system based on certificate provided by the Notified Body. Advantages of electronic data logging and reporting are in the possibilities of automatic analysis, fault detection and comparison of, fast access to the full history of leak checks and various forms of output. Service engineers get quick survey of the customers, cooling circuits, details of all maintenance work and repairs, refrigerants in store, refrigerants added, recovered, reclaimed, and disposed of. Value added of electronic logbook is indirect detection of refrigerant leak. The fault detection classifier estimates the probability of refrigerant leak. Electronic way of the data records enables summarizing, reporting and analysing important data in a chosen period in connection with the internet (***Figure A4.2.2***). Documented, consistent time series of HFCs import-export data exists since 1995. They were collected using the questionnaires (more than 250 companies). The institutions included in data collection are:

- Refrigerants, air-conditioning, heat pumps: SZCHKT. This institution is appointed for personnel and company certification required by 842/2006/EC. This certification activity was started by the Slovak association for cooling and AC Technology (SZCHKT) in the year 2009;
- Firefighting: Association of extinguishing appliances producers (ZVHP);
- MDI: State Institute for Drug Control (SUKL);
- Mobile AC: Automotive Industry Association (ZAP);
- Solvents: (SZCHKT);
- SF_6 use: (SZCHKT).

Reports to the database in subcategories refrigeration, air-conditioning and heat pumps, solvents and SF_6 include two web systems:

- import, export, sales data of bulk chemicals and products (database used since 2003),
- data on type of use (for new equipment or for recharge/service, recovery, reclaimed, disposal)

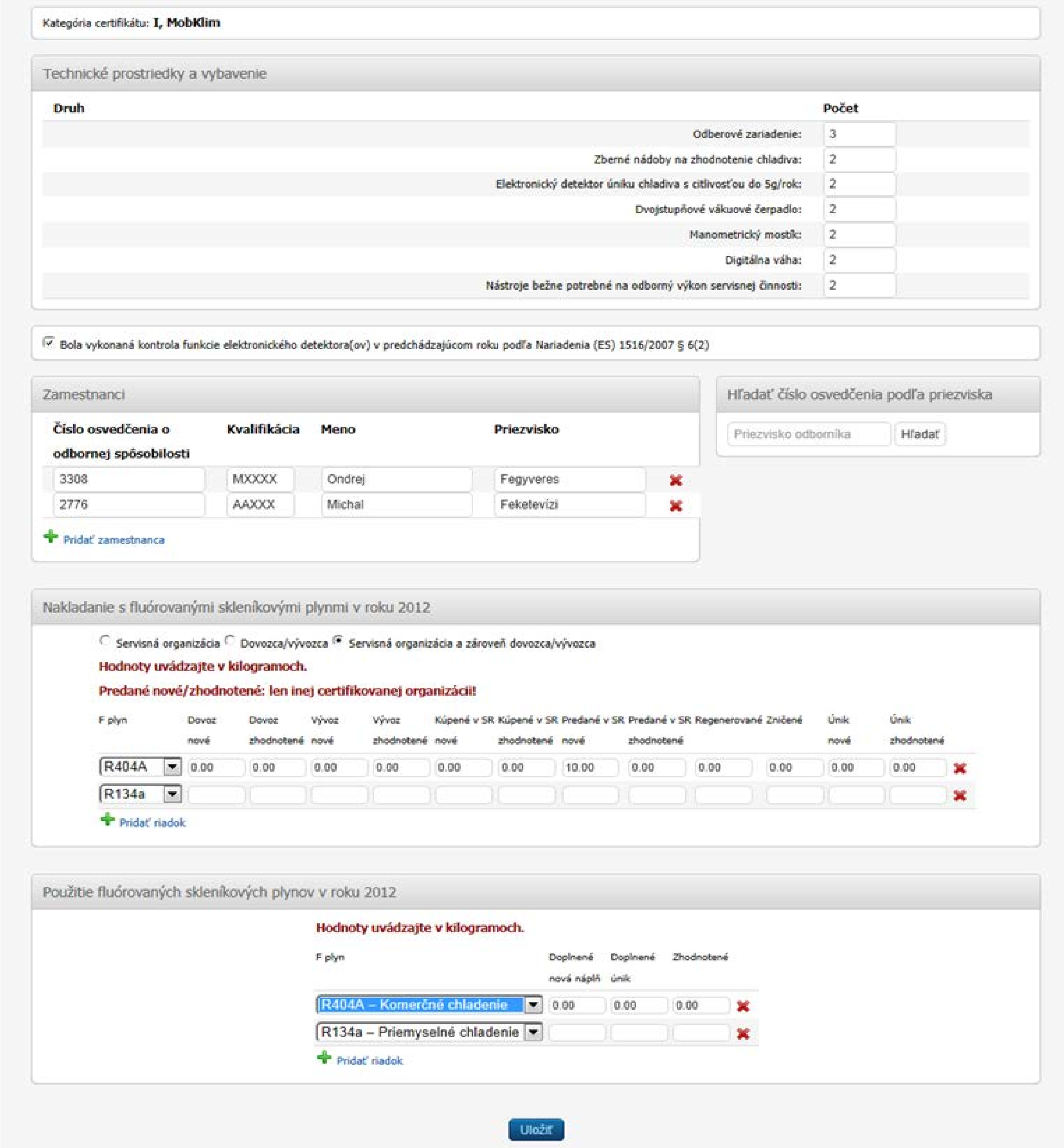
Figure A4.2.2: *Diagram of data flow in reporting (data flow direction: top to down)*



A4.2.1 Reporting of F-gases Imported in Bulks

Refrigerant movements reporting is required according to EU legislation. Every certified company shall restore its certificate annually. Company has to enter website of the Notified Body with its name and password. Table on ***Figure A4.2.3*** is showing front-pages which appear after the signing up of company to the system. In this table, the certified company has to declare the competencies of the employees, possession of technical equipment, regular checking of electronic detectors, and movement of refrigerants from the previous year. The confirmed data are saved and sent to the Notified Body until the end of January annually. After receiving the report, the Notified Body will restore the certificate. Certified companies and competent persons are listed on the website of the Notified Body. This is a part of the web system used since 2003.

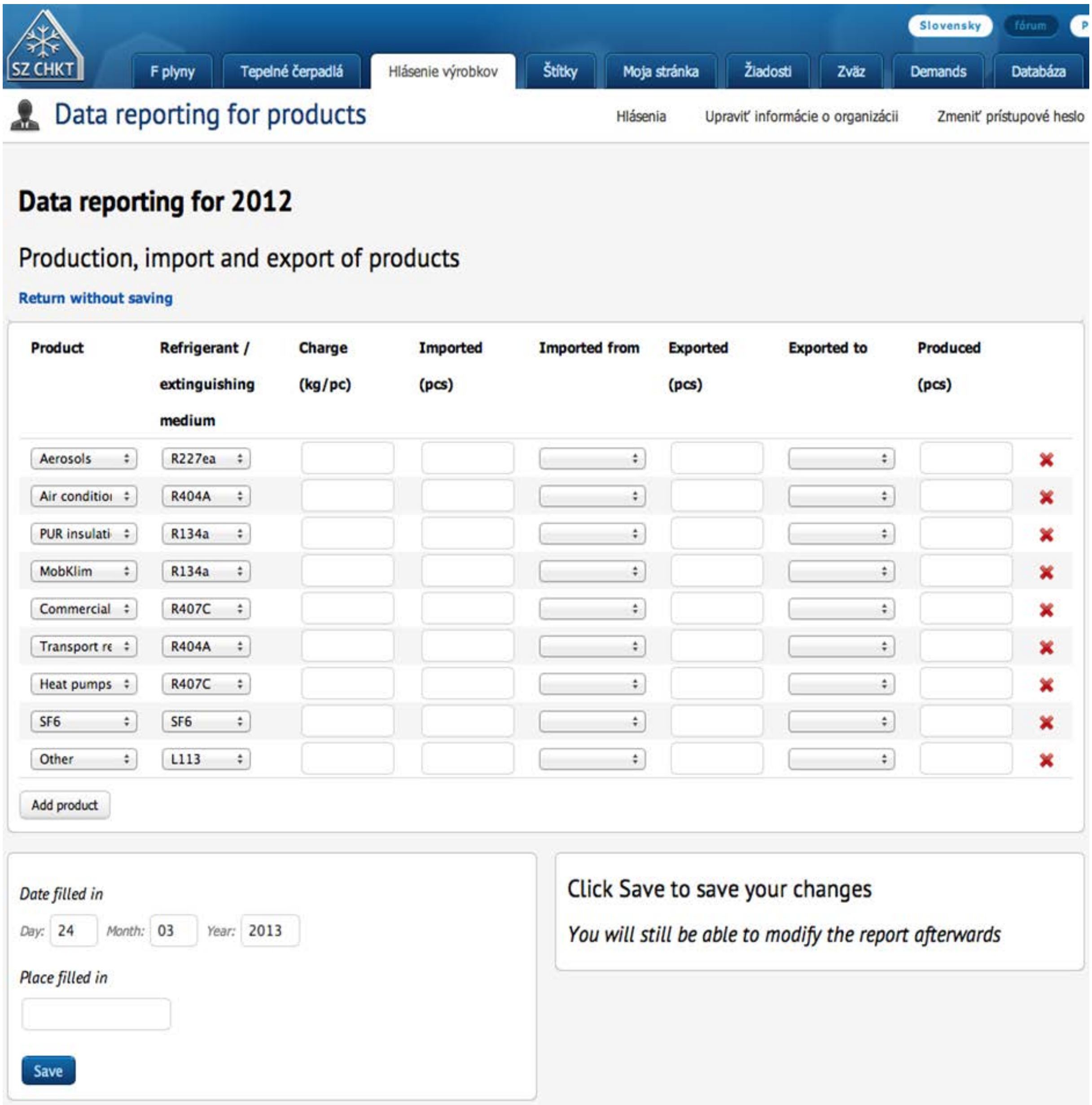
Figure A4.2.3: *Declaration of certified company with the legal status in the EU and in Slovakia about competencies of the employees, technical equipment, regular checking of electronic detectors, and refrigerant management categorized by field of application on the website of notified body*



Reporting of refrigerant movements in products is required according legislation. Every importer, producer or exporter shall report annually. Company has to enter the website of notified body with its name and password.

Figure A4.2.4 presents table of data reporting for products, which will be shown to the company after entering its account and this shall be filled in. In this table, the company has to report movements of refrigerant in products from the previous year. The confirmed data are saved and shall be sent to the Notified Body until the end of January. After receiving the report, data are automatically processed. Reporting companies are listed on the website. All reported data are available for the reporting organizations. Historical development in all monitored refrigerants with emission projections up to 2025 are part of the web system since 2003.

Figure A4.2.4: *Data reporting of importers, producers and exporters on products used*



Important notice: Producers have to confirm, that they filed into products only refrigerants from certified companies (bought in Slovakia or by own import). In this way doubled counting of refrigerants and reported amounts from products and containers is avoiding.

A4.2.3 Reporting of Type of Use (for New Equipment or for Recharge/Service, Recovery, Reclaimed, Disposal) – Logbook Leaklog

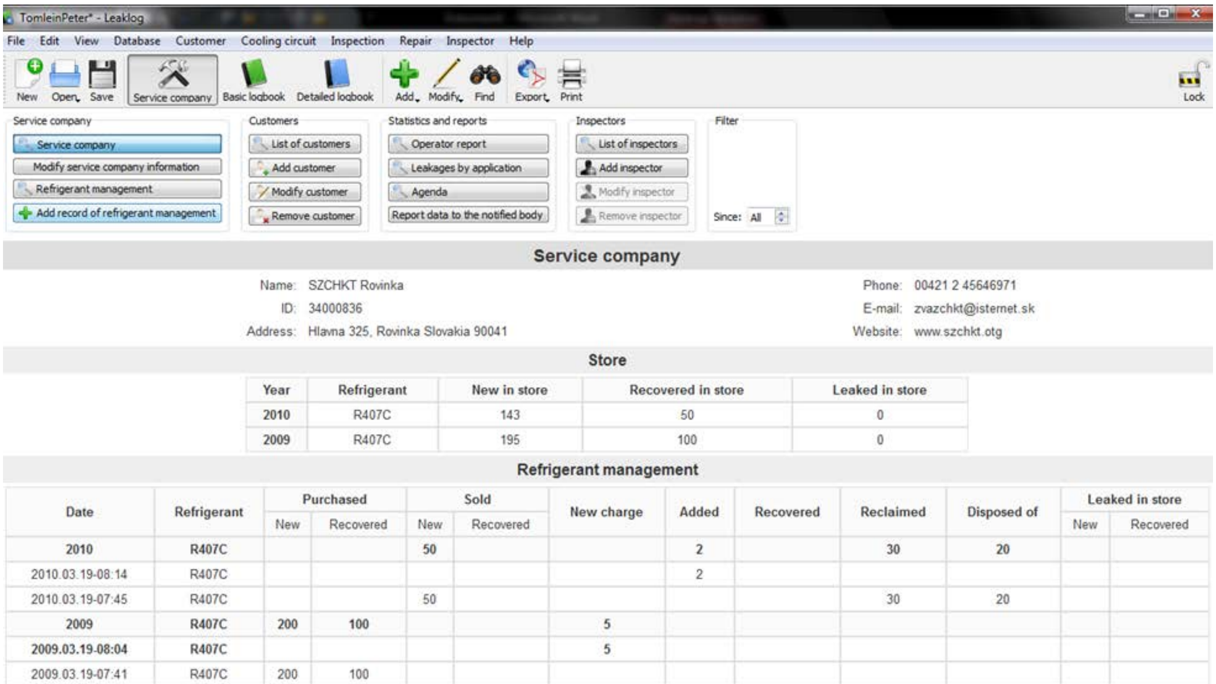
Almost complete activity data used for inventory preparation in the category 2.F is covered by the web reporting system Leaklog. Especially the refrigeration is very complex, there are numerous of small enterprises. This web reporting system receives data from more than 1 200 companies. This system was introduced in 2009 and is still in operation. Therefore, also trends are consistent.

Reporting is made by the Logbook software Leaklog. It includes:

- Quick overview, survey;
- List of customers;
- Cooling circuits;
- Details of all maintenance work and repairs;
- Leakage ratio;
- Refrigerants in store;
- Refrigerants added, recovered, reclaimed and disposed.

Each contractor has to enter the website of notified body with its name and password. Which data are filled in and all details are listed above (***Figures A4.2.5*** and ***A4.2.6***).

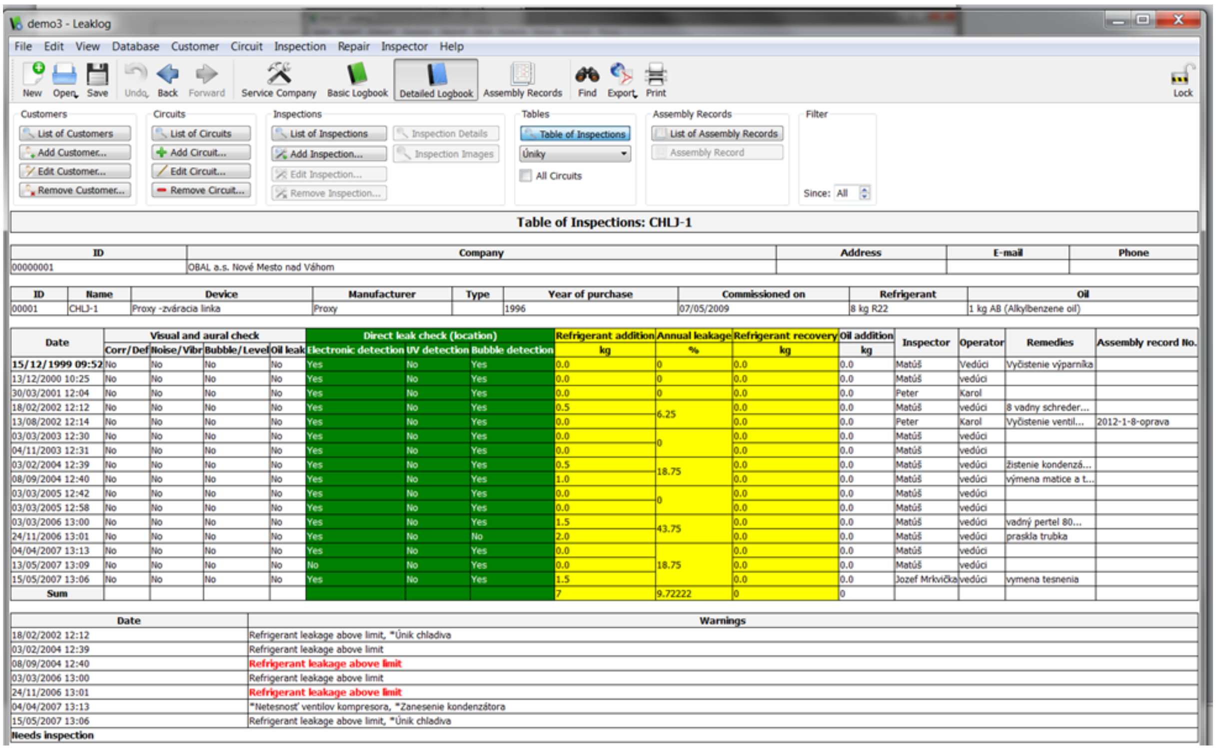
Figure A4.2.5: *Main outputs of logbook*



Year	Refrigerant	New in store	Recovered in store	Leaked in store
2010	R407C	143	50	0
2009	R407C	195	100	0

Date	Refrigerant	Purchased		Sold		New charge	Added	Recovered	Reclaimed	Disposed of	Leaked in store	
		New	Recovered	New	Recovered						New	Recovered
2010	R407C			50			2		30	20		
2010.03.19-08:14	R407C						2					
2010.03.19-07:45	R407C			50					30	20		
2009	R407C	200	100			5						
2009.03.19-08:04	R407C					5						
2009.03.19-07:41	R407C	200	100									

Figure A4.2.6: *Procedure of data reporting of F-gases*



*The inserted data can be presented in table with differentiation by category (**Figure A4.2.7**).*

Figure A4.2.7: *Table of leakages by application*

Tables of Leakages by Application

Back | Tables | Charts by refrigerant | Charts by field of application

Weighted mean leakage

Refrigerant	Commercial refrigeration Average leakage	Industrial refrigeration Average leakage	Transport refrigeration Average leakage	Air conditioning Average leakage	Heat pumps Average leakage	Domestic refrigeration Average leakage
R134a	5.1	2.4	0.0	3.9	7.3	0.0
R22	2.5	0.7	0.0	0.2	16.9	0.0
R404A	8.8	9.5	0.0	17.5	0.0	0.0
R407C	6.3	6.9	0.0	4.7	9.3	0.0
R410A	18.0	8.5	0.0	2.2	20.8	0.0
R417A	33.3	14.6	0.0	25.0	0.0	0.0
R422D	30.5	0.0	0.0	2.3	0.0	0.0
R424A	0.0	0.0	0.0	14.9	0.0	0.0
R507	0.0	31.8	0.0	0.0	0.0	0.0

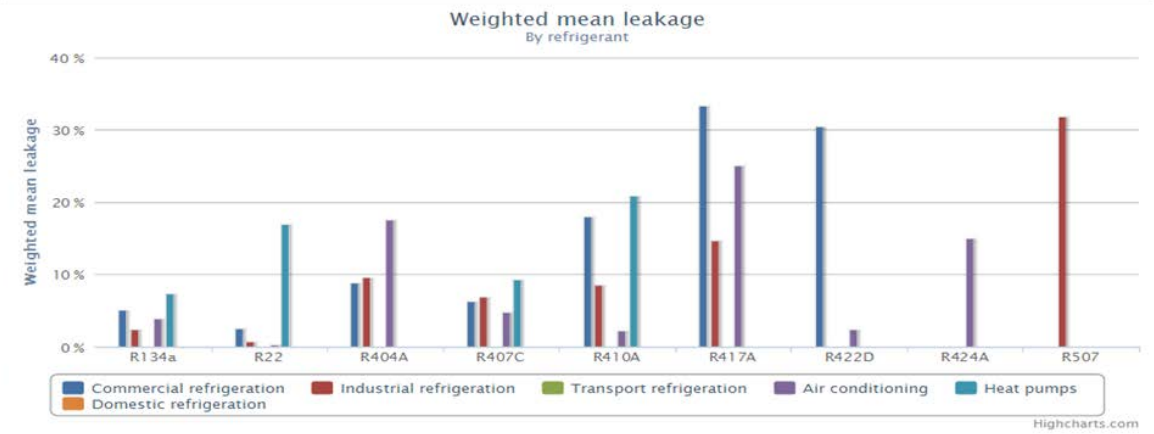
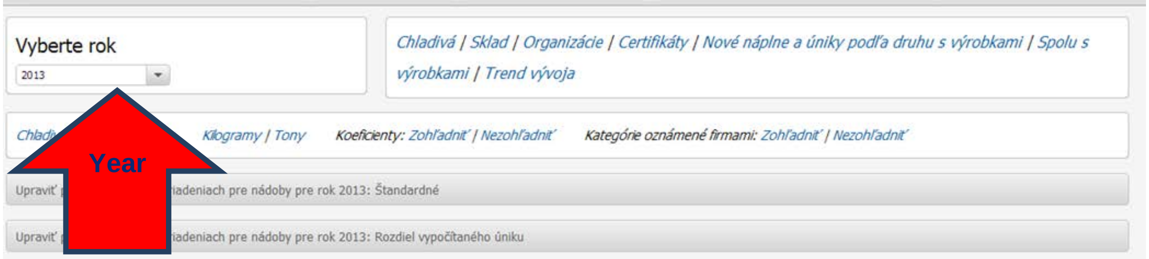


Figure A4.2.8: *Conversion of mixtures to single substances according to the new charges (NN), leaks (Ú) and calculated leaks (ÚV) for different subcategories – Leaklog*



Oznámené nové náplne a úniky podľa druhu zariadení za rok 2013

Skratky: **NN** - Nová náplň, **Ú** - Únik, **ÚV** - Únik vypočítaný

Chlad.	MobKlim			Komerčné chladenie			Priemyselné chladenie			Prepravné chladenie			Klimatizácia a TČ			Domáce chladenie			Hasenie			PUR izolácie			Aerosoly			SF6			Iné			Σ			
	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	Σ
C5H12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	392.6	0	0	0	0	0	0	0	0	0	0	0	392.64	0	0	392.64
CF4	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0	18	23	0	18
CO2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1200	0	0	1200	1200
Ethen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.7	0	0	3.7	3.7
L113	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.4	4.9	0	1.41	4.86	4.86
R12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R123	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R1234yf	2287.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.3	35.6	2287.47	7.34	35.6	2323.07
R124	0	0	0	0	0	0	0	0	0	0	0	0	182.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	546	3.7	-546	728.81	3.73	-546	182.81
R125	0.2	20.3	20.3	7804.8	13429	13429	7564.3	12257.7	12257.7	751	1626.3	1626.3	21410.1	4170.9	4170.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	816.1	2206.4	8837.7	38346.59	33710.62	40341.89	78688.49
R13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R134a	44447.1	25878.9	25878.9	12361.6	9184	9184	18415	10827.4	10827.4	221.6	854.3	854.3	6209.7	7394.8	7394.8	0	0	0	0	0	0	0	0	0	6548.5	0	0	0	0	0	824.8	1417.9	34568.8	89028.38	55557.23	88708.18	177736.56
R141b	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R142b	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.1	0	0	2.15	0	0
R143a	0	8.3	8.3	7781.4	14351.4	14351.4	5256.4	12460.8	12460.8	760.5	1907.9	1907.9	169	73.2	73.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	68.4	588.9	2139.6	14035.69	29390.55	30941.21	44976.9
R152a	0	0	0	0	0	0	0	0	0	0	0	0	69.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0	69.9	1.24	0	69.9
R218	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	5.4	9.1	1.17	5.45	9.09	10.26
R22	0	0	0	0	0	0	0	0	0	0	0	0	285	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	370.2	260.5	-273.2	655.17	260.5	-273.2	381.97
R227ea	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	3971.7	0	0	202	0	0	16.5	0	0	0	0	0	312	94.2	94	4506.16	94.2	94	4600.16
R23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.5	19.7	43.2	2.5	19.65	43.24	45.74
R236fa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	61	0	9	81	0	9	90
R245fa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1520.2	0	0	0	0	0	0	0	0	0	0	0	1520.2	0	0	1520.2
R290	0	0	0	230.1	0	0	0	0	0	0	0	0	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.7	269	232.19	6.65	269	501.19
R318	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R32	0.2	13	13	1191.1	1222.7	1222.7	3039.1	1603	1603	106.9	11.3	11.3	21149.7	3984.6	3984.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	447.2	36.1	4676.7	25934.18	6870.62	11511.24	37445.42
R365mfc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2718	0	0	0	0	0	0	0	0	0	0	0	2718	0	0	2718
R423A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R425A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R428A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9.5	61.6	80.8	9.5	61.55	80.75	90.25
R600a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32.5	54.8	166.7	32.5	54.81	166.7	199.21
R601	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.3	0.03	0.34	0.33	0.36
R601a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0.66	0.66
S316	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SF6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1635.3	0	0	1099.8	439.5	280	2735.05	439.49	280	3015.05
Vertrel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39 chl.	46735	25920.5	25920.5	29369	38187.1	38187.1	34274.8	37148.9	37148.9	1840	4399.8	4399.8	49500.3	15623.5	15623.5	0	0	0	3991.7	0	0	4832.8	0	0	6565	0	0	1635.3	0	0	4591.2	5230.7	51600.6	183335.13	126510.53	172880.25	356215.4

A4.2.4 Data Processing – Inventory Preparation

The 2006 IPCC GL describe two tiers for estimating emissions. The bottom-up approach takes into account the time lag between consumption and emissions explicitly through emission factors. The top-down approach (mass balance) takes the time lag into account implicitly, by tracking the amount of virgin chemical consumed in a year that replaces emissions from the previous year. The using of two web-reporting systems allows estimation emissions in both approaches. The bottom-up approach combined with the top-down approach was used during emissions estimation in Slovakia. The process was based on the following steps:

1. Using the bottom-up approach based on the Logbook Leaklog;
2. Calculation of the total consumptions of individual gases in Slovakia based on the Leaklog;
3. Calculation of the total consumption of individual gases in Slovakia according to the top-down approach based on the older web reporting system available since 2003 (import, export, sales data of bulk chemicals and products);

4. Comparing of the total consumptions calculated by these two approaches;
5. If differences occur, the data for bottom-up approach will be corrected as follows (expert judgement based on the QA process in 2011):

   R134a: Difference is added to leakage from mobile AC;

   R404A: Difference is added between new charge/recharge 0.2/0.8;

   R407C: Difference is added to new charge of stationary AC;

   R410A: Difference is added to leakage from industrial refrigeration and stationary AC 0.1/0.9;
6. If differences below 2% occur, the data for bottom-up approach are corrected proportionally according to the operational emissions.
7. Calculation of emissions inventory by the bottom-up approach using the corrected data.

For the top-down approach the following formulas based on the structure of the reporting systems are:

Emissions = Annual Sales of New Refrigerant – Total Charge of New Equipment + Disposal Emissions

where *Annual Sales* and *Total Charge of New Equipment* are calculated by formulas presented in the 2006 IPCC Guidelines, Chapter 3, p. 7.54 (not simplified formulas).

For bottom-up approach the following formulas are used:

Emissions = Emissions from new fillings + Operational emissions + Disposal emissions

where: *Emissions from new fillings* represent 1% (EF) of the new charges filled in Slovakia (*Chemicals to Charge Domestically Manufactured and Assembled Equipment + Chemical to Charge Equipment that is not Factory-Charged*).

Operational emissions: The approach described in IPCC 2006 GL assumes that servicing of equipment restocks the bank of single chemical and thus the amount of gas used for servicing represents the operational emissions. Slovakia adopted this assumption with a modification in 2017 submission. The servicing of equipment restocks the bank of chemical and its amount used at servicing equals to the emissions. However, equipment that is few years before decommissioning is not serviced and bank is not restock at this equipment. Therefore, the operational emissions are composed from two terms in this submission: (i) data from servicing of equipment; (ii) emissions from non-serviced equipment few years before its decommissioning. The first term in the operational emissions represents the consumption of gases for servicing and container management (these data are reported in Leaklog). It is assumed that the chemical used for servicing restocks the emissions from the bank and thus the bank of the chemical remains constant. The second term in operational emissions represents emissions from non-serviced equipment few years before its decommissioning. These emissions decrease the amount of chemical in equipment and the equipment contains only a part of the chemical at its decommissioning. The product life factors, number of years when the equipment is not serviced and fraction of gas remaining at its decommissioning is consistent. These emissions do not restore the bank of the chemical and are subtracted from the bank.

Disposal emissions represent the emissions from the retired equipment.

For the consistency of operational emissions, the bank of chemical is necessary to follow. The bank is calculated as follows:

$Bank_{in\ year\ t}$ = $Bank_{in\ year\ t-1}$ + New additions to bank – Chemical in retired equipment – Operational emissions from non-serviced equipment

where: *New additions to bank = Chemicals to Charge Domestically Manufactured and Assembled Equipment + Chemicals to Charge Equipment that is not Factory-Charged + Chemicals Contained in Imported Equipment Already Charged – Chemicals Contained in Exported Equipment Already Charged.*

Annex 4.3. Balance of Urea: Import-Export-Production-Use Balance

In the GHG inventory, the downstream of CO_2 emission from ammonia production to urea production is reported. The comparison of CO_2 emissions from the ammonia production and net CO_2 emissions reported is shown in ***Table A4.3.1***. The difference is caused by using of the part of “produced” CO_2 to urea production. In Slovakia, the urea is used in the agriculture as fertilizer (reported under 3.H) and DeNOx application (in cars and in plants, reported in 2.D.3). The difference among the CO_2 used for urea production and CO_2 reported is shown in ***Table A4.3.2***. This difference is attributed to the export of urea in Slovakia. This Annex deals with the comparison of “CO_2 exported in urea” from Slovakia and the above-mentioned difference. The comparison was made since 2010 because no older data were obtained from the Statistical Office of the Slovak Republic due to the change in statistical methodology of import-export data.

Table A4.3.1: *Comparison of technological and net CO_2 emissions since 2010*

YEAR	Ammonia Production	CO_2 Emissions from Ammonia Production	Net CO_2 Emissions
		kt	
2010	233.56	484.65	387.58
2011	455.48	779.42	577.96
2012	377.30	717.42	545.98
2013	474.91	888.08	674.48
2014	346.27	660.68	529.65
2015	476.94	884.82	638.58
2016	403.96	787.01	563.81
2017	458.88	873.80	632.94
2018	516.74	1 028.79	790.46
2019	491.95	822.68	688.35
2020	545.23	883.52	703.09
2021	580.51	930.46	768.62
2022	462.12	750.41	637.81

Table A4.3.2: *Comparison of CO_2 used for urea production and CO_2 reported from the use of urea*

YEAR	CO_2 Used for Urea Production	CO_2 Emissions Reported in 3.H Category	CO_2 Emissions Reported in 2.D.3 Category	CO_2 Emissions Reported in Slovakia From Use of Urea	Difference (“Missing CO_2”)
			kt		
2010	97.074	30.939	2.012	32.951	64.123
2011	201.465	39.708	3.484	43.191	158.274
2012	171.446	45.418	3.925	49.344	122.102
2013	213.603	51.993	6.052	58.045	155.558
2014	131.033	57.941	6.421	64.361	66.672
2015	246.239	60.920	6.073	66.993	179.246
2016	223.200	63.071	8.5493	71.620	151.580
2017	240.860	63.534	8.9813	72.515	168.345
2018	238.324	65.966	9.539	75.505	162.819
2019	134.339	63.539	8.807	72.346	61.993
2020	180.420	63.666	8.258	71.925	108.499
2021	161.834	63.633	9.695	73.329	88.505
2022	112.594	56.619	10.077	66.695	45.898

Data for the comparison were obtained from the urea producer and from the Statistical Office of the Slovak Republic. Data provided by the producer deals with the use of urea for DeNOx application and the composition of urea containing fertilizers. Urea is used for DeNOx application as the product AdBlue (solution containing approx. 30% of urea) and as the so-called technical urea (solution containing 40% of urea). Data were provided as pure urea (***Table A4.3.3***). According to the producer it can be assumed that all urea for DeNOx application was exported (except of data that are reported in the NIR in 2.D.3 category). Import and export data about fertilizers were obtained from the Statistical Office of the Slovak Republic under the commodity codes: (i) 31021010, “Urea containing more than 45% by weight of nitrogen on the dry anhydrous product”; (ii) 31028000, "Mixtures of urea and ammonium nitrate in aqueous or ammoniacal solution". Because urea contains 46% of nitrogen, it can be assumed that the commodity code 31021010 represents the pure urea and export-import difference can be easily calculated from the export and import data (***Table A4.3.3***). On the other hand, the content of urea in products reported under commodity code 3102800 can varying. According to the Slovak law 555/2002 Z. z. the fertilizers with the different content of urea can be used. The nitrogen originating from the urea can be in the range 11-51%. Because import data are reported as kilograms of nitrogen, the amount of urea imported to Slovakia was calculated using this range. According to the data provided by the Slovak fertilizer producer, the fertilizer DAM-390 represents more than 98% of the export of this commodity. It is the mixture of ammonium nitrate and urea containing 29-30% of N, from which 15.5% N origins from urea, the rest is from AN. To ensure conservatism we assumed that 50% of nitrogen origins from urea. Data about import and export of the commodity 31028000 are provided in ***Table A4.3.4***.

Table A4.3.3: *Amounts of exported urea for DeNOx application and import-export data for the commodity code 31021010 since 2010*

YEAR	Urea Exported for DENOX Application	Import of the Commodity Code 31021010	Export of the Commodity Code 31021010	Export-Import
	kt	*kt N*		
2010	24.781	63.758	87.885	24.127
2011	51.43	51.999	110.524	58.525
2012	42.538	61.218	95.638	34.419
2013	52.997	42.736	127.442	84.706
2014	32.309	75.848	77.108	1.259
2015	56.983	67.233	159.628	92.395
2016	47.605	88.352	139.278	50.926
2017	64.982	88.158	144.782	56.623
2018	69.252	63.520	107.337	43.817
2019	56.789	85.887	78.164	-7.723
2020	35.675	61.421	91.333	29.912
2021	54.821	106.510	112.078	5.568
2022	42.109	224.272	162.133	-62.139

Table A4.3.4: *Import-export data for the commodity code 31021010 since 2010*

YEAR	Import of the Commodity Code 31028000	Export of the Commodity Code 31028000	Imported Urea (Range Based on the Possible Urea Content)	Exported Urea	Export-Import (Range Based on the Possible Urea Content)
	kt N		*kt*		
2010	8.622	25.367	2.062-9.559	27.573	18.014-25.512
2011	8.145	46.889	1.948-9.031	50.966	41.935-49.018
2012	7.970	37.384	1.906-8.837	40.635	31.799-38.729
2013	3.929	51.481	0.939-4.356	55.957	51.602-55.018
2014	4.519	36.075	1.081-5.01	39.212	34.202-38.131
2015	5.540	63.135	1.325-6.142	68.625	62.483-67.300

YEAR	Import of the Commodity Code 31028000	Export of the Commodity Code 31028000	Imported Urea (Range Based on the Possible Urea Content)	Exported Urea	Export-Import (Range Based on the Possible Urea Content)
	kt N		*kt*		
2016	6.242	54.192	1.493-6.92	58.904	51.983-57.411
2017	6.242	54.110	1.493-6.92	58.816	51.895-57.323
2018	5.243	64.114	1.254-5.813	69.689	63.876-68.436
2019	4.306	50.128	1.030-4.774	54.487	49.713-53.458
2020	1.741	50.121	0.416-1.930	54.479	52.549-54.063
2021	4.076	54.087	0.975-4.519	58.790	54.271-57.815
2022	4.366	145.670	1.044-4.841	158.337	153.497-157.293

Emission factor of CO_2 from urea is based on the stoichiometry and it is 0.73 t CO_2 / t of urea. Calculated data on the "CO_2 exported" based on the data presented in ***Table A4.3.4*** and their comparison with the difference in the reporting data (so called "missing CO_2" in ***Table A4.3.2***) are listed in ***Table A4.3.5***. The negative values in the last column represent the "good" result, it means that there is not missing CO_2 in this balance. In an ideal balance the difference should be zero, however, there were made several assumptions in this balance and change in stocks were also not considered. The red values (for years 2012 and 2014) mean that there is missing CO_2 in this import-export balance. However, when looking to the difference in years 2013 and 2015, the difference is much higher than usual. It can be assumed that the positive value of missing CO_2 is caused by the time lag between the production and export of the urea products.

Table A4.3.5: *Balance of the "export/import CO_2" from the use of urea*

YEAR	CO_2 from the Exported DENOX Applications	CO_2 from the Commodity Code 31021010	CO_2 from the Commodity Code 31028000	"CO_2 Exported"	"Missing CO_2"	Difference
	Gg					
2010	18.09	38.289	13.150-18.623	69.529-75.002	64.123	(-5.406)-(-10.879)
2011	37.544	92.877	30.613-35.783	161.033-166.204	158.274	(-2.760)-(-7.930)
2012	31.053	54.621	23.213-28.272	108.887-113.946	122.102	13.215-8.156
2013	38.688	134.425	37.669-40.163	210.782-213.276	155.558	(-55.223)-(-57.717)
2014	23.586	1.998	24.968-27.836	50.551-53.419	66.672	16.120-13.252
2015	41.598	146.627	45.612-49.129	233.837-237.354	179.246	(-54.590)-(-58.107)
2016	34.752	80.817	37.948-41.910	153.517-157.479	151.580	(-1.937)-(-5.900)
2017	47.437	89.858	37.884-41.846	175.179-179.141	168.345	(-6.833)-(-10.796)
2018	50.554	69.536	46.630-49.958	166.719-170.048	162.819	(-3.900)-(-7.229)
2019	41.456	-12.256	36.291-39.024	65.490-68.224	61.993	(-3.497)-(-6.231)
2020	26.043	47.4659	38.361-39.466	111.872-112.977	108.499	(-3.374)-(-4.095)
2021	40.019	8.835	39.618-42.205	88.472-91.060	88.505	(-2.555)-0.032
2022	30.740	-98.612	112.052-114.824	44.180-46.952	66.695	(-1.053)-1.718

CHAPTER 5. Agriculture (CRF 3)

This Chapter was prepared using GWP_{100} taken from the 5th Assessment Report of the IPCC by the sectoral experts and institutions involved in the National Inventory System of the Slovak Republic:

INSTITUTE	CHAPTER	SECTORAL EXPERT
Slovak Hydrometeorological Institute	all	Kristína Tonhauzer
Research Institute for Animal Production	3.A and 3.B supported calculation and background data	Zuzana Palkovičová Ondrej Pastierik
Slovak Hydrometeorological Institute	3.D Estimation of humid area of the Slovak Republic	Peter Tonhauzer

The Agriculture sector is the fourth largest sector of the GHG emissions inventory of the Slovak Republic with the contribution equal to 6.5% on the total GHG emissions.

The emissions of greenhouse gases from agricultural activities include:

CH_4 emissions from the Enteric Fermentation (3.A) and the Manure Management (3.B);

N_2O emissions from the Manure Management (3.B) and the Agricultural Soil (3.D);

CO_2 emissions from the Liming (3.H) and the Urea Application (3.G);

Emissions inventory of NVMOC and NO_x were estimated and information is provided in the Informative Inventory Report of the Slovak Republic.

Categories 3.C and 3.E are not reported due to the weather conditions and climatic zone of Slovakia. Category 3.F is reported as not occurring, burning of fields is prohibited by the law.

5.1. Overview of the Agriculture Sector

Agriculture, according to preliminary data, achieved a positive financial result before taxation in the year 2022, Total profit was approximately €347 million in 2022 and the value almost doubled compared to 2021. In comparison with the five-year average for the years 2017-2021, the financial result for the year 2022 was almost three times higher, primarily influenced by a significant increase in revenues from the sale of own products of animal origin (+22.5%) and plant origin (+16.0%). Revenues from the sale of own products accounted for an average of 56% of the total revenues of agricultural primary production enterprises. The subsidies from the Common Agricultural Policies (CAP) had a significant role in the economy of agricultural enterprises, without which the majority of businesses would operate with a loss. The overall volume of financial support to Slovak agriculture decreased by 7.5% year-on-year, amounting to €737 million, of which 57% was provided from EU funds. The proportion of total support to revenues within agriculture decreased annually to 17.5%, with direct payments accounting for 6.6% of that.

Crop production had the continuing dominant share in the economy compared to animal production (60% to 40%). According to data provided by the Statistical Office of the Slovak Republic (ŠÚ SR), the mean hectare productivity of cereals hovered at 4.75 t/ha (a decrease of 1.25 t/ha in contrast to the year 2021), with an aggregate production volume of 3.38 million metric tons (a decrease of 0.92 million metric tons). In the case of wheat, the production intensity experienced a reduction of 11.4%, amounting to 4.97 t/ha, yielding a total production of 2.05 million metric tons. Comparable hectare productivity levels to those of 2021 were recorded for barley and rye; however, the overall production of these commodities failed to attain the threshold of the year 2021 due to diminishing harvest areas. (Green Report 2023).

The emissions balance is compiled annually based on the sectoral statistics on animal livestock, animal performance and consumption of organic and inorganic fertilizers, in recent years on the regional level. The Ministry of Agriculture and Rural Development of the Slovak Republic (MPRV SR) issues annual agricultural statistics in the Green Report, part of which is dedicated to agriculture and food. Activity data are also available in the Statistical Yearbooks published by the ŠÚ SR.

The emissions inventory in agriculture is prepared in the cooperation with the National Agricultural and Food Centre - the Research Institute for Animal Production in Nitra (NPPC - VÚŽV). The NPPC - VÚŽV provided activity data and parameters, improved the methodology and ensured QA/QC activities in animal inventory in the CRF categories 3.A and 3.B. Activity data on number of the livestock and animal productions are provided annually by the ŠÚ SR. The Central Control and Testing Institute in Agriculture (UKSÚP) provides the soil data to the SHMÚ annually, based on cooperation agreement between the both institutions. Emission Inventory System in the Agriculture sector is described on ***Figure 5.1***.

The largest share of methane emissions was generated by enteric fermentation of cattle, which produced 32.48 Gg (91%) of methane within the sector in 2022. The major source of N_2O emissions is agricultural soils with a share of 78%, followed by the category 3.B representing 22% on the total N_2O emissions. Regarding N_2O, direct emissions from synthetic fertilization are the most significant emissions source and it produced 0.9 Gg of N_2O (32%) within the sector in 2022.

CH_4 emissions are calculated separately for each animal sub-category in methane model. For categories 3.B and 3.D, N_2O emissions are calculated based on an N-flow concept, more information is in the Chapter 5.9. In categories 3.G and 3.H, CO_2 emissions are estimated for liming and urea application in line with the IPCC 2006 GL.

Figures 5.1 and ***5.2*** and ***Tables 5.1*** and ***5.2*** show overall emission trends since the base year 1990 according to gases and major categories. ***Table 5.3*** shows an overview of the GHG gases and tiers. In the Slovak Republic, agricultural production stopped increasing in the late ’90s. The decrease was followed by a drop during the years 1990 – 2002, because of the economic and political transition of the country. After entering the EU, agriculture was stabilized. Improving conditions in the Agriculture sector, regeneration of crop production and mineral fertilizers use caused that emissions have increased in the last six years. The inter-annual growth of emissions was caused due to increase of organic nitrogen fertilizers mainly in categories 3.D.1.4 Crop residues and 3.D.1.2.c Other nitrogen organic fertilizers into soils. Increase of nitrogen application into soils had positive effect on increase of yield of selected crops (cereals, legumes and oil plants). After 2005, a stagnant trend of emissions is visible in the agricultural sector, the situation in the entire sector has stabilized, especially the conditions of animals and the consumption of fertilizers for agricultural land. From 2020, there is a visible decrease in the numbers of selected species of farm animals (poultry, pigs and dairy cattle) and the consumption of nitrogen inorganic fertilizers, the reason being mainly the reduction of numbers due to the poor economic situation in livestock production and high natural gas prices, which push the growth of fertilizer prices and their reduced consumption.

Figure 5.1: *Trend in aggregated emissions (in Gg of CO_2 eq.) by categories within the Agriculture sector in 1990 – 2022*

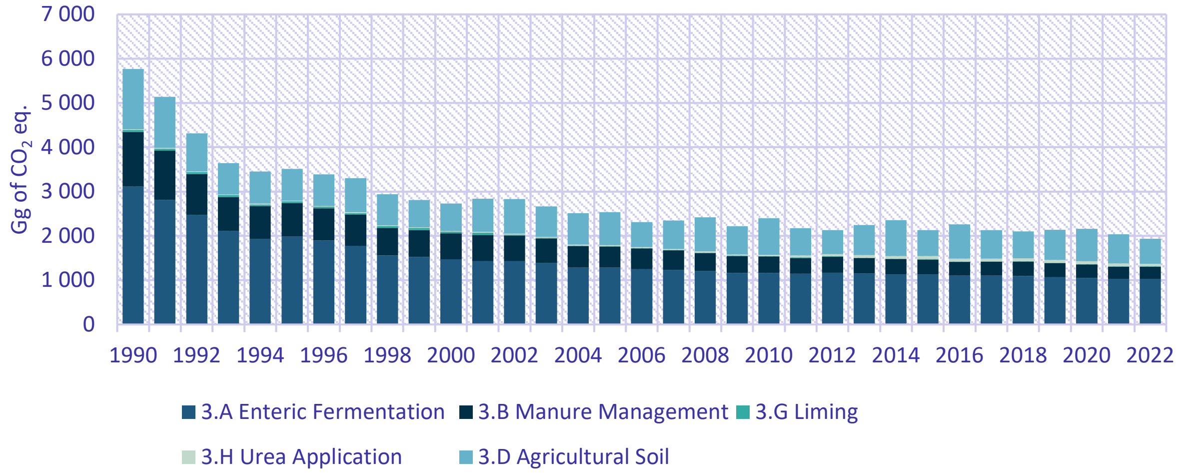


Table 5.1: *Trend of GHG emissions by gases in the Agriculture sector in particular years*

YEAR	CO_2	CH_4	N_2O	NMVOC	NO_X
	Gg				
1990	61.02	136.72	7.09	22.31	13.19
1995	53.29	85.72	3.98	12.66	5.79
2000	46.44	63.55	3.42	10.70	5.92
2005	29.59	54.40	3.71	9.46	6.26
2010	39.17	47.94	3.85	7.84	6.42
2011	54.85	46.90	3.04	7.72	6.99
2012	56.72	47.79	2.79	7.66	6.17
2013	63.94	47.00	3.27	7.49	6.70
2014	69.90	46.07	3.75	7.37	7.05
2015	73.33	45.96	2.90	7.57	6.90
2016	69.85	44.39	3.57	7.24	7.01
2017	66.15	44.58	3.08	7.35	6.85
2018	70.18	44.54	2.97	6.95	7.19
2019	68.25	43.27	3.25	6.74	7.21
2020	72.12	42.06	3.43	6.29	6.97
2021	69.57	40.57	3.12	6.10	6.94
2022	60.84	40.35	2.81	5.92	6.43

Table 5.2: *Trend of GHG emissions by categories in the Agriculture sector in particular years*

YEAR	3.A ENTERIC FERMENTATION	3.B MANURE MANAGEMENT	3.D AGRICUL. SOILS	3.G LIMING	3.H UREA APPLICATION
	Gg of CO_2 eq.(AR 5)				
1990	3 112.01	1 234.60	1 360.05	45.73	15.29
1995	1 983.90	756.81	715.47	38.00	15.29
2000	1 472.19	586.70	626.38	34.34	12.10
2005	1 280.88	480.96	743.22	9.28	20.31
2010	1 159.33	377.85	824.17	8.23	30.94
2011	1 149.05	351.91	616.98	15.14	39.71
2012	1 167.36	362.83	546.00	11.30	45.42
2013	1 156.78	343.01	681.75	11.95	51.99
2014	1 129.24	346.73	808.83	11.96	57.94
2015	1 132.69	335.54	587.46	12.41	60.92

YEAR	3.A ENTERIC FERMENTATION	3.B MANURE MANAGEMENT	3.D AGRICUL. SOILS	3.G LIMING	3.H UREA APPLICATION
	Gg of CO_2 eq.(AR 5)				
2016	1 101.53	315.50	772.39	6.77	63.07
2017	1 100.02	320.42	644.75	2.62	63.53
2018	1 092.89	331.87	609.23	4.21	65.97
2019	1 068.30	318.18	685.41	4.71	63.54
2020	1 053.72	299.43	733.68	8.45	63.67
2021	1 027.74	280.86	654.90	5.94	63.63
2022	1 028.92	279.90	564.77	4.22	56.62

Figure 5.2: *The share of aggregated emissions by main categories within the Agriculture in 2022*

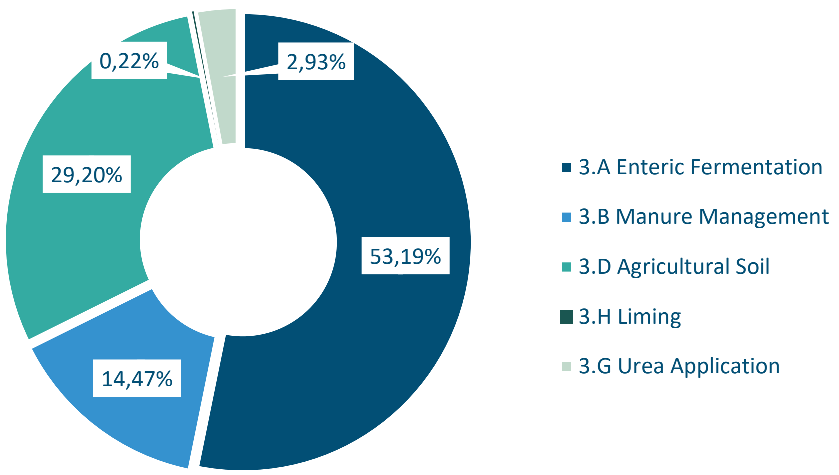


Table 5.3: *Overview of the gases, methodology and tiers reported in the Agriculture sector according to the CRF categories in 2022*

CATEGORY (CODE AND NAME)	METHODOLOGY/TIER	GHG GASES REPORTED
3.A.1 DAIRY CATTLE	T2/CS	CH_4
3.A.1 NON-DAIRY CATTLE	T2/CS	CH_4
3.A.2 MATURE EWES	T2/CS	CH_4
3.A.2 GROWING LAMBS	T2/CS	CH_4
3.A.2 OTHER MATURE SHEEP	T2/CS	CH_4
3.A.3 SWINE	T1/D	CH_4
3.A.4 GOATS	T1/D	CH_4
3.A.4 HORSES	T1/D	CH_4
3.B.1.1 DAIRY CATTLE	T2/CS	CH_4
3.B.1.1 NON-DAIRY CATTLE	T2/CS	CH_4
3.B.1.2 MATURE EWES	T2/CS	CH_4
3.B.1.2 GROWING LAMBS	T2/CS	CH_4
3.B.1.2 OTHER MATURE SHEEP	T2/CS	CH_4
3.B.1.3 SWINE	T2/CS	CH_4
3.B.1.4 GOATS	T1/CS	CH_4
3.B.1.4 HORSES	T1/CS	CH_4
3.B.1.4 POULTRY	T2/CS	CH_4
3.B.2.1 DAIRY CATTLE	T2/CS	N_2O
3.B.2.1 NON-DAIRY CATTLE	T2/CS	N_2O
3.B.2.2 MATURE EWES	T1/CS	N_2O

CATEGORY (CODE AND NAME)	METHODOLOGY/TIER	GHG GASES REPORTED
3.B.2.2 GROWING LAMBS	T1/CS	N_2O
3.B.2.2 OTHER MATURE SHEEP	T1/CS	N_2O
3.B.2.3 SWINE	T2/CS	N_2O
3.B.2.4 GOATS	T1/CS	N_2O
3.B.2.4 HORSES	T1/CS	N_2O
3.B.2.4 POULTRY	T2/CS	N_2O
3.B.2.5 INDIRECT N_2O EMISSIONS	T1/D	N_2O
3.C RICE CULTIVATION	NO	N_2O
3.D.1.1 INORGANIC N FERTILIZERS	T1/D	N_2O
3.D.1.2.a ANIMAL MANURE APPLIED TO SOILS	T1/CS	N_2O
3.D.1.2.b SEWAGE SLUDGE APPLIED TO SOILS	T1/D	N_2O
3.D.1.2.c OTHER ORGANIC FERTILIZERS APPLIED TO SOILS	T1/D	N_2O
3.D.1.3 URINE AND DUNG DEPOSITED BY GRAZING ANIMALS	T1/CS	N_2O
3.D.1.4 CROP RESIDUES	T2/CS	N_2O
3.D.1.5MINERALIZATION/IMMOBILIZATION ASSOCIATED WITH LOSS/GAIN OF SOIL ORGANIC MATTER	T1/D	N_2O
3.D.1.6 CULTIVATION OF ORGANIC SOILS	NA	NE
3.D.2.1 ATMOSPHERIC DEPOSITION	T1/D	N_2O
3.D.2.2 NITROGEN LEACHING AND RUN-OFF	T2/CS	N_2O
3.E PRESCRIBED BURNING OF SAVANNAHS	NA	NO
3.F FIELD BURNING OF AGRICULTURAL RESIDUES	NA	NO
3.G LIMING	T1/D	CO_2
3.H UREA APPLICATION	T1/D	CO_2
3.I OTHER CARBON-CONTAINING FERTILIZERS	NA	NO

5.2. Category-specific Improvements and Implementation of Recommendations

During the inventory preparation no recommendation took place.

5.3. Category-specific QA/QC and Verification

5.3.1. Comparison of the National Activity Data with the FAOSTAT

According to the QA/QC Long-term Plan for agriculture in the area of consistency with the international bodies and statistics, several presentations were made on international and national conferences, publications and references were published in the Meteorological Journal 2017. Results of this article were presented at the international conference Air Protection 2017. Detailed information was presented in the SVK NIR 2018 (**Chapter 5.3.1**). The data comparison is provided annually until full consistency will be achieved. In the 2019 submission, new corrected national data on livestock, harvest and fertilisers were sent to the FAO by the national body (ŠÚ SR).

Inorganic N-fertilizers: The Slovak Republic has had a long-term issue in inorganic nitrogen fertilizers reporting to the world and European institutions. Data inconsistencies cause problems during inventory preparation of greenhouse gases and pollutants. The first expert panel for data providers for agricultural data took place last year (2022).

The Central Agricultural Testing and Controlling Institute (ÚKSÚP) reported inconsistencies in their data of utilisation of nitrogen fertilizers. Fertilization activity is detected on 90% of the agricultural land.

Calculations are provided by the ÚKSÚP each year. 90% of data are collected electronically at the farm level and subsequently reported to the ŠÚ SR which reports data to FAOSTAT and EUROSTAT. Revision of data was done in 2022 submission, the data was harmonized with EUROSTAT database in partial years 2000 and 2010, where the inconsistencies were identified (***Table 5.4***).

The quality control comparison of nitrogen was done. Main inconsistencies between the FAOSTAT 2023 database and national inventory (***Table 5.4***) were identified huge inconsistency from 2000 to 2012 (*cursive*). Databases after 2013 are harmonised except for data from IFASTAT. IFASTAT data are different throughout the time-series (***cursive bold***). Different rounding is a common problem in all datasets (IFASTAT, FAOSTAT, and EUROSTAT). Consumption for the year 2022 was not available in the FAOSTAT, IFASTAT or EUROSTAT at the time of this exercise. In 2021 were available. Data are almost corrected in FAOSTAT and EUROSTAT data, but both organizations rounded the numbers base of internal rules.

The number of livestock: The number of animals is the most important input parameter into the emissions inventory. The differences can be recognized in the methodological approach of data collection used by the FAOSTAT and by the ŠÚ SR. FAOSTAT grouped livestock in 12-months periods ending on 30th September each year. On the other hand, the ŠÚ SR provides annual national data on livestock by 31st December of a given year. The statistical survey is based on data collected from selected farms, animal census, by selected animals' categories, up to the regional level and finally up to national level. Therefore, the animal population 2021 in the FAOSTAT is different. In addition, detailed analysis of the data provides ***Table 5.5***. It shows a shift in the timeline of goats (since 1994), sheep (since 1994), horses (since 1994) and swine (since 1994) (*cursive*). In 2019, FAOSTAT revised number of cattle (dairy and non-dairy cattle). The timeline is shifted since 2000 (*cursive*). Different allocation of cattle population (*cursive bold*) is visible in the years 1994 – 1997 (*cursive bold*). This inconsistency is caused by the different rules for distribution between dairy and non-dairy cattle. Revision of livestock mentioned above led to unification of cattle data between two databases in 2019, but different allocation of dairy and non-dairy and shift in the timeline were corrected partially. In addition, the FAO prepares its own estimates of broilers and layers number, annually. Therefore, the inconsistencies are visible in bold values. The revision of poultry population provided by the ŠÚ SR was not taken into consideration within the FAOSTAT.

The ŠÚ SR as a partner of the EUROSTAT collects, processes and disseminates statistical data in line with the current national and EU legislation. Therefore, use of statistical data is considered as the most appropriate and accurate. However, comparison of data and methodologies with the independent data source FAOSTAT is useful tool for the QA activities. It can be assumed from this exercise that the activity data used in inventory of the Agriculture sector is in a good consistency and accuracy.

Table 5.4: *Comparison of fertilisers in different databases*

YEAR	SVK NIR 2024	FAOSTAT 2024	EUROSTAT 2024	IFASTAT 2024
	kg/year			
1993	64 852 000	64 883 000	NA	NA
1994	68 669 000	68 656 000	NA	***68 700 000***
1995	69 587 000	72 029 000	NA	***72 000 000***
1996	74 464 000	77 644 000	NA	***77 600 000***
1997	88 017 000	72 500 000	NA	***72 500 000***
1998	81 842 000	82 814 000	NA	***82 800 000***
1999	65 392 000	65 357 000	NA	***65 400 000***
2000	84 609 000	82 100 000	84 609 000	***82 100 000***
2001	102 423 000	81 345 000	102 423 000	***85 000 000***
2002	111 507 000	*81 300 000*	111 507 000	***81 000 000***
2003	97 727 000	*79 911 000*	97 727 000	***93 000 000***

YEAR	SVK NIR 2024	FAOSTAT 2024	EUROSTAT 2024	IFASTAT 2024
	kg/year			
2004	97 151 000	*81 317 000*	97 151 000	***90 000 000***
2005	99 760 000	*78 681 000*	99 760 000	***90 000 000***
2006	97 023 000	*88 935 000*	97 023 000	***100 000 000***
2007	113 298 000	*87 737 000*	113 298 000	***105 000 000***
2008	121 435 000	*77 058 000*	121 435 000	***94 000 000***
2009	96 334 000	*86 873 000*	96 334 000	***83 000 000***
2010	106 513 000	*92 969 000*	106 513 000	***96 000 000***
2011	120 555 000	*101 004 000*	120 555 000	***113 000 000***
2012	101 004 000	*113 581 000*	101 004 000	***112 000 000***
2013	113 581 390	*113 581 000*	113 581 000	***118 000 000***
2014	119 036 050	119 036 000	119 036 000	***121 000 000***
2015	114 773 000	114 773 000	114 773 000	***133 300 000***
2016	126 235 769	*126 236 000*	126 236 000	***140 900 000***
2017	122 541 152	122 541 152	122 541 000	***125 900 000***
2018	128 976 885	128 976 885	128 977 000	***155 400 000***
2019	128 532 971	*128 532 970*	128 533 000	***138 200 000***
2020	127 676 520	*127 676 519*	127 676 520	***149 800 000***
2021	127 494 597	*127 494 600*	*127 495 000*	**151 900 000**
2022	115 346 776	NA	NA	NA

Table 5.5: *Comparison of national data and the FAOSTAT in livestock population (heads) for the time series 1993 – 2022*

YEAR	DAIRY CATTLE		NON-DIARY CATTLE		GOATS		SHEEP		HORSES		SWINE		POULTRY	
	SVK NIR 2023	FAOSTAT 2023	SVK NIR 2023	FAOSTAT 2023	SVK NIR 2023	FAOSTAT 2023	SVK NIR 2023	FAOSTAT 2023	SVK NIR 2023	FAOSTAT 2023	SVK NIR 2023	FAOSTAT 2023	SVK NIR 2023	FAOSTAT 2023
	heads													
1996	245 833	***355 199***	646 158	***573 507***	26 147	*25 046*	418 823	*427 844*	9 722	*10 109*	1 985 223	*2 076 439*	14 147 177	***13 214 000***
1997	299 614	***335 381***	503 784	***556 610***	26 778	*26 147*	417 337	*418 823*	9 533	*9 722*	1 809 868	*1 985 223*	14 221 713	***13 985 000***
1998	267 282	***299 614***	437 510	***503 784***	50 905	*26 778*	326 200	*417 337*	9 550	*9 533*	1 592 599	*1 809 868*	13 116 796	***14 071 000***
1999	250 974	***283 895***	414 081	***420 897***	51 075	*50 905*	340 346	*326 199*	9 342	*9 550*	1 562 106	*1 592 599*	12 247 440	***13 027 000***
2000	242 496	*250 974*	403 652	*414 081*	51 419	*51 075*	347 983	*340 346*	9 516	*9 342*	1 488 441	*1 562 105*	13 580 042	***12 160 000***
2001	230 379	*242 496*	394 811	*403 652*	40 386	*51 419*	316 302	*347 983*	7 883	*9 516*	1 517 291	*1 488 441*	15 590 404	***13 482 000***
2002	230 182	*230 379*	377 653	*394 811*	40 194	*40 386*	316 028	*316 302*	8 122	*7 883*	1 553 880	*1 517 291*	13 959 404	***15 352 000***
2003	214 467	*230 182*	378 715	*377 653*	39 225	*40 194*	325 521	*316 028*	8 114	*8 122*	1 443 013	*1 553 880*	14 216 798	***13 817 000***
2004	201 725	*214 467*	338 421	*378 715*	39 012	*39 225*	321 227	*325 521*	8 209	*8 114*	1 149 282	*1 443 013*	13 713 239	***14 052 000***
2005	198 580	*201 725*	329 309	*338 421*	39 566	*39 012*	320 487	*321 227*	8 328	*8 209*	1 108 265	*1 149 282*	14 084 079	***13 565 000***
2006	184 950	*198 580*	322 870	*329 309*	38 352	*39 566*	332 571	*320 487*	8 222	*8 328*	1 104 829	*1 108 265*	13 038 303	***13 932 000***
2007	180 207	*184 950*	321 610	*322 870*	37 873	*38 352*	347 179	*332 571*	8 017	*8 222*	951 934	*1 104 829*	12 880 124	***12 882 000***
2008	173 854	*180 207*	314 527	*321 610*	37 088	*37 873*	361 634	*347 179*	8 421	*8 017*	748 515	*951 934*	11 228 140	***12 718 000***
2009	162 504	*173 854*	309 461	*314 527*	35 686	*37 088*	376 978	*361 634*	7 199	*8 421*	740 862	*748 515*	13 583 284	***11 081 000***
2010	159 260	*162 504*	307 865	*309 461*	35 292	*35 686*	394 175	*376 978*	7 111	*7 199*	687 260	*740 862*	12 991 916	***13 438 000***
2011	154 105	*159 260*	309 253	*307 865*	34 053	*35 292*	393 927	*394 175*	6 937	*7 111*	580 393	*687 260*	11 375 603	***12 846 000***
2012	150 272	*154 105*	320 819	*309 253*	34 823	*34 053*	409 569	*393 927*	7 249	*6 937*	631 464	*580 393*	11 849 818	***11 252 000***
2013	144 875	*150 272*	322 945	*320 819*	35.457	*34 823*	399 908	*409 569*	7 161	*7 249*	637 167	*631 464*	10 968 918	***11 693 000***
2014	143 083	*144 875*	322 460	*322 945*	35 178	*35 457*	391 151	*399 908*	6 828	*7 161*	641 827	*637 167*	12 494 074	***10 786 000***
2015	139 229	*143 083*	318 357	*322 460*	36 324	*35 178*	381 724	*391 151*	6 866	*6 828*	633 116	*641 827*	12 836 224	***13 084 000***
2016	132 610	*139 229*	313 502	*318 357*	36 355	*36 324*	368 896	*381 724*	6 407	*6 866*	585 843	*633 116*	12 130 501	***12 057 000***
2017	129 863	*132 610*	309 963	*313 502*	37 067	*36 355*	365 344	*368 896*	6 145	*6 407*	614 384	*585 843*	13 353 837	***13 133 000***
2018	127 871	*129 863*	310 984	*309 963-*	36 907	*37 067*	351 122	*365 344*	7 102	*6 145*	627 022	*614 384*	14 056 914	***13 354 000***
2019	125 848	125 850	306 405	306 405	35 594	*35 590*	320 555	*320 560*	6 960	*6 960*	589 228	*589 230*	13 131 941	***13 132 000***
2020	122 050	122 050	320 240	320 240	10 589	*35 600*	294 252	*294 252*	6 099	*6857*	538 310	*538 310*	10 603 624	***10 572 000***
2021	120 068	120070	314 021	31402	10 434	32 000	290 918	290 918	6 738	6044	453 076	453080	10 364 509	10 297 703
2022	116 910	116 910	316 265	31 627	11 008	20 500	301 131	301 130	7 044	NA	380 895	380 900	9 340 713	9 275 000

5.4. Category-specific Recalculations

Recalculations made in the Agriculture sector were provided and implemented in line with the Improvement and Prioritisation Plan 2023, reflecting recommendations received during previous reviews and the sectoral expert's proposals and implementation of the IPCC 2019 Refinement (RF). ***Table 5.6*** shows an overview of these recalculations and corrections implemented in 2024 submission. The overall impact of recalculations done in the Agriculture sector resulted in 16.36% decrease of emissions for the year 2021 compared to previous submission (2023), which is 397.64 kt of CO_2 eq. The Agriculture sector is specific sector regarding the recalculations process. Change in one category caused changes also in other categories across sector, due to methodology based on nitrogen and methane balance.

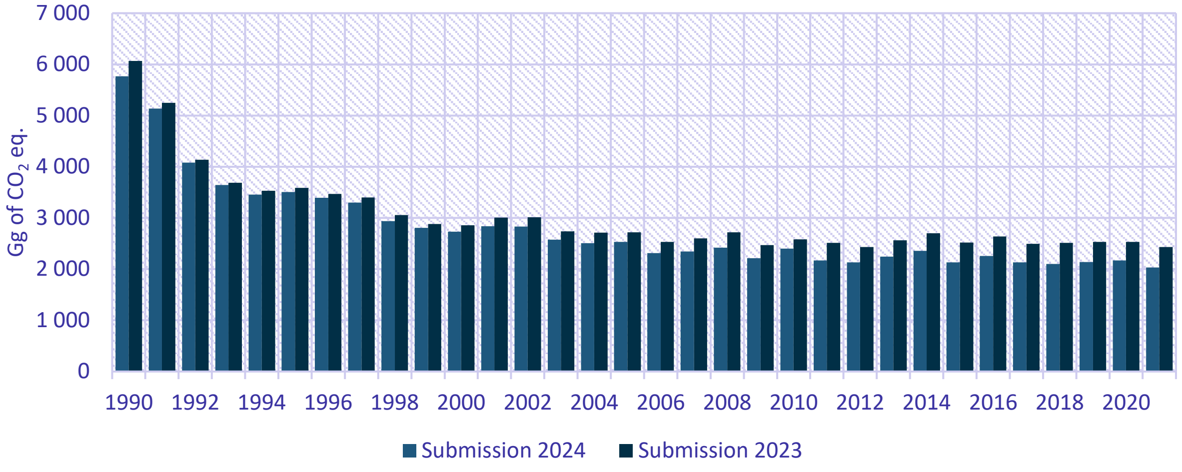
Table 5.6: *Overview of recalculations and implemented improvements in the Agriculture sector*

NUMBER	CATEGORY	DESCRIPTION	REFERENCE
1.	3. Agriculture	Implementation of the IPCC 2019 Refinement (IPCC 2019 RF).	**5.4**
2.	3.A Enteric fermentation	Implementation of the IPCC 2019 RF, Revision of Ym for cattle and sheep.	**5.7,5.4**
3.	3.B.1.Manure management	Revision of AWMS in swine category due to implementation, share of biogas facilities was implemented into market swine and breeding swine. Implementation of the IPCC 2019 RF, Implementation of tier 2 approach in poultry.	**5.8,5.4**
4.	3.B.2.Manure management	Revision of AWMS in swine category due to implementation, share of biogas facilities was implemented into market swine and breeding swine. Implementation of the IPCC 2019 RF, Implementation of tier 2 approach in poultry.	**5.9, 5.4**
5.	3.B.2.5 Indirect emission from manure management	Revision of emissions due to recalculation in 3.B.2.3 and 3.B.2.4. Implementation of new source of emissions 3.B.2.5 N_2O emission from leaching and runoff.	**5.10**
6.	3.D Agriculture soils	Implementation of the IPCC 2019 RF, revision of emission factors from default values to default values for cool temperate dry climate. Revision of EFs in 3.D.2 Indirect emissions from Agricultural soils.	**5.12.9, 5.12.9**
7.	3. A. 1. Enteric fermentation –Non-dairy cattle	Correction of Ym parameter of beef calves from 0 to 3.2% and correction of oxen weigh, these changes have impact on IEF, AGEI and 2022 emissions.	**5.4**
8.	3. A. 2. Enteric fermentation -Mature ewes	Revision of CH_4 emissions and AGEIs in mature ewes subcategory due to inconsistency between the CRF Reporter and calculation sheets (1990-2021).	**5.4**
9.	3. A. 2. Enteric fermentation –Sheep	Revision of CH_4 emissions and digestibility in 3.A.2 Sheep categories due to overestimated digestibility of feed (2022).	**5.4**
10.	3. A. 2. Enteric fermentation –Growing lambs	Revision of Ym in growing lambs subcategory due to inconsistency between the CRF Reporter and calculation sheets (2015).	**5.4**
11.	3. A. 3. Enteric fermentation – Market swine, Breeding swine	Changes in distribution of swine lead to revision of IEFs and average weight. Number of market swine (1990-2021) are increase compare to the breeding swine (1995, 1998), this numbers are decreased. Have impact on incorrect IEF, which are not in line with tier 1 of the IPCC 2019 RF.	**5.4**
12.	3. A. 3. Enteric fermentation – Horses	Revision of average weight in horses - horses 1-3 year subcategory was not included in the total average weight, therefore revision was done.	**5.4**
13..	3.B.1.3 Manure management – Breeding swine	Inconsistent numbers of livestock in swine category between CRF Reporter and spreadsheets was discovered and corrected, numbers were higher ten officially statistical data. Revision was done in particular years 1995 and 1997. Revision and have impact on emissions.	**5.4**
14.	3.B.1.4 Manure management – Horses	Inconsistency in number of horses between CRF table and spreadsheets was discovered in particular years 1992 and 1993 which was not in line with officially statistical data reported by the Statistical Office of the Slovak Republic. Inconsistency has small impact on reported CH_4 emissions.	**5.4**

NUMBER	CATEGORY	DESCRIPTION	REFERENCE
15.	3.B.2.2 Manure management – Other mature sheep	Number of other mature sheep inconsistency between categories was discovered. Change have impact on emissions in particular year 2005.	**5.4**
16.	3.B.2.2 Manure management – Mature ewes	Inconsistency of N_{EX} between calculation sheet and CRF reporter was found.	**5.4**
17.	3.B.2.4 Manure management – Horses	Inconsistency in number of horses between CRF table and spreadsheets was discovered in particular years 1992 and 1993 which was not in line with officially statistical data reported by the Statistical Office of the Slovak Republic. Inconsistency has small impact on reported N_2O emissions.	**5.4**
18.	3.B.2.5 Indirect emission from manure management	Revision of emissions in 1992, 1993 and 2005 due to recalculation in 3.B.2.2 and 3.B.2.4.	**5.4**
19.	3.D.1.1 Inorganic N-fertilizers	Correction of consumption in 2022 have impact on decrease of emissions.	**5.4, 5.12.1**
20.	3.D.1.2.a Animal Manure Applied to Soils	Revision of emissions 1992, 1993 and 2005 due to recalculation in 3.B.2.2, 3.B.2.4.	**5.4**
21.	3.D.1.3 Urine and Dung Deposited by Grazing Animals	Revision of emissions due to recalculation in 3.B.2.4. in 1992 and1993.	**5.4**
22.	3.D.1.4 Crop residues	Correction of the Statistical data was done. Harvested area of the leguminous plants, harvested area decrease and this change have effect of decrease of emissions in 2022.	**5.4, 5.12.6**
23.	3.D.2 Indirect N_2O Emissions From Managed Soils	Revision of emissions in 1992, 1993, 2005 and 2022 due to recalculation in 3.D.1.2.a, 3.D.1.3, 3.D.1.4 and 3.D.1.1.	**5.4**

Figure 5.3 shows overall trend of recalculated emissions and comparison of 2023 and 2024 submissions.

Figure 5.3: *Comparison of 2023 and 2024 submissions in the Agriculture sector (in Gg of CO_2 eq.)*



Ad 1: Brief description of changes related to the implementation of the IPCC 2019 Refinement:

i.) outdated emission factors were updated with new ones, taking into account the latest findings since the adoption of the IPCC 2006 Guidelines. Some new emission factors included in the new IPCC 2019 Refinement methodology come from the EFDB (Emission Factor Database), and they were accepted based on annual meetings of the technical editorial board composed of agricultural experts from around the world.

ii.) new approaches, especially the categorization of livestock into productive farms (intensive animal farming) and less productive farms (extensive animal farming), also bring improvements in the form of a new IPCC classification of livestock, resulting in new refined parameters for estimating emissions.

iii.) changes in the characterization of farm animals among emission sources in the agricultural sector were adopted to facilitate the use of consistent input data. These changes ensured a consistent approach in calculating emissions across categories (3A) methane from enteric fermentation, (3B) estimated methane from manure storage and nitrogen excretion by animals, and application of manure to agricultural soil (3D).

Categories without methodological changes:

In the following categories, there were no methodological changes that would need to be included in reporting greenhouse gas emissions from agriculture in Slovakia: 3.C Rice cultivation, 3.E Savannah fires, 3.F Burning of agricultural residues, 3.G Application of dolomite and limestone, 3.H Application of urea.

Ad 2: the IPCC 2019 Refinement in 3.A Enteric Fermentation relates to the modification of the methane conversion rate (Ym factor), and this change will have an impact on the entire time series. Within the new methodology, guidelines for implementing the methane conversion rate (Ym) into calculations have been updated. The specified values have been expanded to be consistent with different levels of cattle and sheep productivity, taking into account varying dietary conditions in different livestock production systems. A reduction in the Ym factor for dairy cows is expected.

Table 5.7: *Comparison of methane conversion rates in cattle*

IPCC 2006 Guidelines	IPCC 2019 Refinement
Cattle (dairy type)	
Ym factor 6.5%	Ym factor range from 5.7-6.5%
Cattle (meat type)	
Ym factor 6.5%	Ym factor range from 0% (calves) 6.3-7%

The selection of the parameter value will depend on milk production, digestibility of DE%, and the volume of crude detergent fiber NDF% in dry matter. To assign the Ym factor, the category must meet (exceed) all three criteria. If it fails to meet at least one, it moves down a category and is assigned a higher Ym factor. The dry matter intake (DMI) of feed. The dry matter intake for all sheep categories in the inventory is above 0.8 kg per day, so the Ym factor is set at 6.5% (page 10.45, IPCC 2019 RF). For this reason, an increase in enteric methane emissions is expected for non-breeding ewes. The remaining sheep categories will have unchanged methane production rates, so we do not anticipate a difference in reported emissions. The coefficient corresponding to the feeding situation Ca of the animal (Table 10.5, IPCC 2019 RF) has increased from 0.0090 $MJ.d^{-1}.kg^{-1}$ to 0.0096 $MJ.d^{-1}.kg^{-1}$.

Table 5.8 *Amount of dry matter in sheep in Slovakia*

Live weight	Feed dry matter intake	Ym factor IPCC 2019 Refinement
Growing lambs 30-40 kg	1.2-1.4 kg	DMI more than 0.8 kg/day = 6.5%
Sows 60 kg	1.7 kg	DMI more than 0.8 kg/day = 6.5%

Emission factors for non-key animal categories were reviewed and updated where information was available. Emission factors for developed and developing countries were reclassified into low (extensive farming) and high productivity – intensive farming (tier 1) systems. The new emission factors capture dual productivity.

Table 5.9: *Comparison of emission factors for non-key categories*

ANIMAL CATEGORY	Production system SR conditions	Emission factor IPCC 2006 Guidelines	Emission factors IPCC 2019 Refinement
Units	-	*kg CH_4 animal $^{-1}$ year $^{-1}$*	*kg CH_4 animal $^{-1}$ year $^{-1}$*
Swine	Intensive breeding	1.5	1.5
Goats	Extensive breeding	5	5
Horses	Same value for both systems	18	18
Poultry	Neither the new nor the old methodological manual provides emission factors for poultry		

Methane emission from enteric fermentation were recalculated. Recalculations led to a decrease in emissions compared to the previous submission from -3.27% to - 0.6%.

Table 5.10: *The recalculations of CH_4 emissions in 3.A Enteric fermentations in 1990 – 2021*

CATEGORY	3.A ENTERIC FERMENTATION - CH_4		INTER-ANNUAL DIFERENCES
Submission	**2023**	**2024**	
Units	*Gg*		*%*
1990	111.87	111.14	-0.6%
1995	71.10	70.85	-0.3%
2000	53.18	52.58	-1.1%
2005	46.27	45.75	-1.1%
2006	44.88	44.46	-1.0%
2007	44.56	44.01	-1.2%
2008	43.61	43.35	-0.6%
2009	41.94	41.55	-0.9%
2010	41.70	41.40	-0.7%
2011	41.33	41.04	-0.7%
2012	42.60	41.69	-2.1%
2013	42.07	41.31	-1.8%
2014	41.14	40.33	-2.0%
2015	41.16	40.45	-1.7%
2016	40.30	39.34	-2.4%
2017	39.92	39.29	-1.6%
2018	39.76	39.03	-1.8%
2019	38.77	38.15	-1.6%
2020	38.65	37.63	-2.6%
2021	37.94	36.71	-3.3%

Ad 2: The change in Slovakia's classification into the climatic zone - from cool to cool temperate dry area based of definition of the climate zones in the IPCC 2019 GL Chapter. 3 Consistent representation of lands (vol. 4.) is one of the modifications introduced by the IPCC 2019 RF in the category 3.B. This selection took into account climatic parameters such as the 32-year mean of atmospheric precipitation, average evapotranspiration values, and average air temperature. An important change resulting from this refinement is related to the modification of the methane conversion factor (MCF) in category 3.B, particularly affecting significant livestock categories, especially 3.B.1.1 (cattle) and 3.B.1.3 (pigs).

The MCF factor was chosen based on the climatic zone in which the country is located, influencing the entire time series of emissions in crucial livestock categories. During the breeding of these animals, a significant amount of manure is produced, and during its storage, more methane is released compared to other animal species. The MCF parameter for manure and slurry storage has increased from 16% (pigs liquid- below animal confinements 3 month) to 26% (cattle liquid- below animal confinements 6 month). Default methane conversion factors (MCF) are provided in Table 10.17 in the IPCC 2019 Refinement for various manure management systems.

The IPCC 2019 Refinement introduced a new approach at tier 1 for non-key emission categories 3.B.1.4.a (goats) and 3.B.1.4.b (horses), where estimating the VS parameter was necessary. For category 3.B.1.4.c (poultry), a tier 2 approach was implemented (More information is available in 5.8.1 chapter).

Manure and slurry stored and managed as dry material in cold climates do not produce a significant amount of methane. In this case, the methane conversion factor (MCF) is 2%. For excreta generated during animal grazing, the methane conversion rate ranges up to 0.47% percent (***Table 5.11***).

To comprehensively consider manure and slurry storage duration, regional data are lacking. Therefore, calculations were based on the valid law No. 136/2000 Coll. on fertilizers and their application in vulnerable areas. During the IPCC methodology review, a model for calculating MCF was developed based on monthly temperature profiles, manure temperature, and storage length. In the absence of a national approach for estimating MCF, the IPCC model will be used.

The MCF value for grazing has also decreased, while the MCF for manure storage remains unchanged. The applied MCF for biogas stations was also revised. According to the expert judgement in Slovakia are Anaerobic Digester with low leakage, high quality gastight storage, and best complete industrial technology (MCF 1%).

Table 5.11: *Comparison of MCF across different manure management systems*

Methane conversion factor Climate zone	IPCC 2006 Guidelines Cool	IPCC 2019 Refinement Cool temperate dry
Determining the storage period	It was not intended	Based on the law 3 and 6 months
Liquid manure cattle	10±5	26%
Liquid swine	10±5	16%
Pasture	1	0.47%
Solid manure	2	2%
Biogas stations	10	1%
Poultry manure with and without litter	1.5	1.5%

The recalculation of CH_4 emissions from manure management systems was processed due to the implementation of IPCC 2019 Refinement and implementation of tier 2. Recalculations led to an increase in emissions compared to the previous submission from +48% to +26%.

Table 5.12: *The recalculations of CH_4 emissions in 3.B.1 Manure management in 1990 – 2021*

CATEGORY	3.B.1 MANURE MANAGEMENT - CH_4		INTER-ANNUAL DIFERENCES
Submission	**2023**	**2024**	
Units	Gg		%
1990	17.33	25.58	48%
1995	10.17	14.87	46%
2000	7.46	10.97	47%
2005	6.02	8.65	44%
2006	5.92	8.67	46%
2007	5.51	7.90	43%
2008	4.80	6.81	42%
2009	4.64	6.59	42%
2010	4.60	6.53	42%
2011	4.15	5.87	41%
2012	4.35	6.10	40%
2013	4.20	5.69	35%

CATEGORY	3.B.1 MANURE MANAGEMENT - CH_4		INTER-ANNUAL DIFERENCES
Submission	2023	2024	
Units	Gg		%
2014	4.33	5.74	33%
2015	4.28	5.51	29%
2016	3.94	5.05	28%
2017	4.10	5.29	29%
2018	4.22	5.51	31%
2019	3.96	5.11	29%
2020	3.48	4.42	27%
2021	3.06	3.87	26%

Ad 3, 4: Nitrogen excretion values by animals (Nrate) have been updated based on new IPCC 2019 RF. Nrate is used in calculating nitrogen excretion (N_{EX}) for all non-key animal categories (goats, horses, and sheep) in category 3.B. The value depends on the weight of the raised livestock.

Table 5.13: *Comparison of nitrogen excretion rates*

RATE OF NITROGEN EXCRETION *kg N (1 000 kg of animal weight) $^{-1}$ day $^{-1}$*		
Species	**IPCC 2006 Guidelines**	**IPCC 2019 Refinement**
Sheep	0.85	0.36
Goats	1.28	0.46
Horses	0.26	0.26

The nitrogen excretion rates (N_{EX}) by the tier 2 methodology for pigs and cattle (key emission categories) remain unchanged. A new tier 2 methodological approach for poultry was implemented based on the revised IPCC 2019 Refinement. Completely new nitrogen excretion rates were calculated for poultry categories as defined by the ŠÚ SR. Broilers were disaggregated into breeding and finishing. During the implementation of tier 2 a revision of animal weights laying hens, ducks, and geese was also carried out. The revision itself was preceded by a survey conducted by the Poultry Union, which represents the majority of poultry breeders in Slovakia. From the analysis, weight averages were calculated and included in the emission calculations.

The nitrogen excretion rate (N_{EX}) takes into account the amount of nitrogen that an animal consumes for growth and daily activity. When correcting the parameter for pigs, revised data on efficiency were implemented, especially the live weight of piglets at weaning and the live weight of piglets at birth.

Emission factors for direct emissions have been reviewed and updated wherever possible. A new emission factor has also been introduced for biogas stations, taking into account N_2O emissions from the storage of digestate (the product after digestion). These changes lead to increase of emission in time series.

Table 5.14: *Comparison of emission factors*

TYPE OF MANURE MANAGEMENT	IPCC 2019 Refinement	IPCC 2006 Guidelines
	kg N_2O N (kg of excluded nitrogen) $^{-1}$	
Solid storage	0.01	0.005
Liquid storage	0.005	0.005
Biogas stations	0.0006	0
Emission factors unchanged		
Poultry manure without litter	0.001	
Poultry manure without litter	0.001	
Cattle and Swine deep bedding	0.01	

More information on used methodology is available in Chapter 5.9. Recalculations led to increase of emissions in the category 3.B.2 compared to the previous submission from 19% to 38%.

Table 5.15: *The recalculations of N_2O emissions in 3.B.2 Direct emissions from manure management in 1990 – 2021*

CATEGORY	3.B.2 DIRECT N_2O FROM MANURE MANAGEMENT		INTER-ANNUAL DIFERENCES
Submission	**2023**	**2024**	
Units	*Gg*		*%*
1990	1.535	1.956	27%
1995	1.043	1.285	23%
2000	0.849	1.054	24%
2005	0.725	0.901	24%
2006	0.709	0.873	23%
2007	0.678	0.840	24%
2008	0.627	0.784	25%
2009	0.615	0.753	23%
2010	0.601	0.736	22%
2011	0.573	0.708	24%
2012	0.590	0.725	23%
2013	0.573	0.693	21%
2014	0.585	0.702	20%
2015	0.574	0.684	19%
2016	0.548	0.657	20%
2017	0.547	0.650	19%
2018	0.563	0.670	19%
2019	0.547	0.661	21%
2020	0.505	0.663	31%
2021	0.472	0.651	38%

Ad 5 and Ad 18: Indirect N_2O emissions from manure management were recalculated. The revision of category was performed due to changes in category 3.B.2 Manure management. In category 3.B.2.5 Indirect N_2O emissions, a new emission source was included in the emission inventory - N_2O from the leaching of nitrogen from manure and slurry storage systems. Default values for $Frac_{LeachMS}$ parameters for various manure systems and for individual categories of livestock were introduced in the IPCC 2019 Refinement and were used in the calculation of N_2O emissions (Table 10.22, IPCC 2019 RF). In 2024 submission, indirect N_2O emissions from manure management were recalculated. Revision of emissions in 1992, 1993 and 2005 due to recalculation in 3.B.2.2 and 3.B.2.4. All changes are documented in previous paragraphs. Impact of recalculations compared to the previous submission is visible in ***Table 5.16***.

Table 5.16: *The recalculations of N_2O emissions in 3.B.2.5 Indirect emissions from manure management in 1990 – 2021*

CATEGORY	3.B.2.5 INDIRECT N_2O FROM MANURE MANAGEMENT		INTER-ANNUAL DIFERENCES
Submission	**2023**	**2024**	
Units	*Gg*		*%*
1990	0.724	0.658	-9%
1995	0.499	0.438	-12%
2000	0.405	0.359	-11%
2005	0.350	0.311	-11%
2006	0.342	0.301	-12%

CATEGORY	3.B.2.5 INDIRECT N_2O FROM MANURE MANAGEMENT		INTER-ANNUAL DIFERENCES
Submission	2023	2024	
Units	*Gg*		*%*
2007	0.327	0.289	-12%
2008	0.299	0.265	-11%
2009	0.301	0.264	-12%
2010	0.293	0.257	-12%
2011	0.276	0.243	-12%
2012	0.286	0.250	-12%
2013	0.275	0.238	-14%
2014	0.285	0.246	-14%
2015	0.283	0.242	-15%
2016	0.270	0.230	-15%
2017	0.272	0.233	-14%
2018	0.282	0.242	-14%
2019	0.272	0.236	-13%
2020	0.244	0.244	0%
2021	0.230	0.252	10%

Ad 6: Revision of emission factors was processed according to the IPCC 2019 RF. Emission factor for dry climatic zone were selected, similar to methane emissions from manure management. This revision of emission factors led to a reduction in nitrous oxide emissions per unit of fertilizer. Emission factors for the application of organic and inorganic fertilizers decreased by almost 50%. Emission factors for grazing even decreased by up to 80%. These changes had a significant impact on the overall reduction of emissions from this sector. In the same time, methodology approach for categories 3.D.1.2 Manure applied to soil and 3.D.1.4 Crop residues were updated. IPCC 2019 Refinement revised the emission factors from leaching and runoff, which is higher than in previous version of IPCC 2006 GL 0.0075 kg N_2O-N (kg N leaching/runoff)$^{-1}$ and 0.01 kg N_2O-N (kg N leaching/runoff)$^{-1}$. Impact of recalculations compared to the previous submission is visible in the ***Table 5.17***.

Table 5.17: *The recalculations of N_2O emissions in 3.D.1 Emissions from agricultural soils in 1990 – 2021*

CATEGORY	3.D.1 DIRECT N_2O FROM AGRICULTURAL SOILS		3.D.2 INDIRECT N_2O FROM AGRICULTURAL SOILS		INTER-ANNUAL DIFFERENCES 3.D.1	INTER-ANNUAL DIFFERENCES 3.D.2
Submission	2023	2024	2023	2024		
Units	*Gg*		*Gg*		*%*	*%*
1990	5.853	2.931	1.629	2.201	-49.9%	35.1%
1995	2.951	1.585	0.748	1.115	-46.3%	49.0%
2000	2.696	1.430	0.647	0.934	-47.0%	44.3%
2005	3.093	1.626	0.813	1.179	-47.4%	45.0%
2006	2.931	1.535	0.446	0.602	-47.6%	35.0%
2007	3.162	1.633	0.586	0.801	-48.4%	36.6%
2008	3.607	1.849	0.753	1.033	-48.7%	37.2%
2009	3.040	1.557	0.600	0.820	-48.8%	36.6%
2010	3.003	1.532	1.098	1.578	-49.0%	43.7%
2011	3.447	1.754	0.455	0.575	-49.1%	26.4%
2012	2.983	1.522	0.419	0.538	-49.0%	28.5%
2013	3.318	1.683	0.659	0.890	-49.3%	35.1%
2014	3.685	1.881	0.844	1.172	-49.0%	38.7%
2015	3.463	1.751	0.383	0.466	-49.4%	21.8%

CATEGORY	3.D.1 DIRECT N_2O FROM AGRICULTURAL SOILS		3.D.2 INDIRECT N_2O FROM AGRICULTURAL SOILS		INTER-ANNUAL DIFFERENCES 3.D.1	INTER-ANNUAL DIFFERENCES 3.D.2
Submission	**2023**	**2024**	**2023**	**2024**		
Units	*Gg*		*Gg*		*%*	*%*
2016	3.716	1.891	0.745	1.023	-49.1%	37.3%
2017	3.423	1.731	0.534	0.702	-49.4%	31.6%
2018	3.631	1.842	0.375	0.457	-49.3%	21.9%
2019	3.670	1.858	0.555	0.729	-49.4%	31.2%
2020	3.682	1.887	0.643	0.882	-48.8%	37.2%
2021	3.652	1.873	0.453	0.598	-48.7%	32.1%

Ad 7: Correction of Ym parameter of beef calves from zero to 3.2% and correction of oxen weight from 333 kg to 700 kg. These changes have impact on IEF and AGEI. Emission of methane have been increased by 1.5% from 17.95 Gg to 18.21 Gg in this category.

Ad 8, 9 and 10: Revision of CH_4 emissions and AGEIs in 3.A.2 Mature Ewes subcategory due to inconsistency between the CRF reporter and calculation sheets and revision of CH_4 emissions and digestibility in 3.A.2 Sheep categories due to overestimated digestibility of feed in 2022 were done. After consultations with animal husbandry experts, new values for digestibility was implemented into the 2024 submission for growing lambs DE =58.93%, other mature sheep DE= 58.75% and mature ewes 60.8%. After this implementation IEF = 11.66 kg CH_4/head/year which is different from the previous submission by 4.6% and on emission by almost 13.6% cumulatively with previous *Ad 8* corrections. Revision of methane conversion factor (Ym) in Growing lambs subcategory in partial year 2015 was done due to inconsistency between the CRF reporter and calculation sheets (2015). Emissions was calculated with lower Ym value (5.7%). An inconsistency in the number of other mature sheep was identified across categories. This change has a significant impact on emissions, particularly noted in the year 2005. In mature Ewes, a discrepancy in the N_{EX} figures was observed between the calculation sheet and the CRF reporter. More information about differences between reporting is available in ***Table 5.18***.

Table 5.18: *The differences in 2024 submission caused by recalculations of emissions in sheep subcategories in 1990 – 2021*

Category	3.A.2 ENTERIC FERMENTATION - SHEEP DIFERENCES	3.B.1.2 MANURE MANAGEMENT -SHEEP DIFERENCES	3.B.2.2 MANURE MANAGEMENT - SHEEP DIFERENCES
1990	0.068%	0.0000%	0.0000%
1991	0.081%	0.0000%	0.0000%
1992	0.127%	0.0000%	0.0000%
1993	0.153%	0.0000%	0.0000%
1994	0.149%	0.0000%	0.0000%
1995	0.081%	0.0000%	0.0000%
1996	0.147%	0.0000%	0.0000%
1997	0.152%	0.0000%	0.0000%
1998	0.141%	0.0000%	0.0000%
1999	0.143%	0.0000%	0.0000%
2000	0.143%	0.0000%	0.0000%
2001	0.147%	0.0000%	0.0000%
2002	0.154%	0.0000%	0.0000%
2003	0.153%	0.0000%	0.0000%
2004	0.161%	0.0000%	0.0000%
2005	0.168%	0.0000%	**0.0010%**
2006	0.162%	0.0000%	0.0000%
2007	0.158%	0.0000%	0.0000%

Category	3.A.2 ENTERIC FERMENTATION - SHEEP DIFERENCES	3.B.1.2 MANURE MANAGEMENT -SHEEP DIFERENCES	3.B.2.2 MANURE MANAGEMENT - SHEEP DIFERENCES
2008	0.160%	0.0000%	0.0000%
2009	0.157%	0.0000%	0.0000%
2010	0.156%	0.0000%	0.0000%
2011	0.158%	0.0000%	0.0000%
2012	0.155%	0.0000%	0.0000%
2013	0.158%	0.0000%	0.0000%
2014	0.158%	0.0000%	0.0000%
2015	-0.122%	0.0000%	0.0000%
2016	0.157%	0.0000%	0.0000%
2017	0.158%	0.0000%	0.0000%
2018	0.155%	0.0000%	0.0000%
2019	0.160%	0.0000%	0.0000%
2020	0.161%	0.0000%	0.0000%
2021	0.158%	0.0000%	0.0000%

Ad 11, Ad 13: Changes in the distribution of swine subcategories led to the revision of swine categories. In the 2023 submission, "Piglets up to 20 kg" category were divided into "Breeding" and "Fattening pigs" categories. Due to the same breeding conditions and similar breeding practices. Our husbandry expert decided to aggregate back these categories into one category and simplify the differentiation in 2024 submission. Therefore, the numbers of market swine were increased compared to the breeding swine, where the numbers were decreased. The revision has impact on incorrect calculation of implied emission factors. Inconsistent numbers of livestock in swine category between CRF reporter and spreadsheets was discovered and corrected in 2024 submission, numbers were higher ten officially statistical data. Revision was done in particular years 1995 and 1997. Revision caused decrease of emissions. More information about impact of changes is available in ***Table 5.19***.

Table 5.19: *The differences in 2024 submission caused by recalculations of emissions in Swine subcategories in 1990 – 2021*

CATEGORY	3.A.3 ENTERIC FERMENTATION - SWINE DIFERENCES	3.B.1.3 MANURE MANAGEMENT - SWINE DIFERENCES
1990	-0.056%	0.00%
1991	-0.059%	0.00%
1992	-0.054%	0.00%
1993	-0.063%	0.00%
1994	-0.066%	0.00%
1995	-0.063%	**-6.55%**
1996	-0.063%	0.00%
1997	-0.055%	**-4.33%**
1998	-0.058%	0.00%
1999	-0.053%	0.00%
2000	-0.054%	0.00%
2001	-0.035%	0.00%
2002	-0.056%	0.00%
2003	-0.052%	0.00%
2004	-0.033%	0.00%
2005	-0.033%	0.00%
2006	-0.041%	0.00%
2007	-0.045%	0.00%
2008	-0.034%	0.00%

CATEGORY	3.A.3 ENTERIC FERMENTATION - SWINE DIFERENCES	3.B.1.3 MANURE MANAGEMENT - SWINE DIFERENCES
2009	-0.057%	0.00%
2010	-0.031%	0.00%
2011	-0.037%	0.00%
2012	-0.038%	0.00%
2013	-0.040%	0.00%
2014	-0.050%	0.00%
2015	-0.036%	0.00%
2016	-0.072%	0.00%
2017	-0.057%	0.00%
2018	-0.031%	0.00%
2019	-0.028%	0.00%
2020	-0.043%	0.00%
2021	-0.027%	0.00%

Ad 12, 14 and 17: Revision of average weight in Horses category was done due to the incorrect calculation of average weight. Horses 1-3 year subcategory was not included in the total average weight, therefore revision was done. Revision had no impact on reported emission in 3.A.4. Subcategory. Second corrected inconsistencies in numbers were done in 3.B.1.4 Manure management – Horses category and in 3.B.2.4 Manure management – Horses category. In particular years 1992 and 1993, revision of CH_4 emission was done. Number of horses was not in line with official statistical data, therefore revision of estimates was necessary. Information about changes is available in ***Table 5.20***.

Table 5.20: *The differences in 2024 submission caused by recalculations of emissions in Horses subcategories in 1990 – 2021*

CATEGORY	3.A.4 ENTERIC FERMENTATION - HORSES DIFFERENCES	3.B.1.4 MANURE MANAGEMENT - HORSES DIFFERENCES	3.B.2.4 MANURE MANAGEMENT - HORSES DIFERENCES
1990	0%	0.0%	0.00%
1991	-13%	0.0%	0.00%
1992	-14%	**0.1%**	**0.074%**
1993	-16%	**-0.6%**	**-0.330%**
1994	-14%	0.0%	0.00%
1995	-13%	0.0%	0.00%
1996	-15%	0.0%	0.00%
1997	-15%	0.0%	0.00%
1998	-15%	0.0%	0.00%
1999	-14%	0.0%	0.00%
2000	-14%	0.0%	0.00%
2001	-24%	0.0%	0.00%
2002	-20%	0.0%	0.00%
2003	-21%	0.0%	0.00%
2004	-22%	0.0%	0.00%
2005	-21%	0.0%	0.00%
2006	-20%	0.0%	0.00%
2007	-22%	0.0%	0.00%
2008	-20%	0.0%	0.00%
2009	-21%	0.0%	0.00%
2010	-21%	0.0%	0.00%
2011	-20%	0.0%	0.00%
2012	-20%	0.0%	0.00%

CATEGORY	3.A.4 ENTERIC FERMENTATION - HORSES DIFFERENCES	3.B.1.4 MANURE MANAGEMENT - HORSES DIFFERENCES	3.B.2.4 MANURE MANAGEMENT - HORSES DIFERENCES
2013	-21%	0.0%	0.00%
2014	-19%	0.0%	0.00%
2015	-16%	0.0%	0.00%
2016	-17%	0.0%	0.00%
2017	-18%	0.0%	0.00%
2018	-19%	0.0%	0.00%
2019	-18%	0.0%	0.00%
2020	-11%	0.0%	0.00%
2021	-13%	0.0%	0.00%

Ad 19: During QC procedures, inconsistency between officially statistical data provided by the Central and Testing Institute in agriculture in Bratislava and reported consumption of Nitrogen fertilizers in 2022 were found. The revision in consumption of nitrogen fertilizers took place in 2024 submission and data was corrected from 126.86 kt to 115.34 kt. Revision of consumption has impact on N_2O emissions in 3.D.1.1, emissions decreased by 9.1%.

Ad 20: The recalculation in 2024 submission of N_2O emissions from animal manure applied to the soils in 1992 (0.00080%), 1993 (-0.00383%) and 2005 (0.00002%) was processed due to the recalculation in the 3.B.2.4 horses and 3.B.2.2 sheep categories. Recalculations led to an increase in emissions compared to the previous submission by +0.26% in 1992, 1993 and 2005.

Ad 21: The recalculation of N_2O emissions from 3.D.1.3 Urine and Dung Deposited by Grazing Animals in 1992 (0.00238%), 1993 (-0.01253%) was processed due to the recalculation in the 3.B.2.4 horses category. Recalculations led to an increase (1992) and decrease (1993) in emissions compared to the previous submission.

Ad 22: Correction of the Statistical data was done in partial year 2022. Harvested area of the other leguminous plants was corrected from 720 338 hectares to 8 082 hectares This correction has impact on the decrease of N_2O emissions from the 3.D.1.4 Crop Residues and this change has effect on decrease of emissions by 21.19 % in 2022.

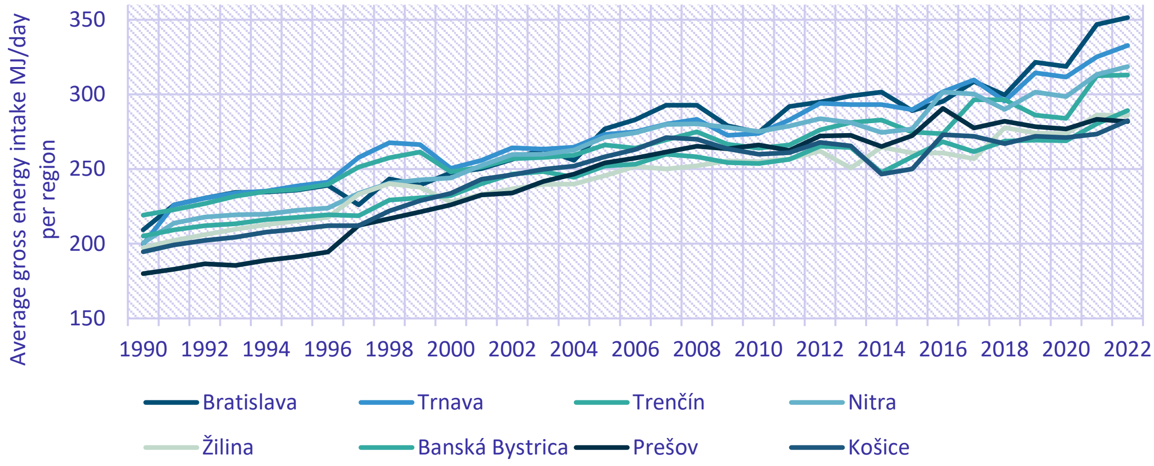
Ad 23: In the 3.D.2 indirect emissions of nitrous oxide (N_2O) from managed soils. These emissions have been revised at various intervals, specifically in 1992 (0.00042%), 1993 (-0.00216%), 2005 (0.0000069%), and 2022 (-6.0%), due to recalculations processed in chapters 3.D.1.2a, 3.D.1.3, 3.D.1.4, and 3.D.1.1. These revisions contribute to a more precise assessment of total N_2O emissions from managed soils.

5.5. National Circumstances and Time-series Consistency

Slovak farmers have been adapted to changes in agriculture after 1990. They invested in the development of their farms to avoid the bankruptcy and to be self-competitive in this sector. The EÚ policy supported the used tools as the base of transformation. The EÚ policy and measures were transformed into the Slovak legal system. Farmers had to follow new strict criteria like changing of housing systems, a decrease of pasture time, new storage capacity for organic waste, which was supported by the Decree No 389/2005 Coll. and Nitrates Directive. These measures are well advanced and copy the practices used in the Western European countries. Therefore, default parameters for the Western Europe are used in inventory. The most significant animals in regard of emissions in Slovakia are cattle and swine.

Cattle breeding in the Slovak Republic is comparable with the Western European countries, which is documented by a high milk yield of dairy cattle and high daily weight gains of non-dairy cattle. To maintain a high milk yield and high daily gains, food rich on proteins and cereals is important. Dairy cows in three Slovak regions (Bratislava, Trnava and Nitra) produce 29-26 litres/day. In other regions, milk productivity is 18-23 litres/day. Lower milk production relates to feeding. In this case, pasture is included in the feeding ratio. It is typical for semi-intensive farming in regions Košice, Prešov, Banská Bystrica or Žilina. These circumstances are documented on ***Figures 5.4*** and ***5.5***. Highly productive dairy cows (milked 25 -30 litres/day) need to be fed by approximately 8 kg of cereals with excellent digestibility and high nutrition. Annual increase in milk productivity is the evidence of increasing productivity of animal production. Balanced and sustainable farming in Slovakia has an impact on the high value of AGEI (304 MJ/head/day) (***Table 5.36***).

Figure 5.4: *Trend in average gross energy intake (MJ/day) in different Slovak regions*



The number of dairy cows decreased according to data from the ŠÚ SR by 71% in 2022 compared to 1990 (***Figure 5.5***). Milk production increased up to 228% in 2022 (***Figure 5.6***) compared to the 1990 and by 3.8% compared to previous year despite the continuously decreasing number of the dairy cows. The main reason of this trend is the increase in an average performance. The high-performance average is the result of good animal husbandry, breeding conditions, new synergy with technologies and animal genetics. All factors contribute together to achieving milk yields of up to 10 000 kg of milk per head.

Figure 5.5: *Correlation of milk production (kg/head/day) and nitrogen excretion rate (kg N/head/year)*

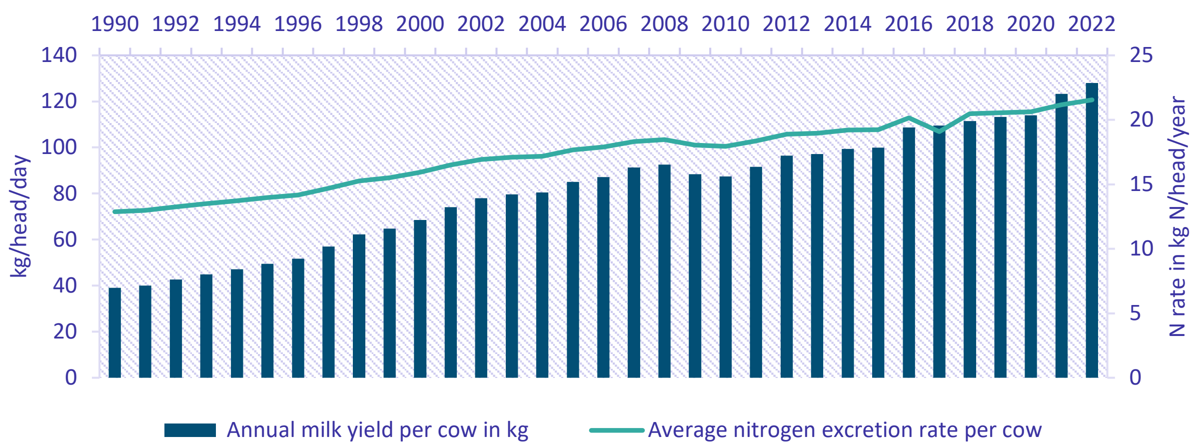
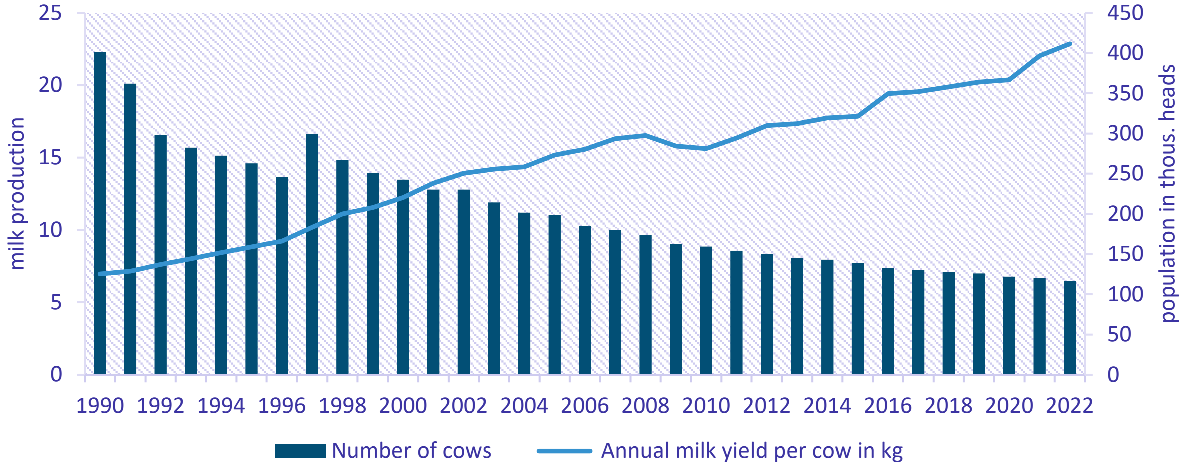


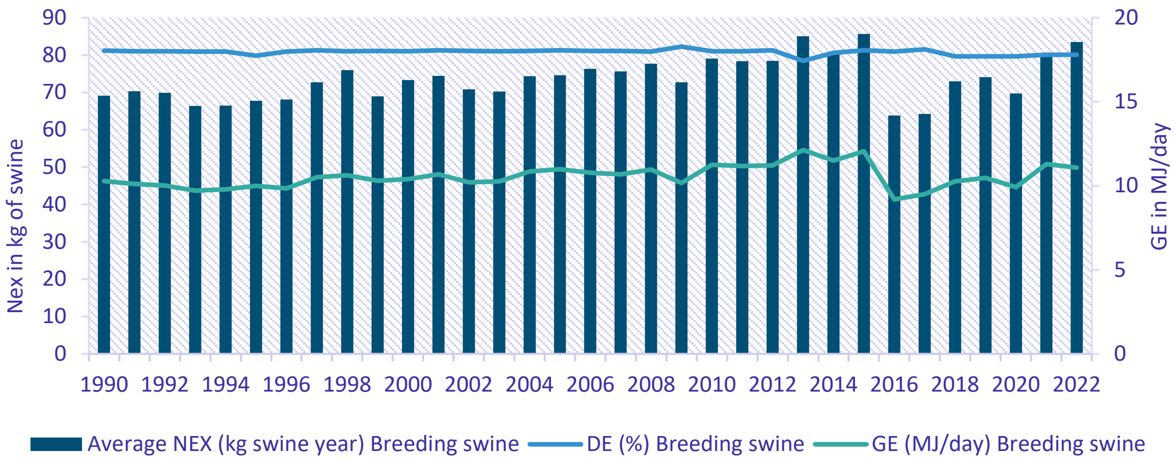
Figure 5.6: Trend in dairy cattle population and dairy milk production (kg/head/day)



The pig farming system in the Slovak Republic is divided into two types - breeding and market pigs. Breeding pigs are bred for reproduction purposes. Fattening pigs are bred mainly for the production of pork meat and fat. Pigs are housed in the Slovak conditions for the whole year. Housing technology and diet can significantly affect the production of greenhouse gases. Stall conditions can be very variable. Pigs are bred in intensive farming on rosette floors, which is one of the low emission technics. Another part of pigs, mainly in semi-intensive farming, are reared on straw. Deep bedding is used mostly at micro and small farms. Diet has a significant impact on emissions production. The main component of the feeding is cereals (barley, triticale, wheat about 80-90%). Complementary feed ingredients are soybean scrap, rapeseed scrap, and beer brewing waste. The resultant feeding rations have a high nutritional value and are easily digestible (***Figures 5.7*** and ***5.8***).

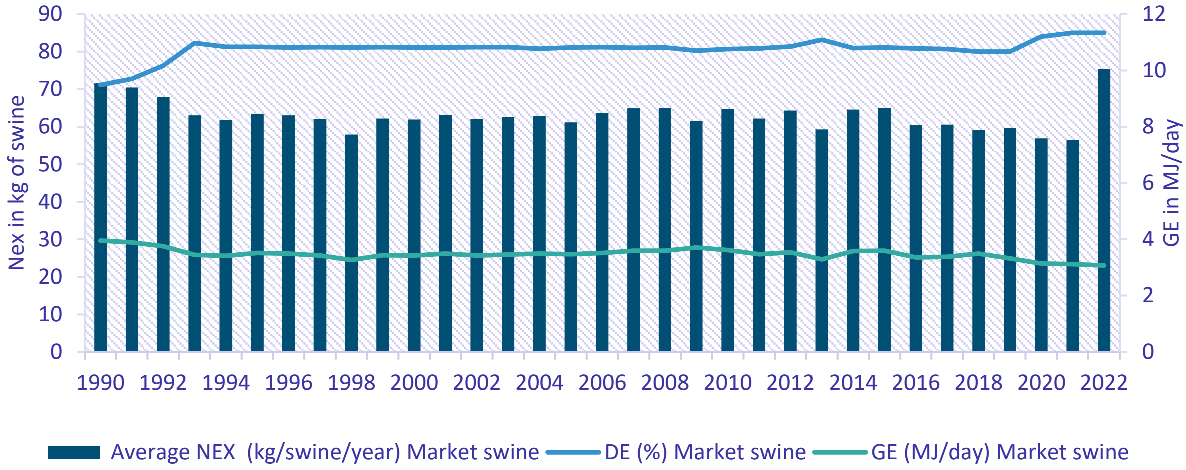
Trends in breeding swine - very dynamical trend is visible in breeding swine. The decrease and increase in crude proteins have impact on the nitrogen excretion rate and gross energy intake. Pig breeding in Slovakia has problems mainly due to risk of persistent morbidity - African swine fever and other economic reasons, which lead to decreasing numbers of breeding pigs after 2016. Low purchase prices create pressure to decrease of numbers of pigs, bud overall effectivity of breeding systems increase continually after 2016 and 2018 decreases.

Figure 5.7: *Trend of feed digestibility, nitrogen excretion rate and gross energy intake of breeding swine in the Slovak Republic*



Trends in market swine - after 1990, the digestibility of feeding dose increased significantly due to the increase of cereals, vitamins, dietary fibre, crude proteins and amino acids. These changes affect the increase in pig performance. After 1994 to 2021 is visible almost stable level of digestibility except 2013 where is visible smoot increase of digestibility which have influence to increase of number of market pigs by almost 10% compared with the previous year. In 2022, visible increase of digestibility of feeding gross energy intake and Nitrogen excretion rate. Base of data published in Green Report 2023. The sector has been a recovered. Presented values were estimated by VÚŽV and correlated with increase of pig performance in that year.

Figure 5.8: *Trend of feed digestibility, nitrogen excretion rate and gross energy intake of market swine in the Slovak Republic*



5.6. Uncertainties

Uncertainty estimates of emissions were performed using tier 2 approach based on the Monte Carlo simulation. The simulation is done using the Python language. The following chapter gives preliminary overview of uncertainty estimates for the CH_4, N_2O and CO_2 emissions from Agriculture for the year 2020. These results have not been officially published yet.

Monte Carlo simulations are used in the modelling of the probability of different outcomes in a process that cannot easily be predicted due to the intervention of random variables. It is a technique used for understanding of the impact of risk and uncertainty in prediction and forecasting models. The Monte Carlo analysis was prepared at the regional level. The uncertainties of livestock population for 2020 are presented in ***Table 5.21***. Uncertainties were estimated according to an assessment of the SHMÚ team. The uncertainty analysis was performed by the coefficient of variation. The coefficient of variation is a statistical measure of the dispersion of data points in a data series around the mean. The coefficient of variation represents the ratio of the standard deviation to the mean, and it is a useful statistic value for comparing the degree of variation from one data series to another, even if the means are drastically different from one another. The overall weighted mean of the uncertainties in the livestock population is ±6.09%.

Table 5.21: *Uncertainty of animal population data for 2020*

CATEGORY	*UNIT*	AGREGATED UNCERTAINITY OF NUMBER OF LIVESTOCK
Dairy cattle	*head*	± 2.77%
Non-dairy cattle	*heads*	±1.94%
Sheep	*heads*	±2.08%
Goats	*heads*	±12.94%
Horses	*heads*	±2.48%
Swine	*heads*	±3.94%

CATEGORY	UNIT	AGREGATED UNCERTAINITY OF NUMBER OF LIVESTOCK
Poultry	*heads*	±6.83%
Overall (weighted mean)	*heads*	±6.09%

The highest uncertainty increment to the total uncertainty of Agriculture sector represents N_2O emissions from agricultural soils, particularly uncertainties of used emission factors. The overall sectoral uncertainty is strongly influenced by uncertainties and distribution among the EF_1, EF_4 and EF_5 emission factors. However, the partial uncertainties on category level were calculated, overall uncertainty of the sector is still not estimated and will be provided in next submission.

Enteric Fermentation (CRF 3.A): Results of the Monte Carlo simulation for methane emissions in the category 3.A – Enteric Fermentation were estimated at 35.52 Gg of CH_4 (38.65 Gg of CH_4 were estimated in inventory) with uncertainty (-15%, +15%), which represent 95% confidence interval in 2020. A probability distribution function for category 3.A is shown on ***Figure 5.9***. In this uncertainty simulation, symmetric confidence intervals is parametrized by Gaussian normal probability density function.

Uncertainties of EFs (CH_4) from enteric fermentation for dairy cattle, non-dairy cattle and sheep were based on uncertainties of milk production, wool production and weight listed in ***Tables 5.22-5.25***. Data on milk production, weight of animals is readily available while the GE is checked against cattle feeding requirements arising from the biology of ruminants (e.g. ratio of crude protein, dry matter intake and proportion of silage in the diet).

Table 5.22: *Uncertainties of parameters used in enteric fermentation*

PARAMETER*	UNIT	UNCERTAINITY						
		Dairy cows	Calves	Heifers un-pregnant milk breed	Heifers pregnant milk breed	Fattening	Oxen	Breeding bulls
Body weight	%	±10	±10	±10	±10	±10	±10	±10
Milk yield	%	±2	-	-	-	-	-	-
DE of feed	%	±4.96	±4.96	±4.96	±4.96	±4.96	±4.96	±4.96
Ym	%	±3	±3	±3	±3	±3	±3	±3
Maintenance NE_m	*MJ/day*	±2.46	±0.021	± 0.314	±0.243	±0.110	±9.66	±5.228
Activity NE_a	*MJ/day*	±0.161		±0.408	±0.165	-	-	±0.838
Lactation N_{El}	*MJ/day*	±2.869	-	-	-	-	-	-
Work		-	-	-	-	-	±12.94	-
Growth NE_g	*MJ/day*	-	±0.000	±1.570	±1.147	±0.562	-	-
Pregnancy NEp	*MJ/day*	±0.321	-	-	±0.165	-	-	-
REM		±0.019	±0.030	±0.057	±0.034	±0.019	±0.18	±0.056
REG		±0.011	±0.019	±0.032	±0.020	±0.011	±0.11	±0.031
Gross energy	*MJ/head/day*	±16.808	±1.812	±11.344	±9.951	±3.351	±116.613	±32.752
EFs	*kg/head/year*	±45.747	±3.915	±13.010	±18.211	±11.469	±62.545	±31.818

Table 5.23: *Uncertainties of parameters used in enteric fermentation*

PARAMETER*	UNIT	UNCERTAINITY						
		Suckling cows	Calves	Heifers un-pregnant milk breed	Heifers pregnant milk breed	Fattening	Oxen	Breeding bulls
Body weight	%	±10	±25	±25	±25	±25	±25	±25
Milk yield	%	±2	-	-	-	-	-	-
DE of feed	%	±4.96	±4.96	±4.96	±4.96	±4.96	±4.96	±4.96
Ym	%	±3	±3	±3	±3	±3	±3	±3
Maintenance NE_m	*MJ/day*	±0.012	±0.052	±0.054	±0.109	±0.110	±7.198	±5.270

PARAMETER*	UNIT	UNCERTAINITY						
		Suckling cows	**Calves**	**Heifers un-pregnant milk breed**	**Heifers pregnant milk breed**	**Fattening**	**Oxen**	**Breeding bulls**
Activity NE_a	*MJ/day*	±0.419	±0.243	±0.673	±0.922	-	-	-
Lactation N_{El}	*MJ/day*	±0.964	-	-	-	-	-	-
Work		-	-	-	-	-	±7.088	-
Growth NE_g	*MJ/day*		±0.0	±1.242	±1.433	±1.848		-
Pregnancy NEp	*MJ/day*	±0.209			±0.465	-	-	-
REM		±0.023	±0.061	±0.055	±0.054	±0.058	±0.097	±0.083
REG		±0.013	±0.036	±0.031	±0.029	±0.032	±0.054	±0.046
Gross energy	*MJ/head/day*	±12.223	±5.065	±13.151	±20.077	±12.006	±68.701	±38.873
EFs	*kg/head/year*	±33.153	±5.715	±15.52	±24.317	±13.764	±47.698	±31.634

Table 5.24: *Uncertainties of emission factors in non-key categories in enteric fermentation*

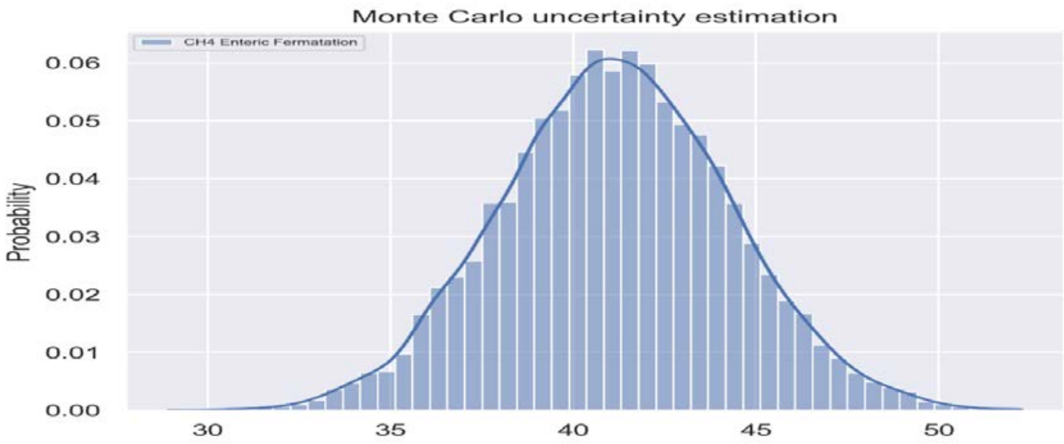
Year	Uncertainty	Animals	Emission factor
2020	4.96%	Swine	1.5 kg/head
2020	4.55%	Horse	18 kg/head
2020	9.60%	Goats	5 kg/head

Table 5.25: *Uncertainties of parameters calculated in enteric fermentation*

PARAMETER*	UNIT	DAIRY SHEEP				BEEFSHEEP			
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
DE of feed	%	±4.96	±4.96	±4.96	±4.96	±4.96	±4.96	±4.96	±4.96
Ym	%	±3	±3	±3	±3	±3	±3	±3	±3
Maintenance NE_m	*MJ/day*	±0.169	±0.630	±0.518	±1.092	±0.169	±0.578	±0.544	±1.180
Activity NE_a	*MJ/day*	±0.064	±0.168	±0.176	±0.154	±0.115	±0.201	±0.273	±0.167
Lactation N_{El}	*MJ/day*	±0.071				±0.111			
Wool production Ne_{wool}	*MJ/day*	±0.005	±0.006	±0.009	±0.006	±0.011	±0.008	±0.021	±0.011
Growth NE_g	*MJ/day*		±0.078	±0.227			±0.176	±0.226	
Pregnancy NEp	*MJ/day*	±0.229		±0.645		±0.425		±1.047	
REM		±0.019	±0.032	±0.033	±0.020	±0.037	±0.057	±0.072	±0.038
REG		±0.010	±0.016	±0.016	±0.011	±0.019	±0.029	±0.036	±0.019
Gross energy	*MJ/head/day*	±2.138	±2.816	±5.166	±4.564	±4.146	±4.036	±8.774	±5.425
EFs	*kg/head/year*	±5.847	±2.584	±6.518	±5.767	±6.644	±3.676	±7.389	±5.170

*A: Mature ewes, B: Growing lambs, C: Growing lambs pregnant, D: Other mature sheep, E: Mature ewes, F: Growing lambs, G: Growing lambs pregnant, H: Other mature sheep, * weighted average*

Figure 5.9: *Probability distribution function for the category 3.A (x-axis in Gg of CH_4)*



Manure Management (CRF 3.B.1): Results of the Monte Carlo simulation for methane emissions in the category 3.B.1 – Manure Management were calculated on the value 3.04 Gg of CH_4 (3.06 Gg of CH_4 were estimated in inventory) with uncertainty (-14.91%, +14.91%) which represent 95% confidence interval in 2020. A probability distribution function for category 3.B.1 is shown on ***Figure 5.10***. In this uncertainty simulation, symmetric confidence intervals is parametrized by Gaussian normal probability density function.

Uncertainties of EFs (CH_4) from manure management for dairy cattle, non-dairy cattle and sheep were based on uncertainties of storage of solid and liquid manure management systems from breeding animals listed in ***Tables 5.26***-***5.31***. Data on storage systems and number of livestock is readily available.

Table 5.26: *Uncertainties of parameters used in manure management for cattle and sheep in 2020*

PARAMETERS	UNIT	DAIRY CATTLE	NON-DAIRY CATTLE	MATURE EWES	GROWING LAMBS	OTHER MATURE SHEEP
B_o*	%	±15%	±15%	±15%	±15%	±15%
Ash content	%	±20%	±20%	±20%	±20%	±20%

Table 5.27: *Uncertainties of parameters used in manure management for market swine in 2020*

PARAMETERS	UNIT	A	B	C	D	E
B_o*	%	±15%	±15%	±15%	±15%	±15%
Ash content	%	±20%	±20%	±20%	±20%	±20%

A: Fattening pigs up to 20 kg; B: Fattening pigs 21-50 kg; C: Fattening pigs 50-80 kg, D: Fattening pigs 80-110 kg; E: Fattening pigs over 110 kg

Table 5.28: *Uncertainties of parameters used in manure management for breeding swine in 2020*

PARAMETERS	UNIT	A	B	C	D	E	F
B_o*	%	±15%	±15%	±15%	±15%	±15%	±15%
Ash content	%	±20%	±20%	±20%	±20%	±20%	±20%

*A: Sows, B: Gilts non-pregnant, C: Gilts pregnant, D: Hogs; E: Piglets up to 20 kg; F: Piglets 21-50 kg; *Bo for Western Europe was chosen*

Figure 5.10: *Probability distribution function for the category 3.B.1 (x-axis in Gg of CH_4)*

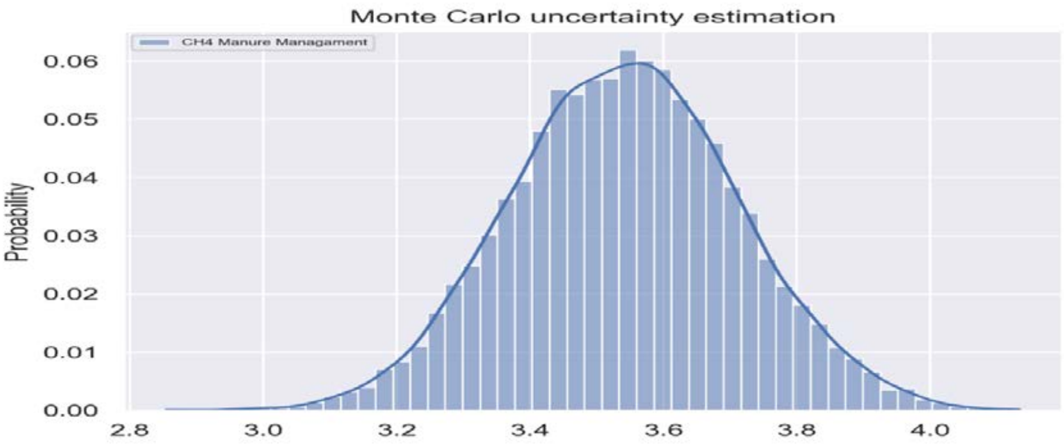


Table 5.29: *Uncertainties of parameters calculated in manure management for sheep in 2020*

ANIMAL		EFs	VSs
		kg VS/day	*kg/head*
DAIRY SHEEP	Mature ewes	±0.032	±0.046
	Growing lambs	±0.044	±0.064
	Growing lambs (pregnant)	±0.081	±0.117
	Other mature sheep	±0.096	±0.103
BEEF SHEEP	Mature ewes	±0.060	±0.089
	Growing lambs	±0.062	±0.091
	Growing lambs (pregnant)	±0.134	±0.199
	Other mature sheep	±0.115	±0.124

Table 5.30: *Uncertainties of parameters calculated in manure management for cattle in 2020*

ANIMAL		VSs	EFs
		kg/head	*kg VS/day*
MILK TYPE	Dairy cows	±0.258	±0.501
	Calves in 6. month	±0.021	±0.018
	Heifers	±0.193	±0.167
	Heifers (pregnant)	±0.167	±0.145
	Fattening	±0.054	±0.067
	Oxen	±1.643	±1.446
	Breeding bull	±0.549	±0.424
BEEF TYPE	Suckler cows	±0.239	±0.153
	Calves in 6. month	±0.070	±0.049
	Heifer	±0.252	±0.161
	Heifer (pregnant)	±0.253	±0.396
	Fattening	±0.228	±0.362
	Oxen	±1.110	±1.260
	Breeding bull	±0.684	±0.528

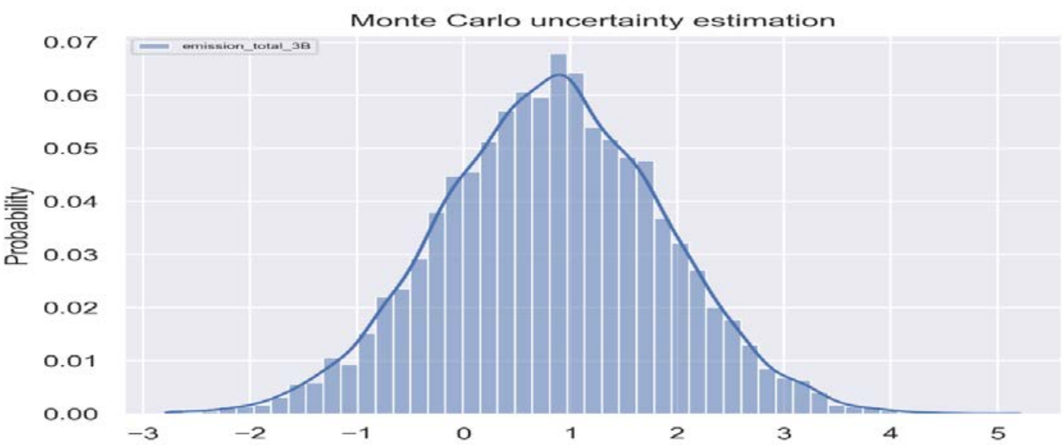
Table 5.31: *Uncertainties of parameters calculated in manure management for swine in 2020*

ANIMAL	VSs	GE	ME	EFs
	kg/head	MJ/day	MJ/day	kg/head
Sows	±0.279	±0.279	±0.28	±5.709
Gilts non-pregnant	±0.314	±0.314	±0.314	±4.872
Gilts pregnant	±0.390	±0.390	±0.390	±3.924
Hogs	±0.390	±0.390	±0.390	±3.924
Piglets 20 kg	±1.258	±1.258	±1.180	±1.217
Piglets 21-50kg	±0.670	±0.670	±0.649	±2.287
Fattening to 20 kg	±1.178	±1.178	±0.062	±0.923
Fattening to 21-50 kg	±0.649	±0.649	±0,649	±1.674
Fattening to 50-80 kg	±0.445	±0.445	±0.445	±2.453
Fattening to 80-100 kg	±0.355	±0.355	±0.355	±4.232
Fattening from 110 kg	±0.317	±0.317	±0.317	±4.721

Manure Management (CRF 3.B.2): Results of the Monte Carlo simulation for N_2O emissions in the category 3.B.2 – Manure Management were calculated on the value 0.34 Gg of N_2O (0.24 Gg of N_2O were estimated in inventory) with uncertainty (±248.3), which represent 95% confidence interval in 2020. A probability distribution function for category 3.B.2 is shown on ***Figure 5.11***. In this uncertainty simulation, symmetric confidence intervals is parametrized by Gaussian normal probability density function.

Uncertainties of N_2O emissions relating to the N excretion for cattle are ±0.015 Gg and for swine ±0.0038 Gg. Uncertainties of other animals' species as poultry are ±0.020 Gg. The uncertainty of the manure management system usage (MST, S) are ±25%, what is in accordance with the default value provided by IPCC 2006 Guidelines. The uncertainty of the EFs is ±2.6%, therefore the lower combined uncertainty (±12.17%) of the activity data and emission factor from manure management are estimated.

Figure 5.11: *Probability distribution function for the category 3.B.2 (x-axis in Gg of N_2O)*



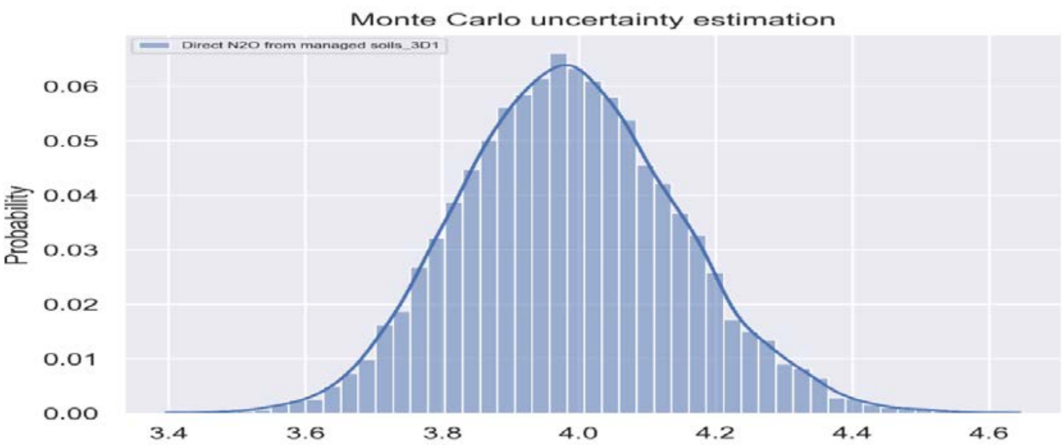
Direct N_2O Emissions from Managed Soils (CRF 3.D.1): Results of the Monte Carlo simulation for N_2O emissions in the category 3.D.1 – Direct N_2O Emissions from Managed Soils were 3.986 Gg od N_2O (3.73 Gg of N_2O were estimated in inventory) with uncertainty (-7.90%, +7.90%), which represent 95% confidence interval in 2020. A probability distribution function for category 3.D.1 is shown on ***Figure 5.12***. In this uncertainty simulation, symmetric confidence intervals is parametrized by Gaussian normal probability density function.

The overall uncertainty of N_2O emissions from agricultural soils was estimated based on information of nitrogen inputs into the soils, used emission factors and their uncertainties (***Table 5.32)***. During the preparation of overall uncertainty, the lack of information on the uncertainty of activity data was identified by the ŠÚ SR and UKSÚP. The uncertainty analysis was performed by the coefficient of variation. Information on animal waste management systems and number of livestock were taken into consideration in emission estimation and uncertainties. The resulted uncertainty for activity data for category 3.D is ±9.50% and the uncertainty in the emission factor is ±6.34%.

Table 5.32: *Uncertainties of activity data in 3.D - Agricultural Soils*

N_2O DIRECT/INDIRECT EMISSION FROM MANAGED SOILS	*UNITS*	UNCERTAINTIES
Animal Manure Applied to Soils	%	±39.32
Urine and Dung deposited by grazing animals	%	±5.27
Crop residues	%	±88.55
Mineralization or Immobilization Associated with Loss or Gain of Soil Organic Matter	%	±92.44
Inorganic N Fertilizers	%	±91.51
Atmospheric Deposition	%	±131.40
Nitrogen Leaching and Run-off	%	±109.50

Figure 5.12: *Probability distribution function for 3.D.1 (x-axis in Gg of N_2O)*

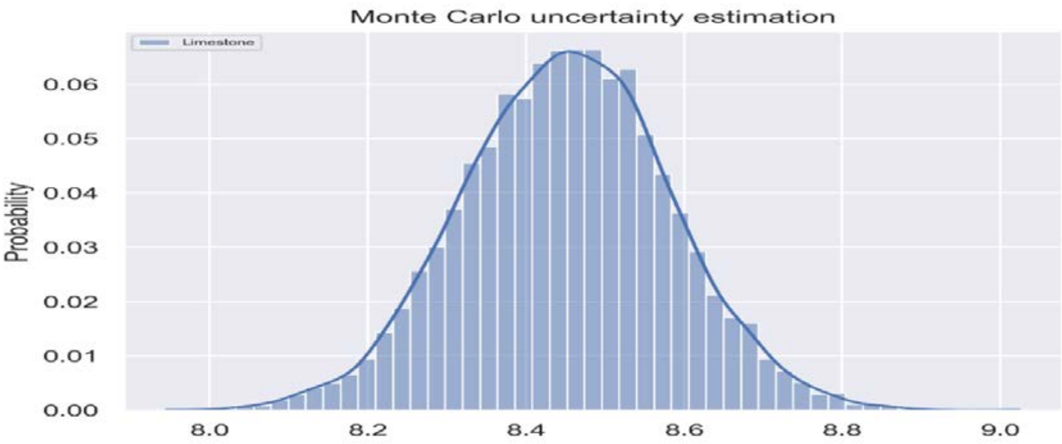


Indirect N_2O Emissions from managed soils (CRF 3.D.2): Results of the Monte Carlo simulation for N_2O emissions in the category 3.D.2 – Indirect N_2O Emissions from Managed Soils were calculated on the value 0.48 Gg of N_2O (0.64 Gg of N_2O were estimated in inventory) with uncertainty (-103.3%, + 103.3%), which represent 95% confidence interval in 2020.

The uncertainty in 3.D.2.1 category of indirect N_2O emissions was estimated based on partial uncertainties in emission factors. These uncertainties were combined with the uncertainties in the $Frac_{GASF}$ (0.03-0.3) and $Frac_{GASM}$ (0.05-0.5). Uncertainties of emission factors in indirect N_2O emissions from soils were calculated at a level of ±133.24%, which represent 95% confidence interval.

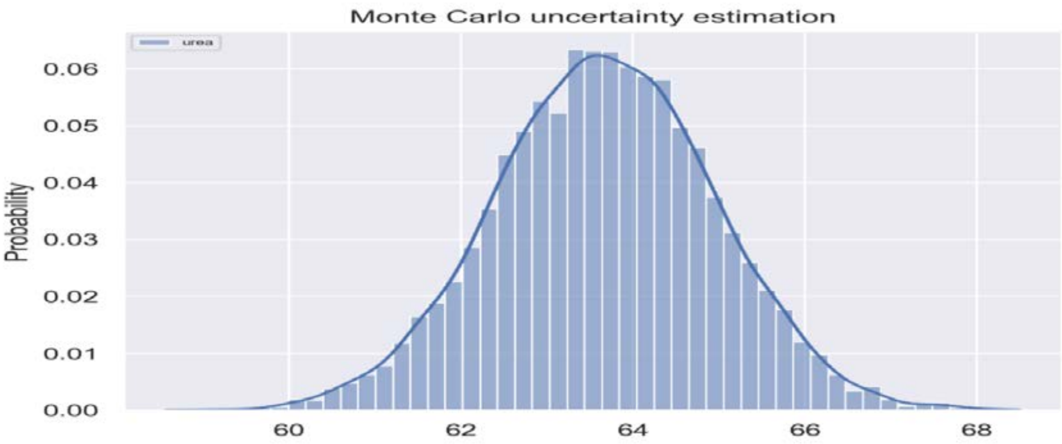
Liming (3.G): Results of the Monte Carlo simulation for CO_2 emissions in the category 3.G – Liming were 8.45 Gg of CO_2 (8.45 Gg of CO_2 were estimated in inventory) with uncertainty (-3.04%, +3.04%), which represent 95% confidence interval in 2020. A probability distribution function for the category 3.G is shown on ***Figure 5.13***. In this uncertainty simulation, symmetric confidence intervals is parametrized by Gaussian normal probability density function.

Figure 5.13: *Probability distribution function for the category 3.G (x-axis in Gg of CO_2)*



Urea Application (3.H): Results of the Monte Carlo simulation for CO_2 emissions in the category 3.H – Urea Application were calculated on the value 63.67 Gg od CO_2 (63.63 Gg of CO_2 were estimated in inventory) with uncertainty (--3.93%, +3.93%), which represent 95% confidence interval in 2020. A probability distribution function for category 3.H is shown on ***Figure 5.14***. In this uncertainty simulation, symmetric confidence intervals is parametrized by Gaussian normal probability density function.

Figure 5.14: *Probability distribution function for the category 3.H (x-axis in Gg of CO_2)*



Agriculture sector: Preliminary summary results of calculated uncertainties across categories in the sector are provided in the following table:

Table 5.33: *Uncertainties of activity data, emission factors and emissions for key and particularly significant categories in agriculture identified by Monte Carlo approach*

3 AGRICULTURE	GHG	UNCERTAINTY OF ACTIVITY DATA	UNCERTAINTY OF EMISSION FACTOR	UNCERTAINTY OF EMISSIONS
3.A Enteric Fermentation	CH_4	±13.10%	±14.91%	±19.85%
3.B.1 Manure Management	CH_4	±6.50%	±9.41%	±11.43%
3.B.2 Manure Management	N_2O	±6.50%	±248.03%	±248.11%
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	±59.3%7	±36.22%	±69.54%
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	±77.10%	±103.30%	±128.90%
3.G Liming	CO_2	±3.04%	±50.00%	±50.09%
3.H Urea Application	CO_2	±3.93%	±50.00%	±50.15%

5.7. Enteric Fermentation (CRF 3.A)

EMITTED GAS: CH_4

METHODS: tier 1 and tier 2

EMISSIONS FACTORS: D, CS

KEY SOURCES: yes

SIGNIFICANT SUBCATEGORIES: Cattle

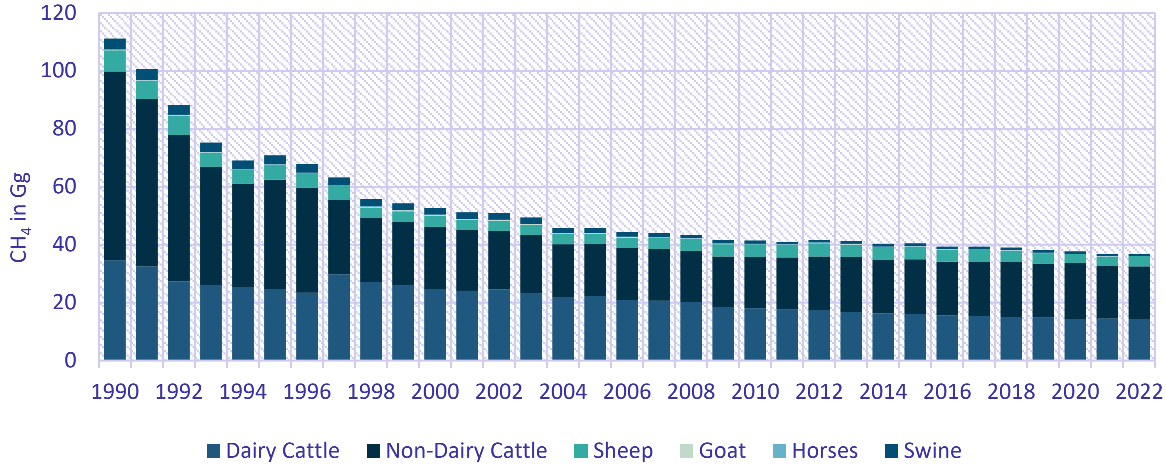
The cattle is the most important producer of methane due to its digestive tract, weight and a relatively high number compared to other population of livestock in the Slovak Republic. Therefore, the trends in total CH_4 emissions reflect a number of animals and milk yield in this category. The number of dairy cattle further decreased in 2022 in comparison with 2021 (-1.4%), non-dairy cattle increased in 2022 in comparison with 2021 (+0.5%). Except for the population of domestic livestock, the amount of emitted methane is influenced by other parameters like age or weight of animals, amount of food and its quality and the consumption of energy for basal metabolisms, milk production per day and fat content, the average amount of work performed, wool growth and feed digestibility.

Methane emissions from enteric fermentation have the major share on GHG emissions in agriculture. The cattle represent nearly 88% of these emissions; from those dairy cattle represent 39% share. Other categories of domestic livestock provide less than 11% of emissions. Intensification of animal husbandry also increased methane emissions. Methane emissions from enteric fermentation of dairy and non-dairy cattle are key categories according to level and trend assessment for the base year and 2022. Total methane emissions from enteric fermentation decreased from 111.14 Gg in 1990 to 36.75 Gg in 2022 (-67%) and increase by nearly 0.11% compared to the previous year. More information is available in ***Table 5.34*** and on ***Figure 5.15***.

Table 5.34: *Methane emissions from enteric fermentation according to livestock in particular years*

YEAR	DAIRY CATTLE	NON-DAIRY CATTLE	SHEEP	GOAT	HORSES	SWINE
	CH_4 in Gg					
1990	34.548	65.246	7.272	0.052	0.245	3.781
1995	24.779	37.623	5.030	0.125	0.182	3.115
2000	24.676	21.454	3.787	0.257	0.171	2.233
2005	22.166	18.011	3.559	0.198	0.150	1.662
2010	18.060	17.653	4.357	0.176	0.128	1.031
2011	17.714	17.829	4.329	0.170	0.125	0.871
2012	17.466	18.452	4.521	0.174	0.130	0.947
2013	16.788	18.858	4.406	0.177	0.129	0.956
2014	16.254	18.488	4.326	0.176	0.123	0.963
2015	15.979	18.903	4.316	0.182	0.124	0.950
2016	15.610	18.489	4.066	0.182	0.115	0.879
2017	15.363	18.709	3.997	0.185	0.111	0.922
2018	15.041	18.837	3.901	0.185	0.128	0.941
2019	14.958	18.477	3.532	0.178	0.125	0.884
2020	14.343	19.377	2.943	0.053	0.110	0.807
2021	14.481	18.125	3.245	0.052	0.121	0.680
2022	14.277	18.207	3.510	0.055	0.127	0.571

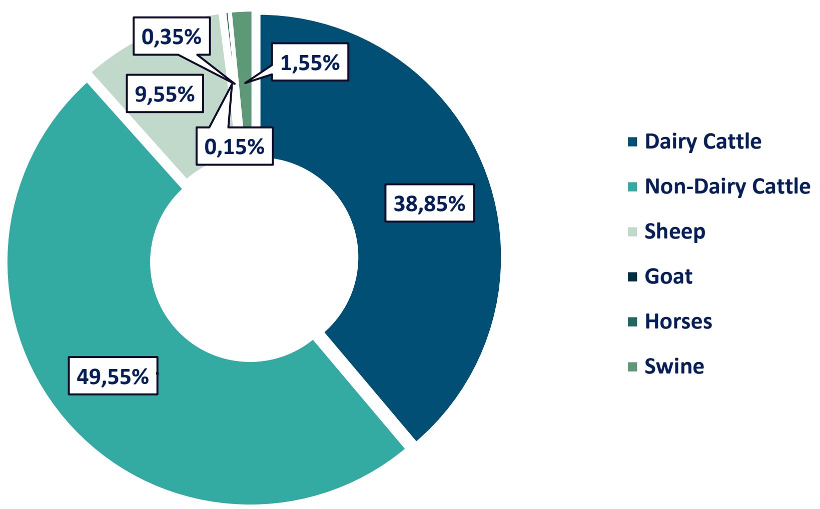
Figure 5.15: *Trend in methane emissions (Gg) by animals in enteric fermentation in 1990 – 2022*



Methane emissions from dairy and non-dairy cattle represent the significant share of emissions in enteric fermentation (39% and 50%). 10% belongs to sheep methane emissions. These animals are significant in this category and were estimated by tier 2 approach. Other animal categories were determined by tier 1 approach. The share of emissions in animal categories in enteric fermentation is on ***Figure 5.16***.

The trend of methane emissions from enteric fermentation correlates with the number of livestock, especially the key categories, where tier 2 approach was implemented. The correlations between important parameters (milk yield, weight gain, percentage digestibility of feed ratio) in the particular years were verified. In 1995, the number of animals increased in the two key categories: sheep (+7.5%) and other cattle (+3.5%). Emissions increased at a comparable rate. A similar situation is visible in 2012, where the number of non-dairy cattle increased by 2% and sheep by 4%. A completely different situation is visible in the partial year 2015, where the increase is mainly due to increases in the number of goats (+3%), and horses (+0.6%). The development of number of livestock had a significant impact on reducing emissions in this sector since 1990.

Figure 5.16: *The share of aggregated emissions by categories within enteric fermentation in 2022*



5.7.1. Methodological Issues – Methods

The cooperation with the NPPC-VÚŽV continues. Changes and improvements are entirely in accordance with tier 2 for key categories of animal categories (cattle and sheep). For other non-key categories of animals (goats, horses, and swine), tier 1 was used (***Table 5.42***). The overview is provided in

Tables 5.35-5.42. Used methodology is based on detailed national data about animals' number (more advanced livestock characteristics and better structured number of livestock). Data on animal numbers were provided by the ŠÚ SR.

The regional input data about feeding, weight, milk production, and wool production were provided by the ŠÚ SR. Other parameters for dairy cattle, non-dairy cattle and sheep categories (significant animal categories in Slovakia) were provided by the NPPC-VÚŽV.

Cattle – due to increase of transparency in methodology and used activity data, emissions estimation was completed by the parameters for average animal weight (597.75 kg), share of pregnancy (68.96%) and share of digestibility of feed (72.74%). Typical feeding for cattle is maize and alfalfa silage, cereal, hay and pasture in the Slovak Republic.

Total methane emissions from enteric fermentation of cattle were estimated based on the detailed classification of animals into the following categories: dairy cattle, high producing dairy cows in the 3.A.1.1 sub-category and other non-dairy cattle in the 3.A.1.2 sub-category (suckler cows, calves six months, heifer, pregnancy heifer, breeding bull, oxen, fattening). Slovak country specific approach is based on the particular division of non-dairy cattle. Part of non-dairy cattle is divided into milk type and beef type. The primary differences are in different breeding conditions and feeding doses. The feeding doses of the beef non-dairy cattle is mostly pasture and hay. Cereal and silage are added mainly into the feeding ration in milk type of non-dairy cattle. Different feeding rations are desirable during muscle mass formation (beef non-dairy cattle need to have higher daily muscle mass gain than milk type of non-dairy cattle). Milk type of non-dairy cattle is bred similarly as dairy cows. On the contrary, beef cattle is bred principally as slaughter. The country specific EFs for dairy and non-dairy cattle are estimated as weighted average of regions based AGEI and other parameters specific for each category.

Table 5.35: *The overview of used country specific parameters for dairy cattle and suckler cows in 2022*

PARAMETER*	UNIT	DAIRY COWS	SUCKLER COWS	SOURCES OF PARAMETERS**
Body weight	*kg*	597.75	595.02	NPPC-VÚŽV
Milk yield	*l/day*	22.18	4.49	Parameter from the ŠÚ SR
Milk yield	*kg/day*	22.86	4.63	Calculated parameter
Fat milk	*%*	3.87	4.00	Parameter from the ŠÚ SR
DE	*%*	72.74	64.83	Calculated parameter – based on feeding statistics
Ym	*%*	6.10	7.00	Default value from IPCC 2019 RF
Maintenance NEm	*MJ/day*	45.51	42.10	Calculated parameter eq. 10.3 (IPCC 2019 RF)
Activity NEa	*MJ/day*	0.95	8.30	Calculated parameter eq. 10.4 (IPCC 2019 RF)
Lactation N_l	*MJ/day*	69.08	14.22	Calculated parameter eq. 10.8 (IPCC 2019 RF)
Pregnancy NEp	*MJ/day*	3.14	3.47	Calculated parameter eq. 10.13 (IPCC 2019 RF)
Ratio of net energy REM		0.54	0.51	Calculated parameter eq. 10.14 (IPCC 2019 RF)
Ratio of net energy REG		0.34	0.31	Calculated parameter eq. 10.15 (IPCC 2019 RF)
Gross energy	*MJ/head/day*	304.04	204.62	Calculated parameter eq. 10.16 (IPCC 2019 RF)
EFs	*kg/head/year*	122.12	93.95	Calculated parameter eq.10.21 (IPCC 2019 RF)

Table 5.36: *The overview of used country specific parameters for non-dairy cattle milk type in 2022*

PARAMETER*	UNIT	CALVES 6 MONTHS	HEIFER	HEIFER PREGNANT	FATTENING	OXEN	BREEDING BULL
Body weight	*kg*	115.53	296.65	502.02	351.34	333.40	800.00
Daily gain	*kg*	0.84	0.67	0.68	0.78	0.62	-
DE	*%*	81.43	70.33	70.83	72.36	72.09	68.80

PARAMETER*	UNIT	CALVES 6 MONTHS	HEIFER	HEIFER PREGNANT	FATTENING	OXEN	BREEDING BULL
Ym	%	3.20	6.30	6.30	6.30	6.30	6.30
Maintenance NE_m	*MJ/day*	11.35	23.01	34.14	30.02	28.87	55.66
Activity NE_a	*MJ/day*	-	1.47	0.92	-	-	-
Growth NE_g	*MJ/day*	12.47	13.33	14.85	10.97	8.74	-
NE_p	*MJ/day*	-	-	3.41	-	-	-
REM		0.55	0.53	0.53	0.53	0.53	0.53
REG		0.37	0.33	0.34	0.34	0.34	0.33
Gross energy	*MJ/head/day*	66.50	122.50	164.72	121.82	110.55	153.92
EFs	*kg/head/year*	13.74	50.62	68.07	50.34	45.68	63.60

Table 5.37: *The overview of used country specific parameters for non-dairy cattle beef type in 2022*

PARAMETER*	UNIT	CALVES 6 MONTHS	HEIFER	HEIFER PREGNANT	FATTENING	OXEN	BREEDING BULL
Body weight	*kg*	127.01	373.70	601.63	349.80	347.37	800.00
Daily gain	*kg*	0.92	0.50	0.50	0.74	0.64	-
DE	*%*	76.29	65.60	64.49	65.94	64.86	68.80
Ym	*%*	3.20	7.00	7.00	6.30	6.30	6.30
Maintenance NE_m	*MJ/day*	12.18	27.36	39.11	29.92	29.77	55.66
Activity NE_a	*MJ/day*	1.39	5.40	7.71	-	-	4.94
Growth NE_g	*MJ/day*	13.55	9.32	11.20	10.71	9.41	-
NE_p	*MJ/day*	-	-	3.22	-	-	-
REM		0.54	0.52	0.51	0.52	0.51	0.53
REG		0.36	0.31	0.31	0.31	0.31	0.33
Gross energy	*MJ/head/day*	82.58	142.42	208.37	139.57	136.49	167.58
EFs	*kg/head/year*	18.38	65.39	95.67	57.67	56.40	69.25

**weighted average **sources of parameters are the same for dairy and non-dairy cattle*

Average weight of cattle was calculated based on breed structure in the Slovak Republic. Breed structure of cattle is divided on the heavy (Slovak spoken, Holsteins, Braunvieh) and light breed (Pinzgauer and others). Average weight of heavy breed is 600 kg and average body weight of light breed is 500 kg. Different annual share of breed in cattle herd caused differences of body weight. Data about breed structure was taken from the PLIS – Information System about Breeds.

Milk production is taken from the Statistical Yearbook. Digestibility of feed (DE) is calculated as a weighted average of calculated values from the feed ration and provided by the NPPC-VÚŽV. The methane conversion factor is in line with the default values provided in the IPCC 2019 RF. Gross energy is the sum of energies calculated by formulas referred to the IPCC 2019 RF with using typical national breed conditions. National emission factors were calculated by this approach for cattle (dairy and non-dairy).

Following formula was used for EFs calculation: $\mathbf{EF} = \frac{GE*\left(\frac{Ym}{100}\right)*365}{55.65}$

Where: **EF** = emission factor in kg CH_4/head, **GE** = gross energy intake in MJ/head/day, $\mathbf{Y_m}$ = methane conversion factor in percent of gross energy in feed converted to methane, **factor 55.65** = the energy content of methane in MJ/kg CH_4.

Table 5.38: *Activity data, EFs and methane emissions for dairy cattle in particular years*

YEAR	POPULATION	MILK YIELD	AGEI	EFs	CH_4 EMISSIONS
	1 000 heads	*kg/day*	*MJ/head/day*	*kg/head*	*Gg*
1990	401.12	6.96	199.83	86.13	34.55
1995	262.66	8.83	218.87	94.34	24.78
2000	242.50	12.24	237.35	101.76	24.68
2005	198.58	15.18	260.90	111.62	22.17

YEAR	POPULATION	MILK YIELD	AGEI	EFs	CH_4 EMISSIONS
	1 000 heads	*kg/day*	*MJ/head/day*	*kg/head*	*Gg*
2010	159.26	15.62	265.09	113.40	18.06
2011	154.11	16.35	268.79	114.95	17.71
2012	150.27	17.22	276.58	116.23	17.47
2013	144.88	17.34	274.69	115.88	16.79
2014	143.08	17.74	270.93	113.60	16.25
2015	139.23	17.85	271.47	114.77	15.98
2016	132.61	19.41	283.01	117.72	15.61
2017	129.86	19.56	283.27	118.30	15.36
2018	127.87	19.89	283.86	117.63	15.04
2019	125.85	20.22	287.56	118.86	14.96
2020	122.05	20.36	287.56	117.52	14.34
2021	120.07	22.02	300.45	120.61	14.48
2022	116.91	22.86	304.04	122.12	14.28

Table 5.39: *Activity data, EFs and methane emissions for non-dairy cattle in particular years*

YEAR	POPULATION	AGEI	EFs	CH_4 EMISSIONS
	1 000 heads	*MJ/head/day*	*kg/head*	*Gg*
1990	1161.95	135.73	56.15	65.25
1995	666.04	136.31	56.49	37.62
2000	403.65	130.63	53.15	21.45
2005	329.31	133.98	54.69	18.01
2010	307.87	139.99	57.34	17.65
2011	309.25	140.51	57.65	17.83
2012	320.82	142.88	57.52	18.45
2013	322.95	144.38	58.39	18.86
2014	322.46	135.85	57.33	18.49
2015	318.36	147.63	59.38	18.90
2016	313.50	146.92	58.97	18.49
2017	309.96	147.73	60.36	18.71
2018	310.98	148.16	60.57	18.84
2019	306.41	146.28	60.30	18.48
2020	320.24	146.67	60.51	19.38
2021	314.02	141.88	57.72	18.13
2022	316.27	141.50	57.57	18.21

Sheep – total methane emissions from enteric fermentation of sheep were estimated based on the detailed classification of animals into two categories: milk sheep (ewes, ewe lambs, mated yearlings, rams) and beef sheep (ewes, ewe lambs, mated yearlings, rams). The emission factors are calculated as a weighted average from these four categories based on gross energy intake (milk productivity, wool productivity, average methane conversion rate) and other country specific information. Presented calculation approach and parameters were published.[1]

[1] Differences in amounts of methane emissions from enteric fermentation from Slovak ewe farming between 2015 and 2016

Table 5.40: *The overview of used country specific parameters for sheep in 2022*

PARAMETER*	UNIT	DAIRY SHEEP				BEEFSHEEP			
		A	B	C	D	E	F	G	H
Body weight	kg	60.00	32.50	55.00	80.00	70.00	47.50	65.00	90.00
Milk yield	l/day	0.46	-	-	-	0.266	-	-	-
Milk yield	kg/day	0.47	-	-	-	0.274	-	-	-
DE of feed	%	65.04	65.04	65.04	65.04	65.48	65.48	65.48	65.48
Ym	%	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50
Maintenance NE_m	*MJ/day*	4.68	3.13	4.38	6.68	5.25	4.16	4.97	7.29
Activity NE_a	*MJ/day*	1.01	0.33	0.93	0.77	1.21	0.48	1.14	0.86
Lactation N_{El}	*MJ/day*	2.17	-	-	-	1.26	-	-	-
Wool production Ne_{wool}	*MJ/day*	0.12	-	0.12	0.12	0.12	-	0.12	0.12
Growth NE_g	*MJ/day*	-	1.20	1.79	-	-	1.64	2.09	-
Pregnancy NEp	*MJ/day*	0.44	-	0.31	-	0.49	-	0.47	-
REM		0.51	0.51	0.51	0.51	0.52	0.52	0.52	0.52
REG		0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
Gross energy	*MJ/head/day*	25.45	16.32	26.47	22.87	24.93	21.81	30.32	24.77
EFs	*kg/head/year*	10.85	6.96	11.28	9.75	10.63	9.30	12.93	10.56

*A: Mature ewes, B: Growing lambs, C: Growing lambs pregnant, D: Other mature sheep, E: Mature ewes, F: Growing lambs, G: Growing lambs pregnant, H: Other mature sheep, *weighted average*

Activity data for sheep is available in individual categories (mature ewes, growing lambs and other mature sheep) on regional level provided by the ŠÚ SR for 1990 – 2022. Data were provided including the input parameters (the wool production and the amount of milk for categories ewes). Milk production is taken from the Statistical Yearbook. Digestibility of feed (DE) is calculated as a weighted average of calculated values from the feed ration and provided by the NPPC-VÚŽV. Emission factors for sheep were estimated based on milk production, wool production, and average gross energy intake. These parameters are country specific. Methane emissions from enteric fermentation of mature sheep reflect milk production for the period 1997 – 2022. The extrapolation (linear function) was used for reconstruction of milk production at regional level back to the base year. The net energy required for pregnancy (NEp) was calculated according to the Equation 10.13 p.10.28 of the IPCC 2019 RF. Pregnancy coefficient (Cp) for mature ewes and pregnant growing lambs was taken from Table 10.7 of the IPCC 2019 RF. Values reported in 2022 were 100% in pregnant growing lambs and 95.7% in mature ewes.

Table 5.41: *Activity data, EFs and methane emissions for sheep in particular years*

YEAR	POPULATION	AGEI	EFs	CH_4 EMISSIONS
	1 000 heads	*MJ/head/day*	*kg/head*	*Gg*
1990	600.43	28.41	12.10	7.27
1995	427.84	27.57	11.75	5.03
2000	347.98	25.52	10.87	3.79
2005	320.49	26.05	11.09	3.56
2010	394.18	25.92	11.04	4.36
2011	393.93	25.78	10.97	4.33
2012	409.57	25.89	11.02	4.52
2013	399.91	25.84	11.00	4.41
2014	391.15	25.94	11.04	4.33
2015	381.72	25.95	11.32	4.32
2016	368.90	25.85	11.00	4.07
2017	365.34	25.66	10.92	4.00
2018	351.12	26.06	11.09	3.90

YEAR	POPULATION	AGEI	EFs	CH_4 EMISSIONS
	1 000 heads	*MJ/head/day*	*kg/head*	*Gg*
2019	320.56	25.84	11.00	3.53
2020	294.25	26.05	11.09	2.94
2021	290.92	26.17	11.14	3.25
2022	301.13	27.34	10.26	3.51

Goats, horses, and swine – emission factors for goats, horses and swine in enteric fermentation are default (IPCC 2019 RF) constantly used for whole time series. EF for goats is 5 kg/head/year (low productivity system, EF for horses is 18 kg/head/year and EF for swine is 1.5 kg/head/year (High productivity system) (***Table 5.42***). According to our long term improvements plans, tier 2 approach in the swine category will be developed in future submissions. Implementation of tier 2 approach for swine is not processed due to lack of reliable data on methane conversion factor (YM). Other categories are insignificant sources of emissions.

Table 5.42: *Activity data, EFs and methane emissions for other animals in particular years*

YEAR	GOATS			HORSES			SWINE		
	HEADS	EFs	CH_4	HEADS	EFs	CH_4	HEADS	EFs	CH_4
	1 000	*kg/head*	*Gg*	*1 000*	*kg/head*	*Gg*	*1 000*	*kg/head*	*Gg*
1990	10.322	5.000	0.052	13.595	18.000	0.245	2520.524	1.500	3.781
1995	25.046	5.000	0.125	10.109	18.000	0.182	2076.439	1.500	3.115
2000	51.419	5.000	0.257	9.516	18.000	0.171	1488.441	1.500	2.233
2005	39.566	5.000	0.198	8.328	18.000	0.150	1108.265	1.500	1.662
2010	35.292	5.000	0.176	7.111	18.000	0.128	687.260	1.500	1.031
2011	34.053	5.000	0.170	6.937	18.000	0.125	580.393	1.500	0.871
2012	34.823	5.000	0.174	7.249	18.000	0.130	631.464	1.500	0.947
2013	35.457	5.000	0.177	7.161	18.000	0.129	637.167	1.500	0.956
2014	35.178	5.000	0.176	6.828	18.000	0.123	641.827	1.500	0.963
2015	36.324	5.000	0.182	6.866	18.000	0.124	633.116	1.500	0.950
2016	36.355	5.000	0.182	6.407	18.000	0.115	585.843	1.500	0.879
2017	37.067	5.000	0.185	6.145	18.000	0.111	614.384	1.500	0.922
2018	36.907	5.000	0.185	7.102	18.000	0.128	627.022	1.500	0.941
2019	35.594	5.000	0.178	6.960	18.000	0.125	589.228	1.500	0.884
2020	10.589	5.000	0.053	6.099	18.000	0.110	538.310	1.500	0.807
2021	10.434	5.000	0.052	6.738	18.000	0.121	453.076	1.500	0.680
2022	11.008	5.000	0.055	7.044	18.000	0.127	380.895	1.500	0.571

5.7.2. Activity Data

Primary data sources used for the emissions evaluations were published in the Census of Sowing Areas of Field Crops in the Slovak Republic, the Annual Census of Domestic Livestock in the Slovak Republic, the Statistical Yearbooks 1990 – 2022 and the research results from projects and studies provided by several organizations inside the NPPC-VÚŽV.

Activity data for dairy, non-dairy cattle, sheep and swine are based on bottom-up statistical information at the regional level. The used input parameters were calculated as weighted averages. The ŠÚ SR provides annual livestock numbers at a detailed regional level in Livestock Census annually on 31st December.

Due to a different regionalisation of Slovakia in years 1990 – 1996 (only three regions: Západoslovenský, Stredoslovenský, and Východoslovenský), it was not possible to use time series immediately. The reallocation of older data into new regions (8 districts after 1997) was necessary. Reallocation was based on the following assumptions:

Západoslovenský region (1990 – 1996) is equal to Bratislavský, Nitriansky, Trnavský, Trenčiansky regions (1997 – present);

- Stredoslovenský region (1990 – 1996) is similar to Banskobystrický and Žilinský regions (1997 – present);
- Východoslovenský region (1990 – 1996) is similar to Prešovský and Košický regions (1997 – present).

A reallocation was prepared by using the linear extrapolation tools to reach statistical totals as reported by the ŠÚ SR and time series was extrapolated back to the base year. The ŠÚ SR and the SHMÚ use a standard statistical approach for data extrapolations. Good statistical practice is described in the EUROSTAT Guidance[2]. After 2017 submission, extrapolated number of swine was reported. The SHMÚ filled the data gap by using a standard statistical approach for extrapolation (linear extrapolation in spreadsheets). In 2017 submission, the ŠÚ SR provided complete time-series of official data, which is consistent with the EUROSTAT and the FAOSTAT (**Chapter 5.3.1**). In addition, time series 1997 – 2020 of the milk production, wool production and daily gain for cattle and sheep at regional level was provided by the ŠÚ SR in 2016. Activity data used for methane emissions estimation is summarized in ***Table 5.43***. Detailed statistical information is available at the regional level and emissions are estimated by bottom-up method (tier 2). The NPPC-VÚŽV implemented the results of a questionnaire farm survey where a better classification and disaggregation of cattle categories were used. Based on survey data, cattle were divided into dairy and non-dairy. Dairy cattle are estimated separately from non-dairy cattle. Dairy cattle are defined as cows that produce milk only for human consumption (highly productive cows). Suckler cows are defined as cows that are farmed for nutrition of calves (low productive cows). Suckler cows are included in non-dairy cattle category. In addition, non-dairy cattle includes breeding bull, oxen, calves, heifer pregnant, un-pregnant heifers and fattening bulls. This categorization is consistent in whole time series. The number of livestock decreased compared to the previous year in all species. The highest declines were recorded in the swine category (-82%) compared to 1990. The main reason for this decrease is the data gap on self-sufficiency - small household's farmers and morbidity of animals. The same reason was the cause of the decline of poultry (-19%) and horses (-12%).

Between 2005 and 2022, the production of most agricultural crops showed a declining trend. The decrease was recorded for tobacco by -99%, for beans by -88%, for beans -83%, for potato by -70% and rye by 63%. On the contrary, the production of meadows increased by +27.8% and oil plants by +37% , wheat by 10%, soya, leguminous plant and clover during the given period.

Since 2005, livestock numbers have decreased for all farmed species. Between 2005 and 2022, the number of dairy cattle decreased by -41%, pigs by -66%, poultry by -34% and sheep by -6%.

[2] EUROSTAT: European Statistics code of practice, 2011, ISBN 978-92-79-21679-4 – doi:10.2785/18474: https://ec.europa.eu/eurostat/documents/3859598/5921861/KS-32-11-955-EN.PDF/5fa1ebc6-90bb-43fa-888f-dde032471e15

Table 5.43: Animal population (heads) according to categories at regional level for the year 2022

REGION		A	B	C	D	E	F	G	H
DAIRY CATTLE		4 755	18 934	13 963	18 111	20 588	15 165	17 539	7 855
NON-DAIRY CATTLE	Suckling cows	1 574	2 083	4 320	1 666	9 158	18 620	23 467	12 299
	Calves in 6 month (milk sort)	1 564	10 236	6 017	8 048	7 161	5 354	5 879	2 751
	Heifer (milk sort)	1 187	5 577	4 641	6 732	7 184	5 515	6 589	2 385
	Heifer (pregnant) (milk sort)	1 530	4 427	3 359	6 502	5 140	3 255	3 726	1 418
	Fattening (milk sort)	452	9 640	4 000	7 442	4 362	3 888	3 213	2 214
	Oxen (milk sort)	1	1	8	13	264	54	9	4
	Breeding bull (milk sort)	22	114	93	197	461	305	477	213
	Calves in 6 month (beef sort)	518	1 126	1 862	740	3 186	6 574	7 865	4 307
	Heifer (beef sort)	393	613	1 436	619	3 196	6 772	8 817	3 735
	Heifer (pregnant) (beef sort)	507	487	1039	598	2 287	3 996	4 985	2 219
	Fattening (beef sort)	149	1061	1 238	685	1 940	4 773	4 300	3 466
	Oxen (beef sort)	0	0	2	1	118	66	11	5
	Breeding bull (beef sort)	45	227	187	393	921	611	953	425
SHEEP	Mature ewes	1 673	1 713	21 134	6 163	52 643	61 903	39 856	17 594
	Growing lambs	611	502	6 299	1 802	16 758	17 963	12 345	4 666
	Growing lambs (pregnant)	411	96	3 962	1 021	8 307	9 834	5 871	2 144
	Other mature sheep	52	45	628	180	1 524	1 794	1 143	494
SWINE	Breeding swine	4 529	21 778	4 815	6 214	122	1 937	420	1 462
	Fattening swine	14 945	145 563	31 112	120 995	1809	9 398	8 261	7 535
HORSES	Horses (0-1 year)	67	16	40	99	19	59	39	45
	Horses (1-3 year)	167	74	132	213	117	96	81	142
	Stallions	36	45	149	127	87	56	43	32
	Mares	398	196	339	454	421	618	478	420
	Castrated stallions	177	100	259	169	284	371	206	173
GOATS	Mature goats	260	245	697	327	1 777	1 619	1 422	1 228
	Growing goats (pregnant)	6	6	18	38	449	88	199	45
	Other mature goats	117	92	182	206	248	572	588	579
POULTRY	Laying hens and roosters	655 763	69 742	245 976	1 313 450	376 957	466 492	27 508	166 447
	Breeding broilers	0	69 260	72 447	32 778	69 575	136 230	2	125 553
	Fattening broilers	46 063	312 347	1 039 447	1 155 754	588 893	1 782 985	2 220	405 207

REGION		A	B	C	D	E	F	G	H
	Turkeys	0	5 744	263	119 411	37 722	18	7	80
	Ducks	0	14 517	9	536	50	360	48	15
	Geese	16	290	9	421	0	26	30	45

REGIONS: A: Bratislava, B: Trnava, C: Trenčín, D: Nitra, E: Žilina, F: Banská Bystrica, G: Prešov, H: Košice

In the breeding of cattle in Slovakia, a slight decline in the numbers of individual animal categories was recorded in the year 2022. By the end of 2022, there were 433.2 thousand head of cattle in Slovakia, which was 2.4 thousand head less compared to the previous year (-0.6%). The number of cows reached 190.1 thousand head, showing inter-annual of 2.0 thousand head (-1.1%). The declining trend in the number of milking cows continued in 2022, with their count reaching only 116.9 thousand head by the end of the year, which is 3.7 thousand head less than in 2021 (-3.2%).

The population of suckling cows increased during the year, reaching 73.2 thousand head by the end of 2022, showing a year-on-year increase of 1.7 thousand head (+2.4%). The share of suckling cows in the total number of cows increased by 1.3 percentage point's year-on-year to 38.6%. In the cattle fattening sector, there were 50.7 thousand head of cattle, an increase of 2.4 thousand head (+4.8%) compared to the previous year. The increase in the number of animals occurred in all weight categories.

Selected reproductive indicators of cattle (excluding households) slightly improved inter-annually. The number of calves born per 100 cows increased by 0.16 head, and the number of reared calves per 100 cows increased by 0.36 head. Average daily weight gains in cattle fattening increased by 0.006 kg/live weight, reaching 0.771 kg per head per day in 2022. Milk utility increased to 8,016.2 kg of milk per dairy cow per year, an increase of 234.3 kg (+3%).

Despite the inter-annual reduction in the number of dairy cows, increased utility resulted in an increase in raw cow's milk production by 8.6 thousand tons (+0.9%), reaching a production of 938.4 thousand tons in 2022. Milk producers sold a total of 867.11 thousand tons (+1.0%) of cow's milk. The volume of milk deliveries amounted to 823.94 thousand tons (-0.03%), and direct sales were 43.17 thousand tons (+26.1%).

In the year 2022, the decline in the number of pigs being raised in Slovakia moderated. The total number of pigs reached 380.9 thousand head, showing inter-annual decrease of 69.3 thousand head (-16.0%). The number of breeding sows decreased by 3.1 thousand head (-11.6%) to reach 24.0 thousand head. The number of pigs in fattening and pre-fattening was lower by 59.1 thousand head (-15.5%) compared to the previous year. The highest number of pigs in fattening was recorded in the second quarter. The inter-annual increase in the number of pigs was observed only in the category of 50 – 80 kg in the second quarter and in the category above 100 kg in the third quarter.

Productivity showed a slight year-on-year increase. With a reduced number of litters per sow, the number of piglets born per sow slightly decreased (-0.07 piglet), while the number of piglets born per litter increased compared to the previous year. Piglet mortality slightly increased (+2.2%). Productivity in average daily weight gains in the fattening and pre-fattening of pigs increased, with average daily weight gains reaching 0.636 kg per live weight, which was 0.011 kg (+1.8%) more than in 2021.

The total number of poultry reached 9 340.7 thousand heads, representing a decrease of 9.9% compared to end of the year 2021. Among them, the number of hens reached 3 257.4 thousand heads, showing an inter-annual increase of 5.2%. The proportion of hens in the total poultry population increased to 34.9% (+5%). The number of roosters increased by 17 662 heads (+12.1%), while the number of chicks decreased by 1 201.4 thousand heads (-17.1%). The number of geese increased by 107 heads (+14.7%), whereas the number of ducks decreased by 359 heads (-2.3%) compared to the previous year.

Sheep farming in Slovakia has shown a positive trend year-on-year. By the end of the year 2022, there were 301.1 thousand heads of sheep, which was an increase of 6.1 thousand heads (+2.3%) compared to the previous year. The number of ewes increased by 1.1 thousand heads (+0.6%) to reach 202.7 thousand heads.

Fertility indicators for ewes improved inter-annually. The number of lambs born (79.9 per 100 ewes) and raised (74.6 per 100 ewes) increased. The average wool shearing per sheep per year reached 1.84 kg (+2.6%).

5.8. Manure Management (CRF 3.B.1) – CH_4 Emissions

EMITTED GAS: CH_4

METHODS: tier 1 and tier 2

EMISSION FACTORS: CS

KEY SOURCES: yes

PARTICULAR SIGNIFICANT SUBCATEGORIES: cattle and swine

Methane can also be emitted in anaerobic conditions due to the decomposition of manure. These conditions can be found in large-scale farms (farms for cattle, fattening pigs and poultry). Methane emissions from manure management are the emissions depending on animal husbandry and the number of animals. Methane from manure management can be better mitigated (proper storage, digesters use) compared to methane originated from enteric fermentation. Mitigation measures possible in enteric fermentation have several limitations. Therefore it can be predicted, that manure management will emit less methane emissions in the future than enteric fermentation.

Methane emissions in manure management decreased from 25.58 Gg in 1990 to 3.60 Gg in 2022 due to decrease in livestock numbers and recovery of manure and slurries in to biogas facilities. The extreme reduction of animals was recorded in swine and cattle due to economic reasons. This situation consequently influenced methane emissions from the manure management. Emissions decreased by 86% compared to the base year. However, swine is a key category by trend assessment, tier 2 category was used for this category. Methane emissions in manure management decreased in comparison with the previous year by 6.9%, caused by decreased number of swine and poultry. ***Figure 5.17*** and ***Table 5.44*** summarize the overall situation. Methane emissions produced in manure management for cattle (dairy and non-dairy), swine and sheep were estimated using tier 2 and country specific emissions factors and parameters.

This estimation was provided in line with the emissions estimation in enteric fermentation based on regional data. In the previous years, the Slovak Republic was constantly developing a new approach of methane emissions estimation from swine. The NPPC-VÚŽV prepared the new country specific parameters, which were used in implementation of tier 2. Swine are divided into two separate categories – market swine (fattening pigs) and breeding swine (sows, piglet’s hogs for breeding purpose and others).

Figure 5.17: *Trend in CH_4 emissions (Gg) by categories within manure management in 1990 – 2022*

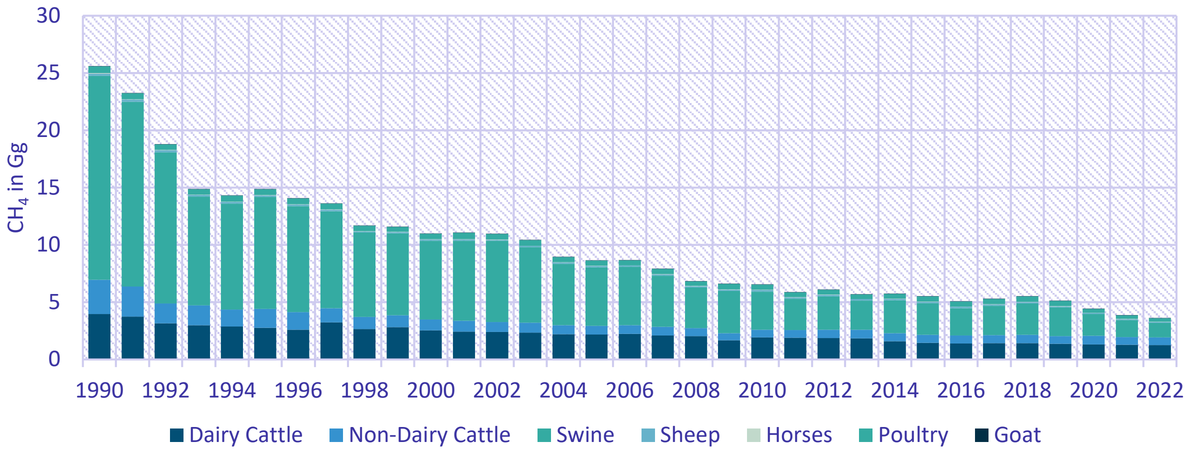


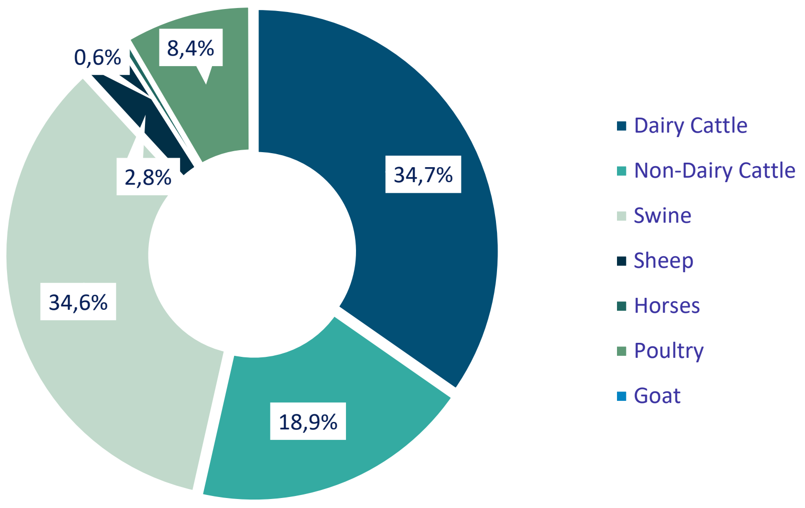
Table 5.44: *CH_4 emissions from manure management according to the animals in particular years*

YEAR	DAIRY CATTLE	NON-DAIRY CATTLE	SWINE	SHEEP	HORSES	POULTRY	GOATS
	CH_4 in Gg						
1990	3.957	3.001	17.780	0.212	0.040	0.584	0.002
1995	2.757	1.646	9.791	0.146	0.029	0.494	0.005
2000	2.542	0.955	6.865	0.111	0.028	0.462	0.010
2005	2.176	0.763	5.108	0.104	0.023	0.470	0.008
2010	1.919	0.689	3.321	0.127	0.019	0.452	0.007
2011	1.891	0.691	2.722	0.126	0.019	0.410	0.007
2012	1.867	0.731	2.914	0.132	0.020	0.425	0.007
2013	1.832	0.756	2.550	0.128	0.020	0.393	0.007
2014	1.594	0.683	2.882	0.126	0.019	0.428	0.007
2015	1.437	0.707	2.771	0.123	0.019	0.445	0.007
2016	1.398	0.692	2.386	0.119	0.018	0.429	0.007
2017	1.421	0.710	2.562	0.116	0.017	0.455	0.007
2018	1.416	0.725	2.750	0.113	0.020	0.479	0.007
2019	1.356	0.692	2.492	0.103	0.020	0.442	0.007
2020	1.324	0.731	1.922	0.095	0.017	0.332	0.002
2021	1.273	0.684	1.472	0.094	0.019	0.324	0.002
2022	1.248	0.679	1.247	0.102	0.020	0.302	0.002

Figure 5.18 shows the share of individual categories on the production of manure methane emissions. Significant share is represented by cattle (53.5%). The important animal category is also swine 34.6%.

Methane emissions are calculated by the same IPCC methodology as used enteric fermentation. Emissions estimation in 3.A and 3.B are estimated with using the common parameters. Anyway, the key category of manure management methane emissions is 3.B.1.3 Swine category with high impact on emission trend in 3.B.1 category. Goats and horses categories have not significant effects on methane level in manure management. The number declined due to the economic situation at that time.

Figure 5.18: *The share of methane emissions by animals within manure management in 2022*



5.8.1. Methodological Issues – Methods

Cattle, sheep, swine, poultry - tier 2 approach based on national data was applied for methane emissions estimation in manure management for cattle, sheep and swine categories. Country specific parameters were introduced into estimation. The national approach is based on the number of animals divided by subcategories per region, the calculation of volatile solid excretion (VS), which is calculated from the gross energy intake, digestibility of the feed, ash urinary energy and methane conversion factor (MCF), expressed as inputs to the equation for the estimation of national EFs (***Tables 5.45- 5.60***).

$$EF = (VS * 365) * \left[B_{0\,(T)} * 0.67 * \sum \frac{MCF_{S,k}}{100} * AWMS_{T,S,k}\right]$$

Where: **VS** = daily volatile solid excreted for livestock category, kg DM animal/day, **365** = annual VS production in days/year, $\mathbf{B_{o(T)}}$ = maximum methane producing capacity for manure by livestock category in m^3 CH_4/kg of VS excreted, **0.67** = conversion factor of m^3 CH_4 to kilogram CH_4, **MCF** = methane conversion factors for each manure management system S by climate region (%), **MS** = fraction of livestock category manure handled using manure management system S in climate region (cool).

The VS calculation is consistent with the equation 10.24, p 10.65 (Update) (IPCC 2019 RF).

Emission factors for cattle, swine and sheep are calculated as weighted average (region and animals). Values of maximum methane production capacity and emission factors for dairy cattle are shown in ***Table 5.52*** for non-dairy cattle in ***Tables 5.53*** and ***5.54***. Data for sheep is in ***Tables 5.55*** and ***5.56***.

Table 5.45: *Overview of country specific parameters used for cattle and sheep in 1990*

PARAMETERS	UNIT	DAIRY CATTLE	NON-DAIRY CATTLE	MATURE EWES	GROWING LAMBS	OTHER MATURE SHEEP
B_o*	*m³/kg VS*	0.24	0.18	0.19	0.19	0.19
Typical animal mass average	*kg*	589.41	330.08	64.50	53.85	84.61
Ash content	*%*	8	8	8	8	8
VS daily excretion	*kg dm/head/day*	3.59	2.51	0.57	0.72	0.62
Liquid system		26	26	NO	NO	NO
Solid storage and dry lot		2	2	2	2	2
PRP		0.47	0.47	0.47	0.47	0.47
Digesters*		NO	NO	NO	NO	NO

Table 5.46: *Overview of country specific parameters used for cattle and sheep in 2022*

PARAMETERS	**UNIT**	**DAIRY CATTLE**	**NON-DAIRY CATTLE**	**MATURE EWES**	**GROWING LAMBS**	**OTHER MATURE SHEEP**
B_o*	*m^3/kg VS*	0.24	0.18	0.19	0.19	0.19
Typical animal mass average	*kg*	598.98	353.81	63.60	44.43	83.51
Ash content	*%*	8	8	8	8	8
VS daily excretion**	*kg dm/head/day*	4.73	2.50	0.49	0.42	0.46
Liquid system		26	26	NO	NO	NO
Solid storage and dry lot		2	2	2	2	2
PRP		0.47	0.47	0.47	0.47	0.47
Digesters		1	NO	NO	NO	NO

Table 5.47: *Overview of country specific parameters used for breeding swine in 1990*

PARAMETERS	**UNIT**	**A**	**B**	**C**	**D**	**E**
B_o*	*m^3/kg VS*	0.45	0.45	0.45	0.45	0.45
Typical animal mass average	*kg*	200	85	140	145	35.5
Ash content	*%*	10	10	10	10	10
VS daily excretion**	*kg dm/head/day*	0.62	0.46	0.38	0.41	0.22
Liquid system		16	16	16	16	16
Solid storage and dry lot		2	2	2	2	2

A: Sows, B: Gilts non-pregnant, C: Gilts pregnant, D: Hogs; E: Piglets 21-50 kg

Table 5.48: *Overview of country specific parameters used for breeding swine in 2022*

PARAMETERS	**UNIT**	**A**	**B**	**C**	**D**	**E**
B_o*	*m^3/kg VS*	0.45	0.45	0.45	0.45	0.45
Typical animal mass average	*kg*	200	85	140	145	35.5
Ash content	*%*	10	10	10	10	10
VS daily excretion**	*kg dm/head/day*	0.64	0.50	0.41	0.41	0.17
Liquid system		16	16	16	16	16
Solid storage and dry lot		2	2	2	2	2
Anaerobic digesters		1	1	1	1	1

A: Sows, B: Gilts non-pregnant, C: Gilts pregnant, D: Hogs; E: Piglets 21-50 kg

Table 5.49: *Overview of country specific parameters used for market swine in 1990*

PARAMETERS	**UNIT**	**A**	**B**	**C**	**D**	**E**
B_o*	*m^3/kg VS*	0.45	0.45	0.45	0.45	0.45
Typical animal mass average	*kg*	10.60	35.50	65	95	110
Ash content	*%*	10	10	10	10	10
VS daily excretion**	*kg dm/head/day*	0.21	0.38	0.56	0.71	0.79
Liquid system		16	16	16	16	16
Solid storage and dry lot		2	2	2	2	2
Deep bedding		26	26	26	26	26

A: Fattening pigs up to 20 kg; B: Fattening pigs 21-50 kg; C: Fattening pigs 50-80 kg, D: Fattening pigs 80-110 kg; E: Fattening pigs over 110 kg

Table 5.50: *Overview of country specific parameters used for market swine in 2022*

PARAMETERS	UNIT	A	B	C	D	E
B_o*	*m³/kg VS*	0.45	0.45	0.45	0.45	0.45
Typical animal mass average	*kg*	10.60	35.50	65	95	110
Ash content	*%*	10	10	10	10	10
VS daily excretion**	*kg dm/head/day*	0.10	0.18	0.26	0.33	0.36
Liquid system		16	16	16	16	16
Solid storage and dry lot		2	2	2	2	2
Deep bedding		26	26	26	26	26
Anaerobic digesters		1	1	1	1	1

*A: Fattening pigs up to 20 kg; B: Fattening pigs 21-50 kg; C: Fattening pigs 50-80 kg, D: Fattening pigs 80-110 kg; E: Fattening pigs over 110 kg; *Bo for Western Europe was chosen; **VS daily excretion were taken from table 10.17 in the IPCC 2019 RF*

Table 5.51: *Overview of country specific parameters used for poultry in 2022*

PARAMETERS	UNIT	A	B	C	D	E	F
B_o*	*m³/kg VS*	0.39	0.36	0.36	0.36	0.36	0.36
Typical animal mass average	*kg*	2	1.02	1.02	3.28	1.53	2.05
Ash content	*%*	0.058	0.027	0.028	0.032	0.027	0.025
VS daily excretion**	*kg dm/head/day*	0.031	0.019	0.018	0.046	0.037	0.043
Poultry manure without bedding		1.5	1.5	1.5	1.5	1.5	1.5
Poultry manure with bedding		1.5	1.5	1.5	1.5	1.5	1.5
Pasture		0.47	0.47	0.47	0.47	0.47	0.47

A: Laying hens and cocks, B: Fattening broilers, C: Breeding broilers, D: Turkeys, E: Geese, F: Ducks

Swine **–** Due to the lack of specific methodology for GE calculation in the IPCC 2019 RF in swine category, the country specific methodology was implemented in 2020 submission. The VS calculation is consistent with the equation 10.23, p 10.64 (IPCC 2019 RF).

Methodological approach introduces more accurate country specific data such as gross energy intake (GE in MJ/head/day), digestibility of feed (DE in %) and new ash content. Digestibility of feed (DE in %) provided by the NPPC-VÚŽV, Department of Animal Feed, is calculated as a weighted average of calculated values from the feed ration. Digestibility was estimated based on each supplemented feeding ration. Metabolizable energy (ME) was taken from publication *Sommer and Petrikovič – Nutrition for Pigs*[3]. Ash content for pigs was taken from publication the *Strauch, Baader, Tietjen – Waste from agricultural production*[4]. Gross energy intake was calculated according to publication *Sommer and Petrikovič – Nutrition for Pigs*. The calculated values are in MJ per day. Values of maximum methane production capacity and emission factors for swine are provided in ***Tables 5.57*** and ***5.58***.

ME was estimated by "Factorial method." This method is based on estimated demand of metabolizable energy for the physiological functions such as maintenance, the growth of muscles, growth, and function of internal bodies, lactation and pregnancy. The sum of energies forms the total energy need for the farm animals. Incorporation of proteins (PR, kg/day) and fats (LR, kg/day) in the body is based on energy estimate. These values are default and are special for each pig subcategory for each day from birth up

[3] Petrikovič, P., Heger, J., Sommer A., 2005, Nutrition for Pigs, The Research Institute of animal production, ISBN 80-88872-45-6 in Slovak

[4] Strauch, D., Baader, W.,Tietjen, C., 1995 Waste from agricultural production, Ulmer Eugen Verlag, ISBN-978-3800143283 in German

to 300 days of animal based on the equations below (derived from the Gompertz function): $PR = B * P * \ln\left({}^{P_{MAT}}/_{P}\right)$; $LR = B * L * \ln\left({}^{L_{MAT}}/_{P}\right)$

Where: **B** = growth parameter, **P** and **L** = protein content, fat in the body in kg/day, **P_{MAT}**, **L_{MAT}** = values of protein content and fat in adult animal body ´s, **PR** = storing proteins in the body (kg/day), **LR** = storing fat in the body (kg/day).

Incorporation of proteins and fat can be characterized as potential growth abilities of pigs' genotype, assumed that the growth parameter (B) is the same value in all genotype.

$$ME_m = 1.02 * H^{0.6}$$

$$ME_P = PR * 37$$

$$ME_L = LR * 47.7$$

Where: **H** = body weight in kg, **PR** = storing proteins in the body (kg/day), **LR** =storing fat in the body (kg/day), **37** = energy storage costs for storing of proteins 37 MJ/kg, **47.7** = energy storage costs for storing of fat 47.7 MJ/kg.

Total demand of metabolized energy is the sum of energy for maintenance (ME_m), energy for protein storage (ME_P), energy for fat storage (ME_L) (Noblet at al.): $ME = ME_m + ME_P + ME_L$

Where: $\mathbf{ME_m}$ = energy for maintenance in MJ/head/day, $\boldsymbol{ME_P}$ = energy for protein storage in MJ/head/kg, $\boldsymbol{ME_L}$ = energy for fat storage in MJ/head/kg, **ME** = metabolizable energy in MJ/head/kg.

ME is the difference between the digestible energy (DE) and the loss of energy in the form of urine and methane gas released by rumen and hind–gut microbes. ME is approximately 96% of DE in pigs, which means that approximately 4% of DE is lost as urine dung and energy. The 4% loss of DE is an approximation of the energy losses, mainly via methane, urinary compounds and heat production by microorganisms in the rumen.

Percentage methane losses from non–ruminants are relatively low, and differences between DE and ME are therefore much smaller: $DE = \frac{ME}{0.96}$

Where: **ME** = metabolizable energy in MJ/head/kg, **DE =** digestible energy, **0.96** = lost as faeces

Gross energy intake was calculated from digestibility energy and feed. Nutrition data were derived based on estimated daily feed intake: $GE = \frac{DE}{\%DE}$

Where: **GE** = gross energy intake in MJ/kg/head, **DE** = metabolizable energy in MJ/head, %**DE** = digestibility of feed in %.

Table 5.52: *The overview of used VS and EFs for dairy cattle in 2022*

PARAMETERS	UNIT	Regions							
		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
VS excretion per day on a dry organic matter base	*kg VS/day*	5.06	4.99	4.89	4.63	4.63	4.58	4.60	4.62
EFs	*kg/head*	5.92	11.10	10.43	16.10	7.82	13.76	8.59	6.70

Table 5.53: *The overview of used emission factors (kg/head) for non-dairy cattle in 2022*

REGION		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
MILK TYPE	Calves in 6. month	0.58	0.63	0.62	0.64	0.72	0.72	0.73	0.54
	Heifers	1.70	1.68	1.87	1.62	1.97	1.70	1.84	1.73
	Heifers (pregnant)	2.29	2.35	2.20	2.51	2.47	2.37	2.12	2.24
	Fattening	3.53	4.07	4.03	3.60	3.46	3.94	3.83	4.01
	Oxen	1.52	1.81	1.79	1.64	1.49	1.73	1.68	1.76
	Breeding bull	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38

REGION		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
BEEF TYPE	Suckler cows	2.14	2.08	2.02	1.93	2.09	2.10	2.03	1.97
	Calves in 6. month	0.33	0.32	0.27	0.26	0.30	0.30	0.28	0.24
	Heifer	1.44	1.43	1.37	1.29	1.43	1.42	1.39	1.34
	Heifer (pregnant)	2.10	2.07	2.07	1.92	2.15	2.11	2.13	2.04
	Fattening	7.18	8.75	8.20	7.69	8.02	7.89	8.23	7.28
	Oxen	2.11	2.30	2.16	2.02	2.12	2.08	2.17	1.91
	Breeding bull	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10

Tables 5.54: *The overview of used VSs (kg VS/day) for non-dairy cattle in 2022*

REGION		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
MILK TYPE	Calves in 6. month	0.65	0.72	0.70	0.72	0.82	0.82	0.83	0.62
	Heifers	1.97	1.94	2.17	1.88	2.28	1.97	2.13	2.00
	Heifers (pregnant)	2.65	2.72	2.54	2.90	2.86	2.75	2.45	2.60
	Fattening	1.82	2.10	2.08	1.86	1.79	2.03	1.98	2.07
	Oxen	1.73	2.06	2.03	1.86	1.69	1.96	1.91	2.00
	Breeding bull	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70
BEEF TYPE	Suckler cows	4.09	4.06	3.91	3.70	4.07	4.06	3.95	3.83
	Calves in 6. month	1.29	1.29	1.07	1.13	1.20	1.19	1.15	0.98
	Heifer	2.82	2.79	2.69	2.52	2.80	2.78	2.72	2.61
	Heifer (pregnant)	4.10	4.05	4.05	3.76	4.21	4.12	4.16	3.99
	Fattening	2.40	2.92	2.74	2.57	2.68	2.64	2.75	2.43
	Oxen	2.40	2.61	2.45	2.29	2.41	2.36	2.47	2.17
	Breeding bull	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94

Tables 5.55: *The overview of used emission factors (kg/head) for sheep in 2022*

REGION		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
DAIRY SHEEP	Mature ewes	0.23	0.27	0.30	0.28	0.29	0.29	0.27	0.26
	Growing lambs	0.00	0.18	0.18	0.18	0.18	0.18	0.18	0.18
	Growing lambs (pregnant)	0.03	0.30	0.29	0.29	0.29	0.30	0.29	0.29
	Other mature sheep	0.35	0.37	0.36	0.36	0.36	0.36	0.36	0.36
BEEF SHEEP	Mature ewes	0.25	0.27	0.26	0.26	0.26	0.26	0.26	0.26
	Growing lambs	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
	Growing lambs (pregnant)	0.31	0.32	0.31	0.31	0.31	0.31	0.31	0.31
	Other mature sheep	0.38	0.40	0.39	0.39	0.39	0.39	0.39	0.39

Due to better disaggregation of sheep based on national data into following subcategories: other mature sheep (VS=0.62 kg dm/head/year), growing lambs (VS=0.58 kg dm/head/year) and mature ewes (VS=0.60 kg dm/head/year), VS can be calculated separately. Values of maximum methane production capacity according to the sheep subcategories are 0.19 m^3/kg VS. MCF for manure management systems in cool climate condition (Table 10.21 of the IPCC 2019 RF) was used. Allocation of animals into AWMS is described in **Chapter 5.9.4**.

Tables 5.56: *The overview of used VSs (kg VS/day) for sheep in 2022*

REGION		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
DAIRY SHEEP	Mature ewes	0.40	0.47	0.52	0.48	0.50	0.51	0.48	0.45
	Growing lambs	0.00	0.32	0.32	0.32	0.32	0.32	0.32	0.32
	Growing lambs (pregnant)	0.06	0.53	0.52	0.52	0.51	0.52	0.52	0.52
	Other mature sheep	0.43	0.46	0.44	0.44	0.44	0.45	0.44	0.44
BEEF SHEEP	Mature ewes	0.46	0.49	0.48	0.48	0.48	0.48	0.48	0.47
	Growing lambs	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
	Growing lambs (pregnant)	0.57	0.59	0.58	0.58	0.58	0.58	0.58	0.58
	Other mature sheep	0.46	0.49	0.48	0.48	0.47	0.48	0.48	0.48

Tables 5.57: *The overview of used emissions factors for swine in 2022*

REGION	Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
Sows	8.28	8.84	8.34	7.86	7.03	8.46	7.58	7.33
Gilts non-pregnant	6.69	6.69	6.69	6.69	6.69	6.69	6.69	6.69
Gilts pregnant	5.39	5.39	5.39	5.39	5.39	5.39	5.39	5.39
Hogs	5.39	5.39	5.39	5.39	5.39	5.39	5.39	5.39
Piglets 21-50kg	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28
Fattening to 20 kg	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43
Fattening to 21-50 kg	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59
Fattening to 50-80 kg	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79
Fattening to 80-100 kg	4.76	4.76	4.76	4.76	4.76	4.76	4.76	4.76
Fattening from 110 kg	5.31	5.31	5.31	5.31	5.31	5.31	5.31	5.31

Tables 5.58: *The overview of used VSs (kg VS/day) for swine in 2022*

REGION	Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
Sows	0.62	0.66	0.63	0.59	0.53	0.64	0.57	0.55
Gilts non-pregnant	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Gilts pregnant	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
Hogs	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
Piglets 21-50kg	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Fattening to 20 kg	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Fattening to 21-50 kg	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Fattening to 50-80 kg	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26

REGION	Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
Fattening to 80-100 kg	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Fattening form 110 kg	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36

Tables 5.59: *The overview of used VSs (kg VS/day) for poultry in 2022*

REGION		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
POULTRY	Laying hens	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
	Fattening broilers	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
	Breeding broilers	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
	Turkeys	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
	Geese	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
	Ducks	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.037

Tables 5.60: *The overview of used emission factors (kg/head) for poultry in 2022*

REGION		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
POULTRY	Laying hens	0.044	0.044	0.044	0.044	0.044	0.044	0.044	0.044
	Fattening broilers	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
	Breeding broilers	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
	Turkeys	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061
	Geese	0.216	0.216	0.216	0.216	0.216	0.216	0.216	0.216
	Ducks	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186

Other animals **–** methodology used for the methane emissions estimation in manure management is based on tier 1 according to the IPCC 2019 RF. Emissions factors are summarized in ***Table 5.61***.

Table 5.61: *Emission factors used for the estimation of CH_4 emissions from manure management*

MANURE MANAGEMENT SYSTEMS	Implied EFs in *kg CH_4/year/head*
Goats	from 0.17 to 0.19
Horses	From 2.71 to 2.96

5.8.2. Activity Data

The number of animals is consistent with the number of animals described in the **Chapter 5.7.2** (***Table 5.43***).

5.9. Direct N_2O Emissions from Manure Management (CRF 3.B.2.1)

EMITTED GAS: N_2O

METHODS: tier 1 and tier 2

EMISSION FACTORS: CS

KEY SOURCES: yes

PARTICULARLY SIGNIFICANT SUBCATEGORIES: cattle and swine

Manure nitrogen (N) from cattle production facilities can lead to negative environmental effects, such as contribution to greenhouse gas emissions, leaching and runoff to aquatic ecosystems leading to eutrophication, and acid rain. To mitigate these effects and to improve the efficiency of N use, accurate prediction of N excretion and secretions is required.

Domestic livestock produces different kinds of nitrogen inputs (liquid, solid and deep bedding, litter) into the ecosystem, also the structure of domestic livestock is important (the ratio of different categories of domestic livestock) from direct emissions as well as the emissions from the AWMS. Except for it, the production of nitrogen per head per year also plays a specific role.

Solid and liquid systems are the most common types of excreta storage in manure management (especially for cattle and swine) in the Slovak Republic. The input of nitrogen oxide from manure management was 0.40 Gg of N_2O in 2022 and the total decrease was 69% compared to the base year and 0.8% increase compared to previous year (***Figure 5.19*** and ***Table 5.62***). ***Figure 5.20*** shows the share of individual categories on the production of nitrogen from manure. A dominant share is represented by dairy cattle (43%), non-dairy cattle (36%) and swine (8.3%).

Figure 5.19: *Trend in N_2O emissions (Gg) by categories within manure management in 1990 – 2022*

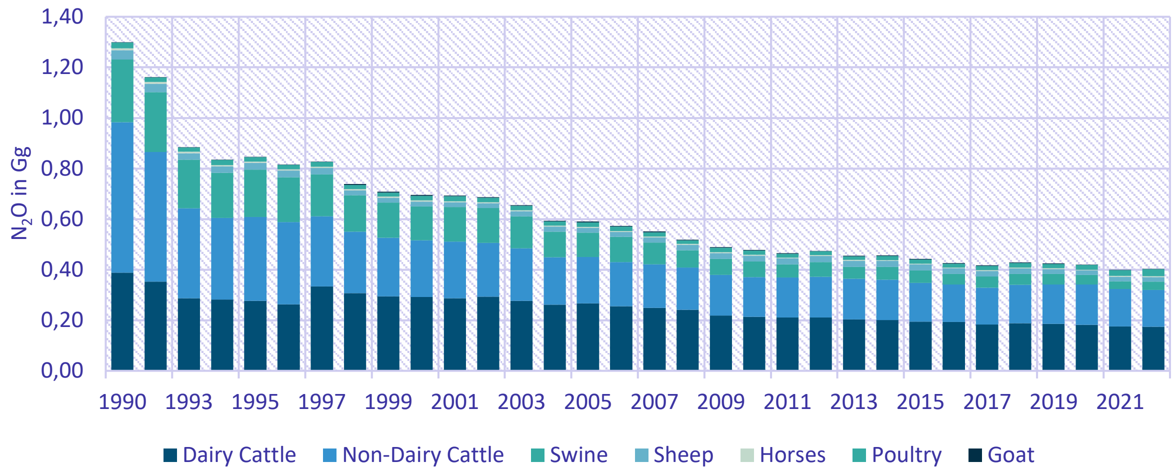
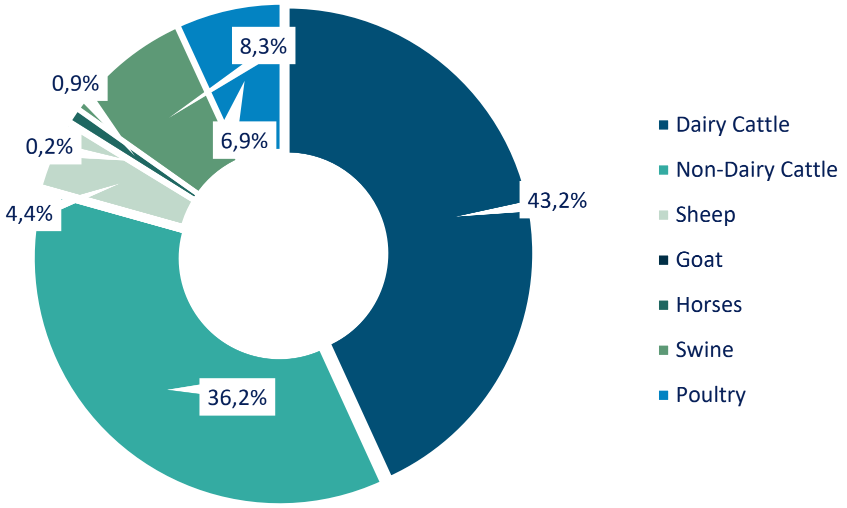


Table 5.62: *N_2O emissions (Gg) in manure management according to the animals in particular years*

YEAR	DAIRY CATTLE	NON-DAIRY CATTLE	SHEEP	GOATS	HORSES	SWINE	POULTRY
1990	0.388	0.595	0.037	0.001	0.008	0.248	0.022
1995	0.277	0.332	0.027	0.002	0.005	0.186	0.018
2000	0.292	0.223	0.020	0.004	0.005	0.134	0.017
2005	0.267	0.183	0.020	0.003	0.004	0.096	0.018
2010	0.213	0.157	0.024	0.002	0.003	0.062	0.017
2011	0.211	0.158	0.024	0.002	0.003	0.051	0.015

YEAR	DAIRY CATTLE	NON-DAIRY CATTLE	SHEEP	GOATS	HORSES	SWINE	POULTRY
2012	0.211	0.161	0.024	0.002	0.003	0.057	0.015
2013	0.203	0.161	0.024	0.002	0.003	0.047	0.014
2014	0.201	0.160	0.023	0.002	0.003	0.051	0.016
2015	0.194	0.154	0.023	0.002	0.003	0.050	0.016
2016	0.194	0.148	0.022	0.002	0.003	0.042	0.015
2017	0.184	0.145	0.022	0.003	0.003	0.044	0.017
2018	0.188	0.152	0.021	0.002	0.003	0.044	0.018
2019	0.186	0.155	0.019	0.002	0.003	0.042	0.017
2020	0.181	0.160	0.018	0.001	0.003	0.037	0.019
2021	0.175	0.148	0.017	0.001	0.003	0.031	0.023
2022	0.174	0.146	0.018	0.001	0.004	0.034	0.028

Figure 5.20: *The share of N_2O emissions by animals within manure management in 2022*



5.9.1. Methodological Issues – Methods

Animal waste management systems (AWMS) – allocation of manure into AWMS is based on survey on manure management practices used. A questionnaire survey in farms was performed in the cooperation with the NPPC-VÚŽV and other research institutions during the year 2014. Farmers reported the total produced amount of solid and liquid manure and amount of manure, which was processed in anaerobic digesters by regions. This survey defined more accurately numbers of days on pasture for cattle, sheep, goats and horses. Manure left on pasture was estimated based on this data. Time-series was completed by extrapolation. In 2023 new data was implemented in poultry and swine categories, this survey was provided by Research Institute of Animal Production in Nitra.

Allocation according to the climatic conditions is 100% for cool temperate dry climate for all animals based on the IPCC 2019 RF and climate data for the Slovak Republic.

Western Europe default value for nitrogen excretion was used, more information is in the **Chapter 5.5**.

Nitrogen excretion rate for cattle – a country specific nitrogen excretion rate based on tier 2 approach was used. This was implemented for each subcategory of cattle based on statistical inputs - milk yield, weight and daily gain of the animal. The average annual requirements of crude protein for the maintenance, lactation, pregnancy and daily gain were estimated. Milk yield, daily gain and share of proteins in milk at the regional level, were taken from the ŠÚ SR statistics. Average body weights were estimated using the country specific method documented in the **Chapter 5.7.1**. While the same activity data was used, the calculation model is in line with enteric fermentation model. This methodology was developed in the cooperation with the NPPC-VÚŽV. Additional information regarding maintenance and pregnancy was taken into account. Country specific parameters are documented in ***Table 5.63.***

Table 5.63: *Additional parameters for estimation of nitrogen excretion rate*

NAME OF PARAMETER	PARAMETERS WITH UNITS*	SOURCE
Crude protein per litter of milk	85 g per litter	P. Petrikovič – A. Sommer: Nutrition for Cattle
Share of protein in calf meat	21.5%	J. Kerešteš at all.: Biotechnology nutrition and health
Usability for maintenance	2%	P. Petrikovič – A. Sommer: Nutrition for Cattle
Usability for pregnancy	20%	P. Petrikovič – A. Sommer: Nutrition for Cattle
Nitrogen overage -dairy cattle	25%	Expert judgement
Nitrogen overage - other cattle	20%	Expert judgement
Share of protein in beef meat	21%	J. Kerešteš at all.: Biotechnology nutrition and health
Conversion factor from CP to N	6.25	IPCC 2019 RF p.10.58
Time without milking	60 days	https://www.plis.sk/
Crude protein for pregnancy begin part of pregnancy	680 g/day	P. Petrikovič – A. Sommer: Nutrition for Cattle
Crude protein for pregnancy begin part of pregnancy	765 g/day	P. Petrikovič – A. Sommer: Nutrition for Cattle

**consistent in all time-series*

The nitrogen excretion rate was determined for the whole time-series with methods according to the publication *P. Petrikovič – A. Sommer: Nutrition for Cattle.*[5] The complex of crude protein contains amount of protein nitrogen and non-protein nitrogen estimated with the Kjeldahl method. Crude protein is multiplied by a conversion factor of 6.25 to dietary nitrogen. The calculation method is based on a reverse estimation of nitrogen excretion from the average parameters of animal production (milk yield and daily gain, body weight) of the cattle. Parameters are multiplied with tabular values of crude protein from individual physiological activities. Subsequently, the partial crude protein from activities is summed to the total crude protein. Total crude protein was recalculated to the nitrogen.

Dairy cattle:

$$CP_{m-Total} = \left[(4.93 \times H^{0.75} \times U_m) - \left(\frac{CP_m}{100} \times U_m\right)\right]$$

$$CP_{l-Total} = \left[(MY \times CP_l) - \left(\frac{MY \times 1000}{100 * SP_l}\right)\right]$$

$$CP_{p-Total} = \frac{C_{p1+}C_{p2}}{100} \times U_p$$

$$Total_{CP} \frac{\frac{(CP_{m-Total} + CP_{l-Total}) \times \text{lactation period}}{1000} + \frac{(CP_{m-Total} + CP_{p-Total}) \times \text{time without milking}}{1000}}{\text{intervening period}} \times 365$$

$$N_{intake\ (T)} = \left(\frac{\frac{Total_{Cp}}{100}}{6.25}\right)$$

$$NEX_{(T)} = N_{intake\ (T)} + (N_{intake\ (T)} \times O_N)$$

Non-dairy cattle:

$$CP_{m-Total} = \left[(4.93 \times H^{0.75} \times U_m) - \left(\frac{CP_m}{100} \times U_m\right)\right]$$

$$CP_{dg-Total} = \left[\left(200 + (4.43 \times H^{0.75})\right) \times dg\right] \times SP_m$$

[5] Perikovič, P., Sommer, A., 2002, Nitrition for Cattle, The Research Institute for Animal Production, ISBN: 80-88872-21-9

$$\text{Total}_{CP} = \frac{(\text{CP}_{m-\text{Total}} + \text{CP}_{dg-\text{Total}})}{1000} \times 365$$

$$\text{N}_{\text{intake (T)}} = \left(\frac{\frac{\text{Total}_{Cp}}{100}}{6.25} \right)$$

$$\text{NEX}_{(T)} = \text{N}_{\text{intake (T)}} + (\text{N}_{\text{intake (T)}} * \text{O}_{N})$$

Where: **$CP_{m\text{-}Total}$** = crude protein for maintenance in g per day, **$H^{0.75}$** = metabolic body size, **H** = average body weight in kg, **U_m** = Usability for maintenance in %, **MY** = milk yield in kg/day **$CP_{l\text{-}Total}$** = crude protein for lactation g per day, **$CP_{p\text{-}Total}$** = crude protein for pregnancy in g per day, **$CP_{dg\text{-}Total}$** = crude protein for daily gain in g per day, dg = daily gain of animal in kg, **4.93** factor for maintenance, **4.43** factor crude protein per daily gain, **SP_l** = share of proteins in milk in %, **SP_m** = share of proteins in meat in %, **lactation period** = period of milk production in days, **intervening period** = is figure indicating the time elapsed between two calves in days, **$Total_{CP}$** = total calculated crude protein in kg, **$NEX_{(T)}$** = annual N excretion rates, kg N animal^{-1} year^{-1}, **6.25** = conversion from kg of dietary protein to kg dietary N, kg feed protein (kg N)$^{-1}$,**O_N** = share of overage of nitrogen in N, **N_{INTAKE} (T)** = daily N consumed per animal of category T , **C_{p1}** = crude protein for pregnancy begin part of pregnancy **C_{p2}=** crude protein for pregnancy final part of pregnancy

Nitrogen Excretion rate for swine, poultry – a country-specific nitrogen excretion rate was used for the swine, poultry categories, based on the tier 2 method from the IPCC 2019 RF. The nitrogen excretion rates were developed based on the nitrogen content of the feed. The amounts of the nitrogen-containing feed ingredients in the diet were determined for the whole time-series. Feeding rations for different subcategories of pigs were estimated with the model "Software for Feeding Ration Optimization" developed by the NPPC-VÚŽV.

The nitrogen intakes were determined from the crude protein content of each feed ingredient in the feeding ration for all subcategories of swine. The value of gross energy intake is consistent with the value used in category 3.B.1.3. Data on dry matter intake were taken according to the publication *P. Petrikovič at all: Nutrition for Pigs*[6] and *J. Zelenka at all: Nutrition for Poultry*[7]. Experimental feeding rations were compiled with "The Animal Optimization Software" from Agrokonzulta Žamberk. Ltd. (CZ). This software uses the feed database, and Nutrition Standards developed at the NPPC-VÚŽV. The nitrogen intakes were determined from the crude protein content of each feed ingredient in the diet for all subcategories of swine and the gross energy intake of the swine.

$$\text{N}_{\text{intake (T)}} = DMI_i \times \left(\frac{\frac{\text{CP }\%}{100}}{6.25} \right)$$

Where: **$N_{INTAKE\ (T)}$** = daily N consumed per animal of category T, kg N/head/day, **DMI_i**=dry matter intake per day during a specific growth stage, (kg DMI animal day^{-1}), **CP** = percent crude protein in diet %, **6.25** = conversion from kg of dietary protein to kg of dietary N, kg feed protein (kg/N).

The values of the annual nitrogen excretions that are retained by animals and their sources are summarized in ***Tables 5.64 - 5.70***. The results for swine for 2022 were presented in ***Table 5.64*** and ***Table 5.65***. The results for poultry for 2022 were presented in ***Tables 5.66 and 5.69***. Sheep are also significant contributors to emissions, but data about crude protein were unavailable. The N-excretion rates were calculated according to Equation 10.32A new of the IPCC 2019 RF:

$$NEX_{(T)} = N_{intake\ (T)} \times (1 - N_{retention}) \times 365$$

Where: **$NEX_{(T)}$)** = annual N excretion rates in kg N/head/yr, **$N_{INTAKE\ (T)}$** = the annual N intake per head of animal of species/category T, kg N /head/yr, **$N_{RETENTION\ (T)}$** = fraction of annual N intake that is retained by animal of species (according to Table 10.20 of the IPCC 2019 RF).

[6] Petrikovič, P.; Heger, J.; Sommer A.: Nutrition for Pigs. Research Institute of Animal Production, 2005, ISBN 80-88872-45-6 in Slovak

[7] J. Zelenka at all: Nutrition for Poultry, Research Institute of Animal Production, 2006, ISBN-80-88872-59-6 in Slovak

__Table 5.64:__ Country specific regional parameters for swine in 1990

1990		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
SOWS	*CP (%)*	15.7%	15.7%	15.8%	15.7%	15.7%	15.6%	15.7%	15.5%
	N-intake (kg N animal/day)	0.083	0.082	0.083	0.082	0.085	0.084	0.083	0.082
	N_{EX} (kg N/animal/year)	21.1	21.0	21.1	21.1	21.6	21.5	21.2	21.0
GILTS PRAGNANT	*CP (%)*	12.86%	13.33%	13.63%	13.54%	13.54%	14.00%	13.38%	13.44%
	N-intake (kg N animal/day)	0.049	0.053	0.055	0.054	0.054	0.057	0.053	0.054
	N_{EX} (kg N/animal/year)	12.4	13.6	14.0	13.9	13.9	14.5	13.6	13.7
GILTS UNPREGNANT	*CP (%)*	12.86%	13.33%	13.63%	13.54%	13.54%	14.00%	13.38%	13.44%
	N-intake (kg N animal/day)	0.039	0.043	0.044	0.044	0.044	0.046	0.043	0.043
	N_{EX} (kg N/animal/year)	10.0	10.9	11.3	11.2	11.2	11.7	11.0	11.0
HOGS	*CP (%)*	16%	16%	16%	16%	16%	16%	16%	16%
	N-intake (kg N animal/day)	0.052	0.051	0.053	0.054	0.052	0.054	0.053	0.052
	N_{EX} (kg N/animal/year)	13.2	18.7	19.5	19.5	19.1	19.5	19.2	19.1
PIGS 21-50 kg	*CP (%)*	12.9%	13.3%	13.6%	13.5%	13.5%	14.0%	13.4%	13.4%
	N-intake (kg N animal/day)	0.023	0.025	0.026	0.025	0.025	0.027	0.025	0.025
	N_{EX} (kg N/animal/year)	5.8	6.4	6.6	6.5	6.5	6.8	6.4	6.4
FATTENING PIGS UP TO 20 kg	*CP (%)*	14.7%	14.3%	15.2%	14.8%	14.4%	14.3%	14.7%	14.1%
	N-intake (kg N animal/day)	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
	N_{EX} (kg N/animal/year)	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
FATTENING PIGS 21-50 kg	*CP (%)*	14.3%	15.0%	14.1%	14.5%	12.6%	14.3%	12.7%	13.7%
	N-intake (kg N animal/day)	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
	N_{EX} (kg N/animal/year)	8.2	8.2	8.1	8.2	8.2	8.2	8.2	8.2
FATTENING PIGS 50-80 kg	*CP (%)*	14.7%	14.3%	15.2%	14.8%	14.4%	14.3%	14.7%	14.1%
	N-intake (kg N animal/day)	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047
	N_{EX} (kg N/animal/year)	12.0	12.0	11.9	12.0	12.0	12.0	12.0	12.1
FATTENING PIGS 80-110 kg	*CP (%)*	14.7%	14.3%	15.2%	14.8%	14.4%	14.3%	14.7%	14.1%
	N-intake (kg N animal/day)	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
	N_{EX} (kg N/animal/year)	15.0	15.1	15.0	15.0	15.1	15.1	15.0	15.1
FATTENING PIGS FROM 110 kg	*CP (%)*	14.7%	14.3%	15.2%	14.8%	14.4%	14.3%	14.7%	14.1%
	N-intake (kg N animal/day)	0.066	0.066	0.065	0.066	0.066	0.066	0.066	0.066
	N_{EX} (kg N/animal/year)	16.8	16.9	16.7	16.8	16.8	16.9	16.8	16.9

Table 5.65: Country specific regional parameters for swine for in 2022

2022		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
SOWS	*CP (%)*	17.3%	16.9%	16.6%	16.5%	16.1%	16.5%	16.8%	15.9%
	N-intake (kg N animal/day)	0.07	0.08	0.07	0.07	0.06	0.07	0.06	0.06
	N_{EX} (kg N/animal/year)	19.7	21.9	21.1	21.0	20.7	22.8	21.5	21.1
GILTS PRAGNANT	*CP (%)*	13.6%	14.0%	12.4%	13.0%	13.6%	13.3%	13.8%	12.8%
	N-intake (kg N animal/day)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	N_{EX} (kg N/animal/year)	12.45	12.45	12.45	12.45	12.45	12.45	12.45	12.45
GILTS UNPREGNAN T	*CP (%)*	13.6%	14.0%	12.4%	13.0%	13.6%	13.3%	13.8%	12.8%
	N-intake (kg N animal/day)	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
	N_{EX} (kg N/animal/year)	15.11	15.11	15.11	15.11	15.11	15.11	15.11	15.11
HOGS	*CP (%)*	15.9%	15.9%	15.9%	15.9%	15.9%	15.9%	15.9%	15.9%
	N-intake (kg N animal/day)	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
	N_{EX} (kg N/animal/year)	27.08	27.08	27.08	27.08	27.08	27.08	27.08	27.08
PIGS 21-50 kg	*CP (%)*	13.6%	14.0%	12.4%	13.0%	13.6%	13.3%	13.8%	12.8%
	N-intake (kg N animal/day)	0.024	0.025	0.022	0.023	0.024	0.024	0.025	0.023
	N_{EX} (kg N/animal/year)	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
FATTENING PIGS UP TO 20 kg	*CP (%)*	14.3%	15.0%	14.1%	14.5%	12.6%	14.3%	12.7%	13.7%
	N-intake (kg N animal/day)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
	N_{EX} (kg N/animal/year)	4.84	4.84	4.84	4.84	4.84	4.84	4.84	4.84
FATTENING PIGS 21-50 kg	*CP (%)*	14.3%	15.0%	14.1%	14.5%	12.6%	14.3%	12.7%	13.7%
	N-intake (kg N animal/day)	0.0448	0.0448	0.0448	0.0448	0.0448	0.0448	0.0448	0.0612
	N_{EX} (kg N/animal/year)	9.4312	9.4312	9.4312	9.4312	9.4312	9.4312	9.4312	9.4312
FATTENING PIGS 50-80 kg	*CP (%)*	14.3%	15.0%	14.1%	14.5%	12.6%	14.3%	12.7%	13.7%
	N-intake (kg N animal/day)	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
	N_{EX} (kg N/animal/year)	13.80	13.80	13.80	13.80	13.80	13.80	13.80	13.80
FATTENING PIGS 80-110 kg	*CP (%)*	14.3%	15.0%	14.1%	14.5%	12.6%	14.3%	12.7%	13.7%
	N-intake (kg N animal/day)	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
	N_{EX} (kg N/animal/year)	17.72	17.72	17.72	17.72	17.72	17.72	17.72	17.72
FATTENING PIGS FROM 110 kg	*CP (%)*	14.3%	15.0%	14.1%	14.5%	12.6%	14.3%	12.7%	13.7%
	N-intake (kg N animal/day)	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
	N_{EX} (kg N/animal/year)	18.67	18.67	18.67	18.67	18.67	18.67	18.67	18.67

Table 5.66: Country specific regional parameters for poultry

1990 – 2022		Bratislava	Trnava	Trenčín	Nitra	Banská Bystrica	Žilina	Prešov	Košice
BREEDING BROILERS	N retention (%)	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300
	N-intake (kg N animal/day)	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
	N_{EX} *(kg N/animal/year)*	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898
DUCKS	N retention (%)	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
	N-intake (kg N animal/day)	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
	N_{EX} *(kg N/animal/year)*	1.295	1.295	1.295	1.295	1.295	1.295	1.295	1.295
FATTENING BROILERS	N retention (%)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	N-intake (kg N animal/day)	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
	N_{EX} *(kg N/animal/year)*	0.739	0.739	0.739	0.739	0.739	0.739	0.739	0.739
GEESE	N retention (%)	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
	N-intake (kg N animal/day)	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
	N_{EX} *(kg N/animal/year)*	1.739	1.739	1.739	1.739	1.739	1.739	1.739	1.739
LAYING HENS INCLUDING COCKS	N retention (%)	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300
	N-intake (kg N animal/day)	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
	N_{EX} *(kg N/animal/year)*	0.794	0.794	0.794	0.794	0.794	0.794	0.794	0.794
TURKEYS	N retention (%)	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
	N-intake (kg N animal/day)	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
	N_{EX} *(kg N/animal/year)*	3.529	3.529	3.529	3.529	3.529	3.529	3.529	3.529

Other animals – the calculation is based on the determination of body weight. All animals have their specific body weight. This parameter was estimated and is country specific. The body weight parameter is consistent across the time-series and specific for animal species. The NPPC-VÚŽV provided specific body mass for animals. Annual nitrogen excretion rates were calculated for sheep, goats, horses and poultry. N-excretion rates were calculated based on the IPCC 2019 RF, Equation 10.30:

$$\mathrm{NEX_T} = \mathrm{N_{rate(T)}} * \frac{\mathrm{TAM}}{1000} * 365$$

Where: $\mathbf{N_{EXT}}$ = annual N-excretion for each livestock spices respectively category in kg N per animal; $\mathbf{N_{RATE(T)}}$ = default N-excretion rate in kg N (100 kg/animal mass)/day (IPCC 2019 RF), **TAM** = country specific animal mass for each livestock species/category in kg per animal

Direct emissions from manure management systems were estimated according to the following equation:

$$\mathrm{N_2O_{EM}} = \left[\sum \left[\sum (\mathrm{N} * \mathrm{N_{EX}} * \mathrm{AWMS})\right] * \mathrm{EF}\right] * \frac{44}{28}$$

Where: $\mathbf{N_2O_{EM}}$ = direct N_2O emissions from manure management in kg N_2O; **N** = number of livestock species respectively category, $\mathbf{N_{EX}}$ = annual average N-excretion/head of species respectively category in kg N/animal, **AMWS** = percentage of total annual nitrogen excretion for each livestock category, that is managed in manure management systems in the country, **EF** = default emission factor for direct N_2O emissions from manure management system in kg N_2O-N/kg N in manure management system, **44/28** = conversion of N_2O-N emissions to N_2O emissions

Table 5.67: Country specific regional parameters for dairy cattle in 1990

CATEGORIES	N_{EX}	Body mass	Liquid	Solid	Pasture	Anaerobic digester
	kg N head/year	*kg*	*%*			
Dairy cows Bratislava region	82.63	589	42.85	56.86	0.29	NO
Dairy cows Trnava region	78.69	589	18.57	79.79	1.64	NO
Dairy cows Trenčín region	74.60	589	7.12	86.92	5.97	NO
Dairy cows Nitra region	75.83	589	16.56	82.62	0.82	NO
Dairy cows Žilina region	66.06	589	5.93	75.34	18.73	NO
Dairy cows Banská Bystrica region	71.65	589	10.67	77.88	11.44	NO
Dairy cows Prešov region	62.65	589	4.06	80.43	15.51	NO
Dairy cows Košice region	69.36	589	2.41	86.29	11.30	NO

Table 5.68: Country specific regional parameters for dairy cattle in 2022

CATEGORIES	N_{EX}	Body mass	Liquid	Solid	Pasture	Anaerobic digester
	kg N head/year	*kg*	*%*			
Dairy cows Bratislava region	130	600	0.00	99.52	0.48	0.00
Dairy cows Trnava region	135	600	8.11	77.01	1.33	13.55
Dairy cows Trenčín region	127	600	7.58	77.18	6.28	8.95
Dairy cows Nitra region	132	600	16.49	80.47	0.64	2.40
Dairy cows Žilina region	110	595	5.89	56.67	30.74	6.70
Dairy cows Banská Bystrica region	116	599	13.95	69.05	11.30	5.70
Dairy cows Prešov region	108	593	6.35	70.46	20.53	2.67
Dairy cows Košice region	109	597	3.04	77.03	11.38	8.55

Table 5.69: Country specific regional parameters for poultry in 2022

CATEGORIES	N_{EX}	Body mass	Pasture	Manure poultry without litter	Poultry manure with litter
	kg N head/year	*kg*	*%*		
Laying hens including cocks	0.79	2	-	75%	25%
Fattening broilers	0.90	1.02	-		100%
Breeding broilers	0.74	1.02	-		100%
Turkeys	3.53	3.28	-		100%
Geese	1.30	1.53	50%	50%	
Ducks	1.74	2.05	50%	50%	

Table 5.70: N_{EX} and share (%) for different domestic livestock and share in AWMS in 2022

	CATEGORIES	N_{EX}	LIQUID	SOLID	PASTURE	OTHER (LITTER)	DIGESTERS
		N kg/head	*%*				
NON-DAIRY CATTLE	Suckler cows	47.43	-	45.21	54.79	-	
	Calves in 6 month (milk type)	19.96	-	-	100.00	-	
	Heifer (milk type)	39.43	-	97.56	2.44	-	
	Heifer (pregnant) (milk type)	59.20	-	97.55	2.45	-	
	Fattening (milk type)	46.14	10.00	90.00	-	-	
	Oxen (milk type)	97.94	-	100.00	-	-	

CATEGORIES		N_{EX}	LIQUID	SOLID	PASTURE	OTHER (LITTER)	DIGESTERS
		N kg/head	*%*				
	Breeding bull (milk type)	66.21	-	100.00	-	-	
	Calves in 6 month (beef type)	21.56	-	100.00	60.00	-	
	Heifer (beef type)	38.18	-	45.21	54.79	-	
	Heifer (pregnant) (beef type)	54.52	-	45.21	54.79	-	
	Fattening (beef type)	51.75	20.00	80.00	-	-	
	Oxen (beef type)	69.51	-	100.00		-	
	Breeding bull (beef type)	43.35	-	75.34	24.66	-	
	2022*	40.47	2,46	71,17	26,37	-	
SHEEP	Mature ewes (milk type)	7.884	-	49.59	50.41	-	
	Mature ewes (beef type)	9.20	-	45.20	54.80	-	
	2022*	8.35	-	48,03	51,97	-	
	Growing lambs (milk type)	4.27	-	49.59	50.41	-	
	Growing lambs pregnant (milk type)	6.24	-	49.59	50.41	-	
	Growing lambs (beef type)	7.23	-	45.21	54.79	-	
	Growing lambs pregnant (beef type)	8.54	-	45.21	54.79	-	
	2022*	5.88		48.08	51,92	-	
	Rams (milk type)	10.51	-	83.56	16.44	-	
	Rams (beef type)	11.83	-	83.56	16.44	-	
	2022*	10.98		81.63	18.37	-	
SWINE	Breeding swine	18.55	73	13.8	-	-	13.2
	Market swine	10.04	73	8.8	-	5	12.2
GOATS	Mature female goats	9.23	-	49.60	50.40	-	-
	Pregnant goats	7.98	-	49.60	50.40	-	-
	Other mature goats	3.61	-	49.60	50.40	-	-
	2022	7.82		49.60	50.40	-	-
HORSES	Young horses up to 1 year	17.32	70.00	-	30.00	-	-
	Young horses from 1 to 3 year	39.858	70.00		30.00		-
	Castrated horses	66.43	70.00	-	30.00	-	-
	Stallions	52.20	70.00	-	30.00	-	-
	Mares	47.45	70.00	-	30.00	-	-
	2022*	49.78	70.00		30.00	-	-

**weighted average*

The IPCC default emission factors for N_2O emissions estimation per AWMS are based on the Table 10.21 of the IPCC 2019 RF (***Table 5.71***).

Table 5.71: *Emission factors for N_2O emissions used in manure management in 2022*

MANURE MANAGEMENT SYSTEMS	EFs (N_2O-N)
	kg N_2O-N/kg N_{EX}
Solid storage and dry lot	0.01
Liquid system	0.005
Anaerobic digesters	0.0006
Cattle and Swine deep bedding	0.01
Poultry manure with litter	0.001
Poultry manure without litter	0.001

5.9.2. Activity Data

The NPPC-VÚŽV is a data provider for animal housing, pasture, and production of manures and slurries. More information on animal numbers can be found in the previous chapters.

5.10. Indirect N_2O Emissions from Manure Management (CRF 3.B.2.5)

5.10.1 Volatilisation from Manure Management Systems

Indirect emissions result from volatile nitrogen losses that occur primarily in the form of ammonia and NO_x. The fraction of excreted organic nitrogen that is mineralized to ammonia nitrogen during manure storage depends mainly on time and temperature. Simple forms of organic nitrogen such as urea and uric acid are rapidly mineralized to ammonia nitrogen, which is highly volatile and easily diffused into the surrounding air. Nitrogen losses begin with excretion in housing and continue with on-site management in storage and treatment systems. Pasture losses are considered separately in emissions from managed soils.

Methodological Issues – Methods

Tier 1 approach of the IPCC 2019 RF for nitrogen estimation of N volatilization in forms of NH_3 and NO_x from manure management systems is based on multiplication of the amount of nitrogen excreted from all livestock categories and managed in each manure management systems by a fraction of volatilized nitrogen. N losses were then summed from all manure management systems. Emission factor is 0.01 kg NH_3-N and NO-N for N_2O emissions from atmospheric deposition of nitrogen. The losses were calculated for all farm animals. Calculations were performed using the following equations:

$$\mathbf{N_{volatilization-MMS}} = \sum_{S}\left[\sum_{T}\left[\left(\left((\mathbf{N_T} * \mathbf{Nex_T}) * \mathbf{AWMS_{T,S}}\right) + N_{cdg(s)}\right) * \mathbf{Frac_{GasMS_{(T,S)}}}\right]\right]$$

$$\mathbf{N_2O_{MM}} = (\mathbf{N_{volatilization-MMS}} * \mathbf{EF}) * \frac{\mathbf{44}}{\mathbf{28}}$$

Where: $\mathbf{N_T}$ = number of head of farm animals' species/category, $\mathbf{Nex_T}$ = annual average N excretion per head of species respectively category in kg N per animal, $\mathbf{MS_{T,\,S}}$ = fraction of total annual nitrogen excretion for each farm animals' species respectively category, that is managed in manure management systems, $\mathbf{Frac_{GasMS}}$ = percent of managed manure nitrogen for livestock category T that volatilizes as NH_3 and NO_x in the manure management systems S in %.

Activity data

Volatilized nitrogen (NH_3 and NO_x) from animal waste was 16 938.59 t of N, which represents 0.27 Gg of N_2O in 2022. Activity data in this category are consistent with the activity data used in animal manure. ***Table 5.72*** shows the time series of input data and emissions.

Table 5.72: *Input parameters and EFs in category 3.B.2.5 - Atmospheric Deposition in particular years*

YEAR	VOLATILIZED N FROM ANIMAL MANURE	IEF	N_2O EMISSIONS
	kg	*kg N_2O-N/kg N*	*Gg*
1990	40 357 857	0.02	0.634
1995	26 922 886	0.02	0.423
2000	22 048 368	0.02	0.346
2005	19 091 596	0.02	0.300
2010	15 812 435	0.02	0.248
2011	14 929 099	0.02	0.235
2012	15 365 617	0.02	0.241
2013	14 606 677	0.02	0.230
2014	15 089 029	0.02	0.237
2015	14 844 678	0.02	0.233
2016	14 150 573	0.02	0.222

YEAR	VOLATILIZED N FROM ANIMAL MANURE	IEF	N_2O EMISSIONS
	kg	*kg N_2O-N/kg N*	*Gg*
2017	14 332 381	0.02	0.225
2018	14 880 705	0.02	0.234
2019	14 484 287	0.02	0.228
2020	14 993 151	0.02	0.236
2021	15 583 763	0.02	0.245
2022	16 938 586	0.02	0.266

5.10.2. Nitrogen Leaching and Run-off from Manure Management Systems

This category was included in the inventory for the first time this year based on the implementation of the IPCC 2019 RF. The new methodological guidelines provide the default values of $Frac_{leachMS}$. The default values were adopted and N_2O emission was possible to estimate.

Methodological Issues – Methods

Tier 1 approach of the IPCC 2019 RF for nitrogen estimation of N leaching and run-off from manure management systems is based on multiplication of the amount of nitrogen excreted from all livestock categories and managed in each manure management systems by a fraction of volatilized nitrogen. N losses were then summed from all manure management systems. Emission factor is 0.011 kg N_2O–N (kg N leaching/runoff)$^{-1}$. The losses were calculated for all farm animals. $N_{cdg\ (s)}$ is define as amount of nitrogen from co-digesters added to biogas plants such as food wastes or purpose grown crops. National data about this activity is missing, therefore value was neglected. Calculations were performed using the following equations:

$$\mathbf{N_{leaching-MMS}} = \sum_{S}\left[\sum_{T,P}\left[\left(\mathbf{N_T} * \mathbf{Nex_T} * \mathbf{AWMS_{T,S}}\right) + N_{cdg(s)} * Frac_{LeachMS_{(T,S)}}\right]\right]$$

$$\mathbf{N_2O_{MM}} = \left(\mathbf{N_{leaching-MMS}} * \mathbf{EF_5}\right) * \frac{\mathbf{44}}{\mathbf{28}}$$

Where: $\mathbf{N_T}$ = number of head of farm animals' species/category, $\mathbf{Nex_T}$ = annual average N excretion per head of species respectively category in kg N per animal, $\mathbf{AWMS_{T,S}}$ = fraction of total annual nitrogen excretion for each farm animals' species respectively category, that is managed in manure management systems, $\mathbf{Frac_{leachMS}}$ = percent of managed manure nitrogen for livestock category T that volatilizes as NH_3 and NO_x in the manure management systems S in %,$N_{cdg\ (s)}$= amount of nitrogen from co-digestates added to biogas plants such as food wastes or purpose grown crops, kg N yr^{-1}

Activity data

N lost through leaching and run-off from animal waste was 431.8 t of N, which represents 0.007 Gg of N_2O in 2022. Activity data in this category are consistent with the activity data used in animal manure. ***Table 5.73*** shows the time series of input data and emissions.

Table 5.73: *Input parameters and EFs in category 3.B.2.5 - Nitrogen leaching and run-off in particular years*

YEAR	N LOST THROUGH LEACHING AND RUN-OFF	IEF	N_2O EMISSIONS
	kg	*kg N_2O-N/kg N*	*Gg*
1990	1 379 053	0.02	0.024
1995	878 359	0.02	0.015
2000	729 345	0.02	0.013
2005	629 871	0.02	0.011
2010	517 946	0.02	0.009
2011	511 561	0.02	0.009
2012	519 205	0.02	0.009
2013	499 529	0.02	0.009

YEAR	N LOST THROUGH LEACHING AND RUN-OFF	IEF	N_2O EMISSIONS
	kg	*kg N_2O-N/kg N*	*Gg*
2014	497 161	0.02	0.009
2015	482 031	0.02	0.008
2016	469 438	0.02	0.008
2017	454 951	0.02	0.008
2018	464 984	0.02	0.008
2019	465 935	0.02	0.008
2020	459 693	0.02	0.008
2021	435 076	0.02	0.008
2022	431 779	0.02	0.007

5.11. Rice Cultivation (CRF 3.C)

No emissions from rice cultivation were estimated because this activity did not occur in the Slovak Republic in 1990 – 2022. Therefore, notation keys NO were used in all time-series.

5.12. Agricultural Soils (CRF 3.D)

EMITTED GAS: N_2O

METHODS: tier 1, tier 2

EMISSION FACTORS: CS, D

KEY SOURCES: yes

SIGNIFICANT SUBCATEGORIES: synthetic fertilizers

Direct emissions are the primary source of N_2O in the Slovak inventory. In 2022, 35% of the national total N_2O emissions originated from this category, which includes N inputs from synthetic N-fertilizer, organic manures as animal manure use, sewage sludge application and compost, emissions from urine and dung N deposited on pasture and crop residues. Trend of total N_2O emissions from the Agriculture sector reflects trend of direct emissions from cultivated soil, emissions from applied manure and indirect emissions from leaching and deposition of ammonia and NOx. The productivity of different categories of domestic livestock varies significantly depending on the scale and the production level of farms in different regions. In the Slovak Republic, both the extensive and intensive farming systems in animal husbandry can be found. Nitrogen inputs can differ from the calculations in the range of ±10%.

Total N_2O emissions from agricultural soils were 2.13 Gg of N_2O in 2022. The emissions decreased by 13.8% in comparison with 2021 and decreased by 58% in comparison with the base year 1990 (***Table 5.74***). The major reason for the overall decreasing trend is a sharp decrease in the use of synthetic fertilizers in early 90-ties and the continual decrease in the use of animal manure caused by the reduction in the number of animals (***Figure 5.21***). ***Figure 5.21*** shows, that since 1999 the trend is stable with the small fluctuations caused by changes in animal population and inter-annual differences in categories 3.D.1.4 - Crop Residues, 3.D.1 - Inorganic Nitrogen Fertilizers and 3.D.2 - Indirect N_2O Emissions. No emissions are reported in the categories 3.D.1.6 - Cultivation of Organic Soils. More information is available in the **Chapter 5.12.8**.

Table 5.74: *N_2O emissions (Gg) in 3.D - Direct Soils according to the subcategories in particular years*

YEAR	3.D.1 DIRECT N_2O EMISSIONS FROM MANAGED SOIL					3.D.2 INDIRECT N_2O EMISSIONS FROM MANAGED SOIL	
	3.D.1.1 Synthetic fertilizers	3.D.1.2 Organic N-fertilizers	3.D.1.3 Urine and dung deposited by grazing animal	3.D.1.4 Crop residues	3.D.1.5 N in mineral soils that is mineralized/ immobilized in association with loss of soil C	3.D.2.1 Atmospheric deposition	3.D.2.2 Nitrogen leaching and run-off
1990	1.746	0.500	0.068	0.617	0.000	0.632	1.569
1995	0.547	0.474	0.047	0.517	0.001	0.345	0.770
2000	0.665	0.416	0.029	0.320	0.001	0.337	0.596
2005	0.784	0.357	0.026	0.457	0.002	0.337	0.841
2010	0.837	0.317	0.030	0.346	0.002	0.335	1.244
2011	0.947	0.319	0.029	0.456	0.002	0.359	0.215
2012	0.794	0.306	0.032	0.389	0.001	0.321	0.217
2013	0.892	0.315	0.032	0.441	0.001	0.347	0.543
2014	0.935	0.340	0.034	0.569	0.001	0.368	0.804
2015	0.902	0.340	0.034	0.473	0.001	0.361	0.106
2016	0.992	0.271	0.034	0.593	0.001	0.351	0.672
2017	0.963	0.272	0.033	0.462	0.001	0.345	0.358
2018	1.013	0.281	0.036	0.510	0.001	0.361	0.096
2019	1.010	0.293	0.035	0.518	0.001	0.365	0.364
2020	1.003	0.296	0.035	0.552	0.001	0.364	0.518
2021	1.002	0.310	0.037	0.524	0.001	0.371	0.227
2022	0.906	0.333	0.037	0.436	0.001	0.360	0.058

Figure 5.21: *Trend in N_2O emissions (Gg) by subcategories within agricultural soils in 1990 – 2022*

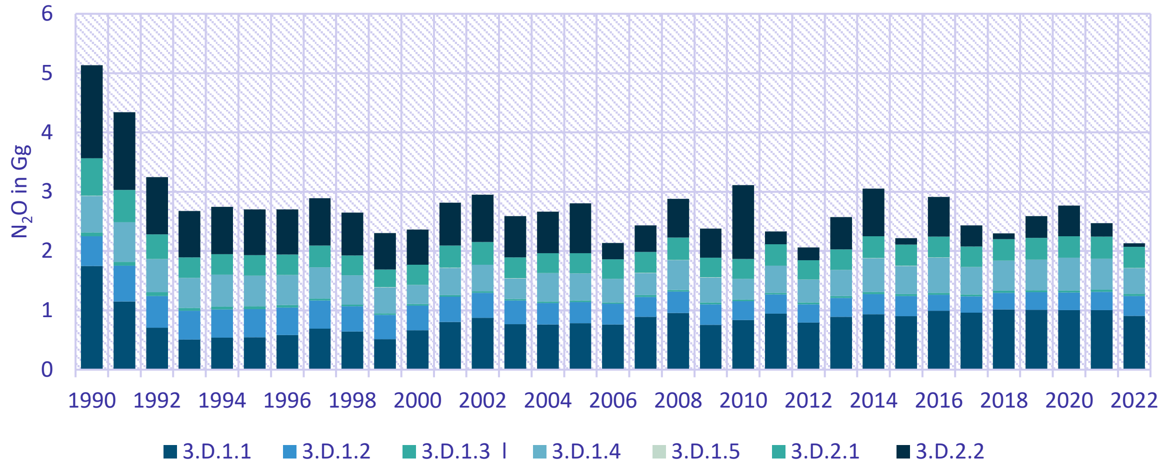
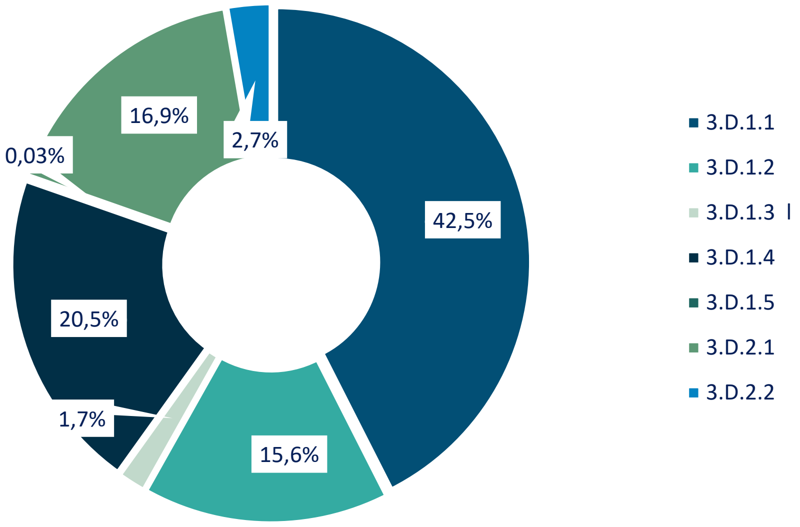


Figure 5.22 shows, that major share of emissions belongs to synthetic fertilizers use (42.5%), crop residues (20.5%), organic nitrogen fertilizers (15.6%) and indirect emissions from agricultural soils (19.6%).

Figure 5.22: *The share of aggregated emissions by categories within agricultural soils in 2022*



5.12.1. Inorganic Fertilizers (CRF 3.D.1.1)

The applied amounts of synthetic fertilizers into cultivated soils decreased in the last 15 years. Nowadays, the amount of synthetic fertilizers applied to the agricultural soils has increased again. This fact is the main driver in increasing emissions in the sector. The potential for the volatilization of ammonia emissions can vary in a very large range. The best information on NH_3 emissions from cultivated soils in the Slovak Republic is based on the applied nitrogen fertilizers. Emissions also depend on the type of fertilizers, soil parameters (pH), meteorological conditions, application technics and time of fertilizers application in relation to crop development. Information on applied nitrogen fertilizers was provided by the ŠÚ SR.

Methodological issues - method

Default emission factor was used from the IPCC 2019 RF (0.005 kg N_2O–N/kg N). Total N_2O emissions from using the synthetic fertilizers were 0.906 Gg in 2022. Tier 1 method was applied in combination with the desegregated default EF for dry climate. According to the prioritization plan, tier 2 approach will be implemented in 2025. Implementation is not processed yet due to missing geographical data on inorganic N fertilizer consumption (including Urea application).

Activity data

The Central Control and Testing Institute in Agriculture (UKSÚP) provided the data annually into the SHMÚ based on cooperation agreement between the both institutions. The UKSÚP collected data on farm level electronically. The farmers are obliged to report the amount of applied nitrogen into the UKSÚP each year. The UKSÚP as administrator of databases makes validation of data each year.

The consumption of synthetic fertilizers decreased during the last decade of the 20^{th} century, from 222 kt in 1990 to 115.4 kt in 2022 (- 48%). On the other hand, consumption of the synthetic fertilizers increased by 16% in 2022 compared to 2005 and decreased by almost -9.53% in comparison with the year 2021. Higher price of natural gas push to lower consumption of synthetic fertilizers.

Activity data on N input from the application of inorganic fertilizers to agricultural soils is summarized in ***Table 5.75***.

Table 5.75: *Input parameters and EFs in 3.D.1.1 - Inorganic N-Fertilizers in particular years*

YEAR	N-INPUT IN FERTILIZERS	EFs	N_2O EMISSIONS
	kg	*kg N_2O-N/kg N*	*Gg*
1990	222 255 000	0.005	1.746
1995	69 587 000	0.005	0.547
2000	84 609 000	0.005	0.665
2005	99 760 000	0.005	0.784
2010	106 513 000	0.005	0.837
2011	120 555 000	0.005	0.947
2012	101 004 000	0.005	0.794
2013	113 581 390	0.005	0.892
2014	119 036 050	0.005	0.935
2015	114 773 000	0.005	0.902
2016	126 235 769	0.005	0.992
2017	122 541 152	0.005	0.963
2018	128 976 885	0.005	1.013
2019	128 532 971	0.005	1.010
2020	127 676 520	0.005	1.003
2021	127 494 597	0.005	1.002
2022	115 346 776	0.005	0.906

5.12.2. Animal Manure Applied to Soil (CRF 3.D.1.2.a)

As domestic livestock produces a different kind of nitrogen inputs (liquid or solid) into the ecosystem, also the structure of domestic livestock is important (the ratio of different categories of domestic livestock) as well as the emissions from the AWMS. In addition, the production of nitrogen per head per year also plays a certain role.

Methodological issues – method

Managed manure nitrogen, available for application to managed soil (NMMS_Avb) was calculated based on the Equations 10.34(update), 10.344_A, 10.34_B (IPCC 2019 RF).

Losses are defined as losses of following gases N_2, NH_3, NO_x and N_2O. Losses are calculated according to the IPCC 2019 RF from the total amount of liquid, deep bedding, solid manure and manure managed in anaerobic digesters. Losses as $Frac_{lossMS}$ used for managed manure as are calculated in line with 3.B.2.5 categories and fractions were calculated from these both categories (equation 10.34_A. Fractions ($Frac_{FEED}$, $Frac_{FUEL}$, $Frac_{CNST}$) in the Equation 11.4 (IPCC 2019 RF) are considered zero. Managed manure nitrogen available for application to managed soils (NMMS_Avb) was calculated based on Equation 10.34 (IPCC 2019 RF). The case of straw-based systems N inputs with straw were also taken into account in the inventory according to the above mentioned equation. Straw N from pigs and poultry for deep litter was considered. The Hungarian value for poultry nitrogen content was used due to absent country specific study concerning of nitrogen content from bedding materials. Hungary is neighbouring country with similar climatic and agricultural conditions.

Table 5.76: *Nitrogen in bedding materials by animal category and manure management systems*

ANIMAL CATEGORY	N-CONTENT OF BEDDING MATERIALS BY MANURE MANAGEMENT SYSTEMS (kg N/head)	SOURCES
	DEEP LITTER	
Market swine	1.6	p. 10.66 of the IPCC 2006 GL
Poultry*	0.022	Expert judgement in accordance with Hungary inventory

**Poultry manure with bedding*

The calculated amount of nitrogen input from animal waste applied to soil was 38 550.5 t/N/year when the default EF = 0.005 kg N_2O-N/kg N was used. Total amount of N_2O emissions from animal excreta applied to soil was 0.303 Gg in 2022.

Table 5.77: *Input parameters and EFs in the category 3.D.1.2.a - Animal Manure in particular years*

YEAR	Total nitrogen from MM	Fraction of leached N	Fraction of volatized nitrogen	Nitrogen from bedding materials (pigs, poultry)	N input from manure applied to soils	EFs	Emissions
	kg N/Year	*%*	*%*	*Kg N/Year*	*kg N/ Year*	*kg N_2O-N/kg*	*Gg*
1990	108 362 687	0.013	0.372	415 531	62 706 801	0.005	0.493
1995	73 404 663	0.012	0.142	319 525	59 521 306	0.005	0.468
2000	61 362 188	0.012	0.114	309 934	51 481 279	0.005	0.404
2005	53 227 319	0.012	0.108	299 021	45 010 243	0.005	0.354
2010	43 850 511	0.012	0.113	233 091	36 868 950	0.005	0.290
2011	41 405 810	0.012	0.120	190 096	34 444 019	0.005	0.271
2012	42 667 569	0.012	0.119	202 753	35 583 157	0.005	0.280
2013	41 291 379	0.012	0.123	192 604	34 265 035	0.005	0.269
2014	42 751 453	0.012	0.118	226 830	35 742 407	0.005	0.281
2015	42 137 267	0.011	0.115	228 504	35 365 711	0.005	0.278
2016	40 119 536	0.012	0.116	207 206	33 585 603	0.005	0.264
2017	40 527 513	0.011	0.112	239 565	34 133 397	0.005	0.268
2018	41 844 662	0.011	0.113	253 338	35 210 076	0.005	0.277
2019	40 699 059	0.011	0.119	240 214	33 989 672	0.005	0.267
2020	41 283 588	0.011	0.122	221 479	34 367 903	0.005	0.270
2021	42 222 791	0.010	0.110	212 643	35 666 129	0.005	0.280
2022	45 162 578	0.010	0.101	181 063	38 550 465	0.005	0.303

Activity data

Livestock number and information on the AWMS are described in the **Chapter 5.9.1**. Direct inputs of nitrogen slightly vary according to the applied methodology. Based on the IPCC 2019 RF, total nitrogen excretion per liquid (4 623.6 t/N/year), per digesters (1 489.2 t/N/year) and solid system (21 290.5 t/N/year) in manure management were used for the estimation of total nitrogen input of manure applied to soil in 2022.

5.12.3. Sewage Sludge Applied to Soils (CRF 3.D.1.2.b)

Reduction of organic matter in the soil depends on the continuous decline of livestock production. The lack of organic fertilizers causes pressure to find alternative sources of organic fertilizers. Sewage sludge is one of the ways to resolve this issue. Sludge is a potential source of nutrients and organic matter. Sewage sludge must be stabilized and afterward applied to the soils. Sludge must be treated biologically, chemically or by heat, long-term storage or any other appropriate process. These processes cause a significant reduction in health risks and save the environment. Act No 188/2003 Coll. on application of sewage sludge and bottom sediments into soil regulates the application of sludge to agricultural soils. Sludge from domestic or urban treatment plants can be applied to agricultural soils.

Methodological issues – method

Tier 1 and default emission factor were used (0.005 kg N_2O-N/kg N) for the estimation of direct N_2O emissions from sewage sludge applied to soils.

The methodology is in accordance with the IPCC 2019 RF. Emissions were estimated by using these equations:

$$N_2O - N_{sewage\ sludge} = N_{sewage\ sludge} * P_N \text{ and } N_2O_{sewage\ sludge} = N_2O - N_{sewage\ sludge} * EF * \frac{44}{28}$$

Where: **N_2O-N**$_{sewage\ sludge}$ = input of pure nitrogen from sewage sludge applied into the soil in kg, **N**$_{sewage\ sludge}$ = amount of sludge from wastewater treatment in kg, **P_N** = weighted percentage of nitrogen from sewage sludge (3.31%), **EF** = default emission factor in kg N_2O-N/kg N

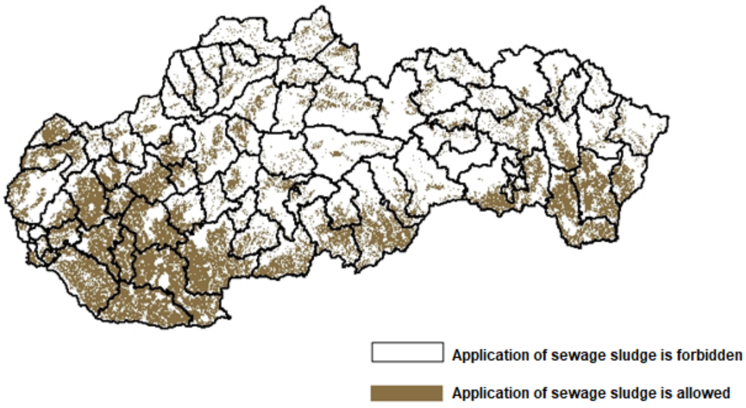
Table 5.78: *Input parameters and EFs used in the category 3.D.1.2.b - Sewage Sludge in particular years*

YEAR	MUNICIPAL SLUDGE	INDUSTRIAL SLUDGE	INPUT INTO SOIL	N-INPUT FROM SEWAGE SLUDGE	N_2O EMISSIONS
		t		*kg*	*Gg*
1990	6 832	3 160	9 992	330 732	0.0025986
1995	4 043	2 251	6 294	208 345	0.0016370
2000	1 254	1 342	2 597	85 957	0.0006754
2005	5 870	2 231	8 101	268 144	0.0021068
2010	923	1 102	2 025	67 023	0.0005266
2011	358	685	1 043	34 536	0.0002714
2012	1 254	478	1 732	57 340	0.0004505
2013	518	627	1 145	37 900	0.0002978
2014	8	688	696	23 021	0.0001809
2015	0	813	813	26 899	0.0002113
2016	0	1 134	1 134	37 523	0.0002948
2017	0	362	362	11 987	0.0000942
2018	0	287	287	9 513	0.0000747
2019	0	49	49	1 620	0.0000127
2020	0	1	1	32	0.0000003
2021	0	1	1	33	0.0000003
2022	0	1	1	33	0.0000003

Activity data

Activity data on sewage sludge consumption in agriculture (***Table 5.78***) is based on the data provided by the Water Research Institute (WRP) (applied sludge from municipal wastewater treatment plants) and the Ministry of Environment of the Slovak Republic (Industrial sludge). In 2022 submission, industrial sludge was implemented into inventory for the first time. The WRP collects data on nitrogen inputs (bottom up approach) into the soils. The Water Research Institute informed, that municipal sewage sludge was not applied into agricultural soils in years 2015 – 2022, therefore notation key NO was used. The data are consistent with the Waste sector. Missing data were extrapolated to enhance completeness before the year 2003 (municipal sewage sludge) and 2002 (Industrial sewage sludge), due to unavailable statistics. Percentage of pure nitrogen from sewage sludge was provided by the Guidelines for the Sewage Sludge Application by the Soil Science and Conservation Research Institute. According to the mentioned publication, the sludge contains 3.31% of the nitrogen.

Figure 5.23: *The map of sensitive areas of the Slovak Republic, where application of sludge is prohibited according to the Nitrate directive*



5.12.4. Other Organic Fertilizers Applied to Soils (CRF 3.D.1.2.c)

Compost is organic matter that has been decomposed in a process called composting. This process recycles various organic materials otherwise regarded as waste products and produces a soil fertilizer. It is used, for example, in gardens, landscaping, horticulture, urban agriculture and organic farming. The compost is beneficial for the land in many ways, including as a soil fertilizer, addition of vital humus or humic acids, and as a natural pesticide for soil. In ecosystems, compost is useful for erosion control, land and stream reclamation, wetland construction, and as landfill cover.

Methodological issues – method

Tier 1 (IPCC 2019 RF) and default emission factor (0.005 kg N_2O-N/kg N) were used for the estimation of direct N_2O emissions from compost applied to soils. Emissions were estimated, by using these equations:

Table 5.79: *Share of pure nitrogen from other nitrogen fertilizers in %*

TYPE OF FERTILIZERS	P_N	SOURCES
	%	
Fugate	0.92	*https://nasepole.sk/digestat-vo-vyzive-a-hnojeni-repky/*
Compost	0.7	*ÚKSÚP*
Natural harmony (organic waste from pharmaceutical production	1	*ÚKSÚP*
Hay	8.2	*https://nasepole.sk/dusikate-hnojenie-po-zbere-obilnin/*
Vitahum (organic - humus fertilizer made from natural substances)	1	*ÚKSÚP*
Green fertilizers	1	*ÚKSÚP*

Activity data

Other organic fertilizers applied to soils include the composted waste, digested slurry from digesters, compost and universal organic - humus fertilizer and green fertilizers. The Consumption is provided with total amount of organic waste into soils (OW) and the data (***Table 5.80)*** is provided by the UKSÚP. The Data are converted into nitrogen content (NC).

Data is available from 2000 to 2022. Other organic nitrogen fertilizers were applied to the soil even before the year 2000, but there are no available statistics. Missing data was extrapolated by linear extrapolation in excel spreadsheets.

Table 5.80: *Input parameters in the category 3.D.1.2.c - Other Organic Fertilizers applied to soils in particular years*

Year	Fugate		Compost		Natural Harmony		Hay		Vitahum		Green fertilizers	
	OW	NC	OW	NC	OW	NC	OW	NC	OW	NC	OW	NC
	tons											
1990	NO	NO	33 430	234	NO	NO	NO	NO	28 290	283	12 013	120
1991	NO	NO	34 303	336	NO	NO	NO	NO	26 501	265	11 752	118
1992	NO	NO	35 177	246	NO	NO	NO	NO	24 713	247	11 492	115
1993	NO	NO	36 050	252	NO	NO	NO	NO	22 924	229	11 231	112
1994	NO	NO	36 924	362	NO	NO	NO	NO	21 136	211	10 970	110
1995	NO	NO	37 797	265	NO	NO	NO	NO	19 348	193	10 709	107
1996	NO	NO	38 671	271	NO	NO	NO	NO	17 559	176	10 449	104
1997	NO	NO	39 544	388	NO	NO	NO	NO	15 771	158	10 188	102
1998	NO	NO	40 418	283	NO	NO	NO	NO	13 982	140	9 927	99
1999	NO	NO	41 291	289	NO	NO	NO	NO	12 194	122	9 666	97
2000	NO	NO	74 923	734	NO	NO	NO	NO	50 641	506	10 245	102
2001	NO	NO	40 885	286	NO	NO	NO	NO	54 338	543	18 285	183
2002	NO	NO	36 422	255	NO	NO	NO	NO	42 810	428	10 920	109
2003	NO	NO	34 225	240	NO	NO	NO	NO	9 321	93	6 206	62
2004	NO	NO	42 904	300	NO	NO	NO	NO	2 845	28	18 990	190
2005	NO	NO	7 006	49	NO	NO	NO	NO	3 552	36	5 905	59
2006	NO	NO	13 878	97	NO	NO	NO	NO	10 828	108	7 006	70
2007	NO	NO	21 762	152	NO	NO	8 868	727	8 758	88	3 540	35
2008	NO	NO	21 317	149	NO	NO	90 977	7 460	7 185	72	13 534	135
2009	NO	NO	25 364	178	NO	NO	68 637	5 628	195	2	16 642	166
2010	NO	NO	40 097	281	NO	NO	36 774	3 015	4 999	50	11 956	120
2011	NO	NO	50 583	354	5 367	54	66 704	5 470	2 261	23	25 837	258
2012	108181	995	18 291	128	7 132	71	25 020	2 052	NO	NO	1 401	14
2013	301580	2 775	63 145	442	5 896	59	30 698	2 517	500	5	2 547	25
2014	382111	3 515	85 907	601	1 693	17	40 912	3 355	NO	NO	6 375	64
2015	543489	5 000	90 967	637	555	6	26 554	2 177	1 015	10	4 036	40
2016	388174	577	46 701	318	NO	NO	NO	NO	NO	NO	NO	NO
2017	32 517	163	46 649	327	NO	NO	NO	NO	17 928	36	NO	NO
2018	28 406	102	43 257	411	NO	NO	NO	NO	1 345	23	NO	NO
2019	776427	3 057	37 618	300	NO	NO	NO	NO	NO	NO	NO	NO
2020	800393	2 936	43 557	250	NO	NO	NO	NO	NO	NO	34 089	83
2021	796945	3 347	60 047	401	NO	NO	NO	NO	NO	NO	NO	NO
2022	36 992	3 403	5 978	418	-	-	-	-	-	-	-	-

5.12.5. Urine and Dung Deposited by Grazing Animals (CRF 3.D.1.3)

Pasture is typical for some livestock categories. Animals as sheep, goats, horses and beef cattle are mainly grazed during spring, summer and autumn in the small farms. Animals are housed during the winter. In 2024 submission for the first time pasture from poultry was introduce. Geese and Ducks are grazed 183 days per year.

Methodological issues – method

The N_2O estimation from pasture is based on default emission factors (0.004 kg N_2O-N/kg N for cattle and poultry and 0.003 kg N_2O-N/kg N for sheep and other animals). Nitrogen excretions per AWMS were estimated in manure management category. Total nitrogen from pasture was 6 259.2 t/N/year in

2022. Total N_2O emissions from pasture were 0.04 Gg of N_2O in 2022. This category is estimated in conjunction with the category 3.B.2.

Table 5.81: *Input parameters and EFs in the category 3.D.1.3 - Urine and Dung Deposited by Grazing Animals in particular years*

YEAR	N-EXCRETION ON PASTURE	EFs	N_2O EMISSIONS
	kg	*kg N_2O-N/kg N*	*Gg*
1990	11 459 399	0.00	0.07
1995	7 950 284	0.00	0.05
2000	4 966 441	0.00	0.03
2005	4 594 925	0.00	0.03
2010	5 171 435	0.00	0.03
2011	5 109 323	0.00	0.03
2012	5 527 423	0.00	0.03
2013	5 595 594	0.00	0.03
2014	5 881 854	0.00	0.03
2015	5 900 678	0.00	0.03
2016	5 796 313	0.00	0.03
2017	5 593 810	0.00	0.03
2018	6 138 114	0.00	0.04
2019	5 999 541	0.00	0.035
2020	5 825 345	0.00	0.03
2021	6 161 192	0.00	0.04
2022	6 259 236	0.00	0.037

Activity data

It is supposed that sheep, goats and horses can stay on pasture for 200 days, 41% of non-dairy cattle stays only for 150 days. The statistical research concerning the amount of pastoral biomass consumed by breeding animals is currently unavailable in Slovakia.

Results of the analysis of different AWMS were used for the calculation of nitrogen input from animal husbandry into N-cycle. This analysis was based on the results collected from questionnaires of the 222 agricultural subjects (21.3% of total subjects in Slovakia). These subjects cultivated 14.7% of total agricultural land and 15.2% of arable land. Duration of the grazing period can vary significantly depending on weather conditions and regions. Reliable data for statistical evaluation is not available, but significant differences can be found in this regard. N_2O emissions from pasture were based on the proportion of the pasture for housing that was made by the NPPC-VÚŽV. The proportions of the pasture are demonstrated in the **Chapter 5.9.1**. Number of animals are summarized in ***Table 5.43***. Activity data in this category are consistent with the activity data used for estimation in category 3.B.2.

5.12.6. Crop Residue (CRF 3.D.1.4)

Directly after incorporation of the crop residues into the soil, the multilateral interactions between organic compounds and nutrients present in the residues with the mineral and organic components of soil take place. The knowledge of nutrient potential in crop residues by crop rotation are mostly actual in the present requirements of sustainable land use - greening in plant production. Incorporation of the crop residues into the soil is used as sustainable agricultural practice, due to high nutrition potential.

Table 5.82: *Input parameters and EFs in the category 3.D.1.4 - Crop Residue in particular years*

YEAR	HARVESTED AREA	CROP $_{(T)}$	CROP RESIDUES	EFs	N_2O EMISSIONS
	ha	*kg d.m./ha*	*kg N/year*	*kg N_2O-N/kg N*	*Gg*
1990	2 147 737	67 462	78 466 264	0.005	0.617
1995	2 152 852	63 386	65 755 818	0.005	0.517

YEAR	HARVESTED AREA	CROP $_{(T)}$	CROP RESIDUES	EFs	N_2O EMISSIONS
	ha	*kg d.m./ha*	*kg N/year*	*kg N_2O-N/kg N*	*Gg*
2000	2 080 004	45 812	40 680 816	0.005	0.320
2005	1 721 125	68 071	58 191 208	0.005	0.457
2010	1 617 786	54 870	44 086 328	0.005	0.346
2011	1 680 333	71 666	58 053 855	0.005	0.456
2012	1 703 613	63 316	49 566 275	0.005	0.389
2013	1 716 326	63 796	56 186 635	0.005	0.441
2014	1 745 299	79 312	72 472 343	0.005	0.569
2015	1 728 043	66 540	60 237 610	0.005	0.473
2016	1 717 480	85 743	75 505 655	0.005	0.593
2017	1 722 049	67 595	58 749 087	0.005	0.462
2018	1 725 424	76 863	64 962 867	0.005	0.510
2019	1 750 468	76 280	65 934 371	0.005	0.518
2020	1 736 499	81 026	70 272 930	0.005	0.552
2021	1 741 541	74 003	66 749 560	0.005	0.524
2022	1 733 440	62 543	55 481 397	0.005	0.436

Total N_2O emissions from crop residues represented 0.44 Gg of N_2O from 55 481 397 kg of nitrogen in crop residues returned to soils in 2022. Total harvested area (wheat, ray, barley, oat, maize, potato, sugar beet, oil plants, tobacco, maize for silage, leguminous, fodder leguminous, soya, meadows) increased in comparison with the previous year. In 2022, harvested area was 1 733 kha.

Methodological issues – method

According to the IPCC 2019 RF, nitrogen input from crop residues was estimated used by equation 11.6 p.11.16.

There is no comprehensive survey on the amount of crop residues burned as fuel in the Slovak Republic. Therefore, no removal from the burning of fuel was assumed. Also, data on fraction of above-ground residues of crop removed annually for a purpose such as feed bedding and construction is not available. The seams and leaves are usually utilized as a fodder of domestic livestock. Data on straw exported abroad are missing.

Country specific nutrition potential: The country specific value for sugar beet regarding potential nitrogen nutrition was considered instead of the IPCC default method which is not accurate for the Slovak conditions. According to the national publication *Postharvest residues of sugar beet and their role in the nutrient cycle by Stanislav Torma*[8], 20 kg N/ha for sugar beet was taken as country specific value. The default values were considered for other crops. The values are presented in ***Table 5.83***.

Table 5.83: *Parameters used to estimate emissions from crop residues*

CROP TYPE	$N_{(AG)}$	$N_{(BG)}$	SLOPE	INTERCEPT	$RS_{(T)a}$	DRY MATTER FRACTION OF HARVESTED PRODUCTS (DRY)	NUTRITION POTENTIAL IN CROP RESIDUES
	kg N (kg d.m.)$^{-1}$				kg d.m. (kg d.m.)$^{-1}$		*kg N/ha*
Wheat	0.006	0.009	1.510	0.520	0.230	0.890	-
Rye	0.005	0.011	1.090	0.880	0.220	0.880	-
Barley	0.007	0.014	0.980	0.590	0.220	0.890	-

[8] Torma, S.; Vilček, J.: Postharvest residues of sugar beet and their role in the nutrient cycle. Listy Cukrovarnické a Reparské; Prague Vol. 133, Is. 9-10, p. 285-287, 2017, in Slovak.

CROP TYPE	$N_{(AG)}$	$N_{(BG)}$	SLOPE	INTERCEPT	$RS_{(T)a}$	DRY MATTER FRACTION OF HARVESTED PRODUCTS (DRY)	NUTRITION POTENTIAL IN CROP RESIDUES
	kg N (kg d.m.)$^{-1}$				kg d.m. (kg d.m.)$^{-1}$		*kg N/ha*
Oat	0.007	0.008	0.910	0.890	0.250	0.890	-
Maize	0.006	0.007	1.030	0.610	0.220	0.870	-
Potato	0.019	0.014	0.100	1.060	0.200	0.220	-
Sugar beet							20
Oil plants	0.008	0.008	1.130	0.850	0.190	0.910	-
Tobacco	0.015	0.012	0.300	0.000	0.540	0.900	-
Maize for silage	0.015	0.007	0.000	0.000	0.540	0.900	-
Meadows	0.015	0.012	0.300	0.000	0.800	0.900	-
Peas	0.008	0.008	1.130	0.850	0.190	0.910	-
Lens	0.008	0.008	1.130	0.850	0.190	0.910	-
Beans	0.008	0.008	1.130	0.850	0.190	0.910	-
Other leguminous plants	0.027	0.022	0.300	0.000	0.400	0.900	-
Soya	0.008	0.008	0.930	1.350	0.190	0.910	-
Clover	0.025	0.016	0.300	0.000	0.800	0.900	-
Alfaalfa	0.027	0.019	0.290	0.000	0.400	0.900	-

Country specific FRACRenew: Equation 11.6 (IPCC 2019 RF) requires use the fractions of the total area of crops, that is renewed annually. For annual crops, $Frac_{Renew}$ equals to 1 and $Frac_{Renew}$ equals to 0.2. These assumptions are for the forage/pasture five-years renewal frequency. The perennial forage such as alfalfa and clover grows in 4 and 3 rotations. The topic was discussed with experts from the National Agricultural and Food Centre – The Research Institute of Grassland and Mountain Farming. Information published in the article - *Growing and Utilization of Grassland and Clover grassland on Arable Land of Foothill and Mountain Areas* (in Slovak) *by Mariana Jančová* assumed clover rotation in 3-years cycle and alfalfa rotation in 4-years cycle. Clover and alfalfa are grown in monocultures for seed growing purpose. In addition, $Frac_{Renew}$ equal to 0.2 was assumed for the forage/pasture renewal, assuming five-year renewal frequency. These values were based on expert judgment.

Country specific $FRAC_{Remove}$: Slovak inventory uses a N-flow approach to calculate the emissions from 3.B and 3.D, which is in line with the IPCC 2006 Guidelines, the N_2O emissions from straw used for bedding is reported in CRF 3.D.a.2 Animal manure applied to soils, and this amount of N was taken into account in the value of $Frac_{Remove}$. The value of $Frac_{Remove}$ was calculated for all year from the N content of straw used for bedding divided by the sum of the N content of the above-ground biomass of grain crops of which straw is used for bedding (wheat, barley, rye and oats). The amount of straw used as bedding material was taken from Articles: *Livestock breeding*[9] by Vojtech Brestenský and Storage of agricultural fertilizers[10] by Vojtech Brestenský (in Slovak) and Removal and storage of fertilizers by Vojtech Brestenský (in Slovak). Publications were provided litter requirements per species and categories per day in kilograms. Nitrogen input from straw was not available in presented publications. Nitrogen input from straw was taken from article Nitrogen fertilization after harvesting cereals[11] by Štefan

[9] Brestenský V., a kol. 2015. Chov hospodárskych zvierat. Research Institute of Animal Production, 2015 http://www.vuzv.sk/pdf/chov_hz.pdf. ISBN 978-80-89418-41-1

[10] Brestenský, V., Botto, Ľ. 2015. Storage of agricultural Fertilizer., 2015: http://www.vuzv.sk/poradcovia/brestensky/hosp-hnoj.pdf

[11] Gáborík, Š., Nitrogen fertilization after harvesting cereals, Agroinstitute, 2019: https://nasepole.sk/dusikate-hnojenie-po-zbere-obilnin

Gáborík (in Slovak). In aforementioned article, average nitrogen inputs from straw in selected cereals (wheat, barley) were estimated as 0.82%. $Frac_{Remove}$ parameter for silage maize was implemented while only below-ground biomass was considered. It is assumed, that maize for silage is used for fodder purpose in Slovakia.

According to the ERT recommendation A.4 from the final ARR 2022, the amount of forage consumed by livestock was removed from below-ground biomass in meadows. Maize for silage is using for biogas production in biogas stations. Based on expert judgement of ERT and country expert judgement $Frac_{Remove}$ for maize is 1. According to the publication Guidelines for the support for selected non-projects measures[12], the farmer is obliged to maintain agricultural areas in a condition suitable for grazing or cultivation in accordance with § 5 of the SR Government Regulation no. 342/2014 Coll. Areas of permanent grassland or meadows must be managed in accordance with agro-technical practice. For areas of meadows, this means maintaining all areas by mowing, grazing and additionally by mulching according to altitude and in following terms: Mowing 4 times per year from 0-800 meters above sea level, grazing 4 times per year from 0-800 meters above sea level and mulching as well. Based on presented information, it was impossible to derivate share for $Frac_{Remove}$. The review analysis of inventories was done and only in Polish inventory $Frac_{Remove}$ parameter was derivate. Poland is neighbouring country with similar agricultural conditions and value was taken to Slovak inventory. Used $Frac_{Remove}$ and $Frac_{Renew}$ values are presented in ***Tables 5.84*** and ***5.85***.

Table 5.84: *Parameters used to estimate emissions from crop residues*

TYPE OF CROP	$FRAC_{Renew}$	$FRAC_{Remove}$
WHEAT	1	0.163
RYE	1	0.163
BARLEY	1	0.163
OAT	1	0.163
MAIZE	1	0
POTATO	1	0
SUGAR BEET	1	0
OIL PLANTS	1	0
TOBACCO	1	0
MAIZE FOR SILAGE	1	1
MEADOWS	0.20	0.95
PEAS	1	0
LENS	1	0
BEANS	1	0
OTHER LEGUMINOUS PLANTS	1	0
SOYA	1	0
CLOVER	0.34	0
ALFALFA	0.25	0

[12] PPA, 2015. Guidelines for the support for selected non-project measures, Bratislava, The Agricultural Paying Agency: https://www.apa.sk/priame-a-agro-environmentalne-podpory-oznamenia/informan-prruka-pre-iadateov-o-podporu-pre-vybran-neprojektov-opatrenia-prv-sr-2014-2020/6446

Table 5.85: *Nitrogen in bedding materials and $Frac_{Remove}$ in particular years*

YEAR	N INPUT FROM BEDDING MATERIALS	N CONTENT OF ABOVE-GROUND BIOMASS OF GRAIN CROPS USED AS BEDDING MATERIAL	$Frac_{Remove}$ (WHEAT, BARLEY, RYE, OAT)
	kg		*%*
1990	415 531	6 167 765	0.07
1995	319 525	5 038 292	0.06
2000	309 934	3 677 159	0.08
2005	299 021	2 921 960	0.10
2010	233 091	1 961 914	0.12
2011	190 096	1 657 890	0.11
2012	202 753	1 789 406	0.11
2013	192 604	1 779 498	0.11
2014	226 830	1 780 288	0.13
2015	228 504	1 818 204	0.13
2016	207 206	1 655 661	0.13
2017	239 565	1 742 469	0.14
2018	253 338	1 828 406	0.14
2019	240 214	1 704 719	0.14
2020	221 479	1 487 173	0.15
2021	212 643	1 316 377	0.16
2022	181 063	1 112 213	0.16

Activity data

Activity data on crop yields and annual area of harvested crops were taken from the ŠÚ SR. To estimate the N added to soils from crop residues and forage/pasture renewal, mainly default parameters from Table 11.2, 11.1A (IPCC 2019 RF) were used. Since yield statistics are reported as field-dry weight, a correction factor was applied to estimate dry matter yields in accordance with the Equation 11.7 IPCC 2019 RF):

$$\mathrm{Crop}_{(T)} = \mathrm{Yield\ Fresh}_{(T)} * \mathrm{DRY}$$

Where: **Crop**$_{(T)}$ = harvested dry matter yield for crop T in kg d.m/ha, **Yield Fresh**$_{(T)}$ = kg of fresh weight per ha, **DRY** = dry matter fraction of harvested crop T in kg of d.m.

Table 5.86: *Growing areas and total nitrogen in crops and legumes in 2022*

CROP		HARVESTED AREA	HARVESTED ANNUAL CROP YIELD CROP $_{(T)}$	ANNUAL AMOUNT OF N IN CROP RESIDUES
		ha	*kg d.m. ha^{-1}*	*kg N yr^{-1}*
CEREALS	Wheat	411 694	4 428	23 299 041
	Ray	8 964	3 124	269 428
	Barley	109 125	4 539	5 865 351
	Oat	10 179	2 115	197 149
OTHER	Maize	158 690	3 748	5 536 193
	Potato	5 734	5 012	143 253
	Sugar beet	19 484	0	389 673
	Oil plants	293 127	2 226	8 011 822
	Tobacco	8	353	37
	Maize for silage	70 800	20 099	5 379 054
	Meadows	503 811	1 850	2 536 560
NITROGEN FIXING CROPS	Peas	5 829	2 720	194 688
	Lens	113	1 469	2 032
	Beans	118	1 184	1 717

CROP		HARVESTED AREA	HARVESTED ANNUAL CROP YIELD CROP (T)	ANNUAL AMOUNT OF N IN CROP RESIDUES
		ha	*kg d.m. ha⁻¹*	*kg N yr⁻¹*
	Other leguminous plants	8 802	1 073	184 516
	Soya	66 651	1 318	912 002
	Clover	11 977	3 117	487 038
	Alfalfa	48 335	4 169	2 071 842
2022 TOTAL		**1 733 440**	**62 543**	**55 481 397**

5.12.7. Mineralization or Immobilization Associated with Loss or Gain of Soil Organic Matter (CRF 3.D.1.5)

Emissions are reported in the categories 3.D.1.5 – Mineralization or immobilization associated with loss or gain of soil organic matter for the first time in 2021 submission.

Methodological issues – method

F_{SOM} refers to the amount of N mineralised from loss in soil organic C in mineral soils through land-use change or management practices. In order to estimate the N mineralised as consequence of this loss of soil carbon, the Equation 11.8 of IPCC 2006 Guidelines was applied:

$$F_{SOM} = \sum_{LU}\left[\left(\Delta C_{Mineral,LU} * \frac{1}{R}\right) * 1000\right]$$

F_{SOM} = the net annual amount of N mineralized in mineral soils as a result of loss of soil carbon through change in land use or management, kg N, Δ**$C_{Mineral, LU}$** = average annual loss of soil carbon for each land-use type (LU), tonnes, **R** = C:N ratio of the soil organic matter. **LU** = land-use and/or management system type

The N_2O estimation from mineralization and immobilization of nitrogen is based on default emission factors according to table 11.1 of the IPCC 2019 RF (0.005 kg N_2O–N/kg N). A default value of 15 for the C:N ratio (R) was applied according to the p.11.20 IPCC 2019 RF. Used activity data is consistent with the LULUCF sector category 4(III) – Direct N_2O emissions from N mineralization/immobilization.

Activity data

The activity data was taken from the carbon loss from management changes under 4.B.1 - Cropland Remaining Cropland/mineral soils. These carbon losses calculated in the LULUCF sector based on the detailed land-use matrices were used as activity data to calculate the N-losses due to mineralization.

Table 5.87: *Activity data and emissions in the category 3.D.1.5 in 1990 – 2022*

YEAR	N IN MINERAL SOILS THAT IS MINERALIZED/IMMOBILIZED IN ASSOCIATION WITH LOSS OF SOIL C	3.D.1.5 - MINERALIZATION/IMMOBILIZATION ASSOCIATED WITH LOSS/GAIN OF SOIL ORGANIC MATTER
	kg/year	*Gg*
1990	30 760	0.0002
1995	102 840	0.0008
2000	157 707	0.0012
2005	206 873	0.0016
2010	208 013	0.0016
2011	202 693	0.0016
2012	188 440	0.0015
2013	176 693	0.0014
2014	168 233	0.0013
2015	167 027	0.0013
2016	160 667	0.0013
2017	158 000	0.0012

YEAR	N IN MINERAL SOILS THAT IS MINERALIZED/IMMOBILIZED IN ASSOCIATION WITH LOSS OF SOIL C	3.D.1.5 - MINERALIZATION/IMMOBILIZATION ASSOCIATED WITH LOSS/GAIN OF SOIL ORGANIC MATTER
	kg/year	*Gg*
2018	143 753	0.0011
2019	121 420	0.0010
2020	116 126	0.0009
2021	92 442	0.0007
2022	83 590	0.0007

5.12.8. Cultivation of Organic Soils (CRF 3.D.1.6)

The area of histosols is very limited in the Slovak Republic. The area of histosols in agricultural area was 450 ha in 2022 and is constant in time series. Emissions from this source are below the threshold of significance for all years as documented in ***Table 5.88***. Therefore, notation key 'NE' is reported for the N_2O emissions in CRF Table 3.D. Used activity data is consistent with the LULUCF sector.

Table 5.88: *Activity data, emission factors and emissions from histosols in particular years*

YEAR	AREA	EFs	N_2O EMISSIONS	GHG Total without LULUCF with indirect	Threshold (0.05%)	Impact on GHG inventory in individual years
	ha	*kg N_2O-N/ha^{-1}*	*Gg*	*Gg*	*%*	*%*
1990	450	0.029	0.0056571	73 455	36.73	0.00002
1995	450	0.029	0.0056571	53 180	26.59	0.00003
2000	450	0.029	0.0056571	48 904	24.45	0.00003
2005	450	0.029	0.0056571	50 682	25.34	0.00003
2010	450	0.029	0.0056571	45 889	22.94	0.00004
2015	450	0.029	0.0056571	40 842	20.42	0.00004
2016	450	0.029	0.0056571	41 279	20.64	0.00004
2017	450	0.029	0.0056571	42 402	21.20	0.00004
2018	450	0.029	0.0056571	42 219	21.11	0.00004
2019	450	0.029	0.0056571	39 911	19.96	0.00004
2020	450	0.029	0.0056571	37 177	18.59	0.00005
2021	450	0.029	0.0056571	41 206	20.60	0.00004
2022	450	0.029	0.0056571	37 052	18.53	0.00005

5.12.9. Atmospheric Deposition (CRF 3.D.2.1)

This part of N_2O emissions resulted from the processes of atmospheric deposition of ammonia and NO_x, as well as due to the transformation of nitrogen from leaching and runoff losses. Because of the decrease in direct nitrogen input to the soil, the indirect emissions decreased during the evaluated period, too. Total indirect emissions from atmospheric deposition were 0.36 Gg in 2022, which were -43% lower compared to 1990 and -2.9% lower compared to previous year.

Methodological issues – method

Tier 1 approach and default emission factor were used for estimation of indirect N_2O emissions from atmospheric deposition. This category is estimated in conjunction with the category 3.B - Manure Management. Emissions were estimated following this equation:

$$N_2O_{(ATD)} = [(F_{SN} * Frac_{GASF}) + ((F_{ON} + F_{PRP}) * Frac_{GASM})] * EF_4 * \frac{44}{28}$$

Where: $\mathbf{N_2O_{(ATD)}}$ = annual amounts of N_2O emissions from atmospheric deposition of N volatilised from managed soils in kg, $\mathbf{F_{SN}}$ = annual N amount of synthetic fertilisers applied to soils in regions in kg, $\mathbf{F_{ON}}$ = annual amount of managed animal manure and sewage sludge applied to soils in kg N, $\mathbf{F_{PRP}}$ = annual amount of urine and dung N deposited by grazing animals in kg, $\mathbf{Frac_{GASF}}$ = fraction of synthetic fertiliser N that volatilised as NH_3 and NO_x kg volatilised in kg of N applied (added), $\mathbf{Frac_{GASM}}$ = fraction of applied organic N fertilizer and urine & dung deposited by grazing animals in kg N volatilised as NH_3 and NO_x, **EF_4** = emission factor for N_2O emissions from atmospheric deposition in kg $N\text{-}N_2O$ on soils and water surfaces (kg NH_3-N + NO_x-N volatilised)

The mean value for leaching of nitrogen varies in the range of 7-10 kg/ha/ year (7% of N-inputs) in national conditions (Bielek, 1998). The IPCC default emission factor (0.010 kg N_2O-N/kg N) was used in time-series. It is assumed, that 10% of nitrogen input from synthetic fertilizers applied on soil volatilizes (NH_3 and NO_x) and 20% of nitrogen from manure applied on soil volatilizes.

Activity data

Activity data in this category is consistent with the activity data in the categories 3.D.1.1 – Synthetic Fertilizers and 3.D.1.2 – Animal Manure Applied to Soil. ***Table 5.89*** shows time series of activity data, emission factors and N_2O emissions in this category.

Table 5.89: *Input parameters, EFs and N_2O emissions in 3.D.2.1 - Atmospheric Deposition in particular years*

YEAR	TOTAL VOLATILIZED N	EFs	N_2O EMISSIONS
	kg	*kg N_2O-N/kg N*	*Gg*
1990	40 226 183	0.01	0.63
1995	21 986 038	0.01	0.35
2000	21 461 114	0.01	0.34
2005	21 477 153	0.01	0.34
2010	21 286 775	0.01	0.33
2011	22 867 781	0.01	0.36
2012	20 440 356	0.01	0.32
2013	22 095 514	0.01	0.35
2014	23 425 860	0.01	0.37
2015	22 949 397	0.01	0.36
2016	22 352 076	0.01	0.35
2017	21 935 023	0.01	0.34
2018	22 985 054	0.01	0.36
2019	23 241 640	0.01	0.37
2020	23 171 444	0.01	0.36
2021	23 595 284	0.01	0.37
2022	22 900 758	0.01	0.36

5.12.10. Nitrogen Leaching and Run-off (CRF 3.D.2.2)

Total losses in soils were 1.5% of nitrogen input due to leaching, runoff, and erosion in the Slovak Republic, which is country specific value. Country specific methodology for estimation of $Frac_{Leach\text{-}National}$ was implemented into the inventory during 2022 submission according to continual improvement of emission estimation. In 2021, used methodology was published in the international publication Atmosphere[13].

Total indirect emissions from nitrogen leaching and run-off were 0.065 Gg, which is more than 86% less than 1990 value and -71% compared to previous year. After 2005, the value of FracLeach(national) has a dynamic character due to the unstable trend of the wet area - alternation of very dry (low FracLeach-national) and very humid years (high $Frac_{Leach\text{-}national}$), which may be caused by changing climatic conditions in Slovakia over the last 30 years - floods (2010) and drought (2015,2022). Please see

[13] Estimation of N_2O emissions from the agricultural soils and determination of nitrogen leakages. Atmosphere. Land-Atmosphere Interactions: Biogeophysical and Biogeochemical Feedbacks, 2020, Zv. 11: https://doi.org/10.3390/atmos11060552

Table 5.91 and ***Figure 5.25***. For more information on national study, please see reference 9 with the link to the scientific article in Atmosphere (p. 311).

Methodological issues – method

Tier 2 method and default emission factor were used for the estimation of indirect N_2O emissions from nitrogen leaching and run-off. This category is estimated in conjunction with category 3.B.2. Emissions were estimated following the equation:

$$N_2O_{(L)} = (F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}) * Frac_{LEACH-(H)} * EF_5 * \frac{44}{28}$$

Where: $\mathbf{N_2O_{(L)}}$ = annual amount of N_2O emissions produced from leaching and run-off of N additions to managed soils in kg, $\mathbf{F_{SN}}$ = annual amount of synthetic fertilizer N applied to soils in kg N, $\mathbf{F_{ON}}$ = annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, where leaching and run-off occurs in kg N, $\mathbf{F_{SOM}}$ = 0, $\mathbf{F_{PRP}}$ = annual amount of urine and dung N deposited by grazing animals where leaching and run-off occurs in kg N, $\mathbf{F_{CR}}$ = amount of N in crop residues including N-fixing crops here leaching a run-off occurs in kg N, $\mathbf{Frac_{LEACH-(H)}}$ = fraction of all N added in managed soils, where leaching run-off occurs, that is through leaching and run-off in kg of N additions, $\mathbf{EF_5}$ = emission factor for N_2O emissions from N leaching and run-off in kg N_2O-N (kg N leached and run-off)

Default emission factor (0.011 kg N_2O-N/kg N) was used for time series.

According to *Mosier et al*, the suggested value of $Frac_{LEACH}$ is 30%. Value is recommended for calculation of N_2O emissions through leaching in the IPCC 2019 GL where it is defined that for the areas with active irrigation and areas where the total precipitation is for a short time higher than evaporation, the value 30% of the proportion of nitrogen leached out of the utilized agricultural land ($Frac_{LEACH}$) is used. For dryland regions, where precipitation and irrigation are lower than evapotranspiration throughout most of the year, leaching is unlikely to occur, $Frac_{LEACH}$ is equal to zero.

Inclusion of irrigated areas and humid areas modify the default nitrogen leached from arable land and grassland $Frac_{LEACH}$ to the country specific value according to the equation:

$$Frac_{LEACH_{NATIONAL}} = (Frac_{IRR} + Frac_{WET}) * Frac_{LEACH}$$

Where: $\mathbf{Frac_{IRR}}$ = the proportion of irrigated areas to the total agricultural land area, $\mathbf{Frac_{WET}}$ = share of the humid area to the total area of arable land and grassland in %, $\mathbf{FracL_{EACHNATIONAL}}$ = the national value of the proportion of the leached nitrogen from the cultivated soil in %.

Analysis of Irrigated Areas in Slovakia

The share of irrigated areas in Slovakia was derived from the official statistics published by the Hydromelioration, the state enterprise. Area for particular years 1990 – 2002 was not available, therefore, the data gap was modelled using linear extrapolation tool in Excel. Obtained data were compared with the EUROSTAT datasets. Identified data gaps and inconsistencies are shown in ***Table 5.90***. The total of the utilized agricultural area was taken from the official statistics of the Statistical Office of the Slovak Republic. For the correct determination of the proportion of irrigated areas, it was important to distinguish the type of irrigation. In the case of drip irrigation, water is gradually soaked into the soil, and no nitrogen leaching occurs. Therefore, drip irrigation areas were excluded from the analysis. From the statistics it is visible, that the proportion of irrigated areas in Slovakia is decreasing due to the obsolescence of the irrigation network, i. e. decrease by 86.4% in 2021 compared to 1990. Statistical data about irrigated areas could not be fully verified because only Hydromelioration publishes this type of data in its annual reports. The Statistical Office of the Slovak Republic did not publish such data type and EUROSTAT published only an incomplete data on proportion of irrigated area (proportions are available for 2006, 2008, 2011 and 2014).

In 2022, total irrigated area in Slovakia was 55 393 hectares, representing only 4.2% of agricultural land. The proportion of irrigated areas to the total utilized agricultural areas is listed in ***Table 5.90.***

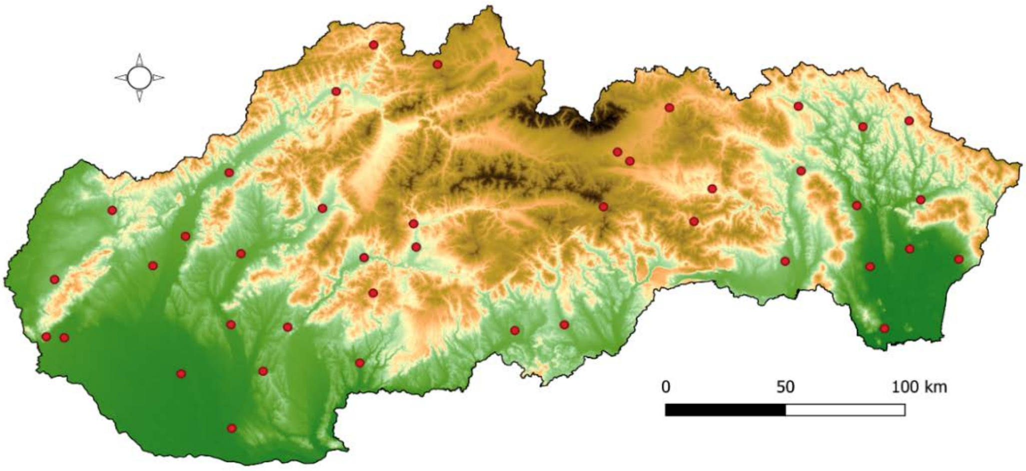
Table 5.90: The proportion of irrigated areas to the total utilized agricultural areas

YEAR	TOTAL IRRIGATED AREAS	UTILIZED AGRICULTURAL AREAS	SHARE OF IRRIGATED AREAS TO THE TOTAL AREAS OF AGRICULTURAL USE $FRAC_{IRR}$	SHARE OF IRRIGATED AREAS ACCORDING TO EUROSTAT
	ha		%	
1990	406 138	1 473 453	27.6%	
1995	348 888	1 487 714	23.5%	
2000	291 638	1 507 178	19.3%	
2001	280 188	1 502 051	18.7%	
2005	147 519	1 504 147	9.8 %	
2010	206 523	1 501 997	13.7 %	
2011	194 215	1 500 905	12.9 %	0.8 %
2012	187 574	1 499 568	12.5 %	
2013	168 277	1 498 986	11.2 %	
2014	154698	1 498 119	10.3 %	1.3 %
2015	62 239	1 495 789	4.2 %	
2016	60 818	1 494 900	4.1 %	
2017	54 421	1 494 566	3.6 %	
2018	56 408	1 406 399	4.0%	
2019	54 952	1 348 919	4.1%	
2020	23 441	1 346 047	1.7%	-
2021	55 393	1 347 023	4.2%	-
2022	25 887	1 403 864	1.8%	-

Estimation of humid areas in Slovakia

Climatic parameters, evapotranspiration and precipitation (***Figure 5.24***) were used to estimate humid areas in Slovakia. Detailed data were obtained from 41 professional meteorological stations operated by the SHMÚ. Data were analysed and aggregated to monthly and annual averages for purposes of the analysis.

Figure 5.24: *Network of meteorological stations in Slovakia*



The evaporation in agricultural areas occurs mainly through evapotranspiration (ET_0) and depends on meteorological conditions, soil characteristics, farming practices and crop types. It means that evapotranspiration can vary within the country or in time and cannot be expressed by one single representative value. For purposes of this study, we assumed the appearance of vegetation during the whole year, therefore we replaced evaporation. Evapotranspiration was estimated by SHMÚ experts for all 41 meteorological stations with the Penman-Monteith combined method. The equation uses standard climatological data of solar radiation (sunshine), air temperature, humidity and wind speed. The weather parameters' measurements should be made at 2 m (or converted to that height) above an extensive surface of green grass, completely shading the ground and with adequate humidity.

A climatic indicator of humidification is a climatological index used for regionalization of the climate in terms of humidification. It represents the relationship between the amount of water, which is possible to evaporate from the surface of sufficiently humidified soil and vegetation. The climatic indicator of humidification is calculated by the relationship:

$$\sum(\mathrm{P}) + \sum(\mathrm{ET_0}) > \mathrm{K}$$

Where: **ET_0** = the sum of potential evapotranspiration, **P** = the precipitation total, **K** = the humidification of soils.

The rainy season has to be identified for the estimation of humid areas. The rainy season is defined as the period when precipitation is higher than evapotranspiration. Parameter of humidification of the soil is higher than 1, the equation adjusts to:

$$\frac{\mathrm{P}}{\mathrm{ET_0}} > 1$$

According to the definition of the $Frac_{LEACH}$ in the IPCC 2006 Guidelines, the determination of 'rainy seasons' is based on precipitation and Pan Evaporation (E_{PAN}) data. Rainy seasons are defined as periods when rainfall > 0.5·Pan Evaporation, then $P/E_{PAN} > 0.5$, where P is the monthly precipitation. In the case of this study, we use evapotranspiration $\sum P/\sum ETo \geq 1$. The share P/ET_0 was analysed for 41 meteorological stations.

To cover the whole area of Slovakia, the presented meteorological data were interpolated. The interpolation was processed in the Geographic Information System (QGIS software) using the Inverse Distance Weighting Interpolation function. Interpolation parameters distance coefficient 2, number of columns 3 000 and number of rows 1 500 were applied. In the raster image (***Figure 5.25***), areas with a $\sum P/\sum ET_0 \geq 1$ were extracted by using the contours function and used to trim the underlying layers by available geoprocessing tools. The highly accurate database called The Land Parcel Identification System (LPIS) was used as the underlying layer. Based on geoprocessing analysis, arable land data was revealed. 2022 data on evapotranspiration and precipitation were available, therefore geoprocessing analysis was performed. Based on ***Figure 5.25***, decrease of humid areas will continue in 2022.

In 2022, the total humid area was 61 292,1 ha, which is 3% of the total agricultural area registered in LPIS ($Frac_{WET}$). The total irrigated area ($Frac_{IRR}$) in Slovakia 25 887 hectares, representing only 1.8% of agricultural land. To calculate the specific national value for nitrogen losses from agricultural land due to leaching ($Frac_{LEACHNATIONAL}$) we used equation:

$$Frac_{LEACH_{NATIONAL}} = (Frac_{irr} + Frac_{wet}) * Frac_{LEACH}$$

Activity data

Activity data in this category is consistent with activity data in categories 3.D.1.1 - Synthetic Fertilizers and 3.D.1.2 – Animal Manure Applied to Soil. ***Table 5.91*** shows the time series of parameters, EFs and N_2O emissions.

Figure 5.25: *Grassland and arable land where ∑P/∑ETo≥1 for 2005, 2010, 2015, 2021 and 2022*

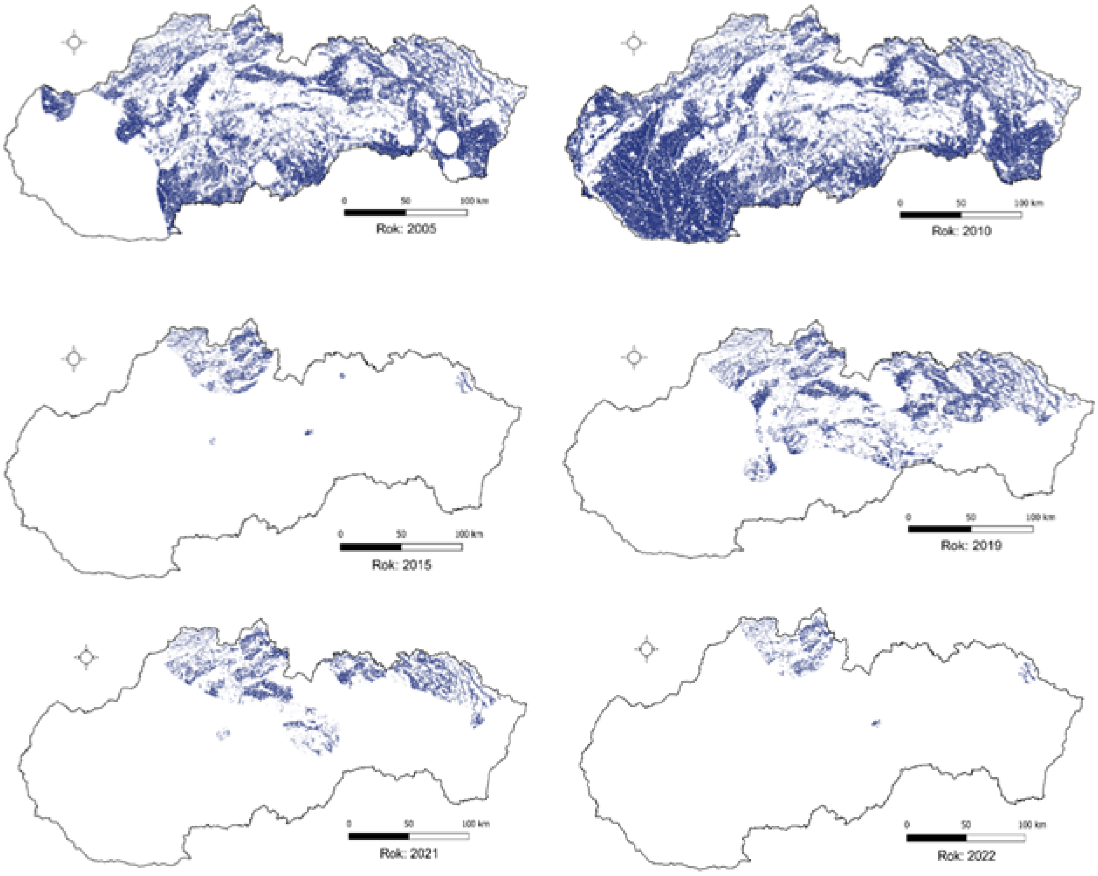


Table 5.91: *Input parameters, EFs and N_2O emissions in 3.D.2.2 - Nitrogen Leaching and Run-off in particular years*

YEAR	TOTAL LOSS OF N	EFs	N_2O EMISSIONS	THE FRACTION OF N INPUT TO MANAGED SOILS THAT IS LOST THROUGH LEACHING AND RUN-OFF
	kg	*kg N_2O-N/kg N*	*Gg*	*%*
1990	90 769 143	0.0110	1.57	24%
1995	44 524 273	0.0110	0.77	22%
2000	34 504 588	0.0110	0.60	19%
2005	48 659 684	0.0110	0.84	23%
2010	71 940 681	0.0110	1.24	37%
2011	12 457 415	0.0110	0.22	6%
2012	12 563 367	0.0110	0.22	6%
2013	31 387 887	0.0110	0.54	15%
2014	46 484 473	0.0110	0.80	19%
2015	6 105 867	0.0110	0.11	3%
2016	38 880 011	0.0110	0.67	16%
2017	20 693 903	0.0110	0.36	9%
2018	5 547 471	0.0110	0.10	2%
2019	21 030 105	0.0110	0.36	9%
2020	29 963 244	0.0110	0.52	12%

YEAR	TOTAL LOSS OF N	EFs	N_2O EMISSIONS	THE FRACTION OF N INPUT TO MANAGED SOILS THAT IS LOST THROUGH LEACHING AND RUN-OFF
	kg	*kg N_2O-N/kg N*	*Gg*	*%*
2021	13 145 034	0.0110	0.227	5%
2022	3 371 495	0.0110	0.06	1.5%

5.13. Prescribed Burning of Savannas (CRF 3.E)

The category 3.E Prescribed Burning of Savannas does not occur in the Slovak Republic. Therefore, notation key 'NO' is reported for CRF 3.E category.

5.14. Field Burning of Agricultural Residues (CRF 3.F)

This form of cultivation is strictly prohibited by the law in the Slovak Republic. No emissions from this category were estimated. Therefore, notation key 'NO' is reported for CRF 3.F category.

5.15. Liming (CRF 3.G)

The soil acidity causes deficient of calcium and magnesium in soils. The presence of the cations of hydrogen and aluminium in the sorption complex causes adverse effects for the growth of the root system of plants. The result is a decrease in the volume of soil and lack of water and nutrients for crops from the soils. The purpose of liming is a correction of soil acidity to normal value with limestone application.

5.15.1. Limestone Application (3.G.1)

Methodological issues – method

Emissions were calculated according to tier 1 method (IPCC 2006 GL). Due to missing geographical data on limestone consumption, tier 2 approach is still not implemented. The CO_2 emissions from liming were calculated according to the equation:

$$CO_2 \text{ emissions} = M * EF * \frac{44}{12}$$

Where: **CO_2 emissions** = emissions from application of besides limestone and other materials, **M** = annual amount of limestone in tonnes, **EF** = default, a **carbon conversion factor (44/12)** = coefficient for conversion CO_2-C to CO_2

The default conversion factor (EF) used for limestone ($CaCO_3$) is 0.12.

Table 5.92: *Activity data, EFs and estimated CO_2 emissions in 3.G.1 – Limestone Application in particular years*

YEAR	TOTAL AMOUNT OF $CaCO_3$	CARBON CONVERSION FACTOR	CO_2 EMISSIONS
	t		*Gg*
1990	99 515	0.12	43.79
1995	82 398	0.12	36.26
2000	72 806	0.12	32.03
2005	20 087	0.12	8.84
2010	17 533	0.12	7.71
2011	32 130	0.12	14.14
2012	23 978	0.12	10.55
2013	25 362	0.12	11.16
2014	25 425	0.12	11.19
2015	26 321	0.12	11.58
2016	11 288	0.12	4.97
2017	4 471	0.12	1.97
2018	7 572	0.12	3.33
2019	8 248	0.12	3.63
2020	14 206	0.12	6.25
2021	8 944	0.12	3.94
2022	2 017	0.12	0.89

Activity data

The consumption of limestone decreased in 2022 compared to 2021 by 77% due to decrease in consumption compared to the previous year (2021) and compare to base year almost 98%. This was caused by the cancellation of subsidies for the purchase of limestone by agricultural enterprises and an increase in the purchase prices of dolomite and limestone.

Data on liming of agricultural soils (cropland) are provided by the ÚKSUP. For the years 1998 – 2022, activity data are based on summarization of records that were submitted by landowners/users to the ÚKSUP according to the Act No 136/2000 Coll. on fertilizers as amended by Act No 555/2004 Coll. For the years 1990 – 1998, only estimated values are available. Data was extrapolated with linear extrapolation tool in Excel sheet. Data contain only limestone or fertilizers containing limestone, which is a difference compared to previous submission. Other calcareous substances containing only Ca and CaO were subtracted from activity data.

5.15.2. Dolomite Application (CRF 3.G.2)

Methodological issues – method

The CO_2 emissions from liming of dolomite were calculated according to the equation:

$$CO_2 \text{ emissions} = M * EF * \frac{44}{12},$$

Where: **CO_2 emissions** = emissions from application of besides components containing dolomite, **M** = annual amount of limestone in tonnes, **EF** = default, a **carbon conversion factor (44/12)** = coefficient for conversion CO_2-C to CO_2

The default conversion factor (EF) used for limestone ($MgCO_3$) is 0.13.

Activity data

The data on consumption of dolomite was provided by the UKSÚP. Consumption of dolomite increased in 2022 compared to 2021 by 67%. For the years 1998 – 2022, data are based on the summarization of records that were submitted by landowners/users to the ÚKSUP according to the Act No 136/2000 Coll. on fertilizers as amended by Act No 555/2004 Coll. Data contain applied $MgCO_3$ substances put on soil annually. The total $MgCO_3$ amount was calculated. For the years 1990 – 1998, only estimated values are available. Data was extrapolated with linear extrapolation tool in Excel sheet. Data contain only dolomite or fertilizers containing dolomite, which is a difference compared to previous submission. Other dolomite substances containing only Mg and MgO were subtracted from activity data.

Table 5.93: *Activity data, EFs and estimated CO_2 emissions in 3. G.2 - Dolomite Application in particular years*

YEAR	TOTAL AMOUNT OF $MgCO_3$	CARBON CONVERSION FACTOR	CO_2 EMISSIONS
	t		*Gg*
1990	4 076	0.13	1.94
1995	3 668	0.13	1.75
2000	4 840	0.13	2.31
2005	922	0.13	0.44
2010	1 083	0.13	0.52
2011	2 108	0.13	1.00
2012	1 579	0.13	0.75
2013	1 660	0.13	0.79
2014	1 626	0.13	0.77
2015	1 744	0.13	0.83
2016	3 791	0.13	1.81
2017	1 366	0.13	0.65
2018	1 845	0.13	0.88
2019	2 269	0.13	1.08
2020	4 615	0.13	2.20
2021	4 198	0.13	2.00
2022	6 995	0.13	3.33

5.16. Urea Application (CRF 3.H)

In conditions of Slovakia, urea as fertilizer is applied mainly on medium heavy and heavy soils and less on light sandy soils because of its high solubility and possible loss of nitrogen without its uptake by plants. The urea is neither applied on very acid soils. Urea is not the primary source of nitrogen.

5.16.1. Methodological Issues – Method

Tier 1 method according to the Equation 11.13 (IPCC 2006 GL) was used for emissions estimation in this category. Default conversion factor (EF) used for urea is 0.20. Estimated emissions are shown in ***Table 5.94***. CO_2 emissions from urea application were calculated as follows:

$$\mathrm{CO_2\ emissions} = \mathrm{M_{CO(NH_2)_2}} * \mathrm{EF} * \frac{44}{12}$$

Where: **CO_2 emissions** = emissions from application of urea in tonnes of CO_2, **$M_{CO(NH2)2}$** = annual amount of urea fertilizers in tonnes, **EF** = default, a **urea conversion factor (44/12)** = coefficient for conversion CO_2-C to CO_2

Table 5.94: *Activity data, EFs and estimated CO_2 emissions in 3.H - Urea Application in particular years*

YEAR	TOTAL AMOUNT OF UREA	UREA CONVERSION FACTOR	CO_2 EMISSIONS
	t		*Gg*
1990	20 846.74	0.20	15.29
1995	20 846.74	0.20	15.29
2000	16 500.69	0.20	12.10
2005	27 699.02	0.20	20.31
2010	42 189.25	0.20	30.94
2011	54 146.88	0.20	39.71

YEAR	TOTAL AMOUNT OF UREA	UREA CONVERSION FACTOR	CO_2 EMISSIONS
	t		*Gg*
2012	61 934.09	0.20	45.42
2013	70 899.73	0.20	51.99
2014	79 009.80	0.20	57.94
2015	83 072.60	0.20	60.92
2016	86 006.26	0.20	63.07
2017	86 636.61	0.20	63.53
2018	89 953.97	0.20	65.97
2019	86 644.29	0.20	63.54
2020	86 817.95	0.20	63.67
2021	86 772.93	0.20	63.63
2022	77 207,45	0.20	56.62

5.16.2. Activity Data

The ÚKSUP provides data on urea application on agricultural soils (cropland). For the years 1998 – 2022, the data was based on the summarization of recordings that had to be submitted by landowners/users to the ÚKSUP according to the national legislation. For the years 1990 – 1997, the data have been estimated as the average of three years' period (1998 – 2000). In the past, the three years' period of urea application was fluctuating with low, medium and higher doses.

5.17. Other Carbon – Containing Fertilizers (CRF 3.I)

This category is not estimated in the current submission. The category will be completed in future submissions. The used notation key is NO.

CHAPTER 6. LULUCF (CRF 4)

This chapter was prepared using GWP_{100} taken from the 5th Assessment Report of the IPCC by the sectoral experts and institutions involved in the National Inventory System of the Slovak Republic:

INSTITUTE	CHAPTER	SECTORAL EXPERT
National Forest Centre – Forest Research Institute (NFC-FRI)	Chapter 6.1 – 6.6 Chapter 6.9 – 6.17 Annex A6.1 Annex A6.2	Tibor Priwitzer Ivan Barka Pavel Pavlenda
National Agriculture and Food Centre - Soil Science and Conservation Research Institute (NAFC-SSCRI)	Chapter 6.7	Michal Sviček
National Agriculture and Food Centre - Grassland and Mountain Agriculture Research Institute (NAFC-GMARI)	Chapter 6.8	Štefan Pollák

6.1. Overview of the LULUCF Sector

The Forestry and Land Use sector covers the wide range of biological and technical processes within the landscape, which are reflected in the GHG inventory. This sector includes all GHGs (CO_2, CH_4 and N_2O) and basic pollutants from forest fires (NOx and CO). Individual inventory of LULUCF categories are linked with all relevant processes related to all five carbon pools (living biomass – above and below ground, dead organic matter – dead wood and litter, soil carbon), as have been defined in the Marrakech Accords. In addition, wood products referred to as harvested wood products (HWP) are reported as an additional pool under LULUCF (CRF sector 4.G).

The inventory in LULUCF sector is based on the definition of representative types of land use categories – Forest Land (FL), Cropland (CL), Grassland (GL), Wetlands (W), Settlements (S) and Other Land (OL). In addition, their temporal changes are reported. The first three categories have the highest importance due to their relative coverage of Slovakia, representing more than 90% of the whole territory. The processes linked to the land use and land-use change are mostly related to CO_2 balance.

Biomass burning, which represents managed processes (i.e. burning of harvest residues) and unmanaged processes (i.e. forest fires), is a special category in the landscape. This category covers all three main GHGs and basic pollutants. The inventory covers also the estimation of CO_2 emissions from the agricultural lime application.

The LULUCF sector with net removals -7 225.74 Gg of CO_2 eq. in 2022 is very important sector and comprises several key categories. ***Table 6.1*** shows summary of total emissions according to the categories. Time series of emissions and removals are illustrated on ***Figure 6.1*** and summarised in ***Table 6.2***. This report uses the GWP 100 based on the IPCC Fifth Assessment Report for the year 2022.

Figure 6.1: *Emissions and removals (Gg of CO_2 eq.) according to the categories in 1990 – 2022*

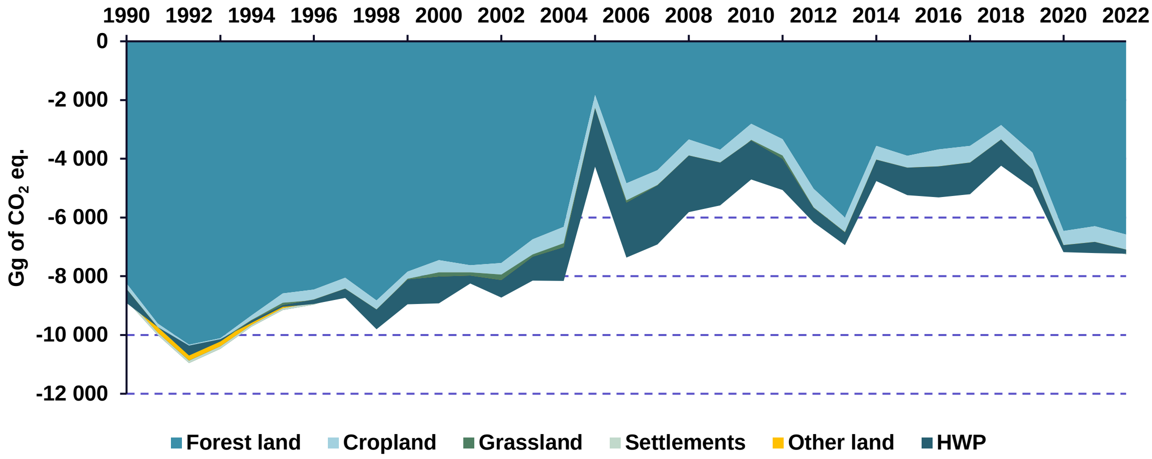


Table 6.1: *Summary of total emissions and removals according to the categories in 2022*

CATEGORY	Net CO_2		CH_4	N_2O	NO_x	CO
	Emissions/Removals (Gg)		*Emissions (Gg)*			
4. LULUCF	**NO**	**-7 316.72**	**1.64**	**0.17**	**1.05**	**37.28**
A. Forest Land	NO	-6 643.65	1.64	0.09	1.05	37.28
B. Cropland	NO	-649.74	NO	0.03	NO	NO
C. Grassland	NO	-36.24	NO	0.00	NO	NO
D. Wetlands	NO	NO	NO	NO	NO	NO
E. Settlements	80.39	NO	NO	0.02	NO	NO
F. Other Land	76.37	NO	NO	0.02	NO	NO

Table 6.2: *Summary of GHG emissions and removals according to the categories in particular years*

YEAR	Forest land	Cropland	Grassland	Settlements	Other land	LULUCF (CO_2. CH_4. N_2O)		
	Net CO_2 in Gg					*Gg*		
1990	-8 262.31	-484.43	-195.77	96.59	293.10	-9 023.23	0.44	0.45
1995	-8 598.32	-371.05	-257.78	61.11	104.09	-9 120.72	0.31	0.31
2000	-7 502.03	-443.24	-309.97	54.04	106.21	-9 015.06	1.08	0.23
2005	-1 876.28	-515.22	-200.82	62.40	186.46	-4 339.92	1.05	0.17
2010	-2 842.11	-559.71	-215.52	102.08	90.36	-4 759.49	0.80	0.12
2011	-3 370.79	-565.49	-274.67	70.27	81.26	-5 128.28	0.96	0.13
2012	-5 098.28	-643.36	-216.49	82.43	116.98	-6 267.12	1.84	0.18
2013	-6 032.18	-502.96	-203.83	97.13	96.93	-6 985.34	0.61	0.12
2014	-3 593.97	-503.93	-182.37	81.38	110.26	-4 817.02	0.90	0.14
2015	-3 940.37	-502.44	-190.85	85.70	185.73	-5 302.92	1.02	0.15
2016	-3 720.88	-590.73	-178.50	80.44	99.35	-5 373.97	0.84	0.14
2017	-3 601.61	-622.22	-164.81	100.99	95.42	-5 269.27	0.93	0.15
2018	-2 893.26	-627.83	-110.83	81.56	143.96	-4 295.58	0.92	0.15
2019	-3 833.66	-633.22	-118.02	84.23	80.62	-5 064.97	1.08	0.15
2020	-6 499.74	-578.04	-92.82	79.30	94.80	-7 243.78	0.98	0.14
2021	-6 330.47	-654.02	-55.23	86.36	72.29	-7 263.27	0.71	0.12
2022	-6 643.65	-649.74	-36.24	80.39	76.37	-7 316.72	1.64	0.17

GHG Inventory submission 2024 of Slovakia reports carbon stock changes, as well as greenhouse gas emissions and removals from Forest Land (CRF 4.A), Cropland (CRF 4.B), Grassland (CRF 4.C), Settlements (CRF 4.E), Other Land (CRF 4.F) and Harvested Wood Products (CRF 4.G). In the category 4.A - FL, carbon stock change in living biomass, dead organic matter and mineral soils is reported. In the 4.B - CL, carbon stock change in living biomass is reported. The carbon stock changes in living biomass, dead organic matter and mineral soils are reported for CL, GL, S and OL converted from the FL. Direct N_2O emissions from N fertilization of Forest Land and Others (CRF 4(I)) as well as non-CO_2 emissions from drainage of soils and wetlands (CRF 4(II)) are not reported. N_2O emissions from N mineralization associated with conversion to Cropland are reported (CRF 4(III). Emissions of CO_2, CH_4 and N_2O from the Biomass Burning are reported in CRF Table 4(V). Summary of all categories and subcategories reported in the inventory year 2022 is described in ***Table 6.3***.

Table 6.3: *Reported emissions, methodological tiers and emission factors (EF) in LULUCF in 2022*

CATEGORY		CO_2		CH_4		N_2O	
		method applied	**EF**	**method applied**	**EF**	**method applied**	**EF**
4.A	FOREST LAND						
4.A.1	Forest Land Remaining Forest Land	T1,T2	CS,D				
4.A.1-4(V)	Biomass Burning	T1,T2	CS,D	T2	CS,D	T2	CS,D
4.A.2	Land Converted to Forest Land	T1, T2	CS, D	T2	CS, D	T2	CS, D
4.A.2.1	Cropland Converted to Forest Land	T1, T2	CS				
4.A.2.2	Grassland Converted to Forest Land	T1, T2	CS				
4.A.2.5	Other Land Converted to Forest Land	T1, T2	CS				
4.A.2-4(V)	Biomass Burning	T2	CS, D	T2	CS, D	T2	CS, D
4.B	CROPLAND						
4.B.1	Cropland remaining Cropland	T1, T2	CS, D				
4.B.2	Land Converted to Cropland	T1, T2	CS, D			T2	CS, D
4.B.2.1	Forest Land Converted to Cropland	T1, T2	CS, D				
4.B.2.2	Grassland Converted to Cropland	T1, T2	CS, D				
4.B.2.5	Other Land Converted to Cropland	T1, T2	CS, D				
4.B.2-4(III)	Direct N_2O Emissions from N Mineralization/ Immobilization					T2	CS, D
4.C	GRASSLAND						
4.C.1	Grassland remaining Grassland	T1					
4.C.2	Land Converted to Grassland	T1, T2	CS, D			T2	CS, D
4.C.2.1	Forestland Converted to Grassland	T1, T2	CS, D				
4.C.2.2	Cropland Converted to Grassland	T1, T2	CS, D				
4.C.2.5	Other Land Converted to Grassland	T1, T2	CS, D				
4.C.2-4(III)	Direct N_2O Emissions from N Mineralization/Immobilization					T2	CS, D
4.E	SETTLEMENTS						
4.E.2	Land Converted to Settlements	T1, T2	CS, D			T2	CS, D
4.E.2.1	Forest Land Converted to Settlements	T1, T2	CS, D				
4.E.2.2	Cropland Converted to Settlements	T1, T2	CS, D				
4.E.2.3	Grassland Converted to Settlements	T1, T2	CS, D				
4.E.2-4(III)	Direct N_2O Emissions from N Mineralization/Immobilization					T2	CS, D
4.F	OTHER LAND						
4.F.2	Land Converted to Other Land	T2	CS, D				
4.F.2.1	Forest Land Converted to Other Land	T2	CS, D				
4.F.2.2	Cropland Converted to Other Land	T2	CS, D				
4.F.2.3	Grassland Converted to Other Land	T2	CS, D				
4.F - 4(III)	Direct N_2O Emissions from N Mineralization/ Immobilization					T2	CS, D
4(IV)	Indirect N_2O emissions from managed soils					T1	D
4.G	HARVESTED WOOD PRODUCTS						
4.G	Harvested Wood Products	T2	CS, D				

The area of Forest Land in the Slovak Republic covers 41.4% of the territory and wood harvesting is historically an important economic activity. The LULUCF sector represents a sink of GHG since 1990. Historically stable trend was disrupted due to high wood extraction from damaged forests in 2005 after strong windstorm from the end of 2004, which consequently resulted in the decrease of total sinks to the half of previous volumes.

Slovakia provides further explanation of the climate domain and ecological zones of Slovakia. The entire territory of Slovak lies in the climatic reference region of Western and Central Europe according to IPCC climatic reference. According to the IPCC 2006 GL (Vol. 4, Chap. 3, Annex 3.A.5, "Default climate and soil classifications"), the Slovakian territory belongs to IPCC climate domain: "Cool Temperate Moist" and ecological zone: "Temperate continental forest".

The identification of the LULUCF categories is based on the data from the Geodesy, Cartography and Cadastre Authority of the Slovak Republic (GCCA), which represents a key data source for identification of spatial extent of individual categories. The GCCA annually issues the Statistical Yearbook of the Soil Resources in the Slovak Republic. It provides updated cadastral information of the LULUCF areas. Since 2007, this book is available on the website of the GCCA. The GCCA database distinguishes ten land categories, six of them belonging to the land utilized by agriculture (arable land, hop-fields, vineyards, gardens, orchards, grasslands) and the rest of them under other use (forest, water surfaces, built-up areas and courtyards, and other land). Six land-use categories have been selected – Forest Land, Cropland, Grassland, Wetlands, Settlements and Other Land as given in the IPCC 2006 GL, Volume 4, Agriculture, Forestry and Other Land Use. The Slovak Republic used the following LULUCF definitions for reporting of GHG emissions and removals in the categories:

Forest Land - this category includes the land covered by all tree species serving for the fulfilment of forest functions and the land on which the forest stands were temporarily removed with aim of their regeneration or establishment of forest nurseries or forest seed plantation. In the Permanent Forest Inventory and the Statistical Office databases, it is referred to as timberland.

Cropland - this category includes lands for growing cereals, root-crops, industrial crops, vegetables and other kinds of agricultural crops. Perennial woody crops are also included in this category. There are included lands temporarily overgrown with grass or used for growing of fodder lasting several years, as well as hotbeds and greenhouses if they are built up on the arable land. This category also includes fallow land, which is arable land left for regeneration for one growing season. During this period there were not sown specific crops or just crops for green manure, eventually it is covered by spontaneous vegetation, which would be ploughed in.

Grassland - this category includes permanent grasslands and meadows used for the pasture or hay production, which is not considered as cropland.

Wetlands - this category include artificial reservoirs and dam lakes, natural lakes, rivers and swamps.

Settlements - this category include all developed land, including transportation infrastructure and human settlements of any size.

Other Land - this category represented by bare soil, rock and all unmanaged land areas that do not fall into any of the other categories. Each of these categories is divided into land remaining in the given category during the inventory year, and land converted into the category from another one. The areas of six LULUCF categories remaining in the specific category are in ***Table 6.4***.

The increasing trend of FL is evident in the Slovak Republic since 1970. The opposite, decreasing trend of Cropland was recorded at the same time. Grassland areas decreased from 1980 to the 1990 and since this year increasing trend was recorded up to 2005. Since 2005, moderately downward trend has been taking place. Settlements category has continuously increasing trend during the whole period. This situation is mostly caused by the development of transport infrastructure, industrial areas, municipal development and raising the standards and infrastructure in the country and is very often connected with decreasing of the Cropland and Other Land area.

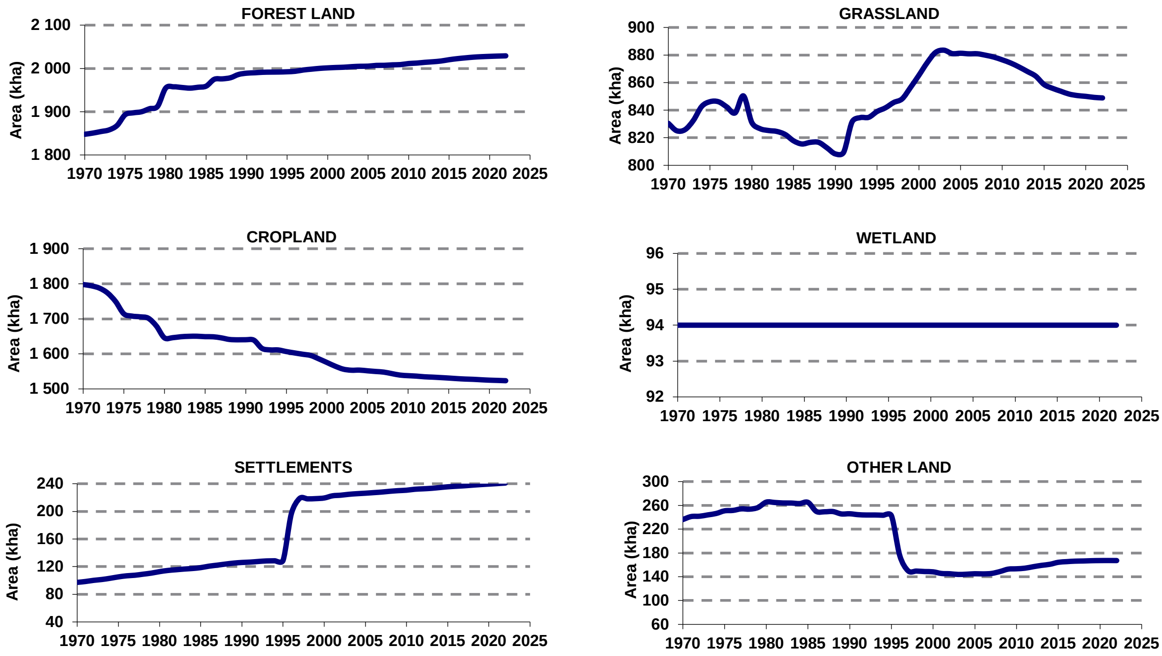
Slovakia provides an explanation for the cause of the abrupt increase in the areas of settlements and decrease in other land occurring around 1995. The abrupt changes in Settlements and Other land occurring around 1995 was likely due to new property owners rushing to get their land recognized as 'settlement' during the country's transition to a market economy. Slovakia assumes that the increase of area in the category of Settlements and reciprocal decline of area in the category of Other Land could be caused by administrative transfer of Other Land to Settlements. The reason for this could be a new territorial administrative division of Slovakia (from 3 to 8 regions) and the effort of the new administrators to obtain property in the form of settlements. This idea results from consultation with the provider of cadastral data (Geodesy, Cartography and Cadastre Authority of the Slovak Republic - GCCA). The abrupt increase in the areas of settlements between 2015 and 2016 in the 4.E.1 LU category was caused by the implementation of the rule about the 20 years long transition period. According to IPCC 2019 GL under the default assumption in every inventory year, the area converted to a land-use category should be added to the category "land converted to" and the same area removed from the land remaining in the land-use category. The area of land that entered that "land converted to" category, 21 years ago (if using the default 20-year period), should be removed and added to the category "land remaining land". Wetland represents 1.9% (94 kha) of the Slovak territory and it is considered constant, not involving any land-use conversions.

Table 6.4: *The area of LU categories remaining in category in particular years*

YEAR	4.A.1	4.B.1	4.C.1	4.E.1	4.F.1
	kha				
1990	1 809.150	1 492.150	685.496	94.694	190.370
1995	1 861.770	1 502.190	740.787	102.634	203.448
2000	1 929.760	1 517.420	766.818	109.566	128.144
2005	1 945.130	1 513.920	762.467	116.753	128.010
2010	1 981.890	1 511.700	766.398	116.845	130.795
2011	1 983.770	1 510.360	766.969	117.402	130.654
2012	1 985.110	1 508.360	786.601	117.592	131.654
2013	1 985.740	1 507.230	787.840	117.177	131.361
2014	1 986.150	1 505.970	785.350	117.373	131.132
2015	1 986.730	1 503.580	784.508	117.897	130.043
2016	1 988.250	1 502.400	786.007	184.435	129.487
2017	1 991.520	1 501.950	788.930	206.448	129.330
2018	1 993.560	1 502.510	791.676	206.336	129.569
2019	1 995.569	1 501.940	800.483	206.645	130.003
2020	1 996.758	1 503.211	811.978	207.603	130.411
2021	1 997.863	1 505.042	823.403	210.729	131.116
2022	1 998.590	1 505.249	831.953	211.609	131.175

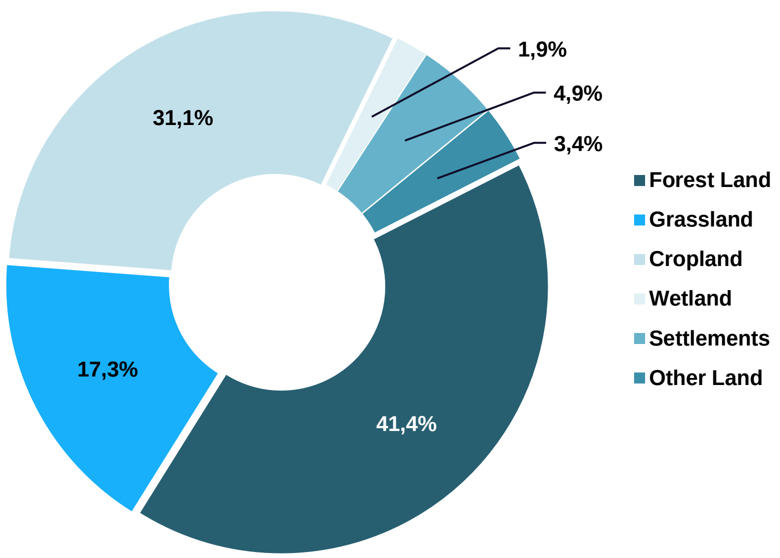
The land-use matrix shown in ***Table A6.1*** and on ***Figure 6.2*** represents the areas of land-use change among the major categories from 1990 to 2022 for individual years. The annual totals for individual years in the matrix do not correspond to the areas referred to in CRF Tables. These areas account for the progressing for 20 years' transition period beginning in the year 1970. This approach represents tier 1 approach of the IPCC 2006 GL for calculation of soil carbon stocks changes. The areas of biomass carbon pools are not the same as for the soil carbon ones.

Figure 6.2: *Overall development trends in area of categories from 1970 – 2022 (based on information from the GCCA of the Slovak Republic)*



Land-use matrix identifying annual conversions among the categories for the period 1990 – 2022 and describing initial and final areas of particular categories are listed in the **Annex A6.1.** (***Table A6.1.1***). The distribution of the LULUCF categories in Slovakia in 2022 is shown on ***Figure 6.3***. Forest Land represents the major category, accounting for 41.4% of the total area, followed by the Cropland with 31.1%, Grassland with 17.3%, Settlements with 4.9%, Other Land with 3.4% and Wetlands with 1.9% of the total country area.

Figure 6.3: *Distribution of the LULUCF categories in Slovakia in 2022*



6.2. Category-specific QA/QC and Verification Process

QA/QC procedures in the LULUCF sector are linked with the QA/QC plans for the National Inventory System at the sectoral level and followed basic rules of QA/QC as defined in the IPCC 2006 GL.

The calculation is based on annually submitted or published input data of several institutions:

- the Geodetic and Cartographic Institute Bratislava;
- the Geodesy, Cartography and Cadastre Authority of the Slovak Republic (GCCA);
- the Statistical Office of the Slovak Republic (ŠÚ SR);
- the National Forest Centre - Institute for Forest Resources and Information (NFC-IFRI);
- the National Forest Centre - Forest Management Planning Institute (NFC-FMPI);
- the Central Controlling and Testing Institute in Agriculture (ÚKSUP);
- or information published by the research organizations: Research Institute of Geodesy and Cartography in Bratislava, National Forest Centre - Forest Research Institute (NFC-FRI), National Agriculture and Food Centre - Soil Science and Conservation Research Institute (NAFC - SSCRI) and National Agriculture and Food Centre – Grassland and Mountain Agriculture Research Institute (NAFC-GMARI).

Each of the institutions has internal quality rules depending on the main tasks of the institution. Published data on carbon content in litter, soil and biomass at national level are based on results of laboratories that follow quality management standards in laboratory praxis and successfully participate in the ring tests (international inter-laboratory comparisons).

The primary input data (values, units) are checked for the plausibility and conformity (time series). When possible, data is checked with data from other sources. Data submitted by responsible institution upon request are compared with the relevant published information. The remarkable changes or trend differences in input data are directly discussed and checked with responsible persons and data provider. The input data sets and sources are archived by sectoral expert.

In the process of the emissions calculation and estimation, all procedures are checked (correctness of equations, interim results, units, trend evaluation). Results (output data) are checked according to the QC procedures. Comparison with data in time series and space (results from other countries) are important steps in the data check. Parameters and emission factors used for NIR are compared with results and factors in other countries or regions that can be comparable (similar bio-geo-region, site conditions, ways and intensity of land management, etc.).

Methods and emission factors used in the emissions inventory are internally consulted or/and reviewed among experts in the NFC that are not involved in the national emission inventory implementation.

The QC checks (e.g. consistency check between CRF data and national statistics) were done during the CRF and NIR compilation by sectoral experts, General QC questionnaire was filled out and archived by the QA/QC manager. The QA is conducted by another LULUCF expert from the NFC and by independent expert from the Ministry of Environment of the Slovak Republic and the Ministry of Agriculture and Rural Development of the Slovak Republic.

6.3. Category-specific Recalculations

Recalculations and reallocations made in the LULUCF sector were provided and implemented in line with the Improvement and Prioritization Plan reflecting recommendations made during previous reviews and expert improvement. Short description of recalculations implemented in 2024 submission is in ***Table 6.6***.

Table 6.6: Description of recalculations implemented in 2024 submission

NUMBER/ RECOMMENDATION	CATEGORY	DESCRIPTION	REFERENCE
1	4. LULUCF	Changed in activity data in Cl and HWP categories	**Chapter 6**
2	4.B CROPLAND	Changed of activity data factors - FLU and FMG	**Chapter 6.7**
3	4.G HWP	Correction of input activity data (Wood base panels Production - year 2021)	**Chapter 6.17**

The Cropland and Harvested wood products categories within the LULUCF sector were recalculated in 2024 submission. Recalculated values for the whole sector differ from the submission in 2023 by 4.08% to 10.91% in particular years (***Figure 6.4***), the net CO_2 eq. removals decreased by 6.63% in average.

Figure 6.4: *Comparison of CO_2 eq. (Gg) in the 2023 and 2024 submissions for LULUCF sector*

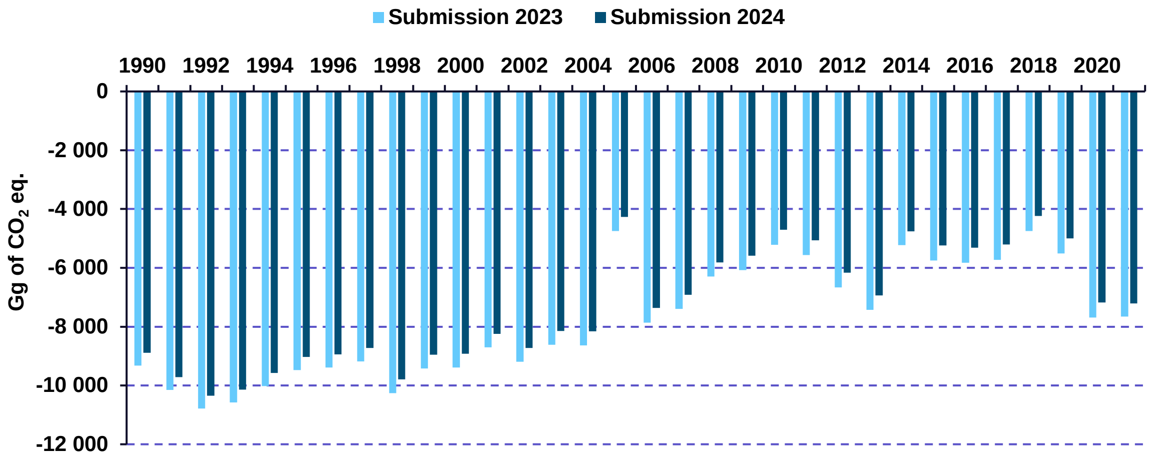
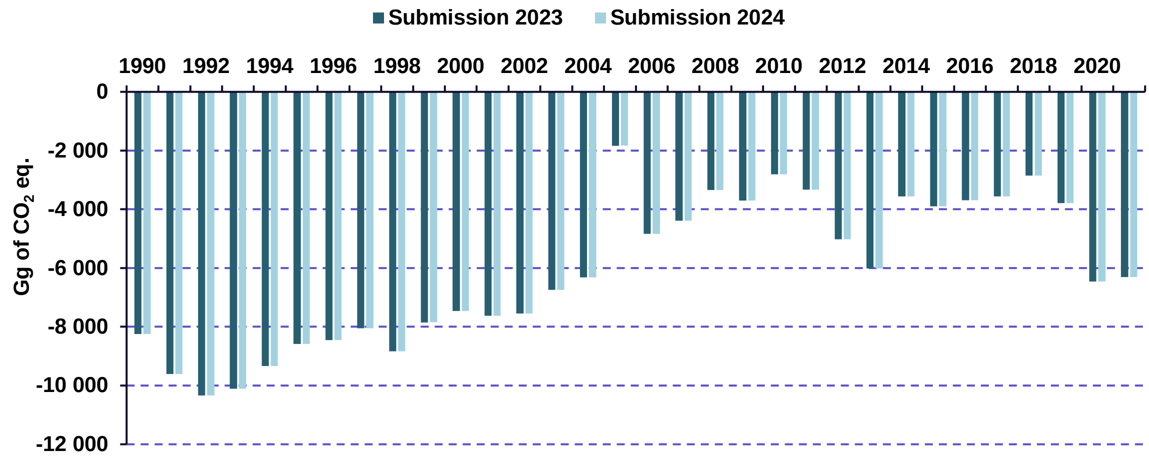


Figure 6.5: *Comparison of CO_2 eq. (Gg) in the 2023 and 2024 submissions for Cropland*

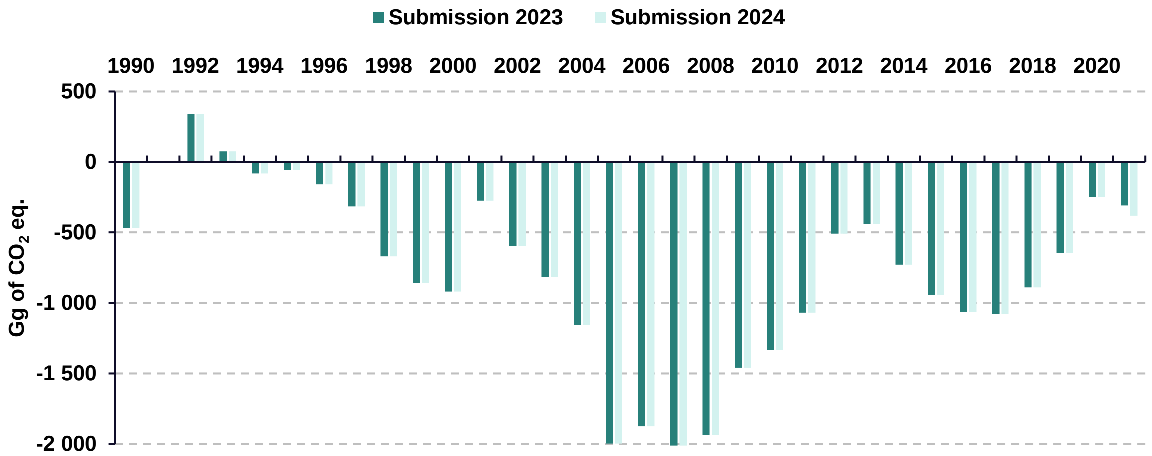


In the category 4.B, the category 4.B.1 Cropland remaining Cropland as well as 4.B.2 Land converted to Cropland was recalculated for the whole time period since 1990. The main reason for recalculation 4.B.1 category included the recalculation of CSC in mineral soil carbon pools using the correction of FLU and FMG factors following the ERT recommendation as well as the correction of small inconsistency in the area of Cropland between table 4.1 and 4.B for the year 2008 following the ESD EU check recommendation. Recalculated values for 4.B category significantly differ from the submission in 2023 by 43.86% to 89.32% in particular years (***Figure 6.5***), the net CO_2 eq. removals decreased by 53.54% in average.

The recalculation was realised also in HWP category in the year 2021. The main reason was correction of input activity data – wood base panel and paper and paper board. Recalculated values for the whole sector differ from the submission in 2023 of 1.32% in year 2020 (***Figure 6.6***), the net CO_2 eq. removals increased by 0.04% in average. Recalculated values for the HWP differ from the submission in 2023 of 23.65% in year 2021 (***Figure 6.6***), the net CO_2 eq. removals increased by 0.74% in average.

These changes improved accuracy of the calculations.

Figure 6.6: *Comparison of CO_2 eq. (Gg) in the 2023 and 2024 submissions for HWP*



6.4. Category-specific Improvements and Implementation of Recommendations

During the inventory preparation and based on the discussion and recommendations from the latest UNFCCC review 2022 (SVK ARR 2022), following room for improvements was identified:

- ERT recommendation (L.1 - draft ARR 2022) was partially implemented. Continuation of the technical research in order to provide reliable data for estimating CSC in living biomass, dead organic matter and soil organic matter is the long-term process and the results will be implemented in the next submissions. Slovakia clarified that the calculation of CSC in deadwood carbon pools in land converted to forest land, based on partial results from the above-mentioned research, was included in the CRF tables and the NIR.
- ERT recommendation (L.4 – draft ARR 2022) was implemented. During the review, the Slovakia clarified that CRF Table 9 is generated automatically by the CRF Reporter software.
- ERT recommendation (L.5 – draft ARR 2022) was implemented. An explanation for the cause of the abrupt increase in the areas of settlements and decrease in other land occurring around 1995 as well as the abrupt increase in the areas of settlements between 2015 and 2016 were provided in the **Chapter 6.1**. The land representation data for 2016 onwards are reported in ***Figure 6.2*** and in ***Table 6.5*** of the same chapter.
- ERT recommendation (L.11 – draft ARR 2022) was implemented. More information about the reasons why periodic cuttings, pruning and thinning is not included in the estimation of annual losses in perennial croplands is explained in the **Chapter 6.7.1**.
- ERT recommendation (L.12 – draft ARR 2022) was implemented. Slovakia provides further explanation of the climate domain and ecological zones of Slovakia in the **Chapter 6.1**.
- ERT recommendation (L.13 – draft ARR 2022) was implemented. Slovakia provides in the **Chapter 6.6.1** information for estimation of CSC of other wooded land.

- <u>ERT recommendation (L.14 – draft ARR 2022)</u> was implemented. Slovakia provides information on the revised coefficients $BCEF_R$ for conifer and broadleaves species and described the related methodological recalculations in the **Chapter 6.6**.
- <u>ERT recommendation (L.15 – draft ARR 2022)</u> was implemented. Slovakia provided information on the revised estimation, revised AD, revised coefficients and related methodological updates in the **Chapter 6.7.2**.
- <u>ERT recommendation (L.16 – draft ARR 2022)</u> was implemented. Slovakia provided information on the revised estimation, revised AD, revised coefficients and related methodological updates in the **Chapter 6.8.2**.
- <u>ERT recommendation (L.17 – draft ARR 2022)</u> was implemented in the SVK CRF 2023, in Table 4Gs2.
- <u>ERT recommendation (L.18 – draft ARR 2022)</u> was implemented. Slovakia provides an explanation of the trend of CSC of HWP in the **Chapter 6.17**.
- <u>ERT recommendation (L.19 – draft ARR 2022)</u> was implemented. Slovakia provides further information on parameters for estimating CSC for HWP in the **Chapter 6.17**.

6.5. Time-series Consistency and Uncertainties

The time series are consistent in the area of using consistent methodology, consistent way of collection of activity data and use of consistent emission factors and other parameters. Disturbances and fluctuations in time series and in emissions or removals are described in the particular chapters and can be reasonably explained by national circumstances. Three recalculation (***Table 6.6***) was performed in this submission.

The uncertainty analysis of the LULUCF sector was performed by the Approach 1 methods using the Equations 3.1 and 3.2 (Volume 1, Chapter 3, IPCC 2006 GL). Used parameters in the Approach 1 uncertainty analyses within the LULUCF sector according to the categories are referred to in ***Table 6.7***. More and detailed information is in the SVK NIR 2018, the **Chapter 6.5** (**Annex A6.2**).

Table 6.7: *Uncertainties of activity data and EFs in individual C pools and LULUCF categories*

LULUCF CATEGORY		ACTIVITY DATA	EMISSION FACTOR	EF REFERENCES
4.A.1	Forest Land remaining Forest Land - living biomass	3%	82.84%	IPCC 2006 GL
4.A.2	Land converted to Forest Land - living biomass	3%	40.61%	IPCC 2006 GL
4.A.2	Land converted to Forest Land – DOM (litter)	3%	75.00%	expert judgement
4.A.2	Land converted to Forest Land - mineral soils	3%	75.00%	expert judgement
4.B.1	Cropland remaining Cropland - living biomass	3%	75.00%	IPCC 2006 GL
4.B.1	Cropland remaining Cropland – mineral soils	3%	76.09%	expert judgement
4.B.2	Land converted to Cropland - living biomass	3%	107.98%	IPCC 2006 GL (tab. 5.1, 6.4), Šmelko et al. 2003
4.B.2	Land converted to Cropland – DOM (DW/litter)	3%	75.24%	SVK NFI, expert judgement
4.B.2	Land converted to Cropland - mineral soils	3%	75.00%	expert judgement
4.C.1	Grassland remaining Grassland - living biomass	3%	75.00%	IPCC 2006 GL

LULUCF CATEGORY		ACTIVITY DATA	EMISSION FACTOR	EF REFERENCES
4.C.1	Grassland remaining Grassland – mineral soils	3%	76.09%	expert judgement
4.C.2	Land converted to Grassland - living biomass	3%	107.98%	IPCC 2006 GL (tab. 5.1, 6.4), Šmelko et al. 2003
4.C.2	Land converted to Grassland – DOM (DW/litter)	3%	75.24%	SVK NFI, expert judgement
4.C.2	Land converted to Grassland - mineral soils	3%	75.00%	expert judgement
4.E.2	Land converted to Settlements - living biomass	3%	107.98%	IPCC 2006 GL (tab. 5.9, 6.4), Šmelko *et al.* 2003
4.E.2	Land converted to Settlements – DOM (DW/litter)	3%	75.24%	SVK NFI, expert judgement
4.E.2	Land converted to Settlements - mineral soils	3%	75.00%	expert judgement
4.F.2	Land converted to Other Land - living biomass	3%	107.98%	IPCC 2006 GL (tab. 5.9, 6.4), Šmelko *et al.* 2003
4.F.2	Land converted to Other Land – DOM (DW/litter)	3%	75.24%	SVK NFI, expert judgement
4.F.2	Land converted to Other Land - mineral soils	3%	75.00%	expert judgement
4.G	Harvested Wood Products	5%	50.00%	IPCC 2006 GL

In a reflection to the ERT recommendations made in previous reviews the NIS SR has started preparation work on improvement of uncertainty analyses of the key categories inside the LULUCF sector. In October 2017, the Expert Working Group for LULUCF (EWG LULUCF) was created. The EWG LULUCF consists of the LULUCF sectoral experts, uncertainty expert, expert for emission modelling, QA/QC expert and NIS SR coordinator. Independent observers are experts for LULUCF legislation from the Ministry of Environment of the Slovak Republic and Ministry of Agriculture and Rural Development of the Slovak Republic. Main task of the EWG LULUCF is the preparation of higher tier uncertainty analyses and further improvement in this sector. The first meeting of the EWG LULUCF agreed on the Working Plan for the next period of approximately three years.

Working Plan (in shortened version):

- Preparation of detailed key category analysis on level and trend assessment in the LULUCF sector using Approach 1 (IPCC 2006 GL);
- Analysis of key categories by trend and level assessment, incorporating formulas and parameters, including comments on availability of national data on uncertainty, literature;
- Uncertainty expert checks information sent by sectoral experts and set up the range of work and other possibility;
- Cooperation with the Cadastral Office;
- Evaluation of input data;
- Preparation of Monte Carlo model;
- Evaluation of results;
- Further improvements.

During the years 2018 – 2022, work on the improvement of uncertainty analyses for the LULUCF categories was ongoing according to the agreed schedule. Several expert meetings were followed by discussions and email communication. During the first part of work done in 2017, key categories were identified as follow:

- Approach 1 – level assessment (CO_2): FL remaining FL, L converted to FL, CL remaining CL and HWP;
- Approach 2 – level assessment (CO_2): FL remaining FL, L converted to FL, CL remaining CL, L converted to GL, L converted to S, L converted to OL and HWP;
- Approach 1 & 2– trend assessment (CO_2): FL remaining FL, L converted to FL, CL remaining CL, L converted to CL, L converted to GL and HWP;
- From non-CO_2 gases, only N_2O emissions from L converted to CL is a key category in level and trend assessment.

According to the key category identification, work on the Monte Carlo simulation started in the second half of 2018 and it has continued during 2019, 2020, 2021 and 2022. Preliminary results of the application of Monte Carlo simulations are provided in the **Annex A6.2** of this Report. Work will continue following the available capacities and sources.

Analyses of uncertainties using Monte Carlo simulations for the main LULUCF categories (including the HWP), as well as for the whole LULUCF sector, were included in this submission.

6.6. Forest Land (CRF 4.A)

Forests currently cover 41.4% of the Slovak Republic. The area of forests in Slovakia is in temperate-zone and is managed. Forests in Slovakia are known for richly diverse species composition mainly with European beech being the dominant forest tree species covering 35.1% of the area, followed by Norway spruce (21.3%), oaks (10.4%) and pine (6.5%). Broadleaved species represent 64.5% of all tree species found in Slovak forests. Percentage of coniferous species (currently at 35.5%) has been steadily decreasing since 1980; since 2000, their presence fell by 7.0%. Due to harmful agents in forests, Norway spruce percentage has fallen from the original 26.8% in 2000 to current 22.1%, a drop by 4.3%. At the same time, the area of European beech has increased by 5.1% whilst the area of noble hardwoods (maples and ash) has grown by 2.4% (Green Report, 2023). In addition to the overall representation of individual tree species, the mixing of tree species in particular forest management units is also an important indicator of species diversity and forest stand stability. At present, the most represented types of forest stands are: beech forests (27.5%), conifer-beech mixtures (25.5%), spruce forests (15.0%) and forests dominated by oak (9.0%). The actual age structure of forest significantly differs from the normal (ideal/optimal) structure. At present, forests 70+ years old are the most represented group of forests. Majority of these forests reached the age when it is desirable to start with their regeneration. Conversely, percentage of young forests (20-70 years old) is below normal. In the last ten years or so, the proportion of the youngest forest stands of the 1st and 2nd age classes has increased significantly. This is due to the high extent of forest damage caused by harmful agents and subsequent regeneration of damaged forests (Green Report, 2023). At present, forest management is focused more on close-to-nature silvicultural procedures, establishment of forest stands with better structural, species diversity, and higher ecological stability. Split by main species groups reads as follows: coniferous forests 31%, broadleaved forests 50%, and mixed forests 19%.

The growing stock has shown a continual increase in the volume of available timber in forests. The estimated growing stock was 482.8 mil. m^3 (merchantable volume, defined as tree stem and branch volume under bark with minimum diameter threshold of 7 cm) in 2022, and decrease of 4.5 mil m^3 compared to 2021. Currently, due to the present age-structure of forests in Slovakia, the growing stock of forests is the highest. However, their volume is already at the culmination point. It is expected that in the coming years and decades these stocks will decrease due to a gradual change in age structure. This trend is also confirmed by the observed decrease in the average annual increase in growing stocks in forests in the SR, which was as follows: 1991 – 1995: 5.9 mil. m^3, 1995 – 2000: 6.4 mil. m^3, 2000 – 2005: 5.8 mil. m^3, 2005 – 2010: 4.6 mil. m^3, 2010 – 2015: 3.2 mil. m^3; 2016-2021, the average annual increase in growing stocks was only 1.32 mil. m^3. A similar trend to the annual change in total growing stocks can be observed also in the development of the annual change in average growing stock per 1 ha. Average hectare growing stock was 248 m^3 in 2022 (Green Report, 2023).

In 2021, the volume of current annual increment (CAI) reached 11.99 mil. m^3, or 6.22 m^3 per ha of FL. Over the last few decades, CAI gradually grew to 12.126 mil. m^3 (6.25 m^3 per ha) in 2012. However, since 2012 it has decreased by 1%, or 119 000 m^3, respectively.

Healthy and resilient forests are also an important part of the landscape due to their significant contribution to carbon sequestration. They directly contribute to reduction of greenhouse gas emissions, carbon dioxide in particular, as carbon is stored for a long time in forest biomass, soil and wood products. Along with the increase in growing stock in forests and FL, there is also an increase in carbon stock bound in individual balance categories.

According to Green Report 2023, the carbon stock in forests found in living biomass (aboveground and underground), dead organic mass (deadwood, litter) and forest soils reached a volume of 507.1 mil. t in 2022, with the largest amount stored in soils (270.5 mil. t) and aboveground tree biomass (164.2 mil. t). As a result of the current trend in the development of the age structure of forests, a decrease in the amount of carbon stocks in individual balance categories will occur simultaneously with the decrease in the wood stocks in the forests. (Green Report, 2023).

The total volume of harvested timber reached 7.68 mil. m^3 in 2022. Compared to 2021, realized felling increased by 0.046 mil. m^3, and it was lower by 2.0 mil. m^3, as the planned felling calculated using actual harvesting possibilities and forest regeneration on urgency. Of the total volume, 48.3% of harvested timber represents the coniferous wood and 51.7% broadleaved wood. Of the total timber volume, 2.76 mil. m^3 (35.8%) was felled due to natural disturbances and pests, of which 65.7% was coniferous wood. Despite this, the actual felling is still below the level of total current increment (the volume of timber that accrues in forests every year) and has been even lower than planned felling since 2012, except for the year 2014. The realized logging was lower than CAI during the completely reporting period (***Figure 6.9***). Planned and actual felling in volume of m^3 are increasing in Slovakia, despite the fact that in 2020 the volume of felling was the lowest in the last 15 years. The main reason behind increased felling volumes is the current age structure of forests with a high proportion of 70+ years old forests. Due to a high percentage of mature forests approaching rotation, the volume of planned felling kept increasing to reach 9.8 million m^3 in 2020, which was 84.9% more than in 2000. Both the growing stock and the area of mature forests have stagnated in recent years, which indicates the onset of a gradual reduction of previously high felling volumes (Green Report, 2023).

All available information about the forests in Slovakia comes from two sources. The first one is the Forest Management Plan (FMP), updated on a regular basis. Investigation is carried out in a 10-years period – i.e. one tenth of the territory is surveyed each year, practically all forest stands are surveyed once in every 10 years. The survey produces detailed maps, as well as description of the forest stands (e.g. species composition, diameter at breast height, mean height, stock volume, number of trees, basal area, crown closure, volume increment etc.). Gathered data are stored in databases and further processed into aggregated files used for reporting and compilation of various documents including the Compendium of Forestry Statistics - the Aggregated Forest Management Plan (AFMP), and the Permanent Forest Inventory (PFI). Professionally and technically competent non-state experts and companies elaborated Forest Management Plans (FMPs). The FMPs are prepared according to the existing legislation, procedures and methodologies. All relations concerning the FMPs can be found in the Act No 326/2005 Coll. on Forests and Public Notice of the Ministry of Agriculture No 453/2006 Coll. on Forest Management Planning and Forest Protection. The FMPs are approved by provincial (governmental) forest authorities and are audited by the National Forest Centre (NFC). The FMPs have been performed for all forests, owners or users within the Slovak territory (Act No 326/2005 Coll.). For the forest management it is mandatory, that activities, including harvest and harvested volume, are recorded and reported yearly to the state authority.

The second source of information are data from the National Forest Inventory and Monitoring (NFIM). The first cycle of the statistical forest inventory (sample based, tree level) was performed during 2005 – 2006 and the second one during 2015 – 2016 by the NFC. The NFIM is a selective statistical method of forest condition inventory. It has two levels – national and regional, and provides data for all forests regardless of land category (forest, non-forest). The NFIM provided a comprehensive set of data on forests relevant to December 31, 2005. Accuracy and reliability of provided outcomes meets the quality expected at the beginning of investigation (standard error 2.1% for total standing volume). This data source is not usable for emissions reporting of Forest Land, because it does not cover reporting period sufficiently. However, it is usable for estimation of carbon pools for example of dead organic matter – dead wood.

The 4.A category includes emissions and removals of CO_2 (Gg) associated with forest. Category is divided into subcategories: 4.A.1 - FL remaining FL and 4.A.2 Land converted to Forest Land (L converted to FL). ***Figure 6.7*** shows area changing during years and ***Figure 6.8*** shows map of Forest Land in Slovakia.

Figure 6.7: *Development of activity data (kha) for the category 4.A - FL in the period 1990 – 2022*

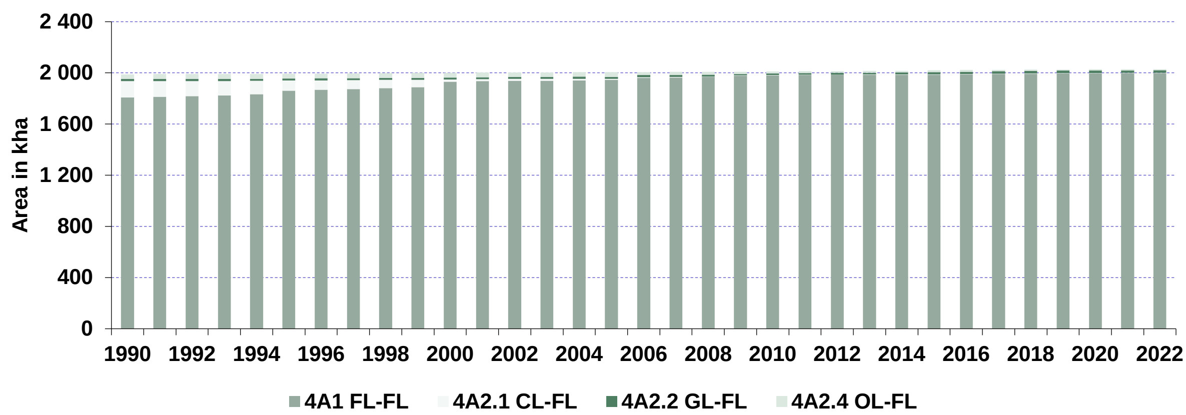
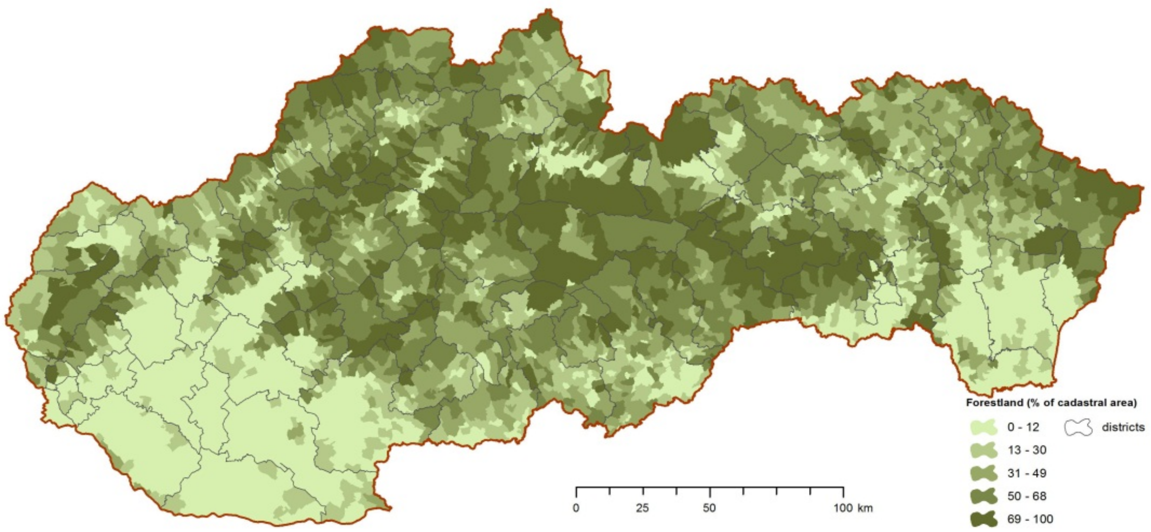


Figure 6.8: *Distribution of FL calculated as a spatial share within individual cadastral units*



6.6.1. Forest Land Remaining Forest Land (CRF 4.A.1)

Emissions estimation is based on the methodology from the IPCC 2006 GL and activity data from the PFI processed continuously on annual basis. Results of estimation were obtained by using the IPCC methodology and national data on area of forested land and land converted to the forest during the inventory year 2022. This category includes carbon stock change in following carbon pools: living biomass (above and below ground), dead organic matter (dead wood and litterfall) and organic soil carbon. Carbon stock change is given by the sum of changes in living biomass, dead organic matter and soil. Total area of Forest Land remaining Forest Land represents 1 998.590 kha.

Methodological issues – methods, activity data, emission factors and parameters

The carbon stock change in living biomass was estimated using a gain-loss method according to the Equation 2.7 of the IPCC 2006 GL. This method is based on separate estimation of increments, removals and its difference. Calculations of carbon stock changes in living biomass as a result of annual biomass increment and annual biomass loss was carried out following the Equations 2.9 - 2.12 of the IPCC 2006 GL.

Current annual increment (CAI) expressed as merchantable volume, defined as tree stem and branch volume under bark with a minimum diameter threshold of 7 cm are the key inputs to calculate the carbon increment. The CAI values are calculated by the NFC-IFRI, which is the FMP database administrator for Slovakia. The calculation is performed at the level of the individual stands and species using the available stand parameters, yield data and models. The CAI is determined based on the average stocks in the different age levels for individual tree species as the sum of the average increment in the different age levels, expressed per unit of actual area of tree species occurrence.

G_{TOTAL} is the expansion of current annual increment of aboveground biomass (G_W) to include its belowground part, involving multiplication by the ratio of belowground biomass to aboveground biomass (often called the root-to-shoot ratio that applies to increments).

The current annual increment (merchantable volume increment - Iv) is converted to the annual biomass increment (G_{TOTAL}) using the biomass conversion expansion factor ($BCEF_I$) and root-to-shoot ratio (R) (Equation 2.10 (A) and (B) of the IPCC 2006 GL) as follows:

- $G_{TOTAL} = G_W * (1 + R)$
- $G_W = I_V * BCEF_I$

The root-to-shoot ratio was differentiated according to Table 4.4 of the IPCC 2006 GL (0.20 for coniferous and 0.24 for other broadleaved species). The input data and factors used in the calculation of the biomass carbon stock increment for different tree species are presented in ***Table 6.8***.

Table 6.8: *Annual biomass increment for individual forest tree species in the Slovak Republic in 2022*

TREE SPECIES	Current annual increment	Biomass conversion/ expansion factor	Average annual above-ground biomass growth	Ratio of below-ground biomass to above-ground biomass	Average annual biomass growth above- and below-ground
	CAI (m^3/ha/yr)	*$BCEF_I$*	*GW (t dm/ha/yr)*	*R*	*G TOTAL (t dm/ha/yr)*
Spruce	8.19	0.45	3.67	0.20	4.41
Fir	7.79	0.45	3.48	0.20	4.18
Pine	5.50	0.67	3.69	0.20	4.42
Larch	6.14	0.80	4.94	0.20	5.92
Other conifer	2.42	0.54	1.30	0.20	1.56
Oak	4.32	0.88	3.75	0.24	4.65
Beech	6.53	0.78	5.06	0.24	6.28
Hornbeam	6.06	0.91	5.53	0.24	6.85

TREE SPECIES	Current annual increment	Biomass conversion/ expansion factor	Average annual above-ground biomass growth	Ratio of below-ground biomass to above-ground biomass	Average annual biomass growth above- and below-ground
	CAI (m^3/ha/yr)	*$BCEF_I$*	*GW (t dm/ha/yr)*	*R*	*G TOTAL (t dm/ha/yr)*
Maple	6.91	0.72	4.96	0.24	6.15
Ash	7.37	0.72	5.29	0.24	6.56
Elm	6.46	0.74	4.79	0.24	5.94
Turkey oak	4.65	0.94	4.34	0.24	5.39
Locust	3.59	0.91	3.27	0.24	4.06
Birch	3.17	0.68	2.17	0.24	2.69
Alder	3.42	0.68	2.34	0.24	2.90
Linden	6.55	0.51	3.36	0.24	4.17
Breeding poplars	12.22	0.48	5.82	0.24	7.22
Poplar	5.43	0.42	2.26	0.24	2.81
Willow	3.92	0.72	2.80	0.24	3.47
Other broad	2.82	0.68	1.93	0.24	2.39

According to present knowledge, about 55-90% (depending on tree species) of the total tree biomass can be assumed stored in the stems (Šebík et al., 1989). The density of wood (at dry weight) varies depending on tree species, from 0.40 to 0.80 t d.m./m^3 in the national conditions (Požgaj et al., 1993). The annual biomass increment per hectare and year (resulting from application of annual wood volume increment data and biomass expansion factor) varies from 1.40 to 6.80 t d.m./ha for different tree species.

The $BCEF_I$ showed in ***Table 6.8*** were calculated as a ratio of CAI expressed as tree volume over bark and CAI expressed as merchantable volume (defined as tree stem and branch volume under bark with a minimum diameter threshold of 7 cm) for spruce, fir, pine, beech, oaks and poplar tree species. This is multiplied by the basic wood density of individual tree species. The values of CAI for individual tree species were based on national growth and yield tables (Halaj and Petráš, 1998) using values of age and "bonita" degree (yield class) calculated by the NFC-IFRI Zvolen annually.

Estimation of annual increase in carbon stocks due to biomass increment in FL remaining FL requires inputs of actual stand area (A), annual increment of total biomass (G_{TOTAL}) and carbon fraction of dry matter and was calculated by the Equation 2.9 of the IPCC 2006 GL as followed:

- $\Delta C_{FFG} = \sum (A * G_{TOTAL}) * CF$

The middle of the range values for the carbon fraction of above-ground biomass in forest (all, broadleaves and conifers) (Table 4.3 of the IPCC 2006 GL) was implemented. The carbon content of 51% for coniferous and 48% for broadleaved wood was used for calculation of carbon gains in living biomass. The annual increase in carbon stock due to biomass increment in the category FL remaining FL represents 5 162.39 kt C in 2022 and is shown in ***Table 6.9***.

Table 6.9: Total carbon uptake increment for individual forest tree species in 2022

TREE SPECIES	Area of tree species for FL remain FL	Average annual biomass growth above- and below-ground	Annual increase in biomass due to biomass growth	Carbon fraction of dry matter	Annual increase in biomass carbon stocks due to biomass growth
	(kha)	*(t dm/ha)*	*(kt/dm/yr)*	*(t C/tdm)*	*(kt C yr)*
Spruce	426.299	4.41	1 879.03	0.51	958.31
Fir	79.944	4.18	333.96	0.51	170.32
Pine	129.309	4.42	571.96	0.51	291.65
Larch	52.363	5.92	310.22	0.51	158.21
Other conifer	20.785	1.56	32.36	0.51	16.50
Oak	206.854	4.65	961.39	0.48	461.47
Beech	701.505	6.28	4 403.71	0.48	2 113.78
Hornbeam	119.516	6.85	819.13	0.48	393.18
Maple	52.363	6.15	322.26	0.48	154.69
Ash	30.578	6.56	200.72	0.48	96.35
Elm	0.600	5.94	3.56	0.48	1.71
Turkey oak	51.963	5.39	279.95	0.48	134.38
Locust	35.375	4.06	143.63	0.48	68.94
Birch	34.775	2.69	93.51	0.48	44.88
Alder	15.189	2.90	44.06	0.48	21.15
Linden	8.794	4.17	36.64	0.48	17.59
Breeding poplars	8.594	7.22	62.04	0.48	29.78
Poplar	8.194	2.81	23.00	0.48	11.04
Willow	1.999	3.47	6.94	0.48	3.33
Other broad	13.191	2.39	31.55	0.48	15.15
TOTAL	**1 998.190**		**10 559.52**		**5 162.39**

The annual decrease in carbon stocks due to biomass loss in FL remaining FL follows Equations 2.12 of the IPCC 2006 GL. Slovakia reports that main/primary source of information for annual harvesting is the harvest statistics. The annual harvest volume (H) is collected in the mandatory reporting of forest managers and elaborated by the NFC-IFRI. It covers managed forests, as the reporting is an integral mandatory part of forest management and covers any annual harvest data including thinning and final cut. Relevant forest companies, forest owners or users are obligated to provide data on forest management activities (harvest, silviculture) to the central forestry database annually (Regulation No 297/2011 Coll. of the Ministry of Agriculture and Rural Development of the Slovak Republic). Annual data on harvest includes biomass harvested in forest in a reported year. Even the stolen timber is notified by owners and is included in the annual harvest each year. All subjects (users, companies) managing forest, which realized or did not realized harvest have the statutory duty (Act No 326/2005 Coll. on Forests) to inform the NFC - IFRI authorities about the amount and type of harvest throughout districts.

The annual amount of total harvest and fuel wood removals is published annually in the Green Reports. The harvesting volumes of coniferous and broadleaved trees, CAI and total harvest during the reporting period 1990 – 2022 in Slovakia are presented on ***Figures 6.9*** and ***6.10***.

Figure 6.9: *The harvesting volume in forest (coniferous and broadleaved) (mil. m³ volume >7 cm under bark) in 1990 – 2022*

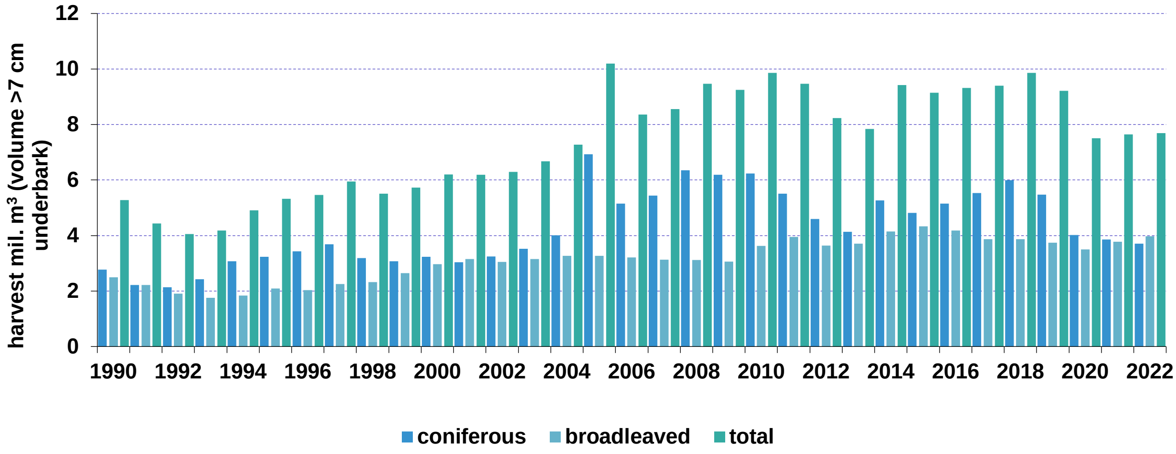
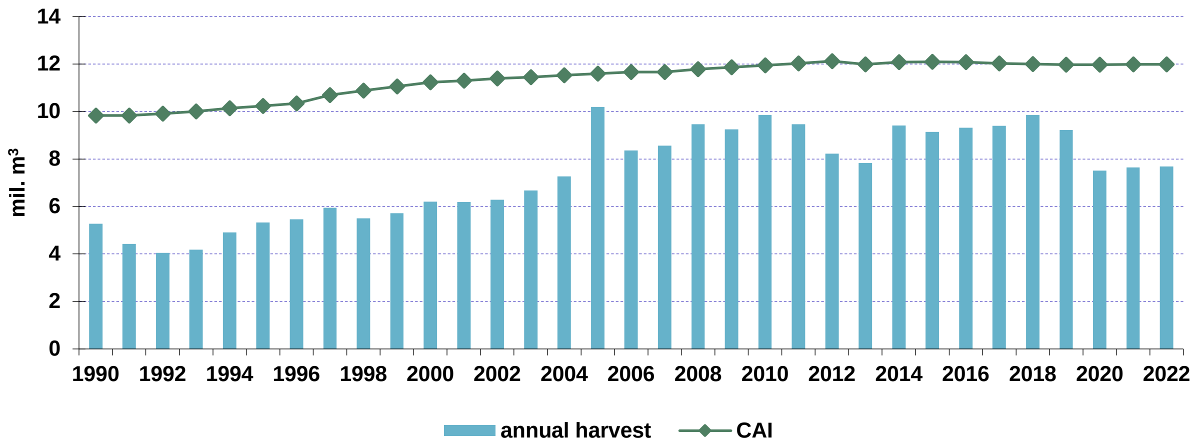


Figure 6.10: *Current annual increment (CAI) and total annual harvest (mil. m³) in 1990 – 2022*



The annual carbon loss due to commercial felling was calculated using the Equation 2.12 of the IPCC 2006 GL:

- $L_{fellings} = H * BCEF_R * (1+R) * CF$

Biomass conversion and expansion factors ($BCEF_R$) were developed based on new NFI data. $BCEF_R$ were developed for Norway spruce (Picea abies), Pine (Pinus sylvestris), Oak (Quercus robur) and Beech (Fagus sylvatica). The methodology follows a common procedure described in literature (Lehtonen et al., 2004) and cited in the IPCC 2006 GL. The BCEF is generally defined as:

- $BCEF_i = W_i / V$

Where: i indicates a tree biomass component, W_i (Mg) is the dry biomass of component, V (m³) is the tree merchantable volume.

Tree-level data of new NFI were used to construct age-related BCEFs. Only inventory plots that contained a dominant share (at least 50% of the basal area) of any of the four key tree species (beech, oak, pine and spruce) were used for the analysis. This selected database contained over 22 thousand trees. Tree merchantable volume and tree aboveground biomass were calculated using national methodology (Petras and Pajtik, 1991). The aboveground biomass functions were used from the studies (Wutzler et al., 2008 for beech trees, Cienciala et al., 2008 for oak trees, Cienciala et al., 2006 for pine trees and Wirth et al., 2004 for spruce). More complete description of the $BCEF_R$ calculation was published in the report "Different Approaches to Carbon Stock Assessment in Slovakia", Chapter 13.

The values of $BCEF_R$ were calculated for each year separately considering actual age structure of forests.

During the review 2022 the ERT suggested recommendation (L.14 - draft ARR 2022) that $BCEF_R$ coefficients for coniferous species be divided by 0.92 and $BCEF_R$ coefficients for broadleaved species be divided by 0.9 for adding bark and harvest losses in accordance with the 2006 IPCC GL. Slovakia revised its calculation on annual carbon losses due to commercial felling for the forest land remaining forest land category of LULUCF and resubmitted the LULUCF CRF tables with the revised calculations, which was accepted by the ERT and the resubmission confirmed. The forest land remaining forest land removals decreased from -7 422.68 Gg CO_2 eq. to -6 290.29 Gg CO_2 eq. (15.3%) for 2020 through this resubmission. This revision affected the whole time series (1990 – 2020).

The CF factors used in calculation are described in ***Table 6.10***. The carbon loss due to fuel wood gathering was not estimated separately as this activity is very rare in Slovakia and fuelwood is included in total harvest. The total annual carbon release from forest harvest was 3 504.61 kt C in 2022.

Table 6.10: *Activity data and BCEFR used in calculation of carbon losses in 2022*

TREE SPECIES	**Annual wood removal - harvest volume**	**Biomass conversion/expansion factor**	**Annual wood removal - biomass**	**Ratio of below-ground biomass to above-ground biomass**	**Annual wood removal - biomass**	**Carbon fraction of dry matter**	**L wood-removals including fuelwood**
	H (m^3/yr)	*$BCEF_R$*	*(t dm/yr)*	*R*	*(t dm/yr)*	*CF (t C/tdm)*	*(kt C/yr)*
Spruce	2 996 384	0.683	2 036 905	0.20	2 444 286	0.51	1 246.59
Fir	230 030	0.683	156 371	0.20	187 645	0.51	95.70
Pine	344 044	0.572	196 240	0.20	235 488	0.51	120.01
Larch	63 008	0.572	35 939	0.20	43 127	0.51	21.99
Other conifer	76 010	0.572	43 355	0.20	52 026	0.51	26.53
Oak	507 942	0.923	467 769	0.24	580 034	0.48	278.42
Beech	2 586 705	0.833	2 148 520	0.24	2 664 165	0.48	1 278.80
Hornbeam	233 973	0.833	194 338	0.24	240 980	0.48	115.67
Locust	69 992	0.833	58 135	0.24	72 088	0.48	34.60
Poplar	91 990	0.833	76 407	0.24	94 744	0.48	45.48
Other broad	486 945	0.833	404 457	0.24	501 526	0.48	240.73
TOTAL	**7 687 023**		**5 818 437**		**7 116 110**		**3 504.61**

According to the ERT recommendation (L.13 - draft ARR 2022), Slovakia clarified that wooded land which is below the thresholds for forest land (tree species covering less than 0.3 ha or with density lower than 20%, woody vegetation which potentially cannot exceed 5 m height) reported as other conifers under the forest land remaining forest land category. According to the FAO - Global Forest Resources Assessment 2020 report, Slovakia considers as other wooded land the Alpine vegetation zone with Pinus mugo plantations, which are reported under forest land. CSC of other wooded land in forest land remaining forest land represents 0.29 to 17.96 kt C/y (0.01 to 2.71% of total removals of FL remaining FL category in individual years). Other wooded land represents a net sink for whole reporting period. The area of other conifers (other wooded land) ranges from 18 to 22 kha (1.00 to 1.12%), of the total forest land area in individual years. All AD are reported in NIR ***Table 6.8*** and ***Table 6.9*** (**Chapter 6.6.1**). Current annual increment of biomass varied from 1.39 to 2.60 m3/ha/y, BCEFI and BCFR are similar as pine tree species.

The assessment of the net carbon stock change in DOM includes dead wood and litter pools.

The dead wood carbon pool contains dead trees from standing, stumps, coarse lying dead wood and small-sized lying dead wood not included in litter or soil carbon pools. The information on dead wood stocks was obtained from the first and second National Forest Inventory (NFI) realized in 2005/2006 and 2015/2016. Before realization of the NFIs, no reliable data on dead wood (except for standing dead trees) were available in Slovakia. Quantification of dead wood was performed by the methodology where all components were determined in the same volume units (m^3 over bark) in order to enable their aggregation. The volume of standing dead trees was determined from the volume equations of living trees (HSK). In order to determine the stump volume, new regression equations were derived, where the diameter at the top of the cut area D and the stump height H represent input variables. The volume of the lying dead wood with the top diameter of 7 cm was calculated from the measured diameters d1 and d2 (cm) outside bark at both ends and the length of each piece inside the inventory plot (IP) or a sub-plot using the Smalian equation (Šmelko, 2000). The volume of small-sized lying dead wood (having diameter from 1 to 7 cm) was estimated by the original method, where the volume of small-sized lying dead wood (in m^3) densely arranged in 1 m^2 is calculated from the biometrical model as a function of the middle diameter of small-sized lying dead wood multiplied by the area of IP, estimated coverage of small-sized lying dead wood, and tree species proportion (Šmelko et al., 2008). The conversion of volume to dry biomass was carried out based on wood density coefficients and using reduction coefficients according to the degrees of decomposition of dead wood (Fresh 1; Hard 0.83; Soft 0.66; Decayed 0.5). The volume was multiplied by the wood dry matter density coefficients according to the NIML List of Forest Tree Abbreviations (Šebeň, 2017) and the above-ground biomass in mass units was calculated. The conversion of biomass to carbon was performed by a coefficient of 0.496 (Šmelko et al., 2011). According the NFIs the average C stock of dead wood was calculated on 6.6 ± 0.5 t C/ha for 2005 as well as 7.4 ± 0.7 t C/ha for 2015 in Forest Land category. Using the estimated trend based on these empirical observations, data for the years between these data points were linearly interpolated and extrapolated accordingly beyond that period. The Equation 2.19 of the IPCC 2006 GL was used for calculation of the net C stocks change of DW.

The litter pool definition used in the inventory includes all non-living biomass with a size less than the minimum diameter defined for dead wood (1 cm). The small-sized lying dead wood (diameter between 1 and 7 cm), in various states of decomposition above the mineral soil are not a part of litter, because they are included in dead wood. The litter includes the surface organic layer (L, F, H horizons) as usually defined in soil profile description and classification. Live fine roots above the mineral or organic soil (of less than the minimum diameter limit chosen for below-ground biomass) are included in litter because they cannot be distinguished empirically. All existing national databases on carbon stocks in forest soil organic layer are based on the same approach and soil data were obtained by standard sampling procedure.

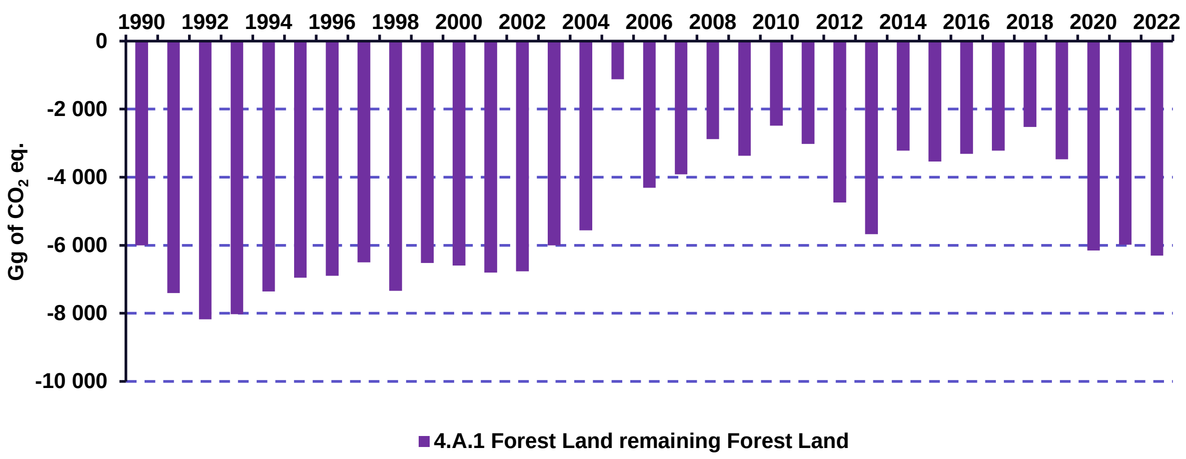
The mean carbon stock in forest litter is 8.3 t C/ha. The value is derived from datasets of the Forest Monitoring System (FMS) and the NFI. The changes of forests management that would dramatically change litter properties and litter carbon changes do not occur, i.e. no significant changes of carbon stocks in litter in the 4.A.1 were assumed (tier 1). Information on soil carbon stocks in forest soils is from soil survey on permanent monitoring plots (16x16 km grid of large-scale forest monitoring), soil survey on the NFI plots and sets of research plots databases. The most detailed information source with respect to soil depth (0-10 cm, 10-20 cm, 20-40 cm, 40-80 cm) and sampling design is the set of 112 plots of large-scale monitoring and 9 intensive monitoring plots. The largest and the most representative information source is the set of plots of the NFI (almost 1 500 plots with sampling depth limited to 20 cm). Carbon stocks per hectare (in both data sources) are calculated using information on carbon concentration in fine soil, bulk density and coarse fragment content. The calculated soil carbon stocks range from 13.7 to 486.8 C t/ha (for the depth 0-20 cm in both the FMS and the NFI datasets). Supplementary information about carbon content and carbon stock in forest soil comes also from other research plots with detailed soil profile description and classification. It is used mainly for derivation of indices for recalculation of carbon stocks for different depths and respective soil types or site units.

For estimation of carbon stock change for mineral soils carbon pool, tier 1 approach was used and assumed that soil carbon stocks change in category 4.A.1 is considered to be zero. Evaluation of results from re-sampling after 13 years (in 16x16 km grid of monitoring plots) has been finished. Though slight increase of soil carbon stocks seems to be possible, tests did not show significant differences (changes). Based on these tests, forest soils (for forests remaining forests) are neither carbon emission source nor sink. Soil data management and evaluation of differences after 10 years from the NFI plots (8x4 km grid of inventory plots) is expected to be done in near future.

In the central European conditions, the mineral soils and the litter are not a source of net emissions (Pavlenda, 2016) in managed Forest Land, based on the principles of sustainable forestry. The same assumption was made in countries with similar soils and climatic conditions (Hungary, the Czech Republic).

Figure 6.11 shows that the net CO_2 removals in the FL remaining FL represent -6 304.61 Gg in 2022. It is necessary to mention that every forest in Slovakia is considered as managed. Uptake of carbon into the biomass of forest trees has slightly increased since 1990 and then decreased after 2004, however fluctuations can be observed in time series of harvested volume, especially in the last ten years, which can be attributed to fluctuations of salvage logging after disturbances.

Figure 6.11: *Summary results of CO_2 removals (Gg) from FL-FL subcategory in 1990 – 2022*



6.6.2. Biomass Burning (CRF 4.A.1 - 4(V))

The biomass burning activity in 4.A.1 - 4(V) includes emissions of CO_2, CH_4, and N_2O associated with forest fires and biomass burning on forest areas. The National Forest Centre – Forest Protection Service summarized activity data from controlled burning and forest fires since 1999.

Slovak harvesting system partly includes burning of harvesting residues if decided by forest managers and the risk of fire is limited (at cleared plots after processing of trees infested by bark beetle or after clear cuts). The harvesting residues are burned on about 50% of the forest clearing area. The differences are in the quantity of burning biomass. For coniferous 10% and for broadleaved about 25% of above ground biomass is burned. Because there is no official estimation of amount of post logging slash, the expert judgment was used for calculation. The biomass fraction burned on clearing areas was quantified on the basis of annually reported amount of main felling, separately for coniferous and broadleaved species as well as the $BCEF_R$ were applied in calculation of harvest losses in FL remaining FL. The emissions from biomass residues burning were calculated according to the Equation 2.27 and the default emission factors provided in Table 2.5 (IPCC 2006 GL). Default combustion factor value for post logging slash burn in other temperate forests is 0.62 according to Table 2.6 (IPCC 2006 GL).

The main information sources on wildfires or forest fires are the internal fires statistics of the Ministry of Interior and the "Reports of the occurrence of harmful agents in Slovakia". Reported forest fires in Slovakia were at the area of 1 210.55 ha in 2022. This number increased compared to the previous year 2021, when the total burnt area was 158.94 ha. The average burnt forest area per one fire was 4.7 ha. The largest forest area damaged by fire was 140 ha. The forest fires occurred mostly in spring and in the summer. The GHG_s emissions from wildfires were calculated based on Equation 2.27 (IPCC 2006 GL) and the mass of fuel available for combustion derived using known areas burnt annually. The average stock per hectare (248 m^3/ha in 2022) and biomass expansion factor was used for estimation. The GHG emissions from wildfires were calculated based on known annual burnt area and the average stock per hectare. ***Table 6.12*** shows biomass burned in forests with emissions in the same units.

Table 6.12: *Biomass burned in Forest land remaining Forest land category, CO_2, CH_4 and N_2O emissions from wildfires and controlled burning in particular years*

YEAR	BIOMASS BURNED	AREA BURNED	CO_2 EMISSIONS		CH_4 EMISSIONS		N_2O EMISSIONS	
			Controlled Burning	Wildfires	Controlled Burning	Wildfires	Controlled Burning	Wildfires
	t d.m.	*ha*	*Gg**		*t*			
1990	104 472.85	208.94	IE	45.83	304.43	137.28	16.84	7.59
1995	89 822.48	65.48	IE	15.57	261.74	46.63	14.48	2.58
2000	132 254.40	892.90	IE	231.79	385.39	694.34	21.32	38.41
2005	214 689.72	511.65	IE	141.62	625.61	424.22	34.61	23.47
2010	218 608.12	189.12	IE	54.72	637.02	163.92	35.24	9.07
2011	210 905.06	396.75	IE	115.83	614.58	346.97	34.00	19.19
2012	126 556.09	1 658.91	IE	490.48	368.78	1 469.26	20.40	81.28
2013	127 582.17	266.23	IE	79.35	371.77	237.71	20.57	13.15
2014	252 540.53	188.74	IE	56.32	735.90	168.72	40.71	9.33
2015	241 696.53	346.65	IE	103.94	704.30	311.37	38.96	17.22
2016	234 857.16	171.87	IE	51.79	684.37	155.15	37.86	8.58
2017	229 233.90	292.80	IE	88.30	667.99	264.50	36.95	14.63
2018	239 997.14	244.33	IE	73.77	699.35	220.99	38.69	12.22
2019	228 119.75	454.87	IE	138.07	664.74	413.59	36.77	22.88
2020	189 340.40	465.32	IE	141.36	551.74	423.45	30.52	23.42
2021	193 403.60	157	IE	47.77	563.58	143.10	31.18	7.92
2022	193 943.68	1 192	IE	360.17	556.41	1 078.91	30.78	59.68

**tier 1 approach, CO_2 emissions from controlled burning are included in the total biomass loss associated with harvesting (CRF Table 4.A).*

Controlled burning

Total methane emissions from controlled burning were 556.41 t and total emissions of N_2O were 30.78 t in 2022. CO_2 emissions from controlled burning are included in the total biomass loss associated with harvesting in CRF Table 4.A.

Wildfires

Total methane emissions from wildfires were 1078.91 t and total emissions of N_2O were 59.68 t in 2022. CO_2 emissions were 360.17 Gg in 2022.

6.6.3. Land converted to Forest Land (CRF 4.A.2)

This category includes all processes connected with conversion of lands into Forest Land. This activity is closely connected with afforestation or reforestation. The changes in the FL were following: CL converted to FL 1.899 kha, GL converted to FL 19.834 kha, and OL converted to FL 8.712 kha in 2022. Total FL area was 2 029.035 kha in 2022.

Methodological issues – methods, activity data, emission factors and parameters

This category includes the calculation of net carbon stock changes in living biomass, DOM and in the mineral soil. Tier 1 and tier 2 approaches (IPCC 2006 GL) were used for calculation of carbon stocks change in living biomass and DOM. Carbon stocks changes in living biomass in the 4.A.2 through the forest regeneration were estimated using the Equation 2.7 (IPCC 2006 GL). The carbon increment is proportional to the extent of afforested areas and the yearly growing biomass. The new afforested areas were determined from the cadastral database. The annual increment of the total tree biomass for four main species (Norway spruce, Scotch pine, European beech and Sessile oak) were selected from experimental database of the NFC-IFRI. These data were published (Priwitzer et al., 2008, Priwitzer et al., 2009 and Pajtík et al., 2011). The annual increment of the above-ground tree biomass (dry mass) for the four main tree species included in the inventory are following: spruce 2.74 t C/ha/y, pine 3.17 t C/ha/y, beech 2.32 t C/ha/y and oak 1.23 t C/ha/y. The activity data comes from representative experimental plots. Then, whole-tree samples including foliage, branches, stem and coarse roots were taken, oven-dried and weighed. Allometric relationships for all tree compartments using tree height and/or diameter on stem base as independent variables were constructed. The tree biomass was measured at the sites and calculated by different compartment (stem, branches, roots and foliage) using allometric functions. Moreover, soil cores for fine roots (diameter up to 2 mm) estimation were taken. Biomass for all tree compartments was calculated on a hectare base.

The annual increments of the below-ground biomass (dry mass) for the four main tree species included in the inventory are following: spruce 0.56 t C/ha/y, pine 0.40 t C/ha/y, beech 0.57 t C/ha/y and oak 0.90 t C/ha/y. The ratio of main tree species from reforestation for different years was taken from the Statistical Office of the Slovak Republic and represented 33% for spruce, 11% for pine, 49% for beech and 6% for oak in 2022.

The carbon loss connected with living biomass due to silvicultural cuttings in the subcategory L-FL was assumed to be insignificant (zero). The reason is that the first significant thinning occurs in older age forest stands.

The net changes of carbon stock in dead organic matter (DOM) were estimated in accordance with the guidance of the Tier 1 method (IPCC 2006 GL), using available country specific information. The changes in DOM were estimated separately for deadwood and litter C pools.

According the NFIs the average C stock of dead wood was calculated on 6.6 ± 0.5 t C/ha for 2005 as well as 7.4 ± 0.7 t C/ha for 2015 in Forest Land category. Using the estimated trend based on these empirical observations, data for the years between these data points were linearly interpolated and extrapolated accordingly beyond that period. The mean net annual accumulation of dead wood over 10-years period is 0.08 t C/ha/y. The net C stocks change of DW was calculated by the Equation 2.23 of the IPCC 2006 GL.

Methodology for carbon estimation in dead wood pool follows conversion of land to forest land just prior to and just following conversion. Most of the categories (CL, GL, OL) does not produce dead wood, so the corresponding carbon pools prior to conversion are zero.

The changes in living biomass and deadwood are assumed to be zero at conversion due to common afforestation practices, if any vegetation exists in Cropland or Grassland it is not removed before conversion to FL and remains in afforested areas. Due to economic reasons, Land converted to FL is located exclusively in mountainous regions of the Carpathians on the steeper slopes with less productive soil, while rich soil in the lowlands remain under managed Cropland or Grassland. Therefore, when converted to Forest Land, existing grass vegetation is not removed to prevent intensive soil erosion on mountain slopes. There is no tree biomass considered present on Grassland. On Cropland, tree biomass is neglected as the Perennial Croplands with tree biomass (orchards, gardens) composes less than 5% of the managed Cropland area. Moreover, orchards and gardens are mostly situated close to built-up area and therefore usually are not subject of conversion to Forest Land.

The net carbon stock change in litter was estimated using the country specific tier 2 approach. It was based on existing data sets from soil inventories and published information (Šály, 1998, Kobza et al., 2002, 2009, 2014, Pavlenda, 2008) with the default assumption of 20 years period for carbon stock equilibrium in "new land-use" conditions. The mean value 8.3 t C/ha for carbon stocks in litter (representing surface organic layer) was used for calculation of net carbon stock change in litter. The mean net annual accumulation of litter over length of transition period is 0.415 t C/ha/y. The Equation 2.23 (IPCC 2006 GL) was used for calculation of annual changes in carbon stocks in litter for this subcategory. The change in litter carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category associated with this subcategory.

The net carbon stock change in mineral soil was estimated using the country specific tier 2 approach. It was based on existing data sets from soil inventories and published information (Šály, 1998, Kobza et al., 2002, 2009, 2014, Pavlenda, 2008) with the default assumption of 20 years period for carbon stock equilibrium in „new land-use" conditions. The approach for calculation of the organic carbon stocks in soil is consistent with the previous submission. Mean values of soil organic carbon stocks in each category were calculated from datasets of FMS (112 representative monitoring plots in forests) and Soil Monitoring System (318 monitoring plots). Data was recalculated to 30 cm soil layer (topsoil) and compared for three altitudinal zones in each category. The significant changes in soil carbon were caused by land-use change during decades and are only in topsoil (soil layers near the soil surface). Partial results were published in several articles (Barančíková et al. 2013, Barančíková et al. 2016, Pavlenda et al., 2016). The case study using different approach (transections at local level for GL, FL, GL converted to FL) proved very similar results (Pavlenda et al. 2015).

For respective categories, following values (calculated as weighted average) were used in calculations of carbon stock changes in mineral soils (0-30 cm, without any surface organic layer):

- Forest Land 89.02 t C/ha
- Cropland 60.11 t C/ha
- Grassland 74.95 t C/ha
- Settlements 53.85 t C/ha
- Other Land 53.85 t C/ha

The average annual carbon stock change in mineral soil for different conversion of Land to FL was calculated as:

- Annual changes in mineral soil carbon stocks for Land converted to FL = average annual change of SOC over length of transition period (t C/ha/y) * converted area (kha). Average annual change of SOC over length of transition period = (mean SOC stock of FL - mean SOC stock of Land converted to FL)/20.

The following factors (mean annual change of soil carbon stock) were calculated for different types of conversion:

- CL converted to FL 1.446 t C/ha/y
- GL converted to FL 0.704 t C/ha/y
- S converted to FL 1.758 t C/ha/y
- OL converted to FL 1.758 t C/ha/y

The change in soil carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category associated with Land converted to Forest Land.

As mentioned in the category FL-FL, the same values as in previous reports were used. For FL, the carbon stock in surface organic layer is separated from carbon stock in mineral soils.

The land-use matrix from 2002 to 2022 is provided in ***Table 6.14***.

The results from the category Land converted to FL are summarized in ***Table 6.13*** and on ***Figure 6.12.***

Table 6.13: *Results for the subcategory Land converted to Forest Land in 2022*

LAND USE CATEGORY	CARBON STOCK CHANGE IN LIVING BIOMASS			NET CARBON STOCK CHANGE& IN DOM	NET CARBON STOCK CHANGE IN SOIL	NET CO_2 EMISSIONS/ REMOVALS
	gains	losses	net			
	kt C					*Gg CO_2*
Land - FL	45.57	NO	45.57	15.07	32.02	-339.77
GL - FL	26.69	NO	26.69	9.82	13.96	-196.05
CL - FL	2.84	NO	2.84	0.94	2.75	-23.94
WL - FL	NO	NO	NO	NO	NO	NO
S - FL	NO	NO	NO	NO	NO	NO
OL - FL	13.04	NO	13.04	4.31	15.32	-119.78

The estimated removals for Land converted to Forest Land were -339.77 Gg CO_2 in 2022. In 2022, the net carbon stock change in living biomass, DOM and soil from Land converted to Forest Land represented gains of 45.57, 15.07 and 32.02 kt of C respectively.

Figure 6.12: *Summary results of CO_2 removals (Gg) in L-FL subcategory in 1990 – 2022*

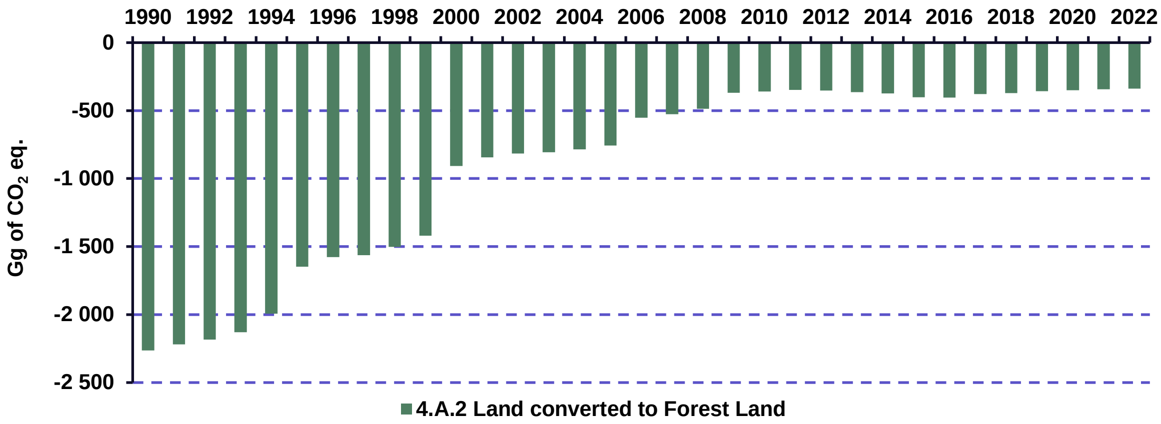


Table 6.14: The land-use matrix from 2002 – 2022

LAND USE	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (2002)
	kha											
Forest Land (managed)	1 998.590	0.000	0.168	0.000	1.263	0.000	0.000	0.000	0.987	1.755	0.000	2 002.773
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	1.899	0.000	1 381.760	0.198	15.641	0.000	0.000	0.000	18.593	15.111	0.000	1 443.202
Cropland perennial	0.000	0.000	3.900	119.391	0.000	0.000	0.000	0.000	0.000	0.000	0.000	123.291
Grassland (managed)	19.834	0.000	15.579	0.000	831.953	0.000	0.000	0.000	7.078	7.413	0.000	881.857
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	211.609	11.746	0.000	223.355
Other Land	8.712	0.000	2.457	0.000	0.000	0.000	0.000	0.000	2.667	131.175	0.000	145.042
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (2022)	**2 029.035**	**0.000**	**1 403.864**	**119.589**	**848.888**	**0.000**	**94.000**	**0.000**	**240.944**	**167.200**	**0.000**	**4 903.520**
Net change	26.262	0.000	-29.338	-3.702	-32.969	0.000	0.000	0.000	17.589	22.158	0.000	

6.6.4. Biomass Burning (CRF 4.A.2 - 4(V))

The biomass burning activity in 4.A.2 - 4(V) includes emissions of CO_2, CH_4, and N_2O associated with the forest fires and biomass burning on forest areas. The National Forest Centre – Forest Protection Service Activity summarized data from the forest fires (wildfires) since 1999. The emissions from wildfires (***Table 6.15***) were calculated according to the Equation 2.27 and Table 2.4 (IPCC 2006 GL) using the default emission factors - available mass of fuel for combustion was used according to Table 2.4 (IPCC 2006 GL).

Table 6.15: *Burned forest area, CO_2, CH_4 and N_2O emissions from wildfires in particular years*

YEAR	AREA BURNED	CO_2 EMISSIONS	CH_4 EMISSIONS	N_2O EMISSIONS
	ha	*t*		
1990	23.06	911.86	2.73	0.15
1995	4.94	195.15	0.58	0.03
2000	34.35	1 358.27	4.07	0.23
2005	16.31	645.00	1.93	0.11
2010	2.84	112.43	0.34	0.02
2011	5.80	229.22	0.69	0.04
2012	24.55	970.61	2.91	0.16
2013	4.03	159.46	0.48	0.03
2014	2.99	118.17	0.35	0.02
2015	5.92	234.24	0.70	0.04
2016	3.01	119.19	0.36	0.02
2017	4.90	194.17	0.58	0.03
2018	4.05	159.95	0.48	0.03
2019	7.30	288.72	0.86	0.05
2020	7.36	291.03	0.87	0.05
2021	2.44	96.40	0.29	0.02
2022	18.44	729.12	2.18	0.12

Wildfires

Total methane emissions from wildfires in category 4.A.2 were 2.18 t and total emissions of N_2O were 0.12 t in 2022. Total CO_2 emissions were 729.12 t in 2022. Due to persistent technical problems with the CRF Reporter software, it was not possible to insert the relevant information of activity data units (ha) and appropriate NK in Table 4(V).

6.7. Cropland (CRF 4.B)

The GHGs emissions and removals in this category were estimated using the 2019 IPCC Refinements methodology the IPCC 2006 GL for AFOLU and national data on area of Cropland and Land converted to Cropland in 2022. The total area of Cropland represented 1 523.453 kha in 2022, i. e. 31.1% of the total country area. This category has been constantly decreasing during reporting period, even since 1970. The total area of Cropland remaining Cropland (CL-CL) represents 1 505.249 kha, of which Annual Cropland remaining Annual Cropland (CLA-CLA) is 1 381.760 kha, Perennial Cropland remaining Perennial Cropland (CLP-CLP) is 119.391 kha, changes from Annual Cropland converted to Perennial Cropland (CLA-CLP) is 0.198 kha and the changes from Perennial Cropland converted to Annual Cropland (CLP-CLA) is 3.900 kha. The changes in the Cropland were following: FL converted to CL 0.168 kha, GL converted to CL 15.579 kha and OL converted to the CL 2.457 kha in 2022 as shown on ***Figures 6.13*** and ***6.14***.

Figure 6.13: *Development of activity data (kha) for 4.B Cropland in the period 1990 – 2022*

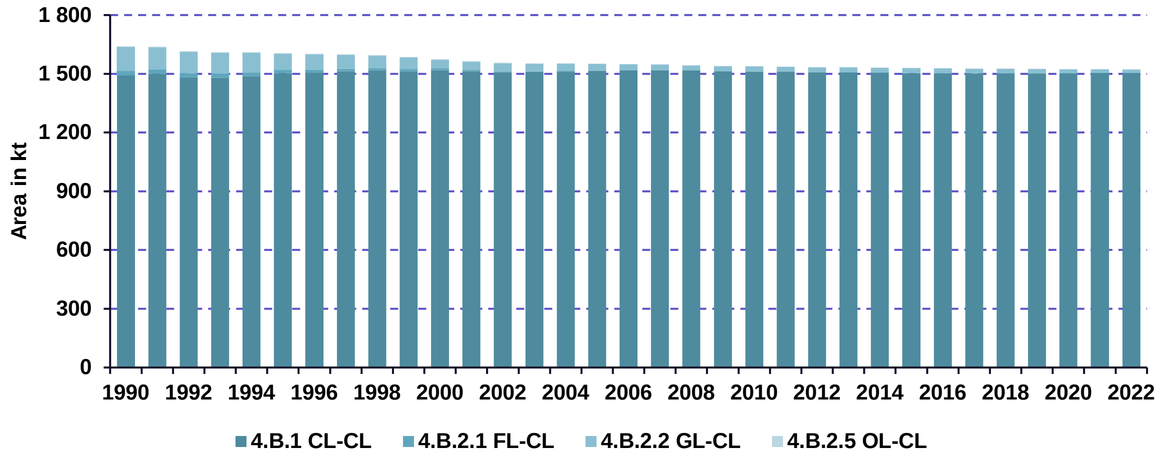
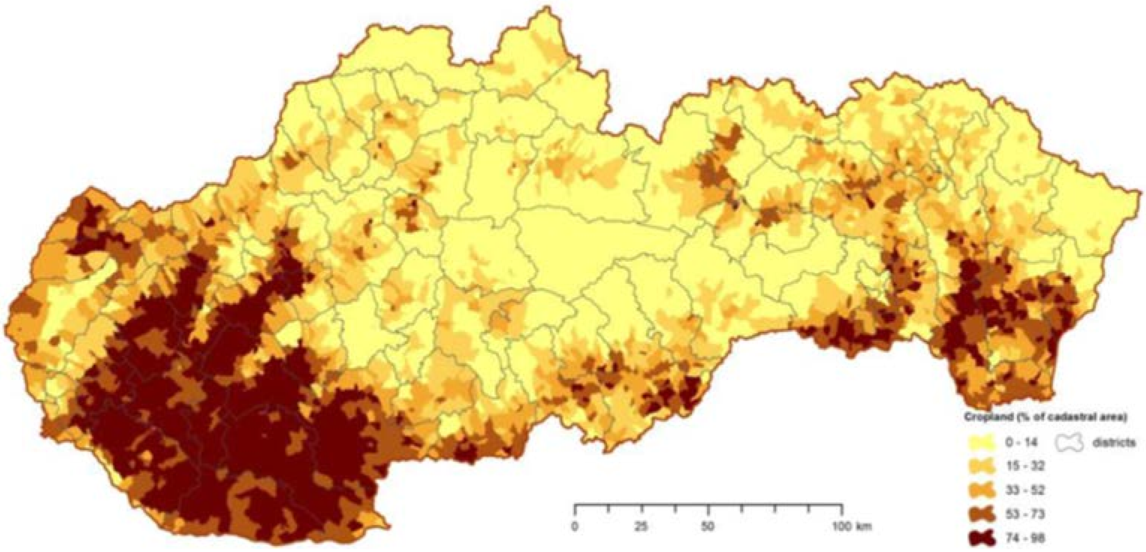


Figure 6.14: *Distribution of Cropland in Slovakia – calculated as a spatial share within individual cadastral units*



6.7.1. Cropland Remaining Cropland (CRF 4.B.1)

The emissions inventory in this category included net carbon stock change in living biomass of Perennial Cropland remaining Perennial Cropland (CLP-CLP) and carbon stock changes in biomass due to land-use change between Annual Cropland (CLA) and Perennial Cropland (CLP) and net carbon stock change in soil of Annual Cropland remaining Annual Cropland (CLA-CLA) and Perennial Cropland remaining Perennial Cropland (CLP-CLP) and due to land-use change between CLA and CLP. The CLA represented arable land planted with annual crops (cereals, oilseeds, crop roots, technical crops, fodder and other) and its area was 1 381.760 kha in 2022. The CLP including vineyards, orchards, hop-gardens and gardens represented 119.391 kha in 2022.

Methodological issues – methods, activity data, emission factors and parameters

Change in biomass carbon stocks of Cropland remaining Cropland were estimated by tier 1 approach.

Changes of carbon stocks in biomass of Annual Cropland remaining Annual Cropland and Perennial Cropland remaining Perennial Cropland

In general, Cropland has no dead wood and only little crop residues or litter, with the exception of agroforestry systems which can be accounted under either Cropland or Forest Land, depending upon definitions adopted by country. Tier 1 approach assumes that dead wood and litter stocks are not present in Cropland or are at equilibrium like in agroforestry systems and orchards.

The carbon stock changes of living biomass in the CLA remaining CLA are estimated to be zero. For annual crops increase in biomass stocks in the CLA remaining CLA in a single year is assumed to be equal to biomass losses from harvest and mortality in the same year – thus there are no net emissions/removals from biomass in the CLA remaining CLA (Chapter 5.2.1.1 of the IPCC 2006 GL).

The emissions/removals were estimated for the changes in woody perennial biomass stocks of the CLP remaining CLP (above-ground and below-ground biomass). So, these emissions/removals were estimated for CLA converted to CLP and vice versa (Chapter 5.3 of the IPCC 2006 GL and in 2019 IPCC Refinements remain unchanged; CLA biomass is not resolved/equilibrium. Also, CLP biomass will not change, as tier 2 is used here for vineyards and orchards). For that purpose, the carbon stock of annual and perennial crops has been estimated and applied in the LUC calculation subsequently. The annual change of carbon stocks in biomass was calculated using the Equation 2.7 of the IPCC 2006 GL.

The immature CLP area accumulates carbon at a rate of approximately 2.35 t for orchards and 4.43 t for vineyards of average carbon stock in living biomass per hectare per year. The emission factors taken from Hungarian inventory was used due to consideration, that carbon accumulation is similar as in Slovakia. The value of above ground biomass carbon stock at harvest is 70.5 t C/ha for orchards and 132.90 t C/ha for vineyards. For gardens and hop-gardens default value was used for CLP (Table 5.1 of the IPCC 2006 GL; Table 5.1 a 5.3 in 2019 IPCC Refinement).

The periodic cuttings, pruning and thinning are not included in the estimation of annual losses in perennial croplands due to low acreage of this areas, lack of historical data and use of these cut material in the production of mulch.

Changes of carbon stocks in biomass of Annual Cropland converted to Perennial Cropland

Total area of CLA converted to CLP was 0.198 kha in 2022. This type of conversion occurred previous year after several years (to 2017 was zero area of CLA-CLP). The applied method follows entirely the IPCC 2006 GL (Chapter 5.3, Chapter 5.3.1.1). The 2019 IPCC Refinements and the IPCC 2006 GL do not foresee any method for land-use change within the Cropland. CLA and CLP have completely different C stocks and C accumulation rates in biomass and soil. For the calculation of the annual change in carbon stock in living biomass of Land converted to Cropland, the equations 2.15 and 2.16 (IPPC 2006 GL) were applied. For CLP, an annual growth 2.1 t C/ha according to the IPCC 2006 GL (Chapter 5.2.1.2, Table 5.1) was assumed for each year of the whole transition period of 20 years.

Annual change in biomass = conversion area for a transition period of 20 years * ΔC_{growth} + annual area of currently converted land * $L_{conversion}$

Where: $L_{conversion} = C_{after} - C_{before;}$

C_{after} = carbon stock immediately after conversion is 0;

ΔC_{growth} = default value for perennial crops carbon accumulation rate is 2.1 t C/ha/y (annual growth rate in each year of the whole LUC transition period of 20 years);

C_{before} = country specific value of carbon stock of annual crops before conversion is 3.25 t C/ha/y (biomass loss accounted only for the year of LUC).

Biomass losses in the year of LUC from CLA to CLP used the country specific average biomass stock in CLA. The average carbon stock of living biomass in CLA was calculated by using country specific data from the ŠÚ SR (Statistical Yearbook of the Slovak Republic, 2016). For all annual crops mentioned in the Statistical Yearbook, the harvested yield biomass (1990 – 2016) has been taken and calculated with use of national coefficient of carbon stocks for crops in total living biomass (Bielek, Jurčová, 2010, Torma and Vilček, 2017). This country specific value (3.25 t C/ha/y) is used for estimates of LUCs to and from CLA and is 35% lower than default value (5.0 t C/ha/y, IPCC 2006 GL).

Changes of carbon stocks in biomass of Perennial Cropland converted to Annual Cropland

Total land-use change area from CLP converted to CLA was 3.900 kha. The rationale for these estimates and used methods are described in the **Chapter 6.7.1**. For the calculation of the annual change in carbon stocks of living biomass of CLP converted to CLA the Equations 2.15 and 2.16 were used (IPCC 2006 GL). According to the 2006 IPPC GL, the gains of the CLA biomass during LUCs to CLA are accounted only once, in the initial year of LUC to CLA (**Chapter 6.7.1** in more details):

Annual change in biomass = annual area of currently converted land * ($L_{conversion} + \Delta C_{growth}$)

Where:

$L_{conversion} = C_{after} - C_{before;}$

C_{after} = carbon stock immediately after conversion is 0;

C_{before} = country specific value of carbon stock of annual crops before conversion is 3.25 t C/ha/y;

ΔC_{growth} = annual growth rate of perennial woody biomass is 2.1 t C/ha/y.

The calculation according to the Austrian methodology was applied. C_before = country specific value of carbon stock of annual crops before conversion is 3.25 t C/ha/y. Annual change of perennial woody biomass (biomass loss accounted only for the year when the Land use change occurred- CLA-CLP Biomass Loss). This happened for years 2019 and 2020. The difference is that with CLA changed to CLP and vice versa, the values 2.1 (annual growth rate of perennial woody biomass) and 3.25 stand (with CLA changed to CLP only in the year of change) on opposite sides of the equation.

Changes of carbon stocks in mineral soils of Annual Cropland remaining Annual Cropland and Perennial Cropland remaining Perennial Cropland

The Cropland category was recalculated this year due to a change in the soil management (FMG) and soil land use (FLU), as the new values of these factors were applied according to the 2019 IPCC Refinements of methodological manuals document. CLA set aside instead of Land use (FLU) Long-term cultivated instead of 0.80 we will use 0.77; Tillage (FMG) instead of 1.10 we will use 1.00.

CLP Land use (FLU) 1.00, we will use 0.72; Tillage (FMG) instead of 1.02 we will use 0.98. These changes mainly concerned GHG removal and emissions from the soil. The decrease in GHG removals was caused especially by the FMG factor for CLP. According to the IPCC 2006 GL, value of FMG was 1.00 ton C/ha/year, and according to the IPCC 2019 Refinement, value is 0.75 tons C/ha/year. Depends on the available capacities and resources, we will improve estimate. Equations for calculating the balance of GHG removals and emissions from biomass and soil from Cropland category and subcategories remain unchanged - no Refinement.

The emissions and removals of the soil carbon stock change in CLA-CLA were calculated using a country specific tier 2 approach. Mean values of soil organic carbon stocks in CLA by the Soil Monitoring System (318 monitoring plots) is 60.11 t C/ha (Barančíková et al. 2013, Barančíková et al. 2016). Mean values of soil organic carbon stocks in CLP was calculated from LUCAS Topsoil Survey (LUCAS data) (Tóth, Jones and Montanarella, 2013). Soil Monitoring System does not contain soil organic carbon stock in CLP, so LUCAS data were used for estimation of the soil carbon stocks of CLP. Mean values of soil organic carbon stocks in CLP (two samples, more samples will be added in the near future) is 66.54 t C/ha (0-30 cm).

The SVK NIR text reports only the summary results of GHG removals for the entire CLP category. But this result is the sum of all four subcategories: orchards, vineyards, gardens and hop gardens (these are calculated separately in the calculation file). The chosen factors are the immature CLP area accumulates carbon at a rate of approximately 2.35 t for orchards and 4.43 t for vineyards of average carbon stock in living biomass per hectare per year. The emission factors taken from the Hungarian inventory were used due to consideration, that carbon accumulation for this specific category is similar as in Slovakia. Only for gardens and hop-gardens default value was used for CLP (Table 5.1 of the IPCC 2006 GL; Table 5.1 and 5.3 in 2019 IPCC Refinement).

Changes of carbon stocks in mineral soils of Annual Cropland converted to Perennial Cropland

The area of CLA converted to CLP changed from 17.266 kha to 0.125 kha from 1990 to 2005. In the year 2018, the area of CLA converted to CLP increased after several years up to 0.150 kha. Total area of CLA converted to CLP was 0.198 kha in 2022. C_before = country specific value of carbon stock of annual crops before conversion is 3.25 t C/ha/y. Annual change of perennial woody biomass (biomass loss accounted only for the year when the Land use change occurred- CLA-CLP Biomass Loss). This happened for years 2019 and 2020. The difference is that with CLA changed to CLP and vice versa, the values 2.1 (Annual growth rate of perennial woody biomass) and 3.25 stand (with CLA changed to CLP only in the year of change) on opposite sides of the equation.

According to the Equation 2.25 of the IPCC 2006 GL, annual rates of carbon stock change are estimated as the difference in stocks at two points in time divided by the time dependence of the stock change factors. Annual change in carbon stock of mineral soils in CLA converted to CLP = ΔSOC_{20} * conversion area for a transition period of 20 years

$$\Delta SOC = (SOC_0 - SOC_{0\text{-}T})/20 = 0.322 \text{ t C/ha/y}$$

Where: ΔSOC_{20} = average annual carbon stock change in soils of annual cropland converted to perennial cropland (t C/ha/y) over land-use change transition period of 20 years; SOC_0 = average c stock in 0-30 cm of CLP soils in Slovakia – 66.54 t C/ha; $SOC_{0\text{-}T}$ = average c stock in 0-30 cm of CLA soils in Slovakia – 60.11 t C/ha.

For a total area of CLA-CLP (0.198 kha in 2020 and also in 2022), the ΔSOC20 is in both years 0.06 kt C.

Changes of carbon stocks in mineral soils of Perennial Cropland converted to Annual Cropland

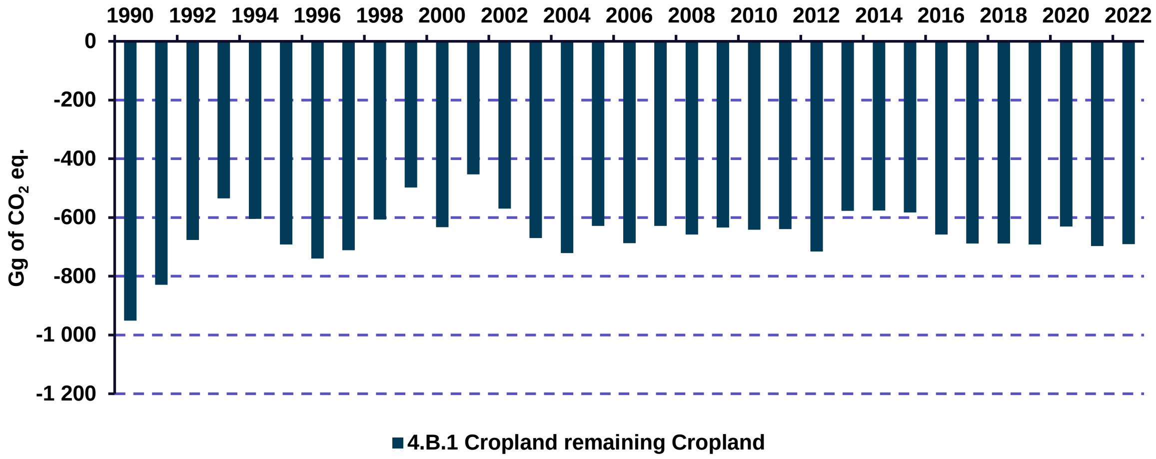
The area of CLP converted to CLA changed from 1.435 kha to 3.900 kha from 1990 to 2022. According to the Equation 2.25 of the IPCC 2006 GL, annual rates of carbon stock change are estimated as the difference in stock at two points in time divided by the time dependence of the stock change factors. Annual change in carbon stock of mineral soils in CLP converted to CLA = ΔSOC_{20} * conversion area for a transition period of 20 years.

$$\Delta SOC = (SOC_0 - SOC_{0\text{-}T})/20 = -0.3215 \text{ t C/ha/y}$$

Where: ΔSOC_{20} = average annual carbon stock change in soils of perennial cropland converted to annual cropland (t C/ha/y) over land-use change transition period of 20 years.

For a total area of CLP – CLA (3.900 kha), the ΔSOC_{20} represented -1.25 kt C. ***Figure 6.15*** shows the net CO_2 removals in the category 4.B.1 Cropland remaining Cropland.

Figure 6.15: Summary results of CO_2 removals (Gg) in CL-CL subcategory in 1990 – 2022



6.7.2. Land Converted to Cropland (CRF 4.B.2)

This category includes all processes connected with the conversion of Land converted to Cropland. Land conversion to Cropland from Forest Land and Grassland usually results in a net loss carbon from biomass and soils to the atmosphere. With regard to changes in carbon stocks in living biomass, only losses for conversion from FL and Grassland were calculated.

Methodological issues – methods, activity data, emission factors and parameters

According to the ERT recommendation (L.15 - draft ARR 2022), Slovakia changed the structure of the AD of forest land converted to cropland by species with weighted tree species proportion, which it used for the calculation of BCEF coefficients and revised $BCEF_R$ values. Slovakia revised its estimation of biomass CSC of forest land converted to cropland by changing the AD structure by tree species and revised $BCEF_R$ coefficients for the forest land converted to cropland category of LULUCF with revised $BCEF_R$ coefficients. Slovakia resubmitted the LULUCF CRF tables with the revised calculation, which was accepted by the ERT. The forest land converted to cropland emissions increased from 2.86 Gg CO_2 eq. to 3.02 Gg CO_2 eq. (5.5%) for 2020 through this resubmission. These revised estimates were also reflected in the entire time series (1990 – 2020) in the resubmission.

Carbon stock changes in biomass were calculated using tier 1 and tier 2 approaches (IPCC 2006 GL). Tier 1 follows the approach used in Land converted to FL where the amount of biomass cleared for Cropland is estimated by multiplying the area converted in one year by the average carbon stock in biomass in FL or GL prior to conversion. For calculation of biomass carbon stocks of FL prior conversion, the annually updated average growing stock volumes, $BCEF_R$ (0.654 for conifers and 0.851 for broadleaf) and default carbon content (0.51 for coniferous and 0.48 for broadleaves) were used. For biomass carbon stock of GL prior the conversion, default values of 13.6 t/ha for above ground and below ground biomass were used (Table 6.4, IPCC 2006 GL). Amount of biomass after land conversion to Cropland was assumed zero (0 t/ha).

Estimated emissions/removals of carbon in dead organic matter pools following conversion of Forest Land to another type of land-use categories (CL, GL, S, OL) require estimates of the carbon stock just prior to and just after conversion. The data obtained from the two National Forest Inventories (NFIs) realized in 2005/2006 and 2015/2016 was used in estimation of dead wood prior the conversion in FL. The NFIs provide data on the mean dead wood biomass stocks (m^3/ha) separately for coniferous and broadleaved trees in the following categories: standing dead trees, stumps, coarse lying dead wood and small-sized lying dead wood. Each of the mentioned categories was classified according to decomposition degree as a fresh, hard, soft and decomposed dead wood. The conversion of volume to dry biomass was carried out based on wood density coefficients and using reduction coefficients according to the degrees of decomposition of dead wood (Fresh 1; Hard 0.83; Soft 0.66; Decayed 0.5). The volume was multiplied by the dry wood density coefficients according to the NIML List of Forest Tree Abbreviations (Šebeň 2017) and the above-ground biomass in mass units was calculated. The conversion of biomass to carbon was performed by a coefficient of 0.496 (Šmelko et al., 2011).

To construct the data series for entire reporting period, data of NFI1 to represent year 2005, and NFI2 to represent year 2015. The average C stocks of dead wood represents 6.6 ± 0.5 t C/ha in 2005 as well as 7.4 ± 0.7 t C/ha in 2015 in national conditions. Using the estimated trend based on these empirical observations, data for the years between these data points were linearly interpolated and extrapolated accordingly beyond that period.

Because the Cropland does not produce dead wood, these carbon pools after conversion can be considered as zero (default assumption).

The net carbon stock change in litter was estimated by using the country specific tier 2 approach. It was based on existing data sets from soil inventories and published information (Šály, 1998, Kobza et al., 2002, 2009, 2014, Pavlenda, 2008). The mean value of 8.3 t C/ha/y for carbon stocks in litter (representing surface organic layer) were used for calculation of net carbon stock change in litter. The Equation 2.23 (IPCC 2006 GL) was used for calculation of annual changes in carbon stocks in litter for Land converted to CL. To apply instant oxidation of carbon in litter, litter stock under the "new category" was set to zero and transition period to be one. The change in litter carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category associated with Land converted to CL.

The calculation of carbon stock change in mineral soils was based on the data from the soil inventory with the default assumption of 20 years' period for carbon stock equilibrium in „new category" conditions. Calculations of carbon stock change in mineral soil as a result of FL and GL conversions to CL were carried out following the IPCC 2006 GL. The net carbon stock change in mineral soils was estimated by using country specific tier 2 approach described in detail in the **Chapter 6.6.3** of this Report. For estimation of net carbon stock change in mineral soil, the average carbon stocks per hectare were used. The soil carbon stock was calculated for the depth 30 cm for each category (**Chapter 6.6.3**). Current results of monitoring of agricultural soil and updated databases were used for calculation.

The average annual carbon stock change in mineral soil for different conversion of Land to CL was calculated as follows:

- Annual changes in mineral soil C stocks for Land converted to CL = average annual change of SOC over length of transition period (t C/ha/y) x converted area (kha);
- Average annual change of SOC over length of transition period = (mean SOC stock of CL – mean SOC stock of land converted to CL)/20.

The following factors (mean annual change of soil carbon stock) were calculated for different types of conversion:

- FL converted to CL   -1.446 t C/ha/y
- GL converted to CL   -0.742 t C/ha/y
- S converted to CL   0.313 t C/ha/y
- OL converted to CL   0.313 t C/ha/y

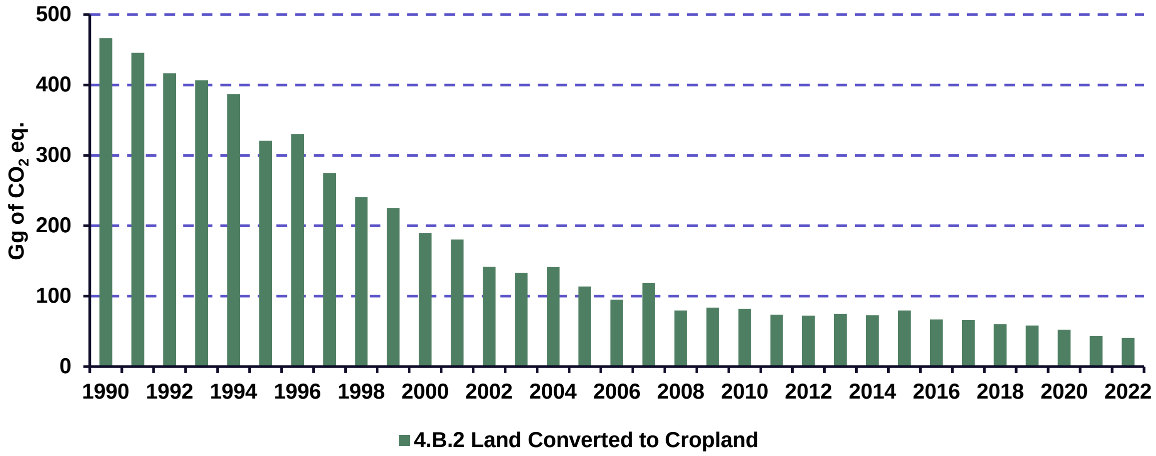
The change in soil carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category associated with Land converted to Cropland. The land-use matrix from 2001 to 2022 is provided in ***Table 6.14***. The results for the subcategory Land converted to Cropland are summarized in ***Table 6.16***, summary of CO_2 emissions are showed in ***Figure 6.16***.

Table 6.16: Result for the Land converted to Cropland subcategory in 2022

LAND USE CATEGORY	CARBON STOCK CHANGE IN LIVING BIOMASS			NET CARBON STOCK CHANGE IN DOM	NET CARBON STOCK CHANGE IN SOIL	NET CO_2 EMISSIONS/ REMOVALS
	gains	losses	net change			
	kt C					*Gg CO_2*
Land - CL	NO	-0.06	-0.06	NO	-11.03	40.69
FL – CL	NO	NO	NO	NO	-0.24	0.89
GL – CL	NO	-0.06	-0.06	NO	-11.56	42.62
WL – CL	NO	NO	NO	NO	NO	NO
S – CL	NO	NO	NO	NO	NO	NO
OL – CL	NO	NO	NO	NO	0.77	-2.82

The Land converted to Cropland represents net emissions 40.69 Gg of CO_2 in 2022. In 2022, the net carbon stock change in living biomass, DOM and soil from Land converted to Cropland represented losses of -0.06, and -11.03 kt of C respectively.

***Figure 6.16:** Summary of CO_2 emissions (Gg) in L-CL subcategory in 1990 – 2022*



6.8. Grassland (CRF 4.C)

The GHG emissions and removals in this category were obtained by using the 2019 IPCC Refinements methodology and the IPCC 2006 GL for LULUCF and national data on Grassland and Land converted to Grassland area in 2022. The total area of Grassland represented 848.888 kha in 2022; this is approximately 17.3% of the total country area. Grassland area decreased from 1980 to beginning of 1990 and since this year increased up to 2005. Since 2005, area of Grassland shows moderately decreasing trend. ***Figures 6.17*** and ***6.18*** show activity data and map of Grassland area in Slovakia.

Figure 6.17: *Development of activity data (kha) for 4.C Grassland in the period 1990 – 2022*

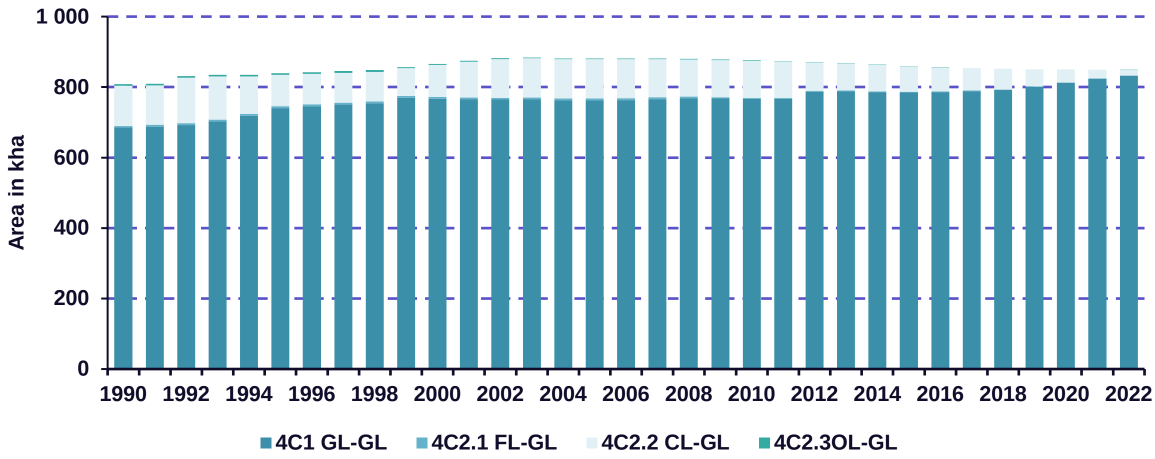
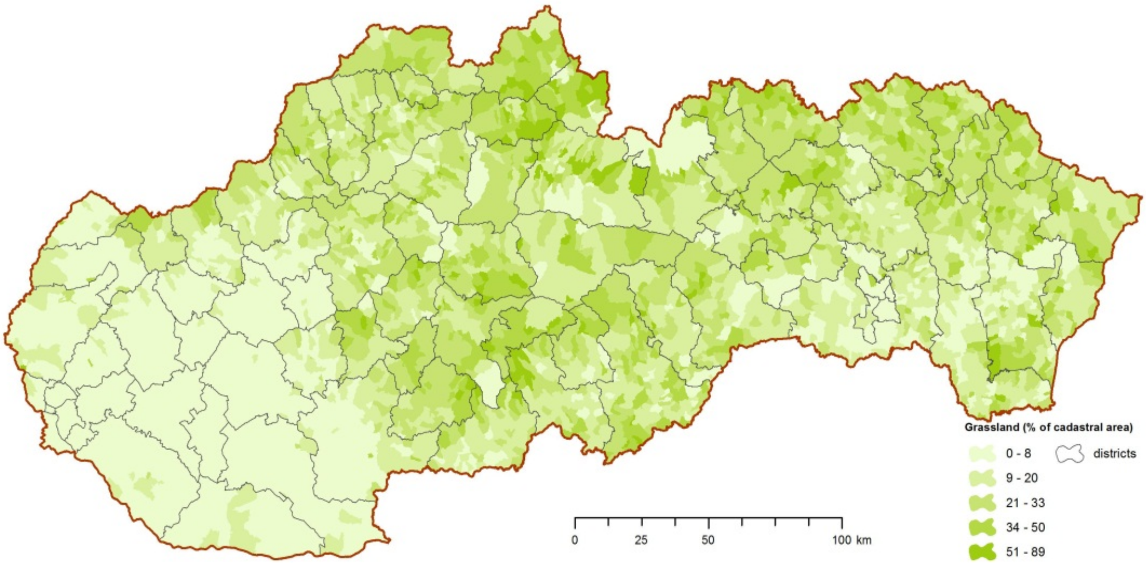


Figure 6.18: *Distribution of Grassland in Slovakia – calculated as a spatial share within individual cadastral units*



The total area of Grassland remaining Grassland was 831.953 kha in 2022, the changes in Grassland were following: Forest Land converted to Grassland 1.263 kha, Cropland converted to Grassland 15.641 kha, Other Land converted to Grassland 0.031 kha in 2022.

6.8.1. Grassland Remaining Grassland (CRF 4.C.1)

According to the tier 1, no change in living biomass in Grassland remaining Grassland occurred. This approach was used in the emissions/removals estimation in this category. This is a conservative approach for the national conditions, where any application of higher tiers would be justified with respect to data requirements and the expected insignificant stock changes. There were no changes in either type or intensity of management and biomass will be in an approximate steady state (carbon accumulation through plant growth is roughly balanced by losses through grazing, decomposition and fire) in Grassland. The CO_2 emissions are considered insignificant as no change in DOM (dead wood and litter). This is a conservative assumption, if the country did not expect significant changes in categories, disturbance or management regimes within the reporting year (tier 1, IPCC 2006 GL). There are no changes in soil carbon for mineral soils for grassland remaining grassland in case there have been no change to the stock change factors for grassland management (see table 6.2 in the 2006 IPCC Guidance). In CRF Table 4.C.1 notation key “NA” is reported. The limestone application is not a practice in Grassland remaining Grassland category in Slovakia and biomass burning activities are strictly prohibited by the Act No 314/2001 Coll. on Fire Protection.

6.8.2. Land Converted to Grassland (CRF 4.C.2)

This category includes all processes connected with conversion of Land into Grassland. For calculation of carbon stock changes in biomass, Tier 1 and tier 2 were used. Tier 1 requires estimate of the biomass of the category before conversion and after conversion. It is assumed, that all biomass is cleared when preparing a site for Grassland, therefore the default value for biomass immediately after conversion is 0 t/ha. Tier 1 follows the approach described in the **Chapter 6.6** of this Report where the amount of biomass that is cleared for Grassland is estimated by multiplying the area converted in one year by the average carbon stock in biomass in the Forest Land or Cropland prior to conversion. The default carbon stock values before conversion for the perennial woody crops in accordance with the IPCC 2006 GL, for carbon stocks in CL converted to GL have been implemented. The conversion of perennial CL to GL does not exist in the national conditions. Slovakia estimates and reports the carbon stock change only for CLA converted to CLP and CLP converted to CLA since 2018 submission. This estimation includes the carbon stock changes in living biomass, DOM and mineral soil carbon pools. More information about the AD and EF used is in the **Chapter 6.7.1**.

Methodological issues – methods, activity data, emission factors and parameters

According to the ERT recommendation (L.16 - draft ARR 2022), Slovakia changed the structure of the AD of forest land converted to grassland by species with weighted tree species proportion, which it used for the calculation of BCEF coefficients and revised $BCEF_R$ values. Slovakia revised its estimation of biomass CSC of forest land converted to grassland by changing the AD structure by tree species and revised $BCEF_R$ coefficients for the forest land converted to grassland category of LULUCF with revised $BCEF_R$ coefficients. Slovakia resubmitted the LULUCF CRF tables with the revised calculation, which was accepted by the ERT. The forest land converted to grassland emissions increased from 7.52 Gg CO_2 eq to 7.87 Gg CO_2 eq (4.7%) for 2020 through this resubmission. These revised estimates were also reflected in the entire time series (1990–2020) in the resubmission.

The annually updated average growing stock volumes, $BCEF_R$ (0.654 for conifers and 0.851 for broadleaves) and default carbon content (0.51 for coniferous and 0.48 for broadleaves) were used for calculation of biomass carbon stocks in FL prior conversion. The default values of 4.7 t C/ha for herbaceous above ground and below ground biomass were used for biomass carbon stock on Grassland prior conversion. Carbon stock from one-year growth Grassland vegetation following the conversion was 13.6 t C/ha (Table 6.4, IPCC 2006 GL).

Estimation of DOM emissions includes the emissions from changes in dead wood related to conversion of Forest Land. The calculation procedure is identical with the estimation described in the Land converted to Cropland category.

The net carbon stock change in litter was estimated by using the country specific tier 2. It was based on existing data sets from soil inventories and published information (Šály, 1998, Kobza et al., 2002, 2009, 2014, Pavlenda, 2008). The mean value of 8.3 t C/ha/y for carbon stocks in litter (representing surface organic layer) was used for calculation of net carbon stock change in litter. The Equation 2.23 (IPCC 2006 GL) was used for calculation of annual changes in carbon stocks in litter for Land converted to CL. To apply instant oxidation of carbon in litter, litter stock under the "new category" was set to zero and transition period to be one. The change in litter carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category associated with Land converted to GL.

The calculation of carbon stock change in mineral soils was based on the data from the soil inventory with the default assumption of 20 years' period for carbon stock equilibrium in „new category" conditions. Calculations of carbon stock change in mineral soil as a result of FL and GL conversions to CL were carried out following the IPCC 2006 GL. For estimation of net carbon stock change in mineral soil, the average carbon stocks per hectare were used. The soil carbon stock was calculated for the depth 30 cm for each category (**Chapter 6.6.3**). Current results of monitoring of agricultural soil and updated databases were used for calculation.

The calculation of carbon stock change in litter was separated from calculations of changes in soil. The information on carbon stocks in surface organic layer of forest soils (based on the data from the soil inventory) was used for calculation of carbon stock change in dead organic matter (FL converted to GL) with the default 20 years' period for carbon stock equilibrium in „new category" conditions. The average annual C stock change in mineral soil for different conversion of the Land converted to GL was calculated as follows:

- Annual changes in mineral soil C stocks for Land converted to GL = average annual change of SOC over length of transition period (t C/ha/y) * converted area (kha).
- Average annual change of SOC over length of transition period = (mean SOC stock of GL - mean SOC stock of land converted to GL)/20.

The following factors (mean annual change of soil carbon stock) were calculated for different types of conversion:

- FL converted to GL -0.704 t C/ha/y
- CL converted to GL +0.742 t C/ha/y
- OL converted to GL +1.055 t C/ha/y

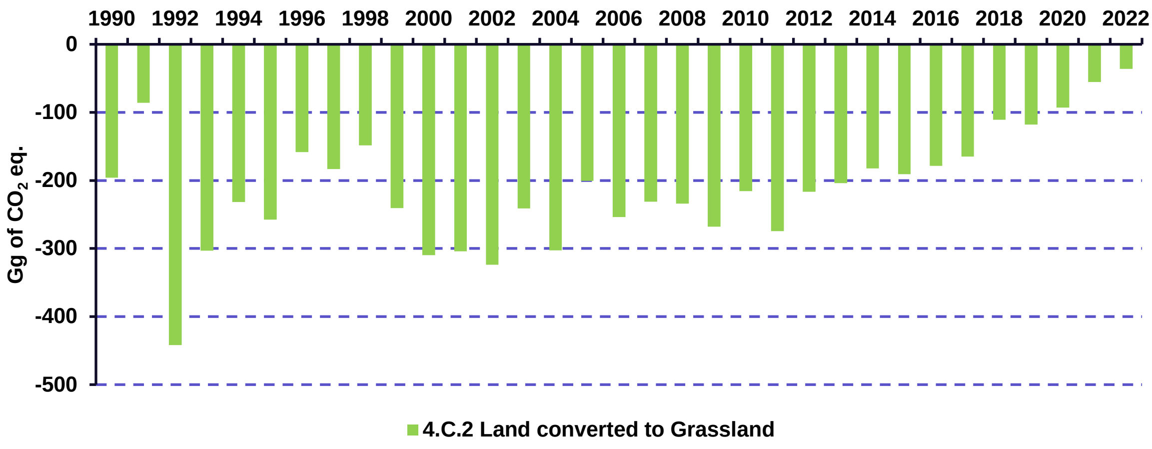
The change in soil carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category associated with Land converted to Grassland. The land-use matrix from 2002 to 2022 is provided in ***Table 6.14.*** The results of balance in the Land converted to Grassland subcategory are summarized in ***Table 6.17***.

Table 6.17: *Results for Land converted to Grassland subcategory in 2022*

LAND USE CATEGORY	CARBON STOCK CHANGE IN LIVING BIOMASS			NET CARBON STOCK CHANGE IN DOM	NET CARBON STOCK CHANGE IN SOIL	NET CO_2 EMISSIONS/ REMOVALS
	gains	losses	net change			
	kt C					*Gg CO_2*
Land - GL	0.12	-0.87	-0.75	-0.11	10.75	-36.24
FL - GL	NO	-0.87	-0.87	-0.11	-0.89	6.87
CL - GL	0.12	NO	0.12	NO	11.61	-42.67
WL - GL	NO	NO	NO	NO	NO	NO
S - GL	NO	NO	NO	NO	NO	NO
OL - GL	NO	NO	NO	NO	NO	NO

Total removals estimated in this category were -36.24 Gg CO_2 in 2022. The net carbon stock change in mineral soils for this category represented gains of 10.75 kt C, but the net carbon stock change in living biomass and DOM from Land converted to Grassland represented the losses of -0.75 and -0.11 kt C in the reporting year 2022. Summary of CO_2 removals are shown on ***Figure 6.19***.

Figure 6.19: Summary of CO_2 removals (Gg) in the L-GL subcategory in 1990 – 2022



6.9. Wetlands (CRF 4.D)

The responsible body for Wetlands conservation and management in Slovakia is the Ministry of Environment of the Slovak Republic (MŽP SR). The MŽP SR represents the national Administrative Authority for the Convention on Wetlands (Ramsar Convention). The MŽP SR administers the protection of Wetlands, the Integrated River Basin Management and planning, monitoring, national and international cooperation. Practical measures concerning Wetlands conservation, management and restoration are carried out by organisations established by the MŽP SR, especially the State Nature Conservancy of the Slovak Republic, the Slovak Water Management Enterprise (state-owned) and Water Management Research Institute.

The Ministry of Agriculture and Rural Development of the Slovak Republic and its organisations are responsible for the inventory of GHGs within the LULUCF sector. There is ongoing update of the cross-sectoral and the inter-institutional coordination for ensuring necessary collection and processing of wetlands relevant data. Administrative steps were already taken in the area of future cooperation in the Wetlands inventory between the Ministry of Environment, the Ministry of the Agriculture and Rural Development of the Slovak republic and corresponding research institutions (the State Environmental Protection agency and the NPPC-VÚPOP).

Based on the cadastral data the area of this category is 94 kha, corresponding to 1.9% of the whole country area. Wetlands consist of surface waters (water courses and water bodies). The share of this category is unchanged since 1990. Permanent surface waters have no carbon stock by definition.

6.10. Settlements (CRF 4.E)

Settlements category was reported separately for the first time in the reporting year 2009. This category represents 4.9% of the total country area. Total area of settlements was 240.944 kha in 2022. The increasing trend of settlements area is visible in the time series. This situation is mostly caused by the development of transport infrastructure, industrial areas, municipal development and raising the standards and infrastructure. It is very often connected with decreased area of Cropland and other categories.

Total area of Settlements remaining Settlements is 211.609 kha, the changes in the Settlements were as follows: FL converted to S 0.977 kha, CL converted to S 18.593 kha, GL converted to S 7.078 kha and OL converted to S 2.667 kha in 2022, as described on ***Figures 6.20*** and ***6.21***.

Figure 6.20: *Development of activity data (kha) in the 4.E Settlements in the period 1990 – 2022*

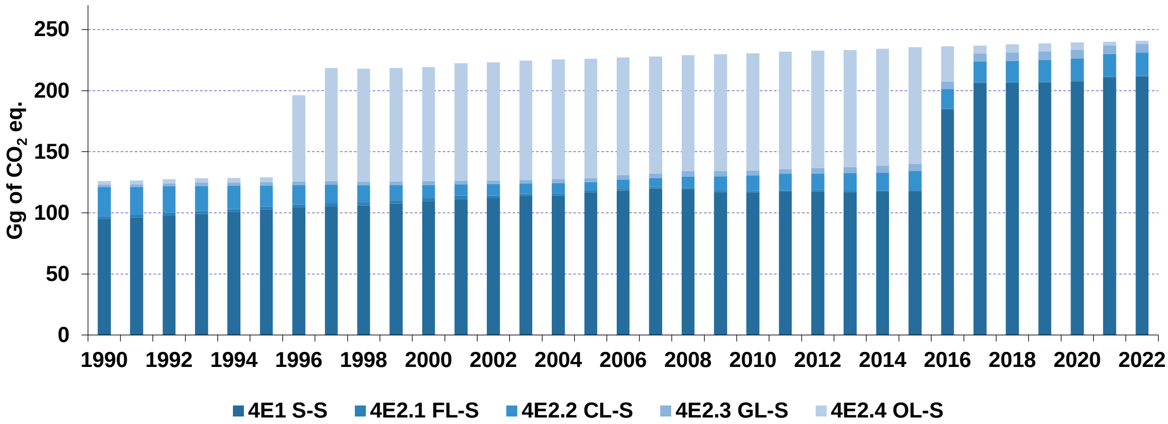
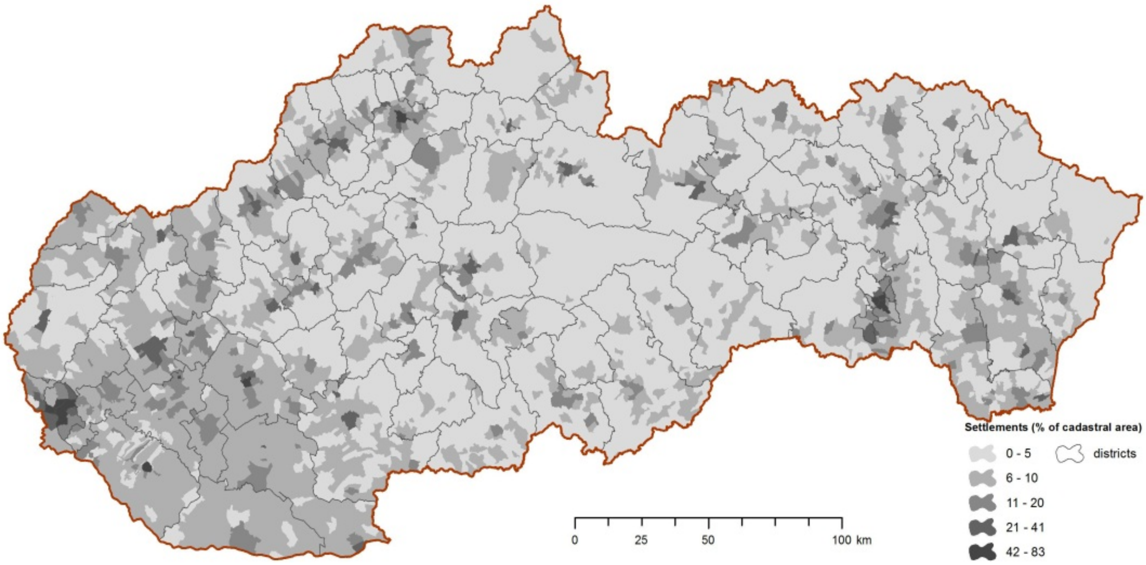


Figure 6.21: *Distribution of Settlements in Slovakia – calculated as a spatial share within individual cadastral units*



6.10.1. Settlements Remaining Settlements (CRF 4.E.1)

For this category, CO_2 emissions are considered insignificant as no change in living biomass, DOM (dead wood and litter) and soil carbon pools is assumed (tier 1, IPCC 2006 GL). This is a conservative assumption, if the country did not expect significant changes in land-use types, disturbance or management regimes within the reporting year.

6.10.2. Land Converted to Settlements (CRF 4.E.2)

This category includes all processes connected with conversion of Land into Settlements.

Methodological issues – methods, activity data, emission factors and parameters

Tier 1 and tier 2 approaches from the IPCC 2006 GL, Vol. 4 were used for carbon stock changes in biomass calculation. Tier 1 requires estimation of the biomass before and after conversion. It is assumed that all biomass is cleared when preparing a site for Settlements, therefore the default value for biomass immediately after conversion is 0 t/ha. Tier 1 follows the approach where the amount of biomass that is cleared for Settlements is estimated by multiplying the area converted in one year by the average carbon stock in biomass in the FL, CL or GL prior to conversion. The calculation procedure is identical as described in detail in the chapters above.

Estimation of DOM includes the emission changes in dead wood related to conversion of Forest Land. The calculation procedure is identical as described in detail in the Chapter Land converted to Cropland.

The net carbon stock change in litter was estimated by using the country specific tier 2 approach. It was based on existing data sets from soil inventories and published information (Šály, 1998, Kobza et al., 2002, 2009, 2014, Pavlenda, 2008). The mean value of 8.3 t C/ha/y for carbon stocks in litter (representing surface organic layer) was used for calculation of net carbon stock change in litter. The Equation 2.23 (IPCC 2006 GL) was used for calculation of annual changes in carbon stocks in litter for Land converted to CL. To apply instant oxidation of carbon in litter, litter stock under the "new category" was set to zero and transition period to be one.

The calculation of carbon stock changes in mineral soils was based on the data from the soil inventory. The default 20 years period for carbon stock equilibrium in „new category" conditions was applied. The net carbon stock change in mineral soils was estimated by using country specific tier 2 applying factors for mean annual change of soil carbon stock described below. Net carbon stock change in mineral soil was used for estimation of the average carbon stock per hectare mentioned also in Land converted to FL subcategory. The soil carbon stocks were calculated for the depth to 30 cm for each category. More information is in the **Chapter 6.6.3** of this Report.

The average annual C stock change in mineral soil for different conversion of Land to Settlement was calculated as follows:

- Annual changes in mineral soil C (kt) stocks for Land converted to S = average annual change of SOC over length of transition period (t C/ha/y) x converted area (kha);
- Average annual change of SOC = (mean SOC stock of S – mean SOC stock of land converted to S).

The following factors (mean annual change of soil carbon stock) were calculated for different types of conversion:

- FL converted to S -1.758 t C/ha/y
- CL converted to S -0.313 t C/ha/y
- GL converted to S -1.055 t C/ha/y

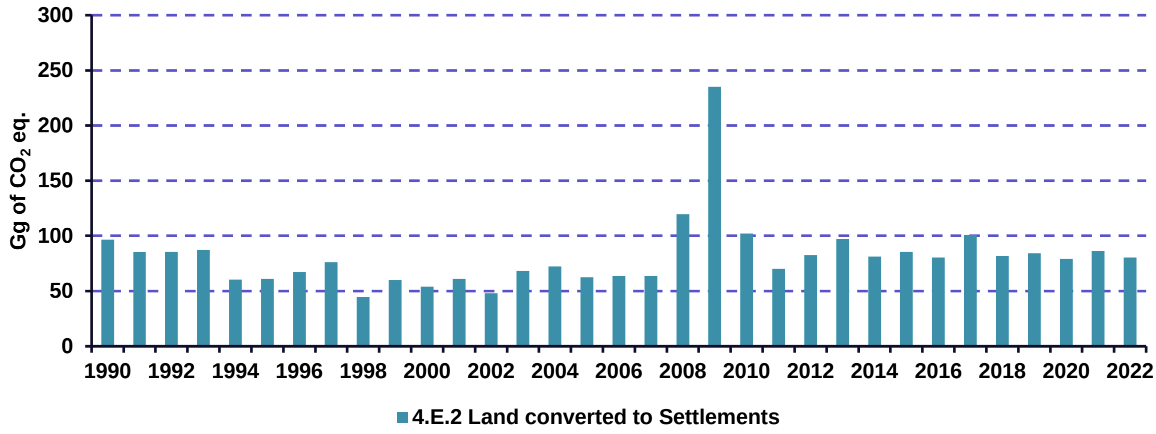
The change in soil carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category associated with Land converted to Settlements. The land-use matrix from 2002 to 2022 is provided in ***Table 6.14***. The results for Land converted to Settlements subcategory are summarized in ***Table 6.18***. Summary of CO_2 removals are shown on ***Figure 6.22***.

Table 6.18: *Results for the subcategory Land converted to Settlements in 2022*

LAND USE CATEGORY	CARBON STOCK CHANGE IN LIVING BIOMASS			NET CARBON STOCK CHANGE IN DOM	NET CARBON STOCK CHANGE IN SOIL	NET CO_2 EMISSIONS/ REMOVALS
	gains	losses	net change			
	kt C					*Gg CO_2*
Land – S	NO	-6.40	-6.40	-0.49	-15.04	80.39
FL – S	NO	-3.73	-3.73	-0.49	-1.75	21.90
CL – S	NO	-2.66	-2.66	NO	-5.82	31.11
GL – S	NO	NO	NO	NO	-7.47	27.38
WL – S	NO	NO	NO	NO	NO	NO
OL – S	NO	NO	NO	NO	NO	NO

In the reporting year 2021, the total emissions estimated in this category were 80.39 Gg CO_2, the net CSC in living biomass, DOM and soil for this category represented losses of -6.40 kt C, -0.49 kt C and -15.04 kt C respectively.

Figure 6.22: *Summary of CO_2 emissions (Gg) in the subcategory Land-S in 1990 – 2022*



6.11. Other Land (CRF 4.F)

The emissions and removals of GHGs in this category were estimated using the IPCC 2006 GL and national data on area of Other Land and Land converted to Other Land during the inventory year 2022. Total area of Other Land represented 167.200 kha in 2022, which is 3.4% of the total country area. Other Land area decreased between 1995 and 1997, since that year the trend was balanced and slightly increasing, especially after 2007.

Total area of Other Land remaining Other Land was 131.175 kha, the changes in Other Land were following: FL converted to OL 1.755 kha, CL converted to OL 15.111 kha, GL converted to OL 7.413 kha, S converted to OL 11.746 kha in 2022, as is described on ***Figures 6.23*** and ***6.24***.

Figure 6.23: *Development of activity data (kha) for 4.F Other Land in the period 1990 – 2022*

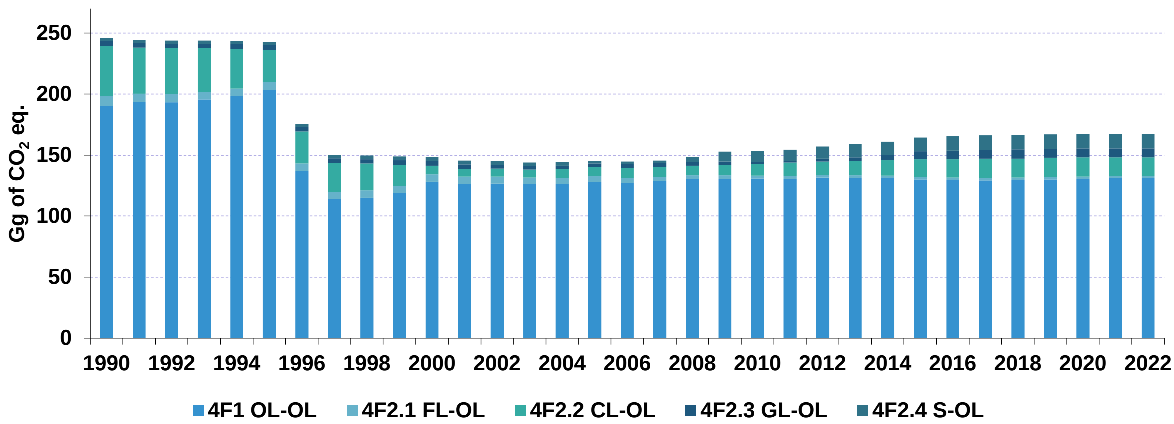
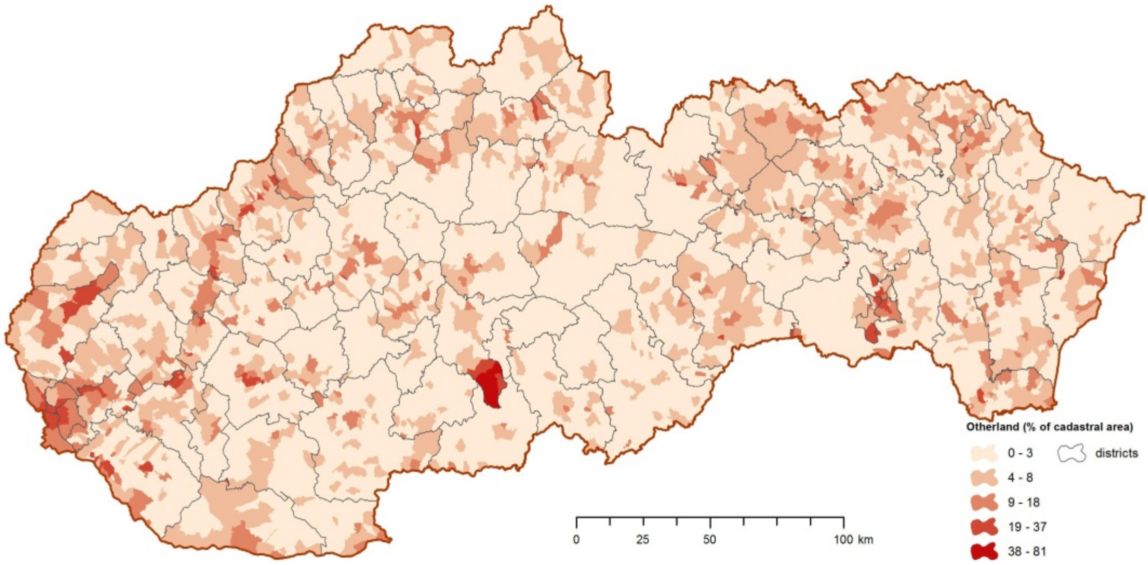


Figure 6.24: Distribution of Other Land in Slovakia – calculated as a spatial share within individual cadastral units



6.11.1. Other Land Remaining Other Land (CRF 4.F.1)

The CO_2 emissions are insignificant as no change in living biomass, DOM (dead wood and litter) and soil carbon pools occurred (tier 1, IPCC 2006 GL) in this category. This is a conservative assumption, if the country did not experience significant changes in land-use types, disturbance or management regimes within the reporting year.

6.11.2. Land Converted to Other Land (CRF 4.F.2)

This category includes all processes connected with conversion of Land into Other Land. Tier 1 and tier 2 approaches (IPCC 2006 GL) for carbon stock changes in biomass calculation were used. Tier 1 requires estimates of the biomass before and after conversion. It is assumed that all biomass is cleared when preparing a site for other land, thus the default value for biomass immediately after conversion is 0 t/ha.

Methodological issues – methods, activity data, emission factors and parameters

Tier 1 and tier 2 approaches follow the approach described in section Forest Land, where the amount of biomass that is cleared for Other Land is estimated by multiplying the area converted in one year by the average carbon stock in biomass in the Forest Land, Cropland or Grassland prior to conversion. The calculation procedure is identical as described in detail in the chapters above.

Estimation of DOM includes the emissions changes in dead wood in Forest Land. The calculation procedure is identical as described in detail in the chapter Land Converted to Settlements.

The net carbon stock change in litter was estimated using the country specific tier 2. It was based on existing data sets from soil inventories and published information (Šály, 1998, Kobza et al., 2002, 2009, 2014, Pavlenda, 2008) and total loss of litter in the year of conversion. The mean value 8.3 t C/ha/y for carbon stocks in litter was used for calculation of net carbon stock change in litter as follows:

- Annual changes in litter C (kt) stocks for Forest Land converted to OL = mean value of carbon in litter in forests (t C/ha/y) * converted area (kha).

The change in litter carbon stock in each year was calculated as the sum of annual changes in C stocks for each category associated with FL converted to OL. To apply instant oxidation of carbon in litter, litter stock under the "new category" was set to zero and transition period to one year.

The calculation of carbon stock changes in mineral soils was based on the data from the soil inventory. The default 20 years period for carbon stock equilibrium in „new category“ conditions was applied. The net carbon stock change in mineral soils was estimated by using country specific tier 2 approach applying factors for mean annual change of soil carbon stock described below. Net carbon stock change in mineral soil was used for estimation of the average carbon stock per hectare mentioned also in Land converted to FL subcategory. The soil carbon stocks were calculated for the depth to 30 cm for each category. More information is in the **Chapter 6.6.3** of this Report.

The average annual C stock change in mineral soil for different conversion of Land to OL was calculated as follows:

- Annual changes in mineral soil C (kt) stocks for Land converted to OL = average annual change of SOC over length of transition period (t C ha/y) * converted area (kha).
- Average annual change of SOC (kt) over length of transition period = (mean SOC stock of OL - mean SOC stock of land converted to OL)/20.

The following factors (mean annual change of soil carbon stock) were calculated for different types of conversion:

- FL converted to OL -1.758 t C ha/y
- CL converted to OL -0.313 t C ha/y
- GL converted to OL -0.704 t C ha/y

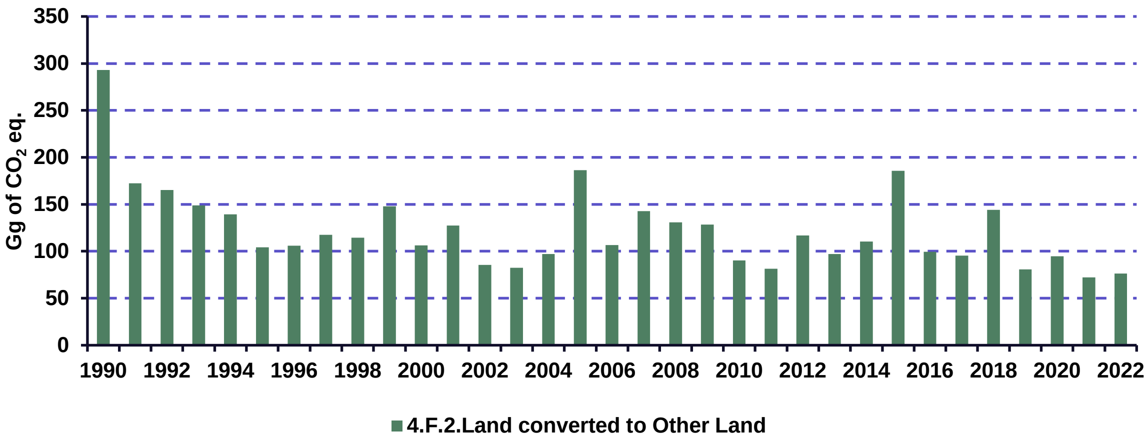
The change in soil carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category associated with Land converted to Other Land. The land-use matrix from 2002 to 2022 is provided in ***Table 6.14***. The results from the subcategory Land converted to Other Land are summarized in ***Table 6.19*** and summary of CO_2 emissions during the years on ***Figure 6.25***.

Table 6.19: *Results for the subcategory Land converted to Other Land in 2022*

LAND USE CATEGORY	CARBON STOCK CHANGE IN LIVING BIOMASS			NET CARBON STOCK CHANGE IN DOM	NET CARBON STOCK CHANGE IN SOIL	NET CO_2 EMISSIONS/ REMOVALS
	gains	losses	net change			
	kt C					*Gg CO_2*
Land - OL	NO	-4.72	-4.72	-0.47	-15.64	76.37
FL – OL	NO	-3.61	-3.61	-0.47	-3.09	26.27
CL – OL	NO	-1.11	-1.11	NO	-4.73	21.43
GL – OL	NO	NO	NO	NO	-7.82	28.68
WL – OL	NO	NO	NO	NO	NO	NO
S - OL	NO	NO	NO	NO	NO	NO

Total emissions estimated in this category were 76.37 Gg CO_2 in 2022. The net carbon stock change in living biomass, DOM and soil for this category represented losses of -4.72 kt C, -0.47 kt C and -15.64 kt C, respectively.

Figure 6.25: *Summary of CO_2 emissions (Gg) in L-OL subcategory in 1990 – 2022*



6.12. Direct N_2O Emissions from N Fertilization of Forest Land and Other (CRF 4(I))

Direct nitrous oxide (N_2O) emissions from nitrogen (N) inputs to managed soils (CRF 4 I):

There are no direct N_2O emissions from N fertilization on Forest Land, Wetlands or Settlements as there is no practice of nitrogen fertilization of forest stands in Slovakia.

6.13. Emissions and Removals from Drainage and Rewetting and Other Management of Organic and Mineral Soils (CRF 4(II))

Emissions and removals from drainage and rewetting and other management of organic and mineral soils (CRF 4 II):

There are no reported CO_2 and non-CO_2 emissions related to drainage and rewetting and other management of organic and mineral soils. The reason is very simple, because the drainage and rewetting and other management of organic and mineral soils are no practice in Slovakia. Only few spots of wet forest soils classified as peat land exist in Slovakia, they are very rare and therefore this land belongs to protected areas without active management. According to (Stanová et al., 2000) the area of peat lands in Slovakia covered only 2 773 ha in 2000.

6.14. 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 (CRF 4(III))

The N_2O emissions (the annual release of N_2O from soils due to mineralisation of soil organic matter after disturbance) were calculated by default tier 1 (Equations 11.8, IPCC 2006 GL). N_2O emissions were estimated based on the detected changes in mineral soils on respective areas of FL and GL converted to CL, S, OL using default emission factor 0.0125 kg N_2O-N/kg N, and C:N ratio = 12. Direct N_2O emissions from N mineralization/immobilization are summarized in ***Table 6.20***.

Table 6.20: *Results for 4(III) – Direct N_2O emissions from N mineralization/immobilization in 2022*

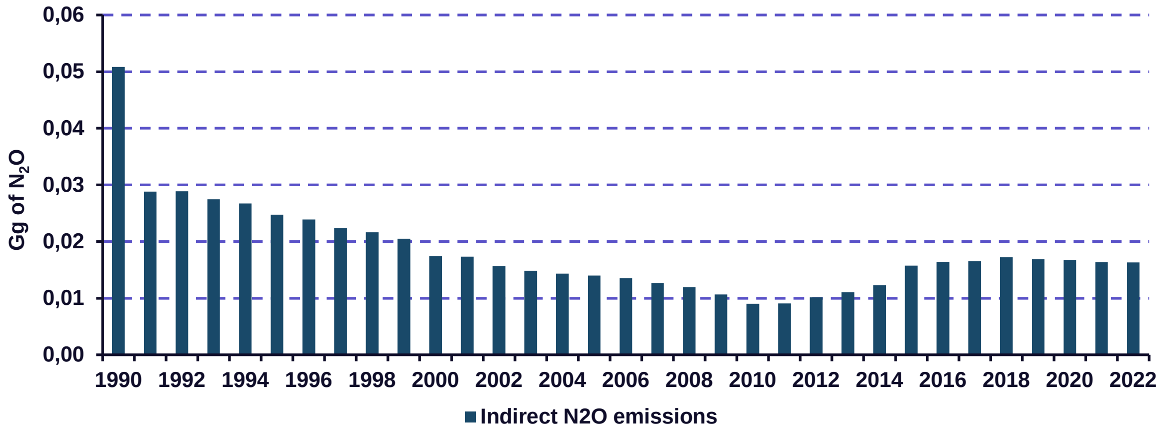
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA	IMPLIED EMISSION FACTORS	EMISSIONS
CATEGORY	Land area converted	N_2O–N emissions per area converted	N_2O
	kha	*kg N_2O–N/ha*	Gg
Total all land-use categories	161.96	0.59	0.06
A. Forest land	NO	NO	NO
1. Forest land remaining forest land	NO	NO	NO
2. Lands converted to forest land	NO	NO	NO
B. Cropland	15.75	1.23	0.03
2. Lands converted to cropland	15.75	1.23	0.03
C. Grasslands	1.26	0.47	0.00
1. Grasslands remaining grasslands	NO	NO	NO
2. Lands converted to grasslands	1.26	0.47	0.00
D. Wetlands	94.00	NO	NO
1. Wetlands remaining wetlands	94.00	NO	NO
2. Lands converted to wetlands	NO	NO	NO
E. Settlements	26.67	0.38	0.02
1. Settlements remaining settlements	NO	NO	NO
2. Lands converted to settlements	26.67	0.38	0.02
F. Other land	24.28	0.43	0.01

Other non-CO_2 emissions related to biomass burning did not occur. Biomass burning is not common practice on Cropland and Grassland in Slovakia, these activities are strictly prohibited by the Act No 314/2001 Coll. on Fire Protection.

6.15. Indirect Nitrous Oxide (N_2O) Emissions from Managed Soils (CRF 4(IV))

The indirect nitrous oxide (N_2O) emissions from managed soil were calculated using Equation 11.10 with *FSOM* based on Equation 11.8, *FracLEACH-(H)* (0.30 - default Table 11.3) and *EF5* (0.0075 - default Table 11.3) of the IPCC 2006 GL. Time series was calculated and included firstly in 2018 submission. The resulting values are reported in CRF Table 4(IV) and on ***Figure 6.26***. Indirect N_2O emissions from Nitrogen Leaching and Run-off represented 0.02 Gg in 2022.

Figure 6.26: *Summary of indirect N_2O emissions (Gg) from managed soils in 1990 – 2022*



6.16. Biomass Burning (CRF 4(V))

Calculation of GHG emissions from biomass burning is included in the categories Forest Land remaining Forest Land as well as Land converted to Forest Land. Biomass burning is not common practice in Cropland and Grassland in Slovakia, these activities are strictly prohibited by the Act No 314/2001 Coll. on Fire Protection.

6.17. Harvested Wood Products (HWP) (CRF 4.G)

Slovakia started to report on the carbon stock changes and associated emissions and removals of CO_2 from the Harvested Wood Products (HWP) pool in 2015. The wood products in the country define HWP activities as a carbon pool. This carbon pool includes products generated from the wood production in the categories FL remaining FL and Land converted to FL. Harvested timber is converted into a wide variety of wood products. Their carbon content moves through different levels during their life cycle. After their use, products are recycled in some cases and ultimately burned or deposited in landfills where they slowly decay (reported in Waste sector). The carbon stored in wood, which was initially captured from the atmosphere, is finally released back into the atmosphere.

For the carbon balance estimation, the round wood is split into industrial round wood and fuelwood. Contrary to the energetic use of wood (fuelwood) for which an instantaneous oxidation is applied, the long-term used HWP as sawn wood, wood-based panels and paper represent a carbon pool with specific half-lives.

For the assessment, the half-lives were applied according to Table 2.8.2 in the IPCC 2006 GL: 35 years for sawn wood, 25 years for wood-based panels and 2 years for paper products were used. According to the ERT recommendation (L.19 - draft ARR 2022), Slovakia provides further information on parameters for estimating CSC for HWP, following default conversion factors (from the Kyoto Protocol Supplement, table 2.8.1) for estimating CSC of HWP were used: sawnwood (aggregate) 0.229, wood-based panels (aggregate) 0.269 and paper and paperboard (aggregate) 0.386.

The approach applied for HWP accounting calculates delayed emissions based on the annual stock change of semi-finished wood products using the first order decay function following Equation 12.1 (Chapter 12, IPCC 2006 GL). The carbon stock changes in forests are estimated in the 4.A (FL).

6.17.1. Methodological Issues – Methods, Activity Data, Emission Factors

The activity data (production and trade of sawn wood, wood based panels and paper and paperboard) are taken from the FAO database on wood production and trade. The data are available since 1961, however, data for Slovakia (SR) and the Czech Republic (ČR) are aggregated before the split of Czechoslovakia (ČS) in 1993. To calculate the share of the SR and the ČR on individual HWP in the period 1961 – 1992, ČS figures were multiplied by the country specific share on the sum of figures for both countries in the period of five years 1993 – 1997 (Raši et al. 2015), i.e., correspondingly as applied earlier in the Czech Republic (Cienciala & Palán 2014).

The share of the ČR and SR production, import and export quantities of main HWP categories, calculated as an average of country specific shares according to the FAO data in the period 1993 – 1997, is provided in ***Table 6.21***.

Table 6.21: *The share of the ČR and SR on the HWP in the period 1993 – 1997 and default half-lives*

WOOD PRODUCT	FAO CODE	PRODUCTION		IMPORT		EXPORT		DEFAULT HALF-LIFE (y)
		ČR	SR	ČR	SR	ČR	SR	
Sawn wood	1 872	0.834	0.166	0.868	0.132	0.723	0.277	35
Wood based boards	1 873	0.716	0.284	0.719	0.281	0.851	0.149	25
Paper and paperboards	1 876	0.655	0.345	0.772	0.228	0.598	0.402	2

The change in carbon stocks was estimated separately for each product category by applying Equation 2.8.4 (IPCC 2013 GL). Instantaneous oxidation was applied to HWPs originating from deforestation, which results in a conservative estimate of carbon stock changes in the HWP-pool.

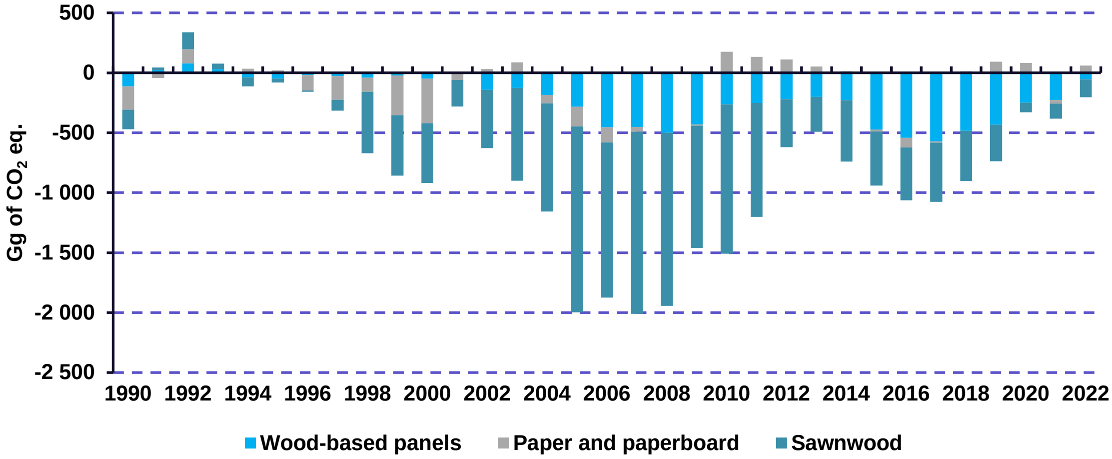
The results of CO_2 gains and losses from domestically produced and used HWP are provided in ***Table 6.22*** and on ***Figure 6.27***.

Table 6.22: *Greenhouse gas emissions (positive values) and removals (negative values) from HWP from Forest Land in particular years*

CO_2 EMISSIONS AND REMOVALS FROM HWP	1990	1995	2000	2005	2010	2015
	Net Emissions/Removals in Gg of CO_2 eq.					
4.G (UNFCCC)	-470.4	-58.8	-920.1	-1 996.5	-1 334.5	-940.7
gains sawn wood	644.3	528.7	1 027.0	2 144.2	1 972.9	1 235.6
gains wood panels	381.9	327.9	330.0	582.4	619.5	866.0
gains paper	606.8	382.8	1 107.8	993.8	710.3	770.2
losses sawn wood	-482.8	-498.8	-526.2	-593.8	-726.0	-785.4
losses wood panels	-268.6	-277.6	-282.0	-299.0	-357.5	-392.7
losses paper	-411.2	-404.2	-736.5	-831.1	-884.6	-752.9

CO_2 EMISSIONS AND REMOVALS FROM HWP	2017	2018	2019	2020	2021	2022
	Net Emissions/Removals in Gg of CO_2 eq.					
4.G (UNFCCC)	-1 077.0	-889.2	-644.9	-247.3	-382.2	-143.9
gains sawn wood	1 298.0	1 231.2	1 125.0	904.1	950.8	977.4
gains wood panels	994.7	921.0	882.9	708.4	692.9	524.7
gains paper	795.3	770.8	671.4	652.0	756.4	660.0
losses sawn wood	-803.5	-812.6	-819.7	-823.6	-825.6	-828.3
losses wood panels	-422.2	-436.9	-449.6	-459.1	-465.7	-469.6
losses paper	-785.3	-784.4	-765.0	-734.6	-726.6	-720.4

Figure 6.27: *CO_2 emissions (positive values) and removals (negative values) from HWP in Slovakia in 1990 – 2022 originating from Forest Land*



According to the ERT recommendation (L.18 - draft ARR 2022), Slovakia provides an explanation of the trend of CSC of HWP.

The CSC of HWP follows the production approach, and the real use of wood products in Slovakia differs owing to trade with wood products. The HWP production structure in countries differs according to the wood industry structure. HWP production culminated in 2006 – 2007, just before the 2008 global financial crisis; in Slovakia, the production of sawnwood also accelerated owing to greater availability of wood processed after the destruction of spruce stands by a windstorm in November 2004. While the production of wood-based panels, paper and paperboard is more stable, sawnwood shows higher fluctuations. The wood production and processing sectors in Slovakia as a relatively small country are sensitive to disturbances, for example, the availability of wood due to disturbances in forests, technological processes in wood-processing factories and the situation in the wood products market. The course of carbon stored in the HWP pool (***Figure 6.27***) shows that the 1990-2000 following 1990 was characterized by balanced losses and gains of carbon in the pool and a trend of increasing carbon gains in sawnwood and paper is evident. The second decennium was characterized by the growth of the production of sawnwood and wood-based panels and increasing carbon gains in these HWP. Later years are characterized by a drop in production in all HWP categories, which is reflected in the annual CSC in HWP (***Figure 6.27***) and 2008 (the start of the economic crisis) can be identified as a break point when the trend of increasing gains in the HWP carbon pool turned into a decrease. It is noticeable that in the years since 2008 felling in Slovakia has been higher than in the previous period, indicating an increase in an alternative use of wood, such as for energy purposes. The inventory results indicate that the HWP pool is a carbon sink; however, if the market does not recover and the production stagnates or drops down, the HWP pool may become a source of carbon emissions owing to the decline in the higher gains accumulated in the past. In addition, since 2018 there has been a decrease in timber harvesting in Slovakia, which has caused a decrease in the supply of wood to the domestic market. The decrease in the wood supply since 2019 was due to a decrease in timber harvesting, mainly owing to the coronavirus disease 2019 pandemic, restrictions by nature conservation authorities and the unfavourable situation in the softwood market.

Annex A6.1. Land-Use Matrix

***Table A6.1**: Land-use matrixes identifying annual conversions among the LUC for the period 1990 – 2022, describing initial and final areas of LUC (kha)*

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**1989**)
Forest Land (managed)	1 985.219	0.000	0.010	0.000	0.353	0.000	0.000	0.000	0.028	0.418	0.000	1 986.028
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.088	0.000	1 507.845	0.000	0.754	0.000	0.000	0.000	0.352	0.000	0.000	1 509.039
Cropland perennial	0.000	0.000	0.203	130.675	0.000	0.000	0.000	0.000	0.000	0.000	0.000	131.081
Grassland (managed)	1.421	0.000	1.407	0.000	807.184	0.000	0.000	0.000	1.293	1.391	0.000	812.696
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	124.361	0.747	0.000	125.108
Other Land	2.261	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	243.307	0.000	245.568
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**1990**)	1 988.989	0.000	1 509.465	130.878	808.291	0.000	94.000	0.000	126.034	245.863	0.000	4 903.520
Net change	2.961	0.000	0.426	-0.203	-4.405	0.000	0.000	0.000	0.926	0.295	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**1990**)
Forest Land (managed)	1 988.001	0.000	0.045	0.000	0.678	0.000	0.000	0.000	0.075	0.190	0.000	1 988.989
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.012	0.000	1 507.130	0.000	2.323	0.000	0.000	0.000	0.000	0.000	0.000	1 509.465
Cropland perennial	0.000	0.000	0.486	129.906	0.000	0.000	0.000	0.000	0.000	0.000	0.000	130.878
Grassland (managed)	0.325	0.000	0.941	0.000	806.475	0.000	0.000	0.000	0.356	0.194	0.000	808.291
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	126.034	0.000	0.000	126.034

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**1990**)
Other Land	1.626	0.000	0.144	0.000	0.000	0.000	0.000	0.000	0.126	243.967	0.000	245.863
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**1991**)	1 989.964	0.000	1 508.746	130.392	809.476	0.000	94.000	0.000	126.591	244.351	0.000	4 903.520
Net change	0.975	0.000	-0.719	-0.486	1.185	0.000	0.000	0.000	0.557	-1.512	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**1991**)
Forest Land (managed)	1 989.640	0.000	0.002	0.000	0.146	0.000	0.000	0.000	0.063	0.113	0.000	1 989.964
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.202	0.000	1 484.552	0.000	22.173	0.000	0.000	0.000	0.492	1.327	0.000	1 508.746
Cropland perennial	0.000	0.000	0.692	129.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	130.392
Grassland (managed)	0.196	0.000	0.793	0.000	808.322	0.000	0.000	0.000	0.165	0.000	0.000	809.476
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	126.591	0.000	0.000	126.591
Other Land	1.069	0.000	0.000	0.000	0.770	0.000	0.000	0.000	0.174	242.338	0.000	244.351
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**1992**)	1 991.107	0.000	1 486.039	129.700	831.411	0.000	94.000	0.000	127.485	243.778	0.000	4 903.520
Net change	1.143	0.000	-22.707	-0.692	21.935	0.000	0.000	0.000	0.894	-0.573	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**1992**)
Forest Land (managed)	1 990.741	0.000	0.002	0.000	0.175	0.000	0.000	0.000	0.071	0.118	0.000	1 991.107
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.008	0.000	1 480.682	0.000	4.595	0.000	0.000	0.000	0.285	0.469	0.000	1 486.039
Cropland perennial	0.000	0.000	0.953	127.794	0.000	0.000	0.000	0.000	0.000	0.000	0.000	129.700
Grassland (managed)	0.227	0.000	0.975	0.000	829.862	0.000	0.000	0.000	0.268	0.079	0.000	831.411

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	Initial area (**1992**)
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	127.485	0.000	0.000	127.485
Other Land	0.487	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.158	243.133	0.000	243.778
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**1993**)	1 991.463	0.000	1 482.612	128.747	834.632	0.000	94.000	0.000	128.267	243.799	0.000	4 903.520
Net change	0.356	0.000	-3.427	-0.953	3.221	0.000	0.000	0.000	0.782	0.021	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	Initial area (**1993**)
Forest Land (managed)	1 991.112	0.000	0.014	0.000	0.186	0.000	0.000	0.000	0.025	0.126	0.000	1 991.463
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.019	0.000	1 481.597	0.000	0.869	0.000	0.000	0.000	0.127	0.000	0.000	1 482.612
Cropland perennial	0.000	0.000	0.767	127.213	0.000	0.000	0.000	0.000	0.000	0.000	0.000	128.747
Grassland (managed)	0.308	0.000	0.553	0.000	833.771	0.000	0.000	0.000	0.000	0.000	0.000	834.632
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	128.267	0.000	0.000	128.267
Other Land	0.232	0.000	0.292	0.000	0.000	0.000	0.000	0.000	0.044	243.231	0.000	243.799
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**1994**)	1 991.671	0.000	1 483.223	127.980	834.826	0.000	94.000	0.000	128.463	243.357	0.000	4 903.520
Net change	0.208	0.000	0.611	-0.767	0.194	0.000	0.000	0.000	0.196	-0.442	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	Initial area (**1994**)
Forest Land (managed)	1 991.536	0.000	0.002	0.000	0.063	0.000	0.000	0.000	0.023	0.047	0.000	1 991.671

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**1994**)
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.028	0.000	1 477.809	0.000	5.386	0.000	0.000	0.000	0.000	0.000	0.000	1 483.223
Cropland perennial	0.000	0.000	0.465	127.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000	127.980
Grassland (managed)	0.556	0.000	0.725	0.000	833.333	0.000	0.000	0.000	0.212	0.000	0.000	834.826
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	128.463	0.000	0.000	128.463
Other Land	0.137	0.000	0.103	0.000	0.243	0.000	0.000	0.000	0.291	242.583	0.000	243.357
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**1995**)	1 992.257	0.000	1 479.104	127.515	839.025	0.000	94.000	0.000	128.989	242.630	0.000	4 903.520
Net change	0.586	0.000	-4.119	-0.465	4.199	0.000	0.000	0.000	0.526	-0.727	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**1995**)
Forest Land (managed)	1 991.789	0.000	0.098	0.000	0.280	0.000	0.000	0.000	0.032	0.058	0.000	1 992.257
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.107	0.000	1 470.639	0.000	4.015	0.000	0.000	0.000	0.474	0.000	0.000	1 479.104
Cropland perennial	0.000	0.000	0.245	126.674	0.000	0.000	0.000	0.000	0.000	0.000	0.000	127.515
Grassland (managed)	1.113	0.000	0.610	0.000	837.302	0.000	0.000	0.000	0.000	0.000	0.000	839.025
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	128.989	0.000	0.000	128.989
Other Land	0.357	0.000	0.000	0.000	0.117	0.000	0.000	0.000	66.648	175.508	0.000	242.630
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**1996**)	1 993.366	0.000	1 472.124	126.919	841.714	0.000	94.000	0.000	196.143	175.566	0.000	4 903.520
Net change	1.109	0.000	-3.443	-0.245	2.689	0.000	0.000	0.000	67.154	-67.064	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**1996**)
Forest Land (managed)	1 992.978	0.000	0.026	0.000	0.203	0.000	0.000	0.000	0.065	0.094	0.000	1 993.366
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.130	0.000	1 470.639	0.000	4.634	0.000	0.000	0.000	0.164	0.000	0.000	1 472.124
Cropland perennial	0.000	0.000	0.245	126.674	0.000	0.000	0.000	0.000	0.000	0.000	0.000	126.919
Grassland (managed)	0.311	0.000	1.214	0.000	840.189	0.000	0.000	0.000	0.000	0.000	0.000	841.714
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	196.143	0.000	0.000	196.143
Other Land	2.954	0.000	0.000	0.000	0.565	0.000	0.000	0.000	22.212	149.835	0.000	175.566
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**1997**)	1 996.373	0.000	1 472.124	126.919	845.591	0.000	94.000	0.000	218.584	149.929	0.000	4 903.520
Net change	3.007	0.000	-3.443	-0.245	3.877	0.000	0.000	0.000	22.441	-25.637	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**1997**)
Forest Land (managed)	1 995.995	0.000	0.004	0.000	0.294	0.000	0.000	0.000	0.000	0.080	0.000	1 996.373
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.067	0.000	1 466.916	0.000	4.724	0.000	0.000	0.000	0.000	0.417	0.000	1 472.124
Cropland perennial	0.000	0.000	0.675	125.569	0.000	0.000	0.000	0.000	0.000	0.000	0.000	126.919
Grassland (managed)	0.845	0.000	1.575	0.000	843.171	0.000	0.000	0.000	0.000	0.000	0.000	845.591
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	218.084	0.500	0.000	218.584
Other Land	1.376	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	148.553	0.000	149.929
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**1997**)
Final area (**1998**)	1 998.283	0.000	1 469.170	126.244	848.189	0.000	94.000	0.000	218.084	149.550	0.000	4 903.520
Net change	1.910	0.000	-2.954	-0.675	2.598	0.000	0.000	0.000	-0.500	-0.379	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**1998**)
Forest Land (managed)	1 997.986	0.000	0.009	0.000	0.086	0.000	0.000	0.000	0.029	0.173	0.000	1 998.283
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.067	0.000	1 458.684	0.000	10.057	0.000	0.000	0.000	0.287	0.075	0.000	1 469.170
Cropland perennial	0.000	0.000	1.042	124.160	0.000	0.000	0.000	0.000	0.000	0.000	0.000	126.244
Grassland (managed)	0.831	0.000	0.868	0.000	846.284	0.000	0.000	0.000	0.000	0.206	0.000	848.189
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	218.084	0.000	0.000	218.084
Other Land	1.204	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.027	148.319	0.000	149.550
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**1999**)	2 000.088	0.000	1 460.603	125.202	856.427	0.000	94.000	0.000	218.427	148.773	0.000	4 903.520
Net change	1.805	0.000	-8.567	-1.042	8.238	0.000	0.000	0.000	0.343	-0.777	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**1999**)
Forest Land (managed)	1 999.961	0.000	0.005	0.000	0.023	0.000	0.000	0.000	0.008	0.091	0.000	2 000.088
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.096	0.000	1 447.768	0.000	12.214	0.000	0.000	0.000	0.244	0.281	0.000	1 460.603
Cropland perennial	0.000	0.000	0.247	124.708	0.000	0.000	0.000	0.000	0.000	0.000	0.000	125.202
Grassland (managed)	0.693	0.000	2.471	0.000	852.983	0.000	0.000	0.000	0.192	0.088	0.000	856.427
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**1999**)
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	218.250	0.177	0.000	218.427
Other Land	0.503	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.643	147.627	0.000	148.773
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2000**)	2 001.253	0.000	1 450.491	124.955	865.220	0.000	94.000	0.000	219.337	148.264	0.000	4 903.520
Net change	1.165	0.000	-10.112	-0.247	8.793	0.000	0.000	0.000	0.910	-0.509	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2000**)
Forest Land (managed)	2 000.951	0.000	0.039	0.000	0.101	0.000	0.000	0.000	0.040	0.122	0.000	2 001.253
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.013	0.000	1 437.399	0.000	12.113	0.000	0.000	0.000	0.212	0.754	0.000	1 450.491
Cropland perennial	0.000	0.000	1.129	122.697	0.000	0.000	0.000	0.000	0.000	0.000	0.000	124.955
Grassland (managed)	0.422	0.000	2.596	0.000	862.202	0.000	0.000	0.000	0.000	0.000	0.000	865.220
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	219.337	0.000	0.000	219.337
Other Land	0.743	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.886	144.635	0.000	148.264
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2001**)	2 002.129	0.000	1 441.163	123.826	874.416	0.000	94.000	0.000	222.475	145.511	0.000	4 903.520
Net change	0.876	0.000	-9.328	-1.129	9.196	0.000	0.000	0.000	3.138	-2.753	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2001**)
Forest Land (managed)	2 001.980	0.000	0.006	0.000	0.064	0.000	0.000	0.000	0.021	0.058	0.000	2 002.129
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.008	0.000	1 431.567	0.000	8.980	0.000	0.000	0.000	0.263	0.345	0.000	1 441.163

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2001**)
Cropland perennial	0.000	0.000	0.535	122.756	0.000	0.000	0.000	0.000	0.000	0.000	0.000	123.826
Grassland (managed)	0.509	0.000	1.094	0.000	872.813	0.000	0.000	0.000	0.000	0.000	0.000	874.416
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	222.475	0.000	0.000	222.475
Other Land	0.276	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.596	144.639	0.000	145.511
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2002**)	2 002.773	0.000	1 433.202	123.291	881.857	0.000	94.000	0.000	223.355	145.042	0.000	4 903.520
Net change	0.644	0.000	-7.961	-0.535	7.441	0.000	0.000	0.000	0.880	-0.469	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2002**)
Forest Land (managed)	2 002.452	0.000	0.009	0.000	0.185	0.000	0.000	0.000	0.065	0.062	0.000	2 002.773
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.050	0.000	1 428.082	0.000	4.562	0.000	0.000	0.000	0.379	0.129	0.000	1 433.202
Cropland perennial	0.000	0.000	0.118	123.055	0.000	0.000	0.000	0.000	0.000	0.000	0.000	123.291
Grassland (managed)	1.110	0.000	1.988	0.000	878.759	0.000	0.000	0.000	0.000	0.000	0.000	881.857
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	223.355	0.000	0.000	223.355
Other Land	0.488	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.872	143.682	0.000	145.042
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2003**)	2 004.100	0.000	1 430.197	123.173	883.506	0.000	94.000	0.000	224.671	143.873	0.000	4 903.520
Net change	1.327	0.000	-3.005	-0.118	1.649	0.000	0.000	0.000	1.316	-1.169	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2003**)
Forest Land (managed)	2 003.934	0.000	0.005	0.000	0.020	0.000	0.000	0.000	0.050	0.091	0.000	2 004.100
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.086	0.000	1 427.075	0.000	2.156	0.000	0.000	0.000	0.517	0.363	0.000	1 430.197
Cropland perennial	0.000	0.000	0.073	123.027	0.000	0.000	0.000	0.000	0.000	0.000	0.000	123.173
Grassland (managed)	0.815	0.000	3.443	0.000	878.878	0.000	0.000	0.000	0.370	0.000	0.000	883.506
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	224.427	0.244	0.000	224.671
Other Land	0.091	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.192	143.590	0.000	143.873
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2004**)	2 004.926	0.000	1 430.596	123.100	881.054	0.000	94.000	0.000	225.556	144.288	0.000	4 903.520
Net change	0.826	0.000	0.399	-0.073	-2.452	0.000	0.000	0.000	0.885	0.415	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2004**)
Forest Land (managed)	2 004.392	0.000	0.015	0.000	0.219	0.000	0.000	0.000	0.038	0.262	0.000	2 004.926
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.023	0.000	1 428.075	0.000	1.146	0.000	0.000	0.000	0.601	0.751	0.000	1 430.596
Cropland perennial	0.000	0.000	0.443	122.214	0.000	0.000	0.000	0.000	0.000	0.000	0.000	123.100
Grassland (managed)	0.455	0.000	0.506	0.000	879.918	0.000	0.000	0.000	0.175	0.000	0.000	881.054
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	225.405	0.151	0.000	225.556
Other Land	0.364	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.038	143.886	0.000	144.288
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2005**)	2 005.234	0.000	1 429.039	122.657	881.283	0.000	94.000	0.000	226.257	145.050	0.000	4 903.520

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	Initial area (**2004**)
Net change	0.308	0.000	-1.557	-0.443	0.229	0.000	0.000	0.000	0.701	0.762	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	Initial area (**2005**)
Forest Land (managed)	2 004.995	0.000	0.000	0.000	0.109	0.000	0.000	0.000	0.024	0.106	0.000	2 005.234
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.044	0.000	1 426.698	0.000	0.984	0.000	0.000	0.000	0.801	0.512	0.000	1 429.039
Cropland perennial	0.000	0.000	0.207	122.243	0.000	0.000	0.000	0.000	0.000	0.000	0.000	122.657
Grassland (managed)	0.504	0.000	0.452	0.000	879.779	0.000	0.000	0.000	0.366	0.182	0.000	881.283
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	225.901	0.356	0.000	226.257
Other Land	1.397	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	143.653	0.000	145.050
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2006**)	2 006.940	0.000	1 427.357	122.450	880.872	0.000	94.000	0.000	227.092	144.809	0.000	4 903.520
Net change	1.706	0.000	-1.682	-0.207	-0.411	0.000	0.000	0.000	0.835	-0.241	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	Initial area (**2006**)
Forest Land (managed)	2 006.486	0.000	0.068	0.000	0.144	0.000	0.000	0.000	0.047	0.195	0.000	2 006.940
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.065	0.000	1 424.648	0.000	1.085	0.000	0.000	0.000	0.742	0.817	0.000	1 427.357
Cropland perennial	0.000	0.000	0.368	121.714	0.000	0.000	0.000	0.000	0.000	0.000	0.000	122.450
Grassland (managed)	0.365	0.000	0.811	0.000	879.692	0.000	0.000	0.000	0.004	0.000	0.000	880.872
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2006**)
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	227.092	0.000	0.000	227.092
Other Land	0.226	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.045	144.538	0.000	144.809
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2007**)	2 007.142	0.000	1 425.895	122.082	880.921	0.000	94.000	0.000	227.930	145.550	0.000	4 903.520
Net change	0.202	0.000	-1.462	-0.368	0.049	0.000	0.000	0.000	0.838	0.741	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2007**)
Forest Land (managed)	2 006.819	0.000	0.010	0.000	0.119	0.000	0.000	0.000	0.058	0.136	0.000	2 007.142
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.084	0.000	1 420.579	0.000	1.248	0.000	0.000	0.000	2.479	1.505	0.000	1 425.895
Cropland perennial	0.000	0.000	0.310	121.462	0.000	0.000	0.000	0.000	0.000	0.000	0.000	122.082
Grassland (managed)	0.847	0.000	0.772	0.000	878.485	0.000	0.000	0.000	0.711	0.106	0.000	880.921
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	225.811	2.119	0.000	227.930
Other Land	0.507	0.000	0.182	0.000	0.000	0.000	0.000	0.000	0.000	144.861	0.000	145.550
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2008**)	2 008.257	0.000	1 421.853	121.772	879.852	0.000	94.000	0.000	229.059	148.727	0.000	4 903.520
Net change	1.115	0.000	-4.042	-0.310	-1.069	0.000	0.000	0.000	1.129	3.177	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2008**)
Forest Land (managed)	2 007.795	0.000	0.014	0.000	0.050	0.000	0.000	0.000	0.262	0.136	0.000	2 008.257
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.044	0.000	1 416.273	0.000	1.264	0.000	0.000	0.000	3.371	0.901	0.000	1 421.853
Cropland perennial	0.000	0.000	0.291	121.190	0.000	0.000	0.000	0.000	0.000	0.000	0.000	121.772

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2008**)
Grassland (managed)	0.472	0.000	1.244	0.000	877.156	0.000	0.000	0.000	0.550	0.430	0.000	879.852
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	225.206	3.853	0.000	229.059
Other Land	0.532	0.000	0.162	0.000	0.000	0.000	0.000	0.000	0.550	147.483	0.000	148.727
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2009**)	2 008.843	0.000	1 417.984	121.481	878.470	0.000	94.000	0.000	229.939	152.803	0.000	4 903.520
Net change	0.586	0.000	-3.869	-0.291	-1.382	0.000	0.000	0.000	0.882	4.022	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2009**)
Forest Land (managed)	2 008.517	0.000	0.022	0.000	0.156	0.000	0.000	0.000	0.066	0.082	0.000	2 008.843
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.035	0.000	1 415.108	0.000	0.562	0.000	0.000	0.000	1.324	0.955	0.000	1 417.984
Cropland perennial	0.000	0.000	0.308	120.865	0.000	0.000	0.000	0.000	0.000	0.000	0.000	121.481
Grassland (managed)	1.218	0.000	0.778	0.000	875.766	0.000	0.000	0.000	0.524	0.184	0.000	878.470
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	228.150	1.789	0.000	229.939
Other Land	1.479	0.000	0.416	0.000	0.000	0.000	0.000	0.000	0.524	150.384	0.000	152.803
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2010**)	2 011.249	0.000	1 416.632	121.173	876.484	0.000	94.000	0.000	230.588	153.394	0.000	4 903.520
Net change	2.406	0.000	-1.352	-0.308	-1.986	0.000	0.000	0.000	0.649	0.591	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2010**)
Forest Land (managed)	2 011.162	0.000	0.000	0.000	0.013	0.000	0.000	0.000	0.023	0.051	0.000	2 011.249
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.115	0.000	1 414.162	0.000	0.157	0.000	0.000	0.000	0.713	1.485	0.000	1 416.632
Cropland perennial	0.000	0.000	0.238	120.697	0.000	0.000	0.000	0.000	0.000	0.000	0.000	121.173
Grassland (managed)	0.933	0.000	1.073	0.000	874.054	0.000	0.000	0.000	0.424	0.000	0.000	876.484
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	230.588	0.000	0.000	230.588
Other Land	0.126	0.000	0.180	0.000	0.000	0.000	0.000	0.000	0.219	152.869	0.000	153.394
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2011**)	2 012.336	0.000	1 415.653	120.935	874.224	0.000	94.000	0.000	231.967	154.405	0.000	4 903.520
Net change	1.087	0.000	-0.979	-0.238	-2.26	0.000	0.000	0.000	1.379	1.011	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2011**)
Forest Land (managed)	2 012.214	0.000	0.002	0.000	0.011	0.000	0.000	0.000	0.037	0.072	0.000	2 012.336
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.274	0.000	1 412.856	0.000	0.546	0.000	0.000	0.000	0.725	1.252	0.000	1 415.653
Cropland perennial	0.000	0.000	0.027	120.881	0.000	0.000	0.000	0.000	0.000	0.000	0.000	120.935
Grassland (managed)	1.044	0.000	0.746	0.000	870.767	0.000	0.000	0.000	0.574	1.093	0.000	874.224
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	231.263	0.704	0.000	231.967
Other Land	0.527	0.000	0.108	0.000	0.000	0.000	0.000	0.000	0.000	153.770	0.000	154.405
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2012**)	2 014.059	0.000	1 413.739	120.908	871.324	0.000	94.000	0.000	232.599	156.891	0.000	4 903.520

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2011**)
Net change	1.723	0.000	-1.914	-0.027	-2.900	0.000	0.000	0.000	0.632	2.486	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2012**)
Forest Land (managed)	2 013.955	0.000	0.006	0.000	0.016	0.000	0.000	0.000	0.036	0.046	0.000	2 014.059
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.057	0.000	1 411.632	0.000	0.258	0.000	0.000	0.000	0.915	0.877	0.000	1 413.739
Cropland perennial	0.000	0.000	0.405	120.098	0.000	0.000	0.000	0.000	0.000	0.000	0.000	120.908
Grassland (managed)	0.800	0.000	0.872	0.000	867.787	0.000	0.000	0.000	0.952	0.913	0.000	871.324
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	231.402	1.197	0.000	232.599
Other Land	0.556	0.000	0.214	0.000	0.000	0.000	0.000	0.000	0.000	156.121	0.000	156.891
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2013**)	2 015.368	0.000	1 413.129	120.503	868.061	0.000	94.000	0.000	233.305	159.154	0.000	4 903.520
Net change	1.309	0.000	-0.610	-0.405	-3.263	0.000	0.000	0.000	0.706	2.263	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2013**)
Forest Land (managed)	2 015.219	0.000	0.004	0.000	0.052	0.000	0.000	0.000	0.037	0.056	0.000	2 015.368
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.168	0.000	1 411.008	0.000	0.113	0.000	0.000	0.000	0.604	1.236	0.000	1 413.129
Cropland perennial	0.000	0.000	0.372	119.759	0.000	0.000	0.000	0.000	0.000	0.000	0.000	120.503
Grassland (managed)	1.582	0.000	0.675	0.000	864.516	0.000	0.000	0.000	0.420	0.868	0.000	868.061
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2013**)
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	233.305	0.000	0.000	233.305
Other Land	0.136	0.000	0.169	0.000	0.000	0.000	0.000	0.000	0.05	158.799	0.000	159.154
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2014**)	2 017.105	0.000	1 412.228	120.131	864.681	0.000	94.000	0.000	234.416	160.959	0.000	4 903.520
Net change	1.737	0.000	-0.901	-0.372	-3.380	0.000	0.000	0.000	1.111	1.805	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2014**)
Forest Land (managed)	2 016.971	0.000	0.008	0.000	0.006	0.000	0.000	0.000	0.039	0.081	0.000	2 017.105
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.273	0.000	1 409.012	0.000	0.448	0.000	0.000	0.000	0.651	1.844	0.000	1 412.228
Cropland perennial	0.000	0.000	0.409	119.313	0.000	0.000	0.000	0.000	0.000	0.000	0.000	120.131
Grassland (managed)	2.302	0.000	1.299	0.000	858.147	0.000	0.000	0.000	0.407	2.526	0.000	864.681
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	233.414	0.002	0.000	234.416
Other Land	0.57	0.000	0.566	0.000	0.000	0.000	0.000	0.000	0.000	159.823	0.000	160.959
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2015**)	2 020.116	0.000	1 411.294	119.722	858.601	0.000	94.000	0.000	235.511	164.276	0.000	4 903.520
Net change	3.011	0.000	-0.934	-0.409	-6.080	0.000	0.000	0.000	1.095	3.317	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2015**)
Forest Land (managed)	2 020.055	0.000	0.000	0.000	0.007	0.000	0.000	0.000	0.014	0.040	0.000	2 020.116
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.090	0.000	1 409.400	0.000	0.187	0.000	0.000	0.000	1.045	0.572	0.000	1 411.294
Cropland perennial	0.000	0.000	0.054	119.614	0.000	0.000	0.000	0.000	0.000	0.000	0.000	119.722

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2015**)
Grassland (managed)	1.908	0.000	0.179	0.000	855.688	0.000	0.000	0.000	0.327	0.499	0.000	858.601
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	234.895	0.616	0.000	235.511
Other Land	0.469	0.000	0.145	0.000	0.000	0.000	0.000	0.000	0.000	163.662	0.000	164.276
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2016**)	2 022.522	0.000	1 409.778	119.668	855.882	0.000	94.000	0.000	236.281	165.389	0.000	4 903.520
Net change	2.406	0.000	-1.516	-0.054	-2.719	0.000	0.000	0.000	0.770	1.113	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2016**)
Forest Land (managed)	2 022.396	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.060	0.056	0.000	2 022.522
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.271	0.000	1 408.090	0.000	0.344	0.000	0.000	0.000	0.497	0.576	0.000	1 409.778
Cropland perennial	0.000	0.000	0.131	119.537	0.000	0.000	0.000	0.000	0.000	0.000	0.000	119.668
Grassland (managed)	1.506	0.000	0.389	0.000	853.403	0.000	0.000	0.000	0.569	0.015	0.000	855.882
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	235.853	0.428	0.000	236.281
Other Land	0.201	0.000	0.050	0.000	0.000	0.000	0.000	0.000	0.000	165.138	0.000	165.389
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Final area (**2017**)	2 024.374	0.000	1 408.660	119.537	853.757	0.000	94.000	0.000	236.979	166.213	0.000	4 903.520
Net change	1.852	0.000	-1.118	-0.131	-2.125	0.000	0.000	0.000	0.698	0.824	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	Initial area (**2017**)
Forest Land (managed)	2 024.125	0.000	0.000	0.000	0.094	0.000	0.000	0.000	0.018	0.137	0.000	2 024.374
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.136	0.000	1 407.487	0.150	0.106	0.000	0.000	0.000	0.557	0.224	0.000	1 408.660
Cropland perennial	0.000	0.000	0.000	119.537	0.000	0.000	0.000	0.000	0.000	0.000	0.000	119.537
Grassland (managed)	1.118	0.000	0.132	0.000	851.485	0.000	0.000	0.000	0.447	0.575	0.000	853.757
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	236.867	0.112	0.000	236.979
Other Land	0.648	0.000	0.110	0.000	0.000	0.000	0.000	0.000	0.000	165.455	0.000	166.213
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2018**)	2 026.027	0.000	1 407.729	119.687	851.685	0.000	94.000	0.000	237.889	166.503	0.000	4 903.520
Net change	1.653	0.000	-0.931	0.000	0.094	0.000	0.000	0.000	0.018	0.137	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	Initial area (**2018**)
Forest Land (managed)	2 025.937	0.000	0.001	0.000	0.026	0.000	0.000	0.000	0.034	0.029	0.000	2 025.937
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.000	0.000	1 406.257	0.026	0.225	0.000	0.000	0.000	0.778	0.443	0.000	0.000
Cropland perennial	0.000	0.000	0.000	119.687	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Grassland (managed)	1.162	0.000	0.121	0.000	850.349	0.000	0.000	0.000	0.053	0.000	0.000	1.162
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	0.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	237.855	0.034	0.000	0.000
Other Land	0.000	0.000	0.020	0.000	0.000	0.000	0.000	0.000	0.000	166.483	0.000	0.000
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2019**)	2 027.099	0.000	1 406.399	119.713	850.600	0.000	94.000	0.000	238.720	166.989	0.000	4 903.520

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2018**)
Net change	1.072	0.000	-1.330	0.026	-1.085	0.000	0.000	0.000	0.831	0.486	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2019**)
Forest Land (managed)	2 026.996	0.000	0.004	0.000	0.009	0.000	0.000	0.000	0.023	0.067	0.000	2 027.099
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.046	0.000	1 405.177	0.022	0.160	0.000	0.000	0.000	0.782	0.212	0.000	1 406.399
Cropland perennial	0.000	0.000	0.000	119.713	0.000	0.000	0.000	0.000	0.000	0.000	0.000	119.713
Grassland (managed)	0.639	0.000	0.024	0.000	849.858	0.000	0.000	0.000	0.051	0.028	0.000	850.600
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	238.591	0.129	0.000	238.720
Other Land	0.171	0.000	0.058	0.000	0.000	0.000	0.000	0.000	0.000	166.760	0.000	166.989
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2020**)	2 027.852	0.000	1 405.263	119.735	850.027	0.000	94.000	0.000	239.447	167.196	0.000	4 903.520
Net change	0.753	0.000	-1.136	0.022	-0.573	0.000	0.000	0.000	0.727	0.207	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2020**)
Forest Land (managed)	2 027.779	0.000	0.000	0.000	0.016	0.000	0.000	0.000	0.036	0.021	0.000	2 027.852
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	0.020	0.000	1 404.459	0.000	0.019	0.000	0.000	0.000	0.545	0.220	0.000	1 405.263
Cropland perennial	0.000	0.000	0.024	119.711	0.000	0.000	0.000	0.000	0.000	0.000	0.000	119.735
Grassland (managed)	0.598	0.000	0.037	0.000	849.238	0.000	0.000	0.000	0.154	0.000	0.000	850.027
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2020**)
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	239.435	0.012	0.000	239.447
Other Land	0.112	0.000	0.059	0.000	0.000	0.000	0.000	0.000	0.000	167.025	0.000	167.196
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2021**)	2 028.509	0.000	1 404.579	119.711	849.273	0.000	94.000	0.000	240.170	167.278	0.000	4 903.520
Net change	0.657	0.000	-0.684	-0.024	-0.754	0.000	0.000	0.000	0.723	0.082	0.000	

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (**2021**)
Forest Land (managed)	1 998.590	0.000	0.168	0.000	1.263	0.000	0.000	0.000	0.997	1.755	0.000	2 002.773
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cropland annual	1.899	0.000	1 381.760	0.198	15.641	0.000	0.000	0.000	18.593	15.111	0.000	1 433.202
Cropland perennial	0.000	0.000	3.900	119.391	0.000	0.000	0.000	0.000	0.000	0.000	0.000	123.291
Grassland (managed)	19.834	0.000	15.579	0.000	831.953	0.000	0.000	0.000	7.078	7.413	0.000	881.857
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Wetland (managed)	0.000	0.000	0.000	0.000	0.000	0.000	94.000	0.000	0.000	0.000	0.000	94.000
Wetland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Settlements	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	211.609	11.746	0.000	223.355
Other Land	8.712	0.000	2.457	0.000	0.031	0.000	0.000	0.000	2.667	131.175	0.000	145.042
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Final area (**2022**)	2 029.035	0.000	1 403.864	119.589	848.888	0.000	94.000	0.000	240.944	167.200	0.000	4 903.520
Net change	26.262	0.000	-29.338	-3.702	-32.969	0.000	0.000	0.000	17.589	22.158	0.000	

Annex A6.2. Uncertainty Analyses in the LULUCF Sector

This Annex provides results of the application of Monte Carlo simulations uncertainty analyses in the LULUCF sector. The methodology of calculations of GHG emissions and removals follows the methods described in this report. If compared to previous submission, analyses of uncertainties of the GHG emissions and removals in the whole LULUCF sector are provided, including deadwood carbon pool in CRF 4A category Forest Land and CRF 4(IV) category Indirect N_2O emission from managed soils (Nitrogen Leaching and Run-off). These were missing in submission 2022.

In order to apply the Monte Carlo iterated simulations, calculations were automated using the Python programming language. Input data and factors (constant values) were modified for each iteration using the level of uncertainty (if known) according to normal or triangle distribution. ***Table A6.2.1*** shows the levels of uncertainties. The number of iterations was set to 100.000.

Results of the Monte Carlo simulations for the main LULUCF categories and HWP, as well as for the whole LULUCF sector, are shown in ***Tables A6.2.2 – A6.2.8*** and on ***Figures A6.2.1 – A6.2.7***.

Table A6.2.1: *The levels of uncertainty for input data and factors*

LULUCF CATEGORY	DATA / FACTOR	DATA TYPE (D-DEFAULT, N-NATIONAL)	UNCERTAINTY IF KNOWN (%)
4.A.1 Forest Land remaining Forest land – Carbon stock change emissions (Gain-Loss method according to the equation 2.7 of the IPCC 2006 GL. Calculations of carbon stock changes in living biomass following the equations 2.9 - 2.12 of the IPCC 2006 GL)	Area of LULUCF category (and transitions, all categories)	N	3
	Share of tree species	N	15
	Mean yield class of tree species	N	
	Mean age of tree species	N	
	Current annual increment	N	30
	Wood density	N	
	Root-to-shoot	D	30
	Carbon fraction	D	2
	Yield tables	N	25
	Harvested wood volume	N	20
	Growing stock	N	20
	Carbon stock in dead wood and its annual change	N	8.5
	NFI data	N	
4.A.2 Land converted to Forest land – Carbon stock change emissions	Share of tree species on afforested land	N	
	Mean annual increment of living biomass	N	
	Mean annual accumulation of litter	N	
	Mean annual carbon stock change in dead wood	N	8.5
	Mean annual carbon stock change in mineral soil	N	75
4.A Forest Land – Biomass burning	Share of area with burned harvesting residues (from total harvested area)	N	
	Biomass fraction burned on clearing areas	N	
	Combustion factor	D	
	BCEF	N	25
	Emission factors	D	
	Area of forest fires	N	
	Available mass of fuel for combustion (4.A.2)	D	
4.B.1 Cropland remaining cropland	Share of used arable land	N	
	Annual growth rate of perennial woody biomass	N, D	0, 75
	Average biomass stock of perennial crops	N, D	0, 75
	Annual growth rate of perennial woody biomass	D	75

LULUCF CATEGORY	DATA / FACTOR	DATA TYPE (D-DEFAULT, N-NATIONAL)	UNCERTAINTY IF KNOWN (%)
	Annual change of perennial woody biomass	D	0
	Mean values of soil organic carbon stocks	D	
	Relative stock change factor (FLU)	D	9, 50
	Relative stock change factor (FMG)	D	5, 6
	Relative stock change factor (FI)	D	0
Land converted to category (4.B.2, 4.C.2, 4.E.2, 4.F.2)	Mean growing stock	N	20
	Mean dead wood biomass stocks	N	75.24
	Mean carbon stock in litter	N	75.24
	Mean carbon stock in mineral soil	N	75
4.G Harvested Wood products	FAO data (roundwood, other)	D	5, 10
	Carbon content	D	10
	Conversion factors	D	25
	Half-lives	D	50

LULUCF Categories

Table A6.2.2: *Results of Monte Carlo simulation for category 4.A Forest Land (Gg CO_2 eq.)*

YEAR	NIR 2023	RESULTS OF MONTE CARLO SIMULATIONS						
		Average	Median	Standard deviation	2.5%	97.5%	Percentile 2.5	Percentile 97.5
	Gg CO_2 eq.						%	
1990	-8 243.35	-8 265.46	-8 191.53	2 086.36	-12 591.60	-4 407.27	-52.34	46.68
1995	-8 585.14	-8 612.05	-8 526.09	2 118.50	-13 026.16	-4 700.32	-51.25	45.42
2000	-7 455.80	-7 528.37	-7 445.75	2 237.14	-12 166.05	-3 397.14	-61.60	54.88
2005	-1 831.42	-1 899.23	-1 835.88	2 590.22	-7 178.81	3 006.97	-277.99	258.33
2010	-2 807.93	-2 861.14	-2 787.36	2 622.42	-8 233.59	2 067.48	-187.77	172.26
2015	-3 897.01	-3 959.41	-3 884.20	2 722.23	-9 520.20	1 188.01	-140.45	130.00
2016	-3 685.05	-3 750.43	-3 684.97	2 745.73	-9 345.03	1 441.15	-149.17	138.43
2017	-3 561.81	-3 616.54	-3 549.28	2 755.30	-9 225.28	1 578.52	-155.09	143.65
2018	-2 853.97	-2 903.97	-2 838.61	2 810.87	-8 583.56	2 450.36	-195.58	184.38
2019	-3 787.62	-3 839.84	-3 768.90	2 741.95	-9 436.37	1 340.49	-145.75	134.91
2020	-5 925.67	-5 979.27	-5 893.60	2 545.79	-11 235.17	-1 235.64	-87.90	79.33
2021	-5 768.52	-5 818.83	-5 730.40	2 547.48	-11 069.68	-1 068.08	-90.24	81.64
2022	-6 573.79	-6 639.48	-6 530.39	2 771.12	-12 380.84	-1 489.34	-86.47	77.57

Figure A6.2.1: *Probability distribution function for the category 4.A Forest Land, 2022*

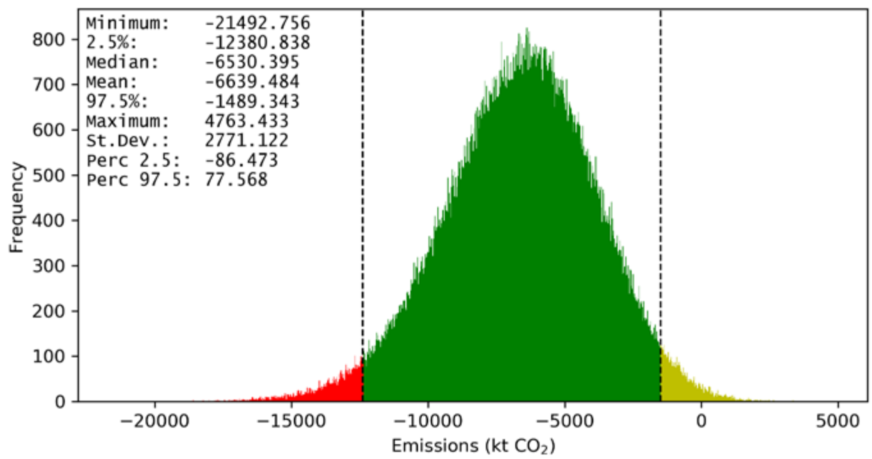


Table A6.2.3: *Results of Monte Carlo simulation for category 4.B Cropland (Gg CO_2 eq.)*

YEAR	NIR 2023	RESULTS OF MONTE CARLO SIMULATIONS						
		Average	Median	Standard deviation	2.5%	97.5%	Percentile 2.5	Percentile 97.5
	Gg CO_2 eq.						%	
1990	-399.36	-399.88	-399.99	348.98	-1 083.54	279.86	-170.97	169.98
1995	-311.62	-311.99	-310.01	331.33	-962.45	333.63	-208.48	206.93
2000	-410.39	-410.55	-410.96	320.67	-1 037.34	214.65	-152.67	152.28
2005	-495.65	-496.78	-496.52	317.90	-1 119.19	120.66	-125.29	124.29
2010	-546.98	-547.38	-546.70	313.09	-1 159.63	59.99	-111.85	110.96
2015	-489.40	-489.65	-488.70	312.10	-1 101.93	113.53	-125.04	123.19
2016	-578.01	-578.17	-577.77	311.42	-1 185.83	26.95	-105.10	104.66
2017	-609.93	-610.40	-610.26	310.77	-1 218.82	-7.13	-99.68	98.83
2018	-616.29	-616.95	-616.51	311.62	-1 224.90	-12.10	-98.54	98.04
2019	-622.07	-624.33	-623.23	309.67	-1 230.76	-21.55	-97.17	96.55
2020	-474.26	-474.51	-474.53	342.30	-1 142.40	188.26	-140.75	139.67
2021	-645.34	-645.47	-644.25	309.37	-1 250.88	-47.21	-93.79	92.69
2022	-641.69	-642.09	-641.41	307.79	-1 245.83	-45.13	-94.03	92.97

Figure A6.2.2: *Probability distribution function for the category 4.B Cropland, 2022*

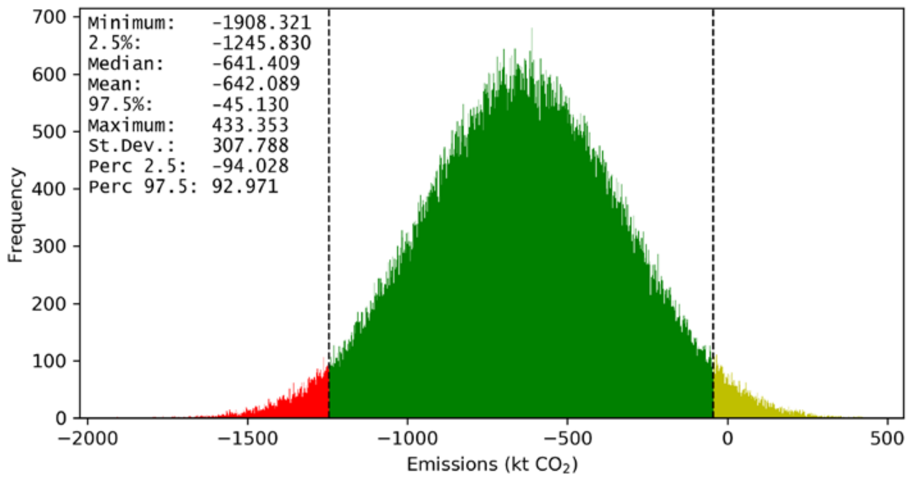


Table A6.2.4: *Results of Monte Carlo simulation for category 4.C Grassland (Gg CO_2 eq.)*

YEAR	NIR 2023	RESULTS OF MONTE CARLO SIMULATIONS						
		Average	Median	Standard deviation	2.5%	97.5%	Percentile 2.5	Percentile 97.5
	Gg CO_2 eq.						%	
1990	-194.92	-192.69	-192.36	119.10	-427.03	41.51	-121.62	121.54
1995	-256.86	-256.10	-255.78	93.07	-439.37	-255.78	-71.56	71.47
2000	-308.98	-309.46	-309.45	94.86	-495.98	-122.83	-60.28	60.31
2005	-199.80	-200.04	-199.61	116.70	-429.40	29.36	-114.66	114.67
2010	-214.87	-214.92	-214.69	109.08	-429.01	-0.80	-99.62	99.63
2015	-190.43	-190.36	-190.36	74.12	-336.48	-44.89	-76.57	76.44
2016	-178.13	-178.26	-178.09	70.09	-316.22	-40.58	-77.39	77.23
2017	-164.48	-164.58	-164.17	65.67	-293.44	-35.01	-78.40	78.71
2018	-110.54	-110.53	-110.24	61.00	-230.29	9.67	-108.36	108.75
2019	-117.74	-117.74	-117.52	50.66	-217.34	-17.91	-84.59	84.79
2020	-92.54	-92.43	-92.25	38.12	-167.25	-17.23	-80.95	81.36
2021	-55.53	-55.68	-55.87	25.47	-105.89	-5.35	-90.17	90.39
2022	-36.32	36.33	36.30	16.33	-68.54	-4.11	-88.64	88.70

Figure A6.2.3: *Probability distribution function for the category 4.C Grassland, 2022*

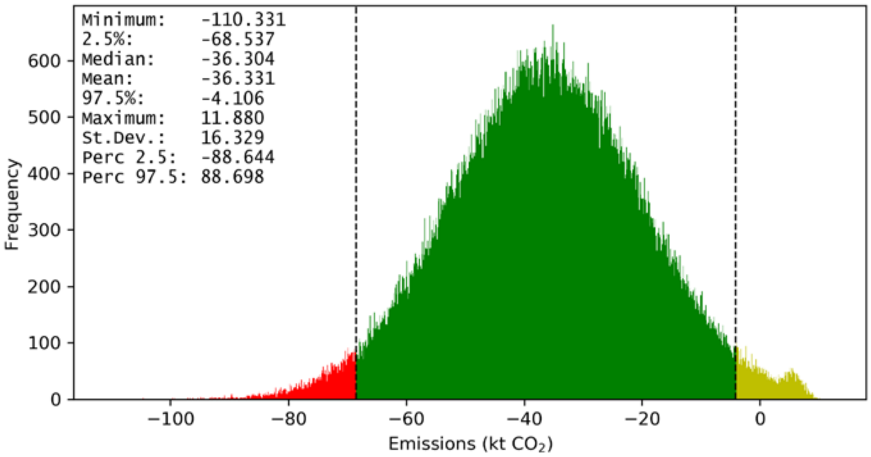


Table A6.2.5. *Results of Monte Carlo simulation for category 4.E Settlements (Gg CO_2 eq.)*

YEAR	NIR 2023	RESULTS OF MONTE CARLO SIMULATIONS						
		Average	Median	Standard deviation	2.5%	97.5%	Percentile 2.5	Percentile 97.5
	Gg CO_2 eq.						%	
1990	100.40	100.63	100.61	13.47	74.29	127.09	-26.17	26.30
1995	64.73	65.13	65.08	11.57	42.47	87.99	-34.79	34.94
2000	57.22	57.24	57.22	10.16	37.39	77.26	-34.68	34.98
2005	64.66	64.71	64.69	7.49	50.13	79.40	-22.53	22.70
2010	104.85	104.84	104.83	9.54	86.25	123.60	-17.73	17.89
2015	89.18	89.15	89.13	12.02	65.58	112.65	-26.44	26.36
2016	84.06	84.03	84.01	12.48	59.64	108.49	-29.03	29.10
2017	104.80	104.77	104.77	13.47	78.49	131.23	-25.09	25.25
2018	85.56	85.52	85.50	13.97	58.15	112.97	-32.00	32.09
2019	88.29	88.25	88.23	14.21	60.40	116.22	-31.56	31.68
2020	83.37	83.63	83.61	14.15	55.93	111.44	-33.12	33.26
2021	89.25	89.26	89.25	14.47	61.02	117.80	-31.63	31.98
2022	83.18	83.20	83.20	14.57	54.80	111.78	-34.13	34.35

Figure A6.2.4: *Probability distribution function for the category 4.E Settlements, 2022*

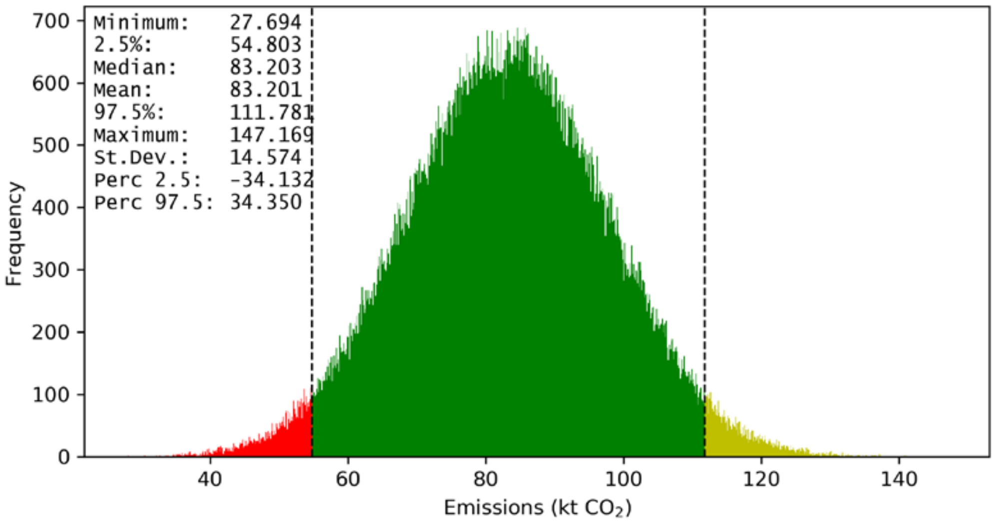


Table A6.2.6: *Results of Monte Carlo simulation for category 4.F Other Land (Gg CO_2 eq.)*

YEAR	NIR 2023	RESULTS OF MONTE CARLO SIMULATIONS						
		Average	Median	Standard deviation	2.5%	97.5%	Percentile 2.5	Percentile 97.5
	Gg CO_2 eq.						%	
1990	301.65	304.83	304.66	31.39	243.74	366.48	-20.04	20.23
1995	110.67	111.45	111.36	22.15	68.30	155.05	-38.71	39.12
2000	110.86	110.88	110.83	17.67	76.17	145.75	-31.31	31.44
2005	190.18	190.13	189.97	17.88	155.60	225.59	-18.16	18.65
2010	92.77	92.78	92.77	8.66	75.93	109.85	-18.16	18.40
2015	189.92	189.90	189.86	14.66	161.33	218.69	-15.05	15.16
2016	103.73	103.73	103.77	14.46	75.47	132.11	-27.24	27.36
2017	99.84	99.84	99.85	14.62	71.26	128.63	-28.62	28.83
2018	148.56	148.57	148.52	16.22	116.80	180.44	-21.38	21.45
2019	85.11	85.11	85.14	14.90	56.00	114.28	-34.20	34.28
2020	99.26	100.10	100.07	15.02	70.72	129.51	-29.35	29.39
2021	75.93	75.93	75.87	14.63	47.46	104.64	-37.50	37.82
2022	79.37	79.45	79.43	14.57	50.87	108.06	-35.97	36.00

Figure A6.2.5: *Probability distribution function for the category 4.F Other Land, 2022*

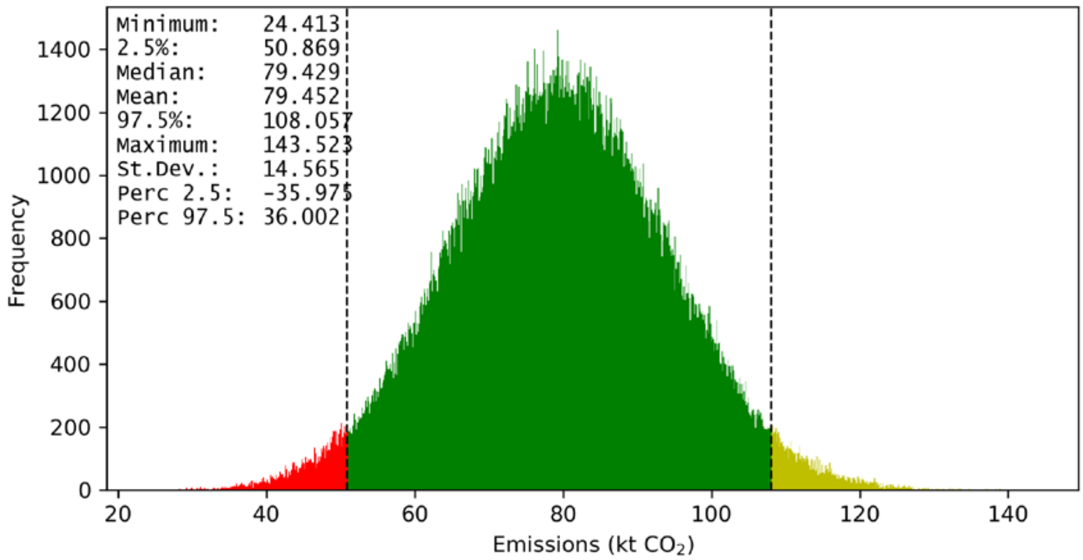


Table A6.2.7: *Results of Monte Carlo simulation for category 4.G HWP (Gg CO_2 eq.)*

YEAR	NIR 2023	RESULTS OF MONTE CARLO SIMULATIONS						
		Average	Median	Standard deviation	2.5%	97.5%	Percentile 2.5	Percentile 97.5
	Gg CO_2 eq.						%	
1990	-470.41	-354.88	-394.37	275.81	-708.00	226.16	-99.50	163.73
1995	-58.77	28.54	-13.56	282.06	-311.70	595.40	-1 192.09	1 986.06
2000	-920.07	-811.04	-856.62	340.35	-1 279.98	-80.34	-57.82	90.09
2005	-1 996.46	-1 874.87	-1 923.86	407.15	-2 440.37	-1 033.88	-30.16	44.86
2010	-1 334.60	-1 197.06	-1 255.53	445.43	-1 802.39	-260.02	-50.57	78.28
2015	-940.70	-798.31	-861.87	445.43	-1 379.40	139.95	-72.79	117.53
2016	-1 063.66	-920.35	-983.03	467.04	-1 518.13	29.29	-64.95	103.18
2017	-1 077.04	-1 002.96	-1 044.34	302.68	-1 458.70	-298.10	-45.44	70.28

YEAR	NIR 2023	RESULTS OF MONTE CARLO SIMULATIONS						
		Average	Median	Standard deviation	2.5%	97.5%	Percentile 2.5	Percentile 97.5
	Gg CO_2 eq.						%	
2018	-889.19	-818.78	-859.45	292.39	-1 264.15	-132.62	-54.39	83.80
2019	-644.91	-578.34	-617.60	282.21	-1 009.64	86.18	-74.57	114.90
2020	-247.28	-182.93	-219.02	272.48	-602.74	457.66	-229.48	350.18
2021	-382.71	-248.80	-283.15	264.92	-660.92	371.56	-165.65	249.34
2022	-144.36	4.763	-62.44	473.89	-529.20	969.90	-12 532	20 262

Figure A6.2.6: *Probability distribution function for the category 4.G HWP, 2022*

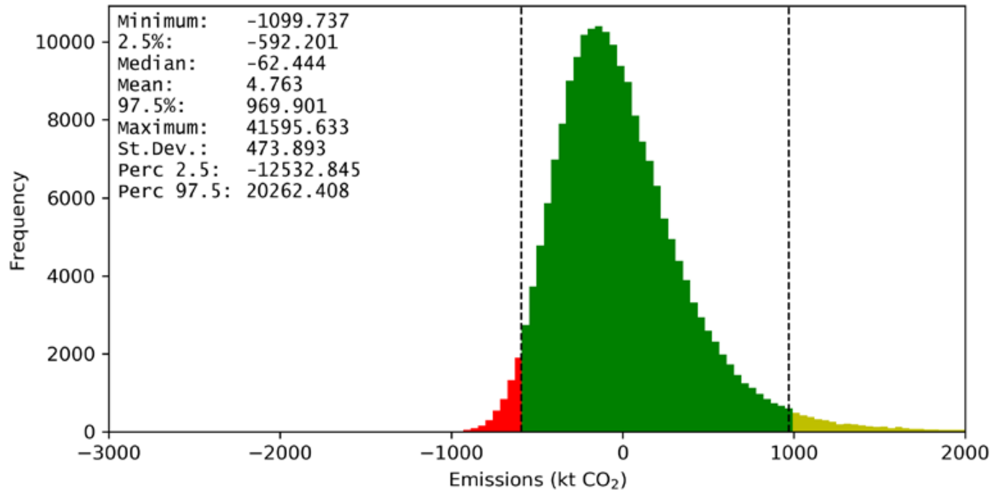
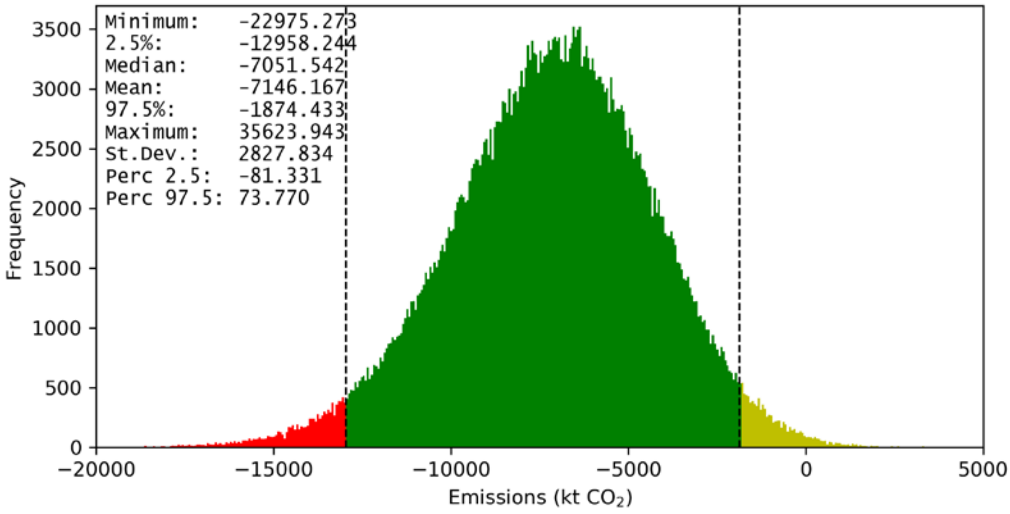


Table A6.2.8: *Results of Monte Carlo simulation for LULUCF sector (Gg CO_2 eq.)*

YEAR	NIR 2023	RESULTS OF MONTE CARLO SIMULATIONS						
		Average	Median	Standard deviation	2.5%	97.5%	Percentile 2.5	Percentile 97.5
	Gg CO_2 eq.						%	
1990	-8 892.53	-8 802.10	-8 733.80	2 139.78	-13 207.45	-4 810.37	-50.05	45.35
1995	-9 030.43	-8 973.09	-8 893.42	2 230.88	-13 592.81	-4 830.51	-51.48	46.17
2000	-8 922.53	-8 879.53	-8 802.73	2 353.24	-13 702.57	-4 494.53	-54.32	49.38
2005	-4 264.77	-4 199.74	-4 167.69	2 868.42	-9 912.75	1 343.60	-136.03	131.99
2010	-4 704.36	-4 620.48	-4 546.54	2 685.70	-10 112.91	441.94	-118.87	109.56
2015	-5 234.27	-5 154.70	-5 084.65	2 780.10	-10 808.11	114.55	-109.67	102.22
2016	-5 312.70	-5 234.99	-5 173.91	2 804.15	-10 895.04	68.43	-108.12	101.31
2017	-5 204.24	-5 112.08	-5 046.63	2 820.26	-10 824.08	220.20	-111.74	104.31
2018	-4 231.31	-4 135.03	-4 076.84	2 867.62	-9 909.92	1 330.26	-139.66	132.17
2019	-4 994.47	-4 900.12	-4 830.12	2 800.23	-10 585.86	399.58	-116.03	108.15
2020	-6 552.69	-6 458.00	-6 388.46	2 609.11	-11 805.60	-1 571.39	-82.81	75.67
2021	-6 682.58	-6 582.07	-6 502.14	2 611.91	-11 917.01	-1 694.48	-81.05	74.26
2022	-7 229.29	-7 146.17	-7 051.54	2 827.83	-12 958.24	-1 874.43	-81.33	73.77

Figure A6.2.7: *Probability distribution function for LULUCF sector, 2022*



CHAPTER 7. WASTE (CRF 5)

This Chapter was prepared using GWP_{100} taken from the 5th Assessment Report of the IPCC by the sectoral experts and institutions involved in the National Inventory System of the Slovak Republic:

INSTITUTE	CHAPTER	SECTORAL EXPERT
External expert of the SHMÚ	Category 5.A, 5.F	Marek Hrabčák
Slovak Hydrometeorological Institute (SHMÚ)	Category 5.B	Kristína Tonhauzer
Slovak Hydrometeorological Institute (SHMÚ)	Category 5.C	Zuzana Jonáček
FCHPT STU Bratislava	Category 5.D	Igor Bodík
Slovak Hydrometeorological Institute (SHMÚ)	Chapter 7.7.2 (partly)	Lea Mrafková

7.1. OVERVIEW OF THE WASTE SECTOR

Inventory of the Waste sector includes direct (CH_4, CO_2, N_2O) and indirect GHG emissions (NMVOCs). Methane is generated from solid waste disposal sites, biological treatment of waste, waste incineration and wastewater treatment. The main source of CO_2 emissions is waste incineration. N_2O emissions are generated from the biological treatment of waste and from wastewater treatment. Estimation of the following emission categories in 2022 submission is presented in this chapter:

- 5.A Solid waste disposal;
- 5.B Biological treatment of solid waste;
- 5.C Incineration and open burning of waste;
- 5.D Wastewater treatment and discharge;
- 5.F Memo Items (HWP).

In 2022, total aggregated GHG net emissions from the Waste sector are relatively stable over the entire period 1990 – 2022 as is shown on ***Figure 7.1***. Total aggregated emissions from the Waste sector were 1 929.92 Gg of CO_2 eq. in 2022 and they decreased by 0.6% compared to the previous year, due to a decrease of the amount of SWDS category responsible for slight decrease in methane emissions. Compared to the reference year 1990, total GHG emissions increased by 38%. The increase of emissions in biological treatment and incineration of waste without energy use was compensated by the decrease of emissions from SWDS and Wastewater. Emissions from waste incineration with energy use were allocated into the Energy sector (1.A.1.a – Other Fuels for municipal waste and 1.A.2.c&1.A.2.f for industrial waste incineration).

Emissions from landfilled waste (5.A) have changed their current trend after the revision of input data for the period 2005 – 2021. The emissions growth from waste disposal slowed down after 2011 and peaked in 2019, since then was already a decrease in time series (albeit minimal) recognised. New methane emissions from landfilled waste in 2022 are slightly lower than in 2021 by -5.0%.Emissions from industrial landfilled waste (ISW) have been steadily declining since 2008 (-16%).

Emissions from biological treatment (5.B) do not vary significantly, but there is an increase in the last year 2022 due to increasing amounts of waste sent for composting by more than 20%.

Emissions from waste incineration without energy recovery (5.C) were recalculated due to reconsideration of the methodological approach. The significant increase in emissions was due to the failure of heat exchange facilities in one facility that use waste to generate energy. The waste was therefore incinerated without energy recovery.

Emissions from wastewater treatment (5.D) are continually decreasing since 2019 due to the modernisation of wastewater treatment plants, in 2022 by 1%.

Figure 7.1: *Trend of Waste sector emissions by categories in 1990 – 2022*

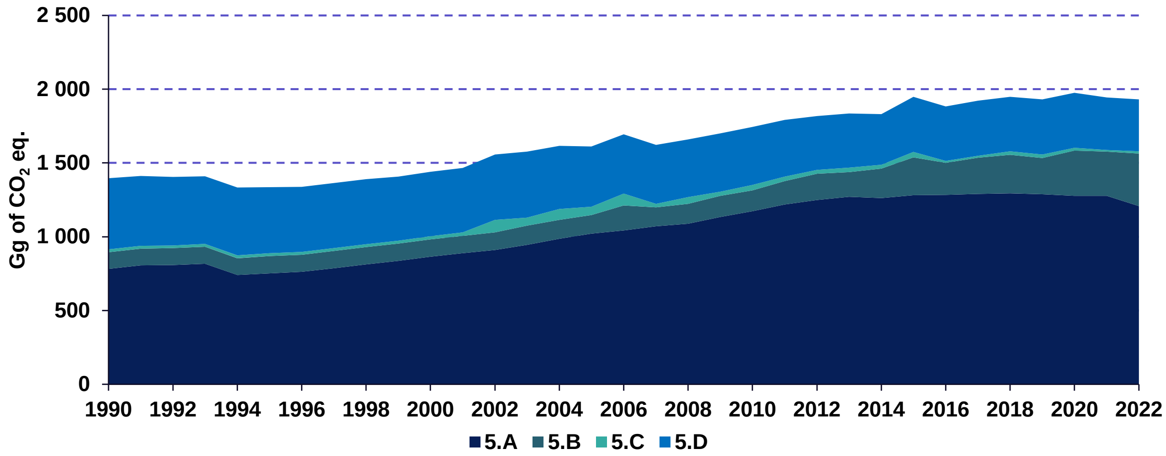
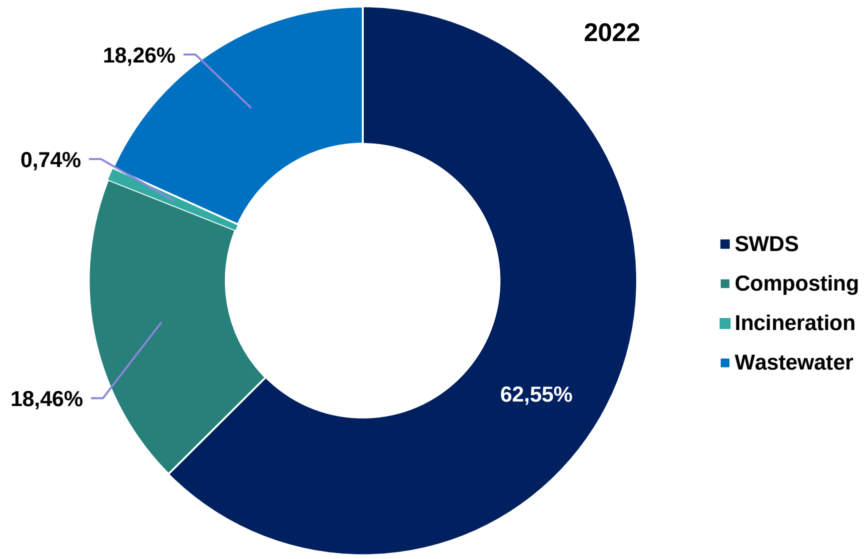


Figure 7.2 bellow shows that the most important source of GHG emissions is solid waste disposal (62.6%), followed by biological treatment (18.5%) and wastewater treatment (18.3%) and incineration of waste without energy recovery (0.7%). The Waste sector contributed 4.2% to total GHG emissions in 2022.

Figure 7.2: *The share of categories in waste sector in 2022*



The majority of GHG emissions from the Waste sector are in form of CH_4 with 89.4% share followed by 10.4% of N_2O and 0.2% of CO_2 as shows in ***Table 7.1*** and on ***Figure 7.3***.

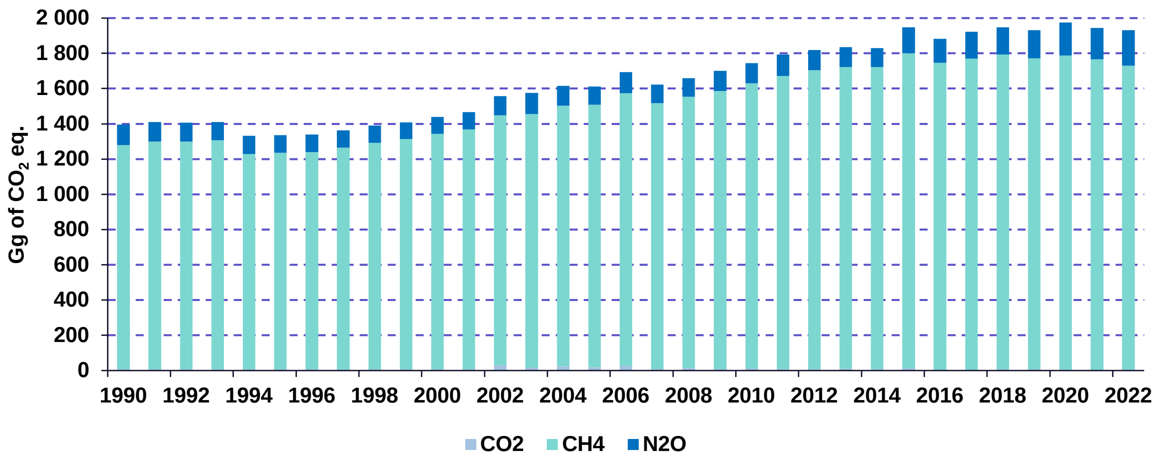
Summary of the GHG emissions inventory expressed in GWP taken from the AR5 is visible in the ***Table 7.1***.

Table 7.1: *GHG emissions in the Waste sector according to the gases and categories in particular years*

YEAR	TOTAL CO_2*	TOTAL CH_4	TOTAL N_2O	GHG	TOTAL 5.A	TOTAL 5.B	TOTAL 5.C	TOTAL 5.D
	Gg of CO_2 eq.			*Gg of CO_2 eq.*				
1990	4.54	1 273.87	116.62	**1 395.03**	781.78	113.98	18.17	481.11
1995	4.57	1 229.50	100.79	**1 334.86**	751.87	116.69	18.09	448.20
2000	4.91	1 337.06	96.48	**1 438.45**	865.28	116.85	19.58	436.74
2005	15.79	1 489.17	105.18	**1 610.14**	1 021.21	126.13	52.57	410.23
2010	9.39	1 618.16	115.33	**1 742.89**	1 172.08	141.40	35.87	393.54
2011	7.17	1 663.58	120.08	**1 790.84**	1 218.28	159.03	29.00	384.53
2012	6.10	1 697.31	114.15	**1 817.56**	1 248.52	178.47	24.93	365.64
2013	7.57	1 712.74	113.03	**1 833.33**	1 270.64	168.46	26.95	367.28
2014	6.13	1 715.05	108.14	**1 829.31**	1 262.24	200.08	23.42	343.57
2015	9.13	1 789.22	147.05	**1 945.41**	1 282.12	254.87	35.72	372.69
2016	2.25	1 743.90	135.87	**1 882.02**	1 282.96	218.02	11.18	369.86
2017	2.02	1 766.42	153.87	**1 922.30**	1 289.40	246.60	10.92	375.38
2018	5.10	1 786.56	155.16	**1 946.82**	1 294.44	261.14	21.95	369.30
2019	5.10	1 765.42	160.03	**1 930.55**	1 288.00	246.52	21.96	374.07
2020	4.02	1 783.59	186.87	**1 974.48**	1 276.52	307.65	17.94	372.37
2021	2.04	1 762.89	178.28	**1 943.21**	1 277.64	299.65	10.79	355.13
2022	3.02	1 724.87	202.03	**1 929.92**	1 207.08	356.31	14.22	352.31

**Only non-bio CO_2 included in category 5.C*

Figure 7.3: *Trend in aggregated emissions by gases within the waste in 1990 – 2022*



The general approach to estimate emissions in the Waste sector is to use the default parameters taken from the IPCC 2006 GL and country-specific data. Overview of used tiers by category is summarised in ***Table 7.2***.

Table 7.2: *Overview of tiers used in the Waste sector in 2022*

EMISSION CATEGORY	GAS/TIER USED		NOTE (RESPONSES TO DECISION TREE)
5.A Solid Waste Disposal	CH_4	T2/CS	Good quality CS AD are available, except of composition of waste landfilled.
			CS models and parameters partly available.
5.B Biological Treatment	CH_4, N_2O	T1/D	CS data on waste available.
			CS emission factors not available.
5.C Incineration and Open Burning	CO_2	T2/CS, D	Plant specific data not available.
			CS data on waste available.

EMISSION CATEGORY	GAS/TIER USED		NOTE (RESPONSES TO DECISION TREE)
5.C Incineration and Open Burning	CH_4, N_2O	T2/CS, D	CS emission factors not available.
			Plant specific data not available.
			CS data on waste available.
5.D Wastewater	CH_4, N_2O	T1, T2/D	Wastewater treatment pathways characterised.
			Measurements are available (BOD, COD, N_{tot}), but CS method not available.
			CS emission factors not available, but CS model developed.
			Wastewater is a key category.

European Waste Catalogue (EWC) – the division of waste to Waste Groups defined in the European System of Waste Classification (Commission Decision 2000/532/EC) was used for estimating of the emissions. The "municipal solid waste" (MSW) means all waste reported in the Waste Group 20. All the other waste types from Waste Groups 1 – 19 are called "industrial solid waste" (ISW). Statistical data on waste generation, disposal, incineration and recovery by waste groups are published by the ŠÚ SR annually in publication "Odpady v Slovenskej republike" (Waste in the Slovak Republic). This is primary source of activity data for estimation of emissions in the Waste sector. ***Table 7.3*** presents overview of the mass flows in percent for the different waste types in 2022, from generation to the different treatment options, including recycling and landfilling.

Table 7.3: *Overview of generated waste and mass flows for the different waste types according to the national statistics in 2022*

CATEGORY	WASTE TOTAL	RECOVERY, REUSE				DISPOSAL			STORAGE
		A	B	C	D	E	F	G	H
	tons	*share*				*share*			
SR Total	**13 190 581**	**43.79%**	**3.08%**	**13.27%**	**0.91%**	**20.78%**	**0.07%**	**2.60%**	**15.50%**
01 Wastes resulting from exploration, mining, quarrying, physical and chemical treatment of minerals	141 717	45%	0%	0%	0%	31%	0%	0%	24%
02 Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing	627 851	44%	7%	19%	1%	1%	0%	7%	22%
03 Wastes from wood processing and the production of panels and furniture, pulp, paper and cardboard	625 819	3%	5%	66%	6%	5%	0%	0%	16%
04 Wastes from the leather, fur and textile industries	12 856	3%	0%	1%	0%	13%	0%	0%	83%
05 Wastes from petroleum refining, natural gas purification and pyrolytic treatment of coal	5 185	3%	0%	0%	0%	3%	5%	35%	53%
06 Wastes from inorganic chemical processes	3 666	23%	0%	38%	0%	5%	0%	12%	22%
07 Wastes from organic chemical processes	63 515	12%	2%	27%	2%	12%	0%	0%	44%
08 Wastes from the manufacture, formulation, supply and use (MFSU) of coatings (paints, varnishes and vitreous enamels), adhesives, sealants and printing inks	13 410	3%	1%	0%	0%	11%	0%	5%	79%

CATEGORY	WASTE TOTAL	RECOVERY, REUSE				DISPOSAL			STORAGE
		A	B	C	D	E	F	G	H
	tons	*share*				*share*			
09 Wastes from the photographic industry	266	11%	0%	0%	0%	10%	0%	14%	64%
10 Wastes from thermal processes	1 283 301	4%	0%	1%	0%	86%	0%	3%	6%
11 Wastes from chemical surface treatment and coating of metals and other materials; non-ferrous hydro-metallurgy	39 486	23%	0%	6%	0%	3%	0%	31%	36%
12 Wastes from shaping and physical and mechanical surface treatment of metals and plastics	808 883	93%	0%	0%	0%	0%	0%	1%	5%
13 Oil wastes and wastes of liquid fuels (except edible oils, 05 and 12)	30 017	27%	0%	0%	1%	0%	0%	25%	47%
14 Waste organic solvents, refrigerants and propellants (except 07 and 08)	2 156	45%	2%	0%	0%	0%	0%	3%	49%
15 Waste packaging; absorbents, wiping cloths, filter materials and protective clothing not otherwise specified	222 568	14%	1%	56%	1%	7%	0%	1%	21%
16 Wastes not otherwise specified in the list	333 026	48%	0%	4%	1%	9%	0%	24%	13%
17 Construction and demolition wastes (including excavated soil from contaminated sites)	4 601 039	68%	0%	1%	1%	4%	0%	1%	26%
18 Wastes from human or animal health care and/or related research (except kitchen and restaurant wastes not arising from immediate health care)	24 892	4%	7%	40%	3%	2%	16%	1%	27%
19 Wastes from waste management facilities, off-site wastewater treatment plants and the preparation of water intended for human consumption and water for industrial use	1 650 796	42%	8%	16%	1%	18%	0%	4%	11%
20 Municipal waste (household waste and similar commercial, industrial and institutional wastes) including separately collected fractions	2 597 457	20%	8%	29%	1%	39%	0%	0%	3%

A=material, B=energy, C=compost, D=other, E=landfilling, F=incineration, G=other

7.2. CATEGORY-SPECIFIC QA/QC AND VERIFICATION PROCESS

QA/QC procedures in the Waste sector are linked with the QA/QC plans for the National Inventory System at the sectoral level and follow basic rules and activities of QA/QC as defined in IPCC 2006 GL. The QC checks (e.g. consistency check between CRF data and national statistics) were done during the CRF and NIR compilation, General QC questionnaire was filled and archived by QA/QC manager.

Due to larger revisions and recalculations provided in the category 5.A – Solid Waste Disposal Sites, implementation process was finalised on national level by public outreach done on April 8, 2023. Presentation of new methodology and resulting emissions from the municipal and industrial solid waste disposal sites followed by discussion introduced several interesting area for further improvements, however the principles and results of the recalculation were accepted on national level.

Verification of activity data used for estimation of emissions from municipal solid waste disposed to SWDS was performed by comparing reported year data to previous years' data. Verification on MSW data was strengthened by correlation with index of real wage.

The period 1950 – 1990 was estimated based on economic growth according to the procedure given in the previous submissions. For the period 1990 – 2004, statistical input data on waste production was available, however the EWC was not adopted until 2001, thus the groups and types of waste from this period are not entirely consistent with the EWC. Therefore, the data on the composition of waste for the period 1990 – 2004 are extrapolated. For the period from 2005 – 2022, summary statistical data on waste production were used according to data from the ŠÚ SR. Data were further analysed up to the level of individual types of waste according to the EWC as maintained in the Information System Waste (IS Waste). These data are sufficiently reliable and valid.

In the retrospective review, inventory is relied on the period since sufficiently reliable statistical data on the waste production and management (2005 – 2022) is available. Another important fact is that, with the exception of wood, the half-time of decay of all other waste components (food, garden, paper, textiles) is less than 12 years according to the IPCC 2006 GL. It follows, that waste landfilled more than 20 years is already negligible source of emissions (with the exception of wood). For this reason, further refining of data on the amount and composition of landfilled waste before the year 2000 is considering not relevant. Details on the recalculations and revisions of landfill data since the previous submission are given in **Chapter 7.5.1**.

Verification of data on recovered methane from landfill gas is ensured by the use of national database of electricity produced from renewable sources, annually published by the Regulatory Office for Network Industries (**Chapter 7.5.1**). Verification of activity data used for estimation of emissions from agricultural and industrial solid waste disposed to SWDS was performed by comparing reported year data to previous years' data.

Verification of data on biological treatment was done by comparing data from the ŠÚ SR with the National Strategy of Biodegradable Waste Management provided by the Ministry of Environment of the Slovak Republic (MŽP SR).

Verification of activity data and estimated emissions from MSW incinerators is ensured by comparing results of modelling with the Reports on Operation and Monitoring of Waste incinerators and data reported to the NEIS database and the Annual Reports from companies OLO Bratislava and KOSIT Košice. Verification of activity data and estimated emissions from the non-MSW incinerators is ensured by a modelling results comparison with the information provided in the Reports on Operation and Monitoring of Waste incinerators and the NEIS database and the Annual Reports from companies incinerating and co-incinerating waste. Activity data are available from the Statistical Yearbook and the NEIS database for the waste incineration. Default emission factors were used, and these were verified to fully comply with the IPCC 2019 Refinements to the IPCC 2006 Guidelines. Because the Slovak incinerators do not monitor dry matter content, parameters for wet weight were used consistently for all calculations.

Data on population were obtained from the demographic information updated by the ŠÚ SR, from the Report on Water Management prepared by the Water Research Institute (VÚVH) and from the national censuses. Data on protein consumption are published annually by the ŠÚ SR, however by December 2023, actual data for 2022 is missing. Therefore, the protein consumption for the year 2022 was provided based on extrapolated real data from the ŠÚ SR for the last 5 years. Sewage sludge data were obtained from the Report on Water Management prepared by the VÚVH.

Data on use of retention tanks (cesspools and septic tanks) are based on population censuses done in years 1991, 2001 and 2011. These censuses are also used for verification of population distribution to individual wastewater pathways. Additional information used in wastewater estimation was collected by the SHMÚ. Data published in statistical reports are verified by a comparison in category and time series. Data on population connected to cesspools and septic tanks, domestic WWTPs as well as others are estimated according discussion with wastewater experts on Slovak University of Technology Bratislava, Association of wastewater treatment experts of Slovak Republic, VÚVH Bratislava a Ministry of Environment SR.

Data on BOD_5, COD and N_{tot} in influents as well as effluents from all Slovak WWTPs was obtained based on information provided by the ŠÚ SR and from the SHMÚ. Additional information used in wastewater estimation was collected by the SHMÚ and the wastewater treatment experts. Data published in statistical reports are verified by a comparison in category and time series.

Information about industrial wastewater is also registered in the Database of Wastewaters at the SHMÚ (Department of Water Quality) and is published by the ŠÚ SR.

7.3. CATEGORY-SPECIFIC RECALCULATIONS

Sectoral experts made some smaller revisions of the methodological approaches and used activity data also in 2024 submission. After analysis, several improvements introduced in this submission led to recalculation or reallocation of data from several categories. This recalculation work is reaction on the implementation of the new ETF system and connected with the implementation of the 2019 IPCC Refinements.

In addition, waste composting was prepared by the sectoral expert for agriculture with the cross-checked of data provided between the Agriculture and Waste sectors. The air pollution expert with the cooperation of the energy sectoral expert prepared inventory in the waste incineration category (without energy use). The crosscheck was done between the Energy and Waste sectors in this submission.

In line with the Improvement and Prioritization Plan for 2024, minor correction of data (waste incineration) took place in this submission. These reflecting recommendations made during previous reviews and suggested experts' improvements.

Table 7.4: *Description of recalculations implemented in 2024 submission*

RECOMME-NDATION NO.	CATEGORY	DESCRIPTION	REFERENCE
1.	5.A	Recalculation based on revision of activity data on waste production 2010 – 2021 provided by the Statistical Office of the Slovak Republic and Ministry of the Environment of the Slovak Republic.	**Chapter 7.5**
2.	5.B	This recalculation is connected with the correction of activity data of composting of municipal waste in 2010 – 2021. The revision of new data is connected with data refinement provided by the Statistical Office of the Slovak Republic.	**Chapter 7.6**
3.	5.C.1.1.b Other waste incineration – biogenic and 5.C.1.2.b Other waste incineration - non biogenic	Emissions of CO_2, CH_4 and N_2O were recalculated for all-time series 1990 – 2021 due to improved statistical information on incinerated waste. These recalculations increased biogenic as well as non-biogenic GHG emissions in equivalents.	**Chapter 7.7**

RECOMME-NDATION NO.	CATEGORY	DESCRIPTION	REFERENCE
4.	5.D	Recalculations based on the implementation of the 2019 IPCC Refinement Guidelines, which caused slight changes in the resulting values throughout the time series. Actual value for protein consumption for 2021 was updated in calculation.	**Chapter 7.8**

Ad. 1: This recalculation is connected with the correction of activity data of annual waste disposal on the SWDS and correction of the composition of the waste in 2010 – 2021. The revision of new data is connected with data refinement provided by the Statistical Office of the Slovak Republic. ***Table 7.5*** is showing changes led to increase or decrease of emissions in this category.

Table 7.5: *Recalculations of the category 5.A for 2010 – 2021 and comparison of the submissions*

YEAR	5.A.1.a – ANNUAL WASTE AT THE SWDS			5.A.1.a – CH_4 EMISSIONS		
	kt			*Gg*		
	2023	**2024**	%	**2023**	**2024**	%
2010	1 586.613	1 620.725	2.10%	41.865	41.865	-0.01%
2011	1 497.914	1 577.264	5.30%	43.369	43.508	0.32%
2012	1 402.580	1 488.803	6.15%	44.155	44.593	0.99%
2013	1 359.303	1 419.773	4.45%	44.660	45.382	1.62%
2014	1 293.917	1 358.482	4.99%	44.212	45.080	1.96%
2015	1 382.630	1 461.233	5.69%	44.777	45.785	2.25%
2016	1 437.935	1 437.935	0.00%	44.639	45.819	2.64%
2017	1 432.658	1 431.321	-0.09%	45.010	46.053	2.32%
2018	1 356.955	1 356.955	0.00%	45.309	46.230	2.03%
2019	1 297.058	1 297.058	0.00%	45.178	45.998	1.82%
2020	1 307.209	1 318.504	0.86%	44.857	45.590	1.63%
2021	1 173.804	1 171.685	-0.18%	44.930	45.626	1.55%

Ad 2: This recalculation is connected with the correction of activity data of composting of municipal waste in 2010 – 2021. The revision of new data is connected with data refinement provided by the Statistical Office of the Slovak Republic. ***Table 7.6*** is showing changes led to increase or decrease of emissions in this category.

Table 7.6: *Recalculations of the category 5.B.1.a for 2010 – 2021 and comparison of the submissions*

YEAR	5.B.1.a - CH_4 EMISSIONS			5.B.1.a - N_2O EMISSIONS		
	kt			*kt*		
	2023	**2024**	%	**2023**	**2024**	%
2010	0.83	0.83	0.002%	0.050	0.050	0.002201%
2011	0.90	0.90	0.001%	0.054	0.054	0.000755%
2012	0.96	0.96	0.000%	0.057	0.057	-0.000310%
2013	0.98	0.98	-0.002%	0.059	0.059	-0.001911%
2014	0.95	0.95	-0.001%	0.057	0.057	-0.000892%
2015	1.15	1.15	-0.001%	0.069	0.069	-0.000648%
2016	1.20	1.20	0.001%	0.072	0.072	0.000859%
2017	1.61	1.61	-0.001%	0.097	0.097	-0.001046%
2018	1.84	1.84	0.000%	0.111	0.111	0.000093%
2019	2.09	2.09	0.000%	0.125	0.125	0.000001%
2020	2.65	3.02	13.857%	0.159	0.181	13.857231%
2021	2.95	3.32	12.712%	0.177	0.199	12.712332%

Ad. 3: Emissions of all GHG for the category Waste Incineration – Industrial waste were recalculated in this submission due to improvement in the statistical information provided by the Statistical Office of the Slovak Republic and consequences to the activity data. These activity data are slightly higher than previously reported and in consistency with the data used in air pollutants' inventory. In addition, methodology for biogenic and non-biogenic share of waste was improved. Revised data on GHG emissions and comparison is provided in the ***Table 7.7***.

Table 7.7: *Recalculations of the category 5.C for 1990 – 2021 and comparison of the submissions*

YEAR	5.C.1.1.b - GHG EMISSIONS			5.C.1.2.b - GHG EMISSIONS		
	Gg CO_2 eq.			*Gg CO_2 eq.*		
	2023	**2024**	%	**2023**	**2027**	%
1990	1.008	3.785	275.47%	3.848	15.493	302.65%
1991	1.007	3.781	275.63%	3.842	15.445	302.00%
1992	1.004	3.763	274.75%	3.833	15.451	303.15%
1993	1.010	3.797	275.83%	3.856	15.482	301.54%
1994	1.010	3.796	275.65%	3.856	15.494	301.78%
1995	0.998	3.717	272.53%	3.808	15.474	306.35%
1996	1.010	3.766	272.74%	3.856	15.653	305.97%
1997	1.028	3.880	277.30%	3.925	15.676	299.40%
1998	0.986	3.604	265.58%	3.762	15.693	317.10%
1999	0.990	3.588	262.50%	3.778	15.945	322.05%
2000	1.084	4.063	274.64%	4.139	16.714	303.82%
2001	1.044	4.128	295.35%	4.597	19.168	316.99%
2002	1.703	9.087	433.52%	19.513	75.354	286.17%
2003	1.394	7.288	422.72%	10.374	46.532	348.54%
2004	1.778	9.872	455.30%	13.794	63.734	362.03%
2005	1.505	7.689	411.06%	10.759	47.443	340.97%
2006	1.569	10.730	583.73%	12.909	68.321	429.25%
2007	0.763	4.181	448.06%	3.691	20.240	448.41%
2008	1.042	7.110	582.35%	5.877	37.412	536.61%
2009	0.941	5.337	467.01%	4.209	24.747	487.91%
2010	1.130	6.525	477.33%	5.349	31.304	485.21%
2011	1.185	6.061	411.40%	4.395	24.702	462.12%
2012	0.882	4.900	455.87%	3.594	21.424	496.13%
2013	0.888	4.518	408.97%	4.884	23.863	388.64%
2014	0.873	4.439	408.50%	3.802	20.323	434.58%
2015	1.276	7.002	448.63%	5.251	30.795	486.43%
2016	0.853	3.535	314.64%	1.946	8.572	340.56%
2017	0.845	3.600	326.11%	1.875	8.206	337.65%
2018	1.058	5.151	386.79%	3.276	18.235	456.56%
2019	1.000	5.039	403.90%	3.163	18.327	479.32%
2020	0.926	4.415	376.63%	2.700	14.733	445.74%
2021	0.813	3.528	334.00%	1.752	8.147	364.90%

Ad 4: Re-calculations of CH_4 and N_2O emissions in the categories 5.D.1 and 5.D.2 were carried out using a new methodology according to the IPCC 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Changes in the production of CH_4 and N_2O emissions were caused by a change in the default MCF and EF values for discharge from treated and untreated systems, for wastewater treatment systems emissions, by efficiency of BOD_5, COD, N_{tot} removal in primary, secondary and tertiary treatment systems, etc.

According to the IPCC 2019 Refinement, the selected default factors for the entire time series 1990 – 2022 were changed, as follows:

- Factor of non-consumed protein added to the wastewater $F_{NON-CON}$ from 1.10 to 1.01 (food waste not allowed in sewer systems).
- Factor of industrial and commercial co-discharged protein into the sewer system $F_{IND-COM}$. This was changed so that a factor of 1 was added to the original value, e.g. the original value of 0.25 was changed to a new 1.25 according to the recommendation of IPCC 2019 Refinement.
- EF for direct emissions from treatment processes in advanced WWTPs: 0.016 (a new EF).
- N_{rem} in septic and cesspool tanks: 15%.
- N_{rem} in secondary treated WWTPs: 40%.
- N_{rem} in tertiary treated WWTPs: 80%.
- N_{rem} in household WWTPs: 50%.
- Content of TN (total nitrogen) in treatment sludge was exactly reported (VÚVH Bratislava) in years 2018 – 2022, years before has been set as average default value 4.52% from TS (total solid).

Changes and the introduction of new default factors as well as the application of new calculation procedures led to significant changes in the resulting emissions in both sectors as well as in both emission gases. In following tables are these changes recorded.

Table 7.8: *Recalculations of the 5.D.1, 5.D.2 and 5.D categories and comparison of the submissions for methane emissions*

YEAR	CH_4 emissions domestic WW			CH_4 emissions industrial WW			CH_4 emissions total		
	kt		*%*	*kt*		*%*	*kt*		*%*
	2023	2024		2023	2024		2023	2024	
1990	17.47	13.21	-24.4%	1.17	1.29	10.0%	18.64	14.50	-22.2%
1991	17.34	13.13	-24.3%	1.12	1.23	10.0%	18.46	14.36	-22.2%
1992	17.27	13.09	-24.2%	1.07	1.17	10.0%	18.34	14.27	-22.2%
1993	17.06	13.05	-23.5%	1.02	1.12	10.0%	18.08	14.17	-21,6%
1994	16.04	13.14	-18.0%	0.93	1.03	10.0%	16,97	14,17	-16,5%
1995	15.72	13.00	-17.3%	0.85	0.93	10.0%	16.56	13.92	-15.9%
1996	15.62	12.96	-17.0%	0.70	0.77	10.0%	16.32	13.74	-15.8%
1997	15.46	12.96	-16.2%	0.66	0.73	10.0%	16.12	13.69	-15.1%
1998	15.49	13.01	-16.0%	0.67	0.74	10.0%	16.16	13.75	-14.9%
1999	15.41	12.95	-15.9%	0.63	0.69	9.9%	16.04	13.65	-14.9%
2000	15.32	12.87	-16.0%	0.73	0.80	10.0%	16.05	13.67	-14.8%
2001	15.33	12.86	-16.1%	0.68	0.75	10.1%	16.01	13.61	-15.0%
2002	15.13	12.81	-15.3%	0.64	0.70	10.0%	15.77	13.51	-14.3%
2003	14.73	12.59	-14.5%	0.66	0.73	10.0%	15.40	13.32	-13.5%
2004	14.30	12.31	-13.9%	0.55	0.61	10.0%	14.85	12.92	-13.0%
2005	14.05	12.06	-14.2%	0.42	0.46	10.0%	14.47	12.52	-13.5%
2006	13.85	11.89	-14.1%	0.32	0.36	9.9%	14.17	12.25	-13.6%
2007	13.59	11.78	-13.3%	0.32	0.35	10.1%	13.91	12.13	-12.8%
2008	13.41	11.57	-13.7%	0.33	0.36	9.9%	13.74	11.93	-13.2%
2009	13.22	11.47	-13.2%	0.35	0.38	10.0%	13.57	11.85	-12.7%
2010	13.04	11.37	-12.8%	0.34	0.37	9.9%	13.38	11.74	-12.2%
2011	12.79	11.15	-12.8%	0.27	0.30	9.9%	13.06	11.45	-12.3%
2012	12.62	10.91	-13.5%	0.25	0.28	10.0%	12.87	11.19	-13.1%
2013	12.42	10.78	-13.2%	0.25	0.27	10.0%	12.67	11.05	-12.8%

YEAR	CH_4 emissions domestic WW			CH_4 emissions industrial WW			CH_4 emissions total		
	kt		%	kt		%	kt		%
	2023	2024		2023	2024		2023	2024	
2014	12.20	10.36	-15.1%	0.23	0.25	9.9%	12.43	10.61	-14.6%
2015	12.04	10.61	-11.9%	0.22	0.24	10.1%	12.26	10.85	-11.5%
2016	11.80	10.42	-11.7%	0.22	0.24	10.2%	12.02	10.66	-11.3%
2017	11.57	10.34	-10.6%	0.21	0.23	10.0%	11.78	10.58	-10.2%
2018	11.40	10.29	-9.8%	0.18	0.20	10.0%	11.58	10.48	-9.5%
2019	11.18	10.12	-9.5%	0.19	0.21	10.0%	11.37	10.33	-9.1%
2020	10.98	9.96	-9.3%	0.16	0.18	10.0%	11.14	10.14	-9.0%
2021	10.49	9.56	-8.8%	0.17	0.19	10.0%	10.66	9.75	-8.5%

Table 7.9: *Recalculations of the 5.D.1, 5.D.2 and 5.D categories and comparison of the submissions for nitrous oxide and N-effluent emissions*

YEAR	N_2O emissions domestic WW			N_2O emissions industrial WW			N_2O emissions total		
	kt		%	kt		%	kt		%
	2023	2024		2023	2024		2023	2024	
1990	0.40	0.25	-37.9%	0.035	0.035	0.0%	0.43	0.28	-34.8%
1991	0.37	0.23	-37.1%	0.033	0.033	0.0%	0.40	0.26	-34.0%
1992	0.33	0.21	-35.8%	0.032	0.032	0.0%	0.36	0.25	-32.6%
1993	0.32	0.20	-37.0%	0.031	0.031	0.0%	0.36	0.24	-33.7%
1994	0.33	0.21	-37.2%	0.030	0.030	0.0%	0.36	0.24	-34.1%
1995	0.32	0.19	-40.3%	0.029	0.029	0.0%	0.35	0.22	-37.0%
1996	0.32	0.19	-40.3%	0.024	0.024	0.0%	0.34	0.21	-37.5%
1997	0.32	0.19	-40.2%	0.023	0.023	0.0%	0.34	0.21	-37.5%
1998	0.31	0.19	-38.8%	0.021	0.021	0.0%	0.33	0.21	-36.3%
1999	0.29	0.18	-38.2%	0.019	0.019	0.0%	0.31	0.20	-35.8%
2000	0.26	0.18	-31.2%	0.023	0.023	0.0%	0.29	0.20	-28.7%
2001	0.25	0.19	-23.5%	0.021	0.021	0.0%	0.28	0.22	-21.7%
2002	0.25	0.23	-9.8%	0.020	0.020	0.0%	0.27	0.25	-9.1%
2003	0.21	0.26	23.4%	0.020	0.020	0.0%	0.23	0.28	21.4%
2004	0.20	0.23	18.5%	0.017	0.017	0.0%	0.21	0.25	17.0%
2005	0.19	0.21	9.7%	0.015	0.015	0.0%	0.21	0.23	9.0%
2006	0.20	0.21	8.1%	0.011	0.011	0.0%	0.21	0.22	7.6%
2007	0.19	0.22	15.6%	0.011	0.011	0.0%	0.20	0.23	14.7%
2008	0.18	0.20	11.1%	0.012	0.012	0.0%	0.19	0.21	10.5%
2009	0.18	0.21	20.4%	0.012	0.023	85.7%	0.19	0.23	24.7%
2010	0.17	0.22	27.7%	0.013	0.023	73.0%	0.19	0.24	30.8%
2011	0.17	0.22	25.8%	0.012	0.022	92.5%	0.19	0.24	29.9%
2012	0.17	0.17	2.2%	0.010	0.023	130.8%	0.18	0.20	9.3%
2013	0.17	0.20	20.7%	0.008	0.014	70.6%	0.18	0.22	23.1%
2014	0.17	0.15	-9.8%	0.007	0.026	295.8%	0.17	0.18	1.9%
2015	0.16	0.24	48.4%	0.006	0.016	171.0%	0.17	0.26	52.6%
2016	0.17	0.25	46.2%	0.007	0.018	172.1%	0.18	0.27	50.8%
2017	0.17	0.27	54.8%	0.006	0.029	367.3%	0.18	0.30	65.5%
2018	0.17	0.27	60.0%	0.005	0.013	161.2%	0.18	0.29	62.8%
2019	0.16	0.31	87.8%	0.005	0.013	173.1%	0.17	0.32	90.2%
2020	0.17	0.32	94.1%	0.004	0.012	186.5%	0.17	0.33	96.4%
2021	0.16	0.30	86.2%	0.003	0.011	326.7%	0.16	0.31	89.9%

YEAR	N-EFFLUENT FROM DOMESTIC WASTEWATER		
	kt		%
	2023	2024	
1990	50.92	54.15	6.3%
1991	46.53	49.07	5.5%
1992	42.30	44.73	5.7%
1993	41.35	42.67	3.2%
1994	41.65	42.59	2.3%
1995	40.76	39.60	-2.9%
1996	40.48	39.26	-3.0%
1997	40.46	39.20	-3.1%
1998	39.39	39.09	-0.8%
1999	36.92	37.36	1.2%
2000	33.42	34.45	3.1%
2001	32.33	32.31	-0.1%
2002	32.06	32.63	1.8%
2003	26.92	27.75	3.1%
2004	24.87	23.91	-3.9%
2005	24.37	22.09	-9.4%
2006	24.83	21.60	-13.0%
2007	23.97	21.23	-11.4%
2008	23.18	20.42	-11.9%
2009	22.39	19.92	-11.0%
2010	22.13	19.60	-11.4%
2011	22.17	19.33	-12.8%
2012	21.75	17.64	-18.9%
2013	21.51	17.90	-16.8%
2014	21.10	15.71	-25.6%
2015	20.93	17.56	-16.1%
2016	21.89	17.53	-19.9%
2017	22.20	17.73	-20.2%
2018	21.73	17.21	-20.8%
2019	20.84	17.34	-16.8%
2020	21.09	17.25	-18.2%
2021	20.43	15.97	-21.8%

By creating a new calculation program for the IPCC 2019 Refinement methodology, some errors (typos) in the previous calculations were identified. The following table shows the original and correct values for the selected parameters and years. Also, an actual data for protein consumption for year 2021 was issued be the ŠÚ SR, so back calculation with actual value was realised. Since 2022, the ŠÚ SR will no longer record data on specific protein consumption. Therefore, these values will be estimated as expert judgement. Available data and results are provided in **Chapter 7.10** of this Report.

Table 7.10: *Recalculations and changes in used parameters*

YEAR	2023	2024	CHANGE 2024/2023
	Total organic product kt DC for domestic wastewater		%
2017	39.55	39.51	-0.10%
Sludge removed kt for domestic wastewater			
2012	29.35	29.38	0.10%
2016	28.21	26.53	-5.95%

N in effluent for industrial wastewater			
2021	0.32	0.62	92.6%
Protein consumption person/year			
2021	34.09	33.91	-0.5%

7.4. CATEGORY-SPECIFIC IMPROVEMENTS AND IMPLEMENTATION OF RECOMMENDATIONS

No UNFCCC review was organised in 2023 and all previous recommendations from the UNFCCC review were implemented in 2023 submission (see **Chapter 7.4** of the SVK NIR 2023). However, sectoral experts implemented in this submission (2024) several methodological changes led to major improvements of the waste inventory. The recalculation reflected the IPCC 2019 Refinement to the IPCC 2006 Guidelines, changes were implemented in all aspects and influenced the inventory on category and gas level. More information can be find in individual chapters of this report.

7.5. SOLID WASTE DISPOSAL (CRF 5.A)

Emissions from Solid waste disposal sites (SWDS) are the major emissions source in the Waste sector. Methane emissions are estimated separately for municipal solid waste and non-municipal (industrial) solid waste disposal using IPCC Waste Model. Emissions of CO_2 influencing national total are not occurring in this category as burning waste on landfills is prohibited by law. The unmanaged waste disposal site was not occurring in the Slovak Republic during the reported period.

Total methane emissions in category CRF 5.A were 43.11 Gg (1 207.08 Gg of CO2 eq.) in 2022 as is shown in ***Table 7.1***. Emissions are significantly lower compared to the previous year, both due to a decrease in waste accumulation and also due to the increased use of methane from landfill gas to generate electricity. However, the decrease in emissions is always slower than the decrease in landfilled waste due to the half-life of the different types of landfilled waste.

"Net" emissions (after deducting oxidised methane and methane used for electricity generation) for 2022 are 6.7% lower than in 2018 when the maximum level of emissions from landfilling was reached. Compared to the previous year (2021), however, total "net" emissions are 5.5% lower, as there has been a significant increase in methane used in electricity generation.

In accordance with the European Landfill Directive (1999/31 EC), Slovak waste legislation also distinguishes between three classes of landfills (= SWDS). Landfills for inert waste are not a source of GHG emissions and waste landfilled for this class of landfills has not been included in the emission calculations. Landfill emissions were calculated separately for municipal waste (MSW) and separately for industrial waste (ISW) as is shown in ***Table 7.11***. In Slovakia, it is possible to observe very well the correlation of municipal waste production from the economic growth of the country (GDP or HFC = Households Final Consumption). In the case of industrial waste, such dependence is less pronounced, as the dominant sources of this waste are energetic industry (group 10), construction (group 17) and, in recent years, the waste treatment sector (group 19). Together with municipal waste (group 20), these four groups account for up to 95% of all landfilled waste.

Figure 7.4: *Major groups of landfilled solid waste (ŠÚ SR) in tons in Slovakia in recent years*

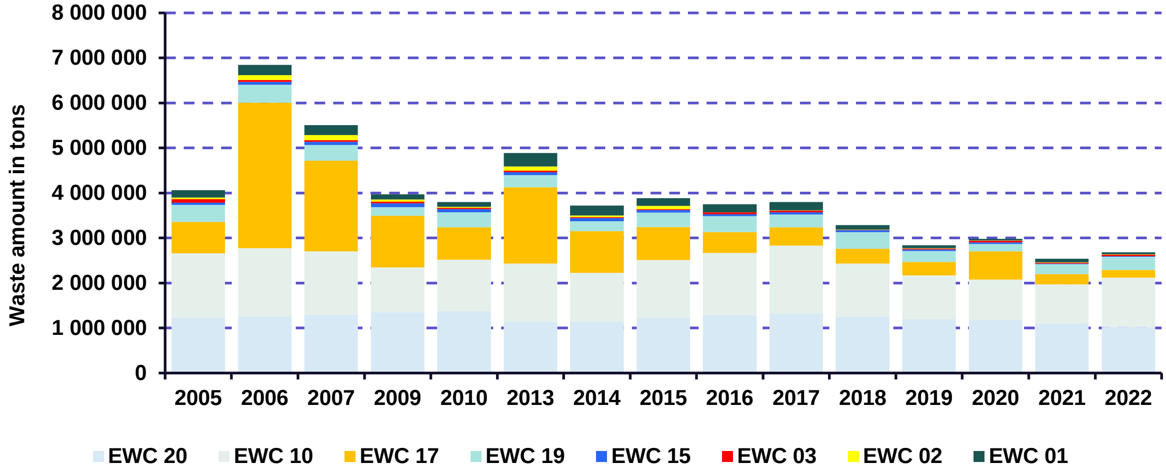


Table 7.11: *Activity data from the total SWDS in Slovakia (MSW + ISW) in particular years*

YEAR	TOTAL SWDS	MUNICIPAL SOLID WASTE			INDUSTRIAL SOLID WASTE				
		GROUP 20	MSW to SWDS	Share	GROUP 1-19	ISW to SWDS	Share	ISWDS DOC > 0	Share
	tons			*%*	*tons*		*%*	*tons*	*%*
2005	1 417 993	1 558 283	1 226 586	78.7%	9 346 816	2 888 366	30.9%	191 407	2.0%
2006	1 509 768	1 623 302	1 259 613	77.6%	12 879 757	5 646 833	43.8%	250 154	1.9%
2007	1 582 192	1 668 660	1 294 853	77.6%	9 252 161	4 261 633	46.1%	287 339	3.1%
2008	1 599 325	1 772 456	1 350 862	76.2%	9 683 380	3 215 530	33.2%	248 463	2.6%
2009	1 597 757	1 745 450	1 349 267	77.3%	6 808 199	2 675 101	39.3%	248 491	3.6%
2010	1 586 613	1 719 012	1 377 430	80.1%	7 814 887	2 483 878	31.8%	209 183	2.7%
2011	1 497 914	1 678 922	1 240 723	73.9%	8 605 496	2 875 331	33.4%	257 191	3.0%
2012	1 402 580	1 654 723	1 211 257	73.2%	7 016 588	2 803 452	40.0%	191 323	2.7%
2013	1 359 303	1 642 354	1 141 436	69.5%	8 216 667	3 797 353	46.2%	217 867	2.7%
2014	1 293 917	1 738 206	1 145 478	65.9%	7 324 208	2 620 480	35.8%	148 439	2.0%
2015	1 382 630	1 780 876	1 225 243	68.8%	8 782 522	2 707 543	30.8%	157 388	1.8%
2016	1 437 935	1 953 478	1 289 895	66.0%	8 717 765	2 499 439	28.7%	148 040	1.7%
2017	1 432 658	2 136 470	1 314 124	61.5%	10 115 259	2 517 432	24.9%	118 534	1.2%
2018	1 356 955	2 319 818	1 250 280	53.9%	10 142 462	2 093 797	20.6%	106 676	1.1%
2019	1 297 058	2 359 047	1 198 249	50.8%	10 037 942	1 666 717	16.6%	98 809	1.0%
2020	1 307 209	2 434 039	1 177 944	48.4%	10 516 841	1 832 869	17.4%	129 265	1.2%
2021	1 173 804	2 702 186	1 099 288	40.7%	9 943 797	1 470 103	14.8%	74 516	0.7%
2022	1 091 497	2 597 457	1 021 584	39.3%	10 593 124	1 720 048	16.2%	69 913	0.7%

7.5.1. Municipal Waste Disposal Sites (Managed)

The first legislation governing the disposal of waste in Slovakia was adopted in 1991, followed by implementing regulations in 1992. The Act No 239/1991 stipulated basic requirements for the operation of waste disposal sites and Governmental Regulation No 606/1992 in the Annex 5 defined three classes of waste disposal sites and technical requirements for their construction. New legislative regulation on solid waste management and disposal entered into force on 1st July 2001 in the process of harmonisation with the EU legislation. The Act No. 223/2001 Coll. and Decree of the Ministry of Environment No. 283/2001 Coll. contain new instruments for waste disposal minimisation, monitoring of waste sites and landfill gas generation. The importance to increase the share of recycled waste resulted in the adoption of the Act No. 79/2015 on waste, which introduces the extended responsibility of producers (mix packages) and transfers organisation and financing waste recycling schemes from the state to producer responsibility organisation. This change indicates an increase of waste diverted from disposal.

Currently in the Slovak Republic, municipalities are obliged to introduce and ensure the implementation of separate collection for the separate collection of classical components of MSW, i.e. paper and cardboard, glass, plastics and metals, and biodegradable municipal waste. Long-term monitoring of separate collection of MSW shows an increasing trend in the amount of separated components. According to the officially published data from the ŠÚ SR, there has been a year-on-year increase in the rate of sorted municipal waste collection.

Decreasing trend in landfilling is visible in the last decade; however, the total municipal waste production increased and represents more than 478 kg/capita/year. In addition, the share of MSW ending on landfills is decreasing compared to about 80% in 1995.represents 39.3% in 2022 according to the ŠÚ SR data (***Figure 7.5***). The proportion of municipal solid waste recovered has increased very significantly over the last seven years (2014 – 2022), from the previous 19.1% to the current 49.5%.

Figure 7.5: *Comparison of total MSW generated and landfilled in tons (y-axis)*

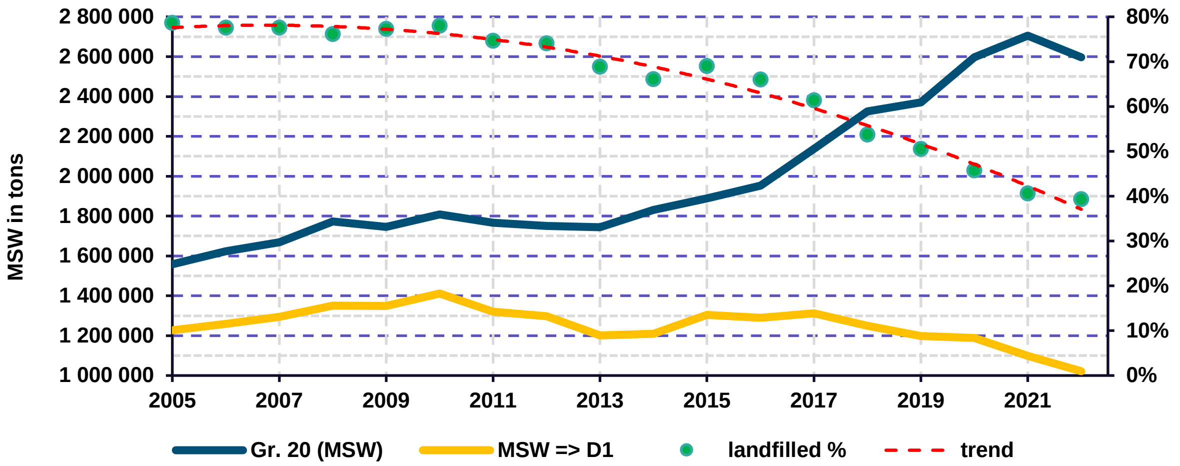
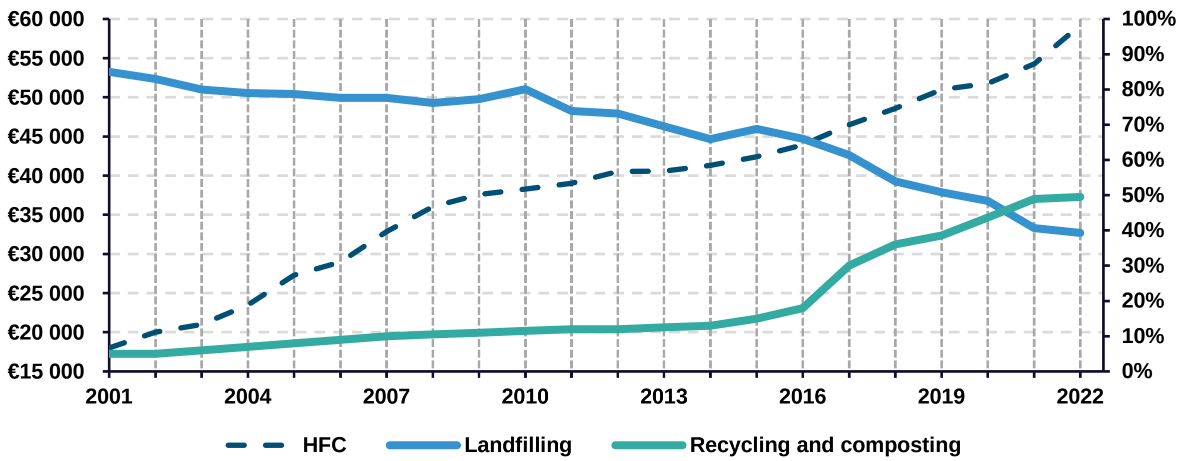


Figure 7.6: *Correlation of the MSW landfilling and recycling/composting with the HFC in tons (y-axis)*



At the time, there are almost 64 non-hazardous waste (NNO) landfills operating in Slovakia, which dispose of municipal and industrial waste in SWDS. Nowadays, all of them were operating as anaerobic sites (CRF 5.A.1.a). Methane recovery takes place at 13 sites, mostly for energy generation at the

SWDS receiving municipal solid waste. Before adopting legislation regulating waste management in 1991, municipal solid waste had been disposed mostly in an uncontrolled manner.

Development of engineered, controlled landfills, including gas collection systems, started in 1993 and old dumps as a disposal destination were gradually replaced over the following decade. It takes some time until a landfill cell is filled, closed and gas generation starts in the landfill body. Thus, the first attempts to flare landfill gas were introduced in 2004.

Law does not allow burning waste on SWDS, neither is it part of operation practice. Fires, which rarely occur on landfills, are considered as emergencies and are extinguished as soon as possible.

Following the IPCC 2006 GL methodology, emissions from the SWDS should be estimated separately for MSW and non-MSW what is industrial solid waste. The CRF tables provide emissions reporting from these two sources together, but data are presented as disaggregated to the MSW and ISW (***Table 7.11***).

Methodological issues

Methane emissions from MSW disposed to SWDSs were calculated using the IPCC 2006 Waste Model. Tier 2 approach is used for emission estimations, using default parameters and country-specific activity data. The IPCC 2006 Waste Model was set to option "Waste by Composition" because the composition of municipal solid waste was modelling including the impact of waste separation.

Methane Generation Rate (k) - defines how fast waste decomposes. IPCC default k-rates are estimated as a function of climate zone, which is characterised by mean annual temperature (MAT) and the ratio of mean annual precipitation and potential evapotranspiration (MAP/PET). Slovakia belongs to the temperate climate zone, because even the warmest parts of Slovakia have MAT around 10°C.

Slovakia falls into a climate area where precipitation exceeds evaporation, although some southern areas of the country fall into a precipitation shadow with the opposite trend.

On the other hand, "k" is also depending on the operation of site. Common praxis in Slovakia, mostly in summer months, is backwards recirculation of landfill leachate into the site to support biodegradability of waste and vaporisation. This praxis lowers the costs on the treatment of this landfill waste liquid and this quantity can be higher than rainfall (in summer 50-90 mm/month). Estimation of k-parameter only from the climatic zone and rainfall can lead to an underestimation of real value of this parameter.

Therefore, "k" values in the sense of IPCC 2006 GL (Table 3.3) for the wet climate zone were used in the calculations.

Degradable Organic Carbon (DOC) - this parameter identifies organic carbon in waste, which is accessible to biochemical decomposition. DOC of municipal solid waste was estimated from the MSW composition in an IPCC model taking into account changes in composition due to changes of fuel used for heating and changes due to separation of recyclable and compostable materials. These changes resulted in variations of DOC over time presented on ***Table 7.12***. The DOC firstly growing due to increasing of biodegradable fraction in the MSW, then decreasing due to diversion of recyclable and compostable waste from landfilled waste.

The content of DOC in MSW began to rise in the late 1990s after a change in the social system and with an increasing living standard. This was mainly reflected in the increased share of food and packaging (paper) in the MSW. The turning point came around 2010, when, in accordance with the Environmental Kuznets Curve theory, the growing environmental awareness of the population began to manifest itself and the DOC value began to decline. Despite the significant growth in the production of municipal waste after 2013, the separate collection of usable components is increasingly being promoted, and a smaller share of MSW ends up in landfills every year (a decrease from 85% to 41%). In recent years, new Mechanical Biological Treatment facilities for the treatment of mixed municipal waste have also contributed to the change in the DOC of landfilled MSW (20 03 01).

Due to the current ongoing change of the Waste Information System (IS OH) and unavailable data, it was not possible to accurately determine the DOC value for recent years. The data used in ***Table 7.12*** for the years 2015 – 2022 is therefore only an expert estimate.

Table 7.12: *Development of the DOC in the MSW disposal*

YEAR	1960	1970	1980	1990	1995	2000	2005	2010	2015	2017	2018-2022
DOC	0.076	0.084	0.098	0.124	0.124	0.141	0.141	0.143	0.129	0.123	0.120

Methane Correction Factor (MCF) – this parameter reflects the disposal management practices. Analysis of disposal sites database of the ŠGÚ DŠ by depth, year of creation and deposited volume resulted in the development of the MCF. The trend of MCF reflects the impact of waste legislation, causing continuous replacement of semi-aerobic dumps by controlled anaerobic landfills in the period 1990 – 2009. Based on the statistical research, Slovakia operated many small-scale landfill sites. Very small-scale landfills sites (ΣW < 5 000 t/y) represent around 18% of existing SWDS in Slovakia. The criteria for managed-anaerobic landfills are difficult to follow – so these sites can be categorised as shallow. Conditions on sites can be categorised more as aerobic, than anaerobic. It means, that the MCF = 1.0 is used since 2010 (***Table 7.13***).

Table 7.13: *Development of the Methane Correction Factor (MCF)*

Year	1950	1960	1970	1980	1990	1995	2000	2005	2010 – 2022
MCF	0.54	0.54	0.54	0.56	0.56	0.61	0.74	0.86	1.0

Oxidation Factor (OX) – reflects the amount of CH_4 from SWDS that is oxidised in the soil or other material covering the waste. There is no reliable information on past practice in covering disposal sites with soil. Due to a lack of relevant information about the real value of the OX in the landfill in Slovakia, the IPCC 2006 GL (Table 3.2) value OX = 0.1 for managed landfill covered with CH_4 oxidising material was used since 1994.

The oxidation factor (10%) was applied in Slovakia reflecting the ESD review 2020 since 1994. The methane emissions were reduced by the default value of the oxidation factor according to the IPCC, when the first anaerobic landfills began to operate. The estimation of the years 1950 – 1993 are without the oxidation factor (OX = 0).

Methane Recovery (R) – means combusting landfill gas generated at SWDS in a flare or energy device. Slovakia reported the amount of CH_4 flared without energy recovery for the years 2006 – 2011. This practise not exists after 2011.

The Regulatory Office for Network Industries (ÚRSO) statistically recorded and published data on electricity generated from the LFG since 2011. The lists of companies who received subsidy for producing electricity from renewable sources, including landfill gas is available. The amount of recovered methane is calculated from electricity produced in MWh and the calorific value of the LFG. Expert judgement is that 50% of the LFG is methane and lower heating value (LHV = 18 MJ/m^3). Emissions from LFG flared with energy use is provided and reported in CRF Table 1.A.5.a. Increase of methane recovery from landfilling is not expected in the next years due to lowering of subsidies for energy recovery LFG. Conversely, the increasing diversion of biodegradable waste away from landfill is leading to a decline in both the quantity and quality of LFG in existing landfills. This is reflected in the cessation of the use of methane from LFG for electricity generation. In recent years, the number of plants has 13.

After further consultations with the ÚRSO, small corrections were made to the data on the amount of electricity produced in older years (2011 and 2012) and a unified calculation of the methane used for the entire period under the same combustion conditions was introduced (***Table 7.14***).

Table 7.14: *Correction of the LFG calculation based on the ÚRSO data for the years 2011 – 2022*

YEAR	ELECTRICITY PRODUCTION	LFG FOR ELECTRICITY PRODUCTION	METHANE RECOVERY
	MWh	*m^3/year*	*tons*
2011	6 463	4 421 775	1.579
2012	8 627	5 902 314	2.108
2013	8 831	6 041 884	2.158
2014	11 141	7 622 311	2.722
2015	8 373	5 728 535	2.046
2016	9 946	6 804 731	2.430
2017	10 223	6 994 245	2.498
2018	10 092	6 904 619	2.466
2019	10 480	7 170 760	2.561
2020	10 794	7 387 158	2.637
2021	9 575	7 607 853	2.363
2022	18 707	12 771 123	4.566

Data about amount of methane used for energy production have been determined only by calculation so far. MŽP SR does not have records or database about number of landfills where LFG is used for energy production or incinerated on flares. The only source of information on the use of LFG from landfills is the ÚRSO data on the amount of electricity produced from landfill gas. Since 2011, this office has been publishing the amount of electricity produced from LFG (MWh) per year for individual companies. Due to the financial bonus that is paid by the state for this amount of electricity produced from waste, the data on the amount of electricity is relatively closely and strictly monitored and controlled by the ÚRSO. Therefore, it can be considered this information to be accurate and reliable.

In determining the amount of methane used from landfilled waste, a back-calculation was used for common in assessing the landfill in terms of prospects for its energy use, just in reverse order. The amount of electricity actually produced is known and the amount of LFG (or methane) used was recalculated with the following formula:

LFG vol. = EG * Cf / LHV * Ef

where LFG vol. = amount of landfill gas used in m^3, EG = Electricity generated (MWh), Cf = conversion from MWh to MJ, LHV = Low Heating Value of LFG (18 MJ/m^3), Ef = Electricity conversion efficiency (30%).

Based on this formula, the amount of LFG processed (m^3) was calculated and, with the theoretical methane content (50%), the weight of fraction RECOVERY methane for each year of calculation was determined. Comparing these data with data from stationary sources database (NEIS) followed, which contains, among other things, data on the amount of used landfill gas. Comparing these two databases (ÚRSO and NEIS), resulted in conclusions that, especially in the past, not all companies were included in both databases. The data for the last 5 years are included in the ***Table 7.15***.

The differences between the “real” data and the calculated values for the years 2016 to 2021 range from 0.8% to 11.4%, which it´s considered a very good agreement. For this reason, the verification of back conversion (from MWh of electricity to LFG consumption in m^3) according to the above formula and at the specified parameters is sufficiently reliable and correct and can be use in inventory. This correction is based on the ERT recommendation W.2 (draft ARR 2022). The comparison exercise will be repeated in the future, when it will be necessary.

Table 7.15: *Correction of the LFG calculation based on the ÚRSO data for the years 2011 – 2021*

YEAR	**NEIS = LFG**	**ÚRSO = EG**	**LFG from EG**	**COMPLIANCE**
	m^3/year	*MWh/year*	*m^3/year*	*%*
2016	6 030 584.00	9 946.00	6 704 731.00	88.60
2017	6 458 409.00	10 222.83	6 994 245.00	92.30
2018	6 715 498.00	10 092.44	6 904 619.00	97.30
2019	7 114 500.00	10 479.81	7 170 760.00	99.20
2020	7 480 799.00	10 793.74	7 387 158.00	101.30
2021	6 717 184.00	9 574.60	6 607 853.00	101.65

Activity data – Total MSW disposed on landfills is used as activity data for estimation of methane emissions from the SWDS annually. Additionally, the overall MSW balance is used for verification of these activity data. The ŠÚ SR published data on MSW generation and disposal only since 1993. Although this creates a timeline of 26 years, additional historical data had to be generated for the use of the FOD method. Analysis of MSW generation data shows a large difference in MSW generation in the years 1992 – 1994, compared to 1995 – 2011. This can be explained by a "learning period" when waste generators were getting familiar with the new system of data recording. Therefore, these "inflated" data were excluded from methane emissions estimation and replaced by interpolated data, as is explained below. It may be interesting, that similar, but smaller "inflation" of data appears also in the period 2002 – 2005, when the EU Waste Classification System was introduced in Slovakia. Extrapolation of data back to 1950 was made by correlating annual waste per capita to index of real wage (IRW), which is defined as nominal wages index corrected for changes in purchasing power measured by the consumer price index (nominal wage index/consumer price index). The ŠÚ SR and before 1993, the Statistical Office of the ČSSR has been publishing this index since 1948.

When assessing the amount of MSW disposed to SWDSs, the key factor influencing the MSW management practice is operation of only two MSW incinerators (Bratislava and Košice). These two incinerators burned on average 150 Gg of MSW per year in the period 1993 – 2011 (Bratislava 100 Gg/yr, Košice 50 Gg/yr) and 185-210 Gg of MSW (period 2011 – 2020).According to data published in the yearbooks of the Statistical Office of the Slovak Republic, the amount of MSW waste incinerated for the years 2010 – 2021 never reached more than 10% of the total MSW production in Slovakia.

An overview of activity data for the entire timeline is shown in ***Table 7.16***. Emissions from municipal waste disposed to SWDSs were estimated from unmanaged disposal sites, created before 1993, managed landfills developed after 1993 and considering that part of municipal solid waste still could be illegally disposed in shallow unmanaged sites. Waste generated from industrial, agricultural and other non-municipal activities is discussed in separate **Chapter 7.5.2**.

The entire time series were recalculated with the use of the IPCC 2006 GL - Waste Model. Consistency of extrapolation of disposed municipal waste time-series is ensured by using country-specific data on mid-year population and the IRW, both available as continuous time series since 1950. Waste composition changes are derived from a share of household using gas as heating fuel, this parameter was identified in national censuses, which are organized in Slovakia every 10 years. The dependence of municipal waste production in Slovakia on GDP (or HFC = Households Final Consumptions) has already been mentioned in **Chapter 7.5**.

Table 7.16: Activity data used for the solid waste disposal sites methane emissions estimation

YEAR	POPULATION	IRW*/HFC**	MSW	MSW/CAP	MSW TO SWDS	MSW TO SWDS
		GDP/capita	*kt*	*kt/capita/year*	*%*	*kt*
1950	3 463 446	75.3	385 745	111	100%	385 745
1960	3 994 270	124.7	736 901	184	100%	736 901
1970	4 528 459	158.5	1 061 904	234	100%	1 061 904
1980	4 984 331	194.2	1 432 061	287	90%	1 288 855
1990	5 297 774	194.0	1 520 550	287	90%	1 368 495
1995	5 363 676	159.8	1 268 355	236	88%	1 116 152
2000	5 400 679	not relevant	1 339 491	248	79%	1 055 925
2005	5 387 285	27 276	1 558 263	289	79%	1 226 570
2010	5 431 024	38 286	1 808 506	333	78%	1 411 543
2011	5 398 384	39 007	1 766 991	327	75%	1 320 073
2012	5 407 579	40 538	1 750 775	324	74%	1 297 480
2013	5 413 393	40 586	1 744 429	322	69%	1 201 906
2014	5 418 649	41 327	1 838 924	339	66%	1 210 043
2015	5 423 800	42 416	1 888 456	348	69%	1 303 845
2016	5 430 798	43 904	1 953 478	360	66%	1 289 895
2017	5 437 754	46 478	2 136 952	393	61%	1 312 787
2018	5 445 382	49 395	2 325 178	427	54%	1 250 280
2019	5 452 257	51 826	2 369 725	434	51%	1 198 249
2020	5 459 781	52 292	2 434 039	446	48%	1 177 944
2021	5 434 712	55 411	2 702 186	497	41%	1 099 288
2022	5 431 056	59 213	2 597 457	478	39%	1 021 584

IRW = income real wage, since the year 2000 not relevant, HFC = household final consumption (EUR) – only year 2005 – 2022, correlation MSW/HFC = 0.86

Uncertainties

The default IPCC uncertainties were used and where possible were adjusted to reflect country-specific data. The total uncertainty of emissions from MSW disposal was estimated to ±30% (***Table 7.17***).

Table 7.17: Uncertainties used in MSW disposal

ACTIVITY DATA AND EMISSION FACTORS	UNCERTAINTY RANGE
Fraction of MSW sent to SWDS (MSWF)	±30% for waste data in period 1950 – 1994 ±10% for waste data in period 1995 – 2004 ±5% for waste data in period 2005 – 2021
Total uncertainty of waste composition:	±50% for the entire modelled period
Degradable Organic Carbon (DOC): Paper/cardboard Textiles Food waste Garden and Park waste Wood waste	Default values: 0.400 0.240 0.150 0.200 0.430
Fraction of Degradable Organic Carbon Dec. (DOCf) = 0,5	±5% (IPCC default values used)
Methane Correction Factor (MCF): = 1.0 = 0.8 = 0.4	IPCC default values used: 0% ±20% ±30%
Fraction of CH_4 in generated Landfill Gas (F) = 0.5	±5% (IPCC default value used)

Source-specific recalculations

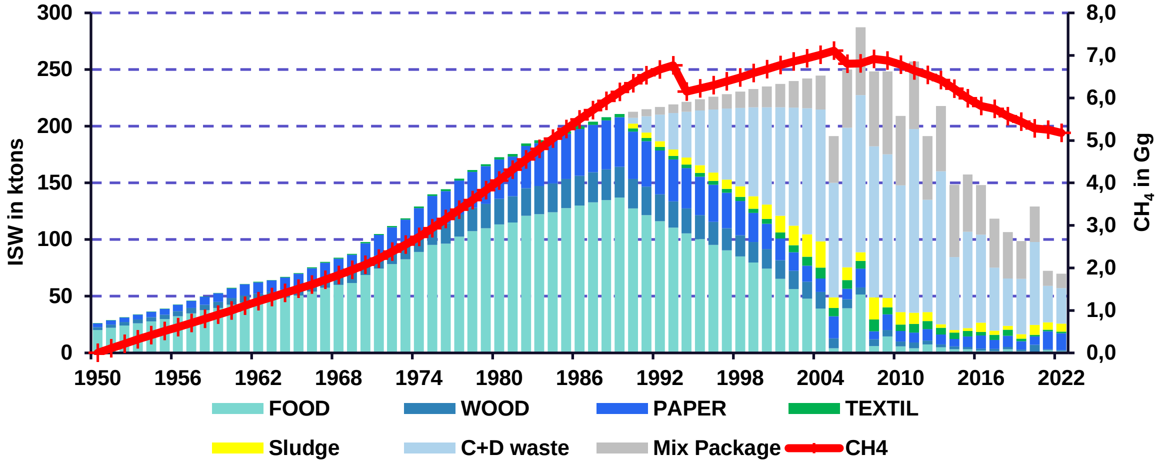
No methodological recalculations were implemented in this submission. However, very little analysis of the composition of household waste has been carried out so far and the available results are not representative of the whole of Slovakia, as they mostly concern only small municipalities. It is likely that the composition of municipal waste in small municipalities (<1000 inhabitants) will be different than in cities (>10 000 inhabitants). In addition, there are significant regional differences in individual production of municipal waste in Slovakia (Trnava region = 657 kg/capita/year, Košice region = 375 kg/capita/year). Therefore, it can be expected that the composition of municipal waste will also differ regionally.

7.5.2. Non-municipal Disposal Sites (Industrial)

In the past, industrial waste was landfilled together with municipal waste in common landfills. It was not until 1991, when the First Waste Act was passed, that some large industrial companies built their own landfills to store their industrial waste. After 2001 (the Second Waste Act), there are three classes of landfills in Slovakia – for inert waste (IO), non-hazardous waste (NNO) and hazardous waste (NO). At the vast majority of NNO landfills (approx. 75), municipal and industrial waste (MSW + ISW) is landfilled together. Only a few large industrial companies operate their own NNO landfills for their industrial waste without MSW. However, the number of such landfills is relatively small and only specific wastes from the energy or metallurgical industries, so waste without organically degradable carbon (DOC = 0), are landfilled.

Since 2005, the records of production and waste management according to the EWC have been significantly improved. The data in the information system managed by the MŽP SR (IS OH) show that there is a change in the composition of landfills for industrial waste. On the other hand, it is necessary to evaluate positively the deviation from landfilling at ISW in recent years. The maximum volumes of landfilled ISW were recorded in the years 2006 – 2011, or shortly after Slovakia's accession to the EU. During this period, the annual quantities of landfilled ISWs ranged from 250 to 300 000 tons of waste. After the 2011 crisis and its repercussions, the amount of landfilled waste decreased in the years 2014 – 2016 to the level of approximately 150 kt. Since 2017, the amount of landfilled ISW has been systematically declining, while in the last year it has fallen below 100 kt. This trend in the decrease in the amount and composition of landfilled ISW is also related to the significant decrease in methane emissions produced in recent years. Compared to 1990, methane emissions from ISW waste decreased by -20%. More information on trend is in ***Figure 7.7***.

Figure 7.7: *ISW production in kt according to the composition and methane emissions*



Methodological issues

The first data on ISW are from the year 1997, but due to change of waste classification system in 2002, reliable continuous time series started in 2005.Preparation of time series back to 1950 is based on two periods in development of the Slovak economy. The first period, centrally planned economy from 1950 – 1989, is characterised by low environmental standards, little innovations and modernisation. For the second period, economic transformation from 1990 – 2013, is typical rapid modernisation, closing of inefficient and polluting industries and strengthening environmental standards. Such development cannot be described by standard approach correlating waste generation to the GDP as recommended in the IPCC 2006 GL.

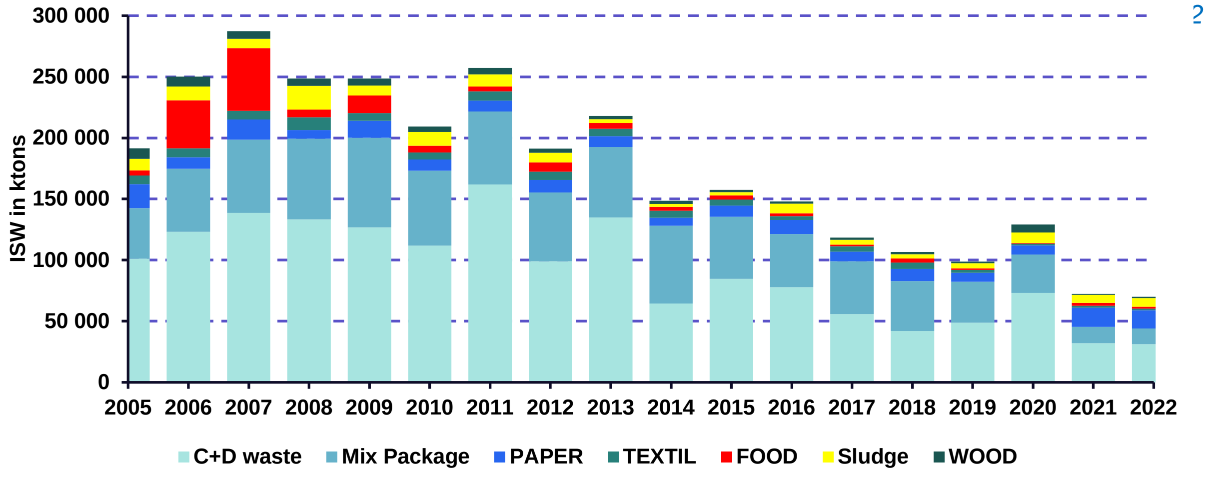
Landfilled biodegradable non-MSW was selected from the database based on the EWC, which is maintained by the MŽP SR and published by the ŠÚ SR. This database is updated annually and summarises reports on waste from individual waste generators. All waste types discussed in the IPCC 2006 GL can be identified in the waste database.

Consistency of time series is ensured by using continuous time series of sectoral growth indicators since 1950. Activity data were completely recalculated in this submission. Time series consistency was maintained by replacing data obtained by waste classification used in 1990 – 2005 using extrapolations to avoid discrepancies caused due to differences in waste classification.

The European Waste Catalogue (EWC) contains 19 groups of industrial waste (=ISW) and one group (20) of municipal waste. For the calculation of emissions from ISW landfills, groups of waste that do not contain biodegradable carbon (DOC) and therefore do not produce GHG emissions were excluded. These were groups 01, 06, 09, 10, 11 and 16. Due to administrative complexity, in the next step, those groups of waste were also excluded from the calculations, which in the given year reached a share in the total landfilled waste Wi < 0.2% ΣWi. It was usually waste from groups 05, 07, 08, 12, 13, 14 and 18. Due to their mass representation in landfilled waste, a completely negligible contribution to the total emissions in a given year can be expected. From the remaining 6 groups of waste (02, 03, 04, 15, 17 and 19), individual types of waste were selected in accordance with the IPCC methodology. It was summarized by weight into seven types of waste according to the main degradable component: Food, Wood, Paper, Textile, C + D waste, Mix_Package and Sludge. Waste from greenery (Garden) was finally also excluded from the calculations, as it landfilled proportion was very low (approximately 500 to 1 000 t/y). An overview of individual types of landfilled ISW is provided in ***Table 7.18*** and on ***Figure 7.8***.

Table 7.18: *DOC and k-rate parameters used in IPCC Waste Model for ISW*

WASTE TYPE	DOC	k	REFERENCE	MAIN WASTE (EWC)
Food	0.15	0.185	IPCC default	groups 02 02, 02 03 and 02 06
Garden and Park	0.20	0.100	IPCC default	groups 02 01 and 19 05
Paper / Cardboard	0.40	0.060	IPCC default	groups 03 03 07+8, 09 01 07+8, 15 01 01 and 19 12 01
Textiles	0.24	0.060	IPCC default	groups 04 01, 15 01 09, 15 02 02 and 19 12 08
Wood	0.43	0.030	IPCC default	groups 03 01, 15 01 03, 17 02 01 and 19 12 06+7
Sludge	0.355	0.185	IPCC default	groups 19 08 05 and 19 08 11-14
C+D waste	0.05	0.030		group 17 09 03+4
Mix_Package	0.10	0.060		group 15 01 06+10



Uncertainties

Uncertainties related to activity data for ISW are particularly significant for the period 1950 – 1990. In accordance with the IPCC 2006 GL (Chapter 3.6), data on the amount of landfilled ISW for this period were only estimated based on the GDP growth and the industrial production index. For the period 1991 to 2004, there are already better statistics on the production and management of industrial waste. However, the records are according to the old (national) waste catalogue, which was not fully compatible with the current EWC. Since 2005, the data have been used from the documents on waste management of the ŠÚ SR and the MŽP SR. During the detailed verification process, discrepancies were found between these two databases in recent years. These discrepancies did not reach 3% and did not have a significant impact on the estimation.

Periods 1950 – 1990, 1991 – 2004 and 2005 – 2022 can be characterised by changes in legislation and information systems. Due to the calculation of emissions by the FOD method, total emissions are spread over a longer period according to the half-time of decay. It should be noted, that the actual composition of the ISW for the 1950 – 1990 period is estimated with a high uncertainty. However, as already stated in **Chapter 7.2**, the half-time of decay for most types of these wastes (with the exception of wood) according to IPCC 2006 GL (Table 3.4) is from 4 to 12 years for Slovakia. This means that waste deposited in landfills before 1995 produces zero emissions nowadays, assuming standard conditions for the degradation of organic carbon in the landfill.

Figure 7.8 shows, that the weight of landfilled waste fraction C + D and Mix_Package is much more significant than other types of waste (Paper, Textile or Wood). These two types of waste are characterized by a relatively high degree of uncertainty on DOC as resulted from their mixed nature. The default IPCC uncertainties were used and adjusted (where possible) to reflect country-specific data or circumstances. The total uncertainty of emissions from disposal of ISW was estimated to be ±27%.

Table 7.19: *Uncertainties for non-MSW disposal*

ACTIVITY DATA AND EMISSION FACTORS	UNCERTAINTY RANGE
Amount of disposed ISW	±50% for waste data in period 1950 – 2004 ±5% for waste data in period 2005 – 2021
Degradable Organic Carbon (DOC) = Paper/cardboard Textiles Food waste Wood waste Sludge C+D waste Mix_Package waste	Default values: 0.40 0.24 0.15 0.43 0.355 0.05 0.10

ACTIVITY DATA AND EMISSION FACTORS	UNCERTAINTY RANGE
Fraction of Degradable Organic Carbon Dec. (DOCf) = 0,5	± 5% (IPCC default value was used)
Methane Correction Factor (MCF) = 1.0 = 0.8 = 0.4	IPCC default values used: +0% ±20% ±30%
Fraction of CH_4 in generated Landfill Gas (F) = 0.5	±5% IPCC default values used
k-rate = Paper/cardboard Textiles Food waste Wood waste Sludge C+D waste Mix_Package waste	Default values: 0.06 0.06 0.185 0.03 0.185 0.03 0.06

Source-specific recalculations

No recalculations were implemented in this submission. Planning improvement is connected with the revision of the industrial solid waste activity data. This is planned in the second half of the year 2024 and will be implemented to the time series in the next submission. Revision of waste statistics was announced by the Statistical Office of the Slovak Republic and the MŽP SR.

7.6. BIOLOGICAL TREATMENT OF SOLID WASTE (CRF 5.B)

Waste Framework Directive 2008/98/EC requires the Member States to reduce the disposal of biodegradable waste in landfills. The EU directive was transposed into the Slovak legislation in the Act No 223/2001, Art, 18 (4) m), which stipulates that disposal of biologically degradable waste from parks and gardens together with the MSW is banned in the Slovak Republic from January 2006. There is a range of private and municipal companies, which provide composting of municipal and agricultural waste. ***Table 7.20*** shows an overview of municipal and industrial composting. With the support of the EU and Governmental grants, the number of municipalities composting waste is growing fast. While 24% of municipalities participated in waste composting in 2002, this number increased to more than 90%. According to the EUROSTAT data 60 kg per capita of biologically degradable waste was recycled in 2022 in comparison with 2005, representing an increase of more than 100% to the 2005 and an increase by 21% compared to the previous year.

7.6.1. Composting (CRF 5.B.1)

The most common is windrow composting. More sophisticated technologies, like anaerobic treatment or mechanical-biological treatment (MBT) plants, are not used. Data on composting are disaggregated into composting of MSW reported in the CRF table 5.B.1.a and composting of non-MSW reported in the CRF table 5.B.1.b.

Table 7.20: *The overview of municipal and industrial composting in 1990 – 2022*

YEAR	MSW (CRF 5.B.1.a)			NON-MSW (CRF 5.B.1.b)		
	WASTE TREATED	CH_4	N_2O	WASTE TREATED	CH_4	N_2O
	kt (dm)	*Gg*		*kt (dm)*	*Gg*	
1990	8.00	0.08	0.00	251.60	2.52	0.15
1995	14.18	0.14	0.01	251.60	2.52	0.15
2000	14.54	0.15	0.01	251.60	2.52	0.15
2005	51.25	0.51	0.03	231.66	2.32	0.14
2010	83.43	0.83	0.05	231.42	2.31	0.14

YEAR	MSW (CRF 5.B.1.a)			NON-MSW (CRF 5.B.1.b)		
	WASTE TREATED	CH_4	N_2O	WASTE TREATED	CH_4	N_2O
	kt (dm)	*Gg*		*kt (dm)*	*Gg*	
2011	90.05	0.90	0.05	261.02	2.61	0.16
2012	95.55	0.96	0.06	290.62	2.91	0.17
2013	97.53	0.98	0.06	247.94	2.48	0.15
2014	94.57	0.95	0.06	291.24	2.91	0.17
2015	114.88	1.15	0.07	374.00	3.74	0.22
2016	119.69	1.20	0.07	285.30	2.85	0.17
2017	161.36	1.61	0.10	306.95	3.07	0.18
2018	184.41	1.84	0.11	313.42	3.13	0.19
2019	208.97	2.09	0.13	262.04	2.62	0.16
2020	301.89	3.02	0.18	315.77	3.16	0.19
2021	332.27	3.32	0.20	272.28	2.72	0.16
2022	335.43	3.35	0.20	398.47	3.98	0.24

7.6.2. Methodological Issues

The default tier 1 approach from the 2006 IPCC GL was used for emission estimations in this category. Emissions from composting were estimated separately for MSW and ISW.

Default IPCC emission factors for dry weight of waste were used:

- Emission factor 10 g CH_4/kg of DM waste treated;
- Emission factor 0.6 g N_2O/kg of DM waste treated.

Activity data in the wet stage was taken from the publication "Waste in the Slovak Republic" and converted to dry matter for reporting purposes in 2022. The second set of activity data was taken from the Water Research Institute – responsible for collecting information regarding the recovery of sewage sludge. The activity data are consistent with the category 5.D Wastewater Treatment and Discharge. Historical activity data of composted municipal solid waste are published since 1992. The missing data for 1990 and 1991 were extrapolated with linear extrapolation.

The data on sewage sludge composting are available since 2003. The latest activity data for wastewater treatment sludge is not in a format compatible with the data series published after 2003, as the European waste catalogue methodology was implemented in 2003. Therefore, emissions from sludge for the period 1990 – 2002 are considered as not estimated. Data on industrial waste composting were collected and published since 1997. No clear trend could be identified, as data vary ±50%, thus the average of the years 2002 – 2013 was used for linear extrapolation.

7.6.3. Anaerobic Digestion at Biogas Facilities (CRF 5.B.2)

Anaerobic digestion of organic waste accelerates the natural decomposition of organic material without the presence of oxygen by maintaining optimal values of temperature, moisture content and pH. The generated methane is used to produce heat or electricity. Fugitive emissions of methane from anaerobic digestion due to unintentional leaks, process malfunctions or other unexpected events are reported in the Waste sector. According to the 2006 IPCC methodology, 0 to 10% of fugitive methane emissions originated from digestion. Generated CO_2 emissions are of biogenic origin and is reported in Energy sector.

Methodological issues

The default tier 1 approach from the 2006 IPCC GL was used for emission estimations in this category. Emissions from anaerobic digesters were estimated from total amount of recovery feedstock.

Default IPCC emission factor for wet weight of waste were used:

- Emission factor 0.8 g CH_4/kg of wet waste treated;
- Emissions of N_2O emissions were assumed as negligible due to notation key NA was used.

Currently, comprehensive data on biogas stations in Slovakia are not available. Activity data on feedstock was obtained directly from the operators. The operators provided data for the years 2014 to 2022, by individual months. The data were then aggregated to the annual total. The rate of data recovery from individual operations was at the level of 10%. The missing data were extrapolated with a time series up to 2001. The time series was estimated based on information on the amount of biogas produced from the NEIS database and from the calculated average consumption of feedstock for the production of a unit amount of biogas (5.7 t/ths.m^3) since 2001.

Table 7.21: *The overview of municipal and industrial anaerobic digestion in 2001 – 2022*

YEAR	MSW (CRF 5.B.2.a)			Non-MSW (CRF 5.B.2.b)		
	WASTE TREATED	CH_4	N_2O	WASTE TREATED	CH_4	N_2O
	kt (dm)	*Gg*		*kt (dm)*	*Gg*	
2001	NO	IE	NA	56.21	0.04	NA
2002	NO	IE	NA	73.87	0.06	NA
2003	NO	IE	NA	73.61	0.06	NA
2004	NO	IE	NA	77.87	0.06	NA
2005	NO	IE	NA	85.75	0.07	NA
2006	NO	IE	NA	91.34	0.07	NA
2007	NO	IE	NA	99.86	0.08	NA
2008	NO	IE	NA	117.14	0.09	NA
2009	NO	IE	NA	132.95	0.11	NA
2010	NO	IE	NA	141.66	0.11	NA
2011	NO	IE	NA	219.67	0.18	NA
2012	NO	IE	NA	399.09	0.32	NA
2013	NO	IE	NA	749.98	0.60	NA
2014	NO	IE	NA	1 372.03	1.10	NA
2015	NO	IE	NA	1 796.88	1.44	NA
2016	NO	IE	NA	1 795.72	1.44	NA
2017	NO	IE	NA	1 829.76	1.46	NA
2018	NO	IE	NA	1 901.41	1.52	NA
2019	NO	IE	NA	1 774.35	1.42	NA
2020	NO	IE	NA	1 628.87	1.30	NA
2021	NO	IE	NA	1 529.10	1.22	NA
2022	NO	IE	NA	1 523.38	1.22	NA

7.6.4. Uncertainties and Time-series Consistency

The default IPCC uncertainties were used and adjusted (where possible) to reflect country-specific data or circumstances. Uncertainties were calculated using the IPCC 2006 GL default method and values. Emissions from biological treatment of waste were estimated to have ±60% uncertainties as is shown in ***Table 7.22***. The highest uncertainty come from CH_4 and N_2O emission factors.

Table 7.22: Uncertainties for biological treatment of waste

ACTIVITY DATA AND EMISSION FACTORS	UNCERTAINTY RANGE
Amount of composted municipal waste	±10% for waste all data
Amount of composted non-MSW	±10%
Emission factor for CH_4	4 (0.03-8)
Emission factor for N_2O	0.24 (0.06-6)

7.6.5. Category-specific Recalculations

Emissions of CH_4 and N_2O for category 5.B – Biological Treatment of Solid Waste were recalculated in this submission due to changes in activity data on composting of municipal waste. The Statistical Office of the Slovak Republic resubmitted 2010 – 2021 data. In the current submissions, 332 kt of the municipal waste were composted. The recalculations were made due to revision of activity data provided by the Statistical Office of the Slovak Republic. Most visible changes are visible in 2020 and 2021 particular years (+13% and +14%). The revision of activity data lead to increased CH_4 and N_2O emissions in this category. More information is available in ***Table 7.6***. Industrial waste composting was not recalculated. ***Table 7.23*** shows the overview of the type of communal waste composting in 2022.

Table 7.23: The overview of type industrial composted waste in 2022

CODE OF INDUSTRIAL WASTE	PERCENTAGE SHARE OF WASTE
Wastes from geological exploration, extraction, treatment and further processing of minerals and stone	0.00%
Wastes from agriculture, horticulture, forestry, hunting and fishing, aquaculture and food production and processing	14.87%
Wastes from wood processing and from the production of paper, board, pulp, lumber and furniture	21.46%
Wastes from the leather, fur and textile industries	0.02%
Wastes from organic chemical processes	0.00%
Wastes from MFSU of paints, varnishes and enamels, adhesives, sealants and printing inks	0.26%
Wastes from inorganic chemical processes	1.71%
Wastes from the photographic industry	0.00%
Wastes from thermal processes	0.00%
Wastes from chemical surface treatment of metals and coating of metals and other materials; wastes from non - ferrous hydrometallurgical processes	1.41%
Wastes from shaping, physical and mechanical treatment of metal and plastic surfaces	0.37%
Wastes from oils and liquid fuels other than edible oils	0.02%
Waste organic solvents, coolants and propellants	0.00%
Waste packaging, absorbents, cleaning cloths, filter material and protective clothing not otherwise specified	0.00%
Wastes not otherwise specified in this catalogue	8.60%
Construction and demolition wastes, including excavated soil from contaminated sites	0.29%
Wastes from health or veterinary care or related research other than catering and restaurant wastes not arising from direct medical care	1.25%
Wastes from off-site treatment plants, off-site waste water treatment plants and drinking water and industrial water treatment plants	1.33%

7.7. WASTE INCINERATION AND OPEN BURNING OF WASTE (CRF 5.C)

Incineration of waste and open burning of waste produces mainly CO_2, in smaller amount also N_2O and CH_4 emissions. Methane emissions may occur in case of incomplete incineration of waste. This category covers incineration of waste in dedicated incinerators and co-incineration facilities.

Open burning of waste is prohibited by law and handled as an emergency in Slovakia. Thus, no emissions were estimated for the category Open Burning of Waste (CRF 5.C.2).

Activity data for emissions estimation of waste incineration were disaggregated into waste incineration with and without energy utilisation. Each group was further divided into biogenic waste incineration and non-biogenic waste incineration. Emissions from waste incineration with energy utilisation are reported in the Energy sector, subcategory 1.A.1.a.iv (other fuels). Emissions from waste incineration without energy utilisation are reported in the Waste sector (5.C).

7.7.1. Waste Incineration (CRF 5.C.1)

Incineration of waste is an accepted practice in the Slovak Republic. It is regulated following EU waste legislation. After a period of modernisation of waste incineration, ones that are more modern replaced smaller and non-compliant facilities.

The following facilities for waste incineration were in operation in 2022 according to ENVIROPORTAL:

Two large MSW incinerators with energy utilisation;

- Five ISW incinerators (three of them with energy utilisation, one of them is co-incinerating wastewater sludge);
- Two clinical waste incinerators without energy utilisation (one temporarily out of order);
- One incinerator for rendering plant residues;
- Five facilities co-incinerating ISW (cement and lime kilns).

The estimation of emissions from waste incineration was reviewed to increase coordination between the Waste and Energy. There are two key outputs from this review:

- Emissions from the incineration of municipal and industrial waste with energy recovery are estimated and reported in the Energy sector. The increasing trend of waste-derived fuel import for the cement, lime and chemical industries is recognised.
- Emission factor for methane used in the Energy sector is now used also in the Waste sector.
- Correction of previously used notation key “IE” to “NO” in the categories 5.C.1.1.a and 5.C.1.2.a took place due to the fact, that there is no municipal waste incinerated without energy use.

Total GHG non-biogenic emissions reported in category 5.C from waste incineration without energy recovery were 14.22 Gg of CO_2 eq. in 2022. The share of emissions in this category originated from the biogenic waste incineration (1.07 Gg of bio-CO_2). Disaggregation of other waste (non-MSW, clinic and other) to biogenic and non-biogenic waste is shown in ***Table 7.24***.

Table 7.24: *Activity data and emissions from waste incineration without energy recovery reported in the Waste sector in particular years*

YEAR	EMISSIONS FROM INCINERATION WITHOUT ENERGY RECOVERY							
	BIOGENIC – OTHER (CRF 5.C.1.1.b)				NON-BIOGENIC – OTHER (CRF 5.C.1.2.b)			
	Amount	CO_2	CH_4	N_2O	Amount	CO_2	CH_4	N_2O
	kt	*Gg*			*kt*	*Gg*		
1990	2.8979	1.1100	0.0941	0.00016	11.8609	4.5432	0.3850	0.00064
1995	2.8382	1.0975	0.0921	0.00015	11.8154	4.5688	0.3834	0.00064
2000	3.1077	1.1940	0.1009	0.00017	12.7845	4.9119	0.4150	0.00069
2005	5.0798	2.5588	0.1804	0.00030	31.3411	15.7876	1.1130	0.00185
2010	4.4376	1.9575	0.1606	0.00027	21.2884	9.3908	0.7705	0.00128
2011	4.2278	1.7602	0.1512	0.00025	17.2318	7.1742	0.6163	0.00103
2012	3.4462	1.3962	0.1232	0.00021	15.0670	6.1043	0.5387	0.00090
2013	3.0166	1.4329	0.1085	0.00018	15.9317	7.5676	0.5729	0.00095
2014	3.0261	1.3386	0.1090	0.00018	13.8554	6.1289	0.4991	0.00083
2015	4.7946	2.0766	0.1732	0.00029	21.0861	9.1328	0.7616	0.00127
2016	2.6733	0.9273	0.0917	0.00015	6.4830	2.2487	0.2223	0.00037
2017	2.8242	0.8842	0.0955	0.00016	6.4365	2.0151	0.2177	0.00036
2018	3.7050	1.4395	0.1305	0.00022	13.1177	5.0965	0.4620	0.00077
2019	3.6125	1.4034	0.1278	0.00021	13.1396	5.1046	0.4649	0.00077
2020	3.2250	1.2059	0.1128	0.00019	10.7618	4.0241	0.3765	0.00063
2021	2.7545	0.8850	0.0929	0.00015	6.3604	2.0436	0.2146	0.00036
2022	2.9842	1.0665	0.1027	0.00017	8.4571	3.0224	0.2910	0.00048

MSW (Biogenic CRF 5.C.1.1.a and Non-biogenic 5.C.1.2.a)

Activity data, as well as the detailed methodology for this source, is reported in the Energy sector, as there is no MSW incineration without energy utilisation in the Slovak Republic.

The amount of incinerated MSW is published by the ŠÚ SR since 1993. There are two large municipal waste incinerators in the country, in Bratislava and Košice. The MSW incinerator in Bratislava was put into operation in 1978 with a significant modernisation in 2002. Currently installed capacity is 135 Gg/y, the incinerator can be characterised as a continuously operated stoker. The MSW incinerator in Košice with a capacity of 80 Gg/yr was put in full operation in 1992, modernised to achieve compliance with emission standards in 2005 and reconstructed (boiler replacement and electricity generation) in 2014. Both incineration plants generate heat (steam) and electricity. For this reason, the CO_2, CH_4 and N_2O emissions from MSW incineration are included completely in the Energy sector, category 1.A.1.a Public electricity and heat production.

Activity data on incinerated MSW are based on input from individual incinerators. No municipal waste was incinerated without energy recovery.

Uncertainties

The default IPPC uncertainties for activity data consistent with the Energy sector were used.

Source-specific recalculations

Please see **Chapter 7.7.1** for recalculations.

Non-MSW (Biogenic CRF 5.C.1.1.b and Non-biogenic 5.C.1.2.b)

The non-MSW category has undergone significant changes since 1990. The key drivers of these changes were stricter legislation, the new standards (EU approximation) and the commercialisation of waste services. This led to replacing small incineration units in factories and hospitals by regional incinerators. In addition, existing large incinerators were modernised to comply with the new standards or were decommissioned.

From the total non-MSW incinerators and co-incineration plants, only a few have incineration without energy use and can be reported here. There are seven facilities incinerating hospital waste and other waste (not categorised). Sludge from industrial waste treatment was reported in this category back to the year 2012 (no sewage sludge was incinerated without energy recovery). Amounts of various types of incinerated waste included in this category are in ***Table 7.25***.

Table 7.25: *Activity data of included types of waste from waste incineration without energy recovery reported in the waste sector in particular years*

YEAR	WASTE TYPES*															
	02	03	04	05	06	07	08	09	11	12	13	14	15	16	17	18	19
Unit	*kilotons*																
1990	0.00	0.01	0.02	0.17	NO	NO	NO	0.00	NO	NO	0.49	NO	NO	2.10	1.55	2.10	1.55
1995	0.00	0.01	0.02	0.16	NO	NO	NO	0.00	NO	NO	0.52	NO	NO	2.08	1.53	2.08	1.53
2000	0.00	0.01	0.02	0.18	NO	NO	NO	0.00	NO	NO	0.53	NO	NO	2.26	1.67	2.26	1.67
2005	0.01	0.00	0.00	0.20	0.10	0.43	0.15	NO	NO	0.02	0.82	0.00	0.58	2.57	7.05	2.57	0.22
2010	0.00	0.00	NO	NO	NO	0.03	0.08	0.00	NO	NO	0.11	0.11	0.32	1.88	5.56	1.88	0.00
2011	0.00	0.00	NO	0.01	0.00	0.09	0.02	0.00	0.00	0.00	0.11	0.06	0.23	2.45	3.69	2.45	0.01
2012	0.01	NO	NO	NO	0.02	0.02	0.04	NO	NO	NO	0.06	0.04	0.79	1.60	3.42	1.60	0.00
2013	0.00	0.00	NO	0.20	0.00	0.01	0.14	0.01	NO	NO	0.12	0.07	0.08	1.53	3.84	1.53	NO
2014	0.01	NO	NO	0.00	0.00	0.02	0.05	0.01	NO	NO	0.08	0.12	0.07	1.56	3.33	1.56	NO
2015	0.00	NO	NO	NO	NO	0.11	0.02	0.00	NO	0.00	0.14	0.00	0.04	2.42	5.21	2.42	0.00
2016	0.00	NO	NO	NO	NO	0.02	0.00	0.00	NO	0.00	0.15	0.02	0.06	2.28	0.21	2.28	NO
2017	0.00	NO	NO	NO	NO	0.01	0.01	0.00	NO	0.00	0.15	0.02	0.53	2.25	0.00	2.25	0.00
2018	0.00	0.01	NO	0.00	0.00	0.01	0.02	0.00	0.05	0.04	0.17	0.01	0.14	2.39	2.32	2.39	0.15
2019	0.01	0.00	NO	0.00	0.00	0.01	0.02	0.00	0.04	0.12	0.13	0.01	0.15	2.18	2.51	2.18	0.12
2020	0.00	0.00	NO	0.00	0.00	0.02	0.02	0.00	0.08	0.13	0.12	0.02	0.12	2.17	1.65	2.17	0.12
2021	0.00	NO	NO	0.00	0.00	0.01	0.00	0.00	0.03	0.08	0.14	0.02	0.10	2.19	0.18	2.19	0.18
2022	0.00	NO	NO	0.00	0.00	0.01	0.01	0.00	0.02	0.08	0.20	0.00	0.16	2.37	0.67	2.37	0.07

**types of waste are following European waste catalogue classification established in Commission Decision 2000/532/EC*

Methodological issues

Emissions from non-MSW are estimated by the IPCC 2019 Refinement, tier 2a approach using country specific data on waste generation and composition. Emissions of CO_2 were estimated using the amount of waste incinerated divided into groups of waste (***Table 7.26***), for each one, the specific parameters such as dry matter content, fossil carbon fraction, oxidation factor and degradable components were determined using *Equation 5.1* of IPCC GL 2006 in Chapter 5.2.1.1. Then the calculations were repeated for selected waste groups containing non-biogenic waste to estimate emissions of non-biogenic origin and biogenic waste to estimate emissions of biogenic origin.

Table 7.26: *Parameters to calculate emissions of* CO_2

WASTE TYPE*	*UNIT*	DRY MATTER	C-FRACTION	FOSSIL C-FRACTION	FCF	OXIDATION FACTOR	DOC
01		0.9	0.04	0.03	0.03	1	0.01
02	%	0.625	0.29	0	0	1	0.29
03		0.9	0.41	0.01	0.01	1	0.4

WASTE TYPE*	UNIT	DRY MATTER	C-FRACTION	FOSSIL C-FRACTION	FCF	OXIDATION FACTOR	DOC
04		0.8	0.4	0.16	0.16	1	0.24
05		1	0.8	0.8	0.8	1	0
06		1	0.8	0.8	0.8	1	0
07		1	0.8	0.8	0.8	1	0
08		1.00	0.8	0.8	0.8	1	0
09		0.9	0.04	0.03	0.03	1	0.01
10		0.9	0.04	0.03	0.03	1	0.01
11		0.9	0.04	0.03	0.03	1	0.01
12		0.9	0.04	0.03	0.03	1	0.01
13		1	0.8	0.8	0.8	1	0
14		1	0.8	0.8	0.8	1	0
15		0.9	0.04	0.03	0.03	1	0.01
16		0.9	0.04	0.03	0.03	1	0.01
17		1	0.24	0.2	0.2	1	0.04
18		0.6	0.4	0.24	0.24	1	0.16
19 without ind. sludge		0.9	0.04	0.03	0.03	1	0.01
Industrial sludge		0.22	0.8	0.91	0.71	1	0.09

**types of waste are following European waste catalogue classification established in Commission Decision 2000/532/EC*

Data on non-MSW incineration are available from 2005 in the NEIS database (more information in the Energy sector). Data for the period 1990 – 2004 were extrapolated using surrogate data, the trend of the impact of air pollution on the forests. Data for sewage sludge incinerated were taken from the calculation as it was confirmed by the producer of the statistics (VÚVH-Water Research Institute), that there is no sewage sludge incinerated without energy recovery. Industrial sludge data are collected by the MŽP SR. Historical data for wastewater treatment sludge is not in a format compatible with the data after 2002, as in this year Slovakia implemented the European Waste Catalogue methodology. Therefore, emissions from sludge for the period 1990 – 2001 are considered as not estimated.

Activity data allow disaggregation into incineration with and without energy use appropriately. The same activity data were used for GHG inventory and Air pollutants inventory. Consistency of the time series was ensured by using the same activity data source for the whole time series. For the estimation of emissions of CH_4 and N_2O, the tier 1 method was used using country specific data on waste generation. The emission factor for batch type incineration – stoker (Table 5.3, Chapter 5.4.2 of the IPCC 2006 GL) was used to estimate CH_4 emissions. For N_2O emissions, the emission factor was taken for Industrial waste from the IPCC 2006 GL (Table 5.6, Chapter 5.4.3).

Uncertainties

The default IPPC uncertainties for activity data were used. The total uncertainty of emissions from the incineration of waste was estimated to be ±45%.

***Table 7.27:** Uncertainties for waste incineration*

ACTIVITY DATA AND EMISSION FACTORS	UNCERTAINTY RANGE
Incinerated waste	±5%
Dry matter content (*dm*)	±11%
Carbon fraction (CF)	±20%
Oxidation factor	±10%
EMISSION FACTORS: Calculated as average	
CO_2	±32%
CH_4	±50%
N_2O	±100%

Category-specific recalculations

Emissions of CO_2, N_2O and CH_4 for the category Waste Incineration – industrial waste were recalculated in this submission due to previously implemented improvements in methodology. The waste composition was taken from the NEIS database, where the operators reports all the types of fuels used for incineration (***Table 7.7***).

Sewage sludge was taken from the calculation after discussion with the activity data producer (VÚVH), which confirmed that sewage sludge is incinerated only with energy recovery (in biogas facilities reported in the Energy sector).

7.7.2. Open Burning of Waste (CRF 5.C.2)

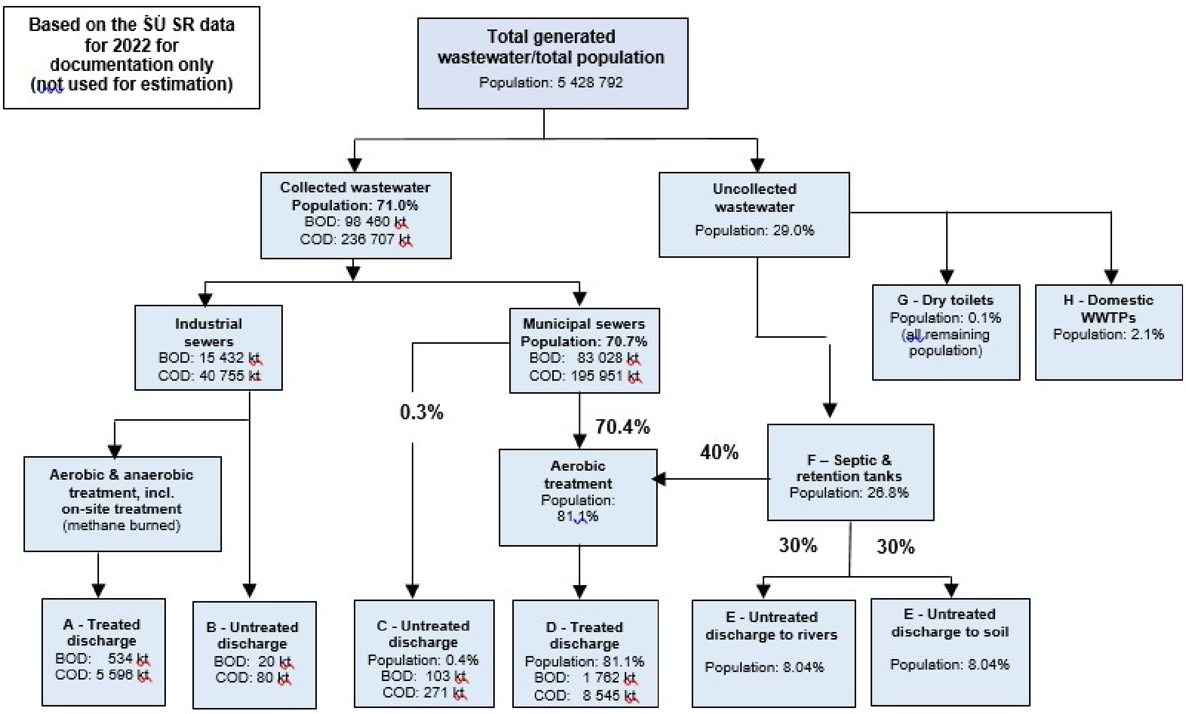
Open burning of waste is prohibited by the law in the Slovak Republic; therefore, this category is reported as not occurring.

7.8. WASTEWATER TREATMENT AND DISCHARGE (CRF 5.D)

This category includes emissions (CH_4 and N_2O) from domestic and industrial wastewater, which are generated after discharging treated or untreated wastewater to the watercourses. The typical distribution of wastewater pollution pathways for domestic and industrial wastewater in Slovakia in the year 2022 is presented on ***Figure 7.9***.

In the line with the 2019 Refinement to the IPCC GL, also direct emissions from modern wastewater treatment plants (WWTPs) and direct emissions from retention tanks (cesspools and septic tanks) are included. CO_2 emissions were not estimated, as they are of biogenic origin

Figure 7.9: *The typical balance of wastewater pathways for domestic and industrial wastewater in Slovakia*



Total methane emissions from wastewater treatment were 9.541 Gg in 2022 and this value was produced dominantly from domestic WW (98.4%). Compared to the previous year, methane emissions continue slowly to decrease (2.2%), which is caused mainly by lower amounts of the population connected to septic and cesspool tanks, which are the dominant producer of methane from wastewater.

Total N_2O emissions from wastewater treatment were 0.321 Gg in 2022, which represents relatively stable emissions production between 2019 – 2022 years. However, a gradual decrease in emissions of N_2O is evident in the long term. In the industrial WWTPs relatively very small but a continuously degreasing trend of N_2O emissions is recorded in all monitored years. The emissions value of N_2O from domestic WW in 2021 was recalculated due to an additional change in the value of protein consumption in year 2021. Emissions of domestic N_2O show slow increasing progress of production caused by additional production of N_2O in the process of advanced nitrogen removal in domestic WWTPs.

Table 7.28 shows trends of emissions from domestic and industrial wastewater during the last years.

Table 7.28: *GHG emissions in individual categories in wastewater handling in 1990 – 2022*

YEAR	DOMESTIC WASTEWATER				INDUSTRIAL WASTEWATER			
	BOD IN EFFLUENT AND RET. TANKS	CH_4	NITROGEN IN EFFLUENT	N_2O	COD IN EFFLUENT	CH_4	NITROGEN IN EFFLUENT	N_2O
	Gg							
1990	108.76	13.214	54.15	0.2486	46.75	1.286	4.435	0.035
1995	79.65	12.995	39.60	0.1912	33.81	0.930	3.669	0.029
2000	73.13	12.874	34.45	0.1807	29.04	0.798	2.905	0.023
2005	59.2	12.057	22.09	0.2101	16.88	0.464	1.902	0.015
2010	51.41	11.371	19.60	0.2220	13.39	0.368	1.671	0.023
2011	49.09	11.155	19.33	0.2191	10.75	0.296	1.463	0.022
2012	47.99	10.908	17.64	0.1746	10.08	0.277	1.283	0.023
2013	46.61	10.781	17.90	0.2041	9.92	0.273	1.041	0.014
2014	44.63	10.359	15.71	0.1495	9.07	0.249	0.836	0.026
2015	43.81	10.607	17.56	0.2440	8.81	0.242	0.745	0.016
2016	41.53	10.417	17.53	0.2515	8.90	0.245	0.829	0.018
2017	39.55	10.343	17.73	0.2701	8.48	0.233	0.788	0.029
2018	38.54	10.286	17.21	0.2730	7.18	0.198	0.624	0.013
2019	37.66	10.123	17.34	0.3074	7.48	0.206	0.595	0.013
2020	37.04	9.959	17.25	0.3217	6.59	0.181	0.536	0.012
2021	35.36	9.565	15.97	0.2988	6.89	0.189	0.624	0.011
2022	34.69	9.385	16.35	0.3116	5.68	0.156	0.514	0.010

The distribution of methane and N_2O emissions from domestic and industrial wastewater in Slovakia is presented on ***Figures 7.10*** and ***7.11***.

Figure 7.10: Distribution of the methane emissions (in Gg) from domestic and industrial wastewater

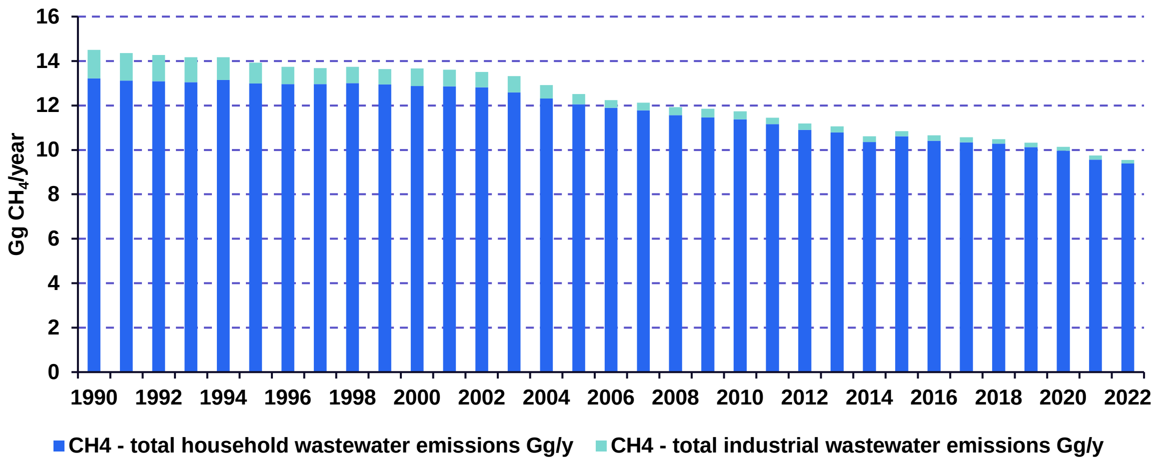
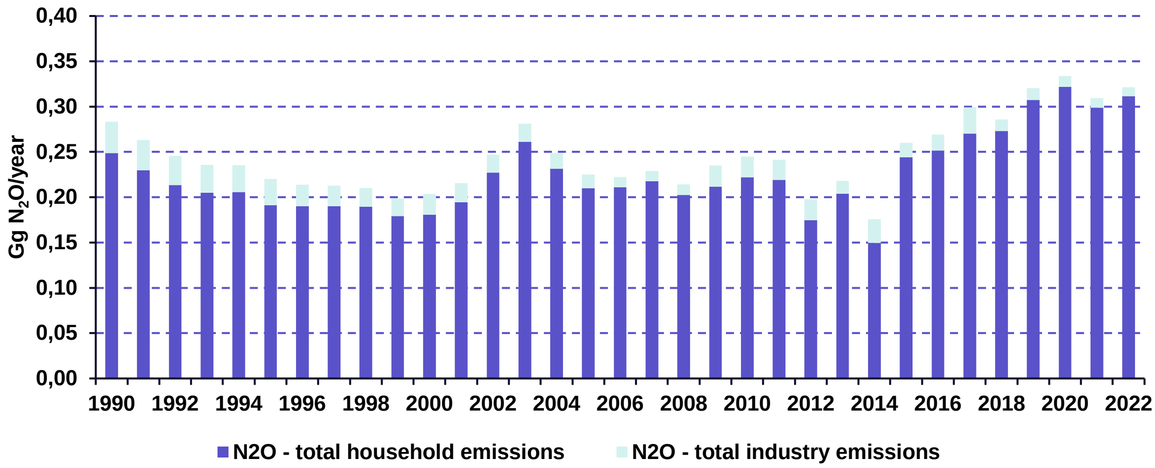


Figure 7.11: Distribution of the N_2O emissions (in Gg) from domestic and industrial wastewater



The legislation and practice in wastewater treatment in Slovakia require that sewage sludge must be stabilised directly by the wastewater treatment plant (e.g. Act No 188/2003 Coll. requires that only stabilised sewage sludge can be further processed outside of WWTP i.e. on compost, in incinerator etc.). Thus, according to the Slovak Technical Norm 75 6401 "Sewage Treatment Plants for more than 500 population equivalents", wastewater treatment plants (WWTPs) with capacity up to 10 000 population-equivalents (p.e.) shall have aerobic sludge stabilisation and larger WWTPs shall have anaerobic sludge stabilisation with biogas production. ***Tables 7.29*** and ***7.30*** provides information on the data sources regarding the share of the distribution of domestic and industrial sludge treatment.

Table 7.29: Distribution of the sludge from domestic WWTPs (data from the WRI)

YEAR	TOTAL GENERATED	TOTAL USE	DIRECT AGR. LAND APPLIC.	COMPOSTED	INCINER.	LANDFILLED	TEMPORARY STORED ON-SITE
	tons						
1990	55 000	45 207	-	-	-	-	-
1995	55 000	45 207	-	-	-	-	-
2000	56 279	35 358	-	-	-	13 796	7 125
2005	56 360	39 120	-	-	-	8 530	8 710
2010	54 760	48 063	923	47 140	-	16	6 681
2011	58 718	50 469	358	50 111	-	2 306	5 946
2012	58 760	50 896	1 254	46 446	3 196	1 615	6 195

YEAR	TOTAL GENERATED	TOTAL USE	DIRECT AGR. LAND APPLIC.	COMPOSTED	INCINER.	LANDFILLED	TEMPORARY STORED ON-SITE
	tons						
2013	57 433	50 787	518	45 261	5 008	1 666	4 980
2014	56 883	52 570	8	36 524	16 038	1 073	3 240
2015	56 242	51 602	NO	34 689	16 913	1 709	2 932
2016	53 054	45 738	NO	34 695	11 043	2 359	4 957
2017	54 517	46 654	NO	34 416	12 238	2 636	5 227
2018	55 929	44 659	NO	32 982	11 677	2 451	8 819
2019	54 832	45 149	NO	32 217	12 932	2 296	7 387
2020	55 519	48 490	NO	36 562	11 928	2 302	4 727
2021	54 764	50 042	NO	37 289	12 753	456	4 266
2022	55 049	43 835	NO	33 509	10 326	1 540	9 674

***Table 7.30:** Distribution of the sludge from industrial WWTPs since 2005 (data from the ŠÚ SR)*

YEAR	TOTAL GENERATED	TOTAL USE	DIRECT AGR. LAND APPLIC.	COMPOSTED	INCINER.	LANDFILLED	TEMPORARY STORED ON-SITE
	tons						
2005	10 307	5 577	2 231	1 037	1 501	785	24
2010	25 571	19 769	1 102	6 369	1 228	11 058	13
2011	29 388	19 460	685	9 977	921	7 620	256
2012	22 567	18 483	478	7 099	1 543	6 351	3 012
2013	19 632	17 167	627	7 727	1 720	1 456	5 636
2014	12 377	8 434	688	4 632	1 763	1 237	114
2015	11 485	7 500	813	3 248	2 496	898	45
2016	13 651	12 200	1 134	3 353	2 021	5 641	50
2017	22 211	15 538	362	3 460	1 206	1 063	9 447
2018	49 669	40 461	287	3 520	3 307	1 006	32 341
2019	12 935	9 393	49	3 361	2 663	1 327	1 993
2020	32 599	28 611	1	3 893	1 326	6 445	16 946
2021	20 724	10 992	1	3 191	1 013	6 034	750
2022	14 240	10 046	1	1 905	925	5 598	1 618

All WWTPs with anaerobic sludge stabilisation utilise biogas for the generation of heat (all these WWTPs need heating for optimal operation of the anaerobic reactor) and/or electricity generation. Gases leaving anaerobic stabilisation are considered as a source of air emissions according to the Air Pollution Control, therefore they must be flared. As a result, no methane emissions are generated from wastewater sludge management in Slovakia.

7.8.1. Domestic Wastewater (CRF 5.D.1)

In 2022, 70.03% of the population was connected to public sewage systems and the rest is using retention tanks or individual treatment systems. Wastewater collection and treatment in Slovakia is developing toward modern, advanced WWTPs. Totally 754 domestic and municipal WWTPs treat yearly about 565 mil. m^3 of wastewater and 70.0% is treated in tertiary level (with nitrogen and phosphorus removal).

The largest domestic WWTPs (52 WWTPs each with a capacity of more than 10 000 p.e.) generate about 80% of total Slovak sewage sludge production. These large WWTPs are processing sludge by anaerobic way with biogas (methane) production. Methane from anaerobic sludge stabilisation is not reported, as all methane is burned for the generation of energy used in WWTPs operation (and reported in the Energy sector) and resulting CO_2 emissions are of biogenic origin. The rest of the domestic WWTPs (about 700 plants with capacity obviously lower than 10 000 p.e.) are using an aerobic sludge stabilisation with sludge retention time (SRT) higher than 25 d. Total methane emissions from domestic wastewater were 9.385 Gg in 2022. The main contribution to these emissions have retention tanks with 7.853 Gg in 2022, which represents about 84% of methane emissions (***Tables 7.31***).

Table 7.31: *Summary of methane emissions from the domestic WW by pathways in particular years*

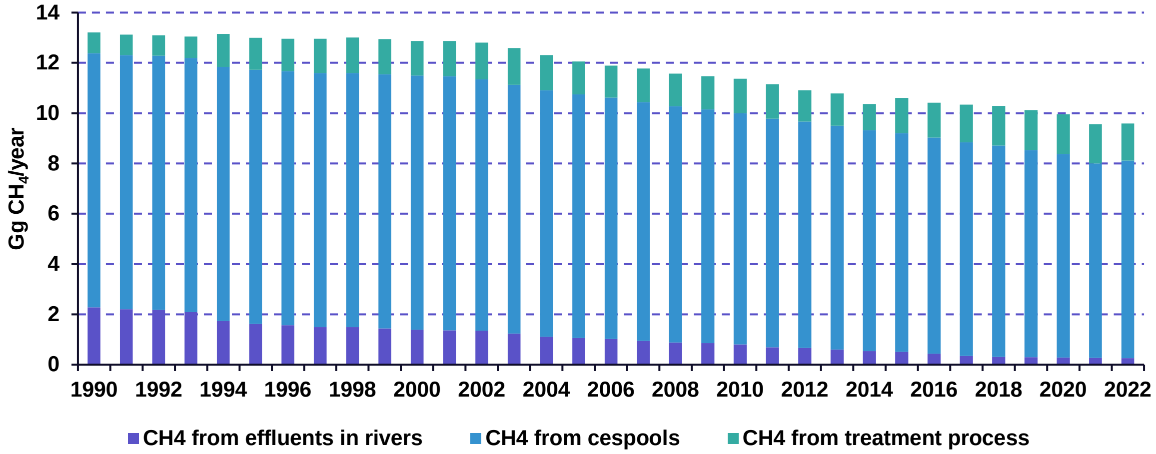
PATHWAY	DOMESTIC WW TREATED AND UNTREATED	TREATMENT PROCESS IN WWTPS	UNTREATED DISCHARGE FROM SEPTIC TANKS	IN AIR FROM SEPTIC AND RETENTION TANKS	REST/ UNCATEGORI-SED	DISCHARGE FROM DOMESTIC WWTPs
	C+D		*E*	*F*	*G*	H
MFC	*0.035*	*0.03*	*0.035*	*0.4*	*0.1*	*0.035*
YEAR	*CH_4 in Gg*					
1990	1.084	0.824	0.295	10.111	0.900	0
1995	0.502	1.274	0.294	10.106	0.819	0
2000	0.412	1.380	0.294	10.100	0.687	0
2005	0.190	1.306	0.283	9.698	0.578	0.002
2010	0.114	1.369	0.241	9.196	0.445	0.006
2011	0.113	1.369	0.239	9.096	0.332	0.006
2012	0.101	1.246	0.236	8.996	0.323	0.007
2013	0.103	1.284	0.234	8.895	0.258	0.007
2014	0.088	1.032	0.231	8.795	0.206	0.008
2015	0.083	1.399	0.228	8.695	0.194	0.008
2016	0.066	1.391	0.226	8.594	0.132	0.008
2017	0.058	1.503	0.223	8.494	0.056	0.009
2018	0.055	1.579	0.220	8.394	0.029	0.009
2019	0.056	1.589	0.216	8.241	0.011	0.010
2020	0.057	1.584	0.212	8.088	0.008	0.010
2021	0.054	1.563	0.203	7.729	0.006	0.010
2022	0.047	1.470	0.201	7.652	0.005	0.010

The new calculation of CH_4 emissions according to IPCC 2019 Refinement caused significant changes in both partial and total emission values. The IPCC 2019 Refinement (Table 6.3 was updated) set many new MCF default values for the calculation procedure, as follows:

- MCF for treated and untreated discharge into rivers: 0.035 from previously 0.1 (tier 2).
- MCF for direct emissions from treatment processes in advanced WWTPs: 0.03 (a new MCF).
- MCF for septic tanks and cesspools: 0.4 from previously 0.5 (retention tanks for wastewater from population non-connected to public sewer systems are dominantly cesspools, where retention time is significantly lower than in septic tanks).

Slovakia has reported an amount of CH_4 for energy recovery as “IE” for domestic wastewater. Biogas generated by the anaerobic treatment of wastewater is used for heating of digestion tanks (37-40°C). In some cases, also natural gas is used for better thermal conditions. The major number of large treatment plants used biogas also for electricity cogeneration and sell electricity to the grid (economic reasons) and therefore it is reported in the Energy sector. This is practicing also in industrial wastewater treatment if anaerobic treatment or digestion is applied (but in very small scale).

Figure 7.12: Distribution of the domestic wastewater methane emissions (in Gg)



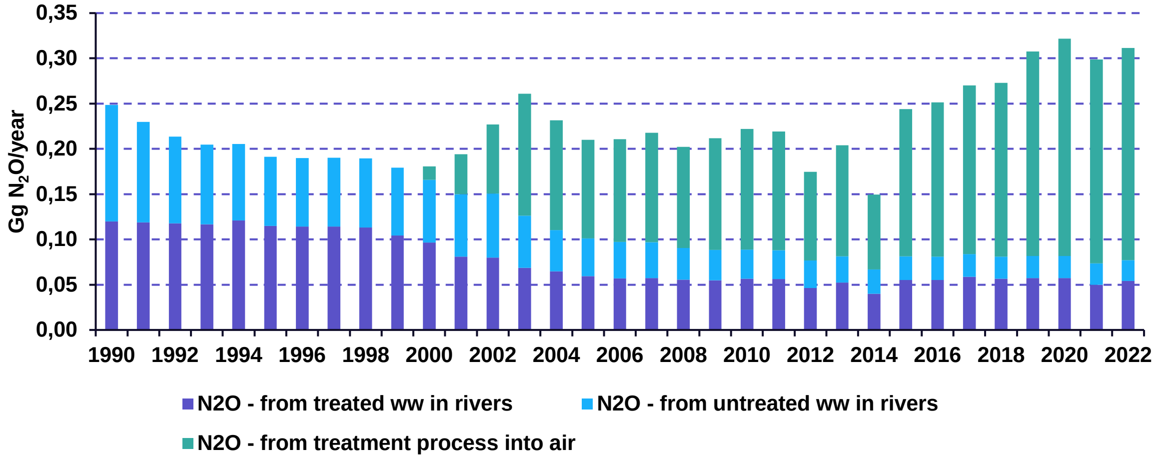
As can be seen from ***Table 7.31*** and from ***Figure 7.12***, methane emissions from effluents into rivers decreased significantly. A similar trend is evident also in methane emissions from cesspools, even though it is still the largest source of methane from wastewater. A slightly increasing trend can be observed for emissions arising in the treatment process. This is due to the gradual increasing of connected population to public sewerage systems and to new WWTPs.

Total N_2O emissions from domestic wastewater treatment were 0.312 Gg. The minority of N_2O emissions is generated both from WWTPs untreated (0.0231 Gg) and treated discharges (0.0539 Gg) (***Table 7.32***).

Table 7.32: *Summary of N_2O emissions from the domestic WW by pathways in particular years*

YEAR	UNTREATED DISCHARGE AND RETENTION TANKS	DIRECT FROM WWT PLANTS	TREATED DISCHARGE	TOTAL
	N_2O in Gg			
1990	0.1288	0.0000	0.1198	0.249
1995	0.0762	0.0000	0.1150	0.191
2000	0.0693	0.0148	0.0693	0.181
2005	0.0417	0.1089	0.0595	0.210
2010	0.0320	0.1334	0.0566	0.222
2011	0.0319	0.1311	0.0561	0.219
2012	0.0303	0.0978	0.0465	0.175
2013	0.0291	0.1227	0.0523	0.204
2014	0.0269	0.0826	0.0400	0.149
2015	0.0263	0.1626	0.0552	0.244
2016	0.0258	0.1704	0.0553	0.251
2017	0.0252	0.1862	0.0587	0.270
2018	0.0246	0.1920	0.0564	0.273
2019	0.0246	0.2256	0.0573	0.307
2020	0.0244	0.2400	0.0573	0.322
2021	0.0236	0.2252	0.0500	0.299
2022	0.0231	0.2346	0.0539	0.312

Figure 7.13: *Distribution of the domestic wastewater N_2O emissions (in Gg)*



As is it evident from ***Table 7.32*** and from ***Figure 7.13***, nitrous oxide emissions from both treated and untreated effluents into rivers decreased continuously. A significantly increasing trend can be observed for emissions arising in the treatment process. This is due to the gradual implementation of nitrification and denitrification processes in new as well as existing WWTPs. It is a new parameter in N_2O emission reports, which completely change emission trends. Similar to what was recorded with methane emissions, a new calculation of N_2O emissions according to IPCC 2019 Refinement caused significant changes in both partial and total emission values. The IPCC 2019 Refinement (Table 6.8 was updated) set many new recommendation calculation procedures as well as new default values, as it is commented in **Chapter 7.3**.

Methodological issues

The IPCC 2019 Refinement to the 2006 IPCC 2006 GL method was accommodated to reflect new available data and observed trends in wastewater management. Known influent and effluent BOD from all individual domestic WWTPs (evidence database from SHMÚ) was used in emissions estimation from WWTPs instead of calculating a difference between theoretical total organics on input (TOW from population equivalent) and organic component removed with sludge (evidence data from VÚVH). At present, we still feel a lack of information about individual treatment systems (cesspools, septic tanks and domestic WWTPs), so emissions for these systems have been calculated on the basis of the estimated number of inhabitants using these systems.

The following wastewater pathways were identified and included in the domestic wastewater emission model:

- Untreated discharge from public sewers (path C)
- Treated discharge from WWTPs (path D)
- Septic and retention tanks (path F)
- Untreated discharge from retention tanks to rivers (path E)
- Rest and uncategorised discharge (path G)
- Individual domestic WWTPs discharge (H)

N_2O emissions estimation is based on the IPCC 2019 Refinement, but due to the increased number of advanced WWT plants, recommended nitrogen removal by nitrification/denitrification had to be included in the calculation. The effectiveness of N removal in WWTPs was adjusted according Table 6.10c. According to the information from the VÚVH, measurements of nitrogen content in sludge was provided also in 2022 (43.3 k/kg TS).

Default parameters and emission factors from the IPCC 2019 Refinement were used for CH_4 and N_2O emissions estimation of domestic wastewater. Default value 0.6 kg CH_4/kg BOD was used for the maximum CH_4 producing capacity (B_O). Default value 0.035 for methane correction factor (MCF) was used for all pathways except for retention tanks where MCF=0.4 was applied. MCF for direct emissions from treatment processes was used 0.03.

Identification of wastewater pathways is based on population using individual pathways. Estimation of CH_4 emissions from individual domestic wastewater is based on BOD data on really generated pollution and pollution discharged to watercourses from public sewers. Emissions of CH_4 from retention tanks, dry toilets, domestic WWTPs and from untreated discharge from public sewers were estimated based on population and BOD_5 per person per day (60 g – country-specific value).

Uncertainties

The default uncertainties based on the IPCC 2019 Refinement were used and adjusted (where possible) to assess emissions estimation and to reflect country-specific data or circumstances. The calculation of methane emissions was based on real pollution data (BOD_5) at the output of existing WWTPs. Emissions from individual treatment systems (septic tanks) were defined on an estimate of the number of inhabitants connected to these facilities. However, the operation of these individual installations is outside the central evidence and therefore emissions from this group are burdened with very high uncertainty.

The list of the most significant emission factors and their uncertainty range is given in ***Table 7.33***. To define the total uncertainty of emissions for methane or N_2O is relatively complicated, as the total uncertainty should be defined as the conjunction of the all individual uncertainties entering into the final emission calculation. Based on expert estimates and discussions, a value of ±15% was defined as the overall uncertainty for methane emissions and a value of ±25% was defined for N_2O emissions.

Table 7.33: *Uncertainties for the category of domestic wastewater treatment*

EMISSION FACTORS AND ACTIVITY DATA	UNCERTAINTY RANGE
Emission factors	
For methane calculation:	
EF_j (kg CH_4/kg BOD) = 0.6 (default value)	±0%
MCF for treated and untreated system = 0.1 (default value)	±10%
MCF for septic systems = 0.5 (default value)	±20% (temperature depend)
For N_2O calculation:	
N_2O Emission factor effluent = 0.005 (default value)	±10%
Activity data	
For methane calculation:	
TOW from operational WWTPs influent and effluent (SHMÚ data)	±10% (sampling and analytical errors)
BOD per person and day (for septic tanks) = 60 g/person per day	±30%
Human population distribution (collected, uncollected)	±5%
For N_2O calculation:	
N_{eff} from real WWTPs influent and effluent (SHMÚ data)	±10% (sampling and analytical errors)
Protein annual consumption (ŠÚ SR data)	±5%
N in sludge (VÚVH data)	±10% (sampling and analytical errors)

Category-specific recalculations

Estimation of CH_4 and N_2O emissions from domestic wastewater sector were re-calculated using a new calculation methodology according to the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. There are many changes on individual level in the calculated CH_4 and N_2O emission data caused by a change of the default MCF and EF values for discharge from treated and untreated systems, for wastewater treatment systems emissions, by efficiency of BOD5, COD, N_{tot} removal in primary, secondary and tertiary treatment systems, etc.

Detailed comments and final comparison of the previous inventory and re-calculated time-series are presented in the **Chapter 7.3**. Recalculation data for methane emissions from domestic wastewater are recorded in the ***Table 7.8*** and in ***Table 7.9***, are recalculation data for nitrous oxide including recalculation data for N-effluent from domestic wastewater.

7.8.2. Industrial Wastewater (CRF 5.D.2)

Water consumption for industrial purposes and resulting pollution discharge of wastewater have significantly decreased in the period 1990 – 2020, but during year 2021 there was a slight increase of pollution (as COD and BOD_5). While 2020 saw a decline in industrial production (such as the amount of wastewater and pollution due to the COVID-19 pandemic), 2021 recorded a slight recovery in industrial production. In the year 2022, a further decrease in industrial wastewater production was observed in the range about 10%, which was also reflected in a relevant decrease in methane, as well as, nitrous oxide emission. This was due to a reduction in the amount of pollution at the WWTP effluents, which is a long-term trend.

Total methane emissions were estimated to be 0.156 Gg and total N_2O emissions were 0.0098 Gg from industrial wastewater treatment in 2022. The pathways A and B (***Figure 7.9***) are included in the estimation of methane emissions. ***Table 7.34*** shows the activity data and resulting emissions estimation.

Due to the specifications of the reporting via the CRF Reporter software, the reporting of activity data of industrial sludge is not relevant for emissions estimation when the COD effluent data is used. This information was included in the CRF Reporter software, however, generated tables not always contain this information. The model used for industrial wastewater does not estimate nitrogen removed with sludge. Industrial treatment sludge from the pulp and paper industry and from the refinery is incinerated as a part of industrial waste. Methane, generated here is used for energy generation and resulting emissions are included in the Energy Sector (categories 1.A.1.a, 1.A.2.c, 1.A.2.f and 1.A.5.a).

Until 2001, produced and removed industrial treatment sludge was reported as “NE” in the CRF table 5.D.2. In the reflection of the discussion during the UNFCCC review 2019, data about sludge production and disposal ways from industrial wastewater treatment (back from the year 2005) were processed based on the ŠÚ SR and the “IS Odpady”, which is a database of waste production operated by the MŽP SR. For the purposes of this submission, the actual values of industrial sludge production have been used (***Table 7.34***).

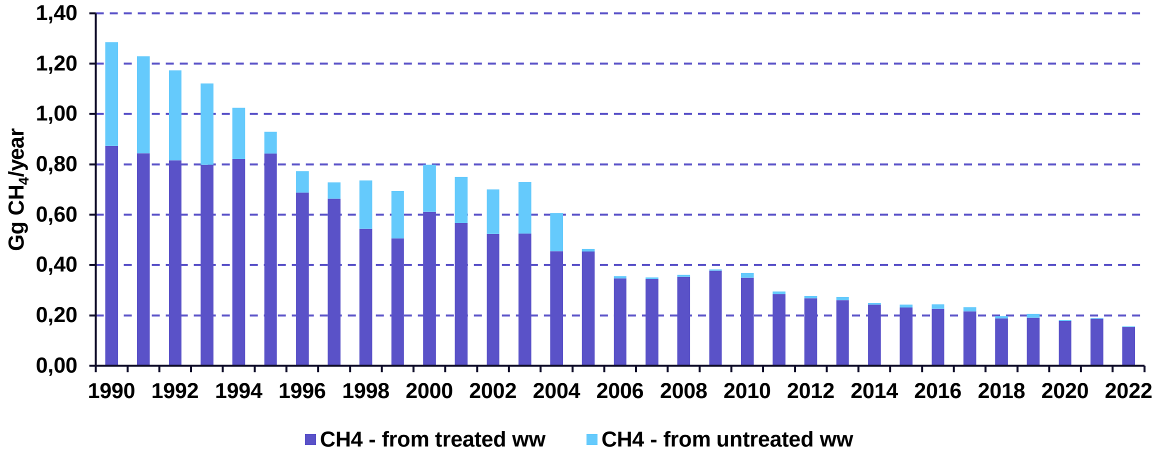
Table 7.34: *GHG emissions from wastewater treatment in particular years*

YEAR	TOTAL ORGANIC PRODUCT	NITROGEN IN EFFLUENT	CH_4	N_2O
	kt DC - COD	*Gg*		
1990	46.75	4.435	1.286	0.0348
1995	33.81	3.669	0.930	0.0288
2000	29.04	2.905	0.798	0.0228
2005	16.88	1.902	0.464	0.0149
2010	13.39	1.671	0.368	0.0227
2011	10.75	1.463	0.296	0.0221
2012	10.08	1.283	0.277	0.0233
2013	9.92	1.041	0.273	0.0140
2014	9.07	0.836	0.249	0.0261
2015	8.81	0.745	0.242	0.0160
2016	8.90	0.829	0.245	0.0177
2017	8.48	0.788	0.233	0.0290
2018	7.18	0.624	0.198	0.0128
2019	7.48	0.594	0.206	0.0128
2020	6.59	0.536	0.181	0.0120

YEAR	TOTAL ORGANIC PRODUCT	NITROGEN IN EFFLUENT	CH_4	N_2O
	kt DC - COD	*Gg*		
2021	6.89	0.624	0.189	0.0107
2022	5.68	0.514	0.156	0.0980

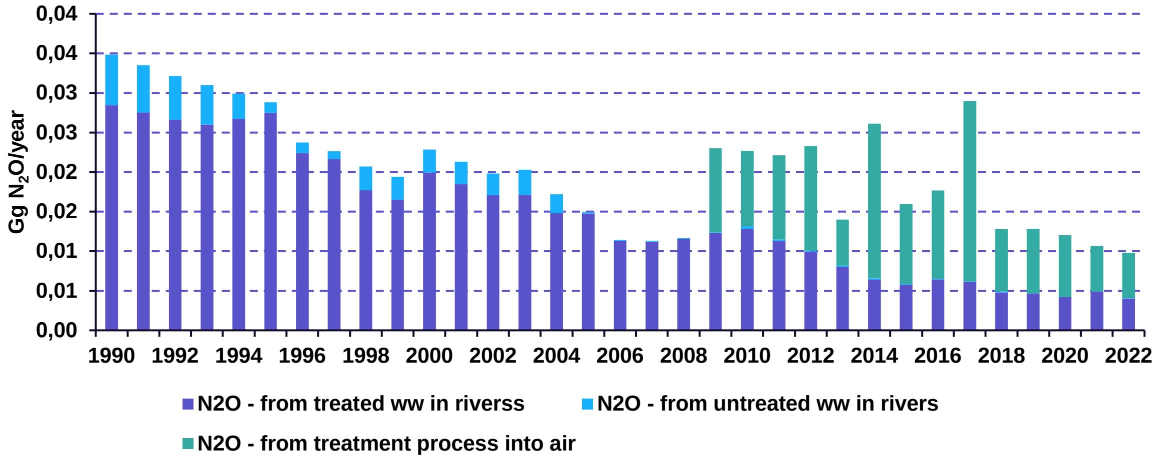
The ***Figure 7.14*** confirms significantly decrease of methane emissions both from treated as well as untreated industrial wastewater. In contrast to domestic wastewater, industrial wastewater does not consider the process of methane formation at a WWTP with activated sludge (default EF = 0). Especially, the proportion of untreated WW is already almost negligible, which indicates a high level of industrial wastewater treatment quality.

Figure 7.14: *Distribution of the industrial wastewater methane emissions (in Gg)*



Even with N_2O emissions, a significant decrease is observed in the items treated and untreated wastewater. Since 2009, balance data on the input and output of industrial WWTPs have been available. Based on these data, the emissions produced in the process of nitrification and denitrification were also calculated. These data also have a decreasing tendency, with the exception of the years 2014 and 2017, when there were extremely high TN loads in wastewater.

Figure 7.15: *Distribution of the industrial wastewater N_2O emissions (in Gg)*



Methodological issues

The new methodology recommended by the IPCC 2019 Refinement to the 2006 IPCC 2006 GL was used for estimating emissions from industrial wastewater. COD values from individual industrial WWTPs reported by the SHMÚ were used in methane emissions estimation. It is assumed that the use of the reported COD data will provide better results than estimation according to the methodology provided in Chapter 6.4.1.3 of the IPCC 2019 Refinement to the IPCC 2006 GL. Treated and untreated pollution (as COD) from industrial wastewater discharged into rivers by separate industrial sewers were considered here as a methane emissions source. Industrial wastewater discharged to public sewers is included in domestic wastewater. Default value 0.25 kg CH_4/kg COD of maximum CH_4 producing capacity (BO) was used. Default value 0.11 of methane correction factor (MCF) for both pathways was used (old methodology used MCF = 0.1). It is expected if anaerobic treatment of industrial wastewater was used (only three facilities), that all methane from this treatment was burned (with or without energy utilization). Unlike domestic wastewater, the new calculation methodology does not consider methane production in the activated sludge process (EF = 0).

In compare to the old methodology, the IPCC 2019 Refinement provides a slightly changed methodology for the estimation of N_2O emissions from industrial wastewater. Slovakia currently collects information on produced and discharged pollution from all sources. The SHMÚ and ŠÚ SR started to publish data on nitrogen discharged to watercourses from 2009. These data allowed to develop a simple model, which estimates N_2O emissions generated from the treated and untreated discharge of industrial wastewater. For emissions estimation from industrial wastewater, default emission factors based on the IPCC 2019 Refinement were used. Default value 0.005 kg N_2O-N/kg N was used. Data on discharged nitrogen are available only for the period 2009 – 2022. A good correlation (0.92) was identified between the discharged TN and COD. COD was used for extrapolation of missing TN activity data in the period 1990 – 2008. Extrapolations were done separately for treated and untreated discharge.

N_2O emissions from nitrification-denitrification processes were realized only for the period 2009 – 2022, when real input and output for N-loads were available. Default EF = 0.016 kg N_2O/kg TN was used to calculate emissions from the cleaning process (according to IPCC 2019 Refinement).

Source-specific recalculations

Due to slight changes in the recommended calculation procedures (according to IPCC 2019 Refinement), there were changes in the resulting values of individual parameters as well as in the resulting total values. A new calculations for both methane and nitrogen emissions were carried out in the industrial wastewater sector. A detailed comparison of the previous inventory submission for time-series and new data for methane emissions are shown in ***Table 7.8***. A detailed comparison of the previous inventory submission for time-series and new data for N_2O emissions are shown in ***Table 7.9***. The actual values of methane and nitrous oxide emissions for the industrial wastewater sector are shown in ***Table 7.34*** and in ***Figure 7.14*** and ***Figure 7.15***.

Uncertainties

The default uncertainties based on the IPCC 2019 Refinement to the IPCC 2006 GL were used to assess methane and N_2O emissions estimation and also to reflect country-specific data or circumstances. The calculation of methane and N_2O emissions was based on real pollution data (COD and TN) at the effluent of all existing industrial WWTPs. Data on the proportion of treated and untreated industrial water were also available.

The list of the most significant emission factors and their uncertainty range is given in ***Table 7.35***. To define the total uncertainty of industrial wastewater emissions for methane or N_2O is relatively complicated, as the total uncertainty should be defined as the conjunction of the individual uncertainties entering into the final emission calculation. Based on expert estimates and also based on recommendation data from the IPCC 2019 Refinement (Table 6.13 was updated), a different value of the overall uncertainty for methane N_2O emissions was defined.

Table 7.35: *Uncertainties for the category of industrial wastewater treatment*

EMISSION FACTORS AND ACTIVITY DATA	UNCERTAINTY RANGE
Emission factors	
For methane calculation: EF_j (kg CH_4/kg COD) = 0.25 (default value) MCF for treated and untreated system = 0.1 (default value) For N_2O calculation: N_2O Emission factor effluent = 0.005 (default value)	 ±0% ±10% ±30%
Activity data	
For methane calculation: TOW from real industrial WWTPs effluent (SHMÚ data) For N_2O calculation: N_{eff} from real WWTPs influent and effluent (SHMÚ data)	 ±20% (sampling and analytical errors) ±25% (sampling and analytical errors)

7.9. MEMO ITEMS (CRF 5.F)

The IPCC Waste Model provides estimates on stored carbon and overview of this parameter is shown in ***Table 7.36***, disaggregated to municipal solid waste and non-municipal solid waste. (Note: These data were not inserted in the CRF table 5.F, as this table requires CO_2 emissions, but SWDS are generating CH_4. The main contradiction is that long-term stored carbon remains as carbon.

Table 7.36: *Accumulated Long-term stored C in SWDS in particular years*

YEAR	ACCUMULATED STORED C	ANNUAL CHANGE IN STORED C	ANNUAL CHANGE IN STORED C IN HWP WASTE
		Gg	
1990	1 043.18	47.67	35.48
1995	1 244.80	42.18	28.26
2000	1 512.78	54.61	32.62
2005	1 852.94	74.89	45.90
2010	2 296.96	98.75	62.30
2011	2 384.14	87.19	54.82
2012	2 467.55	83.40	52.24
2013	2 544.52	76.98	48.03
2014	2 619.90	75.38	46.75
2015	2 698.79	78.89	48.72
2016	2 780.01	81.22	49.94
2017	2 860.62	80.61	49.21
2018	2 935.54	74.92	45.51
2019	3 007.25	71.72	43.50
2020	3 077.75	70.50	42.76
2021	3 143.54	65.79	39.90
2022	3 232.63	61.14	37.08

CHAPTER 8. OTHER (CRF 6)

Slovakia does not report any emissions under the sector Other.

CHAPTER 9. INDIRECT CO_2 AND NITROUS OXIDE EMISSIONS

The CO_2 resulting from the atmospheric oxidation of CH_4, CO and NMVOC is referred to as indirect CO_2. The IPCC 2006 GL and the IPCC 2019 Refinement provide a method how the CO_2 inputs from the atmospheric oxidation of NMVOC in industry can be calculated.

Indirect CO_2 emissions from this processes were estimated and are included in the IPPU sector. Indirect emissions were estimated in the category 2.D – Non-energy products from fuels and solvent use for the first time in this submissions a reported for the time series. More information can be found in **Annex A4.4** of **Chapter 4**.

Indirect N_2O emissions in the Agriculture sector address nitrous oxide (N_2O) emissions that result from the deposition of the nitrogen emitted as NOx and NH_3. N_2O is produced in soils through the biological processes of nitrification and denitrification. Indirect N_2O emissions from manure management are reported in CRF table 3.B(b) as a part of N_2O emissions in this category. These indirect emissions result from volatile nitrogen losses, that occur during manure collection and storage and which are diffused into the surrounding air. Nitrogen losses begin at the point of excretion in houses and other animal production areas and continue through on-site management in storage and treatment systems. Indirect N_2O emissions from these sources are included in the categories 3.B(b).5 – Indirect N_2O emissions from manure management.

Indirect N_2O emissions from managed soils are reported in CRF table 3.D.2 – Indirect N_2O emissions from managed soils as a part of N_2O emissions. These emissions are from the following sources:

- the volatilization of N (as NH_3 and NOx) following the application of synthetic and organic N fertilizers and /or urine and dung deposition from grazing animals,
- and the subsequent deposition of the N as ammonium (NH_4^+) and oxides of N (NOx) on soils and waters, and the leaching and runoff of N from synthetic and organic N fertilizer additions, crop residues, mineralization /immobilization of N associated with loss/gain of soil C in mineral soils through land use change or management practices, and urine and dung deposition from grazing animals.

No indirect emissions are reported in the Energy, LULUCF and Waste sectors.

CHAPTER 10. RECALCULATIONS AND IMPROVEMENTS

10.1. Explanations and Justifications for Recalculations

The main driver for recalculations in the 2024 greenhouse gas inventory submission of the Slovak Republic has been the implementation of the methodologies and categories given in the IPCC 2019 Refinement and further planned improvements among other recommended by the previous reviews. The ERT recommendations from the ARR 2022 published on 4th April 2023 were available from the latest annual UNFCCC (2022) review. Those recommendations were taken into account to the extent they are applicable. The significance of the sources based on the results of the key category and uncertainty analyses are considered when prioritising improvements to be made in the inventory calculations. No UNFCCC review was performed in 2023. The recalculations made since the previous inventory submission (2023) are described also in the appropriate sectoral **Chapters 3-7**. The list of the major recalculations with the short descriptions made in the 2024 submission is summarized in ***Tables 10.3*** and ***10.4***. No recommendation from the EU ESD inventory reviews (2023) have been addressed by the TERT.

10.2. Implications for Emission Levels

Reflecting the QA/QC activities for improving the emissions inventory of GHG and recommendations provided by the experts during the review process for inventory submissions under the UNFCCC, the experts involved in the National Inventory System of the Slovak Republic proposed the recalculations of the several subsectors and categories. The recalculations and reallocations of emissions are based on updated or revised methodologies (for agricultural and LULUCF activities and for waste categories), updated statistical information (waste and households) or based on harmonization between GHG and air pollutant input data (for the IPPU sector in solvents use). The recalculations listed in ***Tables 10.1*** and ***10.2*** were provided in CRF tables 2024, version 2 against previous inventory submission from April 13, 2023 version 6 with and without the LULUCF sector. The ***Table 10.3*** presents list of performed recalculations with the short summarizing description (detailed information is provided in the sectoral chapters in this report). Total GHG emissions without LULUCF and with indirect emissions decreased after recalculations made in 2024 submission for the year 1990 by 0.5%, and for the year 2021 by 0.16% (***Table 10.1***). Regarding total GHG emissions with LULUCF and with indirect emissions, GHG emissions increased in 2023 submission by 1.14% for the year 2021 (***Table 10.2***). This comparison used the GWP taken from AR5.

Table 10.1: *Comparison of the GHG emissions trend without LULUCF and with indirect emissions in 2023 and 2024 submissions*

NATIONAL GHG INVENTORY WITHOUT LULUCF WITH INDIRECT EMISSIONS			
YEAR	Submission 2023 v6	Submission 2024 v2	2024 v2/2023 v6
	Gg of CO_2 eq.		*%*
1990	73 826.44	73 455.32	99.50%
1991	64 429.94	64 199.80	99.64%
1992	58 710.21	58 768.01	100.10%
1993	55 327.13	55 182.38	99.74%
1994	52 769.83	52 665.58	99.80%
1995	53 262.06	53 180.07	99.85%
1996	53 078.93	53 033.33	99.91%
1997	52 899.49	52 826.91	99.86%
1998	52 197.02	52 092.98	99.80%
1999	50 931.09	50 838.56	99.82%
2000	49 051.65	48 904.08	99.70%
2001	51 322.15	51 134.01	99.63%
2002	49 941.91	49 866.18	99.85%
2003	50 041.49	50 096.54	100.11%
2004	50 755.65	50 723.59	99.94%
2005	50 733.24	50 682.48	99.90%
2006	50 516.54	50 706.80	100.38%
2007	48 756.34	48 888.15	100.27%
2008	49 276.86	49 369.45	100.19%
2009	45 014.25	45 145.99	100.29%

NATIONAL GHG INVENTORY WITHOUT LULUCF WITH INDIRECT EMISSIONS			
YEAR	Submission 2023 v6	Submission 2024 v2	2024 v2/2023 v6
	Gg of CO_2 eq.		*%*
2010	45 815.83	45 888.76	100.16%
2011	44 897.51	44 812.42	99.81%
2012	42 497.86	42 442.53	99.87%
2013	42 177.63	42 119.84	99.86%
2014	40 189.74	40 103.47	99.79%
2015	40 925.92	40 842.50	99.80%
2016	41 371.19	41 278.70	99.78%
2017	42 466.76	42 401.89	99.85%
2018	42 329.54	42 218.93	99.74%
2019	40 001.03	39 910.63	99.77%
2020	37 233.76	37 176.89	99.85%
2021	41 270.16	41 206.13	99.84%

Figure 10.1: *Comparison of the recalculated GHG emissions trend without LULUCF and with indirect emissions in 2023 and 2024 submissions for 1990 – 2021 in Gg of CO_2 eq.*

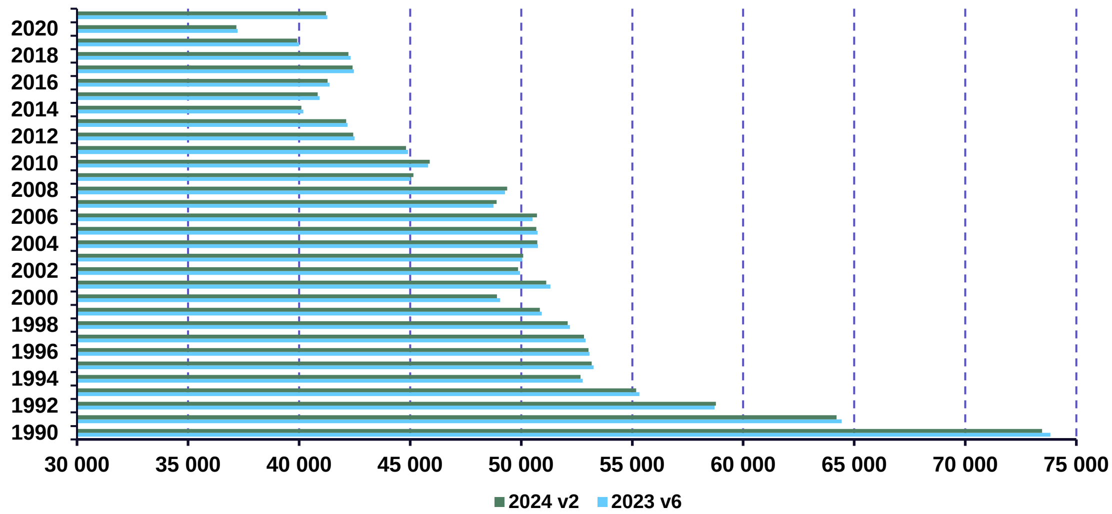
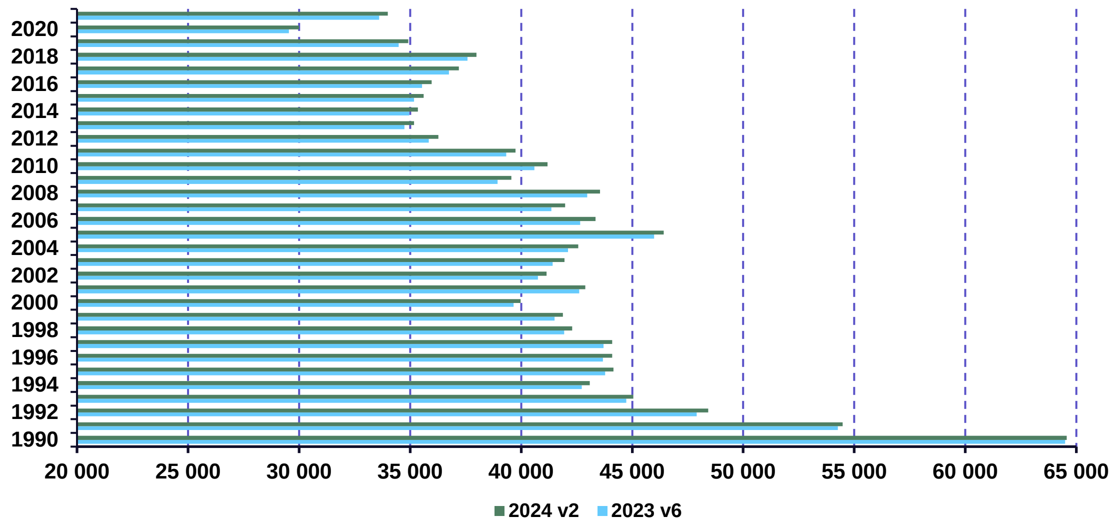


Table 10.2: *Comparison of the recalculated GHG emissions trend with LULUCF and with indirect emissions in 2023 and 2024 submissions for 1990 – 2021 in Gg of CO_2 eq.*

NATIONAL GHG INVENTORY WITH LULUCF AND WITH INDIRECT EMISSIONS			
YEAR	Submission 2023 v6	Submission 2024 v2	2024 v2/2023 v6
	Gg of CO_2 eq.		*%*
1990	64 493.63	64 562.80	100.11%
1991	54 262.96	54 480.23	100.40%
1992	47 909.39	48 419.10	101.06%
1993	44 735.12	45 044.28	100.69%
1994	42 735.87	43 087.65	100.82%
1995	43 775.11	44 149.65	100.86%
1996	43 677.76	44 094.12	100.95%
1997	43 706.37	44 099.60	100.90%
1998	41 933.92	42 299.24	100.87%
1999	41 507.69	41 885.22	100.91%
2000	39 656.30	39 981.55	100.82%
2001	42 609.46	42 890.50	100.66%

NATIONAL GHG INVENTORY WITH LULUCF AND WITH INDIRECT EMISSIONS			
YEAR	Submission 2023 v6	Submission 2024 v2	2024 v2/2023 v6
	Gg of CO_2 eq.		*%*
2002	40 749.96	41 144.36	100.97%
2003	41 419.37	41 950.09	101.28%
2004	42 115.09	42 569.21	101.08%
2005	45 983.22	46 417.70	100.94%
2006	42 654.69	43 348.38	101.63%
2007	41 361.35	41 976.54	101.49%
2008	42 977.54	43 551.22	101.33%
2009	38 941.21	39 556.75	101.58%
2010	40 603.09	41 184.39	101.43%
2011	39 333.86	39 746.09	101.05%
2012	35 836.60	36 275.51	101.22%
2013	34 746.55	35 182.73	101.26%
2014	34 957.29	35 348.12	101.12%
2015	35 170.09	35 608.23	101.25%
2016	35 542.12	35 966.00	101.19%
2017	36 742.07	37 197.65	101.24%
2018	37 578.11	37 987.62	101.09%
2019	34 486.23	34 916.16	101.25%
2020	29 538.43	29 997.91	101.56%
2021	33 612.33	33 994.72	101.14%

Figure 10.2: *Comparison of the recalculated GHG emissions trend with LULUCF and with indirect emissions in 2023 and 2024 submissions for 1990 – 2021 in Gg of CO_2 eq.*



10.3. Recalculations, Including in Response to the Review Process, and Planned Improvements to the Inventory

UNFCCC review: Slovakia was reviewed in the UNFCCC centralised review during the week from 17th – 22th October 2022. Until the date of this submission, Slovakia received final ARR 2022 on 4th April 2023 with several recommendations (these recommendations were already implemented or partly implemented and planned in the Improvement Plans). The status of implementation for the 2022 recommendations is descripted in ***Table A4.3***. No UNFCCC review had been taking place in 2023.

EU ESR review: The requirements for the Union review of the national inventory data submitted by Member States are set out in the regulation (EU) 2018/842 (ESR) and the regulation 2018/1999 (Governance). The initial, annual review 2023 concerning Member States' inventories for the year 2021 was carried out as planned during the spring 2023. Second step of the review of Slovakia was not necessary in the review cycle 2023 due to no issue was found. The reviewers raised 12 issues during the first step of the 2023 ESR review which leads to no recommendation and were resolved during the first step of the review.

Recalculations: In term to further improvements of the GHG emissions inventory, the NIS SR made recalculations for the 2024 submission. These recalculations are listed in ***Table 10.3*** below. Focus is on the main issues highlighted in the regular UNFCCC and ESR reviews performed in the year 2023. In addition, recalculations are also planned by the sectoral experts in the short and long term perspective, especially in the categories prioritised with the key impact on GHG emissions (for example national parameters applied in the agriculture). In addition, recalculations made in the indirect GHG emissions (NO_x, CO, NMVOC and SO_2) are provided in the table below. Major recalculations in sectors are connected with the implementation of the IPCC 2019 Refinement to the 2006 IPCC Guidelines. These changes in methodological approach were developed and prepared under the project funded from EU grand successfully implemented in the years 2022 – 2023. More information can be found on the website: PROJECT EMISSIONS – Preparation of methodology and improvement of emission inventories and emission projections.

The status of recommendations including planned improvements can be found in **Annex 4**, ***Table A4.3*** of this report, but also directly in the sectoral chapters.

Table 4: *List of recalculations in March 15, 2024 submission (version 2) against April 15, 2023 submission (version 4) with short explanation*

RECALCULATED CATEGORY (SUBMISSION 2023 v4 VERSUS SUBMISSION 2024 v1)		YEARS	GHG AFFECTED	EXPLANATION
1. ENERGY SECTOR				
1.A.1.b	Petroleum Refining - Gaseous Fuels	1990-2021	CO_2, CH_4, N_2O	Based on IPCC 2019 Refinement, the emissions from hydrogen production within a refinery as an intermediate product were reallocated from IPPU sector 2.B.10 to Energy sector 1.A.1.b. This reallocation will not affect the country's total emissions.
1.A.4.b	Residential Heating	2012-2021	CO_2, CH_4, N_2O	Recalculation of activity data for liquid fuels and biomass (firewood, other solid biomass and pellets&briquettes) consumption in residential heating was taking place due to improvements in total heat distribution system including central heating. More information in Chapter 3.2.9 of Energy sector. Recalculations are based on data from new 2021 Census.
1.B.1.a	Underground mining - coal	1990 - 2021	CO_2, CH_4, N_2O	Recalculations based on the implementation of the methodology from the IPCC 2019 Refinement and updated data from mining companies.
1.B.1.a.i	Underground mining – coal mining	2022	CH_4	Revision in re-submission due to error in updated calculation.
1.B.1.b	Fuel transformation	1990 - 2021	CO_2, CH_4, N_2O	Recalculations based on the implementation of the methodology from the IPCC 2019 Refinement. New activity data and emission factors used for coke production emissions estimation.
1.B.2.a	Fugitive emissions from oil	1990 - 2021	CO_2, CH_4, N_2O	Recalculations based on the implementation of the methodology from the IPCC 2019 Refinement. These emissions now includes also emissions from venting and flaring in the Tier 1.
1.B.2.b	Fugitive emissions from natural	1990 - 2021	CO_2, CH_4, N_2O	Recalculations based on the implementation of the methodology from the IPCC 2019 Refinement. These emissions now includes also venting and flaring in tier 1.
1.B.2.c	Fugitive emissions from venting and flaring	1990 - 2021	CO_2, CH_4, N_2O	Recalculations based on the implementation of the methodology from the IPCC 2019 Refinement. Most the venting and flaring emissions are now reported within the activity that are associated with.
1.B.2.d	Fugitive emissions – Other (Post-Meter NG fugitive emissions)	1990 - 2021	CO_2, CH_4	Recalculations based on the implementation of the methodology from the IPCC 2019 Refinement. A new source of fugitive emissions.
2. INDUSTRIAL PROCESSES AND PRODUCT USE SECTOR				
2.B.2	Nitric Acid Production	1990-1999	N_2O	Recalculation of the time series 1990 – 1999 with the EF for atmospheric plant.
2.B.10	Hydrogen Production	1990-2021	CO_2, CH_4, N_2O	Reallocation of the hydrogen production into Energy sector.
2.C.1	Iron and Steel Production	1990-2021	CH_4, N_2O	Newly calculated CH_4 and N_2O emissions in this category.
2.C.3	Aluminium Production	1990-2021	PFCs	Recalculation of PFC emissions from high-voltage anode effect and incorporating of PFC emissions from low-voltage anode effect.

RECALCULATED CATEGORY (SUBMISSION 2023 v4 VERSUS SUBMISSION 2024 v1)		YEARS	GHG AFFECTED	EXPLANATION
2.F.1	Refrigeration and Air Conditioning Equipment	2014, 2016	HFCs, PFCs	Reallocation of HFC-152a from 2.F.1.c to 2.F.1.f (heat pump) and correction of PFC c-C_4F_8 to C_2F_6 (PFC-116)
3. AGRICULTURE				
3	Agriculture	1990-2021	CH_4, N_2O	Implementation of the IPCC 2019 Refinement. More information is available in Agriculture Chapter 5.4 of the SVK NIR 2024.
3.A	Enteric fermentation	1990-2021	CH_4	Implementation of the IPCC 2019 Refinement, revision of Ym for cattle and sheep. More information is available in Agriculture Chapters 5.4 and 5.7 of the SVK NIR 2024.
3.B.1	Manure management	1990-2021	CH_4	Revision of AWMS in swine category due to implementation of the IPCC 2019 Refinement. Share of biogas facilities was implemented into market swine and breeding swine. In addition, implementation of tier 2 approach for emissions estimation of poultry. More information is available in Agriculture Chapters 5.4 and 5.8 of the SVK NIR 2024.
3.B.2	Manure management	1990-2021	N_2O	Revision of AWMS in swine category due to implementation of the IPCC 2019 Refinement. Share of biogas facilities was implemented into market swine and breeding swine. In addition, implementation of tier 2 approach for emissions estimation of poultry. More information is available in Agriculture Chapters 5.4 and 5.9 of the SVK NIR 2024.
3.B.2.5	Indirect emission from manure management	1990-2021	N_2O	Revision of emissions due to recalculations in 3.B.2.3 and 3.B.2.4 categories. Implementation of new emissions source: N_2O Emission from Leaching and Runoff (3.B.2.5). More information is available in Agriculture Chapters 5.4 and 5.10 of the SVK NIR 2024.
3. A. 1.	Enteric fermentation –Non-dairy cattle	2022	CH_4	Correction of YM parameter of beef cattle from 0 to 3.2% and correction of oxen weigh, these changes have impact on IEF, AGEI and emissions. More information is available in Agriculture Chapters 5.4 of the SVK NIR 2024.
3. A. 2.	Enteric fermentation -Mature ewes	1990-2021	CH_4	Revision of CH4 emissions and AGEIs in Mature ewes subcategory due to inconsistency between the CRF reporter and calculation sheets. More information is available in Agriculture Chapters 5.4 of the SVK NIR 2024.
3. A. 2.	Enteric fermentation –Growing lambs	2015	CH_4	Revision of Ym in Mature ewes subcategory due to inconsistency between the CRF reporter and calculation sheets. More information is available in Agriculture Chapters 5.4 of the SVK NIR 2024.
3. A. 3	Enteric fermentation – Market swine, Breeding swine	1995, 1998	CH_4	Changes in distribution of swine lead to revision of IEFs and average weight. Number of market swine (1990-2021) are increase compare to the breeding swine this numbers are decreased. Have impact on incorrect IEF, which are not in line with Tier1 2019 IPCC GL approach. More information is available in Agriculture Chapters 5.4 of the SVK NIR 2024.

RECALCULATED CATEGORY (SUBMISSION 2023 v4 VERSUS SUBMISSION 2024 v1)		YEARS	GHG AFFECTED	EXPLANATION
3. A. 3	Enteric fermentation – Horses	1991-2021	CH_4	Revision of average weight in Horses - Horses 1-3 year subcategory was not included in the total average weight, therefore revision was done. More information is available in Agriculture Chapters 5.4 of the SVK NIR 2024.
3.B.1.3	Manure management – Breeding swine	1995 and 1997	CH_4	Inconsistent numbers of livestock in swine category between CRF reporter and spreadsheets was discovered and corrected, numbers were higher ten officially statistical data. Revision was done in particular years 1995 and 1997. Revision and have impact on emissions. More information is available in Agriculture Chapters 5.4 of the SVK NIR 2024.
3.B.1.4	Manure management – Horses	1992 and 1993	CH_4	Inconsistency in number of horses between CRF table and spreadsheets was discovered in particular years 1992 and 1993 which was not in line with officially statistical data reported by the Statistical Office of the Slovak Republic. Inconsistency has small impact on reported CH4 emissions. More information is available in Agriculture Chapters 5.4 of the SVK NIR 2024.
3.B.2.2	Manure management – Other mature sheep	2005	N_2O	Number of other mature sheep inconsistency between categories was discovered. Change have impact on emissions in particular year 2005. More information is available in Agriculture Chapters 5.4 of the SVK NIR 2024.
3.B.2.2	Manure management – Mature ewes	2022	N_2O	Inconsistency of NEX between calculation sheet and CRF reporter was found. More information is available in Agriculture Chapters 5.4 of the SVK NIR 2024.
3.B.2.4	Manure management – Horses	1992 and 1993	N_2O	Inconsistency in number of horses between CRF table and spreadsheets was discovered in particular years 1992 and 1993 which was not in line with officially statistical data reported by the Statistical Office of the Slovak Republic. Inconsistency has small impact on reported N2O emissions. More information is available in Agriculture Chapters 5.4 of the SVK NIR 2024.
3.B.2.5	Indirect emission from manure management	1992,1993 and 2005	N_2O	Revision of emissions due to recalculation in 3.B.2.2 and 3.B.2.4. More information is available in Agriculture Chapters 5.4 of the SVK NIR 2024.
3.D.1.1	Inorganic N-fertilizers	2022	N_2O	Correction of consumption have impact on decrease of emissions. More information is available in Agriculture Chapters 5.4 of the SVK NIR 2024.
3.D.1.2.a	Animal Manure Applied to Soils	1992,1993 and 2005	N_2O	Revision of emissions due to recalculation in 3.B.2.2 and 3.B.2.4. More information is available in Agriculture Chapters 5.4 of the SVK NIR 2024.

RECALCULATED CATEGORY (SUBMISSION 2023 v4 VERSUS SUBMISSION 2024 v1)		YEARS	GHG AFFECTED	EXPLANATION
3.D.1.3	Urine and Dung Deposited by Grazing Animals	1992,1993 and 2005	N_2O	Revision of emissions due to recalculation in 3.B.2.2 and 3.B.2.4. More information is available in Agriculture Chapters 5.4 of the SVK NIR 2024.
3.D.1.4	Crop residues	2022	N_2O	Correction of the Statistical data was done. Harvested area of the leguminous plants, harvested area decrease and this change have effect of decrease of emissions. More information is available in Agriculture Chapters 5.4 of the SVK NIR 2024.
3.D.2	3.D.2 Indirect N2O Emissions From Managed Soils	1992,1993 and 2005	N_2O	Revision of emissions due to recalculation in 3.D.1. 3 inconsistency between CRF and spreadsheets. More information is available in Agriculture Chapters 5.4 of the SVK NIR 2024.
4. LULUCF				
4	LULUCF	1990-2021	CO_2	Revision of net emissions due to recalculation in 4.B and 4.G categories.
4.B	Cropland	1990-2021	CO_2	Revision of net emissions due to recalculation in 4.B. The change in the soil management (FMG) and soil land use (FLU) factors. These factors were applied according to the IPCC 2019 Refinements of methodological manuals document.
4.G	Harvested wood product	2021	CO_2	Revision of removals due to recalculations. Correction of input activity data (Wood Base Panels Production - year 2021).
4.B	Inconsistencies in the area of cropland between table 4.1 and 4.B	2008	CO_2	A small inconsistency in the area of cropland between table 4.1 and 4.B for the year 2008 was corrected.
5. WASTE				
5.A	Solid Waste Disposal	2010-2021	CH_4	Recalculation based on revision of activity data on waste production provided by the Statistical Office of the Slovak Republic and Ministry of the Environment of the Slovak Republic.
5.B	Composting of the Municipal Waste	2010-2021	CH_4, N_2O	This recalculation is connected with the correction of activity data of composting of municipal waste in 2010 – 2021. The revision of new data is connected with data refinement provided by the Statistical Office of the Slovak Republic.
5.C	Waste Incineration without Energy Use: 5.C.1.1.b (biogenic) and 5.C.1.2.b (non-biogenic)	1990-2021	CO_2, CH_4, N_2O	Emissions of CO_2, CH_4 and N_2O were recalculated for all-time series 1990 – 2021 due to new methodology implemented based on improved statistical information on incinerated waste. These recalculations increased biogenic as well as non-biogenic GHG emissions in equivalents.
5.D	Industrial and Domestic Wastewater	1990-2021	CH_4, N_2O	Recalculations based on the implementation of the 2019 IPCC Refinement Guidelines, which caused slight changes in the resulting values throughout the time series. Actual value for protein consumption for 2021 was updated in calculation.

CHAPTER 11. KP-LULUCF

No information required under this submission in this chapter.

CHAPTER 12. INFORMATION ON ACCOUNTING OF KYOTO UNITS

No information required under this submission in this chapter. Slovakia submitted on October 19, 2023, Report upon Expiration of the Additional Period for Fulfilling Commitments for the Second Commitment Period of the Kyoto Protocol. The report contained the information required to be reported upon the expiration of the additional period for fulfilling commitments for the second commitment period of the Kyoto Protocol. This report of the True-Up Period was reviewed by an expert review team in accordance with the “Guidelines for review under Article 8 of the Kyoto Protocol”. The review took place from 19 to 23 February 2024 in Bonn.

The draft review report was received for comments on March 11, 2024. The draft report did contained any findings or discrepancies and was approved by the NFP of Slovakia without comments.

12.1. Background Information for the Second Commitment Period

12.1.1. Identification of base years of Slovakia for the second commitment period

Information can be find in the National Inventory Report of Slovak Republic published on April 13, 2023.

12.1.2. Agreement under Article 4 of the Kyoto Protocol for the Second Commitment Period

Information can be find in the National Inventory Report of Slovak Republic published on April 13, 2023.

12.1.3. Calculation of the assigned amount pursuant to Article 3, paragraphs 7bis, 8 and 8bis

Information can be find in the National Inventory Report of Slovak Republic published on April 13, 2023.

12.1.4. Difference between the Assigned Amount for the Second Commitment Period and the Average Emissions for the First Three Years of the Preceding Commitment Period

Information can be find in the National Inventory Report of Slovak Republic published on April 13, 2023.

12.2. Summary of Information Reported in the SEF Tables

The standard electronic format (SEF) tables are providing information on AAUs, ERUs, RMUs, CERs, lCERs and tCERs in the Slovak National Emission Registry. SEF tables covering year 2022 in format respecting both first and second commitment period (RREG1_SK_2023_1_2.xlsx and RREG1_SK_2023_2_1.xlsx) are included in the submission. The tables include all required information on Kyoto units concerning first and second commitment period in the Slovak National Emission Registry during the reported period as well as information on transfers of these units during the reported period to and from other Parties of the Kyoto Protocol. SEF tables have been filled automatically respecting all requirements and guidance and have been checked for completeness and consistency.

12.3. Discrepancies and Notifications

To minimize discrepancies, internal checks and routines are implemented, including:

- Checks concerning the handling of tCERs and lCERs (such as replacement, expiry date change, cancellations),
- Checks concerning carry-over procedures,
- Checks concerning the handling of notifications,
- Checks concerning net source cancellations and non-compliance cancellations and other procedures that are performed after notification from the ITL,
- Commitment period reserve checks.

Measures to deal with discrepancies, measures to prevent or handle communication problems and measures to prevent the reoccurrence of discrepancies have been established and implemented in order to correct problems in the event of a discrepancy or a communication problem.

During the reported period no discrepant transactions were identified in the Slovak National Emission Registry, no CDM notifications were received, no non-replacements occurred and no invalid units were identified. Therefore no additional actions or changes to established measures were necessary to be undertaken in order to address discrepancies.

12.4. Publicly Accessible Information

Public information is accessible on the National Registry Administrator's webpage and it includes non-confidential information as stated in UN and EU legislation, especially account information, Joint Implementation project information, overall unit holdings and overall transaction information, authorized legal entities information and compliance information.

12.5. Calculation of the Commitment Period Reserve (CPR)

Information can be find in the National Inventory Report of Slovak Republic published on April 13, 2023.

CHAPTER 13. INFORMATION ON CHANGES IN NATIONAL SYSTEM

The regular update of the SVK NIS with all qualitative and quantitative indicators is provided in the NIRs and was provided in the Eight National Communication of the SR on Climate Change, published in February 2023 and in the Fifth Biennial Report in 2023.

There were no significant changes in the arrangement of the National Inventory System of the Slovak Republic during inventory preparation year 2023. National Inventory System description is provided in **Chapter 1.2**.

However, several changes occurred during the year 2023 in the expert team due to including trainees and newcomers into the internal team of SVK NIS. However, the SVK NIS is continuing in the process of strengthening capacity among the national system in line with the improvement and prioritization plans. The uncertainties calculations were previously based on external cooperation, now (since the year 2021), an internal expert is responsible for all sectors across inventory. In addition, a new expert was involved in the cropland category to strengthen new calculations on land-based matrix and new expert was involved into agricultural team.

During previous years, the several new institutions were involved in the inventory, among others in transport (Control and Testing Body for road vehicles), Ministry of Transport of the Slovak Republic – Section of Buildings (for buildings energy balance mostly focusing of residential heating and cooling), State Nature Protection Body (for wetlands identification), new internal (SHMÚ) expert on emission projections and emissions estimation in household sector.

Figure and Tables in **Chapter 1.2.5** provide more information on actual structure and functions of the SVK NIS and changes.

CHAPTER 14. INFORMATION ON CHANGES IN NATIONAL REGISTRY

14.1. Changes in the National Registry

The EU Member States who are also Parties to the Kyoto Protocol plus Iceland, Liechtenstein and Norway decided to operate their registries in a consolidated manner in accordance with all relevant decisions applicable to the establishment of Party registries - in particular Decision 13/CMP.1 and decision 24/CP.8. The consolidated platform which implements the national registries in a consolidated manner (including the registries of Slovakia and EU) is called Consolidated System of EU registries (CSEUR).

The following changes to the national registry of Slovakia have occurred in the reported period:

REPORTING ITEM	DESCRIPTION
15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	No changes regarding name or contact occurred during reported period.
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No changes regarding cooperation arrangement occurred during reported period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	There have been five new EUCR releases in production (versions 13.10, 13.10.2, 13.10.3, 13.10.4 and 13.11.2) after version 13.8.2 (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.

REPORTING ITEM	DESCRIPTION
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	The changes that have been introduced with versions 13.10, 13.10.2, 13.10.3, 13.10.4 and 13.11.2 compared with version 13.8.2 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 to 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 of the registry internet address occurred 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 regarding test results occurred during reported period.

CHAPTER 15. INFORMATION ON MINIMIZATION OF ADVERSE IMPACTS IN ACCORDANCE WITH ARTICLE 3, PARAGRAPH 14

Implementation of increasingly stringent environmental regulations and economic policies, which penalize further use of environmentally harmful substances, technologies and might be associated with a range of side effects. It is not excluded that some of possible adverse economic effects will affect some developing and least developed countries having less means for adequate remedial response measures. The magnitudes of these potential impacts are typically given by the stringency of adopted measures, selection of the particular policy instrument, size and strength of the implementing economy relative to the world markets and the actual macroeconomic set up of the affected developing countries.

In this chapter was updated based on the 5th Biennial Report of Slovakia to the UNFCCC and identified potential channels of how domestically implemented environmental policies in the Slovak Republic might have exercised any impact on third countries. Furthermore, any existing evidence about the potential magnitudes of these effects is highlighted. Similarly, the activities in particular those related to the development aid of the Slovak Republic implemented in order to minimize the negative consequences caused by these policies are described in this chapter. The aim is to meet our commitments under the

Kyoto Protocol in respect with transparent reporting on potential adverse social, environmental and economic impacts particularly on developing countries.

Economic Impacts

Although the Slovak economy has decarbonized significantly in the last thirty years, further decarbonisation is needed. Slovakia went through a period of abrupt decarbonisation in the 1990s and 2000s that was caused by the changing structure of the economy, and technology improvements. Regardless of the improvements achieved so far, further decarbonisation is needed to contribute to the EU-wide decarbonisation goals in 2030 – decrease greenhouse gases by 55% compared to 1990 levels. This equals to abating an additional 6.3 million tonnes of CO_2 equivalent annually by 2030 (approximately 15% of current gross emissions). To model the most cost-effective path of decarbonisation, the first Slovak marginal abatement cost curve (MACC) was constructed. MACC compares various decarbonisation measures from all sectors of the economy by their price for a ton of CO_2 equivalent abated, and their abatement potential in 2030. Three emission-reduction goals were identified as follow: 55%, 67%, and 76% based on the MACC. These goals together with needed levers are discussed below in turn. Slovakia is close to achieving the EU-wide "Fit for 55" target to reduce emissions by 55% (6.3 Gg of CO_2 equivalents) in 2030 compared to the 1990 levels. While there is not yet an official target for Slovakia, a 55% reduction is achievable at a societal net cost (including public and private spending) of 2.7 billion EUR by 2030, via cost-effective levers below 30 EUR per ton of CO2 equivalent (many of which have a negative price). Nevertheless, these levers are individually small and require complex implementation efforts across many stakeholders. Therefore, Slovakia should aim also beyond the 55% target and implement additional levers. Electrification of the steel sector is the key in the push for decarbonisation beyond the "Fit for 55" target. Currently the most polluting industry, it has many levers available that enable deep decarbonisation even without implementing carbon capture and storage (CCS). Electrification and efficiency improvements of the steel sector can abate in total of 6.2 Gg of CO_2 equivalents per year, additional levers across industries before the CCS could abate 1.7 Gg of CO_2 equivalents by 2030. The societal net cost would reach approximately 5 billion EUR by 2030. In total, this would lead to a 67% decrease compared to 1990. Reaching the full 2030 decarbonisation potential requires significant CCS investments. The key lever beyond 14.2 Gg of CO_2 equivalents abatement is the carbon capture and storage technology implemented across key point emitters to capture their remaining emissions. However, investing in CCS is CAPEX-intensive and would require significant political and societal efforts, including implementing supporting regulations. Total abatement compared to 1990 after implementing all the available levers would be 76% at a societal cost of over 13.5 billion EUR. Slovakia has a low-carbon electricity mix and expected electricity oversupply to support decarbonisation. Slovak low emissions intensity electricity creates suitable conditions for decarbonisation via electrification of the key sectors (e.g. transport and steel) as it will not result in significant secondary GHG emissions. With the decommissioning of Nováky and Vojany coal power plants, and the opening of nuclear power plants Mochovce 3 & 4, Slovakia will decarbonize its electricity generation even further (achieving ~90 ton of CO2 equivalent/GWh) and will secure sufficient electricity supply to fulfil an increased demand from decarbonisation levers (e.g. electric arc furnaces). The MACC was constructed before the Russian invasion of Ukraine, but its conclusions remain relevant. The invasion motivated the EU to rapidly reduce dependence on Russian fossil fuels by increasing energy efficiency, which is fully in line with the measures suggested by this study. Importantly, as outlined in the REPowerEU plan, the EU climate targets are not jeopardized by the new geopolitical situation. The study was prepared in a joint collaboration of Value for Money Department, Ministry of Finance (ÚHP), Institute for Environmental Policy (IEP), and Boston Consulting Group (BCG) during October and November 2021. The work was conducted via a joint project team composed of the authors of this study. During the MACC modelling, the authors used various internal and external benchmarks (including BCG proprietary databases and tools).

REFERENCES

GENERAL

2006 IPCC Guidelines for National Greenhouse Gas Inventories

2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands

2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol

Statistical Office of the Slovak Republic (updated every year).

Gera, M.; Bastak, I.; Gerova, E.; Kremler, M.; Szemesova, J. Climatologic Data Downscaling with Dynamical Adaptation for Purpose of Pollutant Spreading Analysis EMS Annual Meeting- ECAS 2008, 8th Annual Meetin of the European Meteorological Society, 7th European Conference on Applied Climatology" (ECAS), 29.9.-3.10.2008, Amsterdam, Abstracts, Vol. 5, 2008, ISSN 1812-7053.

Good Practices in the Slovak Republic with decoupling of the GHG Emission Growth Rate from Economic Development Slovak Hydrometeorological Institute, Ministry of the Environment, Bratislava, July 2008.

Report on the Estimation of Assigned Amount Units under the Kyoto Protocol revised version according FCCC/IRR/2007/SVK from July 2007, MZP SR and SHMU, Bratislava 2007.

The Fourth National Communication of the SR on Climate Change and Report on Demonstrable Progress of the SR to Achieve Commitments under the Kyoto Protocol the Ministry of Environment of the SR, Slovak Hydrometeorological Institute, Bratislava 2005.

The Fifth National Communication of the SR on Climate Change the Ministry of Environment of the SR, Slovak Hydrometeorological Institute, Bratislava 2009.

The Sixth National Communication of the SR on Climate Change the Ministry of Environment of the SR, Slovak Hydrometeorological Institute, Bratislava 2013.

The Seventh National Communication of the SR on Climate Change the Ministry of Environment of the SR, Slovak Hydrometeorological Institute, Bratislava 2018.

The Eight National Communication of the SR on Climate Change and the Fifth Biennial Report of the SR, Bratislava 2023.

IPCC Fifth Assessment Report, Chapter 8, 2014.

CHAPTER 3 – ENERGY

2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Energy 2022, Statistical Office of Slovak Republic (2023) ISBN: 978-80-8121-918-4.

COPERT 5 Computer programme to calculate emissions from road transport - User manual.

Szemesová, J.; Zemko, M.; Petraš, M.; Frankovič, B.: Assessment of the statistical survey on heating systems and fuels consumption in households. Slovenská štatistika a demografia 3/2021.

Szemesová, J.; Jonáček, Z.; Horváth, J.; Zetochová, L.; Labovský, J.: Improving the allocation of road transport emissions in AEA module and coherence between AEA and PEFA modules. Conference on Air protection. Proceedings 2021.

Horváth, J, Szemesová J. and Zetochová, L.: Štatistické odchýlky v údajoch o motorových palivách. Slovenská štatistika a demografia 1/2021.

Horváth, J., Mačala, J. Szemesová, J., Zetochová, L. Scrapping or not scrapping: About whether grants for scrapping and electromobility are effective. Air protection proceedings 2018.

Eva Krtková, Vladimir Danielik, Janka Szemesová, Klára Tarczay, Gábor Kis-Kovács and Vladimir Neuzil, Non-Energy Use of Fuels in the Greenhouse Gas Emission Reporting, Atmosphere 2019, 10, 406; doi:10.3390/atmos10070406.

Ntziachristos, L., Samaras, Z. EMEP/EEA air pollutant inventory guidebook 2023 on Passenger cars, light commercial vehicles, heavy duty vehicles including buses and motor cycles. European Environmental Agency 2019.

Horváth, J.; Szemesová, J.; Zetochová, L.: Roadmap to zero carbon road transport, Proceedings of the 24th International Transport and Air Pollution (TAP) Conference. 2022.

Horváth, J.; et. al: Results of the Eurostat project: New methodology for the Allocation of Emissions from Transport. International Conference Air Protection, High Tatras, 2022.

Jonáček, Z.; et. al.: Integrated Project LIFE AQI - Statistical Survey on the Use of Combustion Devices and Fuels Consumption in Households for the year 2022. International Conference Air Protection, High Tatras, 2022.

Horváth, J.; Szemesová, J.; Jonáček, Z.; Transport emission footprint in the Slovak economy, Proceedings of the 25th International Transport and Air Pollution (TAP) and the 3rd Shipping & Environment (S&E) Conference, 2024.

CHAPTER 4 – INDUSTRIAL PROCESSES

Tomlein, P.; Tomlein M.: Refrigerants Logging and Reporting - Abstract from the IIR Conference on Sustainable Refrigeration and Heat Pump Technology, Stockholm Sweden 2010.

Tomlein, P.: Data collection system in Slovakia and why we consider Articles 5 and 18 of the F-gas proposal to be relevant, Presentation 2013.

Tomlein P., Tomlein Mi., Tomlein Ma.: Reporting System Based on Company Certification in Refrigeration Industry, Abstract, 2012.

Tomlein, P.: Inspection System on cooling circuits, in: IIR Compressors, Papiernička, 2004.

Tomlein, P.: Refrigerants logging and reporting, in: IIR Conference on Sustainable Refrigeration and Heat Pump Technology, Stockholm, Sweden, 2010.

CHAPTER 5 – AGRICULTURE

The Intergovernmental Panel on Climate Change, Agriculture, 2006 IPCC Guidelines for National Greenhouse Gas Inventory, Vol.4 Agriculture, Forestry and Other Land Use Methodology, Chapter 11 N_2O emissions from managed soils, and CO_2 emissions from lime and urea application ,Institute for Global Environmental Strategies, Hayama, Japan ISBN4-87888-032-4, 2006.

Green Report 2022 (Zelená správa 2021). The Ministry of Agriculture and Rural Development of the Slovak Republic 2020.

List of Livestock to the 31.12.2021, (Súpis hospodárskych zvierat k 31.12.2021). Statistical Office of the Slovak Republic.

Crop yields data for crops and vegetables in 2021 (Definitívne údaje o úrode poľnohospodárskych plodín a zeleniny v SR za rok 2020). Statistical Office of the Slovak Republic.

Animal production, sales of agricultural products from the primary production and crop balance in 2020 (Živočíšna výroba, predaj výrobkov z prvovýroby a bilancia plodín za rok 2020). Statistical Office of the Slovak Republic.

Nitrates Directive (Dusičnanová smernica). Ministry of Environment of the Slovak Republic.

The animal production, sales of primary production and crop balance. Statistical Office of the Slovak Republic.

Bielek, P.: Nitrogen in Agricultural Soils of the SR. Research institute of soil fertility Bratislava, 1998, ISBN: 80-85361-44-2 (in Slovak).

EUROSTAT: European Statistics code of practice, 2011, ISBN 978-92-79-21679-4, doi: 10.2785/18474

Bezák, P.: Guidelines for the Sewage Sludge Application (Príručka pre aplikáciu kalu z čistiarní odpadových vôd do poľnohospodárskej pôdy) (in Slovak). Bratislava 2010.

Tonhauzer, K.; Zetochová, L.: Comparison of the FAO GHG database and the Slovak greenhouse gas inventory activity data and emissions in agriculture. Meteorologický časopis, 20, 1, s. 3-9. ISSN 1335-339X, 2017.

Tonhauzer, K.; Tonhauzer, P.; Szemesová, J.; Šiška, B.: Estimation of N_2O emissions from the agricultural soils and determination of nitrogen leakages. Atmosphere. Land-Atmosphere Interactions: Biogeophysical and Biogeochemical Feedbacks, 2020, Zv. 11 (6).

Brouček, J.; Brestenský V.; Palkovičová Z.: Differences in amounts of methane emissions from enteric fermentation from Slovak ewe farming between 2015 and 2016. Ecology & Safety, ISSN 1314-7234, Volume 12, 2017.

Petrikovič, P.; Heger, J.; Sommer A.: Nutrition for Pigs. Research Institute of animal production, 2005, ISBN 80-88872-45-6 in Slovak.

Strauch, D.; Baader, W.; Tietjen, C.: Waste from agricultural production. Ulmer Eugen Verlag, ISBN-978-3800143283, 1995, in German.

Perikovič, P.; Sommer, A.: Nutrition for Cattle. Research Institute for animal production. ISBN: 80-88872-21-9, 2002, in Slovak.

Jančová, M.: Growing and Utilization of Grassland and Clover grassland on Arable Land of Foothill and Mountain Areas. National Agriculture and Food Centre ISBN 978-80-89800-09-4, 2016, in Slovak.

Torma, S.; Vilček, J.: Postharvest residues of sugar beet and their role in the nutrient cycle. Listy Cukrovarnické a Reparské; Prague Vol. 133, Is. 9-10, p. 285-287, 2017, in Slovak.

FAOSTAT: Crops and livestock products, Fertilizers by Nutrient, Milk Production. Food and Agriculture Organization of the United Nations.

IFASTAT: Fertilizer consumption - statistical information on fertilizer & raw materials. International Fertilizers Association.

PLIS: Body weight, Pregnancy of animals, Information System about Breeds.

Lošák, T.; Dostál, J.: Digestát vo výžive a hnojení repky, Mendel university in Brno.

Gáborík, Š.: Dusíkaté hnojenie po zbere obilnín, The Central Control and Testing Institute in Agriculture.

Brestenský, V.; a kol. 2015. Chov hospodárskych zvierat. [Online] Národné poľnohospodárske a potravinárske centrum - Výskumný ústav živočíšnej výroby Nitra, 2015. [Dátum: 13. Marec 2019.] http://www.vuzv.sk/pdf/chov_hz.pdf. ISBN 978-80-89418-41-1.

Brestenský, V.; Botto, Ľ.: 2015. Odstraňovanie a skladovanie hospodárskych. Nitra : Agroinštitút Nitra, 2015.

PPA, 2015. Guidelines for the support for selected non-project measures, Bratislava, The Agricultural Paying Agency

Green Report 2023 (Zelená správa 2023). The Ministry of Agriculture and Rural Development of the Slovak Republic.

Barančíková, G.; Makovníková, J.; Skalský, R.; Tarasovičová, Z.; Nováková, M.; Halás, J.; Koco, Š.; Gutteková, M. 2013: Changes in organic carbon pool in agricultural soils and its different development in individual agro-climatic regions of Slovakia. Agriculture (Poľnohospodárstvo), vol. 59, 2013, no. 1, pp. 9–20.

Barančíková, G.; Makovníková, J.; Halas, J. 2016: Effect of land use change on soil organic carbon. Agriculture (Poľnohospodárstvo), vol. 62, 1, pp. 10-18.

Bielek, P.; Jurčová, O. 2010: Metodika bilancie pôdnej organickej hmoty a stanovenie potreby organického hnojenia poľnohospodárskych pôd. Bratislava: VÚPOP, 2010. 145 s. ISBN 978-80-89128-80-8.

Cienciala, E.; Černý, E.; Tatarinov, F.; Apltauer, J.; Exnerová, Z. 2006: Biomass functions applicable to Scots pine. Trees 20:483–495.

Cienciala, E.; Apltauer, J.; Exnerová, Z.; Tatarinov, F. 2008: Biomass functions applicable to oak trees grown in central-european forestry. Journal of Forest Science 54:109–120.

Cienciala, E.; Palán, Š. 2014: Methodological background for quantification of CO_2 originating from changes in the pool of harvested wood products. Report for the Czech Ministry of the Environment, 26 pp (In Czech).

Halaj, J.; Petráš, R. 1998: Rastové tabuľky hlavných drevín/Yield tables of main tree species. Bratislava, Slovak Academic Press, 325 p.

Kobza, J.; Barančíková, G.; Cepková, V.; Došeková, A.; Fulajtár, E.; Houšková, B.; Makovníková, J.; Matúšková, L.; Medveď, M.; Pavlenda, P.; Schlosserová, J.; Styk, J.; Vojtáš, J. 2002: Soil monitoring of the Slovak republic - present state and development of monitored soil properties 1997-2001. Bratislava, Soil Science and Conservation Research Institute, 178 pp. (in Slovak).

Kobza, J.; Barančíková, G.; Čumová, L.; Dodok, R.; Hrivňáková, K.; Makovníková, J.; Náčiniaková - Bezáková, Z.; Pálka, B.; Pavlenda, P.; Schlosserová, J.; Styk, J.; Širáň, M.; Tothová, G. 2009: Soil monitoring of the Slovak republic - present state and development of monitored soil properties 2002 – 2006, Bratislava, Soil Science and Conservation Research Institute, 200 s. (in Slovak).

Kobza, J.; Barančíková, G.; Dodok, R.; Hrivňáková, K.; Makovníková, J.; Pálka, B.; Pavlenda, P.; Schlosserová, J.; Styk, J.; Širáň, M. 2014: Soil monitoring of the Slovak republic - present state and development of monitored soil properties 2007 – 2012. Bratislava, Soil Science and Conservation Research Institute, 249 s. (in Slovak).

Lehtonen, A.; Cienciala, E.; Tatarinov, F.; Mäkipää, R. 2007: Uncertainty estimation of biomass expansion factors for Norway spruce in the Czech Republic. Annals of Forest Science 64(2): p. 133-140.

Pajtík, J.; Konôpka, B.; Lukáč, M. 2011: Individual biomass factors for beech, oak and pine in Slovakia: a comparative study in young naturally regenerated stands. Trees 25, p. 277-288.

Pavlenda, P. 2008: Quantification of carbon stocks in forest soils. In: Kobza, J. (Ed.): Piate pôdoznalecké dni. Pôda - národné bohatstvo. Zborník z medzinárodnej konferencie, Bratislava: VÚPOP, 2013, s. 243-250 (in Slovak).

Pavlenda, P.; Capuliak, J.; Pavlendová, H. 2015: Soil Organic Carbon and Land Use Change: Can We Detect Soil Density Increase? Pedometrics 2015. 14-18 September, IUSS, University of Cordoba, Spain, p. 184.

Pavlenda, P.; Priwitzer, T.; Capuliak, J.; Šebeň, V.; Bošeľa, M.; Pajtík, J.; Raši, R.; Pavlendová, H. 2016: Proposal for improvement of input data and procedures in the national methodology of greenhouse gases inventory in the LULUCF sector. Applicable deliverable of the project APVV-0243-11 Evaluation and modelling of carbon stocks in forest ecosystems for GHG inventory in the country (C-FORLAND), NFC, 20 pp. (in Slovak).

Petráš, R.; Pajtík, J. 1991: Sústava česko-slovenských objemových tabuliek drevín./The system of Czecho-Slovak tree species volume tables. Lesnícky časopis, 37, (1), p. 49-56.

Požgaj, A.; Chovanec, D.; Kurjatko, S.; Babiak, M., 1993: The Structure and properties of wood. Príroda, Bratislava, 468 pp. 1993, (in Slovak).

Priwitzer, T.; Pajtík, J.; Konôpka, B.; Ištoňa, J.; Pavlenda, P. 2008: Quantification of carbon stocks in the model ecosystems of first age class. Lesn. Čas. Forestry Journal, 54, Supplement, 1, 2008, p. 69 – 79. (in Slovak with English summary).

Priwitzer, T.; Pajtík, J.; Konôpka, B.; Ištoňa, J.; Pavlenda, P. 2009: Carbon allocation in forest ecosystem – case studies from young pine stands. Lesn. Čas. – Forestry Journal, 55(3): p. 239 – 250, (in Slovak with English summary).

Raši, R.; Cienciala, E.; Priwitzer, T.; Palán, Š.; Pavlenda, P. 2015: Bilancia uhlíka v drevných produktoch na Slovensku (Carbon balance in harvested wood products in Slovakia), Lesn. Cas. For. J., 61(2015) 101–106.

Stanová, V., (ed) 2000: Rašeliniská Slovenska. DAPHNE – Inštitút aplikovanej ekológie, Bratislava, 194.

Šály, R. 1998: Pedology and microbiology, 1998, TU Zvolen, Zvolen, in Slovak.

Šebeň, V. 2017: Národná inventarizácia a monitoring lesov SR 2015-2016. Informácie, metódy, výsledky. (National forest inventory and monitoring SR 2015-2016. Information, methods, results) Lesnícke štúdie 65/2017. Národné lesnícke centrum – Lesnícky výskumný ústav Zvolen, 256 p. (in Slovak).

Šebík, L.; Polák, L. 1990: The theory about wood production. Bratislava, Príroda: 322 pp., 1990, in Slovak.

Šmelko, Š. 2000: Dendrometry. TU Zvolen, Zvolen, 399 p., 2000, in Slovak.

Šmelko, Š.; Scheer, Ľ.; Petráš, R.; Ďurský, J.; Fabrika, M. 2003: Measurement of forest and wood. Ústav pre výchovu a vzdelávanie pracovníkov LVH SR, Zvolen, 239 p. (in Slovak).

Šmelko, Š.; Šebeň, V.; Bošela, M.; Merganič, J.; Jankovič, J. 2008: National forest inventory and monitoring of the Slovak republic 2005-2006. Basic concept and selected summary information, NFC-FRI Zvolen, Zvolen, 15 p.

Šmelko, Š.; Šebeň, V.; Priwitzer, T. 2011: Determination of dry wood density and carbon stock in aboveground dendromass from sampling forest inventory in mountain forest ecosystem of the Biosphere Reserve Poľana. Lesn. Čas. – Forestry Journal, 57(2): p. 87–95.

Tóth, G.; Jones, A.; Montanarella, L. (Eds.) 2013: LUCAS TOPSOIL SURVEY - methodology, data and results. Luxembourg: Publications Office of the European Union, 2013. ISBN 978-92-79-32542-7.

Torma, S.; Vilček, J. 2017: Rastlinné zvyšky poľnohospodárskych plodín po zbere úrody – zdroj organickej hmoty. In: Moderná mechanizácia, roč. 20, č.3, s. 22-23. ISSN 1335-6178.

Wirth, C.; Schumacher, J.; Schulze, E. D. 2004: Generic biomass for Norway spruce in central Europe. A meta-analysis approach toward prediction and uncertainty estimation. Tree Physiology 24:121–139.

Wutzler, T.; Wirth, C.; Schumacher, J. 2008: Generic biomass functions for Common beech (Fagus sylvatica L.) in Central Europe - predictions and components of uncertainty. Canadian Journal of Forest Research, 38(6), 1661–1675.

CHAPTER 7 – WASTE

MŽP SR Stratégia obmedzovania ukladania biologicky rozložiteľných odpadov na skládky odpadov Bratislava, XII. 2010.

Báreková, A.: Skúsenosti z realizácie projektu odpadového hospodárstva pre regionálne združenie obcí, TVIP 2014 Hustopoče IV.2014.

Priatelia Zeme SPZ Kompostovanie – Príručka o zbere a zhodnocovaní biologických odpadov, VII.2005.

Kaufman, P.: Metodika analýzy zloženia komunálneho odpadu, SPU Nitra 2009.

Veverka, M.; Lešinský, D.: Analýza stavu a vývoja nakladania s komunálnym odpadom na Slovensku. CEPTA Zvolen 05/2013.

Wagnerová, E.; Uríček, D.: Kogenerace - plyn z TKO ako zdroj energie. Alternatívni energie 5/2005.

MŽP SR Program odpadového hospodárstva SR na roky 2016 – 2020, Bratislava, X. 2015.

Gera, M.; Szemesova, J.: Uncertainty Analysis for Estimation of Landfill Emissions and Data Sensitivity for Input Variation, 2nd International Workshop on Uncertainty in Greenhouse Gas Inventories, International Institute for Applied Systems Analysis A-2361 Laxenburg, Austria, 27.-28.10. 2007.

Slovak Environmental Agency, Database of Waste Management Centre, MŽP Department of waste management, 2008.

Szemesová J.; Gera M.: Uncertainty Analysis for Estimation of Landfill Methane Emissions Contribution to Geophysics and Geodesy, SAS, Vol 37, No 3, 251 – 265, 2007.

Szemesová, J.; Gera, M.: Emission estimation of solid waste disposal sites according to the uncertainty analysis methodology, Bioclimatology and Natural Hazards, ISBN 978-80-228-17-60.

Szemesová J.; Gera M. Uncertainty analysis for estimation of landfill emissions and data sensitivity for the input variation, Climatic Change DOI 10.1007/s10584-010-9919-1, 2010.

Bodík, I.; Hutňan, M.; Sedláček, S.; Lazor M.: Možnosti a perspektívy zvyšovania produkcie bioplynu na komunálnych ČOV s prídavkom externých substrátov, 2009. (Potential and perspectives for increase of biogas generation in municipal WWTP by addition external substrates), in Slovak language only.

Štátny Geologický ústav Dionýza Štúra: Register Skládok odpadov, State Geological Institute of Dionýz Štúr: Disposal sites Registry.

Štatistický Úrad SR: Štatistické ročenky SR, ČSSR, ČSFR za roky 1950 – 2015 (Statistical office of the Slovak Republic: Statistical Yearbooks of Slovakia, Czechoslovak Socialistic Republic and Czech and Slovak Federative Republic Waste Yearbook 1992 -2015).

Bodík, I.; Kubaská, M.: Municipal Sewage Sludge Management in the Slovak Republic, Actual Status and Perspectives, Journal of Residuals Science & Technology, Vol. 10, No. 4 October 2013.

Drahovská, D.; Kozáková, K.; Miháliková, M.; Kohút, M.: Pokrok v zbere, odvádzaní a čistení komunálnych odpadových vôd. In: Zborník konferencie Odpadové vody 2020, AČE SR 2020.

Škôrňová, J.; Korpicsová, A.: Hodnotenie vypúšťaných odpadových vôd na Slovensku za rok 2019. In: Zborník konferencie Odpadové vody 2020, AČE SR 2020.

Kozáková, K.; Sumegová, L.: Produkcia kalov z komunálnych ČOV a nakladanie s nimi. In: Zborník konferencie Kaly a odpady 2020, AČE SR 2020.

Bodík, I.; Mrafková, L.; Szemesová, J.: Odpadové vody ako zdroj emisií skleníkových plynov (Wastewater, a Source of GHG Emissions). 12th Biannual Conference Wastewater 2022.

Bartman et al.: Wastewater Treatment and Discharge. IPCC Guidelines for National Greenhouse Gas Inventories, IPCC Refinements 2019.

Law, Y., Jacobsen, G.E., Smith, A.M., Yuan, Z. & Lant, P. (2013) Fossil organic carbon in wastewater and its fate in treatment plants. Water Research 47(14): 5270-5281.

Griffith, D.R., Barnes, R.T. & Raymond, P.A. (2009) Inputs of Fossil Carbon from Wastewater Treatment Plants to U.S. Rivers and Oceans. Environmental Science & Technology 43(15): 5647-5651.

ANNEX 1. KEY CATEGORIES

Description of methodology used for identifying key categories:

This Annex describes and completed the methodology used to identify key categories. The level of disaggregation is based on the recommendation in the IPCC 2006 GL.

Key categories analysis for the year 2022 according to Approach 1 and Approach 2 (including uncertainties) (IPCC 2006 GL and IPCC 2019 Refinement) was performed with and without LULUCF by level and trend assessments.

By level assessment Approach 1, 29 key categories with LULUCF and 25 without LULUCF were identified and by level assessment Approach 2, 17 key categories with LULUCF and 20 without LULUCF were identified in 2022.

By trend assessment Approach 1, 34 key categories with LULUCF and 29 without LULUCF were identified and by trend assessment Approach 2, 19 key categories with LULUCF and 25 without LULUCF were identified.

The final results are presented in ***Tables A1.1 - A1.4*** and according to the ERT recommendation G.5 from the draft ARR 2022, the summaries are presented in ***Tables A1.5 - A1.6***.

Analysis for the base year 1990 was performed by level assessment and 31 key categories with LULUCF and 26 without LULUCF were identified by Approach 1 and 20 key categories with LULUCF and 19 without LULUCF were identified by Approach 2.

The results are presented in ***Table A1.7*** and ***Table A1.8*** and the summary is presented in ***Table A1.9***.

More information on key categories and uncertainty assessment can be found in **Chapters 1.2.12** and **1.2.13** of this Report.

Table A1.1: *Key categories identified using Approach 1 and Approach 2 by level assessment (L1 & L2) with LULUCF in 2022*

IPCC CATEGORY CODE	IPCC CATEGORY	GAS	EMISSIONS/ REMOVALS 2022	LEVEL ASSESSMENT L1	CUMULATIVE TOTAL	KEY IN LEVEL ANALYSIS
2.F.1	Refrigeration and Air conditioning	HFCs	447.37	0.01	0.01	YES
1.A.1	Fuel combustion - Energy Industries - Liquid Fuels	CO_2	1 427.35	0.03	0.04	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	2 730.23	0.06	0.10	YES
1.A.1	Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	2 033.13	0.05	0.15	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	256.68	0.01	0.16	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	3 228.99	0.07	0.23	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	2 090.31	0.05	0.28	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	297.94	0.01	0.28	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	7 583.91	0.17	0.45	YES
1.A.4	Fuel combustion - Other Sectors - Liquid Fuels	CO_2	262.28	0.01	0.46	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CO_2	415.31	0.01	0.47	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	3 852.64	0.09	0.56	YES
2.A.1	Mineral Industry - Cement Production	CO_2	1 489.72	0.03	0.59	YES
2.A.2	Mineral Industry - Lime Production	CO_2	532.42	0.01	0.61	YES
2.A.4	Mineral Industry - Other Process Uses of Carbonates	CO_2	294.24	0.01	0.61	YES
2.B.1	Chemical Industry - Ammonia Production	CO_2	637.81	0.01	0.63	YES
2.B.8	Chemical Industry - Petrochemical and Carbon Black Production	CO_2	349.63	0.01	0.64	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	3 324.10	0.07	0.71	YES
4.A.1	Forest Land - Forest Land Remaining Forest Land	CO_2	-6 304.61	0.14	0.86	YES
4.A.2	Forest Land - Land Converted to Forest Land	CO_2	-339.04	0.01	0.86	YES
4.B.1	Cropland - Cropland Remaining Cropland	CO_2	-690.43	0.02	0.88	YES
1.A.4	Fuel combustion - Other Sectors - Biomass	CH_4	7.73	0.00	0.89	YES
1.B.1	Fugitive emissions from fuels - Solid Fuels	CH_4	6.43	0.00	0.90	YES
3.A	Enteric Fermentation	CH_4	36.75	0.02	0.93	YES
5.A	Solid Waste Disposal	CH_4	43.11	0.03	0.96	YES
5.B	Biological Treatment of Solid Waste	CH_4	8.56	0.01	0.96	YES
5.D	Wastewater Treatment and Discharge	CH_4	9.54	0.01	0.97	YES
3.B	Manure Management	N_2O	0.68	0.00	0.98	YES
3.D.1	Direct N_2O Emissions From Managed Soils	N_2O	1.71	0.01	0.99	YES

IPCC CATEGORY CODE	IPCC CATEGORY	GAS	EMISSIONS/ REMOVALS 2022	LEVEL ASSESSMENT L2	CUMULATIVE TOTAL	KEY IN LEVEL ANALYSIS
1.A.1	Fuel combustion - Energy Industries - Liquid Fuels	CO_2	1 427.35	0.01	0.01	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	2 730.23	0.01	0.02	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	3 228.99	0.02	0.05	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	7 583.91	0.04	0.10	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	3 852.64	0.01	0.12	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	3 324.10	0.02	0.15	YES
4.A.1	Forest Land - Forest Land Remaining Forest Land	CO_2	-6 304.61	0.54	0.69	YES
4.A.2	Forest Land - Land Converted to Forest Land	CO_2	-339.04	0.02	0.71	YES
4.B.1	Cropland - Cropland Remaining Cropland	CO_2	-690.43	0.05	0.76	YES
1.A.4	Fuel combustion - Other Sectors - Biomass	CH_4	7.73	0.01	0.80	YES
3.A	Enteric Fermentation	CH_4	36.75	0.02	0.83	YES
5.A	Solid Waste Disposal	CH_4	43.11	0.03	0.86	YES
5.B	Biological Treatment of Solid Waste	CH_4	8.56	0.01	0.88	YES
3.B	Manure Management	N_2O	0.68	0.04	0.94	YES
3.D.1	Direct N_2O Emissions From Managed Soils	N_2O	1.71	0.03	0.97	YES
3.D.2	Indirect N_2O Emissions From Managed Soils	N_2O	0.42	0.01	0.98	YES
5.B	Biological Treatment of Solid Waste	N_2O	0.44	0.01	1.00	YES

Table A1.2: *Key categories identified using Approach 1 and Approach 2 by level assessment (L1 & L2) without LULUCF in 2022*

IPCC CATEGORY CODE	IPCC CATEGORY	GAS	EMISSIONS/ REMOVALS 2022	LEVEL ASSESSMENT L1	CUMULATIVE TOTAL	KEY IN LEVEL ANALYSIS
2.F.1	Refrigeration and Air conditioning	HFCs	447.37	0.01	0.01	YES
1.A.1	Fuel combustion - Energy Industries - Liquid Fuels	CO_2	1 427.35	0.04	0.05	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	2 730.23	0.07	0.13	YES
1.A.1	Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	2 033.13	0.06	0.18	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	256.68	0.01	0.19	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	3 228.99	0.09	0.28	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	2 090.31	0.06	0.34	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	297.94	0.01	0.35	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	7 583.91	0.21	0.55	YES
1.A.4	Fuel combustion - Other Sectors - Liquid Fuels	CO_2	262.28	0.01	0.56	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CO_2	415.31	0.01	0.57	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	3 852.64	0.10	0.68	YES
2.A.1	Mineral Industry - Cement Production	CO_2	1 489.72	0.04	0.72	YES
2.A.2	Mineral Industry - Lime Production	CO_2	532.42	0.01	0.74	YES
2.A.4	Mineral Industry - Other Process Uses of Carbonates	CO_2	294.24	0.01	0.74	YES
2.B.1	Chemical Industry - Ammonia Production	CO_2	637.81	0.02	0.76	YES
2.B.8	Chemical Industry - Petrochemical and Carbon Black Production	CO_2	349.63	0.01	0.77	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	3 324.10	0.09	0.86	YES
1.A.4	Fuel combustion - Other Sectors - Biomass	CH_4	7.73	0.01	0.88	YES
1.B.1	Fugitive emissions from fuels - Solid Fuels	CH_4	6.43	0.00	0.88	YES
3.A	Enteric Fermentation	CH_4	36.75	0.03	0.92	YES
5.A	Solid Waste Disposal	CH_4	43.11	0.03	0.95	YES
5.B	Biological Treatment of Solid Waste	CH_4	8.56	0.01	0.96	YES
5.D	Wastewater Treatment and Discharge	CH_4	9.54	0.01	0.97	YES
3.D.1	Direct N_2O Emissions From Managed Soils	N_2O	1.71	0.01	0.99	YES

IPCC CATEGORY CODE	IPCC CATEGORY	GAS	EMISSIONS/ REMOVALS 2022	LEVEL ASSESSMENT L2	CUMULATIVE TOTAL	KEY IN LEVEL ANALYSIS
1.A.1	Fuel combustion - Energy Industries - Liquid Fuels	CO_2	3 819.21	0.03	0.03	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	12 861.05	0.08	0.11	YES
1.A.1	Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	2 293.69	0.01	0.12	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	9 028.53	0.07	0.21	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	3 930.58	0.02	0.23	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	4 503.02	0.03	0.26	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	3 634.43	0.02	0.36	YES
2.B.8	Chemical Industry - Petrochemical and Carbon Black Production	CO_2	428.80	0.01	0.38	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	4 167.97	0.03	0.42	YES
3.H	Urea Application	CO_2	15.29	0.00	0.42	YES
1.A.4	Fuel combustion - Other Sectors - Biomass	CH_4	1.45	0.00	0.46	YES
3.A	Enteric Fermentation	CH_4	111.14	0.08	0.56	YES
5.A	Solid Waste Disposal	CH_4	27.92	0.03	0.60	YES
5.B	Biological Treatment of Solid Waste	CH_4	2.60	0.01	0.61	YES
5.D	Wastewater Treatment and Discharge	CH_4	14.50	0.02	0.62	YES
1.A.3.b	Fuel combustion - Road Transportation	N_2O	0.19	0.00	0.63	YES
3.B	Manure Management	N_2O	1.96	0.17	0.82	YES
3.D.1	Direct N_2O Emissions From Managed Soils	N_2O	2.93	0.07	0.89	YES
3.D.2	Indirect N_2O Emissions From Managed Soils	N_2O	2.20	0.10	0.99	YES
5.B	Biological Treatment of Solid Waste	N_2O	0.16	0.01	0.99	YES

Table A1.3: *Key categories identified using Approach 1 and Approach 2 by trend assessment (T1 & T2) with LULUCF in 2022*

IPCC CATEGORY CODE	IPCC CATEGORY	GAS	TREND ASSESSMENT T1	CONTRIB. TO TREND %	CUMULATIVE TOTAL	KEY IN TREND ANALYSIS
2.F.1	Refrigeration and Air conditioning	HFCs	0.01	1.29	1.29	YES
1.A.1	Fuel combustion - Energy Industries - Liquid Fuels	CO_2	0.00	0.93	2.32	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	0.04	9.11	11.43	YES
1.A.1	Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	0.01	2.82	14.24	YES
1.A.1	Fuel combustion - Energy Industries - Other Fossil Fuels	CO_2	0.00	0.46	14.70	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	0.01	3.04	17.74	YES

IPCC CATEGORY CODE	IPCC CATEGORY	GAS	TREND ASSESSMENT T1	CONTRIB. TO TREND %	CUMULATIVE TOTAL	KEY IN TREND ANALYSIS
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	0.01	2.63	20.37	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	0.00	0.82	21.19	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	0.00	0.59	21.78	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	0.07	15.85	37.64	YES
1.A.3.e	Fuel combustion - Other Transportation	CO_2	0.01	2.34	40.25	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CO_2	0.03	7.84	48.10	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	0.03	6.28	54.38	YES
2.A.1	Mineral Industry - Cement Production	CO_2	0.01	2.35	57.26	YES
2.A.2	Mineral Industry - Lime Production	CO_2	0.00	0.48	57.74	YES
2.B.1	Chemical Industry - Ammonia Production	CO_2	0.01	1.40	59.43	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	0.02	4.06	64.02	YES
4.A.1	Forest Land - Forest Land Remaining Forest Land	CO_2	0.03	8.45	73.05	YES
4.A.2	Forest Land - Land Converted to Forest Land	CO_2	0.04	9.05	82.09	YES
4.B.1	Cropland - Cropland Remaining Cropland	CO_2	0.01	2.23	84.32	YES
4.B.2	Cropland - Land Converted to Cropland	CO_2	0.00	0.50	84.82	YES
4.C.2	Grassland - Land Converted to Grassland	CO_2	0.00	0.76	85.58	YES
4.G	Harvested Wood Products	CO_2	0.01	1.67	87.52	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CH_4	0.00	0.45	88.09	YES
1.A.4	Fuel combustion - Other Sectors - Biomass	CH_4	0.00	0.57	88.68	YES
1.B.1	Fugitive emissions from fuels - Solid Fuels	CH_4	0.00	0.53	89.21	YES
1.B.2.b	Fugitive emissions from fuels - oil, NG and Other - Natural gas	CH_4	0.00	1.13	90.34	YES
1.B.2.c	Fugitive emissions from fuels - oil, NG and Other - Venting and flaring	CH_4	0.00	0.81	91.14	YES
3.A	Enteric Fermentation	CH_4	0.00	1.15	92.29	YES
3.B	Manure Management	CH_4	0.00	0.65	92.94	YES
5.A	Solid Waste Disposal	CH_4	0.01	2.44	95.50	YES
5.B	Biological Treatment of Solid Waste	CH_4	0.00	0.59	96.09	YES
2.B.2	Chemical Industry - Nitric Acid Production	N_2O	0.01	1.26	98.10	YES
3.D.2	Indirect N_2O Emissions From Managed Soils	N_2O	0.00	0.45	99.15	YES

IPCC CATEGORY CODE	IPCC CATEGORY	GAS	TREND ASSESSMENT T2	CONTRIB. TO TREND %	CUMULATIVE TOTAL	KEY IN TREND ANALYSIS
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	0.17	1.69	2.10	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	0.33	3.42	7.84	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CO_2	0.21	2.12	10.53	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	0.10	0.99	11.51	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	0.10	1.06	13.49	YES
4.A.1	Forest Land - Forest Land Remaining Forest Land	CO_2	2.98	30.48	44.46	YES
4.A.2	Forest Land - Land Converted to Forest Land	CO_2	2.17	22.16	66.62	YES
4.B.1	Cropland - Cropland Remaining Cropland	CO_2	0.69	7.07	73.69	YES
4.B.2	Cropland - Land Converted to Cropland	CO_2	0.17	1.76	75.46	YES
4.C.2	Grassland - Land Converted to Grassland	CO_2	0.26	2.70	78.15	YES
4.G	Harvested Wood Products	CO_2	0.35	3.60	82.74	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CH_4	0.09	0.95	83.89	YES
1.A.4	Fuel combustion - Other Sectors - Biomass	CH_4	0.12	1.21	85.10	YES
3.A	Enteric Fermentation	CH_4	0.09	0.96	86.70	YES
5.A	Solid Waste Disposal	CH_4	0.27	2.76	89.81	YES
5.B	Biological Treatment of Solid Waste	CH_4	0.15	1.57	91.38	YES
3.B	Manure Management	N_2O	0.17	1.77	94.75	YES
3.D.2	Indirect N_2O Emissions From Managed Soils	N_2O	0.24	2.46	98.03	YES
5.B	Biological Treatment of Solid Waste	N_2O	0.11	1.11	99.69	YES

Table A1.4: *Key categories identified using Approach 1 and Approach 2 by trend assessment (T1 & T2) without LULUCF in 2022*

IPCC CATEGORY CODE	IPCC CATEGORY	GAS	TREND ASSESSMENT T1	CONTRIB. TO TREND %	CUMULATIVE TOTAL	KEY IN TREND ANALYSIS
2.F.1	Refrigeration and Air conditioning	HFCs	0.01	1.61	1.61	YES
1.A.1	Fuel combustion - Energy Industries - Liquid Fuels	CO_2	0.01	1.76	3.50	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	0.05	13.42	16.91	YES
1.A.1	Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	0.01	3.18	20.09	YES
1.A.1	Fuel combustion - Energy Industries - Other Fossil Fuels	CO_2	0.00	0.57	20.66	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	0.02	4.26	24.92	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	0.02	4.69	29.61	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	0.00	0.43	30.03	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	0.00	0.71	30.75	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	0.07	19.19	49.93	YES
1.A.3.e	Fuel combustion - Other Transportation	CO_2	0.01	3.22	53.55	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CO_2	0.04	10.89	64.55	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	0.03	7.31	71.86	YES
2.A.1	Mineral Industry - Cement Production	CO_2	0.01	2.72	75.31	YES
2.A.2	Mineral Industry - Lime Production	CO_2	0.00	0.48	75.80	YES
2.B.1	Chemical Industry - Ammonia Production	CO_2	0.01	1.70	77.79	YES
2.B.8	Chemical Industry - Petrochemical and Carbon Black Production	CO_2	0.00	0.48	78.40	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	0.02	4.44	82.85	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CH_4	0.00	0.62	84.37	YES
1.A.4	Fuel combustion - Other Sectors - Biomass	CH_4	0.00	0.71	85.10	YES
1.B.1	Fugitive emissions from fuels - Solid Fuels	CH_4	0.00	0.79	85.89	YES
1.B.2.b	Fugitive emissions from fuels - oil, NG and Other - Natural gas	CH_4	0.01	1.60	87.49	YES
1.B.2.c	Fugitive emissions from fuels - oil, NG and Other - Venting and flaring	CH_4	0.00	1.11	88.60	YES
3.A	Enteric Fermentation	CH_4	0.01	1.92	90.52	YES
3.B	Manure Management	CH_4	0.00	0.93	91.45	YES
5.A	Solid Waste Disposal	CH_4	0.01	2.94	94.39	YES
5.B	Biological Treatment of Solid Waste	CH_4	0.00	0.73	95.12	YES
2.B.2	Chemical Industry - Nitric Acid Production	N_2O	0.01	1.75	97.76	YES
3.D.2	Indirect N_2O Emissions From Managed Soils	N_2O	0.00	0.66	99.12	YES

IPCC CATEGORY CODE	IPCC CATEGORY	GAS	TREND ASSESSMENT T2	CONTRIB. TO TREND %	CUMULATIVE TOTAL	KEY IN TREND ANALYSIS
1.A.1	Fuel combustion - Energy Industries - Liquid Fuels	CO_2	0.04	1.13	1.64	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	0.22	6.13	7.77	YES
1.A.1	Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	0.04	1.23	9.00	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	0.10	2.74	12.15	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	0.10	2.80	14.95	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	0.37	10.20	25.84	YES
1.A.3.e	Fuel combustion - Other Transportation	CO_2	0.06	1.71	27.76	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CO_2	0.26	7.27	35.09	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	0.10	2.83	37.93	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	0.10	2.86	43.44	YES
3.H	Urea Application	CO_2	0.03	0.92	44.96	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CH_4	0.12	3.24	48.84	YES
1.A.4	Fuel combustion - Other Sectors - Biomass	CH_4	0.13	3.69	52.55	YES
1.B.1	Fugitive emissions from fuels - Solid Fuels	CH_4	0.03	0.71	53.26	YES
1.B.2.b	Fugitive emissions from fuels - oil, NG and Other - Natural gas	CH_4	0.03	0.90	54.16	YES
3.A	Enteric Fermentation	CH_4	0.14	3.97	58.75	YES
3.B	Manure Management	CH_4	0.04	1.11	59.86	YES
5.A	Solid Waste Disposal	CH_4	0.30	8.17	68.04	YES
5.B	Biological Treatment of Solid Waste	CH_4	0.17	4.79	72.83	YES
5.D	Wastewater Treatment and Discharge	CH_4	0.03	0.76	73.66	YES
1.A.3b	Fuel combustion - Road Transportation	N_2O	0.03	0.93	75.81	YES
3.B	Manure Management	N_2O	0.27	7.55	85.18	YES
3.D.1	Direct N_2O Emissions From Managed Soils	N_2O	0.06	1.68	86.86	YES
3.D.2	Indirect N_2O Emissions From Managed Soils	N_2O	0.32	8.80	95.66	YES
5.B	Biological Treatment of Solid Waste	N_2O	0.12	3.38	99.04	YES

Table A1.5: *Key categories identified using Approach 1 and Approach 2 by level assessment (L1 & L2) with LULUCF in 1990*

IPCC CATEGORY CODE	IPCC CATEGORY	GAS	EMISSIONS/ REMOVALS BASE YEAR	LEVEL ASSESSMENT L1	CUMULATIVE TOTAL	KEY IN LEVEL ANALYSIS
1.A.1	Fuel combustion - Energy Industries - Liquid Fuels	CO_2	3 819.21	0.05	0.05	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	12 861.05	0.15	0.20	YES
1.A.1	Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	2 293.69	0.03	0.23	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	2 867.64	0.03	0.26	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	9 028.53	0.11	0.37	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	3 930.58	0.05	0.41	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	4 503.02	0.05	0.47	YES
1.A.3.e	Fuel combustion - Other Transportation	CO_2	1 813.95	0.02	0.50	YES
1.A.4	Fuel combustion - Other Sectors - Liquid Fuels	CO_2	580.74	0.01	0.50	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CO_2	6 852.15	0.08	0.58	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	3 634.43	0.04	0.63	YES
2.A.1	Mineral Industry - Cement Production	CO_2	1 464.50	0.02	0.65	YES
2.A.2	Mineral Industry - Lime Production	CO_2	794.92	0.01	0.66	YES
2.A.4	Mineral Industry - Other Process Uses of Carbonates	CO_2	446.73	0.01	0.67	YES
2.B.8	Chemical Industry - Petrochemical and Carbon Black Production	CO_2	428.80	0.01	0.68	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	4 167.97	0.05	0.72	YES
4.A.1	Forest Land - Forest Land Remaining Forest Land	CO_2	-5 999.27	0.07	0.80	YES
4.A.2	Forest Land - Land Converted to Forest Land	CO_2	-2 263.04	0.03	0.83	YES
4.B.1	Cropland - Cropland Remaining Cropland	CO_2	-950.94	0.01	0.84	YES
4.B.2	Cropland - Land Converted to Cropland	CO_2	466.51	0.01	0.85	YES
4.G	Harvested Wood Products	CO_2	-470.41	0.01	0.86	YES
1.B.1	Fugitive emissions from fuels - Solid Fuels	CH_4	28.39	0.01	0.87	YES
1.B.2.b	Fugitive emissions from fuels - oil, NG and Other - Natural gas	CH_4	42.34	0.01	0.89	YES
1.B.2.c	Fugitive emissions from fuels - oil, NG and Other - Venting and flaring	CH_4	23.55	0.01	0.90	YES
3.A	Enteric Fermentation	CH_4	111.14	0.04	0.93	YES
3.B	Manure Management	CH_4	25.58	0.01	0.94	YES
5.A	Solid Waste Disposal	CH_4	27.92	0.01	0.95	YES
2.B.2	Chemical Industry - Nitric Acid Production	N_2O	4.05	0.01	0.97	YES
3.B	Manure Management	N_2O	1.96	0.01	0.98	YES
3.D.1	Direct N_2O Emissions From Managed Soils	N_2O	2.93	0.01	0.99	YES
3.D.2	Indirect N_2O Emissions From Managed Soils	N_2O	2.20	0.01	0.99	YES

IPCC CATEGORY CODE	IPCC CATEGORY	GAS	EMISSIONS/ REMOVALS BASE YEAR	LEVEL ASSESSMENT L2	CUMULATIVE TOTAL	KEY IN LEVEL ANALYSIS
1.A.1	Fuel combustion - Energy Industries - Liquid Fuels	CO_2	3 819.21	0.01	0.01	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	12 861.05	0.04	0.05	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	2 867.64	0.01	0.07	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	9 028.53	0.03	0.10	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	4 503.02	0.01	0.12	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CO_2	6 852.15	0.03	0.16	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	4 167.97	0.02	0.20	YES
4.A.1	Forest Land - Forest Land Remaining Forest Land	CO_2	-5 999.27	0.32	0.52	YES
4.A.2	Forest Land - Land Converted to Forest Land	CO_2	-2 263.04	0.08	0.60	YES
4.B.1	Cropland - Cropland Remaining Cropland	CO_2	-950.94	0.05	0.65	YES
4.B.2	Cropland - Land Converted to Cropland	CO_2	466.51	0.02	0.67	YES
4.C.2	Grassland - Land Converted to Grassland	CO_2	-195.77	0.01	0.68	YES
4.F.2	Other land - Land Converted to Other Land	CO_2	293.10	0.02	0.71	YES
4.G	Harvested Wood Products	CO_2	-470.41	0.02	0.72	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CH_4	13.72	0.01	0.73	YES
3.A	Enteric Fermentation	CH_4	111.14	0.04	0.79	YES
5.A	Solid Waste Disposal	CH_4	27.92	0.01	0.80	YES
3.B	Manure Management	N_2O	1.96	0.08	0.91	YES
3.D.1	Direct N_2O Emissions From Managed Soils	N_2O	2.93	0.03	0.94	YES
3.D.2	Indirect N_2O Emissions From Managed Soils	N_2O	2.20	0.05	0.99	YES

Table A1.6: *Key categories identified using Approach 1 and Approach 2 by level assessment (L1 & L2) without LULUCF in 1990*

IPCC CATEGORY CODE	IPCC CATEGORY	GAS	EMISSIONS/ REMOVALS BASE YEAR	LEVEL ASSESSMENT L1	CUMULATIVE TOTAL	KEY IN LEVEL ANALYSIS
1.A.1	Fuel combustion - Energy Industries - Liquid Fuels	CO_2	3 819.21	0.05	0.05	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	12 861.05	0.18	0.23	YES
1.A.1	Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	2 293.69	0.03	0.26	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	2 867.64	0.04	0.30	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	9 028.53	0.12	0.42	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	3 930.58	0.05	0.48	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	4 503.02	0.06	0.54	YES
1.A.3.e	Fuel combustion - Other Transportation	CO_2	1 813.95	0.02	0.57	YES
1.A.4	Fuel combustion - Other Sectors - Liquid Fuels	CO_2	580.74	0.01	0.58	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CO_2	6 852.15	0.09	0.67	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	3 634.43	0.05	0.72	YES
2.A.1	Mineral Industry - Cement Production	CO_2	1 464.50	0.02	0.75	YES
2.A.2	Mineral Industry - Lime Production	CO_2	794.92	0.01	0.76	YES
2.A.4	Mineral Industry - Other Process Uses of Carbonates	CO_2	446.73	0.01	0.76	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	4 167.97	0.06	0.83	YES
1.B.1	Fugitive emissions from fuels - Solid Fuels	CH_4	28.39	0.01	0.86	YES
1.B.2.b	Fugitive emissions from fuels - oil, NG and Other - Natural gas	CH_4	42.34	0.02	0.87	YES
1.B.2.c	Fugitive emissions from fuels - oil, NG and Other - Venting and flaring	CH_4	23.55	0.01	0.88	YES
3.A	Enteric Fermentation	CH_4	111.14	0.04	0.92	YES
3.B	Manure Management	CH_4	25.58	0.01	0.93	YES
5.A	Solid Waste Disposal	CH_4	27.92	0.01	0.95	YES
2.B.2	Chemical Industry - Nitric Acid Production	N_2O	4.05	0.01	0.97	YES
3.B	Manure Management	N_2O	1.96	0.01	0.98	YES
3.D.1	Direct N_2O Emissions From Managed Soils	N_2O	2.93	0.01	0.99	YES
3.D.2	Indirect N_2O Emissions From Managed Soils	N_2O	2.20	0.01	1.00	YES

IPCC CATEGORY CODE	IPCC CATEGORY	GAS	EMISSIONS/ REMOVALS BASE YEAR	LEVEL ASSESSMENT L2	CUMULATIVE TOTAL	KEY IN LEVEL ANALYSIS
1.A.1	Fuel combustion - Energy Industries - Liquid Fuels	CO_2	3 819.21	0.03	0.03	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	12 861.05	0.08	0.11	YES
1.A.1	Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	2 293.69	0.01	0.12	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	2 867.64	0.02	0.14	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	9 028.53	0.07	0.21	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	3 930.58	0.02	0.23	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	4 503.02	0.03	0.26	YES
1.A.3.e	Fuel combustion - Other Transportation	CO_2	1 813.95	0.01	0.28	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CO_2	6 852.15	0.06	0.34	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	3 634.43	0.02	0.36	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	4 167.97	0.03	0.42	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CH_4	13.72	0.03	0.45	YES
3.A	Enteric Fermentation	CH_4	111.14	0.08	0.56	YES
3.B	Manure Management	CH_4	25.58	0.01	0.57	YES
5.A	Solid Waste Disposal	CH_4	27.92	0.03	0.60	YES
5.D	Wastewater Treatment and Discharge	CH_4	14.50	0.02	0.62	YES
3.B	Manure Management	N_2O	1.96	0.17	0.82	YES
3.D.1	Direct N_2O Emissions From Managed Soils	N_2O	2.93	0.07	0.89	YES
3.D.2	Indirect N_2O Emissions From Managed Soils	N_2O	2.20	0.10	0.99	YES

***Table A1.7:** Key categories identified using Approach 1 and Approach 2 by level assessment with and without LULUCF in 2022*

IPCC SOURCE CATEGORIES	GAS	APPROACH 1 2022 WITH LULUCF	APPROACH 1 2022 WITHOUT LULUCF	APPROACH 2 2022 WITH LULUCF	APPROACH 2 2022 WITHOUT LULUCF
2.F.1 Refrigeration and Air conditioning	HFCs	YES	YES	NO	NO
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO_2	YES	YES	YES	YES
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO_2	YES	YES	YES	YES
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	YES	YES	NO	YES
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	YES	YES	NO	NO
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	YES	YES	YES	YES
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	YES	YES	NO	YES

IPCC SOURCE CATEGORIES	GAS	APPROACH 1 2022 WITH LULUCF	APPROACH 1 2022 WITHOUT LULUCF	APPROACH 2 2022 WITH LULUCF	APPROACH 2 2022 WITHOUT LULUCF
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	YES	YES	NO	NO
1.A.3.b Fuel combustion - Road Transportation	CO_2	YES	YES	YES	YES
1.A.4 Fuel combustion - Other Sectors - Liquid Fuels	CO_2	YES	YES	NO	NO
1.A.4 Fuel combustion - Other Sectors - Solid Fuels	CO_2	YES	YES	NO	NO
1.A.4 Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	YES	YES	YES	YES
2.A.1 Mineral Industry - Cement Production	CO_2	YES	YES	NO	NO
2.A.2 Mineral Industry - Lime Production	CO_2	YES	YES	NO	NO
2.A.4 Mineral Industry - Other Process Uses of Carbonates	CO_2	YES	YES	NO	NO
2.B.1 Chemical Industry - Ammonia Production	CO_2	YES	YES	NO	NO
2.B.8 Chemical Industry - Petrochemical and Carbon Black Production	CO_2	YES	YES	NO	YES
2.C.1 Metal Industry - Iron and Steel Production	CO_2	YES	YES	YES	YES
3.H Urea Application	CO_2	NO	NO	NO	YES
4.A.1 Forest Land - Forest Land Remaining Forest Land	CO_2	YES	X	YES	X
4.A.2 Forest Land - Land Converted to Forest Land	CO_2	YES	X	YES	X
4.B1 Cropland - Cropland Remaining Cropland	CO_2	YES	X	YES	X
1.A.4 Fuel combustion - Other Sectors - Biomass	CH_4	YES	YES	YES	YES
1.B.1 Fugitive emissions from fuels - Solid Fuels	CH_4	YES	YES	NO	NO
3.A Enteric Fermentation	CH_4	YES	YES	YES	YES
5.A Solid Waste Disposal	CH_4	YES	YES	YES	YES
5.B Biological Treatment of Solid Waste	CH_4	YES	YES	YES	YES
5.D Wastewater Treatment and Discharge	CH_4	YES	YES	NO	YES
1.A.3.b Fuel combustion - Road Transportation	N_2O	NO	NO	NO	YES
3.B Manure Management	N_2O	YES	NO	YES	YES
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	YES	YES	YES	YES
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	NO	NO	YES	YES
5.B Biological Treatment of Solid Waste	N_2O	NO	NO	YES	YES

Table A1.8: *Key categories identified using Approach 1 and Approach 2 by trend assessment with and without LULUCF in 2022*

IPCC SOURCE CATEGORIES	GAS	APPROACH 1 2022 WITH LULUCF	APPROACH 1 2022 WITHOUT LULUCF	APPROACH 2 2022 WITH LULUCF	APPROACH 2 2022 WITHOUT LULUCF
2.F.1 Refrigeration and Air conditioning	HFCs	YES	YES	NO	NO
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO_2	YES	YES	NO	YES
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO_2	YES	YES	YES	YES
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	YES	YES	NO	YES
1.A.1 Fuel combustion - Energy Industries - Other Fossil Fuels	CO_2	YES	YES	NO	NO
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	YES	YES	NO	YES
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	YES	YES	NO	YES
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	YES	YES	NO	NO
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	YES	YES	NO	NO
1.A.3.b Fuel combustion - Road Transportation	CO_2	YES	YES	YES	YES
1.A.3.e Fuel combustion - Other Transportation	CO_2	YES	YES	NO	YES
1.A.4 Fuel combustion - Other Sectors - Solid Fuels	CO_2	YES	YES	YES	YES
1.A.4 Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	YES	YES	YES	YES
2.A.1 Mineral Industry - Cement Production	CO_2	YES	YES	NO	NO
2.A.2 Mineral Industry - Lime Production	CO_2	YES	YES	NO	NO
2.B.1 Chemical Industry - Ammonia Production	CO_2	YES	YES	NO	NO
2.B.8 Chemical Industry - Petrochemical and Carbon Black Production	CO_2	NO	YES	NO	NO
2.C.1 Metal Industry - Iron and Steel Production	CO_2	YES	YES	YES	YES
3.H Urea Application	CO_2	NO	NO	NO	YES
4.A.1 Forest Land - Forest Land Remaining Forest Land	CO_2	YES	X	YES	X
4.A.2 Forest Land - Land Converted to Forest Land	CO_2	YES	X	YES	X
4.B.1 Cropland - Cropland Remaining Cropland	CO_2	YES	X	YES	X
4.B.2 Cropland - Land Converted to Cropland	CO_2	YES	X	YES	X
4.C.2 Grassland - Land Converted to Grassland	CO_2	YES	X	YES	X
4.G Harvested Wood Products	CO_2	YES	X	YES	X
1.A.4 Fuel combustion - Other Sectors - Solid Fuels	CH_4	YES	YES	YES	YES
1.A.4 Fuel combustion - Other Sectors - Biomass	CH_4	YES	YES	YES	YES
1.B.1 Fugitive emissions from fuels - Solid Fuels	CH_4	YES	YES	NO	YES
1.B.2.b Fugitive emissions from fuels - oil, NG and Other - Natural gas	CH_4	YES	YES	NO	YES

IPCC SOURCE CATEGORIES	GAS	APPROACH 1 2022 WITH LULUCF	APPROACH 1 2022 WITHOUT LULUCF	APPROACH 2 2022 WITH LULUCF	APPROACH 2 2022 WITHOUT LULUCF
1..B2.c Fugitive emissions from fuels - oil, NG and Other - Venting and flaring	CH_4	YES	YES	NO	NO
3.A Enteric Fermentation	CH_4	YES	YES	YES	YES
3.B Manure Management	CH_4	YES	YES	NO	YES
5.A Solid Waste Disposal	CH_4	YES	YES	YES	YES
5.B Biological Treatment of Solid Waste	CH_4	YES	YES	YES	YES
5.D Wastewater Treatment and Discharge	CH_4	NO	NO	NO	YES
1.A.3.b Fuel combustion - Road Transportation	N_2O	NO	NO	NO	YES
2.B.2 Chemical Industry - Nitric Acid Production	N_2O	YES	YES	NO	NO
3.B Manure Management	N_2O	NO	NO	YES	YES
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	NO	NO	NO	YES
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	YES	YES	YES	YES
5.B Biological Treatment of Solid Waste	N_2O	NO	NO	YES	YES

Table A1.9: *Key categories identified using Approach 1 and Approach 2 by level assessment with and without LULUCF in 1990*

IPCC SOURCE CATEGORIES	GAS	APPROACH 1 1990 WITH LULUCF	APPROACH 1 1990 WITHOUT LULUCF	APPROACH 2 1990 WITH LULUCF	APPROACH 2 1990 WITHOUT LULUCF
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO_2	YES	YES	YES	YES
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO_2	YES	YES	YES	YES
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	YES	YES	NO	YES
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	YES	YES	YES	YES
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	YES	YES	YES	YES
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	YES	YES	NO	YES
1.A.3.b Fuel combustion - Road Transportation	CO_2	YES	YES	YES	YES
1.A.3.e Fuel combustion - Other Transportation	CO_2	YES	YES	NO	YES
1.A.4 Fuel combustion - Other Sectors - Liquid Fuels	CO_2	YES	YES	NO	NO
1.A.4 Fuel combustion - Other Sectors - Solid Fuels	CO_2	YES	YES	YES	YES
1.A.4 Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	YES	YES	NO	YES
2.A.1 Mineral Industry - Cement Production	CO_2	YES	YES	NO	NO
2.A.2 Mineral Industry - Lime Production	CO_2	YES	YES	NO	NO
2.A.4 Mineral Industry - Other Process Uses of Carbonates	CO_2	YES	YES	NO	NO

IPCC SOURCE CATEGORIES	GAS	APPROACH 1 1990 WITH LULUCF	APPROACH 1 1990 WITHOUT LULUCF	APPROACH 2 1990 WITH LULUCF	APPROACH 2 1990 WITHOUT LULUCF
2.B.8 Chemical Industry - Petrochemical and Carbon Black Production	CO_2	YES	NO	NO	NO
2.C.1 Metal Industry - Iron and Steel Production	CO_2	YES	YES	YES	YES
4.A.1 Forest Land - Forest Land Remaining Forest Land	CO_2	YES	X	YES	X
4.A.2 Forest Land - Land Converted to Forest Land	CO_2	YES	X	YES	X
4.B.1 Cropland - Cropland Remaining Cropland	CO_2	YES	X	YES	X
4.B.2 Cropland - Land Converted to Cropland	CO_2	YES	X	YES	X
4.C.2 Grassland - Land Converted to Grassland	CO_2	NO	X	YES	X
4.F.2 Other land - Land Converted to Other Land	CO_2	NO	X	YES	X
4.G Harvested Wood Products	CO_2	YES	X	YES	X
1.A.4 Fuel combustion - Other Sectors - Solid Fuels	CH_4	NO	NO	YES	YES
1.B.1 Fugitive emissions from fuels - Solid Fuels	CH_4	YES	YES	NO	NO
1.B.2.b Fugitive emissions from fuels - oil, NG and Other - Natural gas	CH_4	YES	YES	NO	NO
1.B.2.c Fugitive emissions from fuels - oil, NG and Other - Venting and flaring	CH_4	YES	YES	NO	NO
3.A Enteric Fermentation	CH_4	YES	YES	YES	YES
3.B Manure Management	CH_4	YES	YES	NO	YES
5.A Solid Waste Disposal	CH_4	YES	YES	YES	YES
5.D Wastewater Treatment and Discharge	CH_4	NO	NO	NO	YES
2.B2 Chemical Industry - Nitric Acid Production	N_2O	YES	YES	NO	NO
3.B Manure Management	N_2O	YES	YES	YES	YES
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	YES	YES	YES	YES
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	YES	YES	YES	YES

ANNEX 2. ASSESSMENT OF COMPLETENESS

Assessment of completeness is one of the elements of quality control procedure in the inventory preparation on the general and sectoral level. The completeness of the emission inventory is improving from year to year and the updates are regularly reported in the national inventory reports. The completeness check for ensuring time series consistency is performed and the estimation is complete in recent inventory submission (2024).

Several categories are reported as not occurring (NO) due to the not existence of the emission source or activity is not occurring in Slovakia. If the methodology does not exist in the IPCC 2006 GL, the notation key not applicable (NA) was used. Several categories are not estimated (NE) because of emissions are under the threshold. The included elsewhere categories (IE) are listed in CRF table 9 with the explanations and also described in this report in the appropriate sectoral chapters. Lists of information on notation keys used for each sector was prepared, see ***Tables A2.1-A2.7*** below.

Both direct GHGs as well as precursor gases are covered by the inventory of the Slovak Republic. The geographic coverage is complete; the whole territory of the Slovak Republic is covered by the inventory.

Table A2.1: Notation keys in the Energy sector – combustion of fuels which are not occurring in specific subcategory

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS			GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS		
	CO_2	CH_4	N_2O		CO_2	CH_4	N_2O
1.A. Fuel combustion				Biomass	NO	NO	NO
1. A.1. Energy industries				1.A.2 Manufacturing industries and construction			
Peat	NO	NO	NO	a. Iron and steel			
a. Public electricity and heat production				Other fossil fuels	NO	NO	NO
Peat	NO	NO	NO	Peat	NO	NO	NO
1.A.1.a.i Electricity Generation				b. Non-ferrous metals			
Liquid Fuels	NO	NO	NO	Other fossil fuels	NO	NO	NO
Solid Fuels	NO	NO	NO	Peat	NO	NO	NO
Other Fossil Fuels	NO	NO	NO	c. Chemicals			
Peat	NO	NO	NO	Peat	NO	NO	NO
1.A.1.a.ii Combined heat and power generation				d. Pulp, paper and print			
Other Fossil Fuels	NO	NO	NO	Other fossil fuels	NO	NO	NO
Peat	NO	NO	NO	Peat	NO	NO	NO
1.A.1.a.iii Heat plants				e. Food processing, beverages and tobacco			
Peat	NO	NO	NO	Other fossil fuels	NO	NO	NO
1.A.1.a.iv Other (please specify)				Peat	NO	NO	NO
Methane Cogeneration (Mining)	NO	NO	NO	f. Non-metallic minerals			
b. Petroleum refining				Peat	NO	NO	NO
Solid fuels	NO	NO	NO	1.A.2.g.i Manufacturing of machinery			
Other fossil fuels	NO	NO	NO	Solid Fuels	NO	NO	NO
Peat[(5)]	NO	NO	NO	Other Fossil Fuels	NO	NO	NO
Biomass[(6)]	NO	NO	NO	Peat	NO	NO	NO
c. Manufacture of solid fuels and other energy industries				1.A.2.g.ii Manufacturing of transport equipment			
Other fossil fuels	NO	NO	NO	Other Fossil Fuels	NO	NO	NO
Peat	NO	NO	NO	Peat	NO	NO	NO
Biomass	NO	NO	NO	1.A.2.g.iii Mining (excluding fuels) and quarrying			
1.A.1.c.i Manufacture of solid fuels				Other Fossil Fuels	NO	NO	NO
Liquid Fuels	NO	NO	NO	Peat	NO	NO	NO
Other Fossil Fuels	NO	NO	NO	1.A.2.g.iv Wood and wood products			
Peat	NO	NO	NO	Solid Fuels	NO	NO	NO
Biomass	NO	NO	NO	Other Fossil Fuels	NO	NO	NO
1.A.1.c.ii Oil and gas extraction				Peat	NO	NO	NO
Other Fossil Fuels	NO	NO	NO	1.A.2.g.v Construction			
Peat	NO	NO	NO	Other Fossil Fuels	NO	NO	NO

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS			GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS		
	CO_2	CH_4	N_2O		CO_2	CH_4	N_2O
1.A.2.g.vi Textile and leather				e. Other transportation			
Other Fossil Fuels	NO	NO	NO	Liquid fuels	NO	NO	NO
Peat	NO	NO	NO	Solid fuels	NO	NO	NO
1.A.2.g.viii Other (please specify)				Other fossil fuels	NO	NO	NO
Other Fossil Fuels	NO	NO	NO	Biomass	NO	NO	NO
Peat	NO	NO	NO	i. Pipeline transport			
1.A.3 Transport				Liquid fuels	NO	NO	NO
Solid fuels	NO	NO	NO	Solid fuels	NO	NO	NO
a. Domestic aviation				Other fossil fuels	NO	NO	NO
Biomass	NO	NO	NO	Biomass	NO	NO	NO
b. Road transportation				ii. Other	NO	NO	NO
Other liquid fuels	NO	NO	NO	1.A.4 Other sectors			
ii. Light duty trucks				Other fossil fuels	NO	NO	NO
Liquefied petroleum gases (LPG)	NO	NO	NO	Peat	NO	NO	NO
Other liquid fuels	NO	NO	NO	a. Commercial/institutional			
Gaseous fuels	NO	NO	NO	Other fossil fuels	NO	NO	NO
iii. Heavy duty trucks and buses				Peat	NO	NO	NO
Liquefied petroleum gases (LPG)	NO	NO	NO	1.A.4.a.i Stationary combustion			
Other liquid fuels	NO	NO	NO	Other Fossil Fuels	NO	NO	NO
iv. Motorcycles				Peat	NO	NO	NO
Liquefied petroleum gases (LPG)	NO	NO	NO	b. Residential			
Other liquid fuels	NO	NO	NO	Other fossil fuels	NO	NO	NO
Gaseous fuels	NO	NO	NO	Peat	NO	NO	NO
v. Other		NO	NO	1.A.4.b.i Stationary combustion			
Urea-based catalysts		NO	NO	Other Fossil Fuels	NO	NO	NO
Diesel Oil		NO	NO	Peat	NO	NO	NO
c. Railways				c. Agriculture/forestry/fishing			
Solid fuels	NO	NO	NO	Other fossil fuels	NO	NO	NO
Gaseous fuels	NO	NO	NO	Peat	NO	NO	NO
Other fossil fuels	NO	NO	NO	i. Stationary			
d. Domestic Navigation				Other fossil fuels	NO	NO	NO
Residual fuel oil	NO	NO	NO	Peat	NO	NO	NO
Gasoline	NO	NO	NO	ii. Off-road vehicles and other machinery			
Other liquid fuels	NO	NO	NO	Liquefied petroleum gases (LPG)	NO	NO	NO
Gaseous fuels	NO	NO	NO	Other liquid fuels	NO	NO	NO
Other fossil fuels	NO	NO	NO	Gaseous fuels	NO	NO	NO

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS		
	CO_2	CH_4	N_2O
Other fossil fuels	NO	NO	NO
iii. Fishing	NO	NO	NO
Residual fuel oil	NO	NO	NO
Gas/diesel oil	NO	NO	NO
Gasoline	NO	NO	NO
Other liquid fuels	NO	NO	NO
Gaseous fuels	NO	NO	NO
Biomass	NO	NO	NO
1.A.5 Other (Not specified elsewhere)			
a. Stationary (please specify)			
Other			
Other Fossil Fuels	NO	NO	NO
Peat	NO	NO	NO
b. Mobile (please specify)			
Military Gasoline			
Biomass	NO	NO	NO
Military Diesel Oil			
Biomass	NO	NO	NO

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS		
	CO_2	CH_4	N_2O
1.D.1.a International aviation (aviation bunkers)			
Biomass	NO	NO	NO
1.D.1.b International navigation (marine bunkers)			
Residual fuel oil	NO	NO	NO
Gasoline	NO	NO	NO
Other liquid fuels	NO	NO	NO
Gaseous fuels	NO	NO	NO
Biomass	NO	NO	NO
Other fossil fuels	NO	NO	NO
Multilateral operations	NO	NO	NO
Other fossil fuels	NO	NO	NO
Multilateral operations	NO	NO	NO

Table A2.2: *Notation keys in the Energy sector - categories 1.B.1 and 1.B.2*

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS			COMMENT
	CH_4		CO_2	
	Recovery/Flaring	Emissions	Emissions	
1.B.1.a Coal Mining and Handling	NO			CH_4 recovery is not occurring in Slovakia from this activity
i. Underground mines	NO			
Mining activities	NO			
Post-mining activities	NO		NO	Emissions not occurring in this subcategory
Abandoned underground mines	NO			Emissions not occurring in this subcategory
ii. Surface mines	NO	NO	NO	No surface mines are occurring in Slovakia
Mining activities	NO	NO	NO	
Post-mining activities	NO	NO	NO	
1.B.1.b Solid Fuel Transformation	NO		NO	

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS			COMMENT
	CH_4		CO_2	
	Recovery/Flaring	Emissions	Emissions	
1.B.1.c Other		NO	NO	

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4	N_2O	COMMENT
	Emissions	Amount captured			
1.B.2.a Oil		NO, NE			CO_2 is not captured in Slovakia from this activity
1. Exploration	NO	NO	NO	NO	This activity is not occurring in Slovakia
2. Production		NO			Emissions not occurring in this subcategory
3. Transport		NO			Emissions not occurring in this subcategory
4. Refining/storage		NE			Emissions are not estimated from CO_2 capture
5. Distribution of oil products		NO			
6. Other	NO	NO	NO	NO	No other source exists
1.B.2.b Natural Gas		NO			
1. Exploration	NO	NO	NO	NO	This activity is not occurring in Slovakia
2. Production		NO			
3. Processing		NO			
4. Transmission and storage		NO			
5. Distribution		NO			
6. Other		NO			
1 B.2.c Venting and Flaring		NO			
Venting		NO			
i. Oil		NO			
ii. Gas		NO			
iii. Combined	NO	NO	NO		This activity is not occurring in Slovakia
Flaring		NO			
i. Oil		NO			Emissions included in main activity

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4	N_2O	COMMENT
	Emissions	Amount captured			
ii. Gas		NO			Emissions included in main activity
iii. Combined	NO	NO	NO	NO	This activity is not occurring in Slovakia
1 B.2.d Other	NO		NO	NO	
Post-Meter emissions - NG vehicles		NO		NA	
Post-Meter emissions - Industrial plants		NO		NA	
Post-Meter emissions - Appliances		NO		NA	

Table A2.3: *Notation keys in the Energy sector – combustion of fuels which are IE and NE in specific subcategory*

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS			COMMENT
	CO_2	CH_4	N_2O	
1.A.3 Transport				
b. Road transportation				
Other liquid fuels (please specify)	IE	IE	IE	Emissions from combustion of lubricants in two-stroke engines are included in those of gasoline
i. Cars				
Other liquid fuels (*please specify*)	IE	IE	IE	The emissions from combustion of lubricants in two-stroke engines are included in those of gasoline.
iv. Motorcycles				
Other fossil fuels (please specify)			NE	Emissions under threshold and could not be calculated by the model
v. Other (please specify)	IE			Emissions reported in category non-energy products from fuels and solvent use - other (2.D.3)
Urea-based catalysts	IE	IE	IE	Emissions reported in category non-energy products from fuels and solvent use - other (2.D.3)
Diesel Oil	IE			
1. B. 2. a. Oil				
5. Distribution of oil products	NE		NE	This activity is occurring in Slovakia but no EFs are available in the IPCC 2006 GL (Not determined for EFs Table 4.2.4) and also not in the 2019 Refinements.
1. B. 2. c. Venting and flaring				

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS			COMMENT
	CO_2	CH_4	N_2O	
Venting				
i. Oil	IE	IE		Included in appropriate 1.B.2.a categories based on 2019 IPCC Refinement
Flaring				
i. Oil	IE	IE		Included in appropriate 1.B.2.a categories based on 2019 IPCC Refinement
ii. Gas	IE	IE		Included in appropriate 1.B.2.b categories based on 2019 IPCC Refinement

Table A2.4: *Notation keys in the IPPU sector*

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	COMMENT
Total Industrial Processes							NO	
B Chemical Industry				NO	NO	NO	NO	No F-gases are produced in chemical industry
3. Adipic acid production	NO		NO					Production of adipic acid is not occurring in Slovakia
4. Caprolactam, glyoxal and glyoxylic acid production	NO		NO					This production is not occurring in Slovakia
5. Carbide production		NO						No CH_4 emissions occur
6. Titanium dioxide production	NO							This production is not occurring in Slovakia
7. Soda ash production	NO							This production is not occurring in Slovakia
8. Petrochemical and carbon black production		NA,NO						No CH_4 emissions occur
9. Fluorochemical production				NO	NO	NO	NO	This production is not occurring in Slovakia
10. Other *(as specified in table 2(I).A-H)*				NO	NO	NO	NO	This production is not occurring in Slovakia
C Metal Industry			NO	NO		NO	NO	
3. Aluminium production						NO		No SF_6 emissions occur
4. Magnesium production	NO					NO		This production is not occurring in Slovakia
6. Zinc production	NO							This production is not occurring in Slovakia
7. Other *(as specified in table 2(I).A-H)*	NO	NO		NO	NO	NO	NO	No sources are occurring in this subcategory
D Non-energy Products from Fuels and Solvent Use		NO,NE,NA	NO,NE,NA					Different type of activity data was used for calculation, see NIR
1. Lubricant use		NE	NE					No methodology is available
2. Paraffin wax use		NE	NE					No methodology is available

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	COMMENT
3. Other		NO,NA	NO,NA					No sources are occurring in this subcategory
E Electronics Industry				NO	NO	NO	NO	No sources are occurring in this subcategory
1. Integrated circuit or semiconductor						NO	NO	No sources are occurring in this subcategory
2. TFT flat panel display				NO	NO	NO	NO	No sources are occurring in this subcategory
3. Photovoltaics				NO	NO	NO	NO	No sources are occurring in this subcategory
4. Heat transfer fluid						NO	NO	No sources are occurring in this subcategory
5. Other *(as specified in table 2(II))*				NO	NO	NO	NO	No sources are occurring in this subcategory
F Product Uses for ODS						NO	NO	These types of gas are not used
1. Refrigeration and air conditioning						NO	NO	These types of gas are not used
2. Foam blowing agents					NO	NO	NO	These types of gas are not used
3. Fire protection					NO	NO	NO	These types of gas are not used
4. Aerosols					NO	NO	NO	These types of gas are not used
5. Solvents				NO	NO	NO	NO	No sources are occurring in this subcategory
6. Other applications				NO	NO	NO	NO	These types of gas are not used
G Other Product Manufacture and Use	NO	NO		NO	NO		NO	These types of gas are not used
1. Electrical equipment				NO	NO		NO	These types of gas are not used
2. SF_6 and PFCs from other product use					NO	IE		SF_6 emissions are included in G.1 category
4. Other	NO	NO	NO	NO	NO	NO	NO	No sources are occurring in this subcategory
H Other as specified in tables 2(I).A-H and 2(II)	NO	NO,NA	NO,NA	NO	NO	NO	NO	No sources are occurring in this subcategory

Table A2.5: *Notation keys in the Agriculture sector*

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS			COMMENT
	CO_2	CH_4	N_2O	
I. Livestock				
A Enteric Fermentation				
4. Other livestock				
Other		NO		No available activity data (rabbits, fur animals, etc.)
B Manure Management				

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS			COMMENT
	CO_2	CH_4	N_2O	
4. Other livestock				
Other		NO	NO	No available activity data (rabbits, fur animals, etc.)
C Rice Cultivation		NO		No rise cultivation in Slovakia
D Agricultural Soils		NO		
6. Cultivation of organic soils (i.e. histosols)			NE	Activity is under threshold of significance.
7. Other			NO	No methodology is available in the IPCC 2006 GL or in the IPCC 2019 RF for N_2O, CH_4 and N_2O emissions in this subcategory.
E Prescribed Burning of Savannas		NO	NO	No savannahs are occurring in Slovakia.
F Field burning of Agricultural Residues		NO	NO	This practise is forbidden by law in Slovakia.
I Other Carbon-Containing Fertilizers	NO			No methodology is available in the IPCC 2006 GL or in the IPCC 2019 RF for CO_2 emissions in this subcategory.
J Other	NO			No other sources were identified in Slovakia.

Table A2.6: *Notation keys used in the Waste sector*

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS			COMMENT
	CO_2	CH_4	N_2O	
A Solid Waste Disposal	NO			No CO_2 emissions are reported in waste disposal.
1. Managed waste disposal sites	NO			NE is reported for amount of CH_4 flared in 2016.
2. Unmanaged waste disposal sites	NO	NO		Unmanaged waste disposal sites are not occurring in Slovakia
3. Uncategorized waste disposal sites	NO	NO		No uncategorised sites
B Biological Treatment of Solid Waste				No CH_4 emissions are flared as this practise is not occurring in Slovakia
2. Anaerobic digestion at biogas facilities		NA,IE	NA	Not reported due to a lack of available emission factors. According to the 2006 IPCC Guidelines, Volume 5 Waste page 4.6 Table 4.1 emissions in both basis were assumed as negligible The methane emissions from 5.B.2.a category is included in category 5.B.2.b The methane emissions from 5.B.2 is energy recovered in the category 1.A.5
C Incineration and Open Burning of Waste				Biogenic and non-biogenic municipal solid waste incineration is included in energy sector (with energy use incineration, category 1.A.1.a.iv - other fuels).
2. Open burning of waste	NO	NO	NO	This practise is not occurring in Slovakia.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS			COMMENT
	CO_2	CH_4	N_2O	
D Wastewater Treatment and Discharge				No CO_2 emissions are reported in wastewater treatment.
3. Other *(as specified in table 6.B)*	NO	NO	NO	All sources are included in subcategories 5.D.1 and 5.D.2, therefore no emissions are occurring here.
E. Other	NO	NO	NO	No additional emissions sources were identified.

Table A2.7: *Notation keys used in the LULUCF*

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/ removals	CH_4	N_2O	COMMENT
B Cropland		NO		CH_4 emissions biomass burning not occurring in Slovakia CH_4 emissions and removals from drainage and rewetting and other management of organic and mineral soils - this activity not occurring in Slovakia.
1. Cropland remaining cropland		NO	NO	CH_4 and N_2O emissions biomass burning not occurring in Slovakia, CH_4 and N_2O emissions and removals from drainage and rewetting and other management of organic and mineral soils - this activity not occurring in Slovakia. Emissions from histosols are below the threshold, notation key NE was used.
2. Land converted to cropland		NO		CH_4 emissions biomass burning not occurring in Slovakia.
C Grassland		NO		CH_4 emissions biomass burning not occurring in Slovakia.
1. Grassland remaining grassland	NO, NA	NO	NO	CO_2 - tier 1 assumes no change in living biomass, DOM and soil.
2. Land converted to grassland		NO		CH_4 emissions biomass burning not occurring in Slovakia.
D Wetlands	NO	NO	NO	As permanent surface waters have no carbon stock by definition, no emissions are reported.
1. Wetlands remaining wetlands	NO	NO	NO	No changes in AD, area remaining constant for reporting period. Wetlands consist of surface waters (watercourses and water bodies).
2. Land converted to wetlands	NO	NO	NO	No changes in area from and to WE, AD data not exist.
E Settlements		NO		CH_4 emissions biomass burning not occurring in Slovakia.
1. Settlements remaining settlements	NO	NO	NO	CO_2 - change in living biomass DOM and soil no change. Direct N_2O emissions from N input not occurring in Slovakia, CH_4 and N_2O emissions from biomass burning - not occurring in Slovakia.
2. Land converted to settlements		NO		CH_4 emissions biomass burning not occurring in Slovakia.
F Other Land		NO		CO_2, CH_4, N_2O emissions biomass burning not occurring in Slovakia.
2. Land converted to other land		NO	NO	CH_4 and N_2O emissions biomass burning not occurring in Slovakia.
H Other	NO	NO	NO	CH_4 a N_2O not occurring. This category is not reporting in Slovakia.

ANNEX 3. ASSESSMENT OF UNCERTAINTY

Chapter 3 of the IPCC 2006 GL (IPCC 2019 Refinements) provides methods for calculation of uncertainty in emissions inventory. As the Slovak Republic reports the results of Approach 1 the reporting is to be carried out using Table 3.2 for uncertainty calculation. The Slovak Republic provide Approach 2 for uncertainty analyses according to the Chapter 3 of the IPCC 2006 GL (IPCC 2019 Refinements) for the complete Energy and IPPU sectors. The methodology and results are described in the appropriate sectoral chapters of this report. Slovakia intends to use hybrid combination of Approaches 1 and 2 in submissions for calculation of total uncertainty of the inventory. According to the ERT recommendation G.3 from the draft ARR 2022, the table is provide with the final row with the overall uncertainty levels.

Table A3.1: *Approach 1 uncertainty with LULUCF assessment in 2022 (emissions in Gg of CO_2 eq., uncertainty in %)*

CRF	IPCC Category	GAS	BASE YEAR EMISSIONS OR REMOVALS	YEAR 2022 EMISSIONS OR REMOVALS	ACTIVITY DATA UNCERTAINTY	EMISSION FACTOR UNCERTAINTY	COMBINED UNCERTAINTY	CONTRIBUTION TO VARIANCE BY CATEGORY IN YEAR 2022	TYPE A SENSITIVITY	TYPE B SENSITIVITY	UNCERTAINTY IN TREND IN NATIONAL EMISSIONS INTRODUCED BY EMISSION FACTOR / ESTIMATION PARAMETER UNCERTAINTY	UNCERTAINTY IN TREND IN NATIONAL EMISSIONS INTRODUCED BY ACTIVITY DATA UNCERTAINTY	UNCERTAINTY INTRODUCED INTO THE TREND IN TOTAL NATIONAL EMISSIONS
2F1	Refrigeration and Air conditioning	F – gases	0.00	447.37	2.10	0.00	2.10	0.00	0.01	0.01	0.00	0.02	0.00
2F2	Foam Blowing Agents	F – gases	0.00	1.74	8.21	0.00	8.21	0.00	0.00	0.00	0.00	0.00	0.00
2F3	Fire Protection	F – gases	0.00	21.93	13.49	0.00	13.49	0.00	0.00	0.00	0.00	0.01	0.00
2F4	Aerosols	F – gases	0.00	9.85	10.08	0.00	10.08	0.00	0.00	0.00	0.00	0.00	0.00
1A1	Fuel combustion - Energy Industries - Liquid Fuels	CO2	3819.21	1427.35	5.00	3.60	6.16	0.09	-0.01	0.02	-0.02	0.16	0.02
1A1	Fuel combustion - Energy Industries - Solid Fuels	CO2	12861.05	2730.23	2.50	3.60	4.38	0.16	-0.05	0.04	-0.18	0.15	0.05
1A1	Fuel combustion - Energy Industries - Gaseous Fuels	CO2	2293.69	2033.13	2.50	2.75	3.72	0.07	0.02	0.03	0.04	0.11	0.01
1A1	Fuel combustion - Energy Industries - Other Fossil Fuels	CO2	35.61	175.37	5.00	5.00	7.07	0.00	0.00	0.00	0.01	0.02	0.00
1A2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO2	2867.64	256.68	5.00	3.60	6.16	0.00	-0.02	0.00	-0.06	0.03	0.00
1A2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO2	9028.53	3228.99	5.00	2.80	5.73	0.39	-0.01	0.05	-0.04	0.35	0.13
1A2	Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO2	3930.58	2090.31	2.50	2.75	3.72	0.07	0.00	0.03	0.01	0.11	0.01

CRF	IPCC Category	GAS	BASE YEAR EMISSIONS OR REMOVALS	YEAR 2022 EMISSIONS OR REMOVALS	ACTIVITY DATA UNCERTAINTY	EMISSION FACTOR UNCERTAINTY	COMBINED UNCERTAINTY	CONTRIBUTION TO VARIANCE BY CATEGORY IN YEAR 2022	TYPE A SENSITIVITY	TYPE B SENSITIVITY	UNCERTAINTY IN TREND IN NATIONAL EMISSIONS INTRODUCED BY EMISSION FACTOR / ESTIMATION PARAMETER UNCERTAINTY	UNCERTAINTY IN TREND IN NATIONAL EMISSIONS INTRODUCED BY ACTIVITY DATA UNCERTAINTY	UNCERTAINTY INTRODUCED INTO THE TREND IN TOTAL NATIONAL EMISSIONS
1A2	Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO2	200.34	297.94	5.00	5.00	7.07	0.01	0.00	0.00	0.02	0.03	0.00
1A2	Fuel combustion - Manufacturing Industries and Construction - Peat	CO2	0.00	0.00	5.00	5.00	7.07	0.00	0.00	0.00	0.00	0.00	0.00
1A3a	Fuel combustion - Domestic Aviation	CO2	3.74	1.48	1.00	5.00	5.10	0.00	0.00	0.00	0.00	0.00	0.00
1A3b	Fuel combustion - Road Transportation	CO2	4503.02	7583.91	1.00	5.00	5.10	1.71	0.09	0.12	0.43	0.17	0.21
1A3c	Fuel combustion - Railways	CO2	372.29	82.29	1.00	5.00	5.10	0.00	0.00	0.00	-0.01	0.00	0.00
1A3d	Fuel combustion - Domestic Navigation - Liquid Fuels	CO2	0.02	5.29	1.00	5.00	5.10	0.00	0.00	0.00	0.00	0.00	0.00
1A3e	Fuel combustion - Other Transportation	CO2	1813.95	16.12	1.00	5.00	5.10	0.00	-0.01	0.00	-0.06	0.00	0.00
1A4	Fuel combustion - Other Sectors - Liquid Fuels	CO2	580.74	262.28	5.00	3.60	6.16	0.00	0.00	0.00	0.00	0.03	0.00
1A4	Fuel combustion - Other Sectors - Solid Fuels	CO2	6852.15	415.31	5.00	4.00	6.40	0.01	-0.04	0.01	-0.17	0.05	0.03
1A4	Fuel combustion - Other Sectors - Gaseous Fuels	CO2	3634.43	3852.64	2.50	2.75	3.72	0.23	0.03	0.06	0.09	0.21	0.05
1A5	Fuel combustion - Other (Not specified elsewhere) - Stationary - Liquid Fuels	CO2	34.99	1.37	5.00	3.60	6.16	0.00	0.00	0.00	0.00	0.00	0.00
1A5	Fuel combustion - Other (Not specified elsewhere) - Stationary - Solid Fuels	CO2	216.08	0.42	5.00	4.00	6.40	0.00	0.00	0.00	-0.01	0.00	0.00
1A5	Fuel combustion - Other (Not specified elsewhere) - Stationary - Gaseous Fuels	CO2	154.75	51.63	2.50	2.75	3.72	0.00	0.00	0.00	0.00	0.00	0.00
1A5	Fuel combustion - Other (Not specified elsewhere) - Mobile- Liquid Fuels	CO2	70.04	8.43	5.00	3.60	6.16	0.00	0.00	0.00	0.00	0.00	0.00
1B1	Fugitive emissions from fuels - Solid Fuels	CO2	19.76	20.49	2.00	5.00	5.39	0.00	0.00	0.00	0.00	0.00	0.00
1B2a	Fugitive emissions from fuels - oil, NG and Other - Oil	CO2	39.69	31.69	5.00	7.00	8.60	0.00	0.00	0.00	0.00	0.00	0.00
1B2b	Fugitive emissions from fuels - oil, NG and Other - Natural gas	CO2	17.12	4.86	2.00	5.00	5.39	0.00	0.00	0.00	0.00	0.00	0.00
1B2c	Fugitive emissions from fuels - oil, NG and Other - Venting and flaring	CO2	0.23	0.08	5.00	7.00	8.60	0.00	0.00	0.00	0.00	0.00	0.00
2A1	Mineral Industry - Cement Production	CO2	1464.50	1489.72	0.75	1.67	1.83	0.01	0.01	0.02	0.02	0.02	0.00

CRF	IPCC Category	GAS	BASE YEAR EMISSIONS OR REMOVALS	YEAR 2022 EMISSIONS OR REMOVALS	ACTIVITY DATA UNCERTAINTY	EMISSION FACTOR UNCERTAINTY	COMBINED UNCERTAINTY	CONTRIBUTION TO VARIANCE BY CATEGORY IN YEAR 2022	TYPE A SENSITIVITY	TYPE B SENSITIVITY	UNCERTAINTY IN TREND IN NATIONAL EMISSIONS INTRODUCED BY EMISSION FACTOR / ESTIMATION PARAMETER UNCERTAINTY	UNCERTAINTY IN TREND IN NATIONAL EMISSIONS INTRODUCED BY ACTIVITY DATA UNCERTAINTY	UNCERTAINTY INTRODUCED INTO THE TREND IN TOTAL NATIONAL EMISSIONS
2A2	Mineral Industry - Lime Production	CO2	794.92	532.42	0.66	2.33	2.42	0.00	0.00	0.01	0.01	0.01	0.00
2A3	Mineral Industry - Glass Production	CO2	7.88	16.33	1.36	0.00	1.36	0.00	0.00	0.00	0.00	0.00	0.00
2A4	Mineral Industry - Other Process Uses of Carbonates	CO2	446.73	294.24	3.16	0.00	3.16	0.00	0.00	0.00	0.00	0.02	0.00
2B1	Chemical Industry - Ammonia Production	CO2	331.77	637.81	1.50	3.59	3.89	0.01	0.01	0.01	0.03	0.02	0.00
2B5	Chemical Industry - Carbide Production	CO2	0.00	35.49	1.45	7.14	7.29	0.00	0.00	0.00	0.00	0.00	0.00
2B8	Chemical Industry - Petrochemical and Carbon Black Production	CO2	428.80	349.63	1.12	13.24	13.29	0.02	0.00	0.01	0.03	0.01	0.00
2B10	Chemical Industry - Other	CO2	0.00	0.00	2.00	2.00	2.83	0.00	0.00	0.00	0.00	0.00	0.00
2C1	Metal Industry - Iron and Steel Production	CO2	4167.97	3324.10	2.23	5.77	6.19	0.48	0.02	0.05	0.13	0.16	0.04
2C2	Metal Industry - Ferroalloys Production	CO2	296.74	75.98	1.62	0.00	1.62	0.00	0.00	0.00	0.00	0.00	0.00
2C3	Metal Industry - Aluminium Production	CO2	121.32	111.45	1.79	3.36	3.81	0.00	0.00	0.00	0.00	0.00	0.00
2C5	Metal Industry - Lead Production	CO2	0.00	0.08	1.50	20.00	20.06	0.00	0.00	0.00	0.00	0.00	0.00
2D	Non-energy Products from Fuels and Solvent Use	CO2	50.49	40.77	6.89	22.39	23.43	0.00	0.00	0.00	0.01	0.01	0.00
3G	Liming	CO2	45.73	4.22	3.04	50.00	50.09	0.00	0.00	0.00	-0.01	0.00	0.00
3H	Urea Application	CO2	15.29	56.62	3.93	50.00	50.15	0.01	0.00	0.00	0.04	0.00	0.00
4A1	Forest Land - Forest Land Remaining Forest Land	CO2	-5999.27	-6304.61	20.00	82.84	85.22	118.34	-0.06	0.10	-4.57	2.77	28.57
4A2	Forest Land - Land Converted to Forest Land	CO2	-2263.04	-339.04	3.00	57.81	57.88	0.44	0.01	0.01	0.63	0.02	0.39
4B1	Cropland - Cropland Remaining Cropland	CO2	-950.94	-690.43	3.00	75.00	75.06	3.07	0.00	0.01	-0.30	0.05	0.09
4B2	Cropland - Land Converted to Cropland	CO2	466.51	40.69	3.00	83.58	83.63	0.01	0.00	0.00	-0.22	0.00	0.05
4C2	Grassland - Land Converted to Grassland	CO2	-195.77	-36.24	3.00	83.58	83.63	0.01	0.00	0.00	0.07	0.00	0.00
4E2	Settlements - Land Converted to Settlements	CO2	96.59	80.39	3.00	86.07	86.13	0.05	0.00	0.00	0.05	0.01	0.00
4F2	Other land - Land Converted to Other Land	CO2	293.10	76.37	3.00	86.07	86.13	0.05	0.00	0.00	-0.08	0.01	0.01

CRF	IPCC Category	GAS	BASE YEAR EMISSIONS OR REMOVALS	YEAR 2022 EMISSIONS OR REMOVALS	ACTIVITY DATA UNCERTAINTY	EMISSION FACTOR UNCERTAINTY	COMBINED UNCERTAINTY	CONTRIBUTION TO VARIANCE BY CATEGORY IN YEAR 2022	TYPE A SENSITIVITY	TYPE B SENSITIVITY	UNCERTAINTY IN TREND IN NATIONAL EMISSIONS INTRODUCED BY EMISSION FACTOR / ESTIMATION PARAMETER UNCERTAINTY	UNCERTAINTY IN TREND IN NATIONAL EMISSIONS INTRODUCED BY ACTIVITY DATA UNCERTAINTY	UNCERTAINTY INTRODUCED INTO THE TREND IN TOTAL NATIONAL EMISSIONS
4G	Harvested Wood Products	CO2	-470.41	-143.85	10.00	50.00	50.99	0.06	0.00	0.00	0.06	0.03	0.00
5C	Incineration and Open Burning of Waste	CO2	4.54	3.02	5.00	31.10	31.50	0.00	0.00	0.00	0.00	0.00	0.00
1A1	Fuel combustion - Energy Industries - Liquid Fuels	CH4	3.83	1.40	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00
1A1	Fuel combustion - Energy Industries - Solid Fuels	CH4	3.57	0.63	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00
1A1	Fuel combustion - Energy Industries - Gaseous Fuels	CH4	1.16	1.01	3.00	5.00	5.83	0.00	0.00	0.00	0.00	0.00	0.00
1A1	Fuel combustion - Energy Industries - Other Fossil Fuels	CH4	0.31	1.78	5.00	50.00	50.25	0.00	0.00	0.00	0.00	0.00	0.00
1A1	Fuel combustion - Energy Industries - Biomass	CH4	0.63	10.72	3.00	50.00	50.09	0.00	0.00	0.00	0.01	0.00	0.00
1A2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CH4	3.12	0.22	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00
1A2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CH4	18.22	3.86	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00
1A2	Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CH4	1.97	1.04	3.00	5.00	5.83	0.00	0.00	0.00	0.00	0.00	0.00
1A2	Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CH4	1.79	2.70	5.00	50.00	50.25	0.00	0.00	0.00	0.00	0.00	0.00
1A2	Fuel combustion - Manufacturing Industries and Construction - Peat	CH4	0.00	0.00	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00
1A2	Fuel combustion - Manufacturing Industries and Construction - Biomass	CH4	3.05	10.70	3.00	50.00	50.09	0.00	0.00	0.00	0.01	0.00	0.00
1A3a	Fuel combustion - Domestic Aviation	CH4	0.00	0.00	3.00	5.00	5.83	0.00	0.00	0.00	0.00	0.00	0.00
1A3b	Fuel combustion - Road Transportation	CH4	32.63	5.81	3.00	5.00	5.83	0.00	0.00	0.00	0.00	0.00	0.00
1A3c	Fuel combustion - Railways	CH4	0.58	0.14	1.00	40.00	40.01	0.00	0.00	0.00	0.00	0.00	0.00
1A3d	Fuel combustion - Domestic Navigation - Liquid Fuels	CH4	0.00	0.01	1.00	40.00	40.01	0.00	0.00	0.00	0.00	0.00	0.00
1A3e	Fuel combustion - Other Transportation	CH4	0.89	0.01	1.00	40.00	40.01	0.00	0.00	0.00	0.00	0.00	0.00
1A4	Fuel combustion - Other Sectors - Liquid Fuels	CH4	1.40	0.99	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00

CRF	IPCC Category	GAS	BASE YEAR EMISSIONS OR REMOVALS	YEAR 2022 EMISSIONS OR REMOVALS	ACTIVITY DATA UNCERTAINTY	EMISSION FACTOR UNCERTAINTY	COMBINED UNCERTAINTY	CONTRIBUTION TO VARIANCE BY CATEGORY IN YEAR 2022	TYPE A SENSITIVITY	TYPE B SENSITIVITY	UNCERTAINTY IN TREND IN NATIONAL EMISSIONS INTRODUCED BY EMISSION FACTOR / ESTIMATION PARAMETER UNCERTAINTY	UNCERTAINTY IN TREND IN NATIONAL EMISSIONS INTRODUCED BY ACTIVITY DATA UNCERTAINTY	UNCERTAINTY INTRODUCED INTO THE TREND IN TOTAL NATIONAL EMISSIONS
1A4	Fuel combustion - Other Sectors - Solid Fuels	CH4	384.16	20.32	3.00	50.00	50.09	0.00	0.00	0.00	-0.12	0.00	0.01
1A4	Fuel combustion - Other Sectors - Gaseous Fuels	CH4	9.11	9.60	3.00	5.00	5.83	0.00	0.00	0.00	0.00	0.00	0.00
1A4	Fuel combustion - Other Sectors - Biomass	CH4	40.46	216.44	3.00	50.00	50.09	0.13	0.00	0.00	0.15	0.01	0.02
1A5	Fuel combustion - Other (Not specified elsewhere) - Stationary - Liquid Fuels	CH4	0.04	0.00	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00
1A5	Fuel combustion - Other (Not specified elsewhere) - Stationary - Solid Fuels	CH4	0.06	0.00	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00
1A5	Fuel combustion - Other (Not specified elsewhere) - Stationary - Gaseous Fuels	CH4	0.38	0.13	3.00	5.00	5.83	0.00	0.00	0.00	0.00	0.00	0.00
1A5	Fuel combustion - Other (Not specified elsewhere) - Stationary - Biomass	CH4	0.00	0.14	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00
1A5	Fuel combustion - Other (Not specified elsewhere) - Mobile- Liquid Fuels	CH4	0.22	0.03	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00
1B1	Fugitive emissions from fuels - Solid Fuels	CH4	794.91	180.08	5.00	7.00	8.60	0.00	0.00	0.00	-0.02	0.02	0.00
1B2a	Fugitive emissions from fuels - oil, NG and Other - Oil	CH4	13.24	6.16	5.00	7.00	8.60	0.00	0.00	0.00	0.00	0.00	0.00
1B2b	Fugitive emissions from fuels - oil, NG and Other - Natural gas	CH4	1185.60	151.16	2.00	5.00	5.39	0.00	-0.01	0.00	-0.03	0.01	0.00
1B2c	Fugitive emissions from fuels - oil, NG and Other - Venting and flaring	CH4	659.46	22.13	2.00	5.00	5.39	0.00	0.00	0.00	-0.02	0.00	0.00
2B1	Chemical Industry - Ammonia Production	CH4	0.30	0.37	1.50	10.00	10.11	0.00	0.00	0.00	0.00	0.00	0.00
2B10	Chemical Industry - Other	CH4	0.00	0.00	2.00	10.00	10.20	0.00	0.00	0.00	0.00	0.00	0.00
2C2	Metal Industry - Ferroalloys Production	CH4	0.00	0.37	1.50	10.00	10.11	0.00	0.00	0.00	0.00	0.00	0.00
3A	Enteric Fermentation	CH4	3112.01	1028.92	13.10	14.91	19.85	0.48	-0.01	0.02	-0.09	0.30	0.10
3B	Manure Management	CH4	716.14	100.79	6.50	9.41	11.43	0.00	0.00	0.00	-0.03	0.01	0.00
4A1	Forest Land - Forest Land Remaining Forest Land	CH4	12.37	45.79	5.00	5.00	7.07	0.00	0.00	0.00	0.00	0.01	0.00
4A2	Forest Land - Land Converted to Forest Land	CH4	0.08	0.06	5.00	5.00	7.07	0.00	0.00	0.00	0.00	0.00	0.00

CRF	IPCC Category	GAS	BASE YEAR EMISSIONS OR REMOVALS	YEAR 2022 EMISSIONS OR REMOVALS	ACTIVITY DATA UNCERTAINTY	EMISSION FACTOR UNCERTAINTY	COMBINED UNCERTAINTY	CONTRIBUTION TO VARIANCE BY CATEGORY IN YEAR 2022	TYPE A SENSITIVITY	TYPE B SENSITIVITY	UNCERTAINTY IN TREND IN NATIONAL EMISSIONS INTRODUCED BY EMISSION FACTOR / ESTIMATION PARAMETER UNCERTAINTY	UNCERTAINTY IN TREND IN NATIONAL EMISSIONS INTRODUCED BY ACTIVITY DATA UNCERTAINTY	UNCERTAINTY INTRODUCED INTO THE TREND IN TOTAL NATIONAL EMISSIONS
5A	Solid Waste Disposal	CH4	781.78	1207.08	17.35	20.31	26.71	1.19	0.01	0.02	0.27	0.46	0.28
5B	Biological Treatment of Solid Waste	CH4	72.69	239.62	8.42	62.23	62.80	0.26	0.00	0.00	0.20	0.04	0.04
5C	Incineration and Open Burning of Waste	CH4	13.41	11.02	5.00	50.00	50.25	0.00	0.00	0.00	0.00	0.00	0.00
5D	Wastewater Treatment and Discharge	CH4	405.98	267.15	4.44	31.44	31.75	0.08	0.00	0.00	0.04	0.03	0.00
1A1	Fuel combustion - Energy Industries - Liquid Fuels	N2O	7.04	2.31	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00
1A1	Fuel combustion - Energy Industries - Solid Fuels	N2O	48.12	6.80	3.00	50.00	50.09	0.00	0.00	0.00	-0.01	0.00	0.00
1A1	Fuel combustion - Energy Industries - Gaseous Fuels	N2O	1.09	0.96	3.00	5.00	5.83	0.00	0.00	0.00	0.00	0.00	0.00
1A1	Fuel combustion - Energy Industries - Other Fossil Fuels	N2O	0.40	2.25	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00
1A1	Fuel combustion - Energy Industries - Biomass	N2O	0.80	13.52	3.00	50.00	50.09	0.00	0.00	0.00	0.01	0.00	0.00
1A2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	N2O	6.05	0.41	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00
1A2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	N2O	25.54	5.30	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00
1A2	Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	N2O	1.86	0.99	3.00	5.00	5.83	0.00	0.00	0.00	0.00	0.00	0.00
1A2	Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	N2O	2.26	3.41	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00
1A2	Fuel combustion - Manufacturing Industries and Construction - Peat	N2O	0.00	0.00	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00
1A2	Fuel combustion - Manufacturing Industries and Construction - Biomass	N2O	3.84	20.30	3.00	50.00	50.09	0.00	0.00	0.00	0.01	0.00	0.00
1A3a	Fuel combustion - Domestic Aviation	N2O	0.03	0.01	1.00	50.00	50.01	0.00	0.00	0.00	0.00	0.00	0.00
1A3b	Fuel combustion - Road Transportation	N2O	50.23	74.67	1.00	50.00	50.01	0.02	0.00	0.00	0.04	0.00	0.00
1A3c	Fuel combustion - Railways	N2O	38.08	9.05	1.00	50.00	50.01	0.00	0.00	0.00	-0.01	0.00	0.00
1A3d	Fuel combustion - Domestic Navigation - Liquid Fuels	N2O	0.00	0.04	1.00	50.00	50.01	0.00	0.00	0.00	0.00	0.00	0.00

CRF	IPCC Category	GAS	BASE YEAR EMISSIONS OR REMOVALS	YEAR 2022 EMISSIONS OR REMOVALS	ACTIVITY DATA UNCERTAINTY	EMISSION FACTOR UNCERTAINTY	COMBINED UNCERTAINTY	CONTRIBUTION TO VARIANCE BY CATEGORY IN YEAR 2022	TYPE A SENSITIVITY	TYPE B SENSITIVITY	UNCERTAINTY IN TREND IN NATIONAL EMISSIONS INTRODUCED BY EMISSION FACTOR / ESTIMATION PARAMETER UNCERTAINTY	UNCERTAINTY IN TREND IN NATIONAL EMISSIONS INTRODUCED BY ACTIVITY DATA UNCERTAINTY	UNCERTAINTY INTRODUCED INTO THE TREND IN TOTAL NATIONAL EMISSIONS
1A3e	Fuel combustion - Other Transportation	N2O	0.84	0.01	1.00	50.00	50.01	0.00	0.00	0.00	0.00	0.00	0.00
1A4	Fuel combustion - Other Sectors - Liquid Fuels	N2O	8.88	19.04	3.00	50.00	50.09	0.00	0.00	0.00	0.01	0.00	0.00
1A4	Fuel combustion - Other Sectors - Solid Fuels	N2O	24.59	1.30	3.00	50.00	50.09	0.00	0.00	0.00	-0.01	0.00	0.00
1A4	Fuel combustion - Other Sectors - Gaseous Fuels	N2O	1.73	1.82	3.00	5.00	5.83	0.00	0.00	0.00	0.00	0.00	0.00
1A4	Fuel combustion - Other Sectors - Biomass	N2O	5.57	28.74	3.00	50.00	50.09	0.00	0.00	0.00	0.02	0.00	0.00
1A5	Fuel combustion - Other (Not specified elsewhere) - Stationary - Liquid Fuels	N2O	0.07	0.00	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00
1A5	Fuel combustion - Other (Not specified elsewhere) - Stationary - Solid Fuels	N2O	0.80	0.00	3.00	5.00	5.83	0.00	0.00	0.00	0.00	0.00	0.00
1A5	Fuel combustion - Other (Not specified elsewhere) - Stationary - Gaseous Fuels	N2O	0.07	0.02	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00
1A5	Fuel combustion - Other (Not specified elsewhere) - Stationary - Biomass	N2O	0.00	0.02	1.00	50.00	50.01	0.00	0.00	0.00	0.00	0.00	0.00
1A5	Fuel combustion - Other (Not specified elsewhere) - Mobile- Liquid Fuels	N2O	1.47	0.18	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00
1B2c	Fugitive emissions from fuels - oil, NG and Other - Venting and flaring	N2O	0.02	0.00	5.00	7.00	8.60	0.00	0.00	0.00	0.00	0.00	0.00
2B1	Chemical Industry - Ammonia Production	N2O	0.29	0.35	1.50	10.00	10.11	0.00	0.00	0.00	0.00	0.00	0.00
2B2	Chemical Industry - Nitric Acid Production	N2O	1072.65	52.76	2.57	0.00	2.57	0.00	-0.01	0.00	0.00	0.00	0.00
2B10	Chemical Industry - Other	N2O	0.00	0.00	2.00	10.00	10.20	0.00	0.00	0.00	0.00	0.00	0.00
2G3	Other Product Manufacture and Use	N2O	14.58	57.00	9.13	0.00	9.13	0.00	0.00	0.00	0.00	0.01	0.00
3B	Manure Management	N2O	518.46	179.11	6.50	248.03	248.11	2.26	0.00	0.00	-0.23	0.03	0.05
3D1	Direct N2O Emissions From Managed Soils	N2O	776.75	453.96	59.37	36.22	69.54	1.14	0.00	0.01	0.05	0.59	0.35
3D2	Indirect N2O Emissions From Managed Soils	N2O	583.30	110.81	77.10	103.30	128.90	0.23	0.00	0.00	-0.25	0.19	0.10
4A1	Forest Land - Forest Land Remaining Forest Land	N2O	6.48	23.97	5.00	5.00	7.07	0.00	0.00	0.00	0.00	0.00	0.00
4A2	Forest Land - Land Converted to Forest Land	N2O	0.04	0.03	5.00	5.00	7.07	0.00	0.00	0.00	0.00	0.00	0.00

CRF	IPCC Category	GAS	BASE YEAR EMISSIONS OR REMOVALS	YEAR 2022 EMISSIONS OR REMOVALS	ACTIVITY DATA UNCERTAINTY	EMISSION FACTOR UNCERTAINTY	COMBINED UNCERTAINTY	CONTRIBUTION TO VARIANCE BY CATEGORY IN YEAR 2022	TYPE A SENSITIVITY	TYPE B SENSITIVITY	UNCERTAINTY IN TREND IN NATIONAL EMISSIONS INTRODUCED BY EMISSION FACTOR / ESTIMATION PARAMETER UNCERTAINTY	UNCERTAINTY IN TREND IN NATIONAL EMISSIONS INTRODUCED BY ACTIVITY DATA UNCERTAINTY	UNCERTAINTY INTRODUCED INTO THE TREND IN TOTAL NATIONAL EMISSIONS
4B2	Cropland - Land Converted to Cropland	N2O	85.07	8.05	75.00	100.00	125.00	0.00	0.00	0.00	-0.05	0.01	0.00
4C2	Grassland - Land Converted to Grassland	N2O	0.86	0.25	75.00	100.00	125.00	0.00	0.00	0.00	0.00	0.00	0.00
4E2	Settlements - Land Converted to Settlements	N2O	3.81	4.18	75.00	100.00	125.00	0.00	0.00	0.00	0.00	0.01	0.00
4F2	Other land - Land Converted to Other Land	N2O	0.00	0.00	75.00	100.00	125.00	0.00	0.00	0.00	0.00	0.00	0.00
4(IV)	Nitrogen leaching and run-off	N2O	13.46	4.32	58.70	0.00	58.70	0.00	0.00	0.00	0.00	0.01	0.00
5B	Biological Treatment of Solid Waste	N2O	41.29	116.69	8.42	93.34	93.72	0.14	0.00	0.00	0.14	0.02	0.02
5C	Incineration and Open Burning of Waste	N2O	0.21	0.17	5.00	100.00	100.12	0.00	0.00	0.00	0.00	0.00	0.00
5D	Wastewater Treatment and Discharge	N2O	75.12	85.17	6.74	31.44	32.16	0.01	0.00	0.00	0.02	0.01	0.00
2C3	Metal Industry - Aluminium Production	PFCs	213.92	5.88	1.50	10.05	10.16	0.00	0.00	0.00	-0.01	0.00	0.00
2F1	Refrigeration and air conditioning	PFCs	0.00	0.03	2.10	11.00	11.20	0.00	0.00	0.00	0.00	0.00	0.00
2G1	Electrical equipment	SF6	0.06	15.38	2.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL			64 414.40	29 571.99		131.27							30.69
Total Uncertainties			-54.09	Uncertainty in total inventory %:		11.46					Trend uncertainty %:		5.54

ANNEX 4. QUALITY ASSURANCE/QUALITY CONTROL PLAN

Table A4.1: The Quality Assurance/Quality Control Plan 2024 - Internal

ACTIVITY		WHO	CHECK-IN	TIME SCHEDULE	RECORD
1.	Evaluation of Improvement plans for the year 2024	Sectoral experts NIS coordinator Deputy of NIS coordinator	Quality manager MŽP SR – NFP	15.01.2024	Improvement plan for the year 2024 for every sector
2.	Tasks and financial plan of NIS – preparation for the year 2024.	NIS coordinator Deputy of NIS coordinator	MŽP SR – NFP Quality manager Head of the SHMÚ	12.02.2024	Information on budget, capacity (personal, external, internal), training plan, meetings and business trips plan, plan of QA/QC activities for the inventory year 2022.
3.	Update of capacity incorporating updates for each sector	Sectoral experts (SE) Deputy of SE	MŽP SR – NFP Quality manager Head of the SHMÚ	28.02.2024	Responsibilities matrix for 2024 Description of work activities
4.	Work assignment and contracts signing for each sector for the year 2024	NIS coordinator Deputy of NIS coordinator	MŽP SR - NFP Head of the SHMÚ	31.03.2024	Frame contracts with the sectoral experts Specification of tasks for a given year (improvement plan) Nomination letters for sectoral experts
5.	Plan of QA/QC activities for the emission inventory on overall and sectoral level	Sectoral experts (SE) Deputy of SE	NIS coordinator Deputy of NIS coordinator Quality manager	10.03.2024	Description QA/QC activities in each sectoral chapters for the year 2024
6.	Key sources and uncertainty management for each sector for the inventory year 2022	Sectoral expert for uncertainty Sectoral experts NIS coordinator	Deputy of NIS coordinator Quality manager	15.03.2024	Report on key sources and uncertainty evaluation for year 2022 Template for the key sources and uncertainty evaluation for year 2022
7.	Final evaluation of emission data 2016 on sectoral level based on the external audit of the European Commission	Sectoral experts NIS coordinator	Deputy of NIS coordinator Quality manager MŽP SR – NFP	31.05.2024	Verification protocols Description of changes Updated sectoral report
8.	Workshop – meeting of experts, ministries, SNE; Program: evaluation of results, finding from the reviews, proposals for improvement, proposal for the inventory plan for NIR 2025	Sectoral experts NIS coordinator Deputy of NIS coordinator	MŽP SR – NFP Quality manager	April 2024 September 2024 December 2024	Report from the meeting

ACTIVITY		WHO	CHECK-IN	TIME SCHEDULE	RECORD
9.	Completeness check of emission inventory for the year 2024	Sectoral experts	NIS coordinator Deputy of NIS coordinator Quality manager MŽP SR – NFP	30.09.2024	Report from completeness check
10.	Methodical updates, recalculation list on sectoral level, according to IPCC 2006 GL	Sectoral experts	NIS coordinator Deputy of NIS coordinator Quality manager	31.10. 2024	Report of emission for each sector, for inventory year 2023
11.	Sectoral final reports delivery	Sectoral experts	NIS coordinator Deputy of NIS coordinator Quality manager	30.11. 2024	Delivery protocols Drafts of sectoral reports for the inventory year 2023
12.	Participation in individual evaluations and cooperation in preparing of view on the review assessment by the UNFCCC secretariat	Sectoral experts	NIS coordinator Deputy of NIS coordinator Quality manager	continuously	Sectoral assessment reports

***Table A4.2:** The Quality Assurance/Quality Control Plan 2024 - External*

ACTIVITY		WHO	CHECK-IN	TIME SCHEDULE	RECORD
1.	Annual Report 2024 submission according to the Regulation (EÚ) 2018/1999 Article 26 and Implementing regulation 2020/1208/EU, Article 7: - Preliminary Emission GHG inventory for years 2022; - Indicators for the year 2022; - Preliminary National Inventory 2024; - SEF tables for the year 2023.	NIS coordinator Sectoral experts National administrator	Ministry of Environment of the Slovak Republic – NFP Deputy of NIS coordinator	15. 01. 2024	Annual Report SVK 2022 - complete Components of the SVK NIR 2024 - incomplete CRF 1990 - 2022 SEF tables 2023 Tables according directive (EU) 2020/1208
2.	Repeated Annual Report 2024 submission according to the Regulation 2018/1999/EU, Article	NIS coordinator Sectoral experts National administrator	Ministry of Environment of the Slovak Republic – NFP	15. 03. 2024	Indicators form for the year 2022 CRF tables 1990-2022 SVK NIR 2024 - final

ACTIVITY		WHO	CHECK-IN	TIME SCHEDULE	RECORD
	26 and Implementing regulation 2020/1208/EU, Article 8-24: - Emission GHG inventory for year 2022; - Indicators for the year 2022; - National Inventory Report for year 2024; - SEF tables for the year 2023.		Deputy of NIS coordinator		Tables according directive (EU) 2020/1208
3.	ESR annual simplified review 2024	NIS coordinator Deputy of NIS coordinator Sectoral experts	Technical Expert Review Team	15. 02. 2024 20. 04. 2024	Report from the review until 30. 06. 2024 (depending on the findings and their solution)
4.	Nomination letters for the sectoral experts – update for the year 2024.	Ministry of Environment of the Slovak Republic – NFP	Deputy of NIS coordinator	15. 04. 2024	Nomination Letters List of nominated sectoral experts for the year 2024.
5.	National Inventory SVK NID 2024 submission to the secretariat UNFCCC by ETF software: - Emission GHG inventory for the years 1990-2022; - National Inventory Document 2024; - Information from the National Registry for the year 2023.	NIS coordinator Sectoral experts National Registry	Deputy of NIS coordinator Ministry of Environment of the Slovak Republic – NFP	15. 09. 2024	CRT tables 1990-2022 SEF 2023 SVK NID 2024 published on the official web of the UNFCCC
6.	Publicity of the SVK NID 2024 and emissions data on the official web of the SVK NIS.	NIS coordinator Deputy of NIS coordinator	Ministry of Environment of the Slovak Republic – NFP	15. 04. 2024	Update of data on https://oeab.shmu.sk/
7.	Completion and updating of the SVK NID 2024 on the basis of Initial Assessment by the EU review.	NIS coordinator Sectoral experts	Deputy of NIS coordinator Ministry of Environment of the Slovak Republic – NFP	6 weeks after 15. 04. 2024	Repeated Emission GHG inventory and SVK NID 2024 submission (if relevant)
8.	Preparation of the updated inputs for projections and PAMs into NECP according to Art. 14 of Regulation (EU) 2018/1999	MH SR OEaB partially provide inputs	MH SR	30. 6. 2024	Updated NECP
9.	Audit of the status of the preparation of the emission GHG	NIS coordinator Sectoral experts	Deputy of NIS coordinator Ministry of	30. 06. 2024 30. 09. 2024	Report from the coordination meetings of the NIS

ACTIVITY		WHO	CHECK-IN	TIME SCHEDULE	RECORD
	inventory for the year 2023 – check days.		Environment of the Slovak Republic – NFP		
10.	Proxy Inventory SVK 2023 according Regulation 2018/1999/EU, Article 26 and Implementing regulation 2020/1208/EU, Article 7	NIS coordinator Sectoral experts	Deputy of NIS coordinator Ministry of Environment of the Slovak Republic – NFP	31. 07. 2024	Proxy inventory of GHG
11.	Data delivering to the Statistical Office of the Slovak Republic. Distribution of the SVK NID 2024 to the relevant institutions.	NIS coordinator Sectoral experts	Deputy of NIS coordinator Ministry of Environment of the Slovak Republic – NFP	31. 10. 2024	Statistical record Emission GHG inventory for the years 1990-2022
12.	Measures and objectives for improvements in QA/QC procedure of GHG emission inventory for relevant sectors based on the preliminary results of the review NIR SVK 2024.	Sectoral experts Deputy of NIS coordinator	NIS coordinator Ministry of Environment of the Slovak Republic – NFP	30. 11. 2024	Report and Improvement plan for the year 2025
13.	Preliminary the first Biennial Transparency Report under the Paris Agreement	Sectoral experts Deputy of NIS coordinator	NIS coordinator MŽP SR – NFP	30. 11. 2024	The first BTR of Slovakia

Table A4.3: *List of UNFCCC main findings and recommendations, and status of implementation*

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION	CHAPTER/SECTION IN THE NIR
General - Convention reporting adherence	Uncertainty analysis: Include in the NIR a quantitative uncertainty assessment for the base year and the latest inventory year for all categories as required by paragraph 15 of the UNFCCC Annex I inventory reporting guidelines.	G.3 - ARR 2022 (sent on 4. 4. 2023)	Implemented	Annex 3 of the SVK NIR 2023
General - Convention reporting adherence	Key category analysis: Include in the NIR the results of the key category analysis in accordance with paragraphs 39 and 50(d) of the UNFCCC Annex I inventory reporting guidelines.	G.5 - ARR 2022 (sent on 4. 4. 2023)	Implemented	Annex I of the SVK NIR 2023

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION	CHAPTER/SECTION IN THE NIR
General - Convention reporting adherence	The ERT recommends that the Party enhance its QA/QC process to ensure a high-quality key category analysis and report a correct key category analysis in the next annual submission.	G.6 - ARR 2022 (sent on 4. 4. 2023)	Slovakia enhances QA/QC process in key category analysis. Analysis is checked by NIS coordinator and by sector experts.	Annex 1 of the SVK NIR 2023
General - KP reporting adherence	The ERT concludes that this potential problem of a mandatory nature does not influence the Party's ability to fulfil its commitments for the second commitment period of the Kyoto Protocol and therefore this issue was not included in the list of potential problems and further questions raised. The ERT agrees with this value for the CPR.	G.7 - ARR 2022 (sent on 4. 4. 2023)	Implemented	Implemented in the SVK NIR 2023 (Chapter 14)
Energy - 1.A.4 Other sectors – solid fuels – CH_4, (E.6, 2021) (E.17, 2019), (E.36, 2017) Accuracy	Estimate and report CH4 emissions from solid fuels for category 1.A.4 using at least a tier 2 methodology (in accordance with the 2006 IPCC Guidelines) if the emissions are identified as key.	E.2 - ARR 2022 (sent on 4. 4. 2023)	Partly Implemented. Complete will be possible in the future submission due to capacity and budget constraints and difficulties connected with the EFs estimation in services and households.	Implemented in the SVK NIR 2023 (Chapters 3.2.5 & 3.2.9)
Energy - 1.B.2.b Natural gas 1.B.2.c Venting and flaring – natural gas – CH_4, (E.13, 2021) Transparency	Improve the transparency of the description in the NIR of the methodology used to estimate category 1.B.2.b.4 and 1.B.2.c.1.ii emissions by including (a) summary information on the sources of emissions in these categories (e.g. valves or compressors), (b) the method of measurement or estimation (e.g. infrared camera, Bacharach Hi Flow sampler or specific EFs), (c) the method of back calculation of emissions for years before 2013 (e.g. the extrapolation approach or proxy data used) and (d) the verification of the results.	E.6 - ARR 2022 (sent on 4. 4. 2023)	Implemented	Implemented in the SVK NIR 2023 (Chapter 3.5.7.1)
IPPU - 2.A.1 Cement production – CO_2 (I.6, 2021) Transparency	Include the estimated values of magnesium oxide content in table 4.7 of the NIR with notation explaining how these values were estimated and adopt different wording or symbols for aggregated CaO content and CaO content in the cement clinker.	I.1 - ARR 2022 (sent on 4. 4. 2023)	Implemented	Implemented in the SVK NIR 2023 (Chapter 4.6.2.2)

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION	CHAPTER/SECTION IN THE NIR
IPPU - 2.A.3 Glass production – CO_2 (I.9, 2021) Transparency	Include in the NIR a comparison between the country-specific EF with the tier 1 default value from the 2006 IPCC Guidelines (vol. 3, chap. 2.4.1.2) (using the following equation for calculating the difference, (0.1 – 0.057)/0.1 = x100%, which leads to a reduction in estimated emissions of 43 per cent) and explain the large difference between the country-specific EF and the tier 1 default value, in accordance with the 2006 IPCC Guidelines QC procedure (vol. 1, chap. 6, p.6.13).	I.3 - ARR 2022 (sent on 4. 4. 2023)	Implemented	Implemented in the SVK NIR 2023 (Chapter 4.6.4.1)
IPPU - 2.D.3 Other (non-energy products from fuels and solvent use) – CO_2 (I.3, 2021) (I.8, 2019) (I.9, 2017) Transparency	(a) Report the AD used in the estimation of CO2 emissions from urea used in catalytic converters (i.e. equal to 5–7 per cent of fuel consumption for EURO 5 and 3–4 per cent for EURO 6 diesel oil passenger and heavy-duty vehicles) and (b) explain in the NIR how those CO2 emissions are estimated.	I.5 - ARR 2022 (sent on 4. 4. 2023)	Implemented	Implemented in the SVK NIR 2023 (Chapter 4.9.3.1)
IPPU - 2.C.1 Iron and steel production – CH_4, Completeness	The ERT recommends that the Party report CH4 emissions from sintering production under category 2.C.1 (or the category where those emissions are reported) for the entire time series including a description of the methodologies, AD and EFs used in the estimates. Alternatively, if the Party considers these emissions to be insignificant, the ERT recommends that it report them as “NE” and demonstrate that the likely level of emissions is below the significance threshold mentioned in paragraph 37(b) of the UNFCCC Annex I inventory reporting guidelines.	I.6 - ARR 2022 (sent on 4. 4. 2023)	Implemented	Implemented in the SVK NIR 2023 (Annex 4.1. - Table A4.1.5)
Agriculture - 3.D.a.4 Crop residues – N_2O and CH_4, (A.4, 2021) (A.16, 2019), Accuracy	Revise the methodology description in the NIR taking into account the improvements made in response to the list of potential problems and further questions from the ERT, including the use of a country-specific value for sugar beet	A.1 - ARR 2022 (sent on 4. 4. 2023)	Implemented	Implemented in the SVK NIR 2023, Chapter 5.12.6.

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION	CHAPTER/SECTION IN THE NIR
	(20 kg N/ha), consideration of only below-ground residues for maize used for silage, and consideration of alfalfa and clover as perennial crops with a four- and three-year rotation respectively.			
Agriculture - 3. General (agriculture) – CH_4 and N_2O, Convention reporting adherence	The ERT recommends that the Party use the correct figure to compare emissions of the agriculture sector between the subsequent submissions. The ERT also encourages the Party to improve the QA/QC procedures to avoid reporting errors in the future.	A.4 - ARR 2022 (sent on 4. 4. 2023)	Implemented	Implemented in the SVK NIR 2023, Chapter 5.4.
Agriculture - 3.A Enteric fermentation – CH_4, Transparency	The ERT recommends that the Party include in the NIR an explanation of the key livestock types and drivers of the emission trends under enteric fermentation to ensure clarity regarding the factors affecting these trends, and include the information explaining the fluctuations in the trends.	A.5 - ARR 2022 (sent on 4. 4. 2023)	Implemented	Implemented in the SVK NIR 2023, Chapter 5.7.
Agriculture - 3.B Manure management – CH_4, Transparency	The ERT recommends that the Party include in the NIR an explanation of the emission trends under manure management and the factors affecting these trends and fluctuations.	A.6 - ARR 2022 (sent on 4. 4. 2023)	Implemented	Implemented in the SVK NIR 2023, Chapter 5.9.
Agriculture - 3.B.3 Swine – N_2O, Transparency	The ERT recommends that the Party include in the NIR a discussion of the N excretion rate for breeding swine and how this affects the trends.	A.7 - ARR 2022 (sent on 4. 4. 2023)	Implemented	Implemented in the SVK NIR 2023, Chapter 5.9.1.
Agriculture - 3.D.a.4 Crop residues - N_2O, Convention reporting adherence	The ERT recommends that the Party update NIR table 5.73 with new values for the harvested area, crop, and crop residues to reflect the estimates reported in the CRF tables. The ERT also encourages the Party to improve the QA/QC procedures to avoid reporting errors in the future.	A.8 - ARR 2022 (sent on 4. 4. 2023)	Implemented	Implemented in the SVK NIR 2023, Chapter 5.9.1.
LULUCF - 4. General (LULUCF) – CO_2 (L.1, 2021) (L.1, 2019)(L.1, 2017) (L.1, 2016)(L.1, 2015) (66, 2014)(44,	Continue the ongoing technical research to provide reliable data for estimating CSC in living biomass, dead organic matter, and soil organic matter.	L.1 - ARR 2022 (sent on 4. 4. 2023)	Partly implemented in the SVK NIR 2023	Partly implemented in the SVK NIR 2023, Chapter 6

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION	CHAPTER/SECTION IN THE NIR
2013), Accuracy				
LULUCF - 4. General (LULUCF)(L.12, 2021) Comparability	If reporting the area of and emissions from organic soils as "NE" in CRF table 4.B, explain in CRF table 9 the notation key used.	L.4 - ARR 2022 (sent on 4. 4. 2023)	Implemented in the SVK NIR 2023	Implemented in the SVK CRF 2023, Table 9. The CRF table 9 is generated automatically.
LULUCF - Land representation (L.10, 2021) Transparency	Provide in the NIR an explanation for the cause of the abrupt increase in the areas of settlements and decrease in other land occurring around 1995 and report land representation data for 2016 onward.	L.5 - ARR 2022 (sent on 4. 4. 2023)	Implemented in the SVK NIR 2023	Partly implemented in the SVK NIR 2023, Chapter 6.1
LULUCF - 4. General (LULUCF) – CO_2 and N_2O, Transparency	The ERT recommends that the Party provide further explanation of the climate domain and ecological zones of Slovakia in the LULUCF chapter of its NIR.	L.12 - ARR 2022 (sent on 4. 4. 2023)	Implemented in the SVK NIR 2023	Implemented in the SVK NIR 2023), Chapter 6.1
LULUCF - 4. General (LULUCF) – CO_2 and N_2O, Transparency	The ERT recommends that the Party provide in its NIR further information on thresholds for land-use definitions and subcategories used. The ERT also recommends that the Party provide clearer information on CSC, AD (such as annual increment, area, etc.) and selected factors for estimation of CSC of other wooded land.	L.13 - ARR 2022 (sent on 4. 4. 2023)	Implemented in the SVK NIR 2023	Implemented in the SVK NIR 2023), Chapter 6.6.1
LULUCF - 4.A.1 Forest land remaining FL, CO_2, Transparency	The ERT recommends that the Party provide information on the revised coefficients BCEFR for conifer and broadleaves species and clearly describe the related methodological recalculations in the next submission.	L.14 - ARR 2022 (sent on 4. 4. 2023)	Implemented in the SVK NIR 2023	Implemented in the SVK NIR 2023, Chapter 6.6
LULUCF - 4.B.2.1 Forest land converted to Cropland, CO_2, Transparency	The ERT recommends that the Party provide information on the revised estimations, revised AD and revised coefficients and clearly describe the related methodological updates in the next submission.	L.15 - ARR 2022 (sent on 4. 4. 2023)	Implemented in the SVK NIR 2023	Implemented in the SVK NIR 2023, Chapter 6.7.2

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION	CHAPTER/SECTION IN THE NIR
LULUCF - 4.C.2 Land converted to grassland, CO_2, Transparency	The ERT recommends that the Party provide information on the revised estimation, revised AD and revised coefficients and clearly describe the related methodological updates in the next submission.	L.16 - ARR 2022 (sent on 4. 4. 2023)	Implemented in the SVK NIR 2023	Implemented in the SVK NIR 2023, Chapter 6.8.2
LULUCF - 4.G HWP – CO_2, Comparability	The ERT recommends that the Party complete the HWP AD for 1961–1990 in CRF table 4Gs2.	L.17 - ARR 2022 (sent on 4. 4. 2023)	Implemented in the SVK NIR 2023	Implemented in the SVK CRF 2023, Table 4Gs2.
LULUCF - 4.G HWP – CO_2, Transparency	The ERT recommends that the Party provide an explanation of the trend of CSC of HWP in its NIR.	L.18 - ARR 2022 (sent on 4. 4. 2023)	Implemented in the SVK NIR 2023	Implemented in the SVK NIR 2023, Chapter 6.17
LULUCF - 4.G HWP – CO_2, Transparency	The ERT recommends that the Party provide in its NIR further information on parameters for estimating CSC for HWP, such as densities and carbon fraction for each type of HWP.	L.19 - ARR 2022 (sent on 4. 4. 2023)	Implemented in the SVK NIR 2023	Implemented in the SVK NIR 2023, Chapter 6.17
Waste - 5.A.1 Managed waste disposal sites – CO2 (W.8, 2021) Convention reporting adherence	Correct the erroneous references in which the burning of LFG is allocated under the waste sector in the waste chapter of the NIR and clearly indicate the amounts of gas burned and its characteristics in the relevant sections of the NIR.	W.2 - ARR 2022 (sent on 4. 4. 2023)	Implemented	Implemented in the SVK NIR 2023, Chapter 7.5.1.1, Table 7.13
Waste - 5.D.1 Domestic Wastewater - N_2O, Convention reporting adherence	The ERT recommends that the Party corrects this uncertainty value for N2O in the NIR with the correct value as determined by expert judgement and refer to table 7.33 as industrial wastewater treatment.	W.7 - ARR 2022 (sent on 4. 4. 2023)	Implemented	Implemented in the SVK NIR 2023, Chapter 7.8.2.2, Table 7.34.

ANNEX 5. ENERGY BALANCE OF THE ŠÚ SR FOR THE YEAR 2022

ACTIVITY/FUELS	Anthracite	Coking Coal	Other Bituminous Coal	Brown Coal and Lignite	Hard Coal Coke	Brown Coal & Peat Briquettes	Patent Fuel	Coal Tar	Coke Oven Gas	Blast Furnace Gas	Oxygen Steel Furnace Gas
UNITS						*TJ*					
Primary Production	-	-	-	9 620	-	-	-	-	-	-	-
Import	2 284	69 590	13 720	5 468	4 556	1 105	112	-	-	-	-
Export	-	-	-	-	534	-	-	1 909	-	-	-
Stock Changes	51	-529	-365	-188	-3 656	-	-	-	-	-	-
Gross Inland Consumption	2 335	69 061	13 355	14 900	366	1 105	112	-1 909	-	-	-
Transformation Input	744	69 061	5 686	14 016	38 642	-	-	-	929	1 105	314
Electricity Production - Thermal Equipment	744	-	5 686	13 983	-	-	-	-	929	1 098	299
of which: Public	744	-	4 017	13 983	-	-	-	-	-	-	-
Autoproducers	-	-	1 669	-	-	-	-	-	929	1 098	299
Nuclear Plants	-	-	-	-	-	-	-	-	-	-	-
Coke Ovens	-	56 831	-	-	-	-	-	-	-	-	-
Blast Furnaces	-	12 230	-	-	38 614	-	-	-	-	-	-
Refineries	-	-	-	-	-	-	-	-	-	-	-
Heat Production	-	-	-	33	28	-	-	-	-	7	12
Transformation Output	-	-	-	-	41 426	-	-	1 909	10 539	17 056	2 710
Electricity Production - Thermal Equipment	-	-	-	-	-	-	-	-	-	-	-
of which: Public	-	-	-	-	-	-	-	-	-	-	-
Autoproducers	-	-	-	-	-	-	-	-	-	-	-
Nuclear Plants	-	-	-	-	-	-	-	-	-	-	-
Coke Ovens	-	-	-	-	41 426	-	-	1 909	10 539	-	-
Blast Furnaces	-	-	-	-	-	-	-	-	-	17 056	2 710
Refineries	-	-	-	-	-	-	-	-	-	-	-
Heat Production	-	-	-	-	-	-	-	-	-	-	-
Exchanges and Transfers, Backflows	-	-	-	-	-	-	-	-	-	-	-
Product Transferred	-	-	-	-	-	-	-	-	-	-	-
Backflows from Petrochemical Sector	-	-	-	-	-	-	-	-	-	-	-

ACTIVITY/FUELS	Anthracite	Coking Coal	Other Bituminous Coal	Brown Coal and Lignite	Hard Coal Coke	Brown Coal & Peat Briquettes	Patent Fuel	Coal Tar	Coke Oven Gas	Blast Furnace Gas	Oxygen Steel Furnace Gas
UNITS						*TJ*					
Consumption of the Energy Sector	-	-	-	-	-	-	-	-	3 266	5 847	-
Distribution Losses	-	-	-	-	-	-	-	-	107	1 139	375

1st continuation

ACTIVITY/FUELS	Anthracite	Coking Coal	Other Bituminous Coal	Brown Coal and Lignite	Hard Coal Coke	Brown Coal & Peat Briquettes	Patent Fuel	Coal Tar	Coke Oven Gas	Blast Furnace Gas	Oxygen Steel Furnace Gas
UNITS						*TJ*					
Final Consumption	1 591	-	7 669	884	3 150	1 105	112	-	6 237	8 965	2 021
Final Non - Energy Consumption	1 001	-	-	-	731	-	-	-	-	-	-
of which: Chemical Industry	-	-	-	-	-	-	-	-	-	-	-
Final Energy Consumption	590	-	7 ,669	884	2 419	1 105	112	-	6 237	8 965	2 021
Industry	590	-	6 756	110	1 435	-	-	-	6 237	8 965	2 021
of which: Iron and steel	539	-	5 608	-	366	-	-	-	6 237	8 965	2 021
Non - ferrous metals	-	-	-	-	84	-	-	-	-	-	-
Chemical	-	-	-	-	28	-	-	-	-	-	-
Non - metallic minerals	51	-	1 148	55	873	-	-	-	4	-	-
Mining and quarrying	-	-	-	-	-	-	-	-	-	-	-
Food, beverages and tobacco	-	-	-	-	84	-	-	-	-	-	-
Textile and leather	-	-	-	-	-	-	-	-	-	-	-
Pulp, paper and print	-	-	-	-	-	-	-	-	-	-	-
Mach. and transport equipment	-	-	-	55	-	-	-	-	-	-	-
Not elsewhere specified	-	-	-	-	-	-	-	-	-	-	-
Transport	-	-	-	-	-	-	-	-	-	-	-
Other Sectors	-	-	913	774	984	1 105	112	-	-	-	-
of which: Households	-	-	652	697	56	710	-	-	-	-	-
Agriculture	-	-	-	11	-	-	-	-	-	-	-
Commercial and public services	-	-	261	66	928	395	112	-	-	-	-

2nd continuation

ACTIVITY/FUELS	Natural Gas	Crude Oil and NGL	Refinery Feedstock[1]	Refinery Gas	LPG	Naphtha	Gasoline	Kerosene
UNITS				*TJ*				
Primary Production	1 943	126	7 895	-	-	-	-	-
Import	217 948	229 283	175	-	2 530	3 212	7 511	346
Export	-	81	-	-	598	572	38 126	2 165
Stock Changes	-61 136	-2 688	-	-	46	-308	747	-
Gross Inland Consumption	158 755	226 637	8 070	-	1 978	2 332	-29 868	-1 819
Transformation Input	29 640	226 637	30 464	84	-	-	-	-
Electricity Production - Thermal Equipment	21 559	-	-	84	-	-	-	-
of which: Public	20 ,538	-	-	-	-	-	-	-
Autoproducers	1 021	-	-	84	-	-	-	-
Nuclear Plants	-	-	-	-	-	-	-	-
Coke Ovens	-	-	-	-	-	-	-	-
Blast Furnaces	-	-	-	-	-	-	-	-
Refineries	-	226 637	30 464	-	-	-	-	-
Heat Production	8 081	-	-	-	-	-	-	-
Transformation Output	-	-	-	14 787	5 612	19 360	54 949	3 248
Electricity Production - Thermal Equipment	-	-	-	-	-	-	-	-
of which: Public	-	-	-	-	-	-	-	-
Autoproducers	-	-	-	-	-	-	-	-
Nuclear Plants	-	-	-	-	-	-	-	-
Coke Ovens	-	-	-	-	-	-	-	-
Blast Furnaces	-	-	-	-	-	-	-	-
Refineries	-	-	-	14 787	5 612	19 360	54 949	3 248
Heat Production	-	-	-	-	-	-	-	-
Exchanges and Transfers, Backflows	-6 355	-	22 394	-	-2 438	-5 324	-	-
Product Transferred	-6 355	-	14 632	-	-	-	-	-
Backflows from Petrochemical Sector	-	-	7 762	-	-2 438	-5 324	-	-

ACTIVITY/FUELS	Natural Gas	Crude Oil and NGL	Refinery Feedstock[1]	Refinery Gas	LPG	Naphtha	Gasoline	Kerosene
UNITS	*TJ*							
Consumption of the Energy Sector	3 ,675	-	-	11 299	-	-	-	-
Distribution Losses	3 314	-	-	-	-	-	-	-

3rd continuation

ACTIVITY/FUELS	Natural Gas	Crude Oil and NGL	Refinery Feedstock[1]	Refinery Gas	LPG	Naphtha	Gasoline	Kerosene
UNITS	*TJ*							
Final Consumption	115 425	-	-	3 404	5 152	16 368	25 081	1 429
Final Non - Energy Consumption	13 622	-	-	-	2 622	16 368	-	-
of which: Chemical Industry	13 622	-	-	-	2 622	16 368	-	-
Final Energy Consumption	101 803	-	-	3 404	2 530	-	25 081	1 429
Industry	32 089	-	-	3 404	276	-	44	-
of which: Iron and steel	5 629	-	-	-	-	-	-	-
Non - ferrous metals	1 283	-	-	-	46	-	-	-
Chemical	3 720	-	-	3 404	46	-	-	-
Non - metallic minerals	4 495	-	-	-	92	-	-	-
Mining and quarrying	1 358	-	-	-	-	-	-	-
Food, beverages and tobacco	4 200	-	-	-	46	-	-	-
Textile and leather	440	-	-	-	-	-	-	-
Pulp, paper and print	1 401	-	-	-	-	-	-	-
Mach. and transport equipment	5 995	-	-	-	46	-	44	-
Not elsewhere specified	3 568	-	-	-	-	-	-	-
Transport	339	-	-	-	1 564	-	25 037	1 429
Other Sectors	69 375	-	-	-	690	-	-	-
of which: Households	46 376	-	-	-	322	-	-	-
Agriculture	1 319	-	-	-	184	-	-	-
Commercial and public services	21 680	-	-	-	184	-	-	-

[1] *include Additives, Oxygenates and Other Hydrocarbons*

4th continuation

ACTIVITY/FUELS	Natural Gas	Crude Oil and NGL	Refinery Feedstock[1]	Refinery Gas	LPG	Naphtha	Gasoline	Kerosene
UNITS	*mil. m³*	*1 000 t*	*1 000 t*	*1 000 t*	*1 000 t*	*1 000 t*	*1 000 t*	*1 000 t*
Final Consumption	3 294	-	-	122	112	372	571	33
Final Non - Energy Consumption	389	-	-	-	57	372	-	-
of which: Chemical Industry	389	-	-	-	57	372	-	-
Final Energy Consumption	2 905	-	-	122	55	-	571	33
Industry	916	-	-	122	6	-	1	-
of which: Iron and steel	161	-	-	-	-	-	-	-
Non - ferrous metals	37	-	-	-	1	-	-	-
Chemical	106	-	-	122	1	-	-	-
Non - metallic minerals	128	-	-	-	2	-	-	-
Mining and quarrying	39	-	-	-	-	-	-	-
Food, beverages and tobacco	120	-	-	-	1	-	-	-
Textile and leather	13	-	-	-	-	-	-	-
Pulp, paper and print	40	-	-	-	-	-	-	-
Mach. and transport equipment	171	-	-	-	1	-	1	-
Not elsewhere specified	101	-	-	-	-	-	-	-
Transport	10	-	-	-	34	-	570	33
Other Sectors	1979	-	-	-	15	-	-	-
of which: Households	1323	-	-	-	7	-	-	-
Agriculture	38	-	-	-	4	-	-	-
Commercial and public services	618	-	-	-	4	-	-	-

[1] *include Additives, Oxygenates and Other Hydrocarbons*

5th continuation

ACTIVITY/FUELS	Diesel Oil	Light Fuel Oil	HFO - low Sulphur (<1%)	HFO - high Sulphur (>=1%)	White Spirit SBP	Lubricants	Bitumen	Paraffin Waxes	Petroleum Coke	Other Products
UNITS	*TJ*									
Primary Production	-	-	-	-	-	-	-	-	-	-
Import	36 466	1 746	525	2 949	516	2 297	7 155	173	2 962	3 088
Export	66 152	1 381	4 242	7837	387	376	683	-	-	14 891
Stock Changes	-2 695	-41	-323	121	-	-	-	-	103	254
Gross Inland Consumption	-32 381	324	-4 040	-4 767	129	1 921	6 472	173	3 065	-11 549
Transformation Input	42	-	81	3 353	-	-	-	-	-	-
Electricity Production - Thermal Equipment	42	-	81	3 353	-	-	-	-	-	-
of which: Public	-	-	81	-	-	-	-	-	-	-
Autoproducers	42	-	-	3 353	-	-	-	-	-	-
Nuclear Plants	-	-	-	-	-	-	-	-	-	-
Coke Ovens	-	-	-	-	-	-	-	-	-	-
Blast Furnaces	-	-	-	-	-	-	-	-	-	-
Refineries	-	-	-	-	-	-	-	-	-	-
Heat Production	-	-	-	-	-	-	-	-	-	-
Transformation Output	117 692	528	4 121	15 352	-	-	-	-	1 997	14 172
Electricity Production - Thermal Equipment	-	-	-	-	-	-	-	-	-	-
of which: Public	-	-	-	-	-	-	-	-	-	-
Autoproducers	-	-	-	-	-	-	-	-	-	-
Nuclear Plants	-	-	-	-	-	-	-	-	-	-
Coke Ovens	-	-	-	-	-	-	-	-	-	-
Blast Furnaces	-	-	-	-	-	-	-	-	-	-
Refineries	117 692	528	4 121	15 352	-	-	-	-	1 997	14 172
Heat Production	-	-	-	-	-	-	-	-	-	-
Exchanges and Transfers, Backflows	-	-	-	-	-	-	-	-	-	-
Product Transferred	-	-	-	-	-	-	-	-	-	-
Backflows from Petrochemical Sector	-	-	-	-	-	-	-	-	-	-
Consumption of the Energy Sector	-	-	-	-	-	-	-	-	1 997	-
Distribution Losses	-	-	-	-	-	-	-	-	-	-

6th continuation

ACTIVITY/FUELS	Diesel Oil	Light Fuel Oil	HFP - low sulphur (<1%)	HFO - high Sulphur (>=1%)	White Spirit SBP	Lubricants	Bitumen	Paraffin Waxes	Petroleum Coke	Other Products
UNITS						*TJ*				
Final Consumption	85 269	852	-	7 232	129	1 921	6 472	173	3 065	2 623
Final Non - Energy Consumption	-	690	-	-	129	1 921	6 472	173	930	2 623
of which: Chemical Industry	-	690	-	-	-	-	-	-	-	2 623
Final Energy Consumption	85 269	162	-	7 232	-	-	-	-	2 135	-
Industry	379	-	-	7 232	-	-	-	-	2 135	-
of which: Iron and steel	-	-	-	-	-	-	-	-	-	-
Non - ferrous metals	-	-	-	-	-	-	-	-	-	-
Chemical	-	-	-	7 232	-	-	-	-	-	-
Non - metallic minerals	-	-	-	-	-	-	-	-	2 135	-
Mining and quarrying	84	-	-	-	-	-	-	-	-	-
Food, beverages and tobacco	42	-	-	-	-	-	-	-	-	-
Textile and leather	-	-	-	-	-	-	-	-	-	-
Pulp, paper and print	-	-	-	-	-	-	-	-	-	-
Mach. and transport equipment	-	-	-	-	-	-	-	-	-	-
Not elsewhere specified	253	-	-	-	-	-	-	-	-	-
Transport	82 911	-	-	-	-	-	-	-	-	-
Other Sectors	1 979	162	-	-	-	-	-	-	-	-
of which: Households	-	-	-	-	-	-	-	-	-	-
Agriculture	1 979	-	-	-	-	-	-	-	-	-
Commercial and public services	-	162	-	-	-	-	-	-	-	-

7th continuation

ACTIVITY/FUELS	Nuclear Heat	Solar Heat	Geoth. Heat	Ambient heat	Heat	Wood and Charcoal	MSW	Bio-gas	ISW	Wind energy	Hydro Energy	Solar Electri-city	EE	Liquid Bio-fuels	Total
UNITS								*TJ*							
Primary Production	166 072	384	378	3 582	-	57 906	2 576	4 295	8 141	14	13 241	2 340	-	7 408	285 921
Import	-	-	-	-	65	205	-	-	218	-	-	-	60 ,275	5 498	681 978
Export	-	-	-	-	-	590	-	-	-	-	-	-	55 192	4 633	200 352

ACTIVITY/FUELS	Nuclear Heat	Solar Heat	Geoth. Heat	Ambient heat	Heat	Wood and Charcoal	MSW	Bio-gas	ISW	Wind energy	Hydro Energy	Solar Electri-city	EE	Liquid Bio-fuels	Total
UNITS								*TJ*							
Stock Changes	-	-	-	-	-	-463	-	-	-51	-	-	-	-	4	-71 117
Gross Inland Consumption	166 072	384	378	3 582	65	57 058	2 576	4 295	8 308	18	15 329	2 416	2 786	7 697	696 430
Transformation Input	164 236	-	348	-	-	17 629	1 803	3 474	701	-	-	-	-	-	608 989
Electricity Production - Thermal Equipment	-	-	-	-	-	14 809	1 803	3 403	500	-	-	-	-	-	68 373
of which: Public	-	-	-	-	-	8 265	-	1 122	500	-	-	-	-	-	49 250
Autoproducers	-	-	-	-	-	6 544	1 803	2 281	-	-	-	-	-	-	19 123
Nuclear Plants	164 236	-	-	-	-	-	-	-	-	-	-	-	-	-	164 236
Coke Ovens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	56 831
Blast Furnaces	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50 844
Refineries	-	-	-	-	-	-	-	-	-	-	-	-	-	-	257 101
Heat Production	-	-	348	-	-	2 820	-	71	201	-	-	-	-	-	11 604
Transformation Output	-	-	-	-	26 852	-	-	-	-	-	-	-	79 996	-	432 306
Electricity Production - Thermal Equipment	-	-	-	-	16 804	-	-	-	-	-	-	-	22 684	-	39 488
of which: Public	-	-	-	-	14 831	-	-	-	-	-	-	-	13 648	-	28 479
Autoproducers	-	-	-	-	1 973	-	-	-	-	-	-	-	9 036	-	11 009
Nuclear Plants	-	-	-	-	-	-	-	-	-	-	-	-	57 312	-	57 312
Coke Ovens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	53 874
Blast Furnaces	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19 766
Refineries	-	-	-	-	-	-	-	-	-	-	-	-	-	-	251 818
Heat Production	-	-	-	-	10 048	-	-	-	-	-	-	-	-	-	10 048
Exchanges and Transfers, Backflows	-1 836	-2	-	-3 582	5 420	-	-	-	-	-14	-13 241	-2 340	15 595	-8 277	0
Product Transferred	-1 836	-2	-	-3 582	5 420	-	-	-	-	-14	-13 241	-2 340	15 595	-8 277	0
Backflows from Petrochemical Sector	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Consumption of the Energy Sector	-	2	-	-	3 103	-	-	-	-	-	-	-	13 585	-	42 774
Distribution Losses	-	-	-	-	3 262	30	-	-	-	-	-	-	4 756	-	12 983

8th continuation

ACTIVITY/FUELS	Nuclear Heat	Solar Heat	Geoth. Heat	Ambient heat	Heat	Wood and Charcoal	MSW	Bio-gas	ISW	Wind energy	Hydro Energy	Solar Electri-city	EE	Liquid Bio-fuels	Total
UNITS								*TJ*							
Final Consumption	-	380	30	-	25 972	39 399	773	821	7 607	-	-	-	82 333	-	463 644
Final Non - Energy Consumption	-	-	-	-	-	-	-	-	-	-	-	-	-	-	47 282
of which: Chemical Industry	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35 925
Final Energy Consumption	-	380	30	-	25 972	39 399	773	821	7 607	-	-	-	82 333	-	416 362
Industry	-	-	-	-	2 723	13 859	-	8	7 607	-	-	-	35 729	-	131 599
of which: Iron and steel	-	-	-	-	30	123	-	-	-	-	-	-	6 181	-	35 695
Non - ferrous metals	-	-	-	-	82	-	-	-	-	-	-	-	4 586	-	6 081
Chemical	-	-	-	-	391	8	-	-	957	-	-	-	2 581	-	18 367
Non - metallic minerals	-	-	-	-	186	43	-	-	6 584	-	-	-	2 682	-	18 348
Mining and quarrying	-	-	-	-	2	-	-	-	-	-	-	-	166	-	1 610
Food, beverages and tobacco	-	-	-	-	229	186	-	7	-	-	-	-	2 002	-	6 796
Textile and leather	-	-	-	-	30	1	-	-	-	-	-	-	511	-	982
Pulp, paper and print	-	-	-	-	1 167	11 592	-	1	-	-	-	-	3 355	-	17 516
Mach. and transport equipment	-	-	-	-	374	361	-	-	66	-	-	-	9 187	-	16 128
Not elsewhere specified	-	-	-	-	232	1 545	-	-	-	-	-	-	4 478	-	10 076
Transport	-	-	-	-	-	-	-	-	-	-	-	-	2 401	-	113 681
Other Sectors	-	380	30	-	23 249	25 540	773	813	-	-	-	-	44 203	-	171 082
of which: Households	-	342	-	-	17 196	24 919	-	-	-	-	-	-	21 208	-	112 478
Agriculture	-	-	30	-	68	345	-	548	-	-	-	-	706	-	5 190
Commercial and public services	-	38	-	-	5 985	276	773	265	-	-	-	-	22 289	-	53 414

Title: **NATIONAL INVENTORY REPORT OF THE SLOVAK REPUBLIC 2024**

Issued: SLOVAK HYDROMETEOROLOGICAL INSTITUTE

Authors: JURAJ LABOVSKÝ (CHAPTER 3)
JÁN HORVÁTH (CHAPTER 3)
VLADIMÍR DANIELIK (CHAPTERS 3, 4)
KRISTÍNA TONHAUZER (CHAPTERS 5, 7)
TIBOR PRIWITZER (CHAPTERS 6, 11)
IVAN BARKA (CHAPTERS 6, 11)
PAVEL PAVLENDA (CHAPTERS 6, 11)
MICHAL SVIČEK (CHAPTER 6)
PAVOL BEZÁK (CHAPTER 6)
KRISTÍNA BUCHOVÁ (CHAPTER 6)
ŠTEFAN POLLÁK (CHAPTER 6)
IGOR BODÍK (CHAPTER 7)
MAREK HRABČÁK (CHAPTER 7)
ZUZANA JONÁČEK (CHAPTER 7)

Editors JANKA SZEMESOVÁ
ALEXANDRA NADŽADYOVÁ
PETRA KRŠÁKOVÁ

Date JUNE 2024
Version 2

Pages 520
ISBN 978-80-99929-74-7
EAN 9788099929747