SLOVAK REPUBLIC

NATIONAL INVENTORY REPORT 2022

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Submission under the UNFCCC
and under the Kyoto Protocol

Slovak Hydrometeorological Institute

Department of Emissions and Biofuels

Bratislava, April 15, 2022

PREFACE

TITLE OF REPORT	NATIONAL GREENHOUSE GAS INVENTORY REPORT 1990 – 2020 UNDER THE UNFCCC AND UNDER THE KYOTO PROTOCOL
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
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In 2022, the Slovak Republic is submitting report under the UNFCCC and under the Kyoto Protocol. The Slovak Republic is submitting identical report as reported to the European Commission according to Article 7 of the Regulation (EU) No 525/2013 (MMR), Article 7 of the Decision 529/2013/EU and relevant Articles of the Regulation (EU) No 749/2014.[1] The whole package of the 2021 submission of the Slovak Republic comprises:

1. SVK NIR 2022 – Slovakia's National Greenhouse Gas Emission Inventory Report prepared using the UNFCCC reporting guidelines (UNFCCC 2013) and the guidelines for the preparation of the information required under Article 7, paragraph 1 in the Annex to Decision 15/CMP.1 and Annex II to Decision 2/CMP.8 of the Kyoto Protocol;
2. SVK_CRF_1990-2020 – CRF tables version 4 (2022) including KP LULUCF tables for the years 2013 – 2020 generated using the CRF Reporter software, version 6.0.8 accompanied by the xml file;
3. SEF Tables and other documents from the National Registry – update version; SEF (Standard Electronic Tables) for the reporting of Kyoto units of the second commitment period (AAU, ERU, CER, t-CER. l-CER, RMU) in the registry, 31. 12. 2021, and transfers of the units during 2021. In accordance with para. 1 of annex II to the decision 3/CMP.11 SVK SEF tables for the reported year 2020. Further to this, para. 4 of decision 10/CMP.11, the SVK SEF information for the reported years 2013 – 2021 are included.

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.

[1] Regulation (EU) No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting Greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC, OJ,18.6.2013, p. 13;

Commission Implementing Regulation (EU) No 749/2014 of 30 June 2014 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) No 525/2013 of the European Parliament and of the Council, OJ L.203,11:7:2014, p. 23.

This version of the annual GHG emissions inventory is the second submission of the National Inventory Report 2022 of the Slovak Republic to the European Union under the MMR and the first submission under the UNFCCC and under the Kyoto Protocol. In addition, this is the fourth version of CRF tables generated as the official submission 2022 in the CRF Reporter 6.0.8.

Major changes and corrections included in this SVK NIR 2022 are connected with 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 February 15, 2022 in all sectors (**Chapter ES.5**);
- **Energy:** Minor recalculations connected with the correction of electricity consumption in households what led to the correction of biomass consumption for the years 2014 – 2019 occurred in the category 1.A.4.b – Residential heating. This change did not affected total GHG emissions. Charcoal production was harmonized in the national inventory with the FAOSTAT. Continuing improvements were implemented in the Fugitive emissions from oil and natural gas activities reflecting the Improvement Plan for the year 2021 (more information in the **Energy Chapter**).
- **IPPU:** No recalculations needed in this sector.
- **Agriculture:** Several recalculations focused on the major inconsistencies found in the previous inventory were connected with the improvement of methodology in Animal Manure Applied to Soils and Crop Residues. In addition, recalculations connected with the improvements of the activity data in the Agricultural soils represented i.e. correction of time series 2000 – 2011 for inorganic fertilizers consumption, correction of activity data for industrial sludge application, revision of activity data for limestone and dolomite (more information in the **Agriculture sector**).
- **LULUCF:** According to the ERT recommendations, recalculations in 4.A.1 and 4.A.2 included correction in calculation of CSC in DW carbon pools following and correction of root-to-shoot ratios (using only 0.2 for coniferous and 0.24 for broadleaved).
- **Waste:** Major changes in this sector were caused by the improvements in sludge reporting generated in the category 5.D across the categories 5.A, 5.B and 5.C. In addition, activity data on ISW landfilling was revised for the years 1990 – 2019.
- **National Registry:** Update of general information characteristics of the National Registry in the year 2021 (**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**.

This report also includes supplementary information in accordance with the Article 7, paragraph 1, of the Kyoto Protocol. The required information is consistent with relevant decisions and guidelines under Article 7, paragraph 1 and includes information on Slovakia's assigned amount for the second commitment period, corresponding emissions and removals, changes in the national system and national registry, information related to Article 3, paragraphs 3 and 4, and Article 3, paragraph 14. Detailed information can be found in Standard Electronic Tables (SEF) that are part of Slovakia's inventory submission.

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 preliminary report State of the Global Climate in 2021, the growth rate of all three greenhouse gases in 2020 was above the average for the last decade despite a 5.6% drop in fossil fuel CO_2 emissions in 2020 due to restrictions related to the COVID-19 pandemic. In 2020, greenhouse gas concentrations reached new highs, with globally averaged surface mole fractions for carbon dioxide (CO_2) at 413.2 ± 0.2 parts per million (ppm), methane (CH_4) at 1 889 ± 2 parts per billion (ppb) and nitrous oxide (N_2O) at 333.2 ± 0.1 ppb, respectively, 149%, 262% and 123% of pre-industrial (1 750) levels. The increase in CO_2 from 2019 to 2020 was slightly lower than that observed from 2018 to 2019, but higher than the average annual growth rate over the last decade. This is despite the approximately 5.6% drop in fossil fuel CO_2 emissions in 2020 due to restrictions related to the COVID-19 pandemic. For CH_4 and N_2O, the increase from 2019 to 2020 was higher than that observed from 2018 to 2019 and also higher than the average annual growth rate over the last decade.

Photochemical active gases such as carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane volatile organic hydrocarbons (NMVOCs) are not greenhouse gases, but they contribute indirectly to the greenhouse effect in the atmosphere. These gases are generally referred to as ozone precursors because they affect the creation and destruction of ozone in the troposphere. Precursors of sulphates – sulphur dioxide (SO_2) and aerosol – reduce the greenhouse effect.

In a response to the significant increase in GHG emissions since 1992, an urgent need occurred to adopt an additional and efficient instrument that would stimulate mitigation efforts. In 1997, the Parties to the Convention agreed to adopt the Kyoto Protocol (KP) that defines reduction objectives and means to achieve mitigation goals by the countries included in Annex I to the Convention. Developed countries, listed in Annex B to the KP, should reduce emissions of six GHGs (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 Slovak Republic committed itself to an 8% reduction of emissions compared to the base year 1990. The Slovak Republic and the EU Member States ratified the Kyoto Protocol on 31st May 2002.[2]

The Kyoto Protocol, under Article 4, provides the option for Parties to fulfil their commitments under Article 3 jointly. The European Union, its Member States and Iceland have agreed to fulfil their quantified emission limitation and reduction commitments for the second commitment period to the Kyoto Protocol, reflected in the Doha Amendment, jointly. The Union, it's Member States and Iceland agreed to the quantified emission reduction commitment that limits their average annual emissions of greenhouse gases during the second commitment period to 80% of the sum of their base year emissions, which is reflected in the Doha Amendment.

The Paris Agreement is a historic step forward, with almost 200 countries committing to action, which they have to take in account for the first time ever. The Agreement provides a framework to revisit and raise ambition in the future. Countries will now have to come together regularly to review their climate plans and collectively ensure that the necessary actions are taken to tackle climate change and limit global temperature rises to below 2°C, and pursue efforts for 1.5°C. Countries also should strive to prepare long-term low GHG emission development strategies.

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' 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 EU ETS, 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 already fourth EU ETS trading period gone operational. Main change is the increase of linear reduction factor from 1.74% per annum to 2.2% per annum, which should bring 43% reduction within the EU ETS sectors until 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).

[2] Kyoto Protocol came into force on February 14th, 2005

ES.2 SUMMARY OF NATIONAL EMISSION AND REMOVAL TRENDS

The GHG emissions presented in the National Inventory Report 2022 were updated and recalculated using the last updated methods based on 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 20th – 25th September 2021. As a result of the 2021 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. Saturday paper was not applied, while no significant under- or over-estimations were found by the ERT. Slovakia sent comments to the report of "Provisional Main Findings of the ERT" within the deadline with the proposals for deleting or changing of several recommendations. Until April 15, 2022, Slovakia did not received draft of the Review Report 2021. Therefore, the latest available review report is the Review report of the (2019)[3] annual submissions of Slovakia submitted to the UNFCCC in 2019 on March 3, 2020. According to the recommendations of the ERT from the last Review Report 2019, recommendations were reflected in the 2020 and 2021 submissions. In addition, several improvements were already included in reflection to the latest centralized review in 2022 submission. More information is included in **Chapter 1.2**.

Total GHG emissions were 37 002.71 Gg of CO_2 eq. in 2020 (without LULUCF and without indirect emissions). This represents a reduction by 49.57% against the base year 1990. In comparison with 2019, the emissions decreased by 7%. The decrease in total emissions of 2020 compared to 2019 was due to decrease in the **Energy** and **IPPU** sectors. This trend was accompanied on the other side by the inter-annual increase of removals in the **LULUCF** sector by almost 2 Tg.

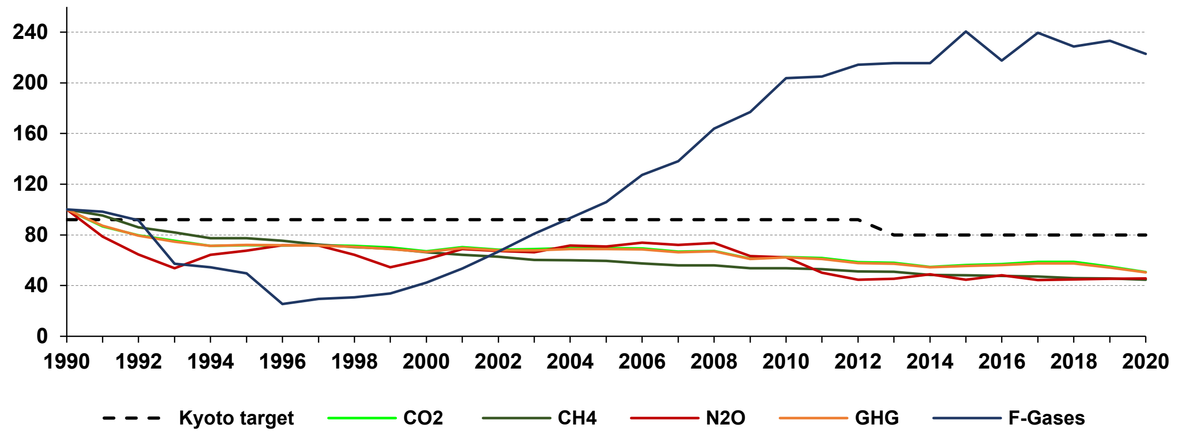
The 2022 submission includes indirect CO_2 emissions in the solvents category (**IPPU**). This means, that the GHG emissions without LULUCF and with indirect emissions were 37 048.58 Gg of CO_2 eq. in 2020. Indirect CO_2 emissions were estimated and reported for the time series 1990 – 2020.

The major changes in the 2022 national inventory of GHG emissions are caused by recalculations in the **Energy** sector (fugitive emissions from oil and natural gas, road transport), the **Agriculture**, **LULUCF** (also **KP LULUCF**) and **Waste** sectors for the particular years or whole time series.

The emissions with LULUCF decreased in 2020 compared with 2019 by 14%. During period 1991 – 2020, 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 – 2020. ***Figure ES.1*** shows trend in the gases without LULUCF comparable to the Kyoto targets in relative expression. 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).

[3] SVK ARR 2019, published on March 3, 2020

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



GHG emissions in % to base years without LULUCF and indirect emissions; emissions are determined as of 15. 04. 2022

Slovakia decreased its emissions by around 19% between 2010 and 2020. The latest available GHG emission projections have demonstrated emissions stabilization 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 Slovakia (approved in February 2020 by the Government). New drivers and parameters reflecting the actual pandemic situation were projected.

According to the International Energy Agency in-depth review performed in 2018, the Slovak Republic has made significant progress on several fronts of energy policy. In addition, the energy intensity of the Slovak economy has declined, and the share of renewable energy in energy supply has increased. Energy-related carbon dioxide emissions have been reduced as well and can be decreased further, thanks to investments in nuclear energy. Energy efficiency is improving, the share of renewable energy is increasing, and energy-related carbon dioxide (CO_2) emissions are declining.

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 2021.

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, it is expected, that the emission trend in following years will be increased back to the pre-pandemic level.

ES.3 OVERVIEW OF SOURCE AND SINK CATEGORY

The emissions without LULUCF in 2020 are lower than in 2019 and reached the lowest level in the time series. This decrease was also expected in the proxy inventory published in July 2021. GHG emissions decreased mostly in the **Energy** and **IPPU** sectors, both in EU ETS and ESD parts across all categories, mostly in manufacturing industry, mineral production, chemical industry and metal industry.

The **Energy sector** (including transport) with the share of 65.5% was the main contributor to total GHG emissions in 2020. Within this sector, transport with 19.1% share on total emissions contributes significantly to the GHG budget. In 2020, the transport in total emissions has decreased by more than 13% in comparison with previous year 2019. 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 is expected also in the next year due to increase in diesel oil.

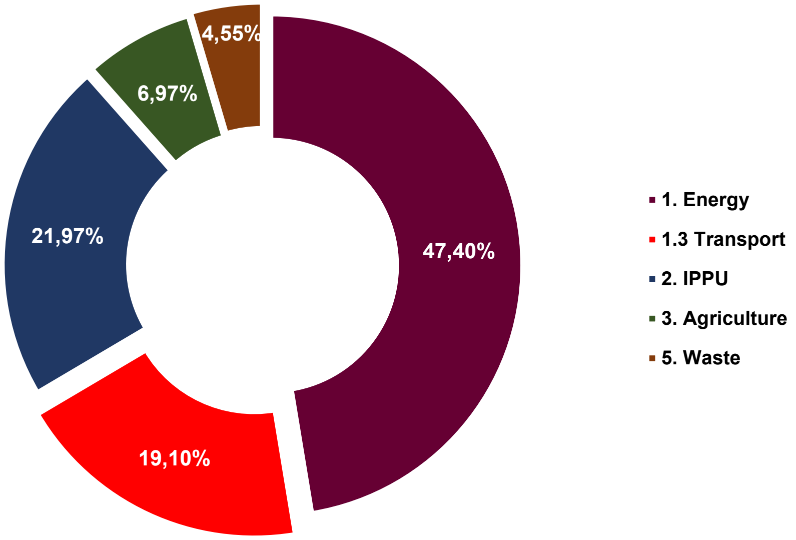
The **Industrial Processes and Product Use sector** was the second important sector in 2020 with its 22% share in total GHG emissions, producing mainly technological emissions from processing mineral products, chemical production and steel and iron production. The reduction of emissions from technological 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 2020, the share of the **Agriculture sector** on total GHG emissions was 7% and the trend in emissions has remained relatively stable 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 4.55% to total GHG emissions in 2020. 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 76% 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 2020*



Aggregated GHG emissions without LULUCF and indirect emissions; emissions are determined as of 15. 04. 2022

ES.4 BACKGROUND INFORMATION AND SUMMARY OF EMISSIONS AND REMOVALS FROM THE KP-LULUCF ACTIVITIES

The Slovak Republic is providing information on the accounting of the anthropogenic GHGs emissions and removals resulting from the LULUCF activities and the Kyoto Protocol as required in the Article 7(1)(d). This information is included in KP CRF tables 2013 – 2020 generated by the CRF Reporter software version 6.0.8 as a part of annual GHG inventory submitted on April 15, 2022.

A report describing the progress in the implementation of LULUCF actions ("Report on progress in implementation of the LULUCF actions to the European Commission") required by Article 3.2 of Decision No 529/2013/EU of the European Parliament and of the Council of 21 May 2013 on accounting rules on greenhouse gas emissions and removals resulting from activities relating to land use, land-use change and forestry and on information concerning actions relating to those activities was submitted as a separate document by March 15, 2021. In addition, Slovakia delivered updated report according to the Article 10 of Decision No 529/2013/EU by the end of 2020 concerning the progress in the implementation of LULUCF actions by the date halfway through each accounting period, and by the end of each accounting period (from 1st January 2013 to 31st December 2020).

In addition, on March 15, 2021 Slovakia submitted the latest Report on reporting methodologies for cropland management and grazing land management to the European Commission accompanied with CRF tables for selected years (1990, 2013 – 2020) for the cropland management and grazing land management as the non-binding estimate. This submission was published according to the Article 40(4)b of the European Commission Implementing Regulation (EU) No 749/2014 of 30 June 2014 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) No 525/2013 of the European Parliament and of the Council.

According to the revised Report to Facilitate Determination of the Assigned Amount for the Second Commitment Period of the Kyoto Protocol from September, 2016, the Slovak Republic has officially declared in Part III of this report the following statement: In order to report under Article 3.3 (ARD activities: afforestation, reforestation and deforestation), the Slovak Republic has selected the following threshold values for the forest definition: forest land includes land with minimum tree crown cover of 20% for trees capable to reach minimum height of 5 m in situ. The minimum area for forest is 0.3 ha. Temporarily unstock areas are included (forest regeneration areas). For linear formations, a minimum width of 20 m is applied. This definition is applicable also for reporting of the second commitment period and under Article 3.4. However, the Slovak Republic has decided not to use voluntary Article 3.4 activities to meet its commitments under the second commitment period. The selected threshold values are consistent with the values used in the reporting to the Food and Agriculture Organization of the United Nations (the GFRA 2005, National Forest Inventory, and MCPFE criteria and indicators of sustainable forest management). The Slovak Republic has chosen to account for the activities under Article 3.3 (afforestation, reforestation and deforestation) and under Article 3.4 (forest management) for the whole commitment period.

Table ES.2 presents, that the total removals from afforestation/reforestation activities were -600.42 Gg of CO_2 eq. (changes in 50.09 kha to the end of 2020). Total emissions from deforestation were 45.17 Gg of CO_2 eq. (changes in 9.02 kha to the end of 2020). In 2020, total removals under the Article 3.3 of the KP were -555.25 Gg of CO_2 eq. with the changed area of 59.12 kha. Net removals from FM activity were -7 384.36 Gg of CO2 eq. with the changes on the area at the end of 2020: 1 977.01 kha.

The emissions/removals for ARD activities were recalculated in 2022 submission since the year 2013. The main reason for recalculation in AR activities was including the new calculation of CSC in DW carbon pools following the ERT recommendation and recalculations in D activities with including the recalculation of CSC in DW carbon pools.

Table ES.2 shows the estimated accounting parameters for the KP second commitment period 2013 – 2020 (CP2) in Slovakia. The total net accounted amount at Slovakia level, as reported for the KP CP2 in the accounting tables is -12 953.15 Gg of CO_2 eq. Afforestation/Reforestation is assumed to give a net credit of 4 303.71 Gg of CO_2 eq. to the Slovak reduction commitment for the KP CP2. Deforestation has been estimated to give a net debit of 446.48 Gg of CO_2 eq. Emissions from Deforestation offset about 10% of the removals accounted in Afforestation/Reforestation. Forest Management activity has shown a net credit of 20 544.94 Gg of CO_2 eq. According to ***Table ES.2***, total sinks under the Articles 3.3 and 3.4 for the second KP accounting period 2013 – 2020 reached -51 409.18 Gg of CO_2 equivalents, particularly sinks in the AR/D activities for the period were -3 857.22 Gg of CO_2 equivalents.

FM cap was calculated based on the base year on the level 20 796.023 Gg of CO_2 eq. for the second commitments period base on April 15, 2022 submission. This value is reported in CRF tables submitted on April 15, 2022 submission into UNFCCC.

Table ES.1: *Summary of the GHG emissions according to the gases and the sectors in 2020 and 2019*

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2020					
	Gg of CO_2 equivalents					
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
1. Energy	23 737.03	671.04	200.45	NO	NO	NO
2. Industrial Processes	7 284.87	1.46	141.81	678.88	5.61	17.20
3. Agriculture	72.12	1 053.22	1 454.37	NO	NO	NO
4. LULUCF	-8 809.32	22.14	40.64	NO	NO	NO
5. Waste	0.71	1 535.84	148.10	NO	NO	NO
KP LULUCF	***-7 976.22***	***0.88***	***0.05***	***NO***	***NO***	***NO***
Memo Items - International Transport	***69.51***	***0.05***	***0.56***	***NO***	***NO***	***NO***
Total (excluding LULUCF)	**31 094.73**	**3 261.56**	**1 944.73**	**678.88**	**5.61**	**17.20**
Total (including LULUCF)	**22 285.40**	**3 283.70**	**1 985.38**	**678.88**	**5.61**	**17.20**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2019					
	Gg of CO_2 equivalents					
	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
1. Energy	25 912.20	717.46	218.80	NO	NO	NO
2. Industrial Processes	7 795.05	1.43	157.05	720.74	5.19	8.86
3. Agriculture	68.25	1 068.04	1 435.95	NO	NO	NO
4. LULUCF	-6 955.86	24.50	43.66	NO	NO	NO
5. Waste	0.69	1 531.45	135.18	NO	NO	NO
KP LULUCF	***-6 023.69***	***0.98***	***0.05***	***NO***	***NO***	***NO***
Memo Items - International Transport	***201.40***	***0.08***	***1.63***	***NO***	***NO***	***NO***
Total (excluding LULUCF)	**33 776.19**	**3 318.38**	**1 946.98**	**720.74**	**5.19**	**8.86**
Total (including LULUCF)	**26 820.32**	**3 342.89**	**1 990.65**	**720.74**	**5.19**	**8.86**

Table ES.2: *Emissions and removals (Gg of CO_2 eq.) resulting from the activities under the Articles 3.3 and 3.4 of the Kyoto Protocol in 2013 – 2020*

ACTIVITIES	2013	2014	2015	2016	2017	2018	2019	2020	TOTAL
	Gg of CO_2 equivalents								
Total 3.3 and 3.4	**-7 719.18**	**-5 754.67**	**-6 336.37**	**-6 223.82**	**-6 151.83**	**-5 300.55**	**-5 983.15**	**-7 939.61**	**-51 409.18**
A. Article 3.3 activities	**-411.43**	**-411.86**	**-449.13**	**-508.18**	**-501.51**	**-467.98**	**-551.88**	**-555.25**	**-3 857.22**
A.1 Afforestation/Reforest.	-454.30	-474.49	-509.65	-536.47	-557.71	-579.55	-591.12	-600.42	-4 303.71
A.2 Deforestation	42.87	62.63	60.53	28.28	56.20	111.57	39.24	45.17	446.48
B. Article 3.4 activities	**-7 307.75**	**-5 342.80**	**-5 887.25**	**-5 715.63**	**-5 650.32**	**-4 832.57**	**-5 431.28**	**-7 384.36**	**-47 551.96**
B.1 Forest Management	-7 307.75	-5 342.80	-5 887.25	-5 715.63	-5 650.32	-4 832.57	-5 431.28	-7 384.36	-47 551.96

Table ES.3: *Summary of the GHG emissions according to the gases in 1990 – 2020*

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	61 470.19	53 283.80	48 884.20	46 348.52	43 754.33	44 142.33	44 023.48	44 095.51
CO_2 emissions including net CO_2 from LULUCF	51 185.47	42 295.70	37 337.48	34 973.55	32 902.07	33 787.53	33 728.77	33 953.88
CH_4 emissions excluding CH_4 from LULUCF	7 300.92	6 950.26	6 270.25	5 971.15	5 654.95	5 644.75	5 507.53	5 278.25
CH_4 emissions including CH_4 from LULUCF	7 311.00	6 958.60	6 281.85	5 992.90	5 660.81	5 651.76	5 517.30	5 285.84
N_2O emissions excluding N_2O from LULUCF	4 288.77	3 374.70	2 767.99	2 300.69	2 750.68	2 897.16	3 075.54	3 070.60
N_2O emissions including N_2O from LULUCF	4 421.08	3 492.24	2 884.93	2 421.22	2 855.83	2 988.49	3 162.69	3 148.46
HFCs	NO	NO	NO	NO	0.20	13.32	28.39	41.21
PFCs	314.86	309.73	288.24	180.32	153.23	132.65	40.72	40.16
SF_6	0.06	0.04	0.04	0.09	17.62	10.15	11.16	11.47
Total (excluding LULUCF)	**73 374.79**	**63 918.51**	**58 210.71**	**54 800.77**	**52 331.01**	**52 840.35**	**52 686.83**	**52 537.20**
Total (including LULUCF)	**63 232.47**	**53 056.30**	**46 792.55**	**43 568.08**	**41 589.76**	**42 583.90**	**42 489.03**	**42 481.03**
Total (excluding LULUCF, including indirect emissions)	***73 462.56***	***64 005.04***	***58 296.14***	***54 885.02***	***52 414.18***	***52 922.44***	***52 767.80***	***52 617.03***
Total (including LULUCF, including indirect emissions)	***63 320.24***	***53 142.82***	***46 877.97***	***43 652.33***	***41 672.93***	***42 665.99***	***42 570.00***	***42 560.86***

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	43 824.66	43 035.49	41 135.93	43 220.93	41 960.93	42 293.77	42 780.24	42 788.86
CO_2 emissions including net CO_2 from LULUCF	32 665.55	32 542.29	30 686.70	33 482.01	31 726.36	32 515.41	32 987.76	36 485.33
CH_4 emissions excluding CH_4 from LULUCF	5 139.78	5 047.36	4 834.14	4 695.02	4 588.10	4 386.27	4 367.43	4 342.42
CH_4 emissions including CH_4 from LULUCF	5 147.23	5 096.31	4 858.74	4 706.42	4 607.19	4 423.50	4 380.34	4 366.33
N_2O emissions excluding N_2O from LULUCF	2 758.15	2 327.99	2 601.09	2 949.10	2 878.62	2 835.45	3 064.39	3 030.29
N_2O emissions including N_2O from LULUCF	2 829.72	2 423.34	2 669.36	3 003.18	2 933.01	2 897.83	3 110.45	3 080.11
HFCs	54.61	77.29	105.04	138.78	178.46	213.52	254.39	292.99
PFCs	29.10	16.27	14.91	16.02	17.18	26.45	23.63	24.16
SF_6	12.65	12.64	13.04	13.33	14.78	15.06	15.43	16.38
Total (excluding LULUCF)	**51 818.95**	**50 517.05**	**48 704.17**	**51 033.18**	**49 638.08**	**49 770.51**	**50 505.50**	**50 495.10**
Total (including LULUCF)	**40 738.86**	**40 168.14**	**38 347.79**	**41 359.75**	**39 476.97**	**40 091.76**	**40 771.99**	**44 265.31**
Total (excluding LULUCF, including indirect emissions)	***51 897.65***	***50 593.85***	***48 769.61***	***51 098.70***	***49 709.84***	***49 838.50***	***50 581.18***	***50 562.03***
Total (including LULUCF, including indirect emissions)	***40 817.56***	***40 244.94***	***38 413.24***	***41 425.26***	***39 548.74***	***40 159.75***	***40 847.66***	***44 332.24***

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	42 552.11	40 968.27	41 359.05	37 622.06	38 403.93	37 984.84	35 910.40	35 565.56
CO_2 emissions including net CO_2 from LULUCF	33 406.78	32 233.13	33 647.70	30 141.47	31 698.95	30 951.78	27 871.52	26 895.18
CH_4 emissions excluding CH_4 from LULUCF	4 194.41	4 085.75	4 074.64	3 921.23	3 907.62	3 866.58	3 740.46	3 718.54
CH_4 emissions including CH_4 from LULUCF	4 209.50	4 110.60	4 090.24	3 944.25	3 925.83	3 888.42	3 782.19	3 732.33
N_2O emissions excluding N_2O from LULUCF	3 157.56	3 085.21	3 151.26	2 713.21	2 670.59	2 145.29	1 911.73	1 952.17
N_2O emissions including N_2O from LULUCF	3 198.86	3 130.71	3 187.75	2 753.44	2 706.15	2 183.20	1 963.50	1 986.25
HFCs	341.49	388.26	454.47	516.93	597.24	605.03	628.20	646.88
PFCs	42.47	29.42	42.76	21.00	25.01	20.11	25.66	9.81
SF_6	16.71	17.39	18.85	19.51	19.62	20.80	21.24	22.30
Total (excluding LULUCF)	**50 304.74**	**48 574.31**	**49 101.03**	**44 813.94**	**45 624.02**	**44 642.64**	**42 237.69**	**41 915.27**
Total (including LULUCF)	**41 215.80**	**39 909.52**	**41 441.77**	**37 396.60**	**38 972.81**	**37 669.33**	**34 292.31**	**33 292.75**
Total (excluding LULUCF, including indirect emissions)	***50 376.31***	***48 631.27***	***49 163.72***	***44 872.78***	***45 673.22***	***44 700.25***	***42 284.17***	***41 961.68***
Total (including LULUCF, including indirect emissions)	***41 287.37***	***39 966.47***	***41 504.46***	***37 455.43***	***39 022.01***	***37 726.94***	***34 338.79***	***33 339.16***

GREENHOUSE GAS EMISSIONS	2014	2015	2016	2017	2018	2019	2020	Change
	Gg of CO_2 equivalents							*%*
CO_2 emissions excluding net CO_2 from LULUCF	33 656.21	34 468.23	34 912.88	36 112.65	36 102.97	33 776.19	31 094.73	-49.41
CO_2 emissions including net CO_2 from LULUCF	26 952.40	27 250.09	27 621.94	28 927.08	29 829.47	26 820.32	22 285.40	-56.46
CH_4 emissions excluding CH_4 from LULUCF	3 521.03	3 518.56	3 470.82	3 442.93	3 340.12	3 318.38	3 261.56	-55.33
CH_4 emissions including CH_4 from LULUCF	3 541.56	3 541.61	3 489.89	3 464.12	3 361.04	3 342.89	3 283.70	-55.09
N_2O emissions excluding N_2O from LULUCF	2 103.42	1 913.49	2 057.47	1 904.94	1 918.74	1 946.98	1 944.73	-54.66
N_2O emissions including N_2O from LULUCF	2 142.89	1 957.13	2 098.65	1 947.27	1 960.64	1 990.65	1 985.38	-55.09
HFCs	653.84	734.88	673.37	739.06	702.77	720.74	678.88	100.00
PFCs	11.15	8.50	6.49	8.62	7.78	5.19	5.61	-98.22
SF_6	14.17	14.31	5.82	7.08	9.39	8.86	17.20	29 370.00
Total (excluding LULUCF)	**39 959.82**	**40 657.98**	**41 126.85**	**42 215.29**	**42 081.77**	**39 776.35**	**37 002.71**	**-49.57**
Total (including LULUCF)	**33 316.01**	**33 506.53**	**33 896.15**	**35 093.23**	**35 871.09**	**32 888.65**	**28 256.17**	**-55.31**
Total (excluding LULUCF, including indirect emissions)	***40 009.36***	***40 714.32***	***41 179.37***	***42 262.77***	***42 134.89***	***39 821.65***	***37 048.58***	***-49.57***
Total (including LULUCF, including indirect emissions)	***33 365.55***	***33 562.87***	***33 948.67***	***35 140.71***	***35 924.21***	***32 933.95***	***28 302.04***	***-55.30***

Total aggregated GHG emissions, emissions are determined as of 15. 04. 2022, indirect emissions are reported in the 2022 submission.

Table ES.4: *Summary of the GHG emissions according to the sectors in 1990 – 2020*

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997
	Gg of CO_2 equivalents							
1. Energy	56 279.49	49 847.40	45 611.66	41 642.02	39 181.66	38 723.51	38 353.40	38 183.69
2. Industrial Processes	9 701.66	7 509.96	7 147.33	8 171.74	8 386.20	9 307.81	9 627.11	9 674.96
4. Agriculture	5 987.29	5 148.28	4 049.95	3 586.17	3 458.56	3 504.26	3 401.06	3 355.57
5. Land Use, Land-Use Change and Forestry	-10 142.32	-10 862.22	-11 418.17	-11 232.69	-10 741.25	-10 256.45	-10 197.80	-10 056.17
6. Waste	1 406.35	1 412.88	1 401.77	1 400.84	1 304.59	1 304.78	1 305.26	1 322.97

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1998	1999	2000	2001	2002	2003	2004	2005
	Gg of CO_2 equivalents							
1. Energy	37 634.91	36 890.74	35 982.78	37 939.61	35 484.42	36 271.90	35 723.70	36 222.32
2. Industrial Processes	9 815.02	9 434.79	8 529.84	8 703.28	9 740.42	9 345.51	10 623.90	10 089.27
4. Agriculture	3 024.87	2 835.08	2 817.09	2 999.84	3 008.11	2 728.74	2 717.18	2 725.96
5. Land Use, Land-Use Change and Forestry	-11 080.09	-10 348.90	-10 356.37	-9 673.43	-10 161.11	-9 678.75	-9 733.52	-6 229.79
6. Waste	1 344.15	1 356.43	1 374.46	1 390.44	1 405.13	1 424.35	1 440.72	1 457.54

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2006	2007	2008	2009	2010	2011	2012	2013
	Gg of CO_2 equivalents							
1. Energy	35 331.43	33 683.04	34 171.36	31 675.45	32 020.50	31 466.97	29 208.81	29 026.03
2. Industrial Processes	10 941.23	10 800.48	10 678.67	9 115.13	9 423.49	9 024.28	8 954.84	8 667.78
4. Agriculture	2 520.27	2 604.87	2 747.98	2 478.74	2 607.63	2 534.11	2 427.73	2 585.58
5. Land Use, Land-Use Change and Forestry	-9 088.93	-8 664.79	-7 659.26	-7 417.35	-6 651.21	-6 973.31	-7 945.38	-8 622.52
6. Waste	1 511.81	1 485.91	1 503.01	1 544.62	1 572.40	1 617.27	1 646.31	1 635.89

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2014	2015	2016	2017	2018	2019	2020	Change
	Gg of CO_2 equivalents							%
1. Energy	26 696.56	27 346.69	27 508.71	28 445.74	28 295.65	26 848.46	24 608.52	-56.27
2. Industrial Processes	8 882.81	9 083.21	9 291.36	9 573.54	9 553.52	8 688.33	8 129.84	-16.20
4. Agriculture	2 744.44	2 537.98	2 682.97	2 521.07	2 543.37	2 572.24	2 579.71	-56.91
5. Land Use, Land-Use Change and Forestry	-6 643.81	-7 151.44	-7 230.70	-7 122.05	-6 210.68	-6 887.70	-8 746.54	-13.76
6. Waste	1 636.01	1 690.10	1 643.80	1 674.94	1 689.23	1 667.33	1 684.65	19.79

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 – 2020 originally submitted under the NECD and the CLRTAP on March 15, 2022. The latest (February) data is included in CRF tables 1990 – 2020 generated by the CRF Reporter software v.6.0.8 as a part of annual GHG inventory submitted in April 15, 2022. 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 in March, 15 for the emissions inventory and in March, 15 for the informative inventory reports (IIR) or emissions data resubmission, respectively.

The overview of NO_X, CO, NMVOC and SO_2 emissions for the year 2020 and reporting on consistency of the reported data on air pollutants in the Tabular format specified in Annexes II to the Implementing Regulation (EU) No 749/2014 (Article 7) of the European Commission accompanied March 15, 2022 submission. Several changes and recalculations were introduced into 2022 NECD submission. Among others for example:

- In the **IPPU sector,** emissions from the category 2.C.4 were reallocated to the category 2.C.7.c.
- In the transport, a new methodology for the non-road transport categories was implemented for the whole time-series.
- Emissions from road transport were redistributed, as the updated version of COPERT was used (switch from version 5.3 to 5.5).
- In the **Agriculture sector**, emissions in the category 3.B were recalculated due to implementation of mitigation measures based on long-term plants and new methodology provided and recommended by the TFEIP.[4]
- The recalculation of emissions from the application of inorganic fertilizers was performed in 2022 submission. This revision was based on new consumption of fertilizers in the soil for the years 2000 – 2011. The revision was prepared in a cooperation with the Central Control and Testing Institute in Agriculture (ÚKSÚP). The Statistical Office of the Slovak Republic assumed the revised data and prepared resubmission to the EUROSTAT.
- The recalculation of emissions from the application of sludge from wastewater treatment plants was performed, because of the implementation of a new database of industrial sludge consumption for agricultural purposes. The source of data comes from the Statistical Office of the Slovak Republic. Simultaneously, the data set used in the emissions estimation is consistent with the data used and presented in the **Waste sector**.
- In addition, the recalculated data on pollutants (indirect GHG emissions) is provided in the 5.C categories. In the category 5.C.b.i, emissions from industrial sludge were calculated for the first time as well as sewage sludge incineration in the category 5.C.b.iv.

These changes are result of the methodological changes in the NECD inventory and are reflected in the March 15, 2022 NECD submission and consequently provided in the GHG inventory submission 2022. According to the analyses, there are no larger inconsistencies (+/-5%) in the reporting under NECD (or CLRTAP) (submitted on 15/03/2022) and the GHG inventory (submitted on 15/04/2022). Due to differences in methodology, small inconsistencies occurred in the aviation transport and shipping (international aviation and shipping is included in NECD totals), emissions from forest fires are not included in the NECD inventory and emissions of NOx in manure management are not included directly

[4] TFEIP = Task Force on Emissions Inventories and Projection

in the GHG inventory (indirect N_2O emissions are calculated based on NOx emissions in the category 3.B.2 – Manure Management).

Table ES.5: *Summary of the indirect GHG emissions according to the gases and the sectors in 2020*

EMISSIONS	TOTAL	ENERGY	INDUSTRY	AGRICULTURE	LULUCF	WASTE
	Gg					
NOx	**54.85**	**41.94**	**5.75**	7.12	0.56	0.04
CO	**278.59**	**208.03**	**70.50**	NO	20.14	0.05
NMVOC	**97.27**	**59.89**	**26.77**	6.74	0.24	3.87
SO_2	**13.35**	**6.65**	**6.65**	NO	0.02	0.05

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 – 2019 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.

Together, the reports provide a scientific base for decision-making at the UN climate change negotiations, which was held from 2 to 15 December 2019 in Madrid, Spain, under the presidency of Chile. The key objective of the meeting is to adopt the implementation guidelines of the Paris Climate Change Agreement, which aims to hold the global average temperature increase to as close as possible to 1.5°C. The Glasgow Climate Change Conference 2021 convened after a yearlong postponement due to the global COVID-19 pandemic. Parties adopted the Glasgow Climate Pact.

Despite setbacks from COVID-19, global greenhouse gas emissions increased in 2020. In 2020, greenhouse gas concentrations reached new highs, with globally averaged surface mole fractions for carbon dioxide (CO_2) at 413.2 ± 0.2 parts per million (ppm), methane (CH_4) at 1 889 ± 2 parts per billion (ppb) and nitrous oxide (N_2O) at 333.2 ± 0.1 ppb, respectively, 149%, 262% and 123% of pre-industrial (1 750) levels. The increase in CO_2 from 2019 to 2020 was slightly lower than that observed from 2018 to 2019, but higher than the average annual growth rate over the last decade. This is despite the approximately 5.6% drop in fossil fuel CO_2 emissions in 2020 due to restrictions related to the COVID-19 pandemic. For CH_4 and N_2O, the increase from 2019 to 2020 was higher than that observed from 2018 to 2019 and also higher than the average annual growth rate over the last decade.

Carbon dioxide (CO_2):

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 1750 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).[5]

Methane (CH_4):

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):

Nitrous oxide (N_2O):

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 – 2019. 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).

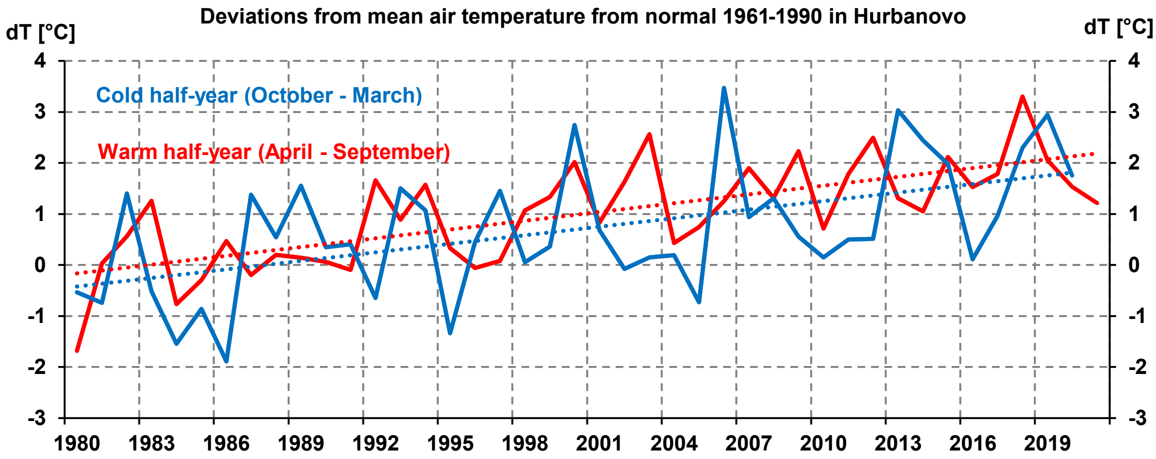
In 2020, GMST was 1.2 ± 0.1 °C warmer than the pre-industrial baseline (1850-1900). ***Figure 1.1*** demonstrates that during the period 1881 – 2020 the significant increase of annual air temperature by 1.8°C and insignificant trend of annual precipitation totals by about 1% were recorded on average in the Slovak Republic. Annual precipitation totals increased up to 3% in the north and decreased also more than 10% in the south of the country. Relative air humidity decreased up to 5% in the south-west. The snow cover decreases up to altitude 800 m was recorded (moderate snow cover increase was only in the highlands, above 1 000 m a. s. l.). There is an evidence of gradual desertification, particularly in the south of the country (increase of potential evapotranspiration and decrease of soil moisture), nevertheless the year 2010 and the cold half-year 2012/2013 were the wettest since 1881. Significant increase in regional floods and flash floods were recorded after 1993. Sun radiation characteristics changed insignificantly, except the temporal decrease in 1965 – 1985.

Particular attention needs to be paid to the climate change and variability, in particular to precipitation totals and hydrologic cycle. Over the last 24 years, a significant increase in the occurrence of extreme daily precipitation totals as well as several day heavy rain events have been observed, mainly compared to period 1975 – 1993. This trend has resulted in higher risk of local floods in several localities of the Slovak Republic. On the other hand, local and regional droughts caused by long periods of relatively warm weather and low precipitation totals in some part of growing seasons, have been recorded in the period of 1989 – 2021. Particularly strong droughts were in 1990 – 1994, 2000, 2002, 2003, 2007, 2009, 2011, 2012, 2015, 2017 and 2021. Based upon the indicators of air temperature, precipitation totals, evapotranspiration, snow cover and some other elements, the decades 1991 – 2000 and mainly 2001 – 2010 and 2011 – 2020, have approached the conditions expected in about 2030/2040 with respect to

[5] https://public.wmo.int/en/resources/bulletin/response-of-carbon-dioxide-and-air-quality-reduction-emissions-due-covid-19

climate change scenarios designed for the Slovak Republic. In 2021, there were at least two major periods with a lack of precipitation and drought (during spring and autumn) in Slovakia. In addition, in the summer, intense and heavy rains with local floods were recorded in some places. The annual spatial total precipitation in 2021 was normal for the whole of Slovakia, but was the 4th lowest in the last 10 years. In 2021, it was not as significantly above normal heat in Slovakia as it was in some years at the end of the 2nd decade of the 21st century. The cold spring of 2021 contributed to this as well.

Figure 1.1: *Deviations of warm and cold half-years from mean air temperatures from normal 1961 – 1990 in the Slovak Republic in 1980 – 2021*[6]



In Slovakia, climate change scenarios as statistical downscaling outputs stared to be used in 1995 (General Circulation Models (GCMs) from the USA – GFD3, GISS, Canada – CCCM, and UK - UKMO). The several other GCMs (CGCM2, CGCM3.1, GISS 1998 and 2000, UKMO, ECHAM5) were applied later. Since 2011, also Regional Circulation Models (RCMs) – Dutch KNMI and German MPI (both with ECHAM5 boundary conditions) were applied. The downscaling was applied mostly for meteorological stations in Slovakia (about 40) and precipitation stations in Slovakia (about 150). Several publications have been issued on climate change scenarios utilization in Slovakia.[7]

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 for the first time in this submission. Indirect N_2O emissions resulting from a deposition of nitrogen due to emissions of nitrogen oxides (NOx) and ammonia (NH_3) are estimated and

[6] Slovak Hydrometeorological Institute, Department of Climatology Service, Peter Kajaba, March 2022

[7] New Climate Change Scenarios for Slovakia Based on Global and Regional General Circulation Models, Milan Lapin, Ivan Bašták-Ďurán, Martin Gera, Ján Hrvoľ, Martin Kremler, Marián Melo; Acta Met. Univ. Comenianae, Volume XXXVII, 2012, pp. 25-74; https://link.springer.com/chapter/10.1007/698_2017_157 - Climate Changes in Slovakia: Analysis of Past and Present Observations and Scenarios of Future Developments, Martin Gera, Milan Lapin, Marián Melo.

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 2022 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 April 15, 2022, the Slovak Republic total anthropogenic emissions of greenhouse gasses expressed as CO_2 equivalent decreased by 45.56% without LULUCF, compared to the base year 1990. This achievement is the result of impacts of several processes and factors, mainly:

- 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 economic and financial crises started in 2009 and the short-term crises in oil and natural gas supply from Ukraine at the beginning of 2009 (January-February).
- 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 ESR emissions (non-EU ETS). Re-introduction of the phased-out furnace took place in beginning of 2021, so the decrease of emissions will continue also in 2020 inventory. This caused the opposite the share of allocated emissions in the EU ETS (48%) and the ESR (52%) emissions (***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 distribution between the EU ETS and ESR for the years 2013 – 2020*

YEAR	**2020**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**
	Gg of CO_2 equivalents							
Total greenhouse gas emissions without LULUCF	37 002.71	39 776.35	42 081.77	42 215.29	41 126.85	40 657.98	39 959.81	41 915.25
Total verified **EU ETS** emissions	18 170.00	19 903.84	22 193.40	22 063.23	21 264.05	21 181.22	20 918.07	21 831.83
CO_2 emissions from 1.A.3.A civil aviation	0.88	1.83	2.85	3.42	3.56	3.66	3.44	3.40
Total verified **ESR** emissions	18 831.83*	20 087.96	21 065.07	21 249.80	19 758.69	20 084.62	19 782.14	21 080.25

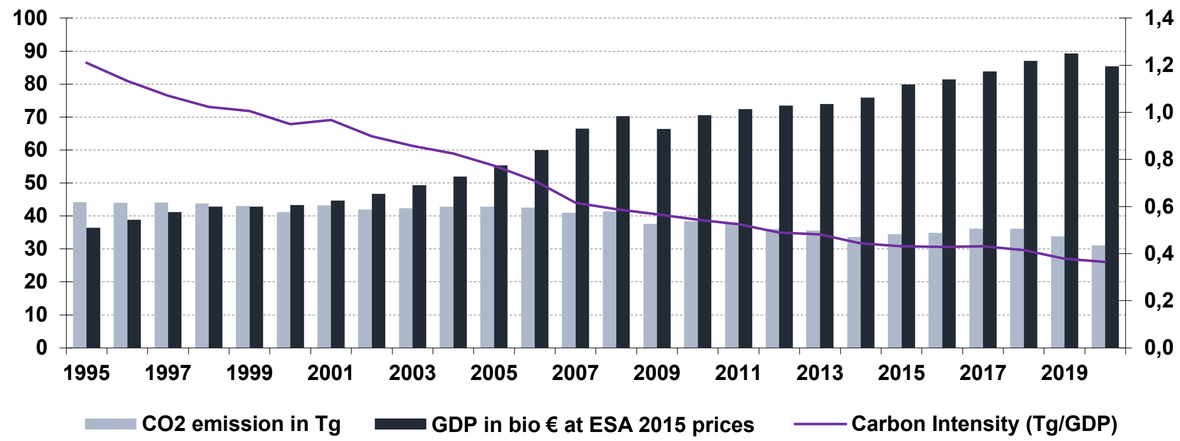
* preliminary data

Table 1.2 and ***Figure 1.2*** 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 (2020) 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 2005 – 2020*

YEAR	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
CO_2 emission *in Tg*	42.79	42.55	40.97	41.36	37.62	38.40	37.98	35.91
GDP *in Bio €* **at ESA 2015 prices**	55.33	60.03	66.53	70.24	66.41	70.59	72.45	73.43
Carbon Intensity *in Tg/GDP*	0.77	0.71	0.62	0.59	0.57	0.54	0.52	0.49
YEAR	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
CO_2 emission *in Tg*	35.57	33.66	34.47	34.91	36.11	36.10	33.78	31.09
GDP *in Bio €* **at ESA 2015 prices**	73.91	75.93	79.89	81.43	83.86	87.04	89.31	85.42
Carbon Intensity *in Tg/GDP*	0.48	0.44	0.43	0.43	0.43	0.41	0.38	0.36

Figure 1.2: *Comparison of CO_2 emissions per GDP (carbon intensity) in 1995 – 2020*



The Slovak Statistical Office, Dpt. of National Accounts. Within the revision of annual national accounts (base year 2015), year 2020 – preliminary.

1.1.3 INTERNATIONAL AGREEMENTS

UN context - The instrument to tackle climate change was the UN Framework Convention on Climate Change (UNFCCC) adopted in 1992. The aim of the Convention was to stabilize the atmospheric concentrations of greenhouse gases to a safe level that enables adapting of ecosystems. The UNFCCC covered 195 countries or international communities, including the Slovak Republic, and the EU, which was also the Party to the Convention. The Convention required adoption of mitigation measures to reduce GHG emissions in developed countries by 25-40% by 2020 compared to 1990. In the Slovak Republic, the Convention came into force on November 23, 1994. The Slovak Republic accepted all the commitments of the Convention, including the reduction of GHG emissions by 2000 to the 1990 level. One of the commitments, resulting from the Convention, was to prepare and submit to the UNFCCC secretariat, greenhouse gas emissions inventory on annual basis.

In a response to the significant increase in GHG emissions since 1992, an urgent need to adopt an additional and efficient instrument that would stimulate mitigation effort has occurred. In 1997, the Parties to the Convention agreed to adopt the Kyoto Protocol (KP) that defines reduction objectives and means to achieve mitigation goals by the countries included in Annex I to the Convention. Developed countries, listed in Annex B to the KP, should reduce emissions of six GHGs (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 has generally extended the options of the countries to choose the way and the instruments that are most appropriate for the achievement of their reduction targets, considering the specific circumstances of the country. The common feature of new mechanisms is the effort to achieve the maximum reduction potential in the most effective way. The Slovak Republic committed itself to an 8% reduction of emissions compared to the base year. Slovakia's base year under the Kyoto Protocol is 1990. In accordance with Article 3, paragraph 8 of Kyoto Protocol Slovakia has elected 1990 also as the base year for emissions of hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride.

The Slovak Republic and the EU Member States ratified the Kyoto Protocol on 31st May 2002.[8] This target of the Kyoto Protocol was achieved and reported in the SVK NIR 2014. Currently, the True-up period for the fulfilment of the first KP period is evaluated.

The second commitment period of the Kyoto Protocol (2CP) was agreed in Doha (COP 18) and started in January 2013 – December 2020. The indicative targets under the 2CP are identical with the CARE package of the European Union and expressed as 20/20/20 (see below). More information can be found in the First and Second Biennial Reports of the Slovakia to the UNFCCC. Currently in the SVK NIR 2022 is reported and evaluated the eight years (2013 – 2020) of the complete second commitment period of the Doha Amendment of the Kyoto Protocol.

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.

The Paris Agreement (PA) was adopted on December 12, 2015 as a result of the international effort of the 196 parties of the UNFCCC. 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. The Paris Agreement entered into force on November 4, 2016 as the world's first ever climate change agreement.

The EU, together with the Heads of State, including the Slovak Republic, signed the Paris Agreement together at the ceremony held on April 22, 2016 in New York. The proposal for the adoption of the Paris

[8] Kyoto Protocol came into force on February 14th, 2005

Agreement was negotiated by the Government of the Slovak Republic on September 14, 2016 and approved by Resolution No 387/2016. Subsequently, the proposal was submitted by the National Council of the Slovak Republic, which approved the Paris Agreement by Resolution No 215/2016 on September 21, 2016. The SR completed its ratification process on September 28, 2016, signed by the President of the Slovak Republic.

EU context – After joining the European Union (May 1, 2004) by the Slovak Republic, set of new environmental legislative requirements has been adopted, including climate change and air protection. 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 strategy shows how Europe can lead the way to climate neutrality by investing into realistic technological solutions, empowering citizens, and aligning action in key areas such as industrial policy, finance, or research – while ensuring social fairness for a just transition. Following the invitations by the European Parliament and the European Council, the European Commission's vision for a climate-neutral future covers nearly all EU policies and is in line with the Paris Agreement objective to keep the global temperature increase below 2°C and pursue efforts to keep it to 1.5°C.

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 sets Europe on a responsible path to become climate neutral by 2050.

In the present period, the EU MMR[9] policy requires reporting of information on annual emission inventories and among other the evaluation of the effects of the measures and planning of new measures as well as monitoring related to legislation under the EU CARE, namely the EU Effort Sharing Decision (406/2009/EC). The decision sets legally binding targets for the sectors not included in the EU Emissions Trading System, nor in the EU LULUCF. Decision from 17 October 2015 (529/2013/EU), which provides requirement for accounting of emissions/removals from LULUCF activities but does not include any targets for them in the period 2013 to 2020. The EU rules and modalities for reporting of greenhouse gas inventory data are based on those applied in the reporting under the UNFCCC and Kyoto Protocol, supplemented with provisions for reporting to enable the assessment of actual and projected progress of the EU and its Member States to meet their commitments under the UNFCCC and the Kyoto Protocol and for Member States under the EU Effort Sharing Decision. In the last 2 years, the European Commission introduced a new set of policy relating to the GHG emissions inventory a reporting. Reporting set in 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 started partly in January 2021 and full implementation will start since 2023 according to new rules based on the Paris Agreement.

Under the Regulation on the Governance of the Energy Union and Climate Action, the EU has adopted 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.

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 to reflect an increased ambition.

[9] OJ L 165/13, 18.06.2013

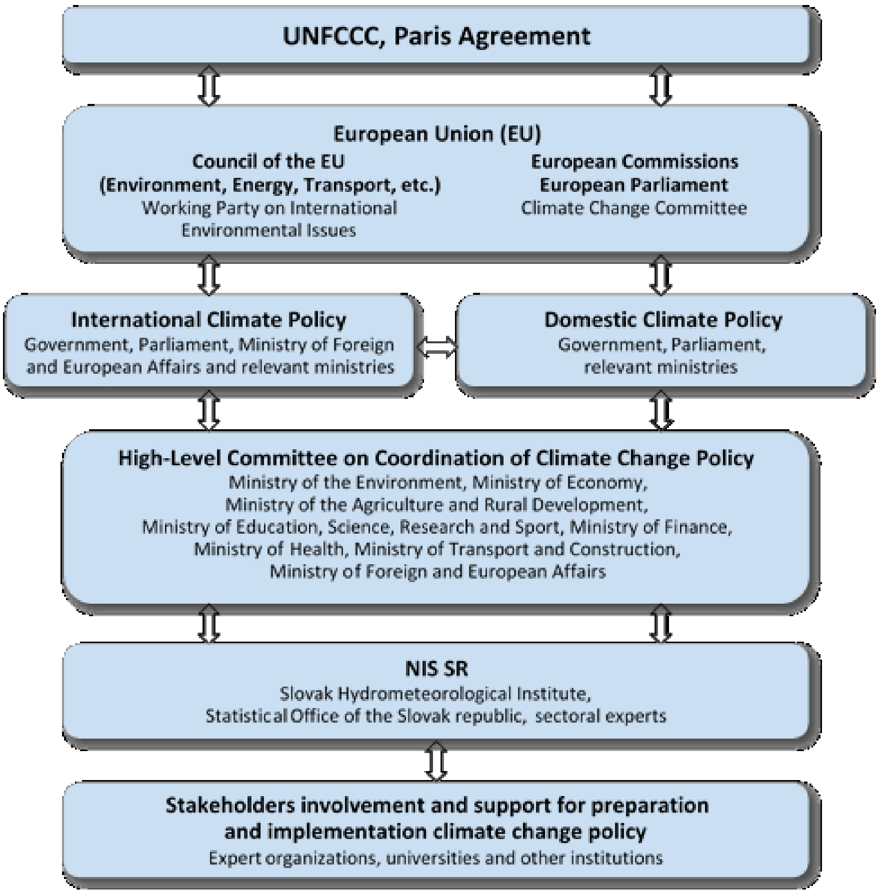
1.2 DESCRIPTION OF THE NATIONAL INVENTORY ARRANGEMENTS

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 for 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 1.3*** provides in depth overview diagram showing the institutional arrangements concerning climate policy and its implementation.

Figure 1.3: *Institutional arrangements in climate change policy and its implementation until 2021*



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, another in April 2013, in April 2014, in April 2015, in April 2016 and in April 2017 and the latest was published in April 2019. This type of report will be published irregularly after 2019. This was decided to publish in 2022 at the earliest.

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.

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 31. December 2020. However, Government of the Slovak Republic prolonged submission by the end of August 2021. This Action Plan was approved on 31. August 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. The next planned revision of the National Adaptation Strategy taking into account new scientific knowledge on climate change is planned in 2025 and 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 https://www.minzp.sk/klima/adaptacia-zmenu-klimy/.

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.[10] 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 Seventh National Communication of the SR on Climate Change, published in December 2017 and in the Fourth Biennial Report in 2020.

1.2.1.1 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 137/2010 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.

1.2.1.2 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 (http://www.shmu.sk/File/statut.pdf). 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

[10] "Vestnik" (Official Journal of the Ministry of Environment), XV, 3, 2007, page 19: National Inventory System of the Slovak Republic for the GHG emissions and sinks under the Article 5, of the Kyoto Protocol

SHMÚ http://www.shmu.sk/File/Kontrakt_SHMU/PHU_OVZDUSIE_2021.pdf. 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 and presented at http://www.shmu.sk//File/Org_Struktura_SHMU/Org_strukt_1_1_2021.pdf. 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.

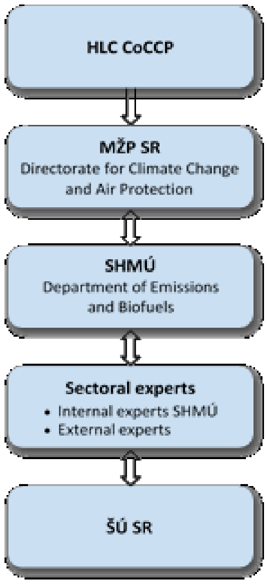
The Single National Entity is a part of the OEaB with the defined structure and overall responsibility for compilation and finalization of the inventory reports and their submission to the UNFCCC Secretariat and the European Commission according to the announcement. The SNE was officially appointed by 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 1.4***). 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.

1.2.1.3 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.

▪ ***Figure 1.4:*** *Structure and responsibilities of the SVK NIS*



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. Lenka Zetochová	Deputy of NIS coordinator and data manager
Dept. of Emissions and Biofuels	Mr. Ján Horváth	Energy expert
Dept. of Emissions and Biofuels	Mr. Marcel Zemko Mr. Jozef Orečný	Emission projections experts
Dept. of Emissions and Biofuels	Ms. Michaela Câmpian Ms. Zuzana Jonáček	Other pollutant experts
Dept. of Emissions and Biofuels	Ms. Kristina Tonhauzer	Agricultural expert
Dept. of Emissions and Biofuels	Ms. Monika Jalšovská	NEIS expert
Dept. of Water Quality	Ms. Lea Mrafková	GHG inventory in wastewater sector
Dept. of Numerical Forecasting Models and Method	Mr. Martin Petraš	Uncertainty analyses, QA activity

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

EXTERNAL INSTITUTIONS/EXPERTS		
INSTITUTION	**NAME**	**RESPONSIBILITY**
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 fertilisers
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
SPIRIT Information Systems – IT services, NEIS databases provider	Mr. Jozef Skákala	NEIS provider, consultation on the NACE classification of sources
ICZ Slovakia a.s.	Mr. Miroslav Hrobák	National Registry focal point
Ministry of Economy	Mr. Juraj Novák	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:	Ing. Miroslav Hrobák
Position:	Emission Registry Manager
E-mail address:	miroslav.hrobak@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.

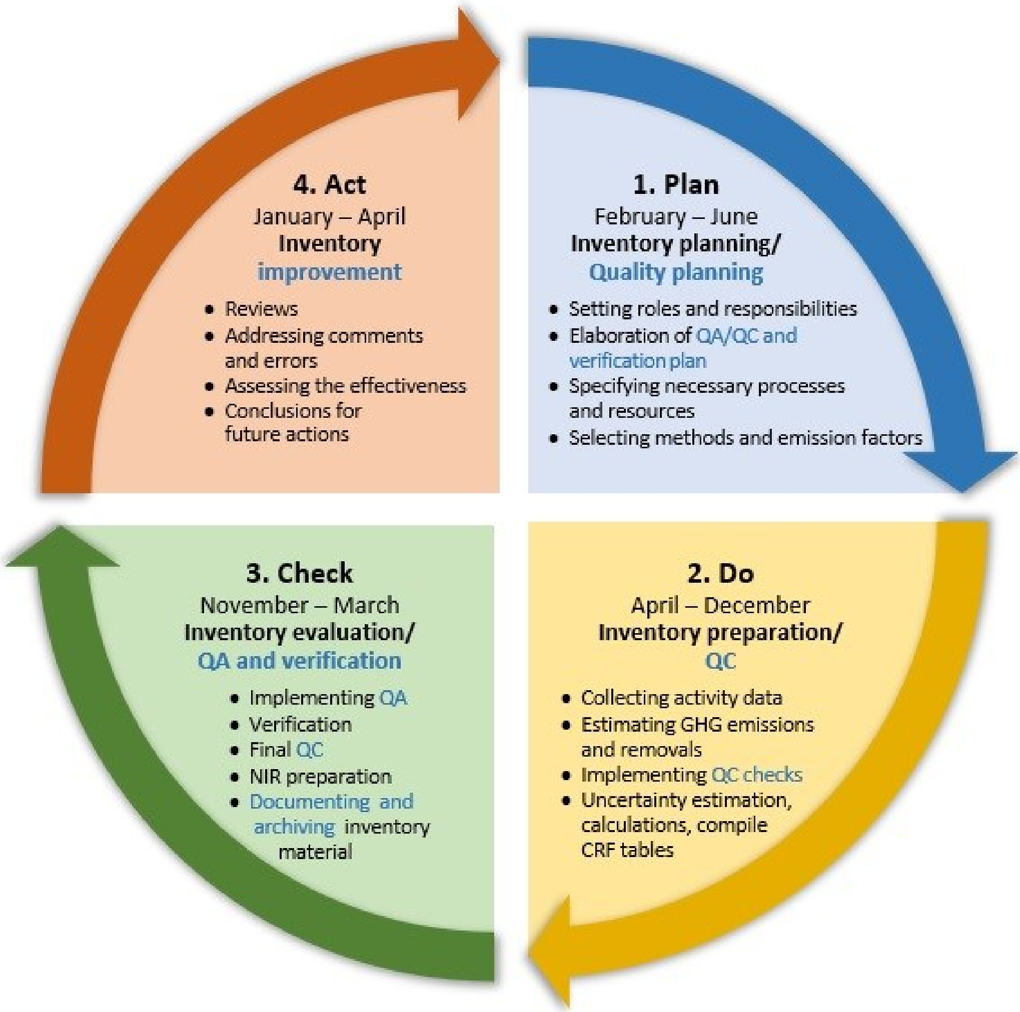
1.2.4.1 Quality management

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 1.5*** shows a model for the timeline steps provided in inventory process, QA/QC and verification procedures.

Figure 1.5: *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 online on October 16, 2020. In 2021, several partial meeting dedicated to the sectors and specific issues took place online due to pandemic situation. Planned in-person NIS meeting in September 2021 was cancelled due to insecure health situation. However, the ways of communication within the SVK NIS are via e-mail, phone call, visits and meetings. Although the efficiency of communication is on a high level in our information system, for further improvement a website forum was created.

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.

1.2.4.2 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.

1.2.4.3 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.

1.2.4.4 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.

According to the recommendation from the SVK ARR 2017 No G.7, 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. Vladimír Pavlovič	MŽP SR
ENERGY	Mr. Mário Gnida Mr. Pavol Široký	MŽP SR Institute of Environmental Policy
TRANSPORT	Mr. Mário Gnida	MŽP SR
IPPU	Mr. Jozef Škultéty	MŽP SR
AFOLU	Ms. Lenka Malatinská Ms. Hana Fratričová Ms. Kristína Buchová	MŽP SR MPaRV SR VÚPOP[11]
WASTE	Ms. Zuzana Jonáček Ms. Viera Špalková Mr. Cyril Burda	SHMÚ MŽP SR MŽP SR

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

[11] Institute for Soil Protection

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 June 2021 online.

The meeting was focus on independent verification process of the recalculated categories and new methodological improvement between both inventory systems, main points were:

- Presentation of the improvements in the residential heating (category 1.A14.b) and discussion;
- Discussion regarding biomass potential, statistics and NCV used in the inventory;
- Inventory preparation and changes of methodologies in fugitive emissions of natural gas and oil;
- Brainstorming in emission projections for EU ETS sources in new model, main constrains and challenges in modelling.

Next in-person meeting is planned for 2022, if the circumstances allow, involving also Poland, Hungary and Austria colleagues.

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. 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, 2021. Presentation of the new methodology and resulting emissions from the municipal and industrial solid waste disposal sites followed by the discussion introduced several interesting area for further improvements, however the principles and results of the recalculation were accepted on national level (**Chapter 7.5**).

1.2.4.5 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 (from 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.

1.2.4.6 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**.

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 (based on the ERT recommendation SVK ARR 2016 and 2019). 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 IPCC 2006 Guidelines. The methodological tiers for significant categories (bases on the UA results) are continuously improving, 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. The improvement of the uncertainties in the **LULUCF sector** started in 2017 and the process is continuing and is fully implemented (**Chapter 6**).

1.2.5 CHANGES IN THE NATIONAL INVENTORY ARRANGEMENTS

During the preparation cycle of the GHG emissions inventory submitted in 2022, 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 2021. 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 continuing of harmonization process between the air pollutants and GHG inventories.

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.

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. 2019, Crop yields data for crops and vegetables in 2019
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 2020; 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 – 2019); Protein Consumption, Statistical Yearbook of Slovakia Table 5-8, State of Environment report 2019; 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. Electronic archiving of the sectoral reports, inventory submissions and other specific documents (ERT reports, ARR, National Reports etc.), with password (all details for experts) and without password (less detailed information for public). 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) and the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol. In line with the recommendations of the expert review teams under the UNFCCC, several methodologies and parameters have been implemented gradually in accordance with the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. 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 2020 and the trend in emissions for the year 2020 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.

Key categories were assessed by Approach 2 by the level of emissions in years 1990 and 2020 and the trend in emissions for the year 2020 with and without LULUCF categories and those key categories have been chosen, whose cumulative contribution is less than 90%. 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 2020, the Slovak Republic determined using the Approach 1 by the level assessment, 33 key categories with LULUCF and 28 key categories without LULUCF. In 2020, the Slovak Republic determined using the Approach 2 by the level assessment, 22 key categories with LULUCF and 22 key categories without LULUCF.

In 2020, the Slovak Republic determined using the Approach 1 by the trend assessment, 33 key categories with LULUCF and 30 key categories without LULUCF. In 2020, the Slovak Republic determined using the Approach 2 by the trend assessment, 16 key categories with LULUCF and 27 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 11.61% level uncertainty and the 6.62% trend uncertainty in 2020. Approach 1 without LULUCF estimated the 3.64% level uncertainty and the 1.14% trend uncertainty in 2020.

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**, **IPPU** and **Waste** sectors for the year 2015 (latest results). The methodology and results were published and described in previous SVK NIR 2018. We decided based on our Improvement Plan (**Chapter 1.2**), not to update Monte Carlo calculation in the **Energy** and **IPPU** sectors annually, but every 5 years due to other more urgent tasks to be performed in this area (Approach 2 in the **LULUCF** uncertainty analyses). Results of the Monte Carlo simulations were almost identical since this exercise was performed (since 2011).

The uncertainty assessment by using the more sophisticated Approach 2 Monte Carlo method was prepared with cooperation with the Faculty of Mathematics, Physics & Informatics. The Approach 2 uncertainty analyses for fuel combustion in the **Energy sector** (including transport) according to the fuels classification was estimated in the range of confidence interval (-2.38%; +3.12%) in 2015. The Approach 2 uncertainty analyses for the **IPPU sector** including solvent and other product use according to the technological emissions was estimated in the range of confidence interval (-3.66%; +3.63%) in 2015. Results of the Monte Carlo method to estimate uncertainty were published in following papers[12,13] and detailed description was in **Chapters 3** and **Chapter 4** in the SVK NIR 2017 and 2018. This will be updated in the next submissions.

Due to prioritization process implemented in the improvement plans and previous ERT recommendations, main tasks during last 2 years in the uncertainty assessment were focused on **Agriculture** and **LULUCF** sector. These sectors are known to examine higher uncertainty and therefore they contributed to the total evaluation more than other sectors. The uncertainty assessment of LULUCF sector was introduced in the previous submission (**Annex A6.2**). Uncertainty evaluation based on Monte Carlo method (tier 2) in **Agriculture sector** is provided in this submission for the first time (**Annex A.5.1**).

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 (2022). 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 2022 submission for 1990 – 2020.

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 2022 submission*

GAS	SECTOR	CATEGORY	DESCRIPTION
CO_2	Agriculture	General	Part of the indirect emissions of CO_2 are included in sectoral tables for agricultural soils indirect emissions from other than agricultural sources are not estimated.
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.
CO_2	LULUCF	4.B.1 and 4.B.2 Organic soils	Reporting connected with the reporting of N_2O emissions from organic soils in agriculture. Due to negligible area of organic soils in Slovakia, emissions are under the threshold of significant.

[12] J. Szemesova, M. Gera: Contributions to Geophysics & Geodesy,37/3, 2007
[13] 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

GAS	SECTOR	CATEGORY	DESCRIPTION
CH_4	IPPU	2.D Non-energy Products from Fuels and Solvent Use/2.D.1 Lubricant Use	No methodology is provided in the 2006 IPCC GL.
CH_4	IPPU	2.D Non-energy Products from Fuels and Solvent Use/2.D.2 Paraffin Wax Use	No methodology is provided in the 2006 IPCC GL.
N_2O	Agriculture	General	Part of the indirect emissions of N_2O are included in 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.
N_2O	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.
N_2O	IPPU	2.D Non-energy Products from Fuels and Solvent Use/2.D.1 Lubricant Use	No methodology is provided in the 2006 IPCC GL.
N_2O	IPPU	2.D Non-energy Products from Fuels and Solvent Use/2.D.2 Paraffin Wax Use	No methodology is provided in the 2006 IPCC GL.

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

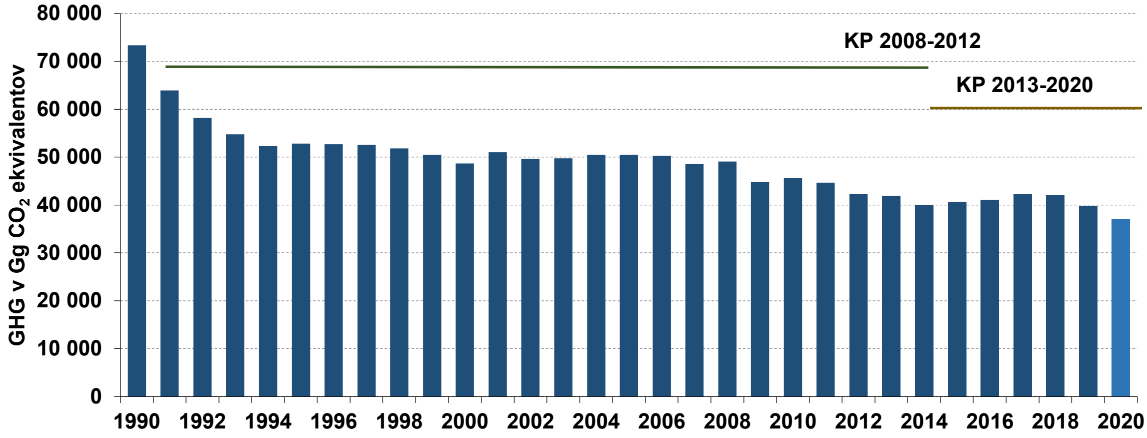
Both direct and indirect GHGs as well as precursor gases are covered by the inventory of the Slovak Republic. The geographic coverage is complete; the whole territory of the Slovak Republic is covered by the inventory.

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 2022 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 37 002.71 Gg CO_2 eq. in 2020 (without LULUCF). This represents a reduction by 49.6% in comparison with the reference (base) year 1990. In comparison with 2019, the emissions decreased by more than 7%. Total GHG emissions in the Slovak Republic decreased in 2020 in comparison with the previous year by more than 2.7 Tg, which was influenced by 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 last year due to special circumstances connected with the COVID-19 and other important changes made in Slovak economy. 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 – 2020, 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 comparable to the Kyoto target (CP1=92%, CP2=80%) in relative expression.

Figure 2.1: *The aggregated GHG emission trends compared with the Kyoto targets (%)*



Aggregated GHG emissions without LULUCF and indirect emissions; emissions are determined as of 15. 04. 2022

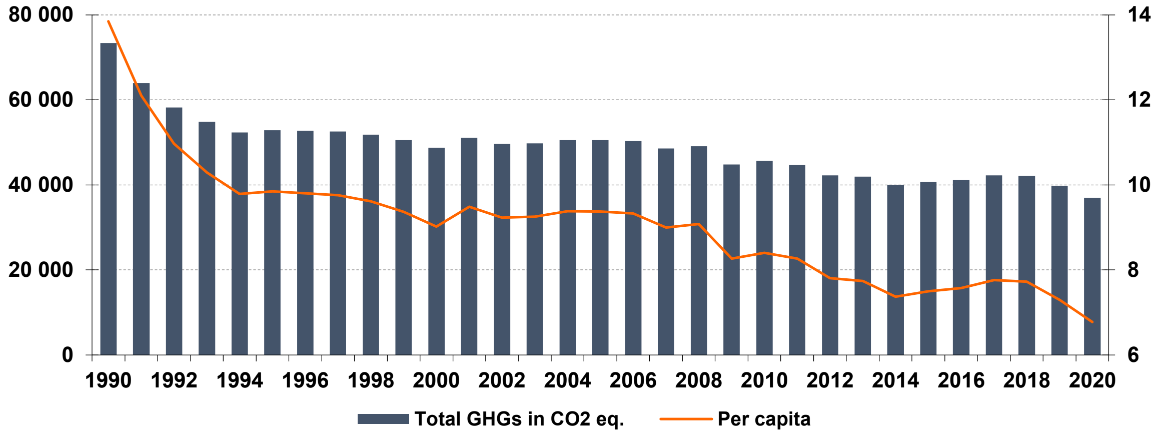
This important reduction of emissions has resulted above all from the strong although temporary decrease in economy activities, followed by restructuring of economy joined with implementing new and more effective technologies, reducing the share of the intensive energy industry and increasing share of 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 – 2020 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 started preparation of the new Climate Change legislation, what will introduce 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.

Figure 2.2: *Total GHG emissions in Gg of CO_2 eq. per capita in 1990 – 2020*



Aggregated GHG emissions without LULUCF and indirect emissions; emissions are determined as of 15. 04. 2022

2.2 DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS BY GAS

Population of the Slovak Republic as of December 31, 2020 was 5 460 136 and has slightly increasing. Average residential density is 111.35 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 6.7% at the end of 2020 (according to the national statistics), what is higher than the previous year 2019, where the lowest unemployment in the history of independent Slovakia was recorded (5.6%). The largest city is Bratislava with approximately 424 428 inhabitants (as of 31st December 2021). It is the capital of the Slovak Republic.

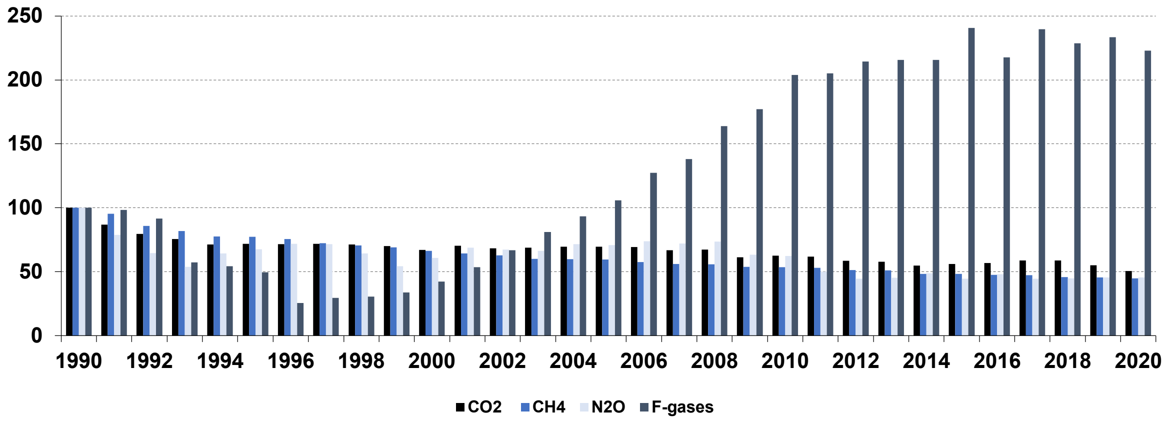
Total anthropogenic emissions of carbon dioxide excluding LULUCF have decreased by 49.41% in 2020 compared to the base year (1990). Nowadays the amount is 31 094.73 Gg of CO_2 without LULUCF. Compared to the previous inventory year 2019, emissions are on the lowest level in history. The reason for the decrease in CO_2 emissions in 2020 is caused mainly by decreasing CO_2 emissions in energy industry, manufacturing industry, iron and steel production, due to decrease in energy demand and heavy industrial production. In 2020, CO_2 emissions including the **LULUCF sector** significantly decreased compared to the previous year and decreased by 56.46% compared to the base year.

Total anthropogenic emissions of methane without LULUCF decreased compared to the base year (1990) by 55.33% and currently the emissions are 3 261.56 Gg of CO_2 eq. In absolute value, CH_4 emissions were 130.46 Gg without LULUCF. Methane emissions from the **LULUCF sector** are 0.89 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 influenced by the implementation of new waste legislation and measures in fugitive emissions and agriculture; while inter-annual moderate decreasing of methane emissions between 2019 and 2020 is visible and was caused by decreasing emissions in agriculture.

Total anthropogenic emissions of N_2O without LULUCF decreased compared to the base year (1990) by 54.66% and currently the emissions are 1 944.73 Gg of CO_2 eq. Emissions of N_2O in absolute value were 6.53 Gg without LULUCF. Emissions of N_2O from the **LULUCF sector** are 0.14 Gg. In contradiction with the decreasing trend in CO_2 and methane emissions, N_2O emissions trend is stabilised compared to the previous years. Overall decreasing trend had been mainly driven by the decrease in agriculture due to declining number of animals and making use of fertilizers.

Total anthropogenic emissions of F-gases 684.49 Gg, from it 678.88 Gg of HFCs, 5.61 Gg of PFCs and 17.20 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 in 2020. 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.

Figure 2.3: *Emission trends by gas for the years 2000 – 2020 relative to the 1990 level (relative in %)*

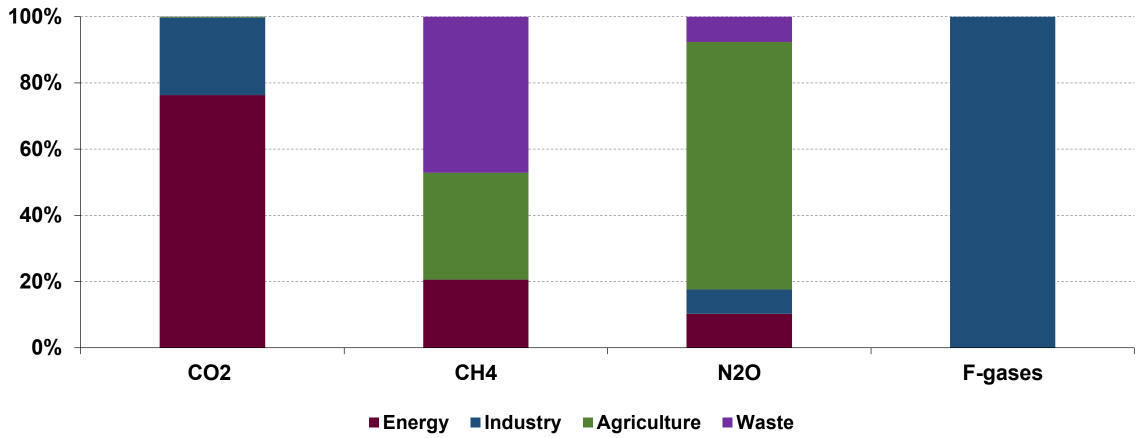


Aggregated GHG emissions without LULUCF and indirect emissions; emissions are determined as of 15. 04. 2022

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 76% share from the total carbon dioxide emissions in 2020 inventory, 23% 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 47% of CH_4 emissions is produced in the **Waste sector** (SWDS), 21% of methane emissions is produced in the **Energy sector** and 32% in the **Agriculture sector**. Almost 75% of N_2O emissions is produced in the **Agriculture sector** (nitrogen from soils), 7% in the **IPPU sector** (nitric acid production), 8% in the **Waste sector** and 10% in the **Energy sector**. F-gases are produced exclusively in the **IPPU**.

Figure 2.4: *Emission trends by gas in the sectors in 2020*



Aggregated GHG emissions without LULUCF and indirect emissions; emissions are determined as of 15. 04. 2022

Aggregated GHG emissions from the **Energy sector** based on the sectoral approach (combustion) data in 2020 were estimated to be 24 183.42 Gg of CO_2 eq. including transport emissions (7 069.21 Gg of CO_2 eq.), which represent the decrease by 55% compared to the base year and decrease compare to previous year by 8%. Transport decreased by 3.6% compared to 2019 and in comparison with the base year it increased by more than 3.5%.

Total emissions from the **IPPU sector** were 8 129.84 Gg of CO_2 eq. in 2020, which was decreased by more than 16% compared to the base year and the decreased by 6.5% 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 2 579.71 Gg of CO_2 eq. It is almost 57% decrease in comparison with the base year but in comparison to the previous year, emissions are slightly increased. 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 1 684.65 Gg of CO_2 eq. The increase is less than 2% compared to the previous inventory year and the time series are stable for last years. Compared to the base year, the increase was almost 20%, 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.

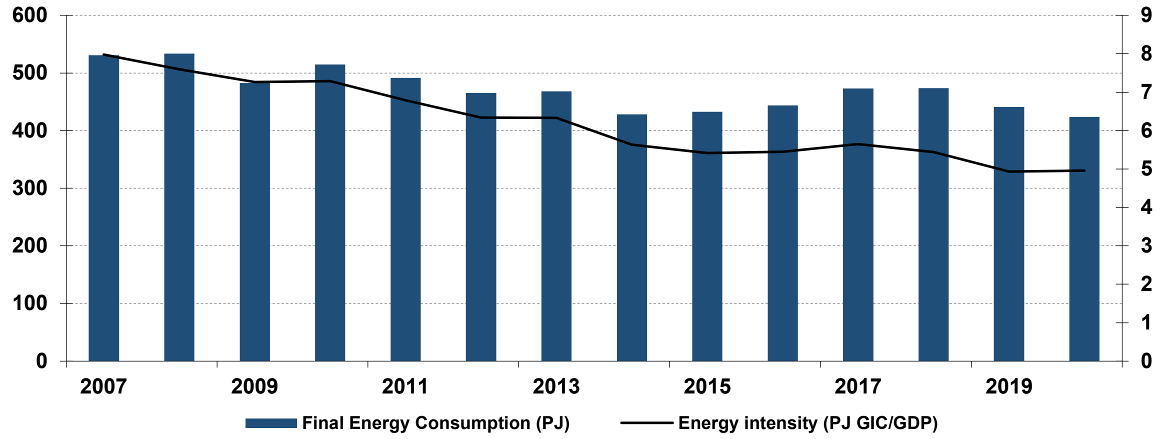
Structural changes in the **Energy sector** and the implementation of economic instruments have played an important role in achieving the status, when the trend of GHG emissions does not copy the fast GDP growth. In this context, the most important measure seems to be the adoption of the national legislation 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 – 2020 are depicted in ***Table ES.3*** in this Report.

According to the statistical information from the Statistical Office of the Slovak Republic – information database Slovstat, industry including industrial processes and energy (NACE B-E) reached almost 43% share in total GDP of the Slovak Republic in 2020. Energy intensity as the ratio of the gross inland consumption and the gross domestic product (GDP) for a given calendar year is an important economic indicator of the national economy. It measures the energy consumption of an economy and its overall energy efficiency. Energy intensity in the Slovak Republic has had a declining trend in the past 10 years as the significant progress in reduction of energy intensity was achieved. In the period 2007 – 2020, the Slovak Republic reduced in addition its energy intensity by 9%. It is the second biggest reduction in terms of percentage among all EU Member States. Additionally, 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%.[14] 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 2020 remained at the same level as in previous year, due to lower GDP growth caused by the pandemic situation.

[14] 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 – 2020 (estimated by the revised statistical approach NACErev.2)



Transport is a significant source of emissions in the **Energy sector**, with 16% share in total GDP (including automotive industry and storage; NACE G-I) 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 2019 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 0.3% share in total GDP) 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. More information can be found in the **Energy chapter**.

The **IPPU sector** includes all GHG emissions generated from technological processes producing raw materials and products (NACE C) with the 36% share in total GDP 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 2019 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 2% share (NACE A) in total GDP 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 41% 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.

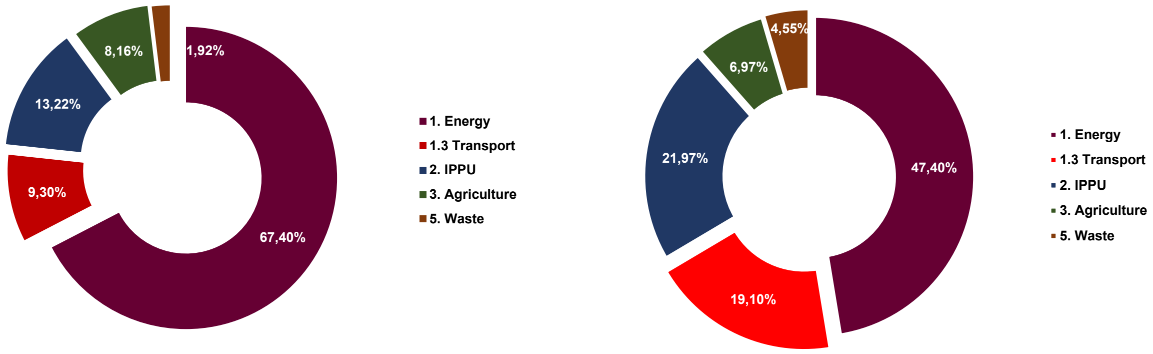
Several significant changes and re-evaluations of the applied methods have been carried out in the **Waste sector**, followed by recalculations in all categories of waste treatment. Methane emissions from solid waste disposal sites (SWDS) have the largest share on total emissions. Waste balance methodology 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.[15] 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 2020 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 70.12 Gg of CO_2 equivalents in 2020 mostly due to dramatically decrease, practically stopping of air transport caused by Covid-19 pandemic situation. Emissions from international aviation have more than 95% share.

[15] Szemesová J., M. Gera 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 2020 (left) and 1990 (right)*



Aggregated GHG emissions without LULUCF and indirect emissions; emissions are determined as of 15. 04. 2022

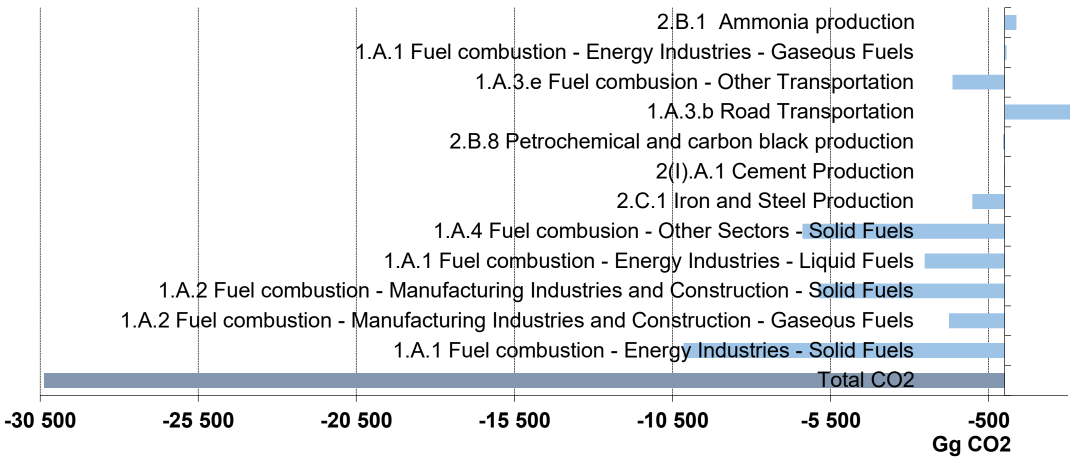
2.3.1 CHANGE IN EMISSIONS FROM KEY CATEGORIES

Key categories are defined as the sources or removals of emissions that have a significant influence 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 2020 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 22% of total CO_2 emissions without LULUCF in 2020. Between 1990 and 2020, CO_2 emissions in road transportation increased by 2.2 Mt of CO_2, which is almost 50% 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*** below shows that, solid fuels from the category 1.A.1 - Energy Industries, solid fuels is the key category without LULUCF (8.7%) with the largest decrease (79%; 10 Mt of CO_2) is between 1990 and 2020. 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 10.1% of total GHG emissions in 2020. Between 1990 and 2020, emissions from this category showed the decrease by 65%.

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 10.1% of total CO_2 emissions in 2020. Emissions decreased by 24.5% 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. Interesting comparison is increase of biomass consumption in category 1.A.1 - Energy Industries between 1990 and 2020, where biomass consumption increased 20 times up to 1 450 Gg of CO_2.

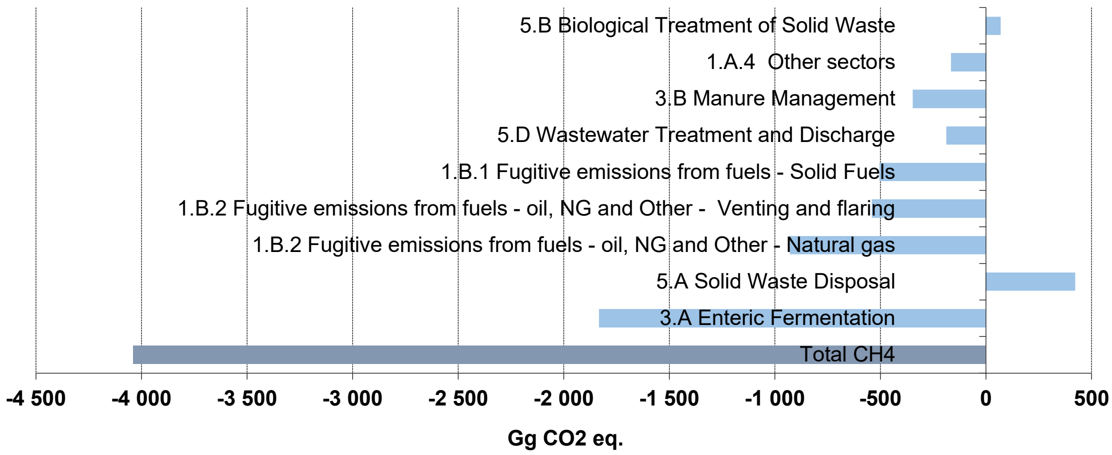
Figure 2.7: *Absolute change of CO_2 emissions by large key categories 1990 to 2020*



Aggregated GHG emissions without LULUCF and indirect emissions; emissions are determined as of 15. 04. 2022

Methane emissions account for almost 8.8% of total GHG emissions in 2020 and decreased by almost 55% since 1990 to 130.46 Gg CH_4 without LULUCF in 2020. The three largest key sources (5.A - Solid Waste Disposal at 35%, 3.A - Enteric Fermentation at 30% and 5.D - Wastewater Treatment at 8.5% of total CH_4 emissions in 2020) account for more than 72% of CH_4 emissions in 2020. ***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.

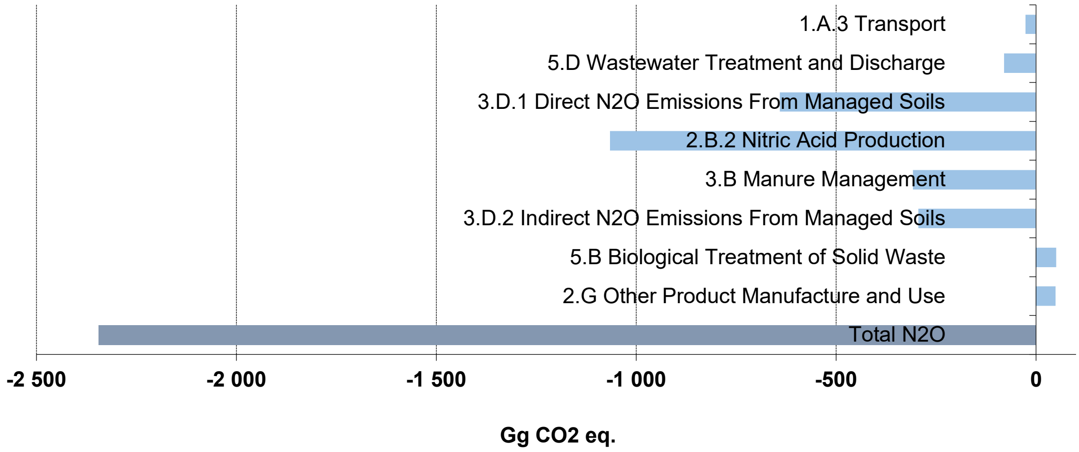
Figure 2.8: *Absolute change of CH_4 emissions by large key categories 1990 to 2020*



Aggregated GHG emissions without LULUCF and indirect emissions; emissions are determined as of 15. 04. 2022

N_2O emissions are responsible for 5.3% of total GHG emissions and decreased by 55% to 6.53 Gg of N_2O without LULUCF in 2020 (***Figure 2.9***). The three largest key sources causing this trend in agriculture are 3.D.1 - Direct N_2O Emissions from Managed Soils 57%, 3.D.2 - Indirect N_2O Emissions from Managed Soils at 10% and 3.B - Manure Management at 7.7% of total N_2O emissions in 2020. 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 2020*



Aggregated GHG emissions without LULUCF and indirect emissions; emissions are determined as of 15. 04. 2022

Fluorinated gas emissions account for 1.9% of total GHG emissions. In 2020, emissions were 701.69 Gg CO_2 eq., which was 2.2 times above 1990 levels. The largest key source is 2.F.1 - Refrigeration and Air Conditioning and accounts for 95% of fluorinated gas emissions in 2020. HFC emissions from the consumption of halocarbons showed large increases between 1990 and 2020. 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 2000.

2.3.2 MAIN REASONS FOR EMISSION CHANGES IN 2018 – 2020

Total GHG emissions in the Slovak Republic decreased by 7% in 2020 in comparison with the previous year, which was influenced by the decrease in the **Energy** and **IPPU** sectors due to the higher share of industrial production and energy demand and economic changes caused by COVID-19. Total GHG emissions excluding the **LULUCF sector** have been decreasing continually from the base year with the almost stable trend in the recent years and more significant drop in last years of inventory. Significant changes in methodologies and emission factors are implemented in the frame of trying to keep consistency with the EU ETS and new IPCC 2006 GL. The main reason for emission changes in 2018 – 2020 were as follows:

- CO_2 emissions decrease in the **Energy sector** - category 1.A.1 – Energy Industry (0.6 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 (0.4 Tg of CO_2) caused by decrease industrial production of heavy metals and chemistry.
- CO_2 emissions decrease in the **Energy sector** - category 1.A.3 – Transport (1 Tg of CO_2) caused by decreasing road transportation, mainly diesel-driven cars and transit.
- CO_2 emissions decrease in the **IPPU sector** – category 2.C - Iron and Steel Production (450 Gg of CO_2) caused by phase-out of the one of three furnace in the largest company.
- CO_2 emissions decrease in the **IPPU sector** - category 2.D.3 - Solvents Use (450 Gg of CO_2) caused by increasing consumption of fuels in services and the residential sector.
- CO_2 removals increase (2 000 Gg of CO_2) in the **LULUCF sector** – category 4.A - Forest Land mostly caused by the decrease of three harvest.

- CH_4 decrease in the **Energy sector** – category 1.B.1 and 1.B.2 - Fugitive Emissions from Fuels mainly caused by improvements made in infrastructure and improvements in equipment and methodology.
- Decrease in the category 2.B - Nitric Acid Production by 5 Gg of N_2O emissions in comparison with the previous year.
- Significant decrease in F-gases (40 Gg of CO_2 eq.) due to decreasing of service activities in equipment.

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 - 8 746.54 Gg of CO_2 eq. in 2020 is very important sector and comprises from several key categories.

The major share represents removals in CO_2 eq. with the contributions of following categories: Forest Land with net removals of -7 608.60 Gg CO_2 eq., Cropland with net removals of -1 083.39 Gg CO_2 eq., Grassland with net removals of -92.86 Gg CO_2 eq., Settlements with the emissions of 82.98 Gg CO_2 eq. and Other Land with the emissions of 97.21 Gg CO_2 eq. Total methane emissions were 22.14 Gg of CO_2 eq. and total N_2O emissions were 40.64 Gg of CO_2 eq. from the **LULUCF sector** in 2020. 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 0.57 Gg and the estimated amount of CO emissions was 20.16 Gg in 2020 (***Table 2.1***).

Table 2.1: *Summary of total emissions and removals according to the categories in 2020*

CATEGORY	Net CO_2		CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	Gg		*Gg of CO_2 eq.*		*Gg*			
4. LULUCF	**NO**	**-8 809.32**	**22.14**	**40.64**	**0.57**	**20.16**	**0.12**	**0.01**
A. Forest Land	NO	-7 645.34	22.14	14.60	0.57	20.16	0.12	NO
B. Cropland	NO	-1 094.54	NO	11.15	NO	NO	NO	NO
C. Grassland	NO	-93.17	NO	0.31	NO	NO	NO	NO
D. Wetlands	NO	NO	NO	NO	NO	NO	NO	NO
E. Settlements	78.40	NO	NO	4.58	NO	NO	NO	NO
F. Other Land	92.19	NO	NO	5.02	NO	NO	NO	NO
G. HWP	NO	-146.86	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. 04. 2022

2.4 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 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** **Annexes A3.1 & A3.2**	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 gross domestic energy consumption is as follow: natural gas 24%, nuclear fuel 23%, coal 20%, crude oil 22% and renewable sources (RES) more than 17% in 2020. 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). Based on the information provided by the Ministry of Economy of the Slovak Republic, share of carbon-free energy on total energy production in 2020 increased up to 14% (excluding nuclear).

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 28% and the decline in gaseous fuels is 29%. By comparison, the consumption of biomass was 7.5 times higher in 2020 than in 1990. General trend in total consumption of fossil fuels is declining by 40% 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 47.40% and 24 183.42 Gg of CO_2 eq. in 2020. Within this sector, ***Figure 3.2*** shows significant contributors (and key categories) to the emissions as follow: transport with its share of 26.3%, fuel combustion in the large (share 24%) and medium stationary sources of pollution (share 22.1%), pollution from small sources of residential heating systems (share 17.4%) and fugitive methane emissions from transmission/transport/distribution, processing and storage of oil and natural gas (share 1.58%).

***Figure 3.1**: Trend in aggregated GHG emissions by categories in Gg of CO_2 eq. in the Energy sector in 1990 – 2020*

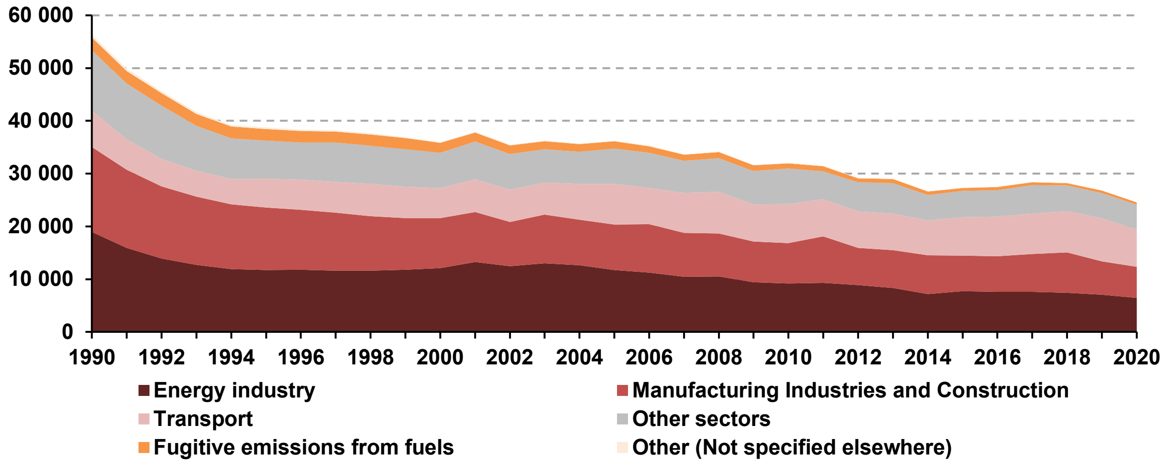


***Figure 3.2**: The share of aggregated GHG emissions by categories within the Energy sector in 2020*

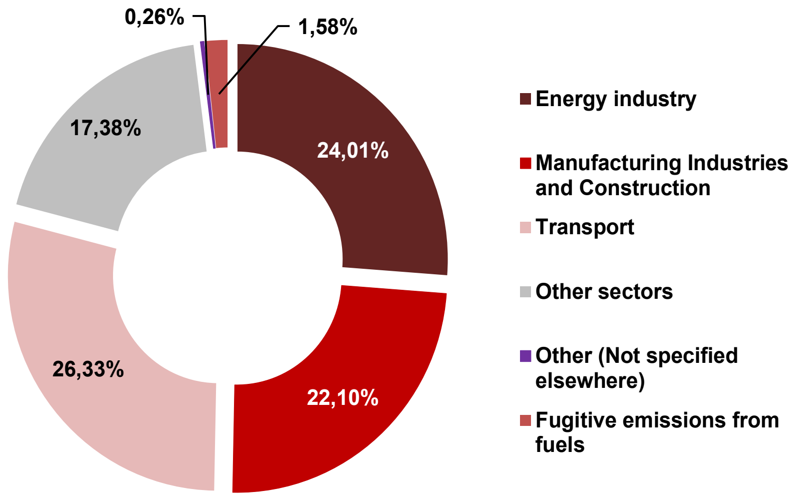


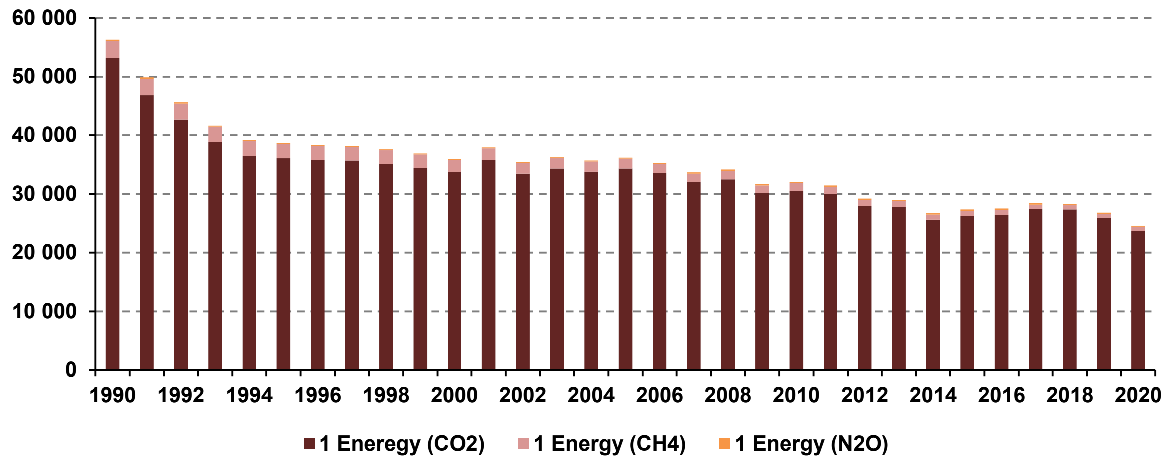
Table 3.1 and ***Figure 3.3*** show overall emissions trends since the base year 1990 according to gases and major categories. The majority of emissions is reported in the category 1.A – Fuels Combustion (more than 90% in all years) and major gas is carbon dioxide (more than 90% in all years). According 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/year								
1990	53 180	53 156	24.18	113.66	18.13	95.54	0.87	0.87	0.00007
1995	36 088	36 061	26.41	98.43	11.15	87.27	0.59	0.59	0.00006
2000	33 729	33 704	25.18	83.08	9.44	73.64	0.59	0.59	0.00005
2005	34 322	34 299	23.24	67.59	12.79	54.80	0.71	0.71	0.00003
2010	30 531	30 510	21.20	51.56	12.69	38.88	0.67	0.67	0.00001
2011	30 031	30 011	20.04	49.18	11.94	37.24	0.69	0.69	0.00002

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/year								
2012	27 953	27 934	19.02	41.73	12.93	28.80	0.71	0.71	0.00001
2013	27 766	27 746	19.62	41.62	12.51	29.11	0.74	0.74	0.00001
2014	25 608	25 581	27.67	34.80	8.34	26.46	0.73	0.73	0.00001
2015	26 278	26 258	20.79	33.30	11.22	22.08	0.79	0.79	0.00001
2016	26 430	26 410	19.83	33.82	11.95	21.87	0.78	0.78	0.00001
2017	27 405	27 382	22.69	32.14	11.71	20.43	0.80	0.80	0.00001
2018	27 376	27 357	19.73	27.67	10.02	17.65	0.76	0.76	0.00001
2019	25 912	25 893	19.08	28.70	10.26	18.44	0.73	0.73	0.00001
2020	23 737	23 724	13.17	26.84	10.36	16.48	0.67	0.67	0.00001

***Figure 3.3**: Trend in aggregated emissions by gases within the Energy sector in 1990 – 2020 (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 – 2020 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. 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 2020

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 transportation						
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

CATEGORY		DESCRIPTION / EMISSIONS / TIER					
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 transportation						
1.A.3.e.i	*Pipeline transport*	**CO_2**	T2	**CH_4**	T1	**N_2O**	T1
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	T2	**CH_4**	T2	**N_2O**	T2
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**	T1	**CH_4**	T2	-	-
1.B.1.a.1.ii	*Post-mining activities*	-	-	**CH_4**	T2	-	-
1.B.1.a.1.iii	*Abandoned underground mines*	-	-	**CH_4**	T2	-	-
1.B.1.b	Solid fuel transformation	Charcoal production					
		-	-	**CH_4**	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**	T3	-	-
1.B.2.a.3	*Transport*	**CO_2**	T1	**CH_4**	T1	-	-
1.B.2.a.4	*Refining / Storage*			**CH_4**	T1	-	-
1.B.2.b	Natural gas						
1.B.2.b.2	*Production*	**CO_2**	T1	**CH_4**	T3	-	-
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**	T3	**CH_4**	T3	-	-
1.B.2.c	Venting and flaring						
1.B.2.c.1	Venting						
1.B.2.c.1.i	*Oil*	**CO_2**	T1	**CH_4**	T1	-	-
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*	**CO_2**	T1	**CH_4**	T1	**N_2O**	T1
1.B.2.c.2.ii	*Gas*	**CO_2**	T1	**CH_4**	T1	**N_2O**	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 65.4% 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 transportation 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 24 183.42 Gg of CO_2 eq. in 2020. ***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***.

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 last year than in the previous period. There are several cumulative reasons for this decrease. Due to Covid-19 pandemic, a significant decrease in transport is observed. Similar decrease is observed in the category 1.A.4.a (services), especially in solid fuels.

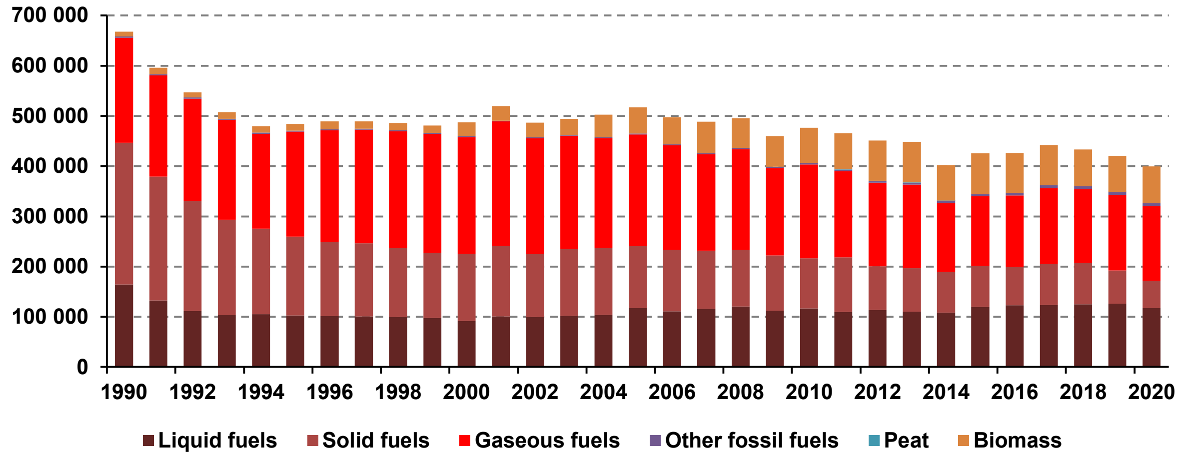
In addition, iron and steel production was significantly reduced. The producer of iron and steel in Slovakia is U. S. Steel Košice, it idled one of its three blast furnaces (June 2019 - January 2021). The inter-annual decrease in CO_2 emissions in fuel combustion is more than 8% in comparison with year 2019 and more than 13% in comparison with year 2018.

***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	18 965.53	16 096.72	6 823.77	11 501.67	479.20
1995	11 744.86	11 810.31	5 495.29	7 185.23	279.55
2000	12 111.24	9 435.52	5 725.61	6 696.25	147.85
2005	11 764.74	8 578.14	7 697.61	6 692.92	95.70
2010	9 179.14	7 666.18	7 425.74	6 686.46	69.86

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				
2015	7 713.10	6 771.02	7 301.70	4 924.30	63.90
2016	7 640.54	6 710.19	7 548.33	4 977.23	65.72
2017	7 616.15	7 136.15	7 691.97	5 401.82	66.18
2018	7 430.52	7 633.27	7 818.02	4 863.71	89.10
2019	7 067.37	6 329.17	8 132.58	4 755.71	83.65
2020	6 446.81	5 932.71	7 069.21	4 665.61	69.09

***Figure 3.4**: Trend in fuels consumption within 1.A category in TJ in 1990 – 2020*

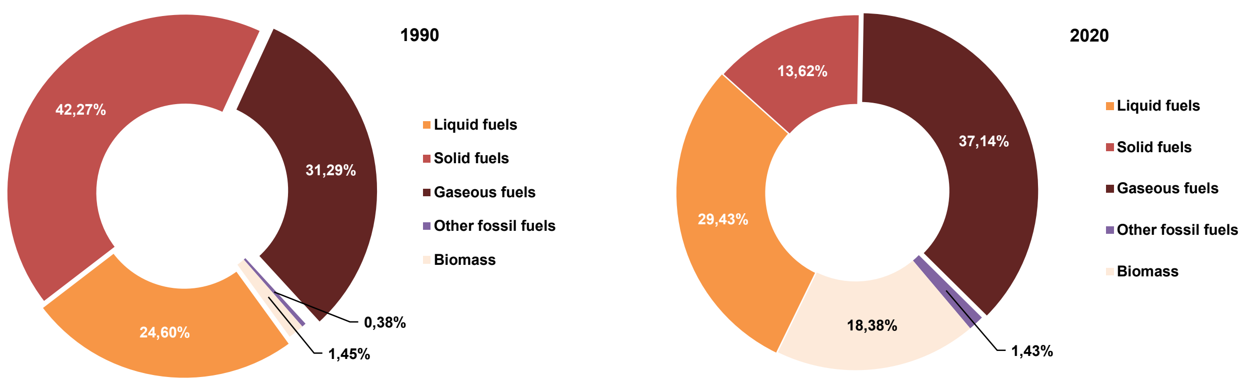


High-level dependency on import of primary energy sources (PES) is a limiting factor for the **Energy sector** and subsequently for the complete economic (mostly industrial) development of Slovakia. Net imports of PES are covered by almost 90% of the total energy demand.

In 2001, the Slovak Republic started transformation and privatization of regional distribution companies. In 2002, the biggest producer of electricity, Slovenské elektrárne – was transformed and split up. Since then, the electricity transmission system, Plc. (Slovenska elektrizačná prenosová sústava, a.s.) has been registered and it acts as the transmission system operator including also the energy dispatch.

In addition, energy intensity of Slovakia is gradually decreasing but it is still higher than the EU average. In January 2004, the transitional period for price subsidies ended and the Regulatory Office for Network Industries terminated provision of the subsidies for electricity, gas and heat for industry and households, in order to change energy consumption pattern.

***Figure 3.5**: The share of fuels' consumption within category 1.A in 1990 and in 2020*



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	14 764.78	2 881.44	1 319.32	2 689.97	1 262.24	2 664.60
1995	8 406.50	2 034.49	1 303.87	2 454.58	534.77	3 067.50
2000	8 927.49	1 934.78	1 248.97	2 782.68	287.52	1 663.77
2005	8 680.51	1 735.36	1 348.87	3 398.16	188.49	875.53
2010	6 269.87	1 600.65	1 308.62	3 752.86	199.52	562.30
2015	4 971.44	1 451.55	1 290.11	2 875.16	139.28	484.59
2016	4 849.66	1 487.00	1 303.88	2 793.44	115.07	502.88
2017	4 924.49	1 472.82	1 218.84	3 095.20	125.60	515.51
2018	4 760.11	1 488.30	1 182.12	3 432.63	97.41	526.32
2019	4 471.51	1 422.37	1 173.48	2 449.10	101.82	473.70
2020	3 961.57	1 507.44	977.80	2 185.27	98.12	474.49

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	2 341.71	1 144.23	3 429.99	2 563.97	3.77	4 588.64	415.63
1995	1 215.24	761.53	1 838.94	1 937.75	2.68	4 114.55	222.81
2000	705.41	570.10	1 502.83	1 923.21	2.67	4 144.58	172.13
2005	548.88	436.91	1 390.30	1 739.86	7.86	6 243.72	116.74
2010	421.01	306.53	1 182.44	1 241.51	5.18	6 502.59	92.35
2015	500.97	329.65	1 248.62	1 192.76	3.69	7 012.29	94.86
2016	419.98	320.32	1 362.96	1 195.55	3.59	7 143.90	97.32
2017	395.27	324.74	1 326.59	1 353.24	3.45	7 269.46	94.90
2018	362.69	323.40	1 510.39	1 380.43	2.88	7 423.04	93.26
2019	451.54	345.83	1 461.73	1 045.45	1.85	7 636.69	91.15
2020	407.95	342.72	1 424.30	999.86	0.89	6 813.31	81.61

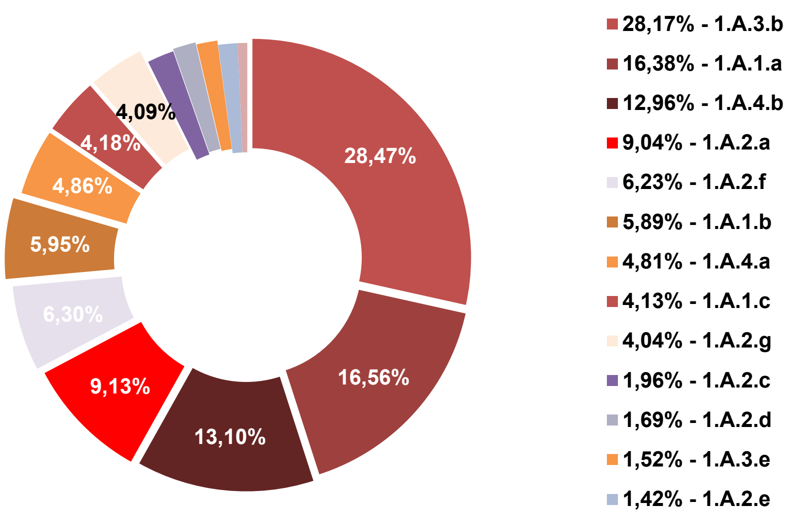
YEAR	1.A.3 TRANSPORT		1.A.4 OTHER SECTORS			1.A.5 OTHER	
	1.A.3.d	1.A.3.e	1.A.4.a	1.A.4.b	1.A.4.c	1.A.5.a	1.A.5.b
	Gg of CO_2 eq./year						
1990	0.02	1 815.70	4 166.53	7 178.45	156.69	407.31	71.89
1995	0.02	1 155.23	2 433.72	4 582.65	168.87	213.73	65.82
2000	0.02	1 406.21	1 569.94	4 751.68	374.63	130.57	17.28
2005	0.04	1 329.25	2 259.35	3 975.40	458.16	76.58	19.12
2010	0.33	825.29	2 571.58	3 704.96	409.92	54.05	15.81

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						
2015	6.28	184.58	1 501.47	2 978.72	444.11	46.55	17.35
2016	4.81	298.71	1 453.61	3 065.54	458.08	49.50	16.23
2017	4.74	319.42	1 607.93	3 367.46	426.43	55.95	10.23
2018	2.58	296.27	1 469.72	3 027.25	366.74	76.42	12.68
2019	4.22	398.67	1 349.50	3 076.54	329.67	72.37	11.29
2020	5.41	167.99	1 163.59	3 135.33	366.69	57.96	11.12

The share of fuels on total fuel consumption in **Energy sector** of the categories 1.A.1, 1.A.2, 1.A.4 and 1.A.5 was 70.7% in 2020 (without transport). The highest share on GHG emissions has category 1.A.1.a - Public Electricity and Heat Production (16.38%), followed by 1.A.4.b - Residential (12.96%) and 1.A.2.a - Iron and Steel (9.04%) categories (***Figure 3.6***). According to the detailed, the major share has category 1.A.3.b - Road Transportation (28.17%) which is the most important key category with one of the highest share on emissions in **Energy sector**. There is a significant decrease in CO_2 emissions in the category 1.A.2.c - Chemicals caused by the decrease of solid fuels consumption by 83%. This decrease is significant and continuous during the period 1990 – 2020. 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). Similar decrease can be observed in gaseous and liquid fuels between 2001 and 2002.

A significant decrease can be observed also in categories 1.A.4.a - Services and 1.A.4.b - Residential. 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 87% 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 a slight increase of emission from natural gas in category 1.A.4.b.

***Figure 3.6**: The share of emissions in CO_2 eq. on different IPCC subcategories within 1.A in 2020*



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 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.

3.2.4 CATEGORY-SPECIFIC RECALCULATIONS

Recalculations made in the **Energy sector** were provided and implemented in the line with the Improvement and Prioritisation Plan, reflecting recommendations made during previous reviews and correction of minor errors from previous inventory.

Table 3.5: *Summary of the recalculations and changes in the category 1.A (except transport 1.A.3)*

NUMBER	CATEGORY	DESCRIPTION
1.	1.A.1.a.iv – Other and Biomass	An issue with incorrect municipal waste consumption in one MSW incinerator was identified. In current submission the consumption was corrected.
2.	1.A.5.a – Biomass	An improvement in LFG consumption was included in current submission. The activity data were modified for the years 2008 – 2019.
3.	1.A.4.b - Biomass	An improvement in biomass consumption was included in current submission. The activity data were modified for years 2014 – 2019.

Ad 1: An energy and emissions inconsistencies in time series of the category 1.A.1.a.iv was identified. The MSW consumption was significantly higher, than it was expected. This issue was identified for reporting year 2019. The reason was reporting of an incorrect value of ISW consumption by major MSW incinerator in Košice (Kosit). Based on the official energy balance, the ISW consumption in year 2019 was 189 kt. This consumption was 61% higher than in year 2018 and 78% lower in comparison with consumption in year 2020. To validate existing data, information from the NEIS database were used. MSW consumption in the NEIS was 109 kt in 2019. Information on MSW consumption provided by the operator in its annual report was 112 kt in 2019. Moreover, both independent sources show practically constant MSW consumption in last five years. Therefore, revision of the MSW consumption according to the NEIS database took place in this submission for the year 2019. As a result of this correction, CO_2 emissions decreased from 208.71 kt to 159.44 kt, CH_4 emissions decreased from 0.122 to 0.093 kt and N_2O emissions decrease from 0.016 to 0.012 kt in 1.A.1.a.iv in 2019. This correction does not affected the emissions in other years.

Ad 2: Based on ERT preliminary recommendation from the 2021 UNFCCC review included in the Main Provisional Findings report, an analysis of landfill gas consumption was performed. This analysis was performed together with waste experts. Analysis was focused on identification of sources, where LFG is processed. In general, emissions from LFG in energy sector is processed together with other biogas and/or other fossil fuels. Disaggregated energy balance is used as source of activity data. Allocation into IPCC categories is mainly done based on NACE codes. Country specific EF and NCV for LFG is provided by the ŠÚ SR. Cogeneration units, where LFG is incinerated, can be referred as small enterprises with low number of employees. Companies with less than 20 employees do not have statistical obligations to send data to the ŠÚ SR. Therefore, information from the NEIS database was used for identification of these sources. According to the analysis, seven cogeneration units were identified previously not included in inventory. In the next step, total LFG consumption was compared against electricity production data. In emissions estimation, default EFs for CO_2, CH_4 and N_2O provided in the IPCC 2006 GL were used. Emissions from LFG incineration, missing in previous submission (2021) were included in category 1.A.5.a in 2022 submission. However, CO_2 emissions from this source is allocated in biomass, only CH_4 and N_2O emissions from LFG cogeneration and energy use are considered in GHG total and this value is negligible. Comparison of LFG consumption and emissions with the 2021 submission are summarised in following table.

Table 3.6: *Summary of the recalculations and comparison in the category 1.A.5.a*

SUBMISSION	YEAR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NIR 2021	**AD** *(TJ)*	383	412	439	849	502	564	535	553	523	560	-
	CO_2 *(Gg)*	22.00	23.80	25.00	49.10	29.90	34.10	30.80	32.60	31.10	32.70	-
	CH_4 *(t)*	7.42	8.92	7.45	20.19	18.57	24.07	12.74	17.69	18.64	16.07	-
	N_2O *(t)*	0.11	0.13	0.11	0.3	0.26	0.34	0.19	0.25	0.26	0.23	-
NIR 2022	**AD** *(TJ)*	434	463	503	918	607	668	643	665	636	664	577
	CO_2 *(Gg)*	24.80	26.60	28.50	52.90	35.70	39.80	36.70	38.70	37.20	38.30	33.90
	CH_4 *(t)*	7.68	9.17	7.77	20.54	19.09	24.59	13.28	18.25	19.21	16.59	15.89
	N_2O *(t)*	0.12	0.14	0.12	0.3	0.27	0.35	0.2	0.26	0.28	0.24	0.23

Ad 3: Recalculations in biomass consumption for the years 2014 – 2019 was based on new data on electricity consumption in households obtained from the SEPS company (main electricity transmission operator). Information on electricity consumption in households is an input parameter model used to estimate total energy demand for heating in households. Information on energy demand, total housing area, energy effectivity of houses and climatological factors are used in mathematical model to estimate the consumption of biomass in households. Updated dataset on electricity consumption in households for the years 2014 – 2019 were sent by SEPS in January 2022 and subsequently it included in mathematical model. Comparison of previous and recalculated data is summarized in following table.

Table 3.7: *Summary of the recalculations and comparison in the category 1.A.4.b*

SUBMISSION	YEAR	2014	2015	2016	2017	2018	2019
NIR 2021	**AD** *(TJ)*	17 118	25 539	28 926	28 024	21 980	24 373
	CO_2 *(Gg)*	1 914	2 856	3 235	3 134	2 458	2 726
NIR 2022	**AD** *(TJ)*	17 453	26 260	29 408	27 857	22 156	23 925
	CO_2 *(Gg)*	1 952	2 937	3 289	3 115	2 478	2 676

Recalculations taking place in the transport and fugitive emissions are described in the **Chapters 3.2.8.4** and **3.5.4**.

3.2.5 CATEGORY-SPECIFIC IMPROVEMENTS AND IMPLEMENTATION OF RECOMMENDATIONS

During the inventory preparation, following room for improvements was identified for future submissions:

- Further improvements in development of the country and plant specific EFs and NCVs, mostly focusing on methane and N_2O emissions.
- 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 is planned for the year 2022. The aim is to improve emissions data on regional level.
- 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. The results will be available in the beginning of 2023. The aim of this project is find more suitable statistical data for emissions estimation in road transportation.
- There were several recommendations in the ARRs 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, this was not implemented. 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 are 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 survey in households focused on the fuel consumption and energy balance estimation 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. 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.

During the inventory preparation, following room for implementation of recommendations was added:

During the previous UNFCCC reviews, the ERT identified a potential issue with a high value of CO_2 IEF in category 1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries – solid fuels – CO_2 (E.6, 2019) (E.25, 2017). More than 99% of emissions in category 1.A.1.c are produced by single iron and steel company - U.S. Steel, a. s. company. Major fuels used here are natural gas, blast furnace gas and coking gas, typical for this production. The reason for high IEF for CO_2 is blast furnace gas combustion in this category with a high carbon content. It represents more than 70% of total fuels combusted in this category. Information on fuel consumption, NCVs and EFs are obtain directly from the operator. Fuels consumption is compared with data from the NEIS database and EU-ETS reports and annually checked with the IPPU expert. The IEF calculated in this category is influenced by the share of individual fuels used here with the high difference between EF for blast furnace gas and EF for coking gas. Therefore, small perturbation of the fuel mix leads to significant inter-annual change of IEF. In recent years, this issue is more visible, because U.S. Steel, a. s. company idled one furnace and reduced steel production. Due to change of technological process and portfolio of products, the fuel mix changed more rapidly, than during standard operation.

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 70 019.70 TJ in 2020. The most significant gas reported here was carbon dioxide, which represented 3 922.58 Gg of CO_2 in 2020. After significant decrease of emissions in years 2013 – 2014, trend was stabilized. The decrease in CO_2 emissions in the comparison with the year 2018 is more than 5%. 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 semi-anthracite coal was more than 50%. The significant trend in the decline of solid fuels continued in 2020. The largest electricity producer in Slovakia (Slovenské elektrárne, a. s.) is preparing for total replacing coal with biomass and therefore a decrease in coal consumption was more than 78% in 2020, Similarly, one of the largest heat plant in Eastern Slovakia (TEKO, a. s.) reduced coal consumption more than 33% in comparison with year 2019 and more than 42% in comparison with year 2018.

On the other hand, natural gas consumption in this sector has a growing trend. The sharp increase of natural gas consumption in 2019 was caused by ZSE Elektrárne, s. r. o. power plant, its 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 (Západoslovenská energetika, a. s.) and was put into operation, again.

Total CH_4 emissions were 0.49 Gg and total N_2O emissions were 0.09 Gg in 2020.

In accordance with the IPCC 2006 GL, 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 6.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 5.6 million tons of crude oil in year 2020 (5.1 million tons of crude oil in 2019). This company is the most important supplier of petrol and diesel fuels in Slovakia (60% of market). Emissions from the petroleum refining, classified by the IPCC (2006) code 1.A.1.b, 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 21 975.01 TJ in 2020. Total CO_2 emissions were 1 503.99 Gg. Total CH_4 emissions were 0.047 Gg and total N_2O emissions were 0.0076 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 5 507.32 TJ in 2020. Total CO_2 emissions were 977.49 Gg in 2020. Total CH_4 emissions were 0.006 Gg and total N_2O emissions were 0.0006 Gg.

3.2.6.1 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 94.1% and in 1.A.2 is 80.6%. 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

[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.

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 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

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

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 2020*

CATEGORY	CO_2 EMISSIONS		NUMBER OF COMPANIES	
	EU ETS	ŠÚ SR	EU ETS	ŠÚ SR
	%		No.	
1.A.1 Energy Industries	93.23	6.77	34	199
1.A.2 Manufacturing Industries and Construction	82.47	17.53	50	1 939
1.A.4 Other Sectors	0.16	99.84	3	646
1.A.5 Other (Not specified elsewhere)	0.00	100.00	0	69

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 more than 93% and in 1.A.2 more than 82%. 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. 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.

3.2.6.2 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 97 companies with the total CO_2 emissions of 18 170 Gg in 2020.

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, IAEA) 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, a. s. 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 gasoline, 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. The CO_2 emission factor of natural gas (55.78 t CO_2/TJ in 2020) is lower than the IPCC default value (56.1 t CO_2/TJ). 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 2020*

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}	C_6H_{14}	CO_2	N_2
	mol %									
I.	94.9362	2.8773	0.6343	0.0953	0.0981	0.0215	0.0159	0.0017	0.0244	0.5346
II.	94.8230	2.9186	0.7013	0.1041	0.1082	0.0232	0.0171	0.0014	0.0245	0.5193
III.	95.3948	2.8105	0.6743	0.1075	0.0985	0.0186	0.0129	0.0010	0.0156	0.2930
IV.	95.2708	2.7567	0.7257	0.1108	0.1082	0.0208	0.0147	0.0009	0.0165	0.3421
V.	95.3728	2.6108	0.8376	0.1273	0.1267	0.0240	0.0169	0.0003	0.0147	0.2303
VI.	95.4347	2.6191	0.7990	0.1190	0.1159	0.0220	0.0153	0.0004	0.0137	0.2272
VII.	95.4651	2.6328	0.7391	0.1144	0.1107	0.0217	0.0153	0.0005	0.0153	0.2588
VIII.	95.5121	2.6258	0.7234	0.1149	0.1100	0.0217	0.0153	0.0006	0.0167	0.2500

MONTH	CH_4	C_2H_6	C_3H_8	$i\text{-}C_4H_{10}$	$n\text{-}C_4H_{10}$	$i\text{-}C_5H_{12}$	$n\text{-}C_5H_{12}$	C_6H_{14}	CO_2	N_2
	mol %									
IX.	95.5409	2.6156	0.7027	0.1100	0.1057	0.0205	0.0144	0.0006	0.0156	0.2516
X.	95.0886	2.6965	0.7594	0.1092	0.1144	0.0229	0.0167	0.0008	0.0191	0.4115
XI.	95.2112	2.6599	0.7363	0.1071	0.1105	0.0221	0.0161	0.0009	0.0182	0.3808
XII.	94.7674	2.9020	0.7241	0.1048	0.1131	0.0241	0.0181	0.0011	0.0251	0.5303

***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 2020*

MONTH	RELATIVE DENSITY	DENSITY	NCV	COMBUSTION HEAT	WOBBE NUMBER	SULPHUR CONTENT	EF C
	mol %	*$kg.m^{-3}$*	*$kWh.m^{-3}$*	*$kWh.m^{-3}$*	*$kWh.m^{-3}$*	*$mg.m^{-3}$*	*t CO_2/TJ*
I.	0.588	0.720	9.696	10.745	14.02	0.02	**55.80**
II.	0.589	0.721	9.715	10.766	14.03	0.06	**55.82**
III.	0.584	0.716	9.734	10.788	14.11	0.14	**55.67**
IV.	0.586	0.718	9.732	10.785	14.09	0.11	**55.71**
V.	0.585	0.718	9.756	10.81	14.13	0.11	**55.68**
VI.	0.585	0.717	9.746	10.8	14.12	0.08	**55.65**
VII.	0.584	0.716	9.734	10.788	14.11	0.05	**55.65**
VIII.	0.584	0.716	9.734	10.788	14.12	0.05	**55.65**
IX.	0.584	0.715	9.726	10.779	14.11	0.07	**55.63**
X.	0.587	0.719	9.717	10.768	14.05	0.07	**55.75**
XI.	0.586	0.718	9.714	10.765	14.06	0.06	**55.72**
XII.	0.589	0.722	9.715	10.766	14.03	0.03	**55.84**
AVERAGE	-	-	-	-	-	-	**55.78**

***Table 3.11:** Overview of country or plant specific CO_2 EFs in t/TJ used in the category 1.A.1 in 2020*

1.A.1.a	WEIGHTED CO_2 EFs	FUEL TYPE	C EFs	CO_2 EFs
Liquid	77.21	Gas/Diesel oil	20.21	74. 10
		Residual fuel oil	21.08	77.29
		Liquefied petroleum gases	17.22	63.14
Solid	97.77	Anthracite	27.44	100.61
		Other bituminous coal	26.46	97.02
		Lignite	26.71	97.93
Gaseous	55.78	Natural gas	15.21	55.78
Biomass	102.24	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	71.21	Residual fuel oil	21.08	77.29
		Petroleum coke	27.83	102.04
		Refinery gas	14.92	54.71
Gaseous	55.78	Natural gas	15.21	55.78
1.A.1.c	**WEIGHTED CO_2 EFs**	**FUEL TYPE**	**C EFs**	**CO_2 EFs**
Liquid	64.26	Liquefied petroleum gases	17.22	63.14
		Gas/Diesel oil	20.21	74.10
Solid	191.01	Lignite	26.73	98.01
		Coke oven gas	11.46	42.02
		Blast furnace gas	74.86	274.49
Gaseous	55.78	Natural gas	15.21	55.78

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 list of actually used EFs is presented 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 0.7% on the total GHG emissions (expressed in CO_2 eq.), in the **Energy sector** (CO_2: 6 404.07 Gg; CH_4: 13.68 Gg CO_2 eq.; N_2O: 29.07 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.

3.2.6.3 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 18 397.16 TJ in 2020. Total CO_2 emissions were 2 178.88 Gg. Total CH_4 emissions were 0.09 Gg and total N_2O emissions were 0.01 Gg.

The main iron and steel producer in the Slovak Republic - U. S. Steel, a. s. 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 current 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 in comparison with year 2019 and more than 2 670 kt in comparison with year 2018. This decrease is reflected in all categories where the emissions from steel production are allocated (1.A.1.c, 1.A.2.a and 2.C.1). This switched off furnace was put back into operation in January 2021.

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 2 838.40 TJ in 2020. Total CO_2 emissions were 95.26 Gg, total CH_4 emissions were 0.04 Gg and total N_2O emissions were 0.006 Gg.

Chemicals (1.A.2.c) – includes emissions from fuels combustion in chemical industry. Chemical industry produces a number of different products such as chemicals, plastics or solvents. In total, around 170 plants are included here, of which 10 use more than 67% of the energy reported here. Total volume of fuels expressed in energy units allocated in 1.A.2.c was 8 087.56 TJ in 2020. The decline of natural gas consumption, which occurred in 2015, was caused by the termination of operation of Shinwha Intertek Slovakia, s. r. o. (operated in the other chemical products and preparation manufacturing industry) with relatively high share of natural gas in previous years but decrease in production. At the beginning of 2016, the company Hnojivá Duslo ceased its operations and the NG consumption decreased sharply in year 2015. Another significant decrease in NG consumption was reported from ENL SK company, which manufactures plastic boards for the automotive industry. The ammonia and other inorganic chemicals producer (Duslo, a. s. Šaľa) caused the inter-annual fluctuation of NG consumption however; the emissions from ammonia production (both process and energy) are reported in IPPU sector. All downstream units, dependent on the ammonia production also reproduce the fluctuations of ammonia unit performance and NG consumption correlates with ammonia production. Other companies in 1.A.2.c sector shows relatively balanced inter-annual natural gas consumption. The decrease of NG consumption is visible, and it is caused mainly by increase of production efficiency.

There is a visible reduction in consumption of solid fuels. This trend is like 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%. Total CO_2 emissions were 473.38 Gg (practically identical to year 2019), total CH_4 emissions were 0.018 Gg and total N_2O emissions were 0.0022 Gg in 2020.

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 22 642.01 TJ in 2020. There was a visible decrease of inter-annual energy consumption between 2015 and 2016 (27 472.10 TJ in 2015 and 22 926.55 TJ in 2016). It was caused by decrease of fuels consumption in three major plants allocated here. Total CO_2 emissions were 390.49 Gg, total CH_4 emissions were 0.17 Gg and total N_2O emissions were 0.04 Gg in 2020.

Food processing, beverage and tobacco (1.A.2.e) – total volume of fuels allocated in 1.A.2.e expressed in energy units represented 5 840.35 TJ in 2020. Total CO_2 emissions were 342.01 Gg, total CH_4 emissions were 0.011 Gg and total N_2O emissions were 0.0014 Gg in 2020.

Non-metallic minerals (1.A.2.f) – total volume of fuels allocated in 1.A.2.f expressed in energy units represented 20 200.51 TJ in 2020. Total CO_2 emissions were 1 408.24 Gg, total CH_4 emissions were 0.24 Gg and total N_2O emissions were 0.03 Gg. The fuels are allocated among solid, liquid, gaseous, other and biomass fuels.

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 18 104.08 TJ in 2020. The sharp decrease of emissions in this category in year 2020 was caused by significant reduction of production in U. S. Steel, a. s. The decrease in natural gas consumption in comparison with previous year is more than 12%. The reduction of blast furnace gas is more than 32% and coke oven gas consumption decrease more than 82%. Throughout 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) causes 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. Total CO_2 emissions were 993.87 Gg, total CH_4 emissions were 0.095 Gg and total N_2O emissions were 0.012 Gg in 2020.

Based on the IPCC 2006 GL, this category was further split into 8 new subcategories. The distribution of individual plants into newly introduced 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 2020*

SUBCATEGORY	CO_2 EMISSIONS	SHARE
	Gg/year	*%*
1.A.2.g.i Man. of machinery	156.33	15.73
1.A.2.g.ii Man. of transport equipment	171.54	17.26
1.A.2.g.iii Mining and quarrying	12.52	1.26
1.A.2.g.iv Wood and wood products	20.02	2.01
1.A.2.g.v Construction	44.03	4.43
1.A.2.g.vi Textile and leather	22.91	2.31
1.A.2.g.viii Other	566.52	57.00

3.2.7.1 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 3.2.6.1**.

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 during last years in cooperation with the **IPPU** experts. The estimation includes and compares information from the iron and steel industry based on the EU ETS report of the biggest iron and steel company in the Slovak Republic (U. S. Steel, a. s.). 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 detail description in the **Annex 4.2** (Methodology for carbon balance of iron and steel production).

3.2.7.2 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 3.2.6.2**. 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 2020*

1.A.2.a	WEIGHTED CO_2 EFs	FUEL TYPE	C EFs	CO_2 EFs
Liquid	69.07	Residual Fuel Oil	21.17	77.62
		Liquefied Petroleum Gases	17.22	63.15
Solid	131.62	Gas Coke	29.19	107.03
		Other Bituminous Coal	25.49	93.46
		Coke Oven Gas	11.46	42.02
		Blast Furnace Gas	74.86	274.49
Gaseous	55.78	Natural gas	15.21	55.78
Biomass	111.53	Wood/Wood Waste	30.50	111.83

1.A.2.b	WEIGHTED CO_2 EFs	FUEL TYPE	C EFs	CO_2 EFs
Liquid	85.78	Gas/Diesel Oil	20.21	74.10
		Petroleum Coke	27.83	102.04
		Liquefied Petroleum Gases	17.22	63.15
Solid	102.34	Other Bituminous Coal	25.77	94.49
		Gas Coke	29.19	107.03
Gaseous	55.78	Natural gas	15.21	55.78
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	72.34	Residual Fuel Oil	21.17	77.62
		Gas/Diesel Oil	20.21	74.10
		Liquefied Petroleum Gases	17.22	63.15
Solid	99.61	Anthracite	27.44	100.61
		Coking Coal	25.38	93.06
		Lignite	26.88	98.56
		Other Bituminous Coal	25.77	94.49
Gaseous	55.78	Natural gas	15.21	55.78
Biomass	128.80	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	142.00
1.A.2.d	**WEIGHTED CO_2 EFs**	**FUEL TYPE**	**C EFs**	**CO_2 EFs**
Liquid	76.50	Residual Fuel Oil	21.17	77.62
		Liquefied Petroleum Gases	17.22	63.15
Solid	98.08	Other Bituminous Coal	25.77	94.49
		Lignite	26.88	98.56
Gaseous	55.78	Natural gas	15.21	55.78
Biomass	98.53	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	63.19	Liquefied Petroleum Gases	17.22	63.15
		Gas/Diesel Oil	20.21	74.10
Solid	99.39	Anthracite	27.44	100.61
		Lignite	26.88	98.56
		Gas Coke	29.19	107.03
Gaseous	55.78	Natural gas	15.21	55.78
Biomass	98.07	Other Primary Solid Biomass	27.30	100.10
		Sludge Gas	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	101.48	Residual Fuel Oil	21.17	77.62
		Petroleum Coke	27.83	102.04
		Liquefied Petroleum Gases	17.22	63.15
		Gas/Diesel Oil	20.21	74.10
Solid	97.09	Anthracite	27.44	100.61
		Other Bituminous Coal	25.77	94.49
		Lignite	26.88	98.56
		Gas Coke	29.19	107.03
Gaseous	55.78	Natural gas	15.21	55.78

Other	97.41	Municipal and Industrial Wastes	26.57	97.42
		Waste Oil	22.15	81.24
Biomass	97.44	Wood/Wood Waste	30.50	111.83
		Waste (biogenic)	26.57	97.42
1.A.2.g	**WEIGHTED CO_2 EFs**	**FUEL TYPE**	**C EFs**	**CO_2 EFs**
Liquid	63.41	Gas/Diesel Oil	20.21	74.10
		LPG	17.22	63.15
		Residual Fuel Oil	21.17	77.62
		Other Petroleum Products	20.01	73.35
Solid	94.81	Blast Furnace Gas	74.86	274.49
		Coke oven Gas	29.19	107.03
		Lignite	26.88	98.56
		Other bituminous coal	27.03	99.11
Gaseous	55.78	Natural gas	15.21	55.78
Biomass	111.83	Other primary solid biomass	27.30	100.10
		Wood/Wood waste	30.50	111.83

3.2.7.3 Uncertainties and time-series consistency

Description of uncertainty is similar to the **Chapter 3.2.6.3** 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 Transportation (1.A.3.b), Railways (1.A.3.c), Domestic Navigation (1.A.3.d) and Pipeline Transport (1.A.3.e.i). As mentioned in previous reports there is still observed shift from public transportation to individual passenger cars in Slovakia. This shift is even more obvious during the COVID-19 pandemic and resulted in rise of emissions in diesel passenger cars as the only in 1.A.3.b category. After a rise in the intensity of transit transport (HDV) in the last years, there is a decrease in 2020. Due to the COVID-19 pandemic, the consumption of fuels in all transport categories has decreased. Total aggregated GHG emissions in transport increased in 2020 against the base year by 3.60% but against the previous year decreased by 13.08%. Road transport emissions rose by 46.97% in 2020 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 – 2020 are presented in CRF Tables. Total GHG emissions in transport were 7 069.21 Gg of CO_2 eq. in 2020. The CO_2 emissions were 6 990.37 Gg, which represent 98.88% share on total transport emissions, the CH_4 emissions were 4.43 Gg of CO_2 eq. with the 0.06% share and N_2O emissions were 74.40 Gg of CO_2 eq. with the 1.05% share on total transport GHG emissions.

Within transport, the share of road transportation was 96.38%, pipeline transport 2.38%, railways 1.15%, domestic aviation represents 0.01% and domestic navigation 0.08% (in CO_2 eq.). Total energy consumption was 102 507.98 TJ of fuels in 2020. 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" represent 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 2020

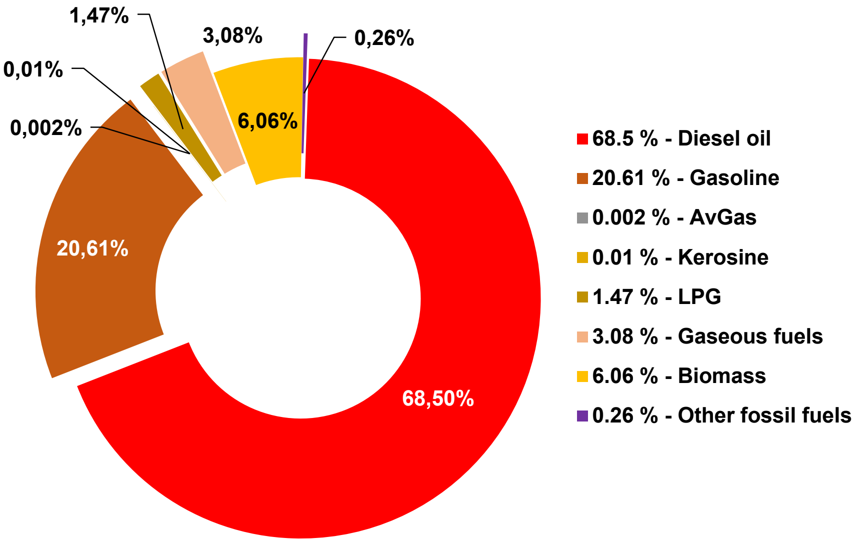


Table 3.14: Fuel consumption and GHG emissions in transport by subcategories in particular years

YEAR	1.A.3.a DOMESTIC AVIATION				1.A.3.b ROAD TRANSPORTATION			
	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

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

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	14 961.55	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	295.97	0.0053	0.0005
2019	7 141.84	398.28	0.0071	0.0007
2020	3 009.14	167.83	0.0030	0.0003

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 Management of Airports, except for the airport in Žilina, where exercises with light aircrafts of the Žilina University predominate, are managed by Slovak airports. 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 – 2020, 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 2020 compared to the base year 1990 by 76.4%. The total jet kerosene consumption was 10.58 TJ and the consumption of aviation gasoline was 1.59 TJ allocated in domestic aviation in 2020 (***Table 3.15***). Total GHG emissions from domestic aviation were 0.88 Gg of CO_2 eq. in 2020. There was a visible increase of emissions in years 2002 – 2008 (***Figure 3.10***). In 2002, air transportation was positively affected by the entry of low cost companies to the Slovak market, like SkyEurope Airlines, Seagle Air and Danube Wings. The time series is influenced by 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 3.15: *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

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*
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

Road transportation (CRF 1.A.3.b) - Short distance passenger transport is an important part of road transportation. 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 2020, the transport network included 521 km of highways, 296 km of motorways and 3 337 km of the category 1st class roads. Total roads network represented 18 130 km of roads in the Slovak Republic[5] in 2020. Road transportation 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. Total aggregated emissions from road transportation reached 6 813.31 Gg of CO_2 eq. in 2020. The decrease in emissions compared to 2019 is 10.68%, and increase compared to the base year is 46.97%. The major share of emissions belongs to heavy duty vehicles and passenger cars (***Table 3.16***). Total blended CO_2 emissions were 7 204.73 Gg in 2020. These blended emissions include also emissions from lube oil from two-stroke gasoline passenger cars (according to the ERT recommendation E.24 from the SVK ARR 2019). After separation of biomass content, the final CO_2 balance for fossil part of fuels was 6 743.79 Gg. Biomass content in fuels increased in 2018 compared to the previous year mainly to introduction of E10 gasoline and subsequently decrease because of COVID-19, emissions actually represent 460.94 Gg of bio-CO_2. The most of the emissions come from the city traffic (***Table 3.17***).

Table 3.16: *Overview of total GHG emissions according to the type of vehicles in 2020*

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*	*kg/year*	
Passenger Cars	**5 059 979**	**127 235**	**139 413**	Diesel N1-III	588 065	1 021	15 055
Petrol Mini	3 161	207	31	**Heavy Duty Trucks**	**912 347**	**17 683**	**45 916**
Petrol Small	812 312	63 898	9 818	Petrol >3,5 t	17	4	NE
Petrol Medium	493 809	33 253	6 252	Rigid <=7,5 t	164 747	4 903	6 278
Petrol Large-SUV-Executive	90 145	3 906	693	Rigid 7,5 - 12 t	168 660	3 045	5 128
2-Stroke	37	13	NE	Rigid 12 - 14 t	46 429	696	2 395
Hybrid Mini	41	3	NE	Rigid 14 - 20 t	58 298	1 924	2 331
Hybrid Small	1 608	133	17	Rigid 20 - 26 t	5 620	294	164
Hybrid Medium	47 375	3 914	533	Rigid 26 - 28 t	432	11	15
Hybrid Large-SUV-Executive	7 753	623	85	Rigid 28 - 32 t	677	41	25
Petrol PHEV Small	323	24	3	Rigid >32 t	595	26	16
Petrol PHEV Medium	660	43	6	Articulated 14 - 20 t	466 700	6 739	29 558
Petrol PHEV Large-SUV-Executive	306	17	2	Articulated 20 - 28 t	173	1	6
Diesel Mini	218	1	15	**Buses**	**287 756**	**10 450**	**9 404**
Diesel Small	49 188	167	1 676	Urban Buses Midi <=15 t	20 532	307	686
Diesel Medium	2 607 797	8 095	97 543	Urban Buses Standard 15 - 18 t	15 486	109	430

[5] Slovak Road Database 2020

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*	*kg/year*	
Diesel Large-SUV-Executive	801 782	1 814	20 650	Urban Buses Articulated >18 t	2 610	10	52
Diesel PHEV Large-SUV-Executive	116	NE	4	Coaches Standard <=18 t	238 429	2 596	8 061
LPG Mini	24	2	NE	Coaches Articulated >18 t	5 016	18	175
LPG Small	68 718	5 214	905	Urban CNG Buses	5 683	7 408	NO
LPG Medium	57 105	4 070	928	**L-Category**	**17 703**	**9 545**	**302**
LPG Large-SUV-Executive	13 511	883	222	Mopeds 2-stroke <50 cm³	13	15	NO
CNG Small	2 731	702	20	Mopeds 4-stroke <50 cm³	824	504	15
CNG Medium	1 164	232	7	Motorcycles 2-stroke >50 cm³	54	78	1
CNG Large-SUV-Executive	94	23	1	Motorcycles 4-stroke <250 cm³	1 609	1 854	57
Light Commercial Vehicles	**926 946**	**4 450**	**23 428**	Motorcycles 4-stroke 250 - 750 cm³	6 987	4 592	107
Petrol N1-I	24 634	1 606	303	Motorcycles 4-stroke >750 cm³	8 195	2 498	121
Petrol N1-II	17 039	596	190	Quad & ATVs	4	1	NE
Petrol N1-III	3 202	127	53	Micro-car	17	1	NE
Diesel N1-I	32 965	200	1 260	**Total**	**7 204 730**	**169 363**	**218 463**
Diesel N1-II	261 041	900	6 567				

Table 3.17: *Results from COPERT model in distribution for agglomeration mode (CO_2 emissions are from blended fuels with bio-component) in 2020*

TRAFFIC	CO_2	CH_4	N_2O
	t/year		
City	3 374 813	118.27	113.86
Road	2 682 896	37.27	78.25
Highway	1 147 021	13.83	26.97
TOTAL	**7 204 730**	**169.36**	**219.08**

Railways (CRF 1.A.3.c) - Railways is the second largest source of emissions in transport (except of pipeline 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 2020, the length of managed railways was 3 627 km of which the length of electric railways was 1 585 km. Total emissions from railways transport reached 81.61 Gg of CO_2 eq. in 2020 and they decreased by 10.47% compared to 2019 (***Table 3.18***) 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.

[6] Annual Report of Slovak Railway 2020, pp. 16-18
[7] Since 2013, social measure was introduced – free railways for students and retired on lower categories of trains.

Table 3.18: *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
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

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 transportation on small lakes for tourist purposes was not included in the 2020 report as those were not operating during the COVID-19 pandemic.

Total aggregated emissions from inland shipping excluding international navigations (on Danube River) reached 5.41 Gg of CO_2 eq. in 2020. After a decrease in 2018, an increase occurred in 2019 and it was ongoing in 2020 (***Table. 3.19***).

Table 3.19: *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

Pipeline transport (CRF 1.A.3.e.i) – Total fuels in 1.A.3.e.i expressed in energy units represented 3 009.41 TJ and total GHG emissions represented 167.99 Gg of CO_2 eq. in 2020. The share of this category on total transport emissions is 2.39% in 2020. The fuel consumption and GHG emissions are shown in ***Table 3.14***.

3.2.8.1 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 share of national and international aviation activities for the period 1990 – 2004 was improved based on the known real numbers for time series 2005 – 2020 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 – 2020 was taken from the EUROCONTROL (***Table 3.20***).

Table 3.20: *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 (in line with the ERT recommendation E.32 from the SVK ARR 2017). 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. These results were thereafter approved by the Ministry of Transport of the Slovak Republic. EUROCONTROL data used tier 3 applying the Advanced Emissions Model (AEM).

Following data were taken from the EUROCONTROL (***Table 3.21***):

- 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 3.21: *Average EFs and NCVs 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

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

Road transportation (1.A.3.b) – COPERT model 5 (v.5.1) was used for estimation of road transportation 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 others 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 2020 (***Tables 3.22*** and ***3.23***). 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 3.24*** for the years 1990 – 2020.

Table 3.22: *Results of the H/C ratio analyses of fuel types and lube oil in 2020*

FUEL	PETROL	DIESEL OIL	LPG	CNG	BIO-ETHANOL	BIO-DIESEL	LUBE OIL
H/C Ratio	1.850	1.946	2.589	3.900	3.000	1.857	2.080

Table 3.23: *Results of the O/C analyses of fuel types and lube oil in 2020*

FUEL	PETROL	DIESEL OIL	LPG	CNG	BIO-ETHANOL	BIO-DIESEL	LUBE OIL
H/C Ratio	0.030	0.005	NA	NA	0.500	0.110	NA

NA=oxygen is not present

Table 3.24: *Net calorific values (NCVs) for the fuel type obtained by the ŠÚ SR for particular years*

YEAR	GASOLINE 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

YEAR	GASOLINE BLENDED	DIESEL OIL BLENDED	LPG	CNG	BIO-ETHANOL	ETBE	ESTERS
	TJ/Gg						
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

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 it would crash the model. 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 agglomeration, road and highway traffic 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 vehicles 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 3.25***). 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 3.25:** Overview of input data used in the COPERT 5 model in 2020*

CATEGORY OF ROAD VEHICLE	ACTIVITY DATA		CATEGORY OF ROAD VEHICLE	ACTIVITY DATA	
	No.	*km/veh.*		*No.*	*km/veh.*
Passenger Cars	**2 409 085**	**9 146**	Diesel N1-II	72 763	14 826
Petrol Mini	8 173	4 784	Diesel N1-III	133 364	13 780
Petrol Small	814 508	5 105	**Heavy Duty Trucks**	**75 676**	**10 738**
Petrol Medium	374 868	5 476	Petrol >3,5 t	113	446
Petrol Large-SUV-Executive	43 556	6 569	Rigid <=7,5 t	24 289	23 306
2-Stroke	148	1 465	Rigid 7,5 - 12 t	13 839	25 453
Hybrid Mini	49	6 918	Rigid 12 - 14 t	3 701	23 971
Hybrid Small	2 345	9 107	Rigid 14 - 20 t	4 887	16 003
Hybrid Medium	12 199	21 597	Rigid 20 - 26 t	1 256	7 658
Hybrid Large-SUV-Executive	4 977	13 465	Rigid 26 - 28 t	52	7 970
Petrol PHEV Small	462	9 072	Rigid 28 - 32 t	205	8 121
Petrol PHEV Medium	703	10 572	Rigid >32 t	145	3 944
Petrol PHEV Large-SUV-Executive	301	8 419	Articulated 14 - 20 t	27 168	19 847
Diesel Mini	406	2 623	Articulated 20 - 28 t	21	15 343
Diesel Small	25 664	8 750	**Buses**	**7 575**	**25 330**
Diesel Medium	874 196	16 164	Urban Buses Midi <=15 t	758	32 385
Diesel Large-SUV-Executive	197 871	15 481	Urban Buses Standard 15 - 18 t	291	34 796
Diesel PHEV Large-SUV-Executive	44	13 990	Urban Buses Articulated >18 t	45	23 204
LPG Mini	23	1 113	Coaches Standard <=18 t	27	31 687
LPG Small	22 120	15 270	Coaches Articulated >18 t	6 256	32 877
LPG Medium	19 845	12 328	Urban CNG Buses	198	32 063
LPG Large-SUV-Executive	5 053	10 840	**L-Category**	**150 359**	**1 133**
CNG Small	1 012	11 420	Mopeds 2-stroke <50 cm^3	667	611
CNG Medium	506	9 524	Mopeds 4-stroke <50 cm^3	27 092	721
CNG Large-SUV-Executive	56	5 007	Motorcycles 2-stroke >50 cm^3	1 886	861
Light Commercial Vehicles	**261 749**	**10 954**	Motorcycles 4-stroke <250 cm^3	42 642	922
Petrol N1-I	25 765	9 022	Motorcycles 4-stroke 250 - 750 cm^3	33 937	2 164
Petrol N1-II	9 280	9 022	Motorcycles 4-stroke >750 cm^3	43 998	1 619
Petrol N1-III	1 979	7 080	Quad & ATVs	59	545
Diesel N1-I	18 598	11 993	Micro-car	78	1 600

[8] Data were published in 2016

CO_2 correction factor was introduced into the COPERT model in 2018. According to the EMEP/EEA air pollutant emission inventory Guidebook 2019, 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, Road and Motorway) 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 3.26***) 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 3.26: *Overview of CH_4 and N_2O IEFs for the road vehicle categories in 2020*

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	**16.10**	**2.40**	Diesel N1-II	0.90	6.57
Petrol Mini	9.41	1.39	Diesel N1-III	0.45	6.65
Petrol Small	12.88	1.98	**Heavy Duty Trucks**	**29.65**	**23.25**
Petrol Medium	12.90	2.43	Petrol >3,5 t	109.90	6.00
Petrol Large-SUV-Executive	13.35	2.37	Rigid <=7,5 t	10.40	13.31
2-Stroke	79.45	NE	Rigid 7,5 - 12 t	9.59	16.15
Hybrid Mini	9.37	1.25	Rigid 12 - 14 t	8.47	29.16
Hybrid Small	9.37	1.23	Rigid 14 - 20 t	21.47	26.02
Hybrid Medium	9.37	1.28	Rigid 20 - 26 t	42.78	23.87
Hybrid Large-SUV-Executive	9.37	1.28	Rigid 26 - 28 t	18.97	25.42
Petrol PHEV Small	9.37	1.23	Rigid 28 - 32 t	53.66	32.41
Petrol PHEV Medium	9.37	1.24	Rigid >32 t	37.87	23.60

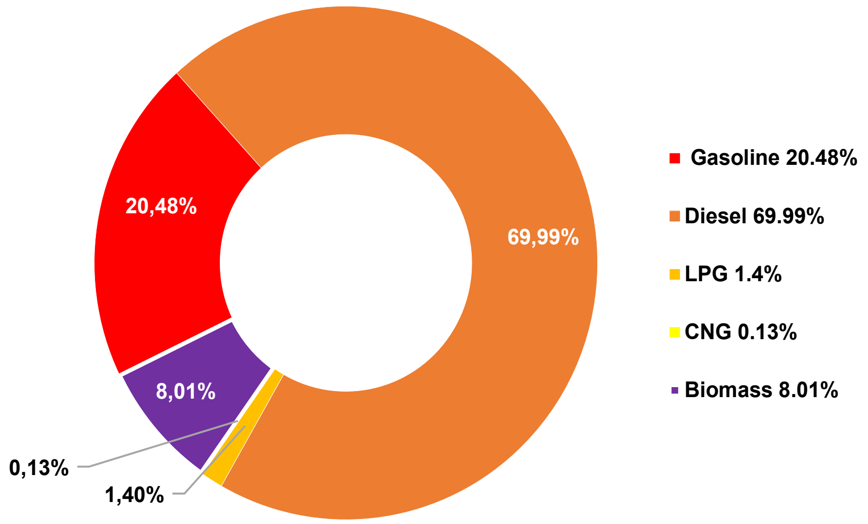
CATEGORY OF ROAD VEHICLE	EMISSION FACTORS		CATEGORY OF ROAD VEHICLE	EMISSION FACTORS	
	CH_4	N_2O		CH_4	N_2O
	mg/km			*mg/km*	
Petrol PHEV Large-SUV-Executive	9.37	1.22	Articulated 14 - 20 t	7.88	34.56
Diesel Mini	0.40	6.66	Articulated 20 - 28 t	5.23	25.30
Diesel Small	0.63	6.30	**Buses**	**202.52**	**21.68**
Diesel Medium	0.52	6.26	Urban Buses Midi <=15 t	9.40	20.99
Diesel Large-SUV-Executive	0.55	6.26	Urban Buses Standard 15 - 18 t	5.80	22.79
Diesel PHEV Large-SUV-Executive	0.03	NE	Urban Buses Articulated >18 t	4.17	21.04
LPG Mini	10.63	2.87	Coaches Standard <=18 t	9.64	29.93
LPG Small	12.77	2.22	Coaches Articulated >18 t	3.71	35.35
LPG Medium	12.67	2.89	Urban CNG Buses	1 182.43	NE
LPG Large-SUV-Executive	13.00	3.27	**L-Category**	**59.78**	**1.50**
CNG Small	43.36	1.26	Mopeds 2-stroke <50 cm^3	74.87	1.00
CNG Medium	41.75	1.32	Mopeds 4-stroke <50 cm^3	34.05	1.00
CNG Large-SUV-Executive	38.55	1.34	Motorcycles 2-stroke >50 cm^3	125.23	2.00
Light Commercial Vehicles	**6.00**	**4.83**	Motorcycles 4-stroke <250 cm^3	64.63	2.00
Petrol N1-I	10.96	2.07	Motorcycles 4-stroke 250 - 750 cm^3	85.60	2.00
Petrol N1-II	9.33	2.97	Motorcycles 4-stroke >750 cm^3	41.22	2.00
Petrol N1-III	10.72	4.49	Quad & ATVs	47.28	2.00
Diesel N1-I	1.00	6.27	Micro-car	5.36	NE

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 gasoline 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 the Ministry of Economy of the Slovak Republic (MH SR). According to the latest QA/QC these consumptions are the most accurate (**Chapter 3.2.8.3**). 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 transportation 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 69.99%, followed by gasoline with 20.48% share, then LPG (1.40%), CNG (0.13%) and biomass (8.01%) in 2020 (***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). Fuels 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 (***Table 3.27***). 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 5.33% 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) (according to the ESD observation SK-1A3b-2019-0001). Fossil part of FAME was calculated as national average according to data from the report under Fuel Quality Directive Art. 7(a) (***Table 3.27***).

Figure 3.8: *Share of fuels on total consumption in road transportation in 2020*



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 3.27: *Estimated activity data and share of biomass for the time series 2007 – 2020*

YEAR	GASOLINE		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

FEEDSTOCK	VOLUME	C FOSSIL PART	CARBON CONTENT	g FOSSIL CO_2/g FAME
	m^3	%	%	
Rapeseed	87 972 649.08	5.30%	75.50%	0.147
Palm oil	829 811.39	5.50%	71.80%	0.145
Sunflower seed	11 530 367.58	5.30%	77.20%	0.150
Used cooking oil*	46 545 590.00	5.40%	74.40%	0.147
NATIONAL AVERAGE	-	5.33%	75.26%	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 PC Euro 6 a, b, c, d-temp and d". These vehicles occurred in Slovakia since 2010 and therefore, time series 2010 – 2020 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 2022 submission. The IPCC default emission factors were used, except for CO_2 were country-specific emission factor was used (***Table 3.28***). 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 3.24***.

Table 3.28: *The emission factors used in GHG inventory for railways transport*

IPCC DEFAULT EMISSION FACTORS		
CO_2	CH_4	N_2O
kg/TJ		
74 052.07	4.15	28.60

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 transportation 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 3.27***).

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 2022 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 tourisms), 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 in ***Table 3.32***.

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 3.24***. The emission factors are taken from the IPCC 2006 GL and GHG emissions were recalculated for time series. The default emission factors used in categories 1.A.3.d and 1.D.1.b are identical (***Table 3.29***). Activity data for domestic navigation are shown in ***Tables 3.30*** and ***3.31***.

Table 3.29: *The emission factors used in GHG inventory for navigation in 2020*

PARAMETER	EMISSIONS FACTORS	
EMISSIONS	DOMESTIC NAVIGATION	INTERNATIONAL NAVIGATION
	kg/TJ of fuel	
CO_2	74 052.07	74 052.07
CH_4	7	7
N_2O	2	2

Table 3.30: *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

YEAR	FUEL CONSUMPTION	
	TJ	*t*
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

Table 3.31: *Diesel oil sold by shipping companies and allocation to the categories 1.A.3.d and 1.D.1.b in selected years*

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	130.0
	International shipping companies	-	84.0	84.0
	Total	**1.3**	**212.7**	**214.0**
2010	Slovak Shipping and Ports (Danube)	91.8	9 087.2	9 179.0
	International shipping companies	0.0	1 363.0	1 363.0
	Total	**91.8**	**10 450.2**	**10 542.0**
2011	Slovak Shipping and Ports (Danube)	79.7	7 895.3	7 975.0
	Slovak Water Management Enterprise	175.0	-	175.0
	Other Companies	1.0	102.0	103.0
	International shipping companies	-	1 104.0	1 104.0
	Total	**255.8**	**9 101.2**	**9 357.0**
2012	Slovak Shipping and Ports (Danube)	21.0	2 080.0	2 101.00
	Slovak Water Management Enterprise	321.0	-	321.0
	Other companies	0.7	69.3	70.0
	International shipping companies	-	764.0	764.0
	Total	**342.7**	**2 913.3**	**3 256.0**
2013	Slovak Shipping and Ports (Danube)	1 083.1	3 249.3	4 332.4
	Slovak Water Management Enterprise	NO	-	NO
	Other companies	NO	NO	NO
	International shipping companies	-	801.0	801.0
	Total	**1 083.1**	**4 050.3**	**5 133.4**
2014	Slovak Shipping and Ports (Danube)	1 244.0	3 732.0	4 976.0
	Slovak Water Management Enterprise	149.0	-	149.0
	Other companies	NO	NO	NO
	International shipping companies	-	844.0	844.0
	Total	**1 393.0**	**4 576.0**	**5 969.0**

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		
2015	Slovak Shipping and Ports (Danube)	1 981.8	5 945.4	7 927.2
	Slovak Water Management Enterprise	NO	-	NO
	Other companies	0.5	47.5	48.0
	International shipping companies	-	1 016.0	1 016.0
	Total	**1 982.3**	**7 008.9**	**8 991.2**
2016	Slovak Shipping and Ports (Danube)	1 515.1	4 545.4	6 060.5
	Slovak Water Management Enterprise	-	NO	NO
	Other companies	2.0	189.0	191.0
	International shipping companies	-	1 272.0	1 272.0
	Total	**1 517.0**	**6 006.5**	**7 523.5**
2017	Slovak Shipping and Ports (Danube)	1 492.9	4 478.7	5 971.6
	Slovak Water Management Enterprise	-	NO	NO
	Other companies	2.4	236.6	239.0
	Morsevo (Komárno)	NO	1 034.0	1 034.0
	International shipping companies	-	168.5	168.5
	Total	**1 495.3**	**5 917.8**	**7 413.1**
2018	Slovak Shipping and Ports (Danube)	3 239.00	809.75	2 429.25
	Slovak Water Management Enterprise	-	NO	NO
	Other companies	232.00	2.32	229.68
	Morsevo (Komárno)	824.00	NO	824.00
	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	326.00
	International shipping companies	-	760.00	760.00
	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	161.00	NO	161.00
	International shipping companies	-	94.00	94.00
	Morsevo (Komárno)	NO	NO	NO
	Total	**1 716.75**	**4 761.25**	**6 478.00**

According to the ERT recommendation E.25 SVK ARR 2019, Slovakia reconstructed the time series for gasoline fuel consumption back to the time series. 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 gasoline consumption. Outcomes of this calculation are presented in ***Table 3.32.*** During the data investigation it was found out that the company started the operation of these ships only in the year 2008.

Table 3.32: *Outcomes of the gasoline consumption reconstruction and emission estimation for the years 2008 – 2020*

YEAR	FOSSIL GASOLINE				BIO-GASOLINE			
	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

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 55.78 t (CO_2)/TJ in 2020.

3.2.8.2 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, road 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 transportation 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 transportation (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 transportation 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 gasoline 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 this 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).[9] 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 transportation 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.

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[9] Companies do not have English equivalent names

Domestic navigation (1.A.3.d) - Emissions from domestic navigation represent emissions from shipping on lakes for the period 1990 – 2020 and emissions from shipping on lakes and movements between national ports on Danube River for the years 1990 – 2020. In 2020, 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).

3.2.8.3 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.

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. Gasoline, 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 – 2020:

- 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).

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 (***Figure A3.1***).[10,11]

[10] 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

[11] 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/

Table 3.33: *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[12]
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 3.33*** 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:

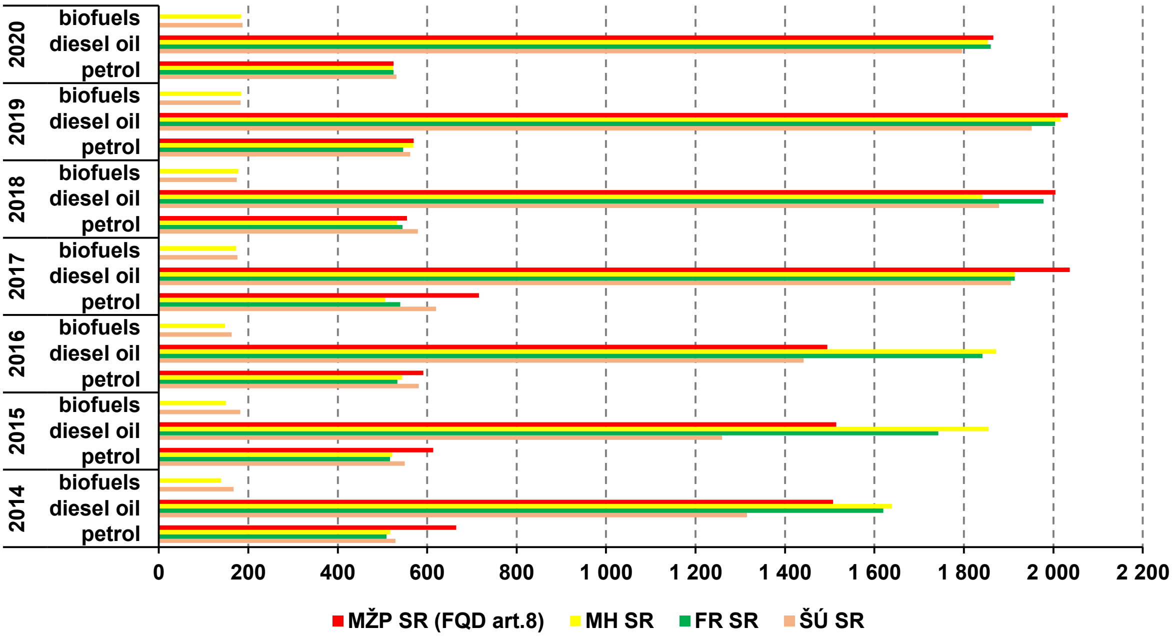
- Each authority report different data in different forms for different institutions or requirements (***Table 3.33*** and ***Figure A3.1***);
- The conversion factors (e.g. density) differ throughout all data suppliers not only between authorities and companies, but also for each delivered supply has own characteristics;
- Dates of collection for tax reports and reports to the ŠÚ SR differ.

Table 3.34: *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	-
DATA SOURCE	**MH SR**			**MŽP SR (FQD ART.8)**		
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	-

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

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



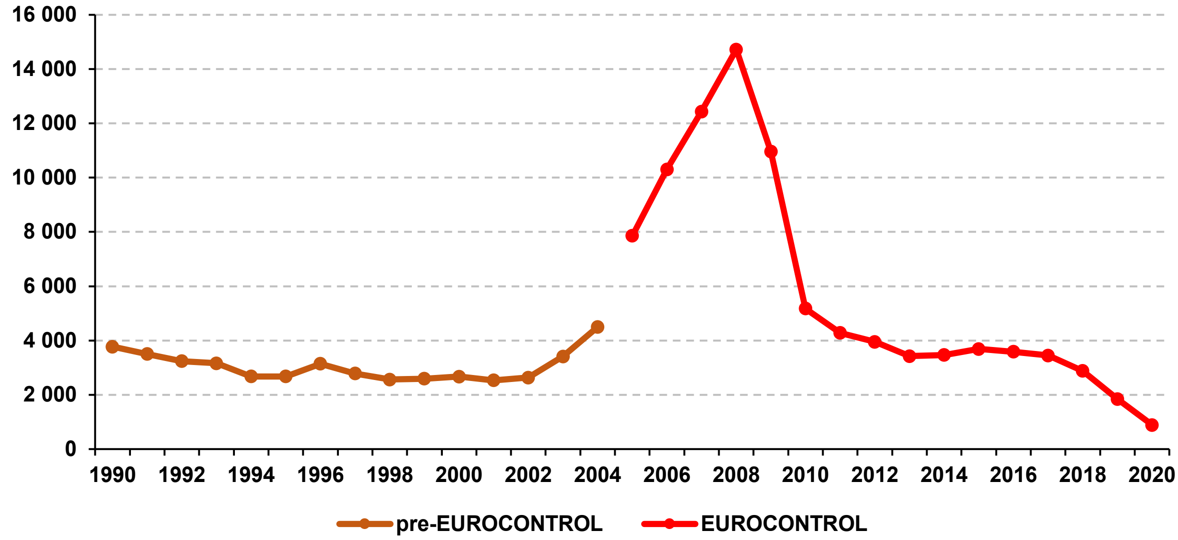
The main outcomes of this analysis is harmonisation of fuels consumption in country on the most possible level and lowering the differences in reporting by different subjects to 1.5% for fossil fuels and 2% for biofuels in 2020. Full consistency of data on national level is not possible. This is due to different legislation that each authority is required to fulfil (e.g. statistical reporting to EU institutions, tax collection, etc.).[13]

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 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.

[13] 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

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



Road transportation (1.A.3.b) - QC activities ensuring the quality standards for the preparation of the emissions inventory in the road transportation 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 transportation.

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.

3.2.8.4 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 3.35***), that most of deregistered cars were in EURO 1 emission category or older categories.

Through deeper analysis (***Table 3.36***) 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 degrease). 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 3.35: *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 3.36*: 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**

3.2.8.5 Category-specific recalculations

This chapter describes the recalculations of emissions from road transportation and its subcategories with respect to the previous submission for years 2013 – 2019.

Revision of activity data:

Slovakia revised the activity data for road transport with respect to the outcomes of the EUROSTAT project ESTAT-2020-PA8-E-ENVACC for years 2013 – 2019:

- Revision of vehicle fleet disaggregation to the correct categories was performed, which resulted in re-distribution of total vehicle numbers mostly in passenger vehicles.
- With update of the COPERT model, new vehicle categories were introduced into calculation such as plug-in hybrid petrol passenger cars, plug-in hybrid diesel passenger cars and Quads & ATV's and micro-cars in the L-category.
- Emission standards were previously based on the year of vehicle registration, whereas now, distribution of vehicles is based on assigned emission directive in the database. The new version of model reflects more precisely the emission directives EURO 1 – 5 and 6a, b, c, d-temp, d and introduction of differentiated EURO VI (A/B/C and E/F) standards for HDV.
- Changes in energy balance were also introduced, which resulted in a small deviation in the balanced blended petrol consumption. This deviation is up to 2%.
- New average annual mileage for each vehicle category was calculated based on the methodology described in **Chapter 3.2.8.1**. New mileage calculation resulted in re-distribution of energy consumption.

Table 3.37: *Differences in energy consumption between previous submission and current submission caused by recalculation*

YEAR	1.A.3.b	1.A.3.b.i	1.A.3.b.ii	1.A.3.b.iii	1.A.3.b.iv
	TJ				
2013	-4.20	2 959.79	-2 852.51	-104.98	-6.50
2014	-1.31	4 682.20	-4 587.16	-118.94	22.60
2015	-0.20	10 030.96	-1 708.45	-8 343.62	20.91
2016	10.57	6 309.51	-613.27	-5 626.05	-59.62
2017	5.81	6 169.98	-1 202.76	-4 913.94	-47.46
2018	9.87	4 834.34	-1 075.52	-3 711.59	-37.37
2019	665.63	3 524.09	-713.36	-2 173.33	28.23

Revision of CO_2 emissions:

Changes caused by recalculations in the category 1.A.3.b in CO_2 emissions are shown in ***Table 3.38***. Recalculations of CO_2 emissions in 2013 – 2019 are mainly due to revision of activity data:

- Emissions from fossil part of FAME is reported separately as "other fossil fuels".
- Revision and correction of H/C ratio in petrol affected CO_2 emissions.
- Change of energy balance calculation in petrol affected CO_2 emissions.

Table 3.38: *Differences in CO_2 emissions between previous submission and current submission caused by recalculations*

YEAR	1.A.3.b	1.A.3.b.i	1.A.3.b.ii	1.A.3.b.iii	1.A.3.b.iv
	Gg				
2013	67.50	231.89	-185.94	22.07	-0.53
2014	73.58	355.93	-305.46	21.66	1.46
2015	70.32	727.66	-105.85	-552.81	1.32
2016	71.45	465.88	-31.13	-359.22	-4.09
2017	88.28	468.39	-69.67	-307.30	-3.15
2018	82.55	367.99	-60.90	-221.98	-2.57
2019	59.77	258.62	-49.03	-151.84	2.02

Revision of CH_4 and N_2O emissions:

Changes in non-CO_2 emissions caused by recalculations in road transportation are shown in ***Tables 3.39*** and ***3.40***. In the year 2016, the emissions of N_2O were under the threshold as the model was unable to export any number, thus the notation key "NE" was used. Recalculations of non-CO_2 emissions in 2013 – 2019 are mainly due to revised activity data:

- Emissions from fossil part of FAME is reported separately as "other fossil fuels".
- Change of energy balance calculation in petrol affected non-CO_2 emissions.
- Correction in the calculation of N_2O emissions for passenger vehicles fuelled with LPG & CNG and Urban Buses CNG.
- Corrected CH_4 Hot EFs for passenger and light-commercial vehicles.

Table 3.39: *Differences in CH_4 emissions between previous submission and current submission caused by recalculations*

YEAR	1.A.3.b	1.A.3.b.i	1.A.3.b.ii	1.A.3.b.iii	1.A.3.b.iv
	tons				
2013	-117.91	-34.63	-4.51	-78.26	-0.52
2014	-111.61	-31.04	-5.86	-75.20	0.49
2015	-75.98	-21.64	-4.56	-49.93	0.15
2016	-127.57	-78.18	-8.14	-37.32	-3.92
2017	-34.65	6.18	-3.93	-31.96	-4.94
2018	-112.06	-70.99	-6.10	-31.07	-3.91
2019	-83.56	-75.99	-0.06	-7.44	-0.07

Table 3.40: *Differences in N_2O emissions between previous submission and current submission caused by recalculations*

YEAR	1.A.3.b	1.A.3.b.i	1.A.3.b.ii	1.A.3.b.iii	1.A.3.b.iv
	tons				
2013	24.748	10.418	-2.394	16.748	-0.024
2014	34.127	12.844	-6.231	27.501	0.013
2015	-2.804	26.173	-0.611	-28.373	0.007
2016	-8.715	7.228	-1.040	-14.805	-0.097
2017	3.921	14.515	-0.343	-10.167	-0.084
2018	-1.251	5.512	-1.921	-4.783	-0.059
2019	1.506	10.313	-0.737	-8.087	0.018

3.2.8.6 Category-specific improvements and implementation of recommendations

During the inventory preparation following room for improvements was identified:

- Updated mileages for road transport was implemented for the years 2013 – 2020.
- More correct calculation of fossil carbon in biofuels was implemented.

Improvements are implemented in line with the Improvement and Prioritization Plan for the year 2022.

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 20 623.38 TJ in 2020. Total CO_2 emissions were 1 149.82 Gg, total CH_4 emissions were 0.44 Gg and total N_2O emissions were 0.009 Gg in 2020.

Residential (1.A.4.b) – total volume of fuels in 1.A.4.b expressed in energy units represented 74 666.90 TJ in 2020. Total CO_2 emissions were 2 894.03 Gg, total CH_4 emissions were 8.37 Gg and total N_2O emissions were 0.11 Gg in 2020.

Agriculture, forestry and fisheries (1.A.4.c) – total volume of fuels in 1.A.4.c expressed in energy units represented 6 370.45 TJ in 2020. Total CO_2 emissions were 335.28 Gg, total CH_4 emissions were 0.13 Gg and total N_2O emissions were 0.09 Gg in 2020. The fuels are allocated among 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.

3.2.9.1 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,[14] 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 8.5% share on the total GHG emissions in the year 2020. 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

[14] Energy 2019, Statistical Office of Slovak Republic (2020) ISBN: 978-80-8121-389-2

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 statistics is missing. Due to these reasons, several inconsistencies between fuels consumption reported in this category were recorded and commented in the previous submissions. Major differences occurred between the data reported in the national energy balance provided by the ŠÚ SR and data reported by the companies selling solid fuels to households (data reported in the NEIS database). The challenge of the NIS experts in this area was to harmonise national statistics in this field.

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 conference "Air Protection in Slovakia" held on 11-13 November 2019. The Project Grant was carried out in cooperation with the Statistical Office of the Slovak Republic.

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 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 for the first time. 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.

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. The results will be published in journal, process is ongoing.

Table 3.41: *Overview of the country or plant specific CO_2 EFs in t/TJ the category 1.A.4 in 2020*

1.A.4.a	WEIGHTED CO_2 EFs	FUEL TYPE	C EFs	CO_2 EFs
Liquid	68.55	Liquefied Petroleum Gases	17.22	63.15
		Gas/Diesel Oil	20.22	74.14
		Residual Fuel Oil	21.08	77.29
		Other petroleum products	20.01	73.35
Solid	103.09	Lignite	29.19	107.03
		Brown coal briquettes	26.61	97.57
		Other Bituminous Coal	26.10	95.07
		Gas Coke	29.19	107.03
Gaseous	55.78	Natural gas	15.21	55.78
Biomass	88.70	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	63.15	Liquefied Petroleum Gases	17.22	63.15

Solid	97.08	Other Bituminous Coal	26.10	95.07
		Lignite	29.19	107.03
		Brown coal briquettes	26.61	97.57
		Gas Coke	29.19	107.03
Gaseous	55.78	Natural gas	15.21	55.78
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	73.38	Liquefied petroleum gases	17.22	63.15
		Gas/Diesel oil	20.22	74.14
		Diesel oil	20.20	74.05
		Gasoline	19.10	70.04
Solid	96.26	Lignite	29.19	107.03
		Gas coke	29.19	107.03
		Other bituminous coal	26.10	95.07
		Brown coal briquettes	26.61	97.57
Gaseous	55.78	Natural gas	15.21	55.78
Biomass	66.21	Other biogas	14.90	54.63
		Wood/Wood waste	30.50	111.83
		Other primary Solid biomass	27.30	100.10

3.2.9.2 Uncertainties and time-series consistency

Description of uncertainty is similar to the **Chapter 3.2.6.3** 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).

3.2.9.3 Category-specific recalculations

Recalculations in households are summarized in the **Chapter 3.2.4**.

3.2.9.4 Category-specific improvements and implementation of recommendations

Improvements are implemented in line with the Improvement and Prioritization Plan for the year 2022. Further improvements in the category 1.A.1.4.a are planned in connection with the verification of activity data.

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 1 739.66 TJ in 2020. Total CO_2 emissions were 68.17 Gg, total CH_4 emissions were 0.022 Gg and total N_2O emissions were 0.0012 Gg in 2020.

3.2.10.1 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 3.2.6.1** and **3.2.6.2** 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 1 590.69 TJ in 2020. Total CO_2 emissions were 57.33 Gg, total CH_4 emissions were 0.021 Gg and total N_2O emissions were 0.00035 Gg in 2020.

The jet kerosene, gasoline 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 gasoline and diesel oil are estimated since 2016. Data for military gasoline and military diesel oil before 2016 were statistically estimated by the sectoral experts using linear regression back to basic year 1990 (recommendation from preliminary findings E.7 from the UNFCCC review 2021). The information is directly provided by the Ministry of Defence of the Slovak Republic. 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 3.42*** provides overview of the weighted average emission factors and fuels in the category 1.A.5 for the year 2020.

Table 3.42: *Overview of the country or plant specific CO_2 EFs in t/TJ in the category 1.A.5 in 2020*

1.A.5	WEIGHTED CO_2 EFs	FUEL TYPE	C EFs	CO_2 EFs
Liquid	71.53	Liquefied petroleum gases	17.22	63.15
		Residual fuel oil	21.08	77.29
		Diesel oil	20.20	74.05
		Jet kerosene	19.84	72.75
		Gasoline	19.10	70.04
Solid	98.62	Gas coke	29.19	107.03
		Lignite	29.19	107.03
		Other bituminous coal	26.10	95.07
Gaseous	55.78	Natural gas	15.21	55.78
Biomass	58.71	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

3.2.10.2 Uncertainties and time-series consistency

Description of uncertainty is similar to the **Chapter 3.2.6.3** 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).

3.2.10.3 Category-specific recalculations

Recalculations in the **Energy sector** are summarized in the **Chapter 3.2.4**.

3.2.10.4 Category-specific improvements and implementation of recommendations

Improvements are implemented in line with the Improvement and Prioritization Plan for the year 2022, 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.

Complete time series of CO_2, CH_4 and N_2O emissions for the reference and sectoral approach have been estimated since the base year 1990. The higher difference between the sectoral and reference approach identified in the previous submissions was caused by the inconsistencies between the national database NEIS, the changes in the air protection legislative and in different classification of fuel types in statistics and national legislative.

Based on the actual data provided in the 2022 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 four years. In 2020, the difference in CO_2 emissions was 0.82% and difference in the total energy consumption was 0.33%.

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 3.43*** - ***3.48***. 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 (2009, 2016), the results show the major inconsistencies in 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 3.43*** summarize the effect of the uncertainty in the estimation of these parameters.

Table 3.43: *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	-4307	-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 previous 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 uses peat as fuel. The SA is mainly based on information provided by the operators in the EU ETS reports. On the other hand, the RA 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). 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. From year 2020 there was no peat consumption reported in SA (the last company also stopped using peat as a fuel).

In 2018, a detail review of solid and gaseous fuels was performed. Based on review, several discrepancies in activity data were identified. These deviations were identified for years 1990 – 2000. Therefore, the complete time series of activity data were compared to information provided by the ŠÚ SR. Currently, the information about import, export production and stock changes reported in the RA of the inventory are fully correlated with information in international databases (EUROSTAT, IEA). The information on the emission factors used in the sectoral approach is presented in **Chapter 3.2**. The minor differences were caused by the use of average NCVs (net calorific values) in the RA and fuel specific NCVs in the SA. Since 1990, total fuels combustion decreased significantly. After the medium increase of solid fuels in 2001, the decreasing trend in 2002 – 2014 appeared. After a mild increase of emissions in 2015 – 2018, a significant decrease is observed in years 2019 and 2020. The emissions decrease in the last two years is mainly due to decrease of iron/steel production and lower fuel consumption in transport.

Figure 3.11: *Difference between the reference and sectoral approaches CO_2 emissions (in Gg) in 1990 – 2020*

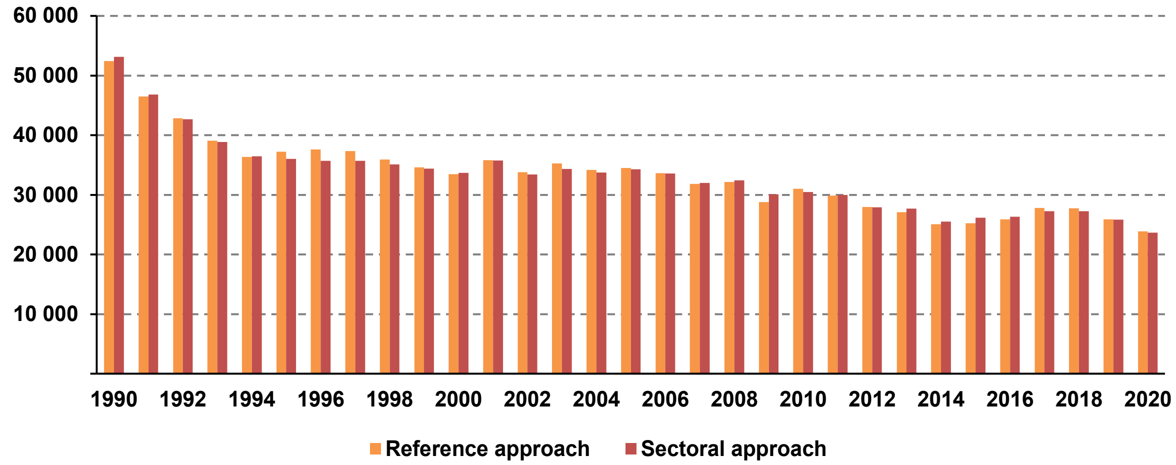


Table 3.44*: The comparison of the RA and the SA in total fuels consumption and CO_2 emissions in 1990 – 2020*

YEAR	RA	SA	APPARENT ENERGY CONSUMPTION	ENERGY CONSUMPTION DIFFERENCE	RA	SA	EMISSIONS DIFFERENCE
	PJ			*%*	*Gg of CO_2*		*%*
1990	753	658	650	-1.28	52 455	53 156	-1.32
1991	659	583	583	0.02	46 478	46 815	-0.72
1992	625	537	537	-0.02	42 843	42 675	0.40
1993	587	494	492	-0.48	39 078	38 852	0.58
1994	562	467	458	-1.90	36 351	36 456	-0.29
1995	591	471	483	2.66	37 219	36 061	3.21
1996	600	473	490	3.64	37 624	35 732	5.30
1997	600	475	491	3.53	37 360	35 694	4.67
1998	583	472	473	0.31	35 937	35 095	2.40
1999	566	466	458	-1.86	34 647	34 424	0.65
2000	546	460	451	-2.02	33 465	33 704	-0.71
2001	577	491	490	-0.13	35 843	35 774	0.19
2002	560	457	452	-1.03	33 793	33 445	1.04
2003	565	462	460	-0.48	35 296	34 337	2.80
2004	555	457	440	-3.79	34 171	33 775	1.17
2005	567	465	457	-1.66	34 498	34 299	0.58
2006	551	443	435	-1.95	33 622	33 568	0.16
2007	531	426	415	-2.41	31 836	31 998	-0.51
2008	533	436	424	-2.87	32 198	32 473	-0.85
2009	482	399	376	-5.61	28 821	30 130	-4.34
2010	514	406	407	0.21	31 016	30 510	1.66
2011	492	393	387	-1.71	29 897	30 011	-0.38
2012	466	371	363	-2.06	28 004	27 934	0.25
2013	468	368	359	-2.36	27 120	27 746	-2.26
2014	428	332	323	-2.53	25 078	25 581	-1.96
2015	433	345	330	-4.21	25 276	26 258	-3.74

YEAR	RA	SA	APPARENT ENERGY CONSUMPTION	ENERGY CONSUMPTION DIFFERENCE	RA	SA	EMISSIONS DIFFERENCE
	PJ			*%*	*Gg of CO_2*		*%*
2016	443	347	338	-2.63	25 909	26 410	-1.90
2017	473	362	366	1.03	27 830	27 382	1.64
2018	474	360	362	0.60	27 772	27 357	1.52
2019	441	348	347	-0.53	25 900	25 893	0.03
2020	424	326	327	0.33	23 919	23 724	0.82

Table 3.45: *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
2016	138	123	115	-6.69	8 553	9 053	-5.53
2017	154	124	131	6.08	9 760	9 103	7.23
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

Table 3.46: *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
2016	135	76	76	-0.49	8 923	8 923	0.00
2017	140	81	80	-0.95	9 295	9 324	-0.31
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	6 263	6 303	-0.64

Table 3.47: *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	209	208	-0.66	10 945	11 710	-6.53
1995	221	209	204	-2.44	11 296	11 638	-2.94
2000	244	233	226	-2.93	12 513	12 835	-2.51
2005	247	223	225	1.20	12 442	12 251	1.56
2010	210	187	192	2.87	10 659	10 326	3.23
2015	162	139	138	-1.13	7 678	7 766	-1.14
2016	165	143	142	-0.56	7 916	7 961	-0.57
2017	174	151	149	-1.56	8 296	8 428	-1.56
2018	171	148	146	-1.14	8 141	8 236	-1.14
2019	171	150	149	-0.73	8 318	8 378	-0.72
2020	171	148	148	-0.11	8 268	8 276	-0.10

Table 3.48: *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	179	-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
2016	5.38	4.95	5.38	8.76	517	455	13.59
2017	5.34	5.82	5.34	-8.28	478	509	-6.01
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

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 1 774.1 Gg in 2020, which represented 6 505.2 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 (42.1% and 41.7%, respectively) The other significant source of carbon excluded is using of natural gas (23.7% in fuel consumption and 19.6% 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 – 2020.

Figure 3.12: *The share of different fuels consumption for feedstock and non-energy use in 2020*

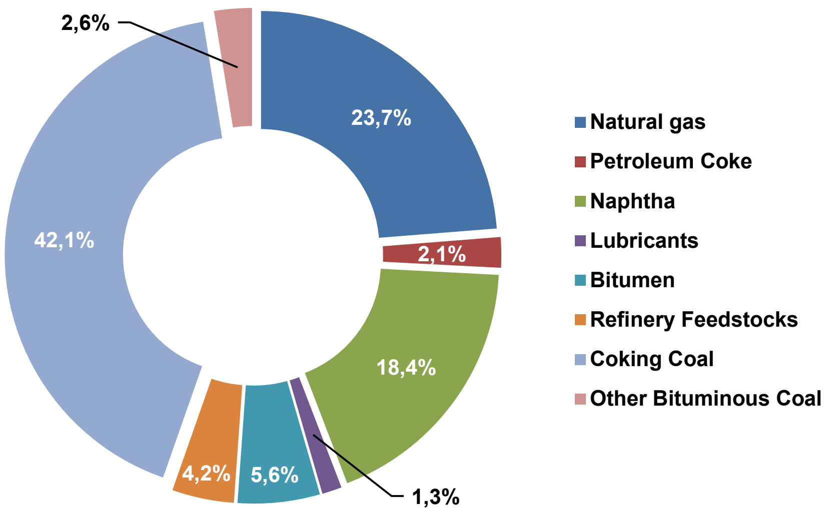


Figure 3.13: *The share of carbon for feedstock and non-energy use in 2020*

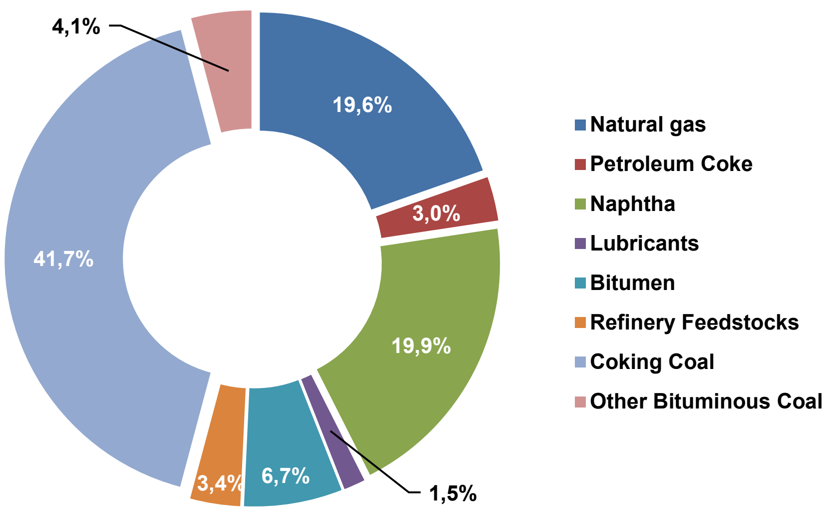
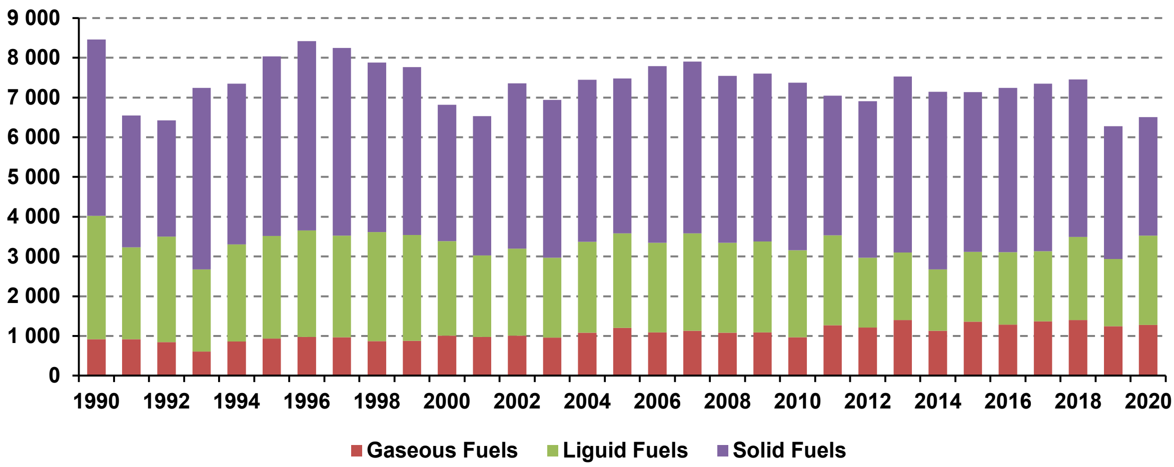


Figure 3.14: *The CO_2 emissions (Gg) according to the fuels excluded from the RA in 1990 – 2020*



Liquid fuels (petroleum coke, naphtha, and refinery feedstock), 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 3.49*** and ***3.50***.

Table 3.49: *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 3.50***.

Table 3.50: *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

IE - included in coking coal

The ethylene production represents a complex problem for the calculation of carbon used as feedstock. The simplified scheme is shown on ***Figure 4.6*** (**Chapter 4**). Naphtha, refinery gas, low-pressurized methane and natural gas are used as feedstock. 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. Therefore, the low-pressurized methane cannot be excluded from the RA (as it was made in previous submissions). The rest of 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). On the other hand, another stream of refinery gas is outgoing from refinery and it represents the input stream in the ethylene unit). In addition, the naphtha stream originates in the refinery. Total amount of carbon excluded from the RA is the difference between carbon contained in input flows (naphtha, excess refinery gas, natural gas) and carbon in off-gases going to the refinery. The highest amount of carbon in inputting streams contains the naphtha stream. Therefore, it is assumed that all carbon present in the natural gas and refinery gas is "stored" in products (and excluded from the RA); while only a part of the carbon from naphtha is excluded from the RA (the difference between carbon in inputting stream of naphtha and outgoing off-gases). The carbon excluded from the RA is presented in ***Table 3.51***. In the previous submissions, all carbon from naphtha has been excluded from the RA. Therefore, from ***Table 3.50*** it can be seen the impact of the changed approach. Data in ***Table 3.51*** presented as Naphtha input are equal the data about carbon stored presented in previous submissions while the new data about carbon stored can be found in Naphtha stored columns.

Table 3.51: *Comparison of amount of naphtha and carbon inputting into ethylene production and amount of naphtha and carbon excluded from the RA in particular years*

YEAR	NAPHTHA INPUT		NAPHTHA STORED	
	ENERGY	CARBON	ENERGY	CARBON
	TJ	*kt*	*TJ*	*kt*
1990	14 868	297.35	14 806	296.25
1995	19 271	385.42	18 023	362.98
2000	21 626	432.51	19 580	395.73
2005	17 440	348.80	17 379	347.70
2010	17 004	340.08	16 943	338.98
2011	16 742	334.85	16 681	333.75
2012	10 900	218.00	10 839	216.90
2013	11 510	230.21	11 449	229.11
2014	11 264	225.39	9 732	197.85
2015	14 916	298.32	8 255	198.40
2016	10 472	209.44	10 411	208.34
2017	11 176	223.52	11 129	222.59
2018	13 948	278.96	13 920	278.41
2019	13 244	264.88	13 209	264.18
2020	17 732	354.64	17 689	353.79

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 NMVOC emissions from coke production are included in the category 1.B.1.b – Solid Fuel Transformation.

In 2020, total aggregated fugitive emissions in the category 1.B represented 425.09 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 3.52*** and ***3.53*** 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 do not include methodologies to estimate them (ERT recommendation No E.20 of the SVK ARR 2019), therefore the notation key "NE" is used here.

The trend is steadily decreasing as an outcome of introduction of new technologies, methodologies and closing part of 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. 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 3.52: *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	CH_4	CH_4
	Gg				
1990	19.01	25.11	2.08	NO	NO
1995	21.54	27.44	2.27	NO	0.09
2000	21.51	26.62	2.20	NO	0.15
2005	20.78	14.66	1.51	NO	1.44
2010	19.74	13.86	1.43	NO	0.09
2015	19.51	11.32	1.17	0.26	0.12
2016	18.62	10.85	1.11	0.44	0.04
2017	21.40	9.29	1.11	0.50	0.12
2018	18.64	7.34	0.91	0.84	0.12
2019	17.89	8.13	0.86	0.71	0.12
2020	12.26	5.75	0.59	0.69	0.11

Table 3.53: *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.1 VENTING			
					1.B.2.c.1.i Oil		1.B.2.c.1.ii Gas	
	CO_2	CH_4	CO_2	CH_4	CO_2	CH_4	CO_2	CH_4
	Gg							
1990	0.03	0.59	0.58	44.14	0.0069	0.05	0.23	23.55
1995	0.03	0.55	0.53	36.25	0.0071	0.05	0.23	20.62
2000	0.02	0.49	0.49	27.65	0.0056	0.04	0.21	16.50
2005	0.01	0.40	0.50	21.93	0.0029	0.02	0.23	14.83
2010	0.01	0.32	0.41	12.65	0.0012	0.01	0.20	10.51
2011	0.01	0.35	0.38	10.98	0.0014	0.01	0.21	9.54
2012	0.01	0.31	0.35	8.47	0.0010	0.01	0.14	3.92
2013	0.01	0.33	0.38	8.25	0.0010	0.01	0.16	4.21
2014	0.01	0.29	0.31	7.06	0.0011	0.01	0.14	3.75
2015	0.01	0.33	0.32	6.99	0.0011	0.01	0.17	1.87
2016	0.01	0.31	0.33	7.13	0.0010	0.01	0.19	1.98
2017	0.01	0.30	0.34	7.38	0.0008	0.01	0.20	1.73

YEAR	1.B.2.a OIL		1.B.2.b NATURAL GAS		1.B.2.c.1 VENTING			
					1.B.2.c.1.i Oil		1.B.2.c.1.ii Gas	
	CO_2	CH_4	CO_2	CH_4	CO_2	CH_4	CO_2	CH_4
	Gg							
2018	0.01	0.29	0.33	6.70	0.0007	0.01	0.19	1.44
2019	0.01	0.27	0.34	6.69	0.0006	0.005	0.21	1.65
2020	0.01	0.33	0.33	7.00	0.0004	0.003	0.18	2.00

YEAR	1.B.2.c.2 FLARING					
	1.B.2.c.2.i Oil			1.B.2.c.2.ii Gas		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
	Gg		*kg*	*Gg*		*kg*
1990	2.9986	0.0018	46.81	1.3320	0.0009	20.42
1995	3.0441	0.0019	47.52	1.0320	0.0007	15.82
2000	2.4190	0.0015	37.76	0.5190	0.0003	7.95
2005	1.2710	0.0008	19.84	0.4410	0.0003	6.76
2010	0.5330	0.0003	8.32	0.3120	0.0002	4.78
2011	0.6150	0.0004	9.60	0.3630	0.0002	5.56
2012	0.4510	0.0003	7.04	0.4500	0.0003	6.90
2013	0.4100	0.0003	6.40	0.3720	0.0002	5.70
2014	0.4920	0.0003	7.68	0.3000	0.0002	4.60
2015	0.4290	0.0003	7.68	0.2790	0.0002	4.28
2016	0.4100	0.0003	6.40	0.2760	0.0002	4.23
2017	0.3280	0.0002	5.12	0.4200	0.0002	6.44
2018	0.2870	0.0002	4.45	0.2790	0.0002	4.30
2019	0.2594	0.0002	4.05	0.3720	0.0002	5.70
2020	0.1817	0.0001	2.84	0.2114	0.0001	3.24

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, 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.

According to the ERT recommendation No E.31 (ARR 2016) and No E.20 (SVK ARR 2017) and the ESD recommendation SK-1B2b-2020-0001, Slovakia was requested to use higher tier for fugitive methane emissions from oil and NG activities in key categories.

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.

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 improvements and changes implemented in the inventory. The list of recalculations is provided in this chapter.

3.5.4.1 Revisions in activity data:

- Slovakia revised the activity data for charcoal production in the category 1.B.1.b which are provided by the FAO STAT and the ŠÚ SR and compared with data provided by companies allocated in this category. Charcoal production in Slovakia for the year 2019 was revised according to data provided by FAO STAT and corrected value is 4 kt. Emissions were recalculated for year 2019. Impact of this recalculation on total emissions is negligible.

- Natural gas production in the category 1.B.2.b.2 for the years 2010 – 2019 was revised by the new data provided directly by the Nafta, a. s. company. There were significant differences between statistical data and real data from real operation. Slovakia in this NIR started to use real data on tier 3 level of disaggregation. The difference was between -4% and -40%, which correspond to decrease in NG production between 4.11 to 59.30 million m^3. This data also affected emissions of NG processing in the category 1.B.2.b.3.
- Natural gas storage in the category 1.B.2.b.6 for the years 2010 – 2019 revised by the new data provided directly by the Nafta, a. s. company which is operating NG reservoirs for the Slovak Republic. These data were cross-checked by the national expert with statistical data. After this cross-check it was found out that there was a difference in the methodology of companies and the ŠÚ SR. Nafta, a. s. reported NG that flowed through the reservoirs throughout the year and the ŠÚ SR reported only the balance of the reservoirs in the end of the year. Thus Slovakia decided to move to plant specific activity data. These data significantly increased in the recalculated period 2010 – 2019 and varied between years according to the needs. The difference was between 63% and 3 235%.
- Crude oil production in the category 1.B.2.a.2 for the years 2010 – 2019 was provided directly by the Nafta, a. s. company. There were significant differences between statistical data and the real data. As the data provided directly are more accurate, Slovakia in this NIR started to use real data on tier 3 level of disaggregation. The difference for years 2010 – 2019 was between -53% and 4%. Between the years 2010 and 2013, there is a small rise in crude oil production and afterwards the real production was significantly lower than statistical data. These data are measured directly by the wells and are connected to direct measurements of fugitive emissions reported in **Chapters 3.5.4.2** and **3.5.4.3**.

3.5.4.2 CO_2 recalculations 1.B:

Table 3.54 shows the recalculations of CO_2 emissions for the categories of 1.B - Fugitive Emissions. Recalculations of CO_2 emissions in 2010 – 2019 are mainly due to revised sources of activity data (see above). There was a shift from statistical data to plant-based in some subcategories. The correction in FAO STAT statistics did not affect CO_2 emissions in the category 1.B.2 as there are only CH_4 emissions identified during solid fuels transformation.

Table 3.54: *Differences in CO_2 emissions between previous submission and current submission caused by recalculations*

YEAR	1.B	1.B.2
	kt	
2010	-0.004	-0.004
2011	-0.012	-0.012
2012	-0.023	-0.023
2013	-0.012	-0.012
2014	-0.006	-0.006
2015	-0.004	-0.004
2016	-0.002	-0.002
2017	-0.021	-0.021
2018	-0.004	-0.004
2019	-0.021	-0.021

3.5.4.3 CH_4 recalculations 1.B:

Table 3.55 shows the recalculations of CH_4 emissions for the categories in 1.B - Fugitive Emissions.

Recalculations of CH_4 emissions in the subcategories of 1.B.2 are mainly due to revised sources of data in 2010 – 2019. There was a shift from statistical data to plant-based in some subcategories (see **Chapter 3.5.4.1**).

In addition, further change in the category 1.B.1.b - Solid Fuel Transformation was due to revision of data from FAO STAT for the year 2019. Also, in the category 1.B.2.b.4 the incorrect parameters for natural gas according to the temperature (15°C) was used, which resulted in incorrect methane emissions for the years 2014 – 2019. This was corrected in this submission.

Table 3.55: *Differences in CH_4 emissions between previous submission and current submission caused by recalculations*

YEAR	1.B	1.B.1	1.B.2
	kt		
2010	0.364	0.000	0.364
2011	0.287	0.000	0.287
2012	0.326	0.000	0.326
2013	0.375	0.000	0.375
2014	0.364	0.000	0.364
2015	0.178	0.000	0.178
2016	0.177	0.000	0.177
2017	0.050	0.000	0.050
2018	0.258	0.000	0.258
2019	0.180	0.090	0.090

3.5.5 CATEGORY-SPECIFIC IMPROVEMENTS AND IMPLEMENTED RECOMMENDATIONS

During the inventory preparation following improvements were made:

- Improvements in the category 1.B.2 were made. Recalculation were made based on data provided by oil and NG producers and companies providing transport and reserve of oil and NG.

Improvements are implemented in line with the Improvement and Prioritization Plan for the year 2022.

3.5.6 SOLID FUELS (CRF 1.B.1)

Coal mining and handling (CRF 1.B.1.a) – 980 kt of brown coal was mined from underground mines in the Slovak Republic in 2020, mostly for domestic consumption (energy industry and households). Total methane emissions from the underground coal mining were estimated to be 7.03 Gg (5.75 Gg of CH_4 from mining activities, 0.59 Gg of CH_4 from post-mining activity and 0.69 Gg from abandoned mines) in 2020. Methane recovery and flaring in mine Handlová-east shaft was in practice since 2007 until 2014. Total CO_2 emissions from the underground coal mining were estimated to be 12.26 Gg in 2020.

Table 3.56: *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	25.114	NO	2.084	NO	27.198	19.008
1995	3 759.10	27.437	NO	2.267	NO	29.704	21.542
2000	3 649.30	26.620	NO	2.201	NO	28.821	21.513
2005	2 511.20	14.658	NO	1.514	NO	16.173	20.781
2010	2 377.53	13.862	0.032	1.434	NO	15.295	19.740
2015	1 939.33	11.324	NO	1.169	0.264	12.758	19.512
2016	1 847.13	10.845	NO	1.114	0.437	12.396	18.617
2017	1 834.00	9.286	NO	1.105	0.498	10.889	21.398
2018	1 502.00	7.342	NO	0.906	0.837	9.085	18.642
2019	1 431.00	8.125	NO	0.863	0.713	9.702	17.891
2020	980.00	5.750	NO	0.591	0.687	7.028	12.261

Solid fuel transformation (CRF 1.B.1.b) - fugitive methane emissions from charcoal production in the Slovak Republic is reported in this category since 2015. This activity 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 – 2020. Total volume of wood charcoal produced in Slovakia was 3 800 t in 2020. Total CH_4 emissions were 0.11 Gg in 2020.

3.5.6.1 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 IPCC 2006 GL, 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), Volume 2: Energy Chapter 4: Fugitive Emissions: 4.1 fugitive emissions from mining, processing, storage and transportation of coal. According to the IPCC 2006 GL, 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 2006 GL (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 3.58***.

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 – 2020 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 3.57, point 2***).

Table 3.57: *Coal production, characteristics of mines and the emission factors for mining and post-mining in single mines in the Slovak Republic in 2020*

MINE	COAL PRODUCTION	DEPTH OF MINE	EF CH_4					
			1. IPCC 2006 GL		2. IEA - CIAB		3. HPB, a.s.	
			Mining	Post-mining	Mining	Post-mining	Mining	Post-mining
	t/year	*m*	*m^3/t*					
Mine Nováky	595 000	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	173 900	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	211 600	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 methane EF for mining activities was 5.87 kg/t in 2020.

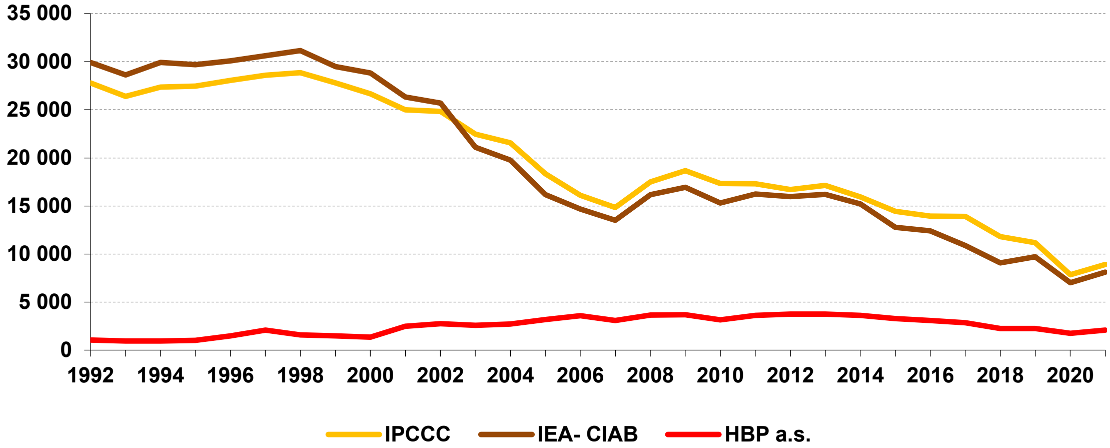
Five localities of underground mines operated by two companies are in the Slovak Republic. Data of coal production from the underground mines were obtained from official sources (MH SR, ŠÚ SR) and directly from the companies: Hornonitrianske bane Prievidza (HBP) and Baňa Dolina Veľký Krtíš (BD). According 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 – 2020*



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 2020.

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. This is an approximation with respect to the accuracy of the measuring instruments for measuring the mining air. The mines Dolina and Čáry have the same depth as the mines of the HBP, a. s. company, therefore the same EFs were used. There is no production registered in the mine Cigeľ in 2020.

Table 3.58: *Overview of CO_2 emission factors for single mines in the Slovak Republic in 2020*

MINE	COAL PRODUCTION	EF	EMISSIONS CO_2
	t/year	*t CO_2/t*	*t/year*
Mine Nováky	595 000	0.012356	11 429.52
Mine Handlová	173 900	0.013243	3 016.70
Mine Čáry	211 600	0.012339	3 444.32
TOTAL	**980 500**	**0.012505**	**12 261.00**

Solid Fuel Transformation (CRF 1.B.1.b) - CH_4 fugitive emission from solid fuel transformation have been calculated by the IPCC tier 1 default approach with using Revised IPCC 1996 GL – Table 1-13 Energy Content of Biomass Fuels: Default Net Calorific Values (no methodology available in the IPCC 2006 GL for this category). For the calculation of CH_4 emissions, the default emission factor related to the production of the wood charcoal was used from Revised IPCC 1996 GL – Table 1-14 (no methodology available in the IPCC 2006 GL for this category). Fugitive methane emissions from charcoal production were used based on the IPCC default EF (CH_4) = 1 000 kg/TJ. The GHG emissions from charcoal combustion are included in the **Energy sector**, where the activity data represents the quantity of production excluding export.

Production of charcoal in Slovakia were obtained from the official FAO statistic. 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.

Table 3.59: *Charcoal production and fugitive emissions in particular years*

YEAR	CHARCOAL PRODUCTION	CH_4 EMISSIONS
	kt/year	*Gg/year*
1993	3.00	0.09
1995	3.00	0.09
2000	5.00	0.15
2005	48.00	1.44
2010	3.02	0.09
2011	4.23	0.13
2012	4.30	0.13
2013	4.00	0.12
2014	4.20	0.13
2015	4.00	0.12
2016	1.45	0.04
2017	4.00	0.12
2018	4.10	0.12
2019	4.00	0.12
2020	3.80	0.11

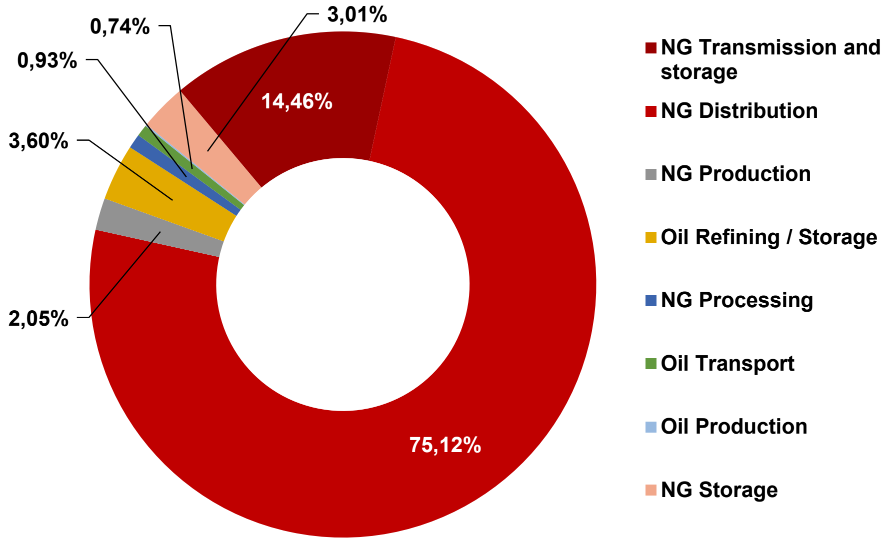
3.5.6.2 Source specific recalculations

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 234.27 Gg of CO_2 eq. (9.33 Gg of CH_4) in 2020. Total CO_2 emissions were 0.91 Gg in 2020. Total N_2O emissions were 6.07 kg in 2020. The major share of emissions belongs to the NG distribution (75.12%) and NG transmission and storage (14.46%). Production of natural gas has sharply decreased in 2020 and represented 2.05% from the total fugitive emissions from oil and NG activities.

Figure 3.16: *The share of individual activities in fugitive emissions of oil and natural gas in 2020*



Total fugitive GHG emissions from oil activities (1.B.2.a) were 8.14 Gg of CO_2 eq. (5.43 t of CO_2 and 325.34 t of CH_4) in 2020, excluding emissions from distribution of oil products (1.B.2.a.5), which are not estimated as the outcome of missing methodology in IPCC 2006 GL (SVK ARR 2017, recommendation No E.38). Total GHG emissions are decreasing continuously due to decrease in production and storage.

Table 3.60: *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*	*t CH_4*
1990	73.14	19.02	263.29	13 581.00	6.65	73.34	6 221.14	255.07
1995	74.25	19.30	267.29	13 581.00	6.14	67.66	5 168.47	211.91
2000	59.00	15.34	212.40	9 300.00	4.56	50.22	5 442.00	223.12
2005	31.00	8.06	111.60	10 662.34	5.22	57.58	5 598.00	229.52
2010	13.08	3.40	47.10	10 075.33	4.94	54.41	5 453.00	223.57
2011	15.43	4.01	55.55	9 919.73	4.86	53.57	5 991.00	245.63
2012	11.45	2.97	41.21	8 417.68	4.12	45.46	5 399.00	221.36
2013	9.98	2.60	35.94	9 788.06	4.80	52.86	5 871.00	240.71
2014	8.97	2.33	32.30	8 945.00	4.38	48.30	5 220.00	214.02
2015	9.59	2.49	34.51	9 932.04	4.87	56.63	5 954.53	244.14
2016	8.36	2.17	30.09	9 171.32	4.49	49.52	5 738.02	235.26
2017	5.78	1.50	20.79	9 582.25	4.69	51.47	5 557.00	227.83
2018	5.14	1.34	18.50	9 460.16	4.63	51.08	5 457.49	223.76
2019	4.34	1.13	15.61	8 997.64	4.41	48.59	5 109.01	209.47
2020	2.09	0.54	7.52	9 974.83	4.89	53.86	6 437.93	263.96

Total fugitive GHG emissions from natural gas activities (1.B.2.b) were 175.38 Gg of CO_2 eq. (0.33 Gg of CO_2 and 7.00 Gg of CH_4) in 2020. 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 3.61:** 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		
	Production	Emissions		Processing	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	36.41	1 021.2	444.00	142.08	457.32	73 600	64.77	35 328
1995	344.00	28.21	791.2	344.00	110.08	354.32	73 600	64.77	27 968
2000	173.00	14.19	397.9	173.00	55.36	178.19	68 600	60.37	19 209
2005	147.00	12.05	338.1	147.00	47.04	151.41	73 900	65.03	13 303
2010	94.03	7.71	216.3	94.03	30.09	96.85	65 302	57.47	5 226
2011	89.68	7.35	206.3	89.68	28.70	92.37	68 093	59.92	4 087
2012	90.70	7.44	208.6	90.70	29.03	93.42	45 470	40.01	1 820
2013	93.59	7.67	215.3	93.59	29.95	96.40	52 780	46.45	1 057
2014	86.06	7.06	197.9	86.06	27.54	88.64	46 500	40.92	1 364
2015	84.57	6.93	194.5	84.57	27.06	87.11	55 800	49.10	1 393
2016	87.89	7.21	202.1	87.89	28.12	90.53	60 600	53.33	1 451
2017	87.29	7.16	200.8	87.29	27.93	89.91	64 200	56.49	1 465
2018	84.15	6.90	193.5	84.15	29.93	86.67	59 700	52.54	867
2019	73.60	6.04	169.3	73.60	23.55	75.81	69 060	60.77	810
2020	65.26	5.35	150.1	65.26	20.88	67.22	56 980	50.14	1 060

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	339.97	7 332.60	1.00	$1.1E^{-5}$	0.025
1995	6 485.00	330.74	7 133.50	159.40	0.02	3.985
2000	7 136.00	363.94	7 849.60	524.30	0.06	13.108
2005	7 399.00	377.35	8 138.90	50.00	0.01	1.250
2010	6 098.00	311.00	6 707.80	3 435.21	0.38	400.179
2011	5 630.00	287.13	6 193.00	2 414.64	0.27	399.597
2012	5 289.00	269.74	5 817.90	2 197.23	0.32	531.905
2013	5 820.00	296.82	6 402.00	3 757.48	0.41	479.808
2014	4 014.00	204.71	4 415.40	3 807.59	0.42	417.196
2015	4 639.00	236.59	5 102.90	4 017.26	0.44	210.269
2016	4716.00	240.52	5 187.60	3 969.67	0.44	197.985
2017	4 901.25	249.96	5 391.37	4 246.87	0.47	235.749
2018	4 777.99	243.67	5 255.78	3 724.15	0.41	299.593
2019	4 841.46	246.91	5 325.60	3 129.80	0.34	306.986
2020	5 003.88	255.20	5 504.26	2 783.82	0.31	220.604

Total fugitive GHG emissions from flaring and venting activities (1.B.2.c) were 50.75 Gg of CO_2 eq. (0.57 Gg of CO_2, 2.01 Gg of CH_4 and 6.07 kg of N_2O) in 2020 (***Table 3.62***). Total emissions slightly increased due to the increase of natural gas transit and storage. Activity data are consistent with activity data used in oil and NG estimation. The major emissions share on the total fugitive emissions from venting and flaring of oil and NG represents venting of natural gas (99.06%) in 2020.

***Table 3.62:** 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.1.i Oil		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)*	*CO_2 (t)*	*CH_4 (t)*	*CO_2 (t)*	*CH_4 (t)*	*N_2O (t)*	*CO_2 (t)*	*CH_4 (t)*	*N_2O (t)*
1990	6.95	52.66	228.16	23 552	2 999	1.83	0.047	1 332	0.87	0.020
1995	7.05	53.46	228.16	20 625	3 044	1.86	0.048	1 032	0.67	0.016
2000	5.61	42.48	212.66	16 496	2 419	1.48	0.038	519	0.34	0.008
2005	2.95	22.32	229.09	14 831	1 271	0.78	0.020	441	0.29	0.007
2010	1.24	9.36	202.44	10 509	533	0.33	0.008	312	0.20	0.005
2011	1.43	10.80	211.09	9 542	615	0.38	0.010	363	0.24	0.006
2012	1.05	7.92	140.96	3 922	451	0.28	0.007	450	0.29	0.007
2013	0.95	7.20	163.62	4 208	410	0.25	0.006	372	0.24	0.006
2014	1.14	8.64	144.15	3 744	492	0.30	0.008	300	0.20	0.005
2015	1.14	8.64	172.98	1 864	492	0.30	0.008	279	0.18	0.004
2016	0.95	7.20	187.86	1 983	410	0.25	0.006	276	0.18	0.004
2017	0.76	5.76	199.02	1 727	328	0.20	0.005	420	0.27	0.006
2018	0.67	5.04	185.07	1 439	287	0.18	0.005	279	0.18	0.004
2019	0.60	4.56	214.09	1 644	259	0.16	0.004	372	0.24	0.006
2020	0.42	3.20	177.66	2 004	182	0.11	0.002	211	0.14	0.003

3.5.7.1 Methodological issues

The fugitive emissions from oil and natural gas in the Slovak Republic were calculated according to the IPCC 2006 GL using default tier 1 approach. Emission factors for CH_4, CO_2, N_2O and NMVOC were used from the following sources:

- IPCC 2006 GL, table 4.2.4 - tier 1 EFs for fugitive emissions from oil and gas operations in developed countries. The upper limit was used.

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 Eustream, a. s. 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. To monitor each of these possibilities infrared cameras are used.

Despite the expansion of the distribution system, the trend in fugitive CH_4 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.

3.5.7.2 Source specific recalculations

According to recalculations presented in **Chapter 3.5.4** there is an overview of source specific recalculation in ***Tables 3.63*** - ***3.65***.

***Table 3.63:** Recalculations made in activity data according to the subcategories of 1.B.2*

YEAR	1.B.2.a.2	1.B.2.b.2	1.B.2.b.3	1.B.2.b.6
	kt	*mil m³*	*mil m³*	*mil m³*
2010	0.08	-9.97	-9.97	3 332.21
2011	0.43	-31.32	-31.32	2 019.64
2012	0.45	-59.30	-59.30	2 532.23
2013	-0.02	-30.41	-30.41	3 625.48
2014	-3.03	-13.94	-13.94	3 488.59
2015	-2.41	-8.43	-8.43	3 878.26
2016	-1.64	-4.11	-4.11	3 723.67
2017	-2.23	-52.71	-52.71	3 828.87
2018	-1.86	-8.85	-8.85	3 301.15
2019	-1.99	-50.40	-50.40	1 207.80

***Table 3.64:** Recalculations made in CO_2 emissions according to the subcategories of 1.B.2*

YEAR	1.B.2.a.2	1.B.2.b.2	1.B.2.b.3	1.B.2.b.6
	t			
2010	0.02	-0.82	-3.19	0.37
2011	0.11	-2.57	-10.02	0.22
2012	0.12	-4.86	-18.97	0.28
2013	0.00	-2.49	-9.73	0.40
2014	-0.79	-1.14	-4.46	0.38
2015	-0.63	-0.69	-2.70	0.43
2016	-0.43	-0.34	-1.32	0.41
2017	-0.58	-4.32	-16.87	0.42
2018	-0.48	-0.73	-2.83	0.36
2019	-0.52	-4.13	-16.13	0.13

***Table 3.65:** Recalculations made in CH_4 emissions according to the subcategories of 1.B.2*

YEAR	1.B.2.a.2	1.B.2.b.2	1.B.2.b.3	1.B.2.b.4	1.B.2.b.6
	t				
2010	0.30	-22.94	-10.27	-	397.60
2011	1.55	-72.04	-32.26	-	389.72
2012	1.61	-136.38	-61.08	-	522.28
2013	-0.06	-69.93	-31.32	-	476.51
2014	-10.90	-32.07	-14.36	3.31	409.22
2015	-8.69	-19.39	-8.68	3.38	206.79
2016	-5.91	-9.45	-4.23	3.52	191.84
2017	-8.01	-121.24	-54.29	3.56	225.30
2018	-6.70	-20.36	-9.12	2.11	289.02
2019	-7.17	-115.91	-51.91	1.97	258.94

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.

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 – 2020. 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 – 2020, 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 2020, the emissions in the international civil aviation represented 55.13 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 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 – 2020 from the available EUROCONTROL data. The changes are shown in ***Table 3.20*** (**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 2021 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 2022 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 3.66***. 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 750.40 TJ and total consumption of aviation gasoline was 1.16 TJ in international flights in 2020.

***Table 3.66:** 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

3.6.1.1 Source specific recalculations

No recalculations were made in this category.

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 14.99 Gg of CO_2 eq. in 2020. 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 ***Table 3.24*** 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 3.67***.

***Table 3.67:** 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	74 100	74 100
CH_4	7	7
N_2O	2	2

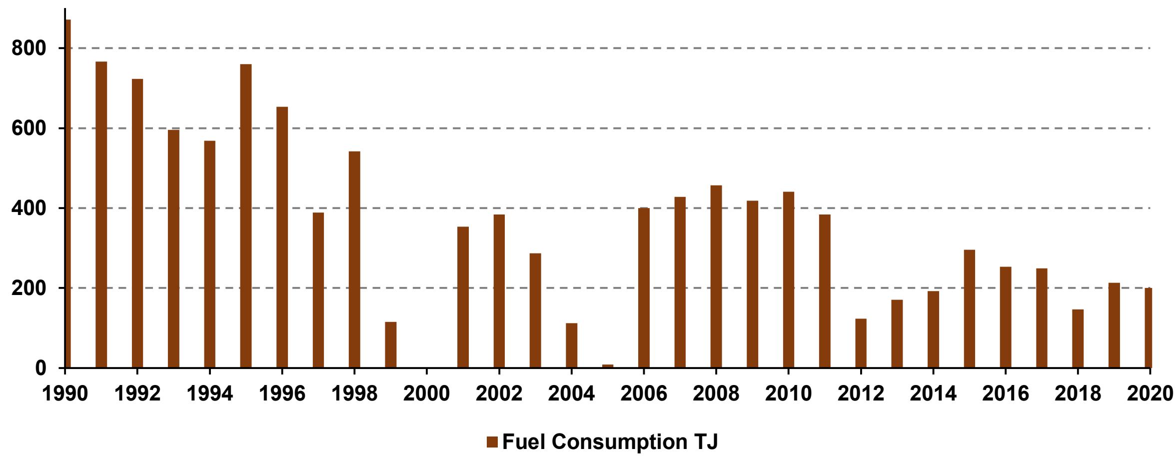
The Slovak Shipping and Ports Company provided detailed information on diesel oil consumption on the Danube River. The consumption is allocated between national and international companies. It was assumed that total fuel sold to international companies is reported in the memo items category (1.D.1.b) 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 transportation in the important Slovak ports Bratislava and Komárno were balanced is shows in ***Table 3.68***.

Table 3.68: *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	65 248.5
1995	18 066.00	760.14	56 326.7	5.32	1.52	56 912.8
2000	NO	NO	NO	NO	NO	NO
2005	212.70	8.98	665.2	0.06	0.02	672.2
2010	10 450.21	441.19	32 692.0	3.09	0.88	33 032.1
2015	7 008.90	295.38	21 887.4	2.07	0.59	22 115.1
2016	6 006.47	253.08	18 753.9	1.77	0.51	18 949.2
2017	5 917.84	249.30	18 473.2	1.75	0.50	18 665.4
2018	3 482.93	146.67	10 868.4	1.03	0.29	10 981.5
2019	5 063.74	213.24	15 793.7	1.49	0.42	15 958.1
2020	4 761.25	200.38	14 838.70	1.40	0.40	14 993.19

The sources of activity data for the period 1994 – 2020 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 – 2020*

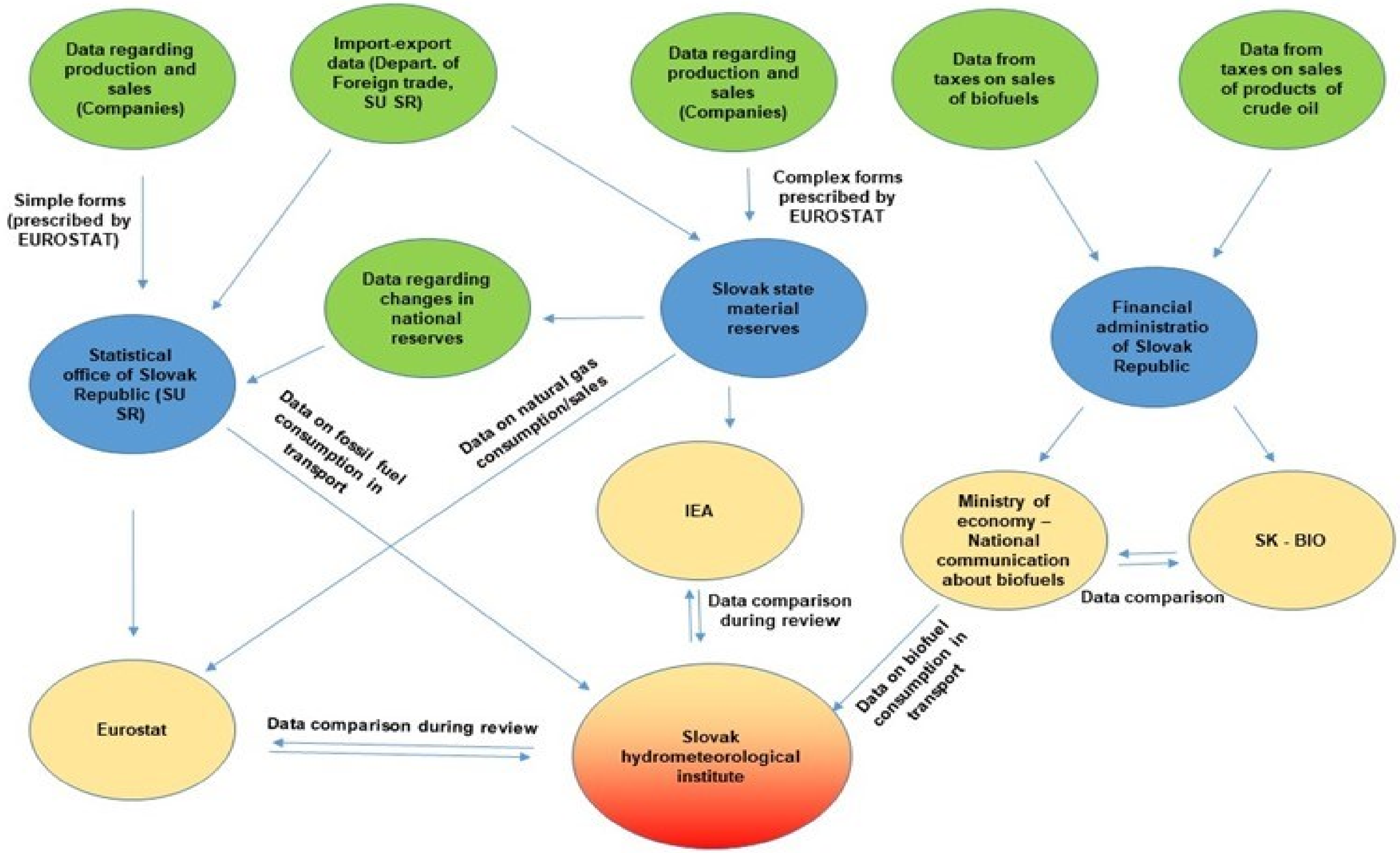


3.6.2.1 Source specific recalculations

No recalculations were made in this category.

ANNEX A3.1: DATA FLOW OF FUELS

Figure A3.1: *Flowchart of data reporting and utilisation (green – original data, blue – primary users, yellow – secondary users, red – tertiary users)*



CHAPTER 4: IPPU (CRF 2)

This Chapter was prepared by the sectoral experts and institutions involved in the National Inventory System of the Slovak Republic:

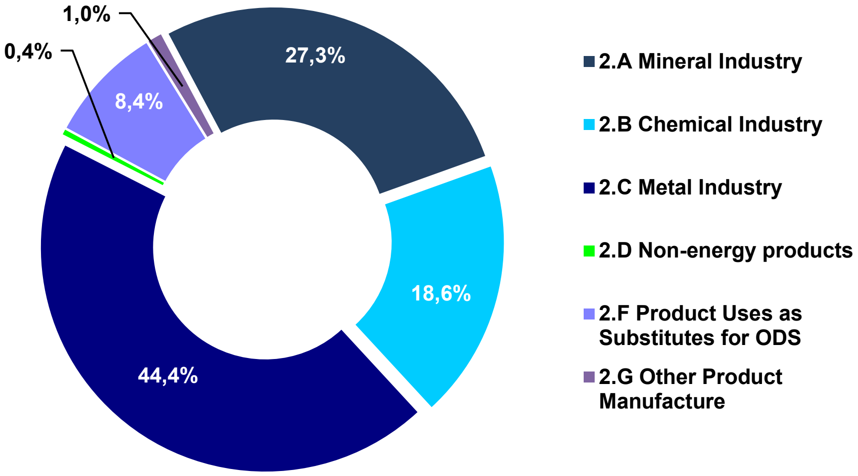
INSTITUTE	CHAPTER	SECTORAL EXPERT
Faculty of Chemical and Food Technology, Slovak Technical University	**All chapters**	Vladimir Danielik
Faculty of Chemical and Food Technology, Slovak Technical University	**2.D – NMVOC inventory**	Vladimir Danielik
Slovak Hydrometeorological Institute, Department of 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. 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 2020, total aggregated GHG net emissions from the sector of industrial processes and product use were 8 129.84 Gg of CO_2 eq. and they decreased compared with the previous year by approximately 6.0%. The decrease is largely due to the decreased production of iron and steel. Compared to the base year 1990 the emissions decreased by 16%. CO_2 is the most important gas with the share of 89.6%, followed by F-gases (8.6%) and N_2O emissions (1.7%) shares. The most important emission sources are categories of metal production (44.4%), mineral products (27.3%), chemical industry (18.6%) and substituents for ODS (8.3%). Other product manufacture and non-energy products categories shares 1.0% and 0.4%, 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 2:1.

Figure 4.1: *The share on emissions of individual categories in the IPPU sector in 2020*



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 2020 is presented in ***Table 4.1***.

Table 4.1: *GHG gases reported in the IPPU sector according to the CRF categories in 2020*

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	T3	CO_2, CH_4, N_2O
2.C.1 Iron and Steel Production	T2, T3	CO_2

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	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 in 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
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 2020, 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 2020.

The most important indicator is decrease in fuels, electricity and heat consumption in industry in 2020 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	8 228.11	0.32	1 158.31	314.92
1995	8 000.46	0.37	1 150.86	156.12
2000	7 359.07	0.66	1 037.12	133.00
2005	8 436.36	1.00	1 318.38	333.53
2010	7 833.56	1.20	946.86	641.88
2011	7 898.63	1.46	478.26	645.93
2012	7 899.65	1.40	378.69	675.10
2013	7 734.85	1.63	252.31	678.99
2014	7 976.68	1.71	225.26	679.16
2015	8 115.18	1.77	208.56	757.70
2016	8 412.81	1.49	191.39	685.68
2017	8 641.44	2.01	175.32	754.76
2018	8 655.88	1.93	175.76	719.94
2019	7 795.05	1.43	157.05	734.79
2020	7 284.87	1.46	141.81	701.69

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	2 019.80	4 900.90	50.49	NO	NO	16.45
1995	2 070.94	2 383.51	4 749.59	50.49	NO	13.32	39.95
2000	2 230.10	2 392.92	3 717.46	50.49	NO	106.46	32.40
2005	2 532.96	2 719.87	4 413.45	30.17	NO	293.43	99.39
2010	1 941.18	2 172.89	4 597.96	16.94	NO	597.24	97.28
2011	2 359.34	1 969.15	3 973.15	23.90	NO	605.03	93.71
2012	2 116.99	1 654.97	4 412.13	33.55	NO	628.20	109.00
2013	2 030.23	1 600.55	4 204.48	41.10	NO	646.88	144.53
2014	2 181.08	1 364.75	4 552.77	36.17	NO	653.84	94.20
2015	2 151.36	1 525.18	4 553.91	35.46	NO	734.88	82.42
2016	2 183.45	1 470.82	4 850.98	37.49	NO	673.37	75.25
2017	2 277.13	1 534.59	4 906.04	39.96	NO	739.06	76.76
2018	2 279.54	1 697.97	4 754.03	40.32	NO	702.77	78.89
2019	2 284.96	1 498.76	4 074.22	34.96	NO	720.74	74.69
2020	2 218.73	1 514.34	3 605.61	29.85	NO	678.88	82.43

Figure 4.2: Trend of emissions (Gg of CO_2 eq.) in the IPPU sector in individual gases in 1990 – 2020

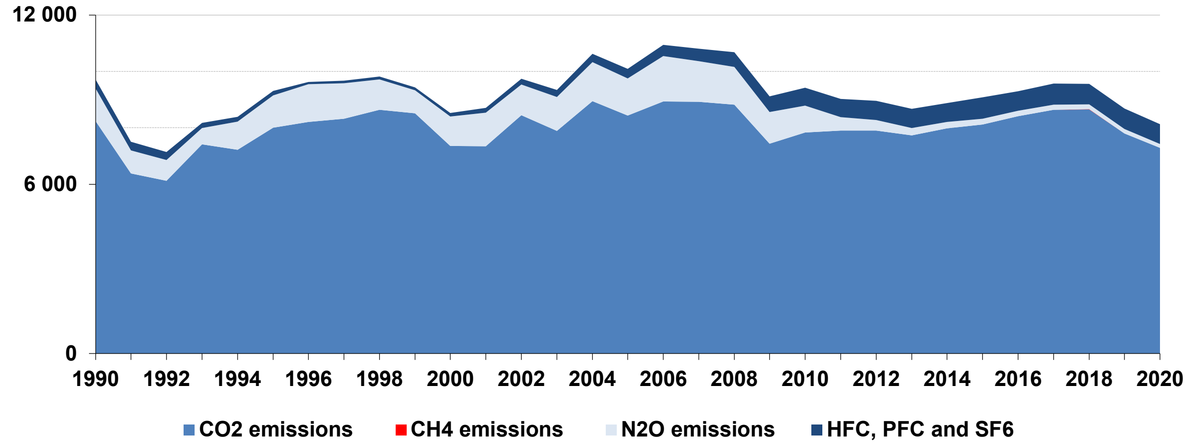
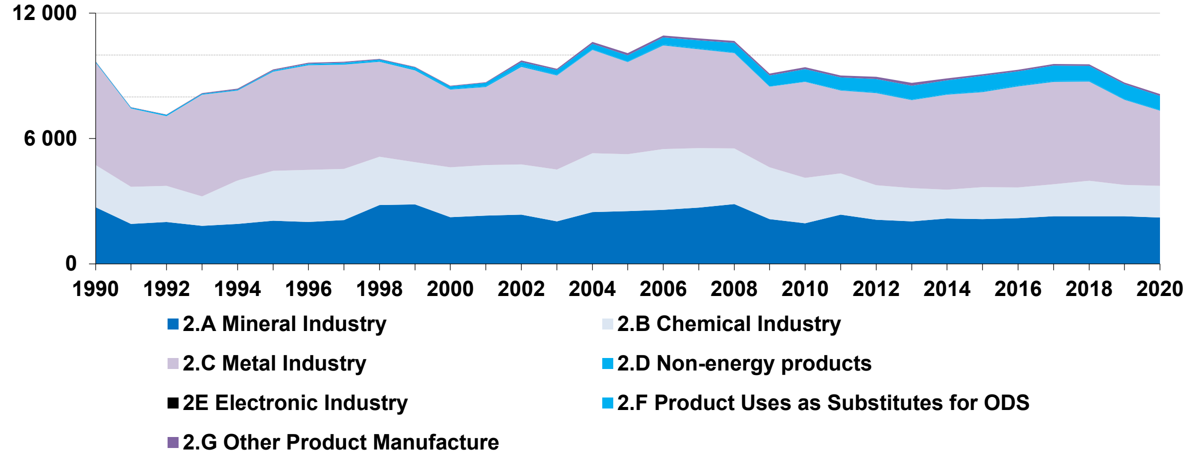


Figure 4.3: Trend of emissions (Gg of CO_2 eq.) in the IPPU sector in categories in 1990 – 2020



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. The latest Monte Carlo simulation was performed for the year 2016. Due to capacity reasons and according to the QA/QC plan in this sector, new calculation of Monte Carlo uncertainty (Approach 2) in the **IPPU sector** and categories will be performed every five years (next is planned for the year 2021, submission 2023). For more information, please see the **Chapter 1.2** of this Report. Results of the Monte Carlo simulations were almost identical since this exercise had been performed (since 2011).

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 used method is Monte Carlo. 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 in the SVK NIR 2017 and 2018.

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),
- 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).

[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)

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 1 444.72 Gg. All sources reported in this category are included in the EU ETS. The emissions reported in the national inventory were nearly the same (lower by 0.11%). 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 2020, 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 0.03 Gg of CO_2 (higher emissions are in GHG inventory). The difference is caused by rounding.

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 263.64 Gg in 2020 and are nearly the same as in the GHG inventory (-0.01 Gg).

Other Carbonates - All sources reported in this category are included in the EU ETS, however, part of them are not calculated but measured. CO_2 emissions calculated in the EU ETS reports were 30.62 Gg in 2020. In the GHG inventory, CO_2 emissions were calculated to be 46.47 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 180.42 Gg of CO_2 was used for the urea production. The CO_2 emissions from the urea consumption were 70.76 Gg in Slovakia (DeNOx technologies and using as fertilizers). The difference between these two values (109.66 Gg) is caused by the exporting of urea, because the rest of urea was exported. Based on the data provided by producer approximately 35.68 kt of urea was used for the production of AdBlue (catalyst for vehicles); from which a large majority was exported. This production represents the value of CO_2 as follows: 26.04 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 29.91 kt of nitrogen in favour of ***export***, which represents ***47.47 Gg of “exported” 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 0.41-1.93 kt (1.74 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 54.48 kt. It results from the balance that the difference between import and export of urea under commodity code 31028000 was 52.55-54.06 kt in favour of ***export***, which ***represents 38.36-39.47 Gg of “exported” CO_2***. Balancing of CO_2 from the export/import of urea gives the range ***111.87-112.98 Gg of “totally exported” CO_2*** from Slovakia. Comparing with the value of “missing” CO_2 from the balance of production and use (109.66 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 – 2020 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.

Hydrogen Production - Activity data from the EU ETS reports and information provided by the operators in questionnaires (requested by the SNE) is 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 emissions calculated from these two sources is 0.06% in 2020.

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

Recalculations 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 in Transport sector.

NUMBER/ RECOMME-NDATION	CATEGORY	DESCRIPTION	REFERENCE
1	2.D.3	Recalculations focused on the CO_2 emissions from SCR in vehicles	Energy sector in transport categories (**Chapter 3.2.8**)

Ad 1: Recalculations focused on the CO_2 emissions from SCR in vehicles for 2010 – 2019. This recalculation is explained in the road transportation category. Effect of total recalculations in 2.D.3 category is presented in the following ***Table 4.4***. Impact on the total emissions in IPPU sector is negligible.

Table 4.4: *Recalculations and changes in the 2.D.3 category*

YEAR	SUBMISSION 2021	SUBMISSION 2022	CHANGES 2021/2022
	Gg CO_2		%
2010	2.012	2.012	0.0%
2011	3.484	3.484	0.0%
2012	3.925	3.925	0.0%
2013	3.903	6.052	55.1%
2014	4.200	6.421	52.9%
2015	7.731	6.073	-21.4%
2016	9.583	8.549	-10.8%
2017	9.514	8.981	-5.6%
2018	9.660	9.539	-1.3%
2019	9.601	8.807	-8.3%

4.6 SECTOR-SPECIFIC IMPROVEMENTS AND IMPLEMENTATION OF RECOMMENDATIONS

During the inventory preparation following room for improvements in categories 2.A, 2.B, 2.D and 2.F was identified:

- Improved explanation of low IEF from ammonia production.
- More details about correction factor in cement production are presented.
- Planned improvements for F-gases are provided in the **Chapter 4.12.8** of this Report.

Improvements are prepared according to the UNFCCC review 2021 and the list of the provisional main findings 2021.

4.7 MINERAL PRODUCTS (CRF 2.A)

4.7.1 SOURCE-CATEGORY DESCRIPTION

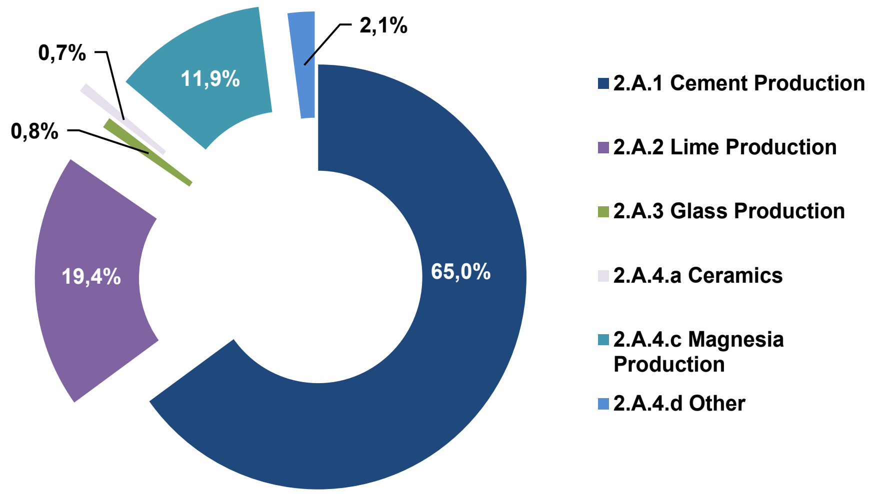
The major share of CO_2 emissions comes from the production and transformation of mineral products. Total emissions were 2 218.73 Gg of CO_2 in 2020 (only CO_2 emissions are reported in this category), lower by 3% compared with previous year 2019. Compared to 1990, the decrease in mineral production is approximately 18%. 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 (65.0%), lime production (19.4%) and dead burned magnesia production (11.9%). The ceramics production shared 0.7% and glass production 0.8%. The rest of emissions (2.1%) are reported in other category. Emissions in 2.A.4.b are not occurring.

Table 4.5: *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

Figure 4.4: The share of CO_2 emissions on individual categories in the 2.A in 2020



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 1 443.15 Gg in 2020 and were higher by ca 3% than the year before. In comparison with the base year 1990, the CO_2 emissions in this category decreased by 1%. The reasons for declining trend are described in the previous Chapter.

Table 4.6: 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

* Aggregated CaO content = CaO Content + 1.092/0.785×MgO content

4.7.2.1 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 4.7*** (C = confidential, but available for the sectoral experts).

Table 4.7: *Input data used for the CO_2 emissions estimation in the category 2.A.1 in 2020*

PLANT/OPERATOR	CEMENT CLINK	CaO CONTENT	MgO CONTENT	CKD	COMPOSITION FACTOR	CO_2
	kt	*%*	*%*			*Gg*
Cemmac	C	65.99%	1.76%	1.0082	0.9551	201.86
VSH (CRH)	C	64.71%	4.30%	1.0103	0.6494	242.16
CRH – Portland	C	65.72%	2.12%	1.0033	0.9741	556.47
CRH – white	C	67.90%	2.09%	1.0064	1.0000	77.41
Považská cementáreň	C	64.35%	0.91%	1.0203	1.0000	365.25
TOTAL	**2 944.94**	**65.31%**	**2.28%**	**1.0095**	**0.9030**	**1 443.15**

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 0.4900 t CO_2/t of cement clink in 2020 (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.

4.7.2.2 Uncertainties and time-series consistency

In the period 1990 – 1999 the average 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 CaO content is based on the average value of the CaO content in 2000 – 2003. The 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 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 – 2020no 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. The uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

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 12% when compared with the previous year and were 430.65 Gg in 2020. The decrease in emissions by 46% is achieved when compared with the base year.

Table 4.8: *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%	-

"Hypothetic" CaO content = CaO Content + 1.092/0.785×MgO content

4.7.3.1 Methodological issues

Table 4.8 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 4.8*** since 2014. 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 4.9***.

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 0.777 t CO_2/t of lime in 2020 (correction factor is included in the IEF). Correction factor presented in ***Table 4.9*** 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 554.22 kt in 2020. Activity data used for inventory are summarized in ***Table 4.8***. 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 4.9: *Activity data necessary for the estimation of CO_2 emissions in the category 2.A.2 in 2020*

PLANT	LIME PRODUCTION	CaO CONTENT	MgO CONTENT	LKD	CO_2 EMISSIONS
	kt				*Gg*
Calmit	C	90.79%	1.04%	1.0042	84.22
Dolvap Varín	C	86.20%	7.60%	1.0058	77.25
Carmeuse	C	86.88%	8.43%	1.0340	253.27
Others*	C	92.50%	2.00%	1.0200	15.91
TOTAL	**554.22**	**87.78%**	**6.49%**	**1.0225**	**430.65**

C = confidential, *aggregated data from small plants not covered by the EU ETS as sugar producers

4.7.3.2 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 scheme 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. The uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

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 18.39 kt in 2020.

4.7.4.1 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. Calculation of EFs is based on weighted average based of used carbonates and CO_2 emissions in individual production unit. Implied emission factor was 0.423 t/t of used carbonates mixture or 0.052 t/t of glass produced in 2020. 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, colemanit 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.

Glass production based on direct information from producers was as follows: 352.3 kt of white glass in 2020. No leaded glass or green glass was produced in 2020. Total amount of produced glass was 352.3 kt. $SrCO_3$ and Li_2CO_3 were not used for glass production. Total amounts of used carbonates were 43.44 kt in 2020 and time series is presented in ***Table 4.10***.

Table 4.10: *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**

[a)] Carbonates are included in the form of calcium carbonate (based on stoichiometry).

4.7.4.2 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. The uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

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 16.45 Gg CO_2 in 2020.

4.7.5.1 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 2020 was 0.47 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 35.22 kt in 2020 and time series is presented in ***Table 4.11***.

Table 4.11: *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

YEAR	$CaCO_3$	$MgCO_3$	TOTAL CARBONATES	CO_2 EMISSIONS
	kt			*Gg*
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

4.7.5.2 Uncertainties and time-series consistency

The same tier approach is used for period 1990 – 2020. 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. The uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

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 263.63 Gg in 2020 and decreased by ca 11% when compared with the year 2019. When compared to 1990, the decrease is approximately 39%. 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).

4.7.7.1 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 – 2020 are summarized in ***Table 4.12***. 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 560.73 kt in 2020. The composition of raw materials is summarized in ***Table 4.12***. 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 4.12: *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

*carbonates reported in $MgCO_3$ on the basis of stoichiometry

4.7.7.2 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. The uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

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.

4.7.8.1 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 volume of consumed carbonates according to the different sources and CO_2 emissions in the period 1990 – 2020 are summarized in ***Table 4.13***.

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 2020 was 0.442 t/t of used carbonates mixture.

Total volume of carbonates used at desulphurization was 105.24 kt in 2020, the activity data are summarized in ***Table 4.13***. 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 46.47 Gg in 2020.

Table 4.13: *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
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

4.7.8.2 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 4.13*** 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. The uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

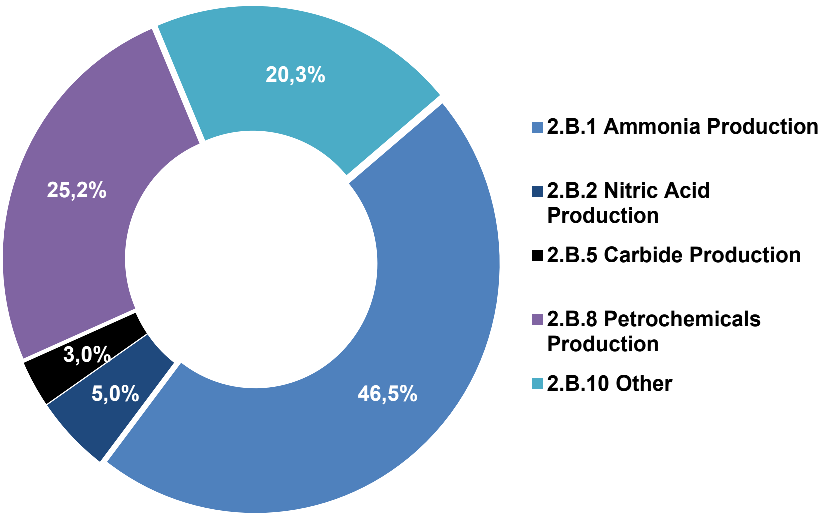
4.8 CHEMICAL INDUSTRY (CRF 2.B)

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 1 514.34 Gg of CO_2 eq. in 2020. The increase of emissions in the comparison with the previous year is approximately 1% and decrease by 26% in the comparison with the base year. The increase is caused by higher 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 (46.5%) in emissions belongs to ammonia production, 25.2% belongs to petrochemicals production, 20.3% belongs to hydrogen production (other), and 5.0% belongs to nitric acid production and 3.0% to carbide production.

Table 4.14: *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	332.37	1 141.53	NO	428.80	117.10
1995	488.47	1 120.62	139.01	459.91	175.50
2000	521.74	1 017.26	156.73	462.68	234.51
2005	573.24	1 234.79	176.72	371.40	363.73
2010	388.06	868.77	197.56	403.75	314.76
2011	578.73	404.75	222.28	425.75	337.65
2012	546.69	290.35	141.26	319.26	357.41
2013	675.36	129.41	95.35	330.79	369.65
2014	530.30	144.69	85.76	250.60	353.39
2015	639.45	139.78	48.47	331.82	365.65
2016	564.59	121.33	63.16	338.22	383.53
2017	633.80	104.98	59.35	357.84	378.61
2018	791.48	105.54	68.26	399.41	333.28
2019	689.15	90.62	62.05	344.14	312.80
2020	703.96	75.95	45.83	381.66	306.94

Figure 4.5: *The share in CO_2 emissions of individual subcategories in 2.B in 2020*



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 4.15***.

4.8.1.1 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 (35.014 in 2020); CCF is content of carbon in the fuel in t/TJ (15.196 in 2020) 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 1.29 t CO_2 per 1 t of ammonia produced in 2020 and is based on plant specific data (after subtracting of CO_2 used for urea production). 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). The consumption of natural gas in TJ was calculated based on consumption in mil m^3 and annual specific net calorific vales used in the **Energy sector**. Results are provided in ***Tables 4.15*** and ***4.16***. Production of ammonia increased by 11% in 2020 when compared with 2019 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 2020 that are necessary for the calculation of emissions. The presented data are based on direct measurements in plant. In 2019, new ammonia technological line started, which resulted in lower CO_2 emission.

Table 4.15: *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. m^3*	*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

* CO_2 emissions without consideration of urea production

Table 4.16: *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

*CO_2 emissions with consideration of urea production, C = confidential (available in NIS archive)

4.8.1.2 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 analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

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 was almost the same as in 2019. However, the N_2O emissions decreased by 16% in 2020 when compared with 2019. 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.

4.8.2.1 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 used until this year.
- 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 4.17***.

Table 4.17: *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.

According to the ERT recommendation, 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 2019 is presented in ***Table 4.18***. The overall EF = 0.439 kg N_2O/t of HNO_3 in 2020 was estimated as weighted average. N_2O emissions were 254.85 t in 2020. The detailed results are in ***Tables 4.18*** and ***4.19***.

Table 4.18: *Detailed information on measured N_2O concentrations and EFs in 2020*

PLANT	N_2O CONCETRATION	WEIGHTED AVERAGE EF
	ppm	*kg/t*
MEDIUM PRESSURE PLANT 1	156.79	0.445
MEDIUM PRESSURE PLANT 2	42.30	0.175
HIGH PRESSURE PLANT	149.55	0.494

Table 4.19: 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	9.564	1 953.77	1 876.88	NO	3 830.65
1995	398.80	9.429	1 818.70	1 941.77	NO	3 760.47
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

4.8.2.2 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 EF = 4.5 kg/1 t of HNO_3 was used for atmospheric plant where the production ended in 1999.

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.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. The uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

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)

4.8.5.1 Silicon carbide (CRF 2.B.5.a)

Silicon carbide is not produced in the Slovak Republic therefore notation key “NO” was used.

4.8.5.2 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 45.83 Gg of CO_2 in 2020 and decreased by 26% in comparison with 2019. It corresponds to the decrease of the production. Since 2015, the calcinated anthracite is used instead of other bituminous coal.

4.8.5.3 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 is used to produce the vinyl chloride monomer. 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 4.20*** (C = confidential data are available in the SNE archive).

Table 4.20: *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 BITUMINOUS 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

YEAR	CARBIDE PROD.	CARBIDE EXPORT-IMPORT	CARBIDE FOR VCM PROD.	$CaCO_3$ CONSUM.	COKING COAL CONSUM.	OTHER BITUMINOUS COAL CONSUM.	IEF CO_2	CO_2
	kt						*t/t*	*Gg*
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

* 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 2020 was 0.89 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 0.96 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 2020). No calcium carbide was imported to Slovakia in 2020. The rest of produced calcium carbide was used for acetylene production for welding applications (conservative approach). No production of CaO occurred in 2020. 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.

4.8.5.4 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 4.20***). 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. The uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

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.

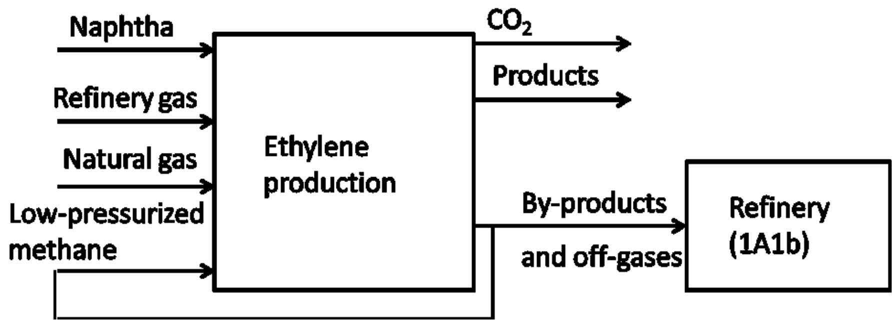
4.8.9 ETHYLENE (CRF 2.B.8.b)

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 379.68 Gg in 2020, which is higher by 12% compared with previous year. The increase is caused by increasing the production.

4.8.9.1 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 4.6***). Methane emissions do not occur when using approach described in the IPCC 2006 GL.

Figure 4.6: *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 4.21*** 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 4.21***.

Table 4.21: *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
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

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

4.8.9.2 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

[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

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 4.21*** 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. The uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

4.8.10 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 1.98 Gg in 2020 and decreased by ca 50% in comparison with the previous year 2019. The decrease was caused by the significant decrease in the production.

4.8.10.1 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 4.7***).

Ethylene dichloride and vinyl chloride monomer is produced by one operator in Slovakia. All streams (inputs) shown on ***Figure 4.7*** 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 4.22***.

Figure 4.7: *Carbon material balance used in emissions estimation of the category 2.B.8.c*

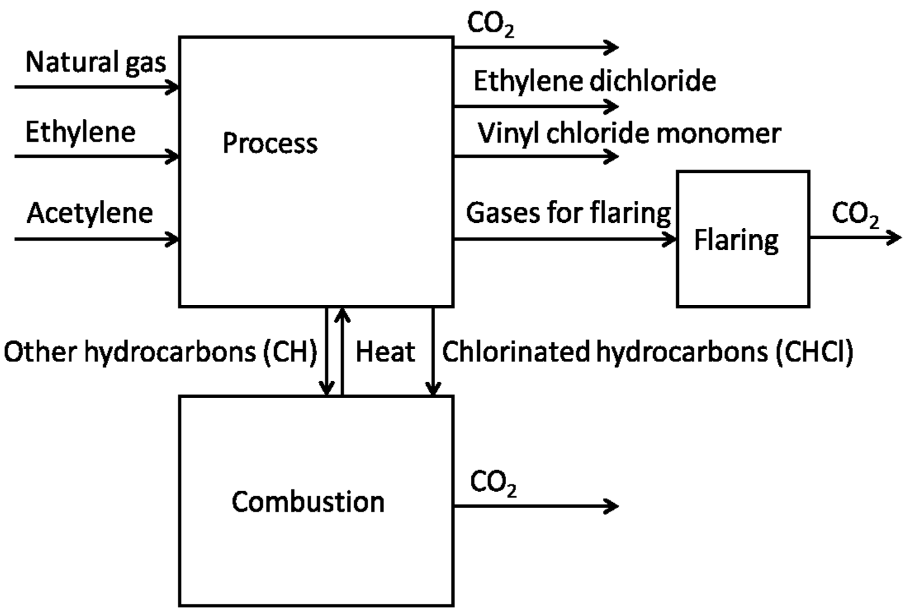


Table 4.22: *Activity data and related CO_2 emissions from the EDC and VCM production in particular years*

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

YEAR	GAS FOR FLARING	CHCl**	CH***	PROC. CO_2	COMBUS. 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
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

YEAR	GAS FOR FLARING	CHCl**	CH***	PROC. CO_2	COMBUS. CO_2	FLARING CO_2	TOTAL CO_2	IEF (CO_2)
	1 000 m³	*kt*		*Gg*				*t/t VMC*
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

*production of EDC that is used as a product, not an intermediate to VCM; **chlorinated hydrocarbons; ***other hydrocarbons

4.8.10.2 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. The uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

4.8.11 HYDROGEN PRODUCTION (CRF 2.B.10)

Hydrogen production in refinery is included in this category. Hydrogen is produced by steam reforming of natural gas in the Slovak Republic. This production process results in hydrogen and CO_2 emissions are released. Natural gas used for the reforming reaction is used as feedstock and as energy source (heating). Because it is very complicated to separate natural gas used as feedstock and for heating, total volume of natural gas used for production (as feedstock and as energy source) is reported in this category. The same approach was used in ammonia production (where the preparation of synthesis gas by steam reforming is the same technology as hydrogen production). The CO_2 emissions were 306.64 Gg in 2020 and lower by 2% when compared the previous year.

4.8.11.1 Methodological issues

While the hydrogen production by steam reforming of natural gas is also a part of ammonia production, the same approach for CO_2 emissions estimation was used:

$$E(CO_2) = FR \cdot CF \cdot CCF \cdot OF \cdot \frac{44}{12}$$

where: FR is the total consumption of natural gas for hydrogen production (in Nm³) and CF is a conversion factor (in MJ/m³); CCF is content of carbon in the fuel (in t/TJ) and OF is oxidation factor of the fuel. It should be noted that all parameters used for natural gas are consistent with the parameters used in the **Energy sector** (NCV, EF C).

In addition, hydrogen is produced only by one operator in Slovakia. All parameters used in the emission balance are country specific (NCV and CO_2 emission factor of natural gas). The methane and N_2O emission factors are the IPCC default: 1 kg/TJ of natural gas (CH_4) and 0.1 kg/TJ of natural gas (N_2O), due to lower significance of these emissions. The consumption of natural gas in TJ was calculated based on consumption in mil m^3 and annual specific net calorific vales.

Total hydrogen production was 36.88 kt in 2020. Detailed activity data are presented in ***Table 4.23***. The volume of used natural gas presented in this category was subtracted from the **Energy sector** in order to avoid the double counting.

Table 4.23: *Activity data and related CO_2 emissions from 2.B.10 hydrogen production in particular years*

YEAR	HYDROGEN PRODUCTION	NG CONSUM.	CO_2 EMISSIONS	IEF (CO_2)	CH_4 EMISSIONS	N_2O EMISSIONS
	kt	*TJ*	*Gg*	*t/t*	*t*	
1990	11.34	2 053.75	116.99	10.32	2.05	0.21
1995	19.93	3 136.38	175.33	8.80	3.14	0.31
2000	27.09	4 256.60	234.28	8.65	4.26	0.43
2005	43.25	6 613.48	363.37	8.40	6.61	0.66
2010	30.67	5 706.23	314.45	10.25	5.71	0.57
2011	38.05	6 120.16	337.31	8.86	6.12	0.61
2012	36.82	6 464.06	357.06	9.70	6.46	0.65
2013	38.64	6 644.78	369.29	9.56	6.64	0.66
2014	39.41	6 340.38	353.04	8.96	6.34	0.63
2015	41.99	6 555.50	365.29	8.70	6.56	0.66
2016	44.08	6 871.21	383.16	8.69	6.87	0.69
2017	43.68	6 789.81	378.24	8.66	6.79	0.68
2018	39.58	5 979.76	332.95	8.41	5.98	0.60
2019	38.00	5 603.54	312.50	8.22	5.60	0.56
2020	36.88	5 497.44	306.64	8.31	5.50	0.55

4.8.11.2 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 natural gas used for energy purposes. Sensitivity of time series is caused also by the limited number of operators producing in Slovakia and their actual activity or production capacity. The production undertook technological modification in 2010. It resulted in higher EF in 2010 (year of reconstruction) and lower EF in the subsequent years. Moreover, the IEF can fluctuate because the produced hydrogen is not sold; it is consumed in the same plant as it is produced (in refinery). No strict requirements on the CO content are needed; CO is burned with the hydrogen together. CO_2 emissions from CO burning are included in the hydrogen production because all carbon from the used natural gas is reported here.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. The uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

4.9 METAL PRODUCTION (CRF 2.C)

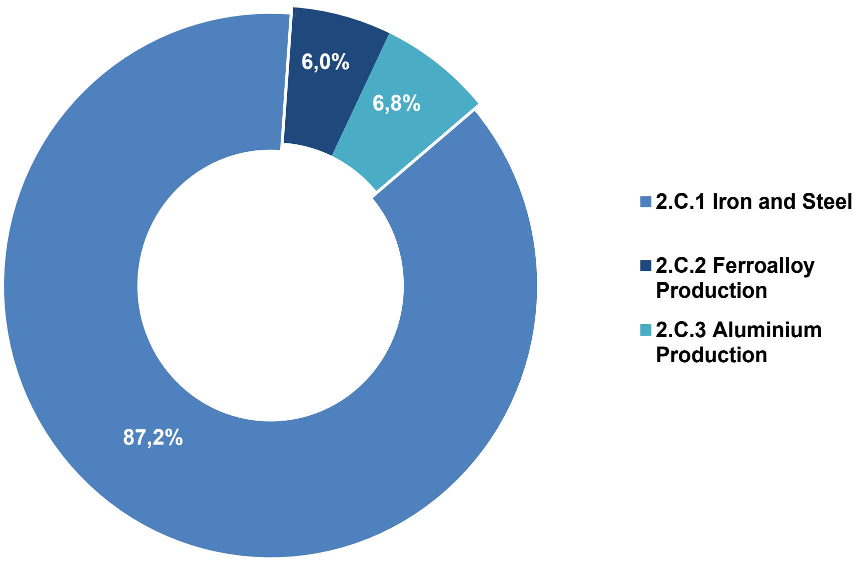
This category produces emissions of CO_2, CH_4 and PFCs emissions (Aluminium Production). Total emissions were 3 605.61 Gg of CO_2 eq. in 2020; the decrease was 11% when compared with 2019 due the significant decrease production of iron and steel. Comparing with the base year, the emissions are lower 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 4.24: *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	4 167.97	296.74	436.18	NO	NO
1995	4 322.63	235.64	191.33	NO	NO
2000	3 344.72	182.69	190.05	NO	NO
2005	3 907.36	228.16	277.94	NO	NO
2010	4 089.57	219.91	288.48	NO	NO
2011	3 488.82	202.93	281.38	0.01	NO
2012	3 860.47	266.42	285.18	0.04	0.02
2013	3 763.30	166.07	275.05	0.05	0.01
2014	4 051.40	224.15	277.14	0.06	0.01
2015	4 028.13	240.88	284.84	0.06	NO
2016	4 334.99	238.02	277.90	0.06	NO
2017	4 328.02	295.33	282.63	0.06	NO
2018	4 187.82	282.89	283.31	0.01	NO
2019	3 554.28	240.02	279.91	0.01	NO
2020	3 145.82	215.45	244.32	0.03	NO

The major share of emissions (87.2%) belongs to the iron and steel production, 6.0% belongs to the ferroalloy production and 6.8% to the aluminium production. Other subcategories are not significant in emission share within the category 2.C.

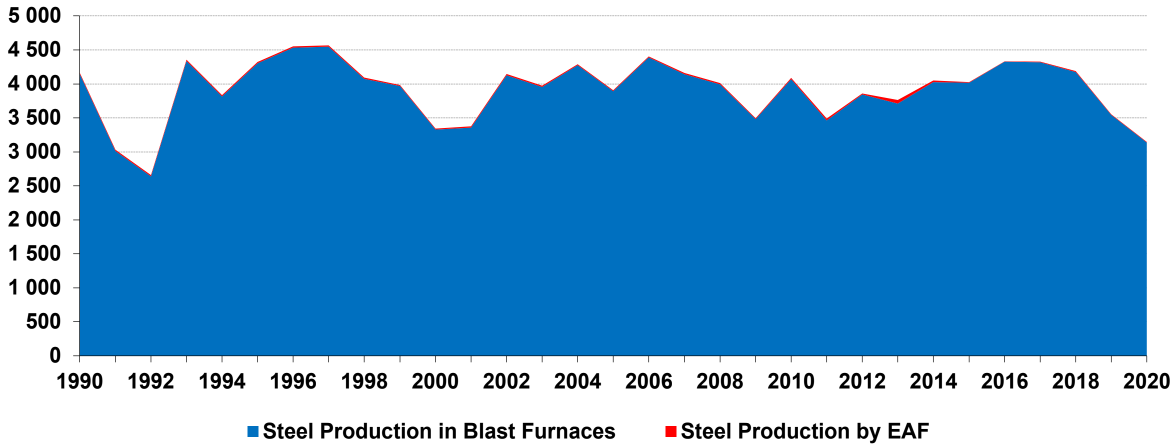
Figure 4.8: *The share in GHG emissions in the category 2.C by subcategories in 2020*



4.9.1 IRON AND STEEL PRODUCTION (CRF 2.C.1)

Total CO_2 emissions in this category were 3 145.82 Gg in 2020, lower by 11% when compared with the year 2019. Comparing the base year, the decrease was 25%. 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.

Figure 4.9: *Emission trend in the category 2.C.1 (in Gg of CO_2 eq.) in 1990 – 2020*



4.9.1.1 Methodological issues

Pig iron and steel are produced mainly in blast furnaces and by the EAF processes. 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 as described in the IPCC 2006 GL.

The CO_2 emissions were calculated by using following equation:

$$E(\text{steel BF}) = \left(\sum\left(\text{mass of C in input stream}_i\right) - \sum\left(\text{mass of C in output stream}_i\right)\right) \cdot \frac{44}{12}$$

$$E(\text{steel EAF}) = EF(\text{steel in EAF}) \cdot \text{mass of Steel produced in EAF}$$

$$\text{Total Emissions} = \sum_i E(i)$$

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 in line with the IPCC 2006 GL.

EFs 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 3.273 kg/t, in pig iron it was 45.50 kg/t and 0.799 kg/t in steel (data supplied directly) in 2020. Emission factors and other parameters are summarized in ***Tables 4.25-4.27***. The CO_2 emissions from the EAF process are estimated based on carbon balance, where all material flows are considered.

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 (which was sold and not processed to steel) and 3 119.01 kt of steel in 2020. Total production of steel produced by the EAF technology was 279.85 kt in 2020. 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. 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 4.25: *Activity data, emission factors and CO_2 emissions in integrated iron and steel production in 2005 – 2020*

YEAR	COAL CON.	COKE	NG CON.	CG OUTPUT	BFG OUTPUT	STEEL PROD.	LIMESTO-NE USED	CO_2	IEF (CO_2)
	kt		*mil. m^3*	*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

CG = coking gas, BFG = blast furnace gas, con. = consumption, prod. = production

Table 4.26: *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
1994	3 330.40	581.39	3 815.70	1.146
1995	3 207.40	562.16	4 304.41	1.342

YEAR	STEEL PRODUCTION	LIMESTONE USED	CO_2 EMISSIONS	IEF (CO_2)
	kt		*Gg*	*t/t*
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 4.27: *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

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
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

4.9.1.2 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 – 2020. 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.

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. In 2019 and 2020, the plant did 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. The uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

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 214.52 Gg of CO_2 and 37.04 t of CH_4 in 2020. According to the IPCC 2006 GL, also limestone used for the production was included in this estimation.

4.9.2.1 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 4.28-4.30***.

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 4.28***.

Table 4.28: *Activity data used for carbon balance and CO_2 emissions in ferroalloys production in 2020*

CARBON IN "RAW MATERIALS"	CARBON IN COALS	LIMESTONE CONSUMED	CARBON IN PRODUCTS	CO_2 EMISSIONS
t				*Gg*
3 076.8	58 178.0	NO	2 748.1	214.524

Table 4.29 *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
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 4.30: *Activity data, CO_2 and CH_4 emissions in ferroalloys production in 2002 – 2020*

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

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
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

4.9.2.2 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. The uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

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.

4.9.3.1 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 PFCs emissions estimation. According to the information from producers, 61 823 t of graphite anodes were used with the sulphur and ash contents 1.36% and 0.16%, respectively in 2020. 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 (223.24 Gg CO_2 in 2020). 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: 8.03 Gg and 7.44 Gg, respectively. The total PFC emissions were 0.71 t (5.61 Gg of CO_2 eq.) in 2020 and it was calculated according to the Slope method (tier 2).

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 PFCs (CF_4, C_2F_6) emissions were calculated according to the Slope method with default values of Slope coefficient and ratio of CF_4/C_2F_6 (tier 2 method). According to the data from the plant operator, the number of anode effects per pot day equals to 0.051 and their average duration was 0.57 min in 2020. It follows that the emission of CF_4 was 0.633 t and C_2F_6 emission was 0.077 t. Production of aluminium was 151 875 t in 2020. Consumption of graphite in electrolysis was 61 823 t and from 84 110 t of “green” anodes 81 253.1 t of anodes was produced. SF_6 is not used in aluminium castings in the Slovak Republic.

Table 4.31: *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
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

Table 4.32: *PFC emissions and EFs in aluminium production in particular years*

YEAR	CF_4	EF per ALUMINIUM	C_2F_6	EF per ALUMINIUM	TOTAL PFC
	t	*kg/t*	*t*	*kg/t*	*Gg CO_2 eq.*
1990	36.60	0.5430	3.64	0.0540	314.86
1995	15.42	0.4730	1.53	0.0470	132.65
2000	1.52	0.0139	0.18	0.0017	13.49
2005	2.67	0.0168	0.32	0.0020	23.72
2010	2.82	0.0173	0.34	0.0021	25.01
2011	2.27	0.0139	0.28	0.0017	20.11
2012	2.90	0.0180	0.35	0.0022	25.66
2013	1.11	0.0068	0.13	0.0008	9.81
2014	1.26	0.0075	0.15	0.0009	11.15
2015	0.96	0.0056	0.12	0.0007	8.50
2016	0.73	0.0042	0.09	0.0005	6.49
2017	0.97	0.0056	0.12	0.0007	8.62
2018	0.88	0.0051	0.11	0.0006	7.78
2019	0.59	0.0033	0.07	0.0004	5.19
2020	0.63	0.0042	0.08	0.0005	5.61

4.9.3.2 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.

As described in the **Chapter 4.2**, tier 2 approach to the uncertainty analysis of the subcategories was chosen. The uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

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 25.00 t in 2020.

4.9.5.1 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, 125 t of lead was produced from the secondary raw materials in 2020.

Table 4.33: *The overview of activity data and CO_2 emissions from lead production in 1990 – 2020*

YEAR	LEAD PRODUCTION FORM 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

4.9.5.2 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 uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

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. In 2020, the production was not occurring.

4.9.6.1 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 2020.

Table 4.34: *The overview of activity data and CO_2 emissions from zinc production in 1990 – 2020*

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 – 2020	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 29.85 Gg in 2020 and decreased by approximately 17% compared with the previous year. When comparing with the base year, the decrease was 41% mostly caused by the decrease use of lubricants.

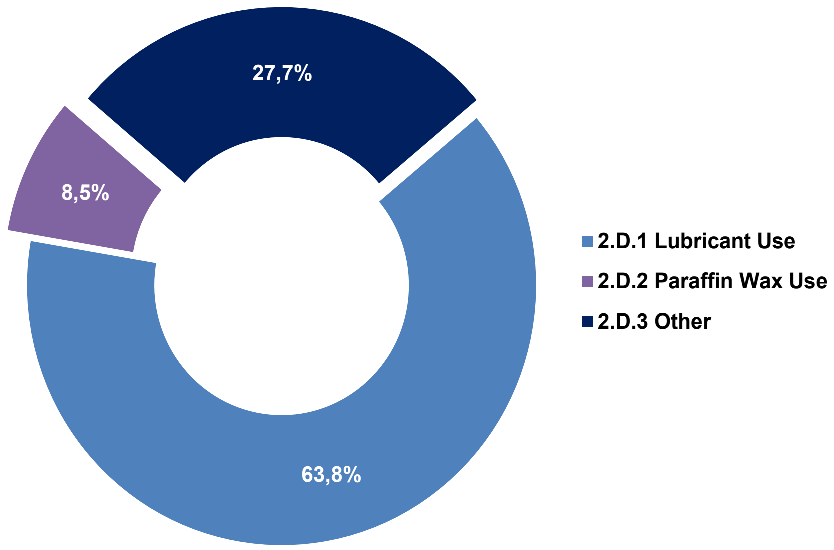
Table 4.35: *Emissions in the category 2.D according to subcategories in particular years*

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

YEAR	2.D.1 LUBRICANT USE	2.D.2 PARAFFIN WAX USE	2.D.3 OTHER
	Gg of CO_2 eq.		
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

The major share (63.8%) in emissions belongs to the lubricant use category, 27.7% belongs to the other used (urea use) and 8.5% to the paraffin wax use.

Figure 4.10: *The share of GHG emissions in individual subcategories of the 2.D in 2020*



In 2021 submission, according to the ERT recommendation No I.14 (FCCC/ARR/2019), 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**. 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". The reallocation of the CO_2 emissions has higher impact on the total emissions in the IPPU as the recalculated emissions. 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 19.05 Gg in 2020.

4.10.1.1 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 1 300.0 TJ in 2020. 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 4.36: *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
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

4.10.1.2 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 uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

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 2020.

4.10.2.1 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 2020. 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 4.37: *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

4.10.2.2 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 uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

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** 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 and the calculation is described in the **Annex 4.4**.

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. Due to technical characterisation of the COPERT model, where the CO_2 emissions from urea based catalysts are calculated automatically from diesel oil consumption and no urea consumption is presented, the notation key “NE” is used for activity data in the category 2.D.3 – Other – Urea Catalytic Converter (according to the ERT recommendation).

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 8.26 Gg of CO_2 eq. in 2020. Total NMVOC emissions were 20.85 kt. ***Table 4.38*** summarizes CO_2 and NMVOC emissions for particular years of time series.

Table 4.38: *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	87.751	NO
1995	35.824	82.077	NO
2000	29.601	65.441	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

4.10.3.1 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 4.38-4.39***. Detailed data are presented in the **Annex 4.4**.

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 – 2020. 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. Due the mixing of two types of activity data (number of vehicles and amount of used urea) the notation key “NE” was used. The CO_2 emissions from urea based catalysts are presented in ***Table 4.41***.

Table 4.39: *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

YEAR	NMVOC EMISSIONS	INDIRECT CO_2 EMISSIONS
	kt	*Gg*
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

Table 4.40: *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	137.180	102.777
1995	171.0	65.9	29.067	23.659	63.947	52.051
2000	52.5	46.5	10.363	16.323	22.800	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	6.6	15.197	2.907	33.434	6.396
2014	79.2	18.5	13.746	2.635	30.242	5.797
2015	147.3	NO	20.067	0.973	44.147	2.141
2016	150.8	NO	18.942	1.959	41.672	4.310
2017	115.0	NO	18.737	1.290	41.221	2.838
2018	146.0	NO	19.933	2.096	43.852	4.611
2019	132.5	NO	16.455	1.900	36.201	4.180
2020	132.9	NO	15.082	2.186	33.180	4.810

Table 4.41: *CO_2 emissions originating from the use of urea in catalytic converters in 2010 – 2020*

YEAR	UREA CONSUMPTION IN INDUSTRY	CO_2 EMISSIONS IN INDUSTRY	CO_2 EMISSIONS IN CARS	TOTAL CO_2 EMISSIONS
	t			
2010	NO	NO	2 012.2	2 012.2
2011	NO	NO	3 483.5	3 483.5
2012	NO	NO	3 925.3	3 925.3
2013	NO	NO	6 051.6	6 051.6
2014	NO	NO	6 420.6	6 420.6
2015	NO	NO	6 072.8	6 072.8
2016	2 227.8	1 632.6	6 916.2	8 549.2
2017	2 271.0	1 664.2	7 316.8	8 981.0
2018	1 997.8	1 464.0	8 075.0	9 539.0
2019	732.4	536.7	8 171.4	8 807.1
2020	1 568.8	1 149.6	7 108.6	8 258.2

4.10.3.2 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 analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

4.11 ELECTRONIC INDUSTRY (CRF 2.E)

No halocarbons, SF_6 or NF_3 were used in the Slovak Republic in 1990 – 2020 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).

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 4.42: *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	11.223	NO	2.095	NO	NO	NO	13.318
2000	88.476	6.157	7.745	2.667	1.420	NO	106.464
2005	266.953	5.280	13.959	6.800	0.443	NO	293.435
2010	568.550	2.324	18.550	7.816	NO	NO	597.240
2011	574.336	2.410	19.905	8.376	NO	NO	605.027
2012	597.847	2.764	19.118	8.466	NO	NO	628.195
2013	616.885	2.343	18.752	8.899	NO	NO	646.878
2014	623.422	2.190	18.990	9.238	NO	NO	653.840
2015	702.399	1.978	20.549	9.960	NO	NO	734.885
2016	638.972	1.967	22.252	10.178	NO	NO	673.370

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.						
2017	706.040	1.957	21.903	9.157	NO	NO	739.057
2018	670.955	1.947	20.955	8.914	NO	NO	702.771
2019	686.802	1.938	22.857	9.141	NO	NO	720.738
2020	645.665	1.928	22.151	9.133	NO	NO	678.876

Figure 4.11: *The share of emissions in the 2.F category according to the subcategories in 2020*

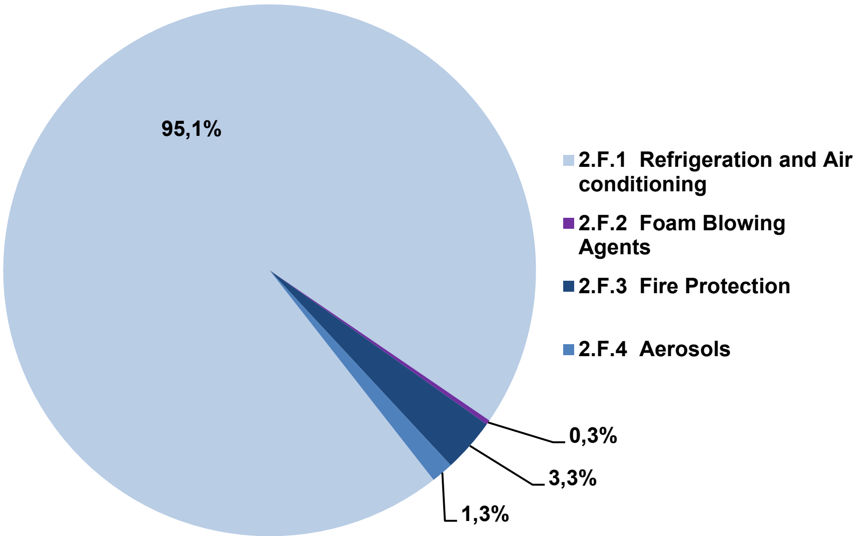
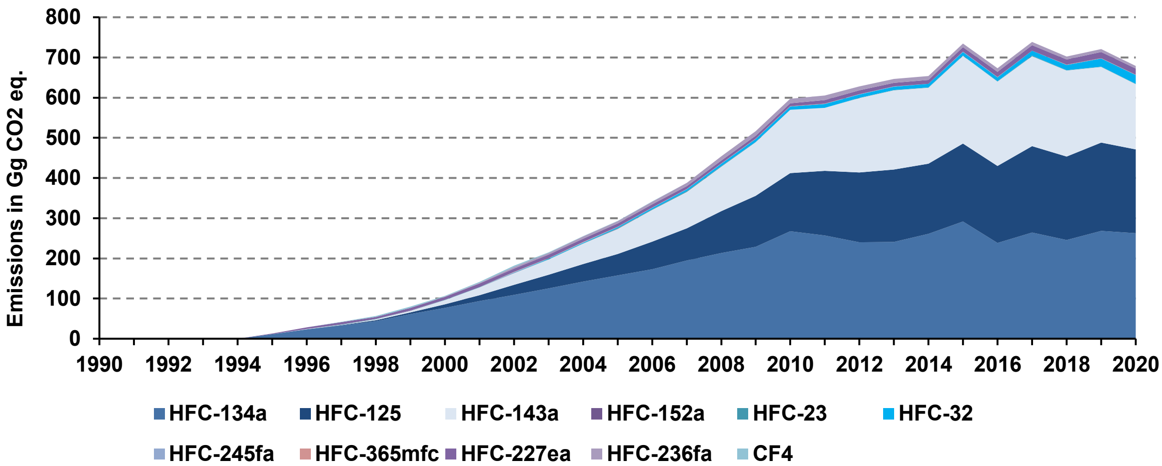


Figure 4.12: *Trend in individual gases (Gg CO_2 eq.) according to the categories in 1990 – 2020*



Total actual HFCs emissions reported in the category 2.F Product uses as substitutes for ODS were 678.876 Gg of CO_2 eq. in 2020 and they decreased by 6% compared to the previous year. The decrease is occurring 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 can occur in few next years.

Generally, increasing trend is visible since the base year and is caused by supplying HCFCs gases by the HFCs. 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 2020 the ratio is ca 4:1.

The actual emissions of PFCs in the category 2.F did not occur in 2020.

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.

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, no recalculation has been made.

4.12.8 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

No improvements are planned.

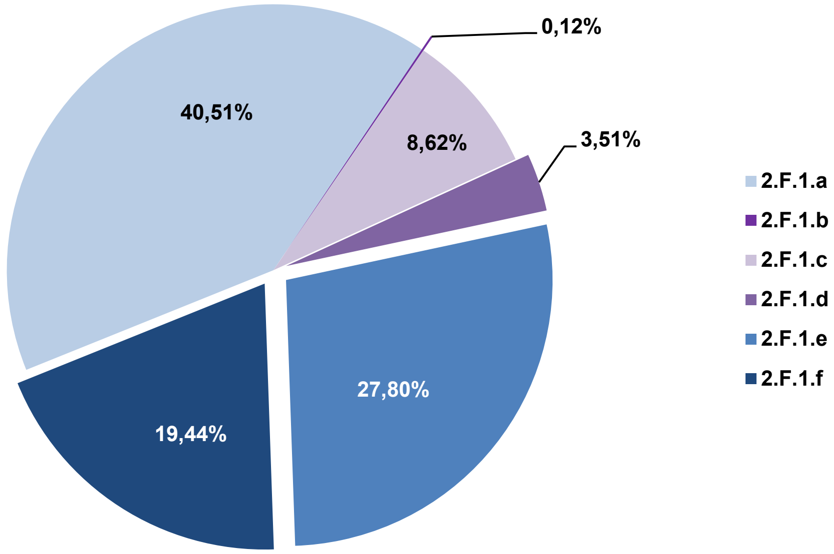
4.12.9 REFRIGERATION AND AIR CONDITIONING EQUIPMENT (CRF 2.F.1)

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 645.665 Gg of CO_2 eq. in 2020 and they decreased by 6% 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 occurred. It is caused by several reasons. One of them is end of using of new R404A gas with GWP 3922 (only recovered gas can be used since now). Another reason is using of new replacements of R404A with low GWP (in Slovakia new gases R448A (GWP 1387) and R449A (GWP 1397) were introduced into the market). It is expected that due to the above-mentioned Regulation the decrease will continue more significantly.

The emissions of PFCs 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 and HFC-152a in 2.F.1.a - Commercial refrigeration.
- HFC-134a in 2.F.1.b - Domestic refrigeration.
- HFC-32, HFC-125, HFC-134a, HFC-143a and HFC-152a 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 4.13: *The share of individual subcategories within the category 2.F.1 in 2020*



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 in 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 2020, 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, yet. The use of blends containing HFC-143a recorder a significant decrease. On the other hand the use of natural refrigerants is of increased importance in this submission.

Approximately 40% 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 (28%) in 2020 (***Figure 4.13***). This relates to the high share of automotive industry in last years in Slovakia. About 19% emissions are allocated in 2.F.1.f – Stationary AC, 8% 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 4.42-4.47***.

Figure 4.14: *The share of individual gases in the category 2.F.1 in 2020*

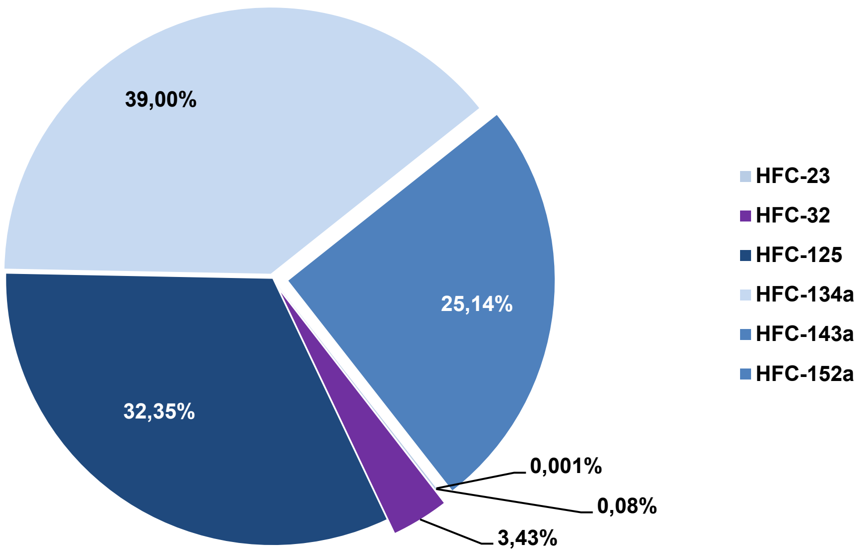


Table 4.43: *Aggregated data on HFCs use in the subcategory 2.F.1.a in particular years*

YEAR	NEW FILLINGS	NEW ADDITION TO BANK	BANK	RETIRED EQUIP.	EMISSIONS FROM:			RECOV.	TOTAL
					NEW FILLINGS	BANK	DISPO.		
	Gg CO_2 eq.								
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	2.535	4.470	4.470	NO	0.025	0.844	NO	NO	0.870
2000	33.933	59.330	122.778	NO	0.339	18.169	NO	NO	18.509
2005	83.295	109.242	622.122	3.443	0.833	88.347	2.630	0.814	92.464
2010	116.909	137.032	1 334.966	35.169	1.169	199.273	28.608	6.561	229.808
2011	85.433	135.156	1 398.752	52.985	0.854	183.755	43.211	9.774	228.608
2012	73.018	141.758	1 452.349	67.501	0.730	204.167	55.143	12.358	260.833
2013	80.593	154.303	1 504.274	79.572	0.806	214.459	65.107	14.465	281.170
2014	101.631	91.859	1 485.629	85.709	1.016	212.214	67.612	18.097	281.690
2015	113.639	105.765	1 466.922	96.739	1.136	236.164	81.040	15.699	319.280
2016	106.929	128.564	1 451.400	101.619	1.069	227.766	73.095	28.524	302.943
2017	71.960	81.544	1 388.417	120.250	0.720	216.750	110.470	9.780	328.868
2018	52.969	49.643	1 264.469	139.486	0.530	194.630	124.872	14.614	320.904
2019	43.632	43.210	1 140.230	134.707	0.436	180.633	125.290	9.416	307.359
2020	13.246	35.309	1 007.779	138.080	0.132	140.340	119.629	18.451	261.544

Table 4.44: *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:			RECOV.	TOTAL
					NEW FILLINGS	BANK	DISPO.		
	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	14.443	14.298	62.415	NO	0.144	0.312	NO	NO	0.457
2005	1.745	1.495	82.436	NO	0.017	0.412	NO	NO	0.430
2010	NO	0.208	76.972	4.719	NO	0.385	2.831	1.888	3.216
2011	NO	6.357	70.825	9.695	NO	0.354	5.817	3.878	6.171
2012	NO	10.523	65.300	12.555	NO	0.326	7.533	5.022	7.859
2013	NO	13.734	60.333	14.700	NO	0.302	8.820	5.880	9.121

2014	NO	1.827	48.326	10.826	NO	0.242	4.915	5.911	5.157
2015	NO	0.019	39.832	6.618	NO	0.199	4.745	1.873	4.944
2016	NO	NO	34.733	4.079	NO	0.174	2.871	1.207	3.045
2017	NO	NO	31.942	2.233	NO	0.160	1.585	0.648	1.745
2018	NO	NO	29.817	1.700	NO	0.149	1.411	0.289	1.560
2019	NO	NO	28.589	0.982	NO	0.143	0.935	0.048	1.078
2020	NO	NO	27.697	0.714	NO	0.138	0.658	0.056	0.796

Table 4.45: *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:			RECOV.	TOTAL
					NEW FILLINGS	BANK	DISPO.		
	Gg CO_2 eq.								
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	3.766	0.721	0.721	NO	0.038	0.107	NO	NO	0.144
2000	39.539	8.608	17.426	NO	0.395	2.297	NO	NO	2.693
2005	96.033	15.966	90.928	NO	0.960	11.727	NO	NO	12.687
2010	134.236	13.852	203.027	0.115	1.342	25.957	0.070	0.045	27.370
2011	146.067	142.687	345.232	0.346	1.461	33.344	0.232	0.114	35.037
2012	95.305	77.158	421.615	0.544	0.953	54.013	0.380	0.164	55.347
2013	86.625	57.588	477.928	0.923	0.866	56.516	0.678	0.244	58.061
2014	53.384	55.605	531.453	1.411	0.534	47.637	0.971	0.440	49.142
2015	50.895	54.105	581.819	2.673	0.509	54.476	2.196	0.477	57.181
2016	49.189	53.309	629.151	4.268	0.492	55.937	3.070	1.198	59.499
2017	49.646	51.971	672.514	6.534	0.496	60.840	5.973	0.561	67.310
2018	58.899	98.449	760.025	8.292	0.589	50.342	7.429	0.863	58.361
2019	22.308	64.846	811.348	10.583	0.223	45.938	9.885	0.698	56.045
2020	6.488	15.527	811.700	11.760	0.065	45.368	10.221	1.539	55.654

Table 4.46: *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:			RECOV.	TOTAL
					NEW FILLINGS	BANK	DISPO.		
	Gg CO_2 eq.								
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	NO	1.271	1.271	NO	NO	0.267	NO	NO	0.267
2000	2.895	4.414	13.036	NO	0.029	2.331	NO	NO	2.360
2005	6.708	9.689	48.245	0.760	0.067	7.294	0.480	0.280	7.841
2010	10.539	13.034	95.354	3.347	0.105	15.059	2.527	0.820	17.691
2011	13.163	18.316	105.337	3.796	0.132	14.667	2.863	0.933	17.662
2012	11.273	15.661	111.532	4.277	0.113	16.153	3.237	1.040	19.503
2013	5.184	6.413	107.369	4.796	0.052	15.700	3.650	1.146	19.402
2014	1.803	1.795	97.125	5.581	0.018	12.925	3.971	1.610	16.914
2015	4.929	4.929	88.388	5.981	0.049	22.878	4.813	1.167	27.740
2016	3.488	9.971	83.414	6.934	0.035	23.970	4.887	2.047	28.892
2017	2.881	6.314	73.581	8.437	0.029	21.202	7.436	1.002	28.666
2018	3.661	4.605	62.437	7.583	0.037	20.550	6.655	0.928	27.242
2019	1.216	2.187	49.781	7.837	0.012	20.547	7.305	0.532	27.864
2020	0.649	1.390	38.891	8.494	0.006	15.185	7.445	1.049	22.637

***Table 4.47:** 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:			RECOV.	TOTAL
					NEW FILLINGS	BANK	DISPO.		
	Gg CO_2 eq.								
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	23.627	65.128	65.128	NO	0.236	7.125	NO	NO	7.361
2000	70.880	84.504	425.276	NO	0.709	46.525	NO	NO	47.234
2005	118.134	127.856	986.570	NO	1.181	107.931	NO	NO	109.112
2010	264.693	128.391	1 445.796	33.058	2.647	182.350	19.835	13.223	204.832
2011	302.645	143.363	1 514.098	34.456	3.026	164.830	20.673	13.782	188.529
2012	438.012	76.648	1 509.551	35.599	4.380	150.559	21.359	14.239	176.298
2013	454.154	62.491	1 480.852	40.593	4.542	144.204	24.356	16.237	173.102
2014	357.195	62.297	1 442.423	45.600	3.572	165.511	20.703	24.898	189.785
2015	533.434	74.259	1 407.014	50.569	5.334	169.631	36.258	14.311	211.223
2016	445.105	34.295	1 323.547	55.590	4.451	116.533	39.135	16.455	160.120
2017	215.818	26.471	1 226.017	59.183	2.158	136.535	42.020	17.163	180.713
2018	286.510	13.389	1 109.647	62.491	2.865	117.564	51.867	10.623	172.296
2019	248.058	24.825	1 000.835	64.805	2.481	118.541	61.662	3.143	182.684
2020	175.167	18.353	882.094	67.118	1.752	115.951	61.823	5.296	179.526

***Table 4.48:** 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:			RECOV.	TOTAL
					NEW FILLINGS	BANK	DISPO.		
	Gg CO_2 eq.								
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	13.982	13.982	13.982	NO	0.140	2.441	NO	NO	2.581
2000	35.474	23.322	103.369	NO	0.355	16.870	NO	NO	17.225
2005	78.509	40.914	293.972	NO	0.785	43.634	NO	NO	44.419
2010	116.843	40.231	560.648	12.606	1.168	76.729	7.736	4.870	85.633
2011	116.089	109.959	653.410	13.213	1.161	88.927	8.241	4.971	98.330
2012	132.554	125.023	759.002	14.532	1.326	67.343	9.339	5.192	78.008
2013	98.089	88.265	823.904	17.342	0.981	63.654	11.395	5.947	76.030
2014	50.715	94.492	889.505	21.851	0.507	67.417	12.810	9.041	80.735
2015	107.496	143.378	998.754	26.315	1.075	61.575	19.378	6.936	82.029
2016	59.545	103.314	1 063.523	30.008	0.595	64.149	19.730	10.278	84.474
2017	274.137	193.437	1 215.134	32.506	2.741	69.813	26.183	6.324	98.737
2018	104.111	154.098	1 322.667	35.798	1.041	60.255	29.297	6.502	90.592
2019	71.636	83.854	1 355.104	38.761	0.716	76.353	34.703	4.058	111.772
2020	58.668	52.707	1 347.390	47.368	0.587	84.238	40.683	6.685	125.508

4.12.9.1 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 2020, 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 4.49***. 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 4.49*** 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 4.49: 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 2020 are presented in ***Table 4.50***. 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 4.51***. For years before 2013, the average value of the years 2014 and 2015 is assumed.

Table 4.50: Comparison of amount of gases in retired units and amount of recovered gases in 2020

F-GAS	AMOUNT IN RETIRED EQUIPMENT	RECOVERY AMOUNT	RATIO
	t		
HFC-23	0.014	NO	-
HFC-32	11.358	1.8104	15.9%
HFC-125	26.676	4.2514	15.9%
HFC-134a	58.964	4.6533	7.9%
HFC-143a	19.680	2.3083	11.7%
HFC-152a	NO	NO	-

Table 4.51: 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	-

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 4.51***. 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-134a, R-404A, R-32, R-407C, R-410A, R-448A, R-406, R-449A, R-452A, R-600A, R-290, R-507, R-407A, R-407F, R-407H, R-23, R-508B, R-422A, R-422D, R-417A, CO_2 and 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 4.49*** and the recovered fraction is presented in ***Table 4.51***.

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 4.49*** and the recovered fraction is presented in ***Table 4.51***.

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-407C,

R-404A, R-407F, R-417A, R-449A, R-452A, R-32, R-410A, R-407A, R-422D, R-448A, R-600a, R-407H, R-437A, R-290, R-507 and R-1234ZE. 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 4.49*** and the recovered fraction is presented in ***Table 4.51***.

2.F.1.d – Transport Refrigeration: This group includes refrigerated road vehicles. Recently used refrigerants are: R-134a, R-404A, R-410A, R-452A, R-407C, R-32, R-449A and CO_2. 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 4.49*** and the recovered fraction is presented in ***Table 4.51***.

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 2020, 84 909 new vehicles were registered in Slovakia. In these vehicles, the average charge was assumed 0.123 kg of HFC per one new car in 2020. 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 2020, the average charge was 0.572 kg while the share of HFC-134a was 21.6%). 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 19 119 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 4.52***.

Table 4.52: *Loads of HFCs into new vehicles*

YEAR	UNIT	2016	2017	2018	2019	2020
Number of produced vehicles	*No.*	1 095 191	1 266 289	1 093 215	1 122 067	990 598
Amount of HFC-134a used in new vehicles	*t*	310.517	150.150	199.950	173.113	122.211
Amount of HFO-1234yf used in new vehicles	*t*	354.577	386.606	532.000	461.324	444.738
Fraction of HFC-134a from total HFC use		0.4669	0.2797	0.2732	0.2729	0.2156
Average HFC load per one vehicle	*kg*	0.607	0.424	0.670	0.565	0.572
Average HFC-134a load per one vehicle	*kg*	0.284	0.119	0.183	0.154	0.123

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 4.49*** and the recovered fraction is presented in ***Table 4.51***.

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 includes 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-134a, R-32, R-407C, R-410A, R-404A, R-449A, R-407H, R-417A, R-437A, R-600A, R-1234YF, R-407A, R-290, R-507, R-422D, CO_2, R-401A and R-513A. 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 4.49*** and the recovered fraction is presented in ***Table 4.51***.

4.12.9.2 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 emissions 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 4.53*** 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.

Table 4.53: *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 uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

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 1.93 Gg CO_2 eq. in 2020 (***Table 4.54***).

4.12.10.1 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 4.54: *Aggregated data on HFCs using in the category 2.F.2 in particular years*

YEAR	NEW FILLINGS	BANK	RETIRED EQUIP.	EMISSIONS FROM:			RECOV.	TOTAL
				NEW FILLINGS	BANK	DISPO.		
	Gg CO_2 eq.							
1990	NO	NO	NO	NO	NO	NO	NO	NO
1995	NO	NO	NO	NO	NO	NO	NO	NO
2000	58.916	53.024	NO	5.892	0.265	NO	NO	6.157
2005	37.685	302.363	NO	3.769	1.512	NO	NO	5.280
2010	4.013	384.517	NO	0.401	1.923	NO	NO	2.324
2011	4.789	386.206	NO	0.479	1.931	NO	NO	2.410
2012	8.209	388.584	NO	0.821	1.943	NO	NO	2.764
2013	3.724	394.030	NO	0.372	1.970	NO	NO	2.343
2014	2.126	395.411	NO	0.213	1.977	NO	NO	2.190
2015	0.014	395.348	NO	0.001	1.977	NO	NO	1.978
2016	NO	393.384	NO	NO	1.967	NO	NO	1.967
2017	NO	391.417	NO	NO	1.957	NO	NO	1.957
2018	NO	389.460	NO	NO	1.947	NO	NO	1.947
2019	NO	387.513	NO	NO	1.938	NO	NO	1.938
2020	NO	385.575	NO	NO	1.928	NO	NO	1.928

4.12.10.2 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 uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

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 22.15 Gg CO_2 eq. in 2020.

4.12.11.1 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 4.55: *Aggregated data on HFCs used in the category 2.F.3 in particular years*

YEAR	NEW FILLINGS	NEW ADDITION TO BANK	BANK	RETIRED EQUIP.	EMISSIONS FROM: NEW FILLINGS	EMISSIONS FROM: BANK	EMISSIONS FROM: DISPO.	RECOV.	TOTAL
	Gg CO_2 eq.								
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	32.499	32.361	35.395	NO	0.325	1.770	NO	NO	2.095
2000	31.170	31.057	148.665	NO	0.312	7.433	NO	NO	7.745

YEAR	NEW FILLINGS	NEW ADDITION TO BANK	BANK	RETIRED EQUIP.	EMISSIONS FROM:			RECOV.	TOTAL
					NEW FILLINGS	BANK	DISPO.		
	Gg CO_2 eq.								
2005	22.969	22.908	274.578	NO	0.230	13.729	NO	NO	13.959
2010	16.616	16.255	367.681	NO	0.166	18.384	NO	NO	18.550
2011	40.996	40.761	389.892	NO	0.410	19.495	NO	NO	19.905
2012	10.712	10.236	380.223	NO	0.107	19.011	NO	NO	19.118
2013	11.992	11.529	372.633	NO	0.120	18.632	NO	NO	18.752
2014	21.861	21.539	375.421	NO	0.219	18.771	NO	NO	18.990
2015	40.939	46.356	402.788	NO	0.409	20.139	NO	NO	20.549
2016	30.736	26.062	400.248	6.442	0.307	20.012	1.933	4.510	22.252
2017	36.178	15.873	386.583	7.374	0.362	19.329	2.212	5.162	21.903
2018	20.658	11.593	369.259	7.382	0.207	18.463	2.286	5.096	20.955
2019	37.199	27.296	358.067	15.855	0.372	17.903	4.582	11.273	22.857
2020	23.611	7.772	340.958	5.285	0.236	17.048	4.867	0.419	22.151

4.12.11.2 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 uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

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 9.13 Gg of CO_2 eq. in 2020. The production of MDI does not occur in Slovakia.

4.12.12.1 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 4.56: *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
2000	NO	2.667	NO	2.667	2.667
2005	NO	6.800	NO	6.800	6.800
2010	NO	7.816	NO	7.816	7.816
2011	NO	8.376	NO	8.376	8.376
2012	NO	8.466	NO	8.466	8.466
2013	NO	8.899	NO	8.899	8.899
2014	NO	9.238	NO	9.238	9.238
2015	NO	9.960	NO	9.960	9.960
2016	NO	10.178	NO	10.178	10.178
2017	NO	9.157	NO	9.157	9.157
2018	NO	8.914	NO	8.914	8.914

YEAR	FILLED INTO NEW PRODUCTS	BANK	EMISSIONS FROM:		TOTAL EMISSIONS
			NEW FILLINGS	BANK	
	Gg CO_2 eq.				
2019	NO	9.141	NO	9.141	9.141
2020	NO	9.133	NO	9.133	9.133

4.12.12.2 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 analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

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 2020. 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 4.57: *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	0.680	NO	0.680	0.680
1998	NO	2.253	NO	2.253	2.253
1999	NO	2.857	NO	2.857	2.857

YEAR	FILLED INTO NEW PRODUCTS	BANK	EMISSIONS FROM:		TOTAL EMISSIONS
			NEW FILLINGS	BANK	
	Gg CO_2 eq.				
2000	NO	1.420	NO	1.420	1.420
2001	NO	2.501	NO	2.501	2.501
2002	NO	3.695	NO	3.695	3.695
2003	NO	1.774	NO	1.774	1.774
2004	NO	0.776	NO	0.776	0.776
2005	NO	0.443	NO	0.443	0.443
2006	NO	0.111	NO	0.111	0.111

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 – 2020.

4.13 OTHER PRODUCT MANUFACTURE (CRF 2.G)

4.13.1 SOURCE CATEGORY DESCRIPTION

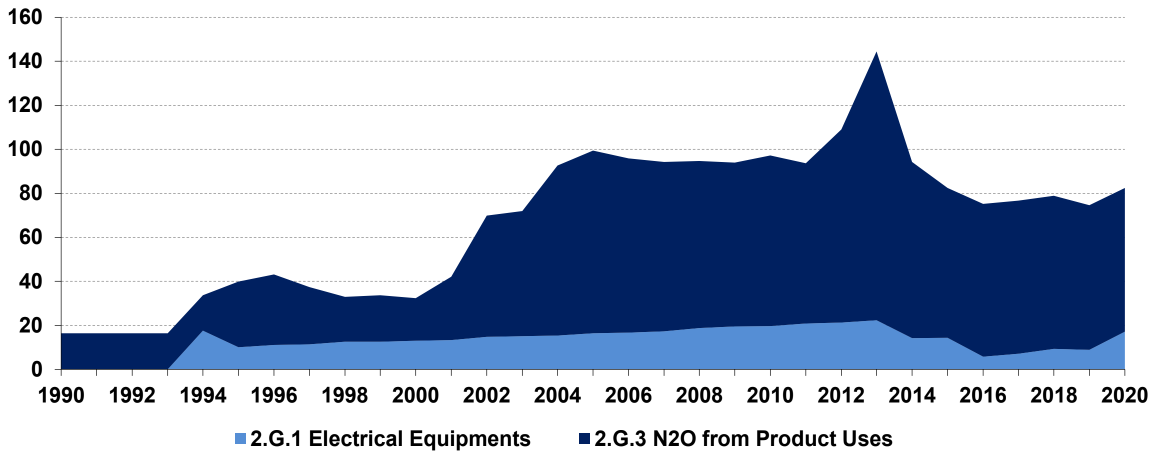
Emissions of SF_6 from the high voltage switchgears and emissions of N_2O from use for anaesthesia and in food industry (aerosol cans) are reported in this category. Total emissions in CO_2 eq. were 82.43 Gg in 2020, increased by 10% in comparison with the previous year. The increase is caused by increased 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 4.58: *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	16.39
1995	10.15	IE	29.79
2000	13.04	IE	19.36
2005	16.38	IE	83.01
2010	19.62	IE	77.66
2011	20.80	IE	72.91
2012	21.24	IE	87.76
2013	22.30	IE	122.23
2014	14.17	IE	80.03
2015	14.31	IE	68.11
2016	5.82	IE	69.43
2017	7.08	IE	69.67
2018	9.39	IE	69.49

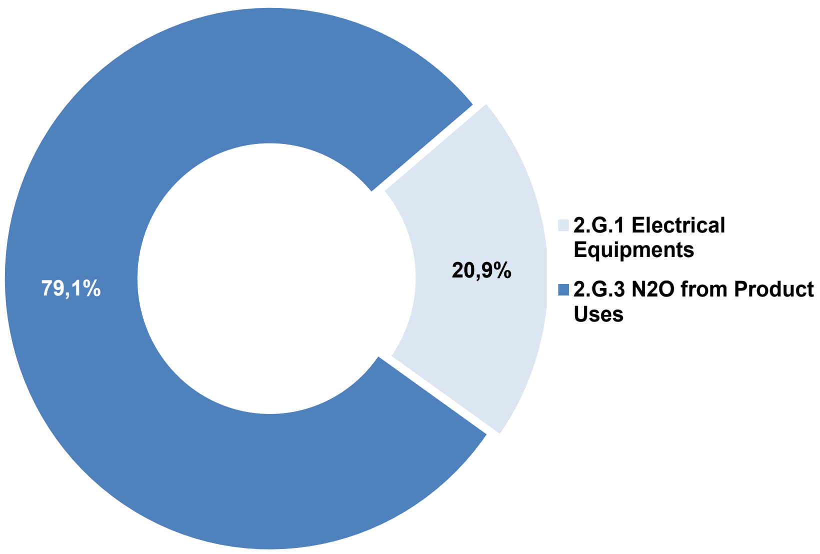
YEAR	2.G.1 ELECTRICAL EQUIPMENT	2.G.2 SF_6 AND PFCs FROM OTHER PRODUCT USE	2.G.3 N_2O FROM PRODUCT USE
	Gg of CO_2 eq.		
2019	8.86	IE	65.83
2020	17.20	IE	65.23

Figure 4.15: *The trend of individual subcategories (Gg of CO_2 eq.) in the category 2.G in 1990 – 2020*



The major share (79.1%) in emissions belongs to the N_2O emissions from the product use, 20.9% belongs to SF_6 emissions from electrical equipment.

Figure 4.16: *The share in GHG emissions on individual categories of the 2.G in 2020*



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 17.20 Gg CO_2 eq. (0.754 t SF_6) in 2020 (***Table 4.59***). 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 4.59: *SF_6 emissions in the category 2.G.1 in particular years*

YEAR	NEW FILLINGS	NEW ADDITION TO BANK	BANK	RETIRED EQUIP.	EMISSIONS FROM:			RECOV.	TOTAL
					NEW FILLINGS	BANK	DISPO.		
	Gg CO_2 eq.								
1990	2.918	2.918	2.918	NO	0.029	0.029	NO	NO	0.058
1995	69.973	61.131	945.498	NO	0.700	9.455	NO	NO	10.155
2000	53.147	41.047	1 251.253	NO	0.531	12.513	NO	NO	13.044
2005	85.956	71.145	1 552.461	NO	0.860	15.525	NO	NO	16.384
2010	67.511	49.015	1 898.805	NO	0.675	18.949	NO	NO	19.624
2011	99.271	80.286	1 979.090	NO	0.993	19.809	NO	NO	20.802
2012	82.627	62.839	2 041.929	NO	0.826	20.417	NO	NO	21.244
2013	62.472	47.880	2 079.321	10.488	0.625	21.500	0.178	10.31	22.303
2014	45.809	60.863	2 006.765	133.419	0.458	11.442	2.268	131.15	14.168
2015	117.429	148.235	2 144.193	10.806	1.174	12.956	0.184	10.623	14.314
2016	6.505	160.275	2 286.855	17.614	0.065	5.454	0.299	17.314	5.818
2017	17.106	83.992	2 361.321	9.526	0.171	6.750	0.162	9.364	7.083
2018	39.159	72.272	2 411.738	21.856	0.392	8.618	0.383	21.473	9.393
2019	9.060	45.445	2 436.303	20.880	0.091	8.421	0.353	20.527	8.865
2020	4.071	37.535	2 460.870	12.969	0.041	16.935	0.226	12.743	17.201

4.13.2.1 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 2020);
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 98.3% of SF_6 is recovered for repeated used or destroyed (in 2020, 0.086 t was destroyed). Thus, the disposal loss factor is 1.7%. 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.

4.13.2.2 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 uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

4.13.3 USE OF SF_6 AND PFC_S 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 – 2020. 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 199.1 t and total N_2O emissions from anaesthesia were 19.8 t in 2020.

4.13.4.1 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 4.60***.

Table 4.60: *N_2O emissions from product use in particular years*

YEAR	TOTAL N_2O		
	2.G	2.G.3.a MEDICAL APPL. (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
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

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.

4.13.4.2 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. The uncertainty analysis is presented in the SVK NIR 2017 and 2018. This approach has been chosen because no changes of uncertainties in IPPU subcategories and no changes in methodology of any subcategory have been made. The results of the uncertainty analysis of the subcategories (probability density function, percentiles, overall uncertainty) are nearly the same as in the previous submission. Therefore, the calculation of the statistical characteristics in the subcategories will be made every third year since this submission or it has been made in the case when the methodology or uncertainties of any used data is changed.

4.14 OTHER PRODUCTION (CRF 2.H)

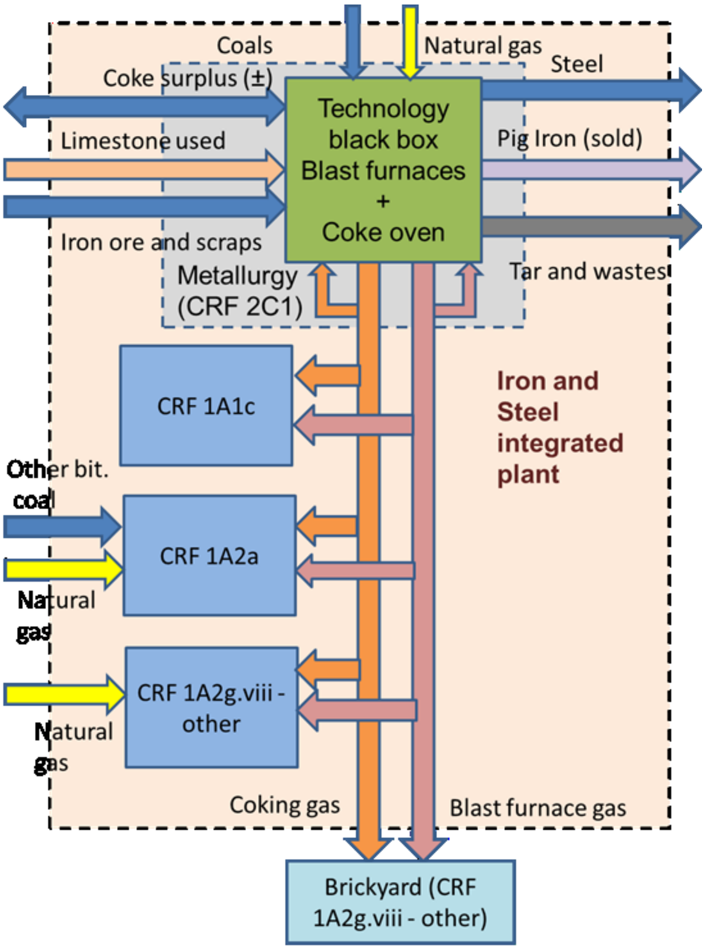
The NMVOC emissions mainly from food industry were reported in this category in 2020. Total emissions of NMVOC were 2 998 t and are consistent with the CLRTAP inventory. No GHG emissions occurred in the time series 1990 – 2020.

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 2020*

STREAM	AD	NCV	EF (C)	CARBON
	kt; mil. m^3	*TJ /m.j.*	*t/TJ; mass fraction*	*kt*
Coking coal	1 905.69	29.534	25.484	1 434.31
Anthracite	9.11	26.415	28.407	6.84
Coke surplus	92.42	24.272	29.428	66.01
Natural gas	17.15	35.009	15.207	9.13
Tar and wastes	-1 385.41	NA	0.043	-60.22
Coking gas	-477.18	16.011	11.458	-87.54
Blast furnace gas	-2 687.21	3.014	74.855	-606.27
Iron ore	5 347.99	NA	3.273E-03	17.50
Steel	-3 119.01	NA	7.990E-04	-2.49
Pig iron sold	NO	NA	NO	0.00
Limestone used	650.71	NA	1.201E-01	78.14
TOTAL	**855.41**			

CO_2 emissions estimation in the 2.C.1 is based on the carbon balance (from that plant) and represents the value 3 136.29 Gg (total carbon × 44/12).

Table A4.1.2: *Balance of the category 1.A.1.c in 2020*

STREAM	AD	NCV	EF (C)	CARBON
	kt; mil. m^3	*TJ /m.j.*	*t/TJ; mass fraction*	*kt*
Natural gas	0.162	35.009	15.21	0.09
Coking gas	110.36	16.01	11.46	20.25
Blast furnace gas	1 052.79	3.01	74.86	237.52
TOTAL	**257.85**			

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 945.46 Gg (total carbon × 44/12).

Table A4.1.3: *Balance of the category 1.A.2.a in 2020*

STREAM	AD	NCV	EF (C)	CARBON
	kt; mil. m^3	*TJ /m.j.*	*t/TJ; mass fraction*	*kt*
Other bituminous coal	293.55	26.113	25.492	195.41
Natural gas	13.91	35.009	15.207	7.41
Coking gas	212.89	16.011	11.458	39.06
Blast furnace gas	1 394.27	3.014	74.855	314.57
TOTAL	**556.44**			

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 2 040.27 Gg (total carbon × 44/12).

Table A4.1.4: *Balance of 1.A.2.g.viii – Other in 2020*

STREAM	AD	NCV	EF (C)	CARBON
	kt; mil. m^3	*TJ /m.j.*	*t/TJ; mass fraction*	*kt*
Natural gas	95.32	35.009	15.207	50.75
Coking gas	153.68	16.011	11.458	28.19
Blast furnace gas	240.15	3.014	74.855	54.18
TOTAL	**133.12**			

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 488.10 Gg (total carbon × 44/12).

The output from the plant was 0.249 mil. m^3 of coking gas and 0 mil. m^3 of blast furnace gas in 2020. 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 0.06%: (i) NIR: 6 612.32 Gg CO_2; (ii) EU ETS: 6 608.22 Gg CO_2. It should be noted that in both values compared the CO_2 from desulphurization and DENOX applications are included (1.57 and 0.63 Gg CO_2).

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.

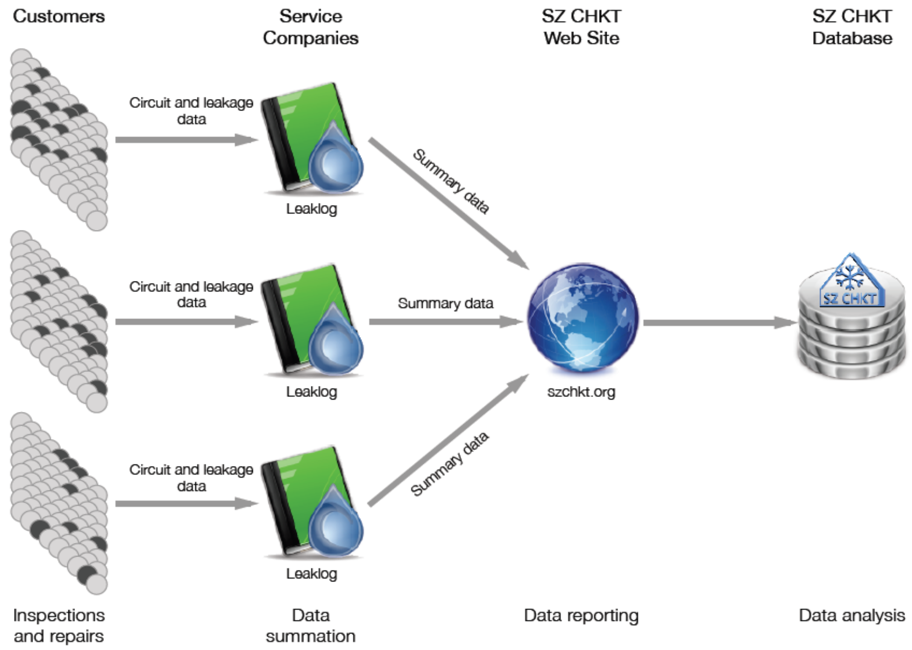
In the year 2003, Slovakia started software with access to the processing and data assessment. This software system is based on the activities of the Slovak Association for Cooling and Air-conditioning Technology (SZCHKT). The electronically led documentations have been developed from the previous paper 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	08 Move of substances during the year

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.

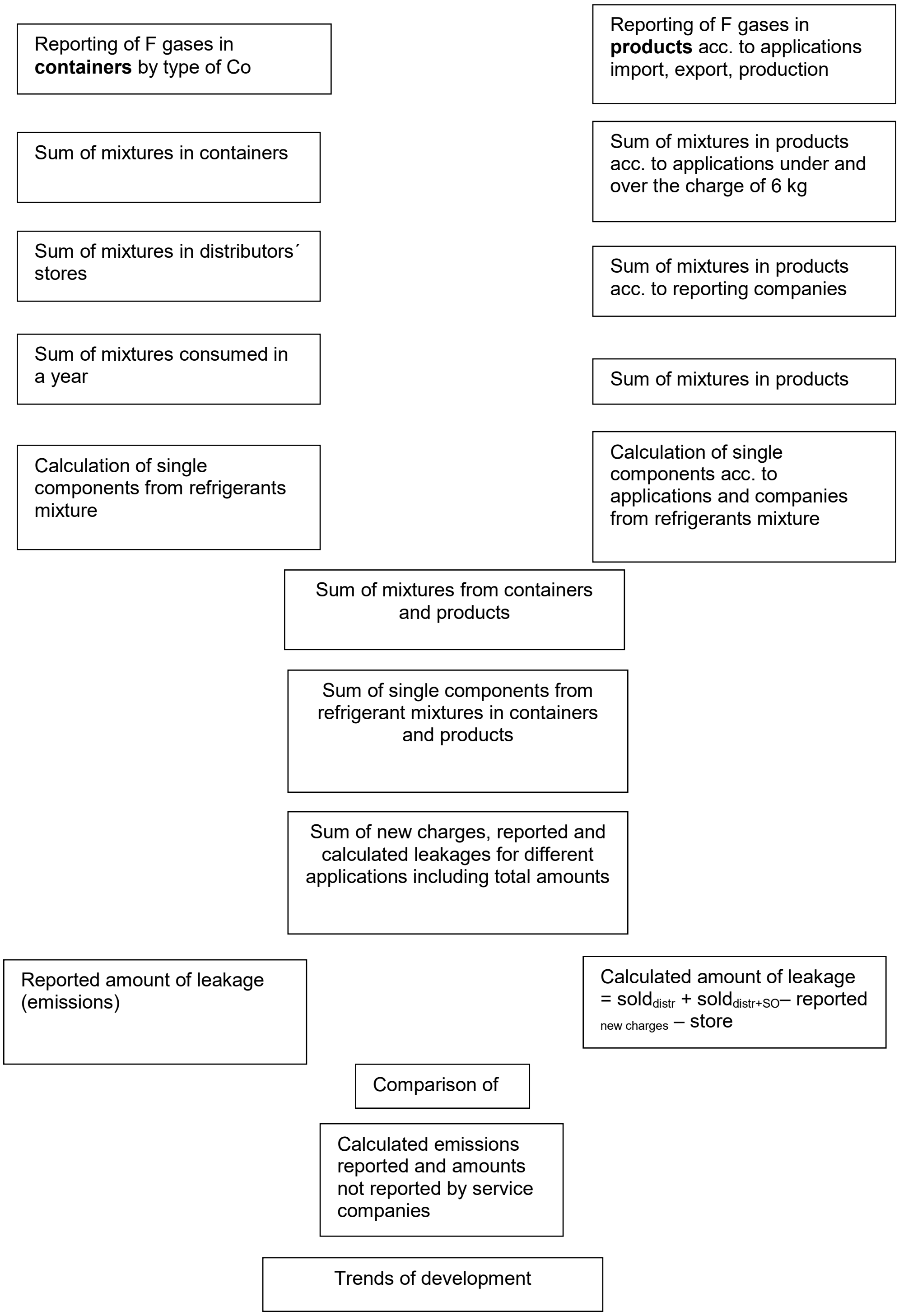
All companies dealing with the F-gases have access to the electronic system based on certificate provided by the Notified Body. Advantages of electronic data logging and reporting are in the possibilities of automatic analysis, fault detection and comparison of, fast access to the full history of leak 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)

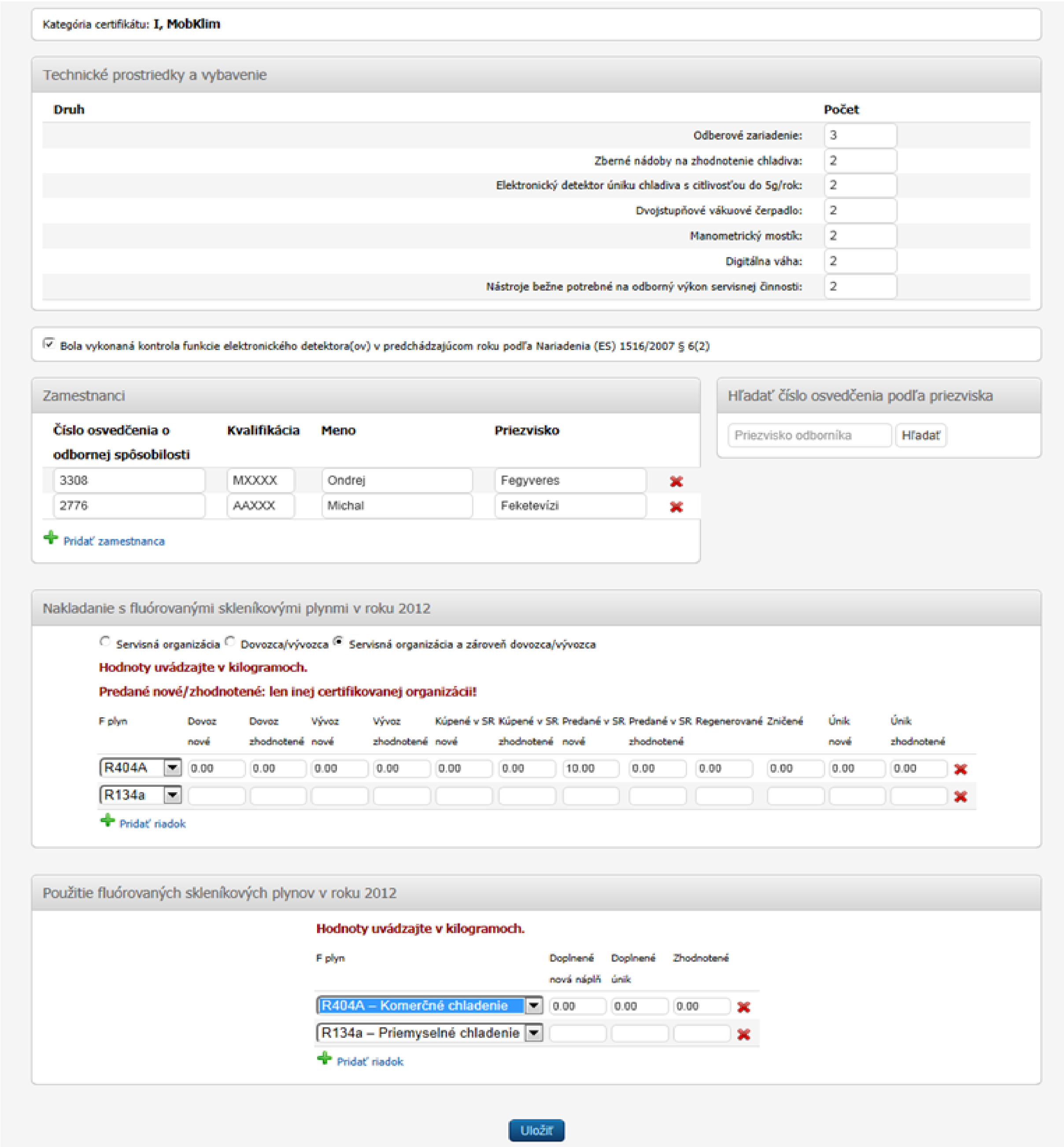
Figure A4.2.2: *Diagram of data flow in reporting (data flow direction: top to down)*



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*



Kategória certifikátu: **I, MobKlim**

Technické prostriedky a vybavenie

Druh	Počet
Odberové zariadenie:	3
Zberné nádoby na zhodnotenie chladiva:	2
Elektronický detektor úniku chladiva s citlivosťou do 5g/rok:	2
Dvojstupňové vákuové čerpadlo:	2
Manometrický mostík:	2
Digitálna váha:	2
Nástroje bežne potrebné na odborný výkon servisnej činnosti:	2

☑ Bola vykonaná kontrola funkcie elektronického detektora(ov) v predchádzajúcom roku podľa Nariadenia (ES) 1516/2007 § 6(2)

Zamestnanci

Číslo osvedčenia o odbornej spôsobilosti	Kvalifikácia	Meno	Priezvisko
3308	MXXXX	Ondrej	Fegyveres
2776	AAXXX	Michal	Feketevízi

Pridať zamestnanca

Hľadať číslo osvedčenia podľa priezviska

Priezvisko odborníka | Hľadať

Nakladanie s fluórovanými skleníkovými plynmi v roku 2012

○ Servisná organizácia ○ Dovozca/vývozca ● Servisná organizácia a zároveň dovozca/vývozca

Hodnoty uvádzajte v kilogramoch.

Predané nové/zhodnotené: len inej certifikovanej organizácii!

F plyn	Dovoz nové	Dovoz zhodnotené	Vývoz nové	Vývoz zhodnotené	Kúpené v SR nové	Kúpené v SR zhodnotené	Predané v SR nové	Predané v SR zhodnotené	Regenerované	Zničené	Únik nové	Únik zhodnotené
R404A	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00
R134a												

Pridať riadok

Použitie fluórovaných skleníkových plynov v roku 2012

Hodnoty uvádzajte v kilogramoch.

F plyn	Doplnené nová náplň	Doplnené únik	Zhodnotené
R404A – Komerčné chladenie	0.00	0.00	0.00
R134a – Priemyselné chladenie			

Pridať riadok

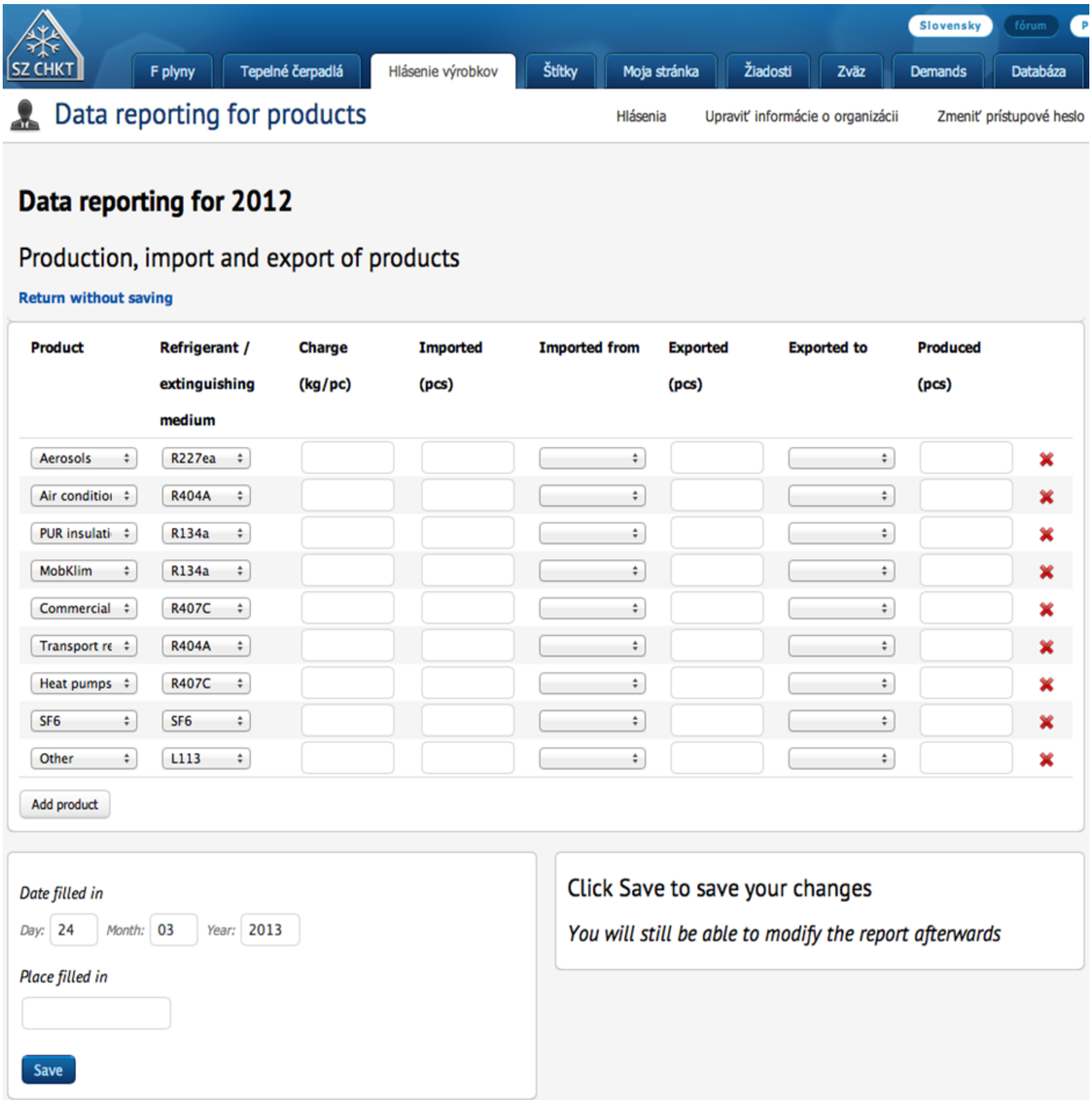
Uložiť

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

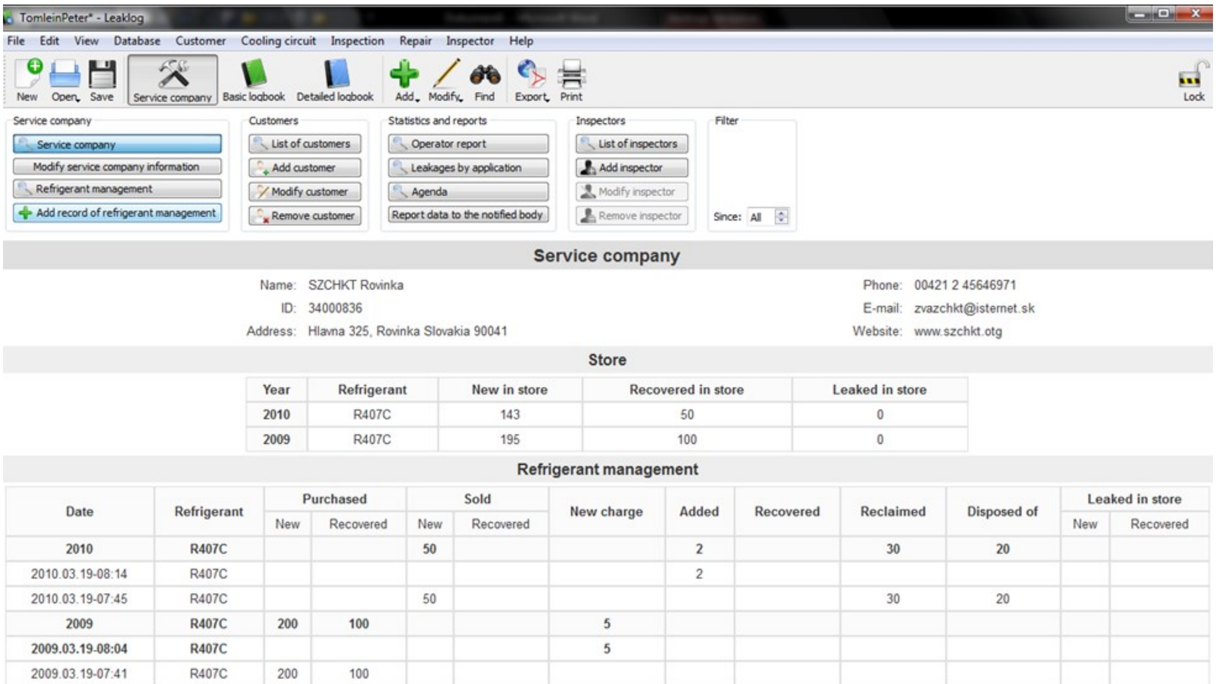
Almost complete activity data used for inventory preparation in the category 2.F is covered by the web reporting system Leaklog. Especially the refrigeration is very complex, there are numerous of small enterprises. This web reporting system receives data from more than 1 200 companies. This system was 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***).

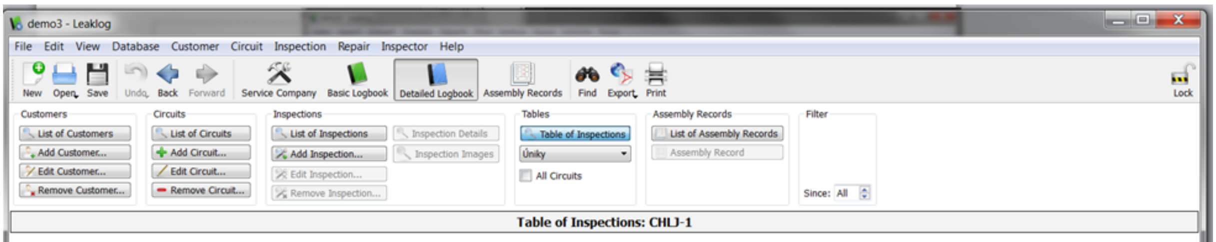
Figure A4.2.5: *Main outputs of logbook*



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*



ID	Company	Address	E-mail	Phone
00000001	OBAL a.s. Nové Mesto nad Váhom			

ID	Name	Device	Manufacturer	Type	Year of purchase	Commissioned on	Refrigerant	Oil
00001	CHLJ-1	Proxy -zváracia linka	Proxy		1996	07/05/2009	8 kg R22	1 kg AB (Alkylbenzene oil)

Date	Visual and aural check				Direct leak check (location)			Refrigerant addition	Annual leakage	Refrigerant recovery	Oil addition	Inspector	Operator	Remedies	Assembly record No.
	Corr/Def	Noise/Vibr	Bubble/Level	Oil leak	Electronic detection	UV detection	Bubble detection	kg	%	kg	kg				
15/12/1999 09:52	No	No	No	No	Yes	No	Yes	0.0	0	0.0	0.0	Matúš	Vedúci	Vyčistenie výparnika	
13/12/2000 10:25	No	No	No	No	Yes	No	Yes	0.0	0	0.0	0.0	Matúš	vedúci		
30/03/2001 12:04	No	No	No	No	Yes	No	Yes	0.0	0	0.0	0.0	Peter	Karol		
18/02/2002 12:12	No	No	No	No	Yes	No	Yes	0.5	6.25	0.0	0.0	Matúš	vedúci	8 vadny schreder...	
13/08/2002 12:14	No	No	No	No	Yes	No	Yes	0.0		0.0	0.0	Peter	Karol	Vyčistenie ventil...	2012-1-8-oprava
03/03/2003 12:30	No	No	No	No	Yes	No	Yes	0.0	0	0.0	0.0	Matúš	vedúci		
04/11/2003 12:31	No	No	No	No	Yes	No	Yes	0.0		0.0	0.0	Matúš	vedúci		
03/02/2004 12:39	No	No	No	No	Yes	No	Yes	0.5	18.75	0.0	0.0	Matúš	vedúci	žistenie kondenzá...	
08/09/2004 12:40	No	No	No	No	Yes	No	Yes	1.0		0.0	0.0	Matúš	vedúci	výmena matice a t...	
03/03/2005 12:42	No	No	No	No	Yes	No	Yes	0.0	0	0.0	0.0	Matúš	vedúci		
03/03/2005 12:58	No	No	No	No	Yes	No	Yes	0.0		0.0	0.0	Matúš	vedúci		
03/03/2006 13:00	No	No	No	No	Yes	No	Yes	1.5	43.75	0.0	0.0	Matúš	vedúci	vadný pertel 80...	
24/11/2006 13:01	No	No	No	No	Yes	No	No	2.0		0.0	0.0	Matúš	vedúci	praskla trubka	
04/04/2007 13:13	No	No	No	No	Yes	No	Yes	0.0	18.75	0.0	0.0	Matúš	vedúci		
13/05/2007 13:09	No	No	No	No	No	No	Yes	0.0		0.0	0.0	Matúš	vedúci		
15/05/2007 13:06	No	No	No	No	Yes	No	Yes	1.5		0.0	0.0	Jozef Mrkvička	vedúci	vymena tesnenia	
Sum								7	9.72222	0	0				

Date	Warnings
18/02/2002 12:12	Refrigerant leakage above limit, *Únik chladiva
03/02/2004 12:39	Refrigerant leakage above limit
08/09/2004 12:40	**Refrigerant leakage above limit**
03/03/2006 13:00	Refrigerant leakage above limit
24/11/2006 13:01	**Refrigerant leakage above limit**
04/04/2007 13:13	*Netesnosť ventilov kompresora, *Zanesenie kondenzátora
15/05/2007 13:06	Refrigerant leakage above limit, *Únik chladiva
Needs inspection	

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	Industrial refrigeration	Transport refrigeration	Air conditioning	Heat pumps	Domestic refrigeration
	Average leakage	Average leakage	Average leakage	Average leakage	Average leakage	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

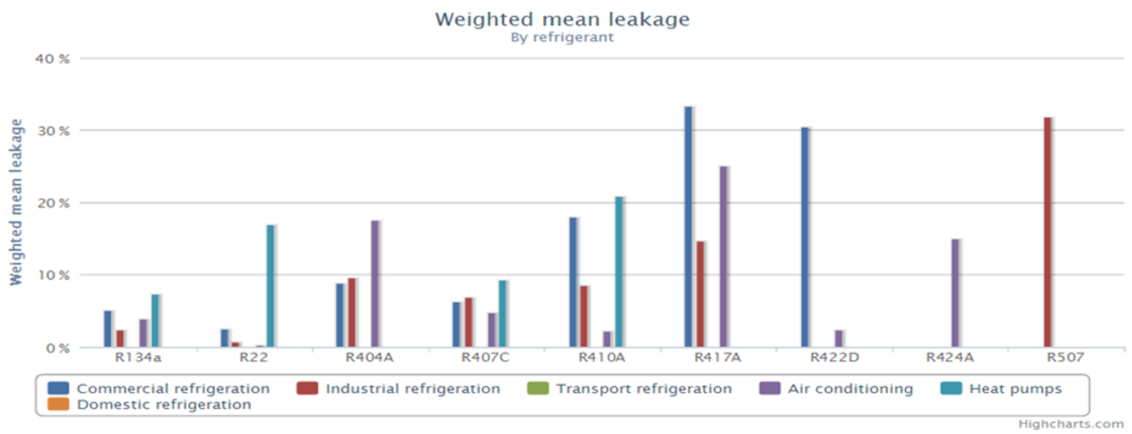
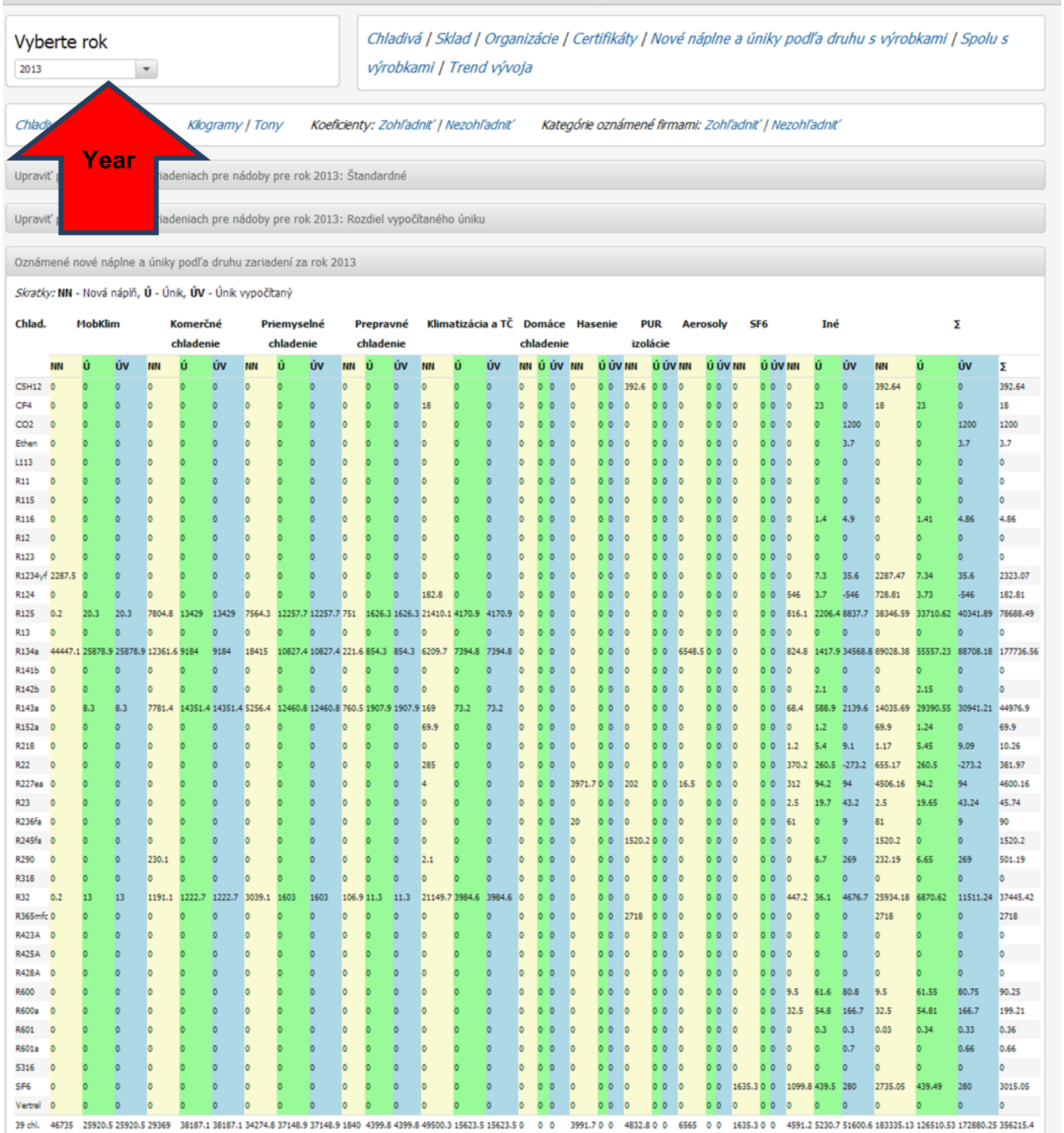


Figure A4.2.8: *Conversion of mixtures to single substances according to the new charges (NN), leaks (Ú) and calculated leaks (ÚV) for different subcategories – Leaklog*



Chlad.	MobKlim			Komerčné chladenie			Priemyselné chladenie			Prepravné chladenie			Klimatizácia a TČ		
	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV
C5H12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CF4	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0
CO2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ethen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
L113	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
R115	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
R12	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
R1234yf	2287.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R124	0	0	0	0	0	0	0	0	0	0	0	0	182.8	0	0
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
R13	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
R141b	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
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
R152a	0	0	0	0	0	0	0	0	0	0	0	0	69.9	0	0
R218	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R22	0	0	0	0	0	0	0	0	0	0	0	0	285	0	0
R227ea	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
R23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R236fa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R245fa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R290	0	0	0	230.1	0	0	0	0	0	0	0	0	2.1	0	0
R318	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
R365mfc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R423A	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
R428A	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
R600a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R601	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R601a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S316	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
Vertrel	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

Chlad.	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	Σ
C5H12	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	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	1200	0	0	1200	1200
Ethen	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
R11	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
R116	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
R123	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R1234yf	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	0	0	0	546	3.7	-546	728.81	3.73	-546	182.81
R125	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
R134a	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
R142b	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	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	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	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	0	0	0	370.2	260.5	-273.2	655.17	260.5	-273.2	381.97
R227ea	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	2.5	19.7	43.2	2.5	19.65	43.24	45.74
R236fa	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	1520.2	0	0	0	0	0	0	0	0	0	0	0	1520.2	0	0	1520.2
R290	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
R32	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	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
R425A	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
R600	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	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	0.3	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	0.7	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
SF6	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
39 chl.	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 THE 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

Table A4.3.2: *Comparison of CO_2 used for urea production and CO_2 reported from the use of urea since 2010*

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	43.192	158.273
2012	171.446	45.418	3.925	49.343	122.103
2013	213.603	51.993	3.903	55.896	157.707
2014	131.033	57.941	4.200	62.141	68.893
2015	246.239	60.920	7.731	68.651	177.588
2016	223.200	63.071	9.583	72.6541	150.546
2017	240.860	63.534	9.514	73.0471	167.812
2018	238.324	65.966	9.660	75.6261	162.698
2019	134.339	63.539	9.601	73.140	61.199
2020	180.420	63.666	7.096	70.762	109.660

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 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 USED 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

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
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

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 – A4.3.5*** and their comparison with the difference in the reporting data (so called "missing CO_2" in ***Table A4.3.2***) are listed in ***Table A4.3.6.*** 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 A4.3.6: *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	158.273	(-2.76)-(-7.93)
2012	31.053	54.621	23.213-28.272	108.887-113.946	122.103	13.216-8.156
2013	38.688	134.425	37.669-40.163	210.782-213.276	157.707	(-53.075)-(-55.569)
2014	23.586	1.998	24.968-27.836	50.551-53.419	68.893	18.341-15.473
2015	41.598	146.627	45.612-49.129	233.837-237.354	177.588	(-56.249)-(-59.766)
2016	34.752	80.817	37.948-41.910	153.517-157.479	150.546	(-2.971)-(-6.934)
2017	47.437	89.858	37.884-41.846	175.179-179.141	167.812	(-7.366)-(-11.328)
2018	50.554	69.536	46.630-49.958	166.719-170.048	162.698	(-4.021)-(-7.350)
2019	41.456	-12.256	36.291-39.024	65.490-68.224	61.199	(-4.292)-(-7.025)
2020	26.043	47.4659	38.361-39.466	111.872-112.977	109.661	(-2.211)-(-3.316)

ANNEX 4.4 NMVOC RECALCULATIONS AND METHODOLOGICAL CHANGES IN CRF 2.D.3 CATEGORY

This annex presents a brief description of recalculations and methodological changes made in the NECD and CLRTAP inventory in 2021 submissions. During several recent years thorough QA/QC procedure was implemented for the preparation of CLRTAP inventory in the frame of the National Program for Emission Reduction of Non-Methane Volatile Organic Compounds in the Slovak Republic. Due the fact that the emissions of NMVOC are the source of indirect CO_2 emissions in the GHG inventory, the QA/QC process resulted also in the recalculations of CO_2 emissions in this category. During the QA/QC process approximately 1 000 sources of NMVOC emissions were checked and, if necessary, corrected in categorization.

The QA/QC process of harmonisation finished in 2020. The main recalculation occurring in this submission was the recalculation of the Domestic solvent use including fungicides category. To see how NMVOC emissions have evolved over time during QA/QC process, the comparison of NMVOC emissions in 2.D.3 – solvents category per submissions 2015 – 2020 is depicted in ***Table A4.4.1.*** As can be seen, significant changes have occurred in NMVOC emission during QA/QC process. However, it should be noted that the QA/QC process has been performed for years after 2000. The most significant changes occurred in the 1990 – 2000 period as the result of the extrapolation of the corrected data. As an example of the influence of the extrapolation, comparison of the NMVOC emissions from two last submissions for the category 2.D.3.i – Other solvent use is shown on ***Figure A4.4.1.***

In previous submissions there were problems with the consistency of CLRTAP and GHG inventory. It was caused due to different reporting deadlines of inventories (submission of CLRTAP inventory is February 15th). Therefore the last-minute revisions have not been included in the GHG inventory (or vice-versa). To avoid this problem, since this submission, reporting of the emissions in both inventories perform the same work team.

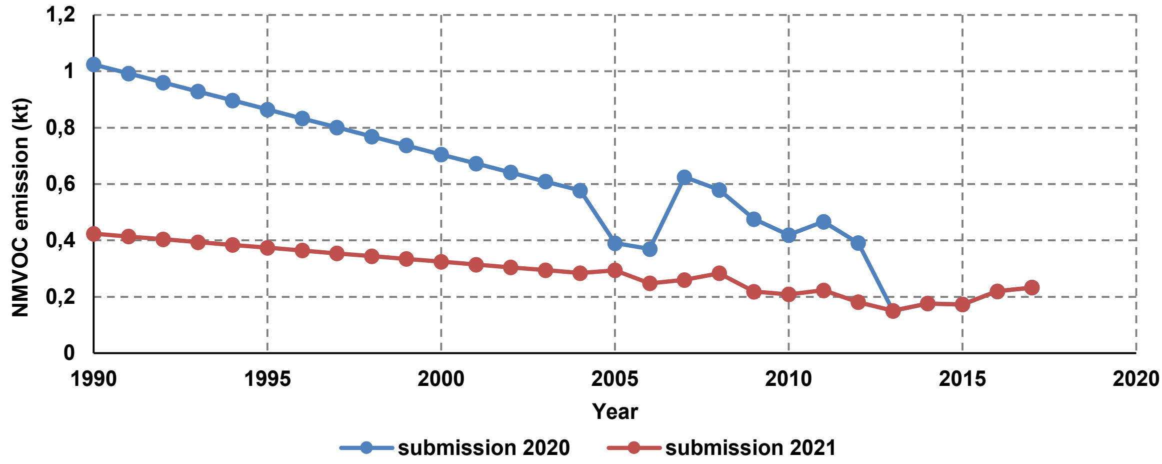
In order to retain the transparency, this Annex is the same as in previous submission, only data for 2020 are added.

Table A4.4.1: *NMVOC emissions in 2.D.3 Solvents in GHG inventory, comparison of the submissions 2015 – 2021*

YEAR	SUBMISSION 2015	SUBMISSION 2016	SUBMISSION 2017	SUBMISSION 2018	SUBMISSION 2019	SUBMISSION 2020	SUBMISSION 2021
	NMVOC in kt						
1990	65.75	52.66	93.59	83.72	57.61	67.78	38.39
1991	57.43	44.31	86.23	81.82	57.15	66.75	37.86
1992	50.95	37.80	79.68	79.91	56.69	65.72	37.33
1993	47.83	34.69	75.48	78.01	56.23	64.70	36.81
1994	49.19	36.04	74.79	76.11	55.78	63.68	36.29
1995	49.93	36.72	73.74	74.22	55.33	62.67	35.77
1996	46.76	33.51	70.63	72.31	54.87	61.64	35.25
1997	42.20	28.92	65.61	70.41	54.41	60.61	34.72
1998	43.07	29.82	64.44	68.50	53.95	59.59	34.19
1999	41.37	28.06	61.22	66.59	53.48	58.55	33.30
2000	39.92	26.68	62.66	63.92	51.81	56.32	29.57
2001	42.58	28.53	59.18	60.94	50.42	54.36	28.63
2002	45.92	30.78	61.59	62.26	53.11	56.48	31.73
2003	48.50	32.11	58.70	59.08	51.42	54.23	30.43
2004	51.10	32.62	60.29	59.01	52.66	54.91	32.13
2005	52.31	33.37	50.79	48.18	47.30	47.48	30.71
2006	54.02	34.48	59.84	51.67	50.92	51.14	32.75

YEAR	SUBMISSION 2015	SUBMISSION 2016	SUBMISSION 2017	SUBMISSION 2018	SUBMISSION 2019	SUBMISSION 2020	SUBMISSION 2021
	NMVOC in kt						
2007	53.45	33.43	53.98	47.90	47.12	47.47	26.03
2008	54.05	33.64	55.09	51.93	51.21	51.50	28.43
2009	53.55	33.18	51.14	47.53	46.89	47.10	26.70
2010	52.00	31.70	67.91	44.01	51.62	43.80	22.40
2011	56.99	36.72	60.26	45.23	51.82	45.21	26.13
2012	51.01	30.88	49.92	38.02	46.31	39.79	21.18
2013	52.28	32.06	46.12	28.04	38.77	27.67	21.07
2014		39.95	45.70	24.54	37.60	24.12	22.49
2015			47.21	28.12	41.03	27.69	25.62
2016				25.45	37.72	25.04	23.90
2017					33.16	21.69	21.70
2018						22.15	24.13
2019							20.53

***Figure A4.4.1:** Comparison of the NMVOC emissions in 2.D.3.i Other solvents use in submissions 2020 and 2021*



A4.4.1 METHODOLOGY OF NMVOC EMISSION ESTIMATES USED IN CLRTAP INVENTORY

The NEIS is covering almost all industrial sources (see the **Energy sector**). Thus, several categories and sources concerned to domestic use are logically not occurring in the NEIS. Therefore, the long-term activity data from the Statistical Office of the Slovak Republic for export, import and production for particular items was obtained. However, the first step required to arrange a revision of existing Agreement on cooperation in the field of statistics between the Ministry of Environment (MŽP SR) and ŠÚ SR and create closer cooperation. The Agreement was amended and enlarged for historical timeline and new data. Data in statistical database before 2001 is not available.

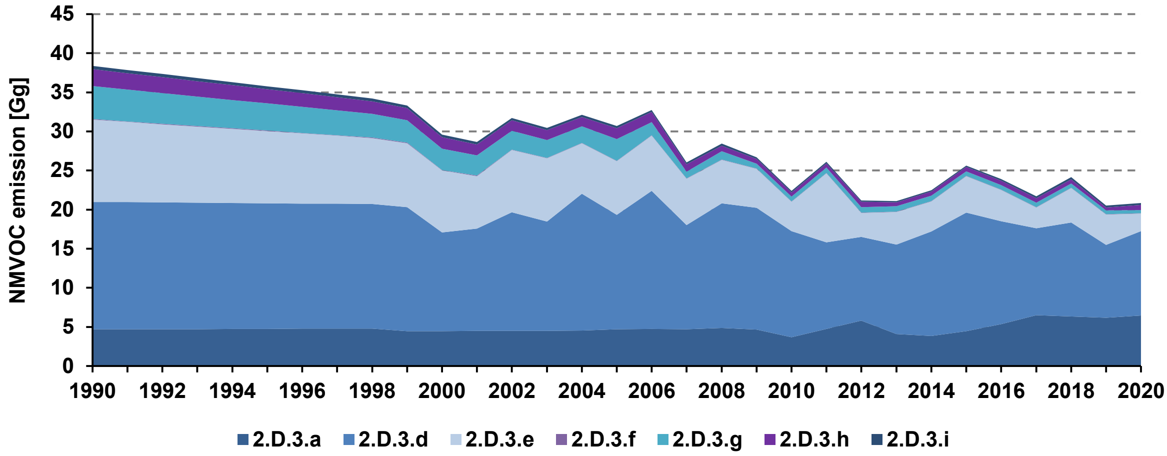
In CLRTAP inventory, 2.D.3 category consists of following subcategories:

- 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

All categories except 2.D.3.b and 2.D.3.c are reported under 2.D.3 Other – solvent use. The share of the subcategories in the Solvent use category is shown on ***Figure A4.4.2*** for the whole time series. 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, respectively.

Figure A4.4.2: *The NMVOC emissions from the 2.D.3 – Other solvent use category*



As a main source of the NMVOC emission calculation is NEIS database. When other source is used (Statistical Office of the Slovak Republic), the methodology is described separately in the following chapters.

Table A4.4.2: *The overview of activity data, method and tier used for solvents categories in NMVOC inventory*

NMVOC NFR	TIER	ACTIVITY DATA	NEIS CATEGORIES	METHODOLOGY USED
2.D.3.a	T2	ŠÚ SR	-	Em_{TOTAL} = Sources * EF
2.D.3.b	T3	NEIS	NEIS: 3.5	Em_{TOTAL} = 100% NEIS
2.D.3.c	T3	NEIS	NEIS: 4.37	Em_{TOTAL} = 100% NEIS
2.D.3.d	T3 + T2	ŠÚ SR + NEIS	NEIS: 6.1; 6.2; 6.3; 6.9	Em_{TOTAL} = Small sources * EF + Em_{NEIS}
2.D.3.e	T3 + T2	ŠÚ SR + NEIS	NEIS: 6.4	Em_{TOTAL} = Small sources * EF + Em_{NEIS}
2.D.3.f	T3	NEIS	NEIS: 6.5	Em_{TOTAL} = 100% NEIS
2.D.3.g	T3	NEIS	NEIS: 4.19; 4.20; 4.33; 4.38	Em_{TOTAL} = 100% NEIS
2.D.3.h	T3 + T2	ŠÚ SR + NEIS	NEIS: 6.7	Em_{TOTAL} = Small sources * EF + Em_{NEIS}
2.D.3.i	T3 + T2	ŠÚ SR + NEIS	NEIS: 4.35; 6.6	Em_{TOTAL} = Small sources * EF + Em_{NEIS}

A4.4.2 DOMESTIC SOLVENT USE INCLUDING FUNGICIDES (NFR 2.D.3.a)

This category was calculated by the combination of Tier 2a and 2b method. Activity data representing data on the production/import/export of the products were obtained from the Statistical Office of the Slovak Republic. Due to the lack of detailed composition of the products, recommended data on the content of solvents in different applications the default values from EEA/EMEP GB_{2019} were used. Where available in EEA/EMEP GB_{2019} amount of product was recalculated into amount of solvent and then appropriate EF was was used (tier 2a). When the composition of solvent was not presented in EEA/EMEP GB_{2019}, EF for the specific product was taken from GB2019.

A4.4.3 COATING APPLICATIONS (NFR 2.D.3.d)

This category in Slovak legislation covers more activities concerning to the wood processing as defined in the NFR. Therefore, it is not possible to separate mechanical processing of wood from the category. Decree No 410/2012 Coll. as amended defined limit > 0 for obligation of solvents evidence and registering into the NEIS as a source of air pollution. Numbers of operators that covers large and medium sources vary around 450 yearly. Moreover, small sources have to be balanced. The balance of small sources is performed by top down approach. The statistical data is processed and total solvents consumption is calculated according to the studies on specific solvents content. Emissions taken from the NEIS database are processed by the system and abatement of environmental technology, recovery fluxes or separators are already taken into account in final emissions. For the small sources the assumption of no separator technology is used, thus the conversion of solvents used to the air is 100%.

Emissions calculation:

$$Em_{TOTAL} = \text{Small sources} * EF + Em_{NEIS}$$

Small sources calculation:

Production + Import – Export = Total Product Consumption

Total Product Consumption → Total Solvents Consumption

Total Solvents Consumption - Industrial Solvents Consumption = Small Sources

A4.4.4 DEGREASING (NFR 2.D.3.e)

This category is included in the NEIS database, sources assigned to the category 6.4 according to the Annex No 6 of Decree No 410/2012 Coll. as amended are defined as degreasing and cleaning of metal surfaces, electrical component, plastic and other materials, including paint stripping organic solvents with projected consumption in t/year. Annual numbers of operators were declined from 65 to 51 in recent years. Decree No 410/2012 Coll. as amended defined similarly the limit > 0 for obligation of solvents evidence and registering into the NEIS as a source of air pollution. Therefore, the calculation of small sources is balanced likewise in 2.D.3.d. The balance of small sources is performed by top down approach. The statistical data is processed and total solvents consumption is calculated without the step of calculating the VOC specific content due to specific pure solvents used for this purposes in the SR. Emissions taken from the NEIS database are processed by the system and abatement of environmental technology, recovery fluxes or separators are already taken into account in final emissions. For the small sources the assumption of no separator technology is used, thus the conversion of solvents used to the air is 100%.

Emissions calculation:

$$Em_{TOTAL} = \text{Small sources} * EF + Em_{NEIS}$$

Small sources calculation:

Production + Import – Export = Total Product Consumption

Total Product Consumption = Total Solvents Consumption

Total Solvents Consumption - Industrial Solvents Consumption = Small Sources

A4.4.5 PRINTING (NFR 2.D.3.h)

This category source is included in the NEIS database, sources assigned to the category 6.7 according to the Annex No 6 of Decree No 410/2012 Coll. as amended are defined as polygraphs on projected consumption of organic solvents in tonnes / year:

a) Publication rotogravure;

b) Other rotogravure;

c) Thermal rotary offset;

d) Flexography;

e) Varnishing and laminating technology;

f) Rotary screen printing on textiles, paperboard;

g) Other printing techniques, such as cold offset, sheet-fed equipment and other.

The combination of bottom-up approach (tier 3) and top-down approach (tier 2) is used in accordance with equation $Em_{TOTAL} = Em_{NEIS}$ + small sources * EF, where small sources are balanced in the category 2.D.3.d. From the total balance of 2.D.3.d the printing inks has been separated and allocated into 2.D.3.h as small sources. The drivers for the emissions decline are the implantation of effective techniques in the industrial sources.

A4.4.6 OTHER SOLVENT USE (NFR 2.D.3.i)

Category covers Industrial extraction of vegetable oil and animal fat and vegetable oil refining with a projected consumption of organic solvents and Adhesive coating - bonding materials other than wood, wood products and agglomerated materials, leather and footwear production with a projected consumption of organic solvents.

The combination of bottom-up approach (tier 3) and top-down approach (tier 2) is used in accordance with equation $Em_{TOTAL} = Em_{NEIS}$ + small sources * EF, where small sources are balanced in the category 2.D.3.d. From the total balance of 2.D.3.d the adhesive coatings have been separated and allocated into 2.D.3.i as small sources.

According to the ESD review, recommendation SK-1A3b-2018-0001, lubricant consumption in road transport was calculated for the first time and allocated into this category. Emissions of SOx and heavy metals were added.

A4.4.7 METHODOLOGY OF CO_2 EMISSION ESTIMATES BASED ON THE NMVOC EMISSIONS

During the QA/QC process a great effort was made to identify the chemical compounds in NMVOC emissions. 98 chemical compounds were identified. Due to this big 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 so high number of chemical compounds in the NMVOC emission made the CO_2 emission estimate more accurate than in the previous submissions where only several groups of the chemicals were used. CO_2 emissions were calculated for each subcategory separately (2.D.3.a – 2.D.3.i) since 2000. Extrapolation by the trend was used for the years 1990 – 1999 for each category, as well. The results are presented in ***Tables A4.4.3-A.4.4.11***. Comparison of CO_2 emissions from the solvent use for submission 2020 and

2021 is presented in ***Table A4.4.12*** (except of 2.D.3.b and 2.D.3.c categories that are presented separately in the GHG inventory). The share of the subcategories in the Solvent use category is shown on ***Figure A4.4.3*** for the whole time series.

Table A4.4.3: *NMVOC and CO_2 emissions in 2.D.3.a – Domestic solvent use including fungicides*

YEAR	NMVOC EMISSIONS	CO_2 EMISSIONS	IEF (CO_2)
	Gg		*t/t of NMVOC*
1990	4.689	10.315	2.2
1991	4.699	10.338	2.2
1992	4.709	10.360	2.2
1993	4.720	10.383	2.2
1994	4.739	10.426	2.2
1995	4.759	10.470	2.2
1996	4.770	10.495	2.2
1997	4.781	10.518	2.2
1998	4.790	10.538	2.2
1999	4.436	9.759	2.2
2000	4.448	9.785	2.2
2001	4.478	9.852	2.2
2002	4.490	9.878	2.2
2003	4.484	9.865	2.2
2004	4.550	10.010	2.2
2005	4.686	10.309	2.2
2006	4.758	10.468	2.2
2007	4.715	10.372	2.2
2008	4.878	10.733	2.2
2009	4.663	10.259	2.2
2010	3.680	8.095	2.2
2011	4.722	10.389	2.2
2012	5.816	12.794	2.2
2013	4.073	8.961	2.2
2014	3.858	8.488	2.2
2015	4.440	9.768	2.2
2016	5.333	11.733	2.2
2017	6.496	14.292	2.2
2018	6.324	13.913	2.2
2019	6.161	13.553	2.2
2020	6.447	14.184	2.2

Table A4.4.4: *NMVOC and CO_2 emissions in 2.D.3.b – Road paving with asphalt*

YEAR	NMVOC EMISSIONS	CO_2 EMISSIONS	IEF (CO_2)
	Gg		*t/t of NMVOC*
1990	0.070	0.155	2.2
1991	0.031	0.069	2.2
1992	0.038	0.083	2.2
1993	0.025	0.054	2.2
1994	0.029	0.064	2.2
1995	0.033	0.072	2.2
1996	0.037	0.080	2.2
1997	0.027	0.060	2.2
1998	0.027	0.059	2.2

YEAR	NMVOC EMISSIONS	CO_2 EMISSIONS	IEF (CO_2)
	Gg		*t/t of NMVOC*
1999	0.029	0.064	2.2
2000	0.012	0.026	2.2
2001	0.011	0.024	2.2
2002	0.011	0.025	2.2
2003	0.014	0.031	2.2
2004	0.014	0.031	2.2
2005	0.019	0.042	2.2
2006	0.028	0.061	2.2
2007	0.020	0.045	2.2
2008	0.025	0.054	2.2
2009	0.015	0.034	2.2
2010	0.014	0.032	2.2
2011	0.018	0.040	2.2
2012	0.015	0.033	2.2
2013	0.015	0.033	2.2
2014	0.014	0.030	2.2
2015	0.020	0.044	2.2
2016	0.019	0.042	2.2
2017	0.019	0.041	2.2
2018	0.020	0.044	2.2
2019	0.016	0.036	2.2
2020	0.015	0.033	2.2

Table A4.4.5: *NMVOC and CO_2 emissions in 2.D.3.c – Asphalt roofing*

YEAR	NMVOC EMISSIONS	CO_2 EMISSIONS	IEF (CO_2)
	Gg		*t/t of NMVOC*
1990	0.047	0.103	2.2
1991	0.030	0.066	2.2
1992	0.030	0.066	2.2
1993	0.018	0.040	2.2
1994	0.022	0.049	2.2
1995	0.024	0.052	2.2
1996	0.022	0.048	2.2
1997	0.021	0.045	2.2
1998	0.018	0.040	2.2
1999	0.022	0.049	2.2
2000	0.016	0.036	2.2
2001	0.015	0.032	2.2
2002	0.015	0.034	2.2
2003	0.010	0.023	2.2
2004	0.006	0.013	2.2
2005	0.006	0.013	2.2
2006	0.004	0.009	2.2
2007	0.004	0.009	2.2
2008	0.003	0.007	2.2
2009	0.003	0.006	2.2
2010	0.002	0.005	2.2
2011	0.002	0.005	2.2
2012	0.002	0.005	2.2

YEAR	NMVOC EMISSIONS	CO_2 EMISSIONS	IEF (CO_2)
	Gg		*t/t of NMVOC*
2013	0.003	0.006	2.2
2014	0.003	0.006	2.2
2015	0.001	0.002	2.2
2016	0.002	0.004	2.2
2017	0.001	0.003	2.2
2018	0.002	0.005	2.2
2019	0.002	0.004	2.2
2020	0.002	0.005	2.2

Table A4.4.6: *NMVOC and CO_2 emissions in 2.D.3.d – Coating application*

YEAR	NMVOC EMISSIONS	CO_2 EMISSIONS	IEF (CO_2)
	Gg		*t/t of NMVOC*
1990	16.292	41.218	2.530
1991	16.244	41.098	2.530
1992	16.197	40.978	2.530
1993	16.150	40.859	2.530
1994	16.102	40.739	2.530
1995	16.055	40.619	2.530
1996	16.007	40.499	2.530
1997	15.960	40.379	2.530
1998	15.913	40.259	2.530
1999	15.865	40.139	2.530
2000	12.617	30.865	2.446
2001	13.111	33.928	2.588
2002	15.184	38.610	2.543
2003	14.000	35.400	2.529
2004	17.486	44.587	2.550
2005	14.625	32.448	2.219
2006	17.647	39.111	2.216
2007	13.294	29.600	2.227
2008	15.902	35.309	2.220
2009	15.569	34.457	2.213
2010	13.574	30.060	2.215
2011	11.085	24.563	2.216
2012	10.709	23.748	2.218
2013	11.473	25.415	2.215
2014	13.362	29.569	2.213
2015	15.184	33.570	2.211
2016	13.164	29.122	2.212
2017	11.126	24.645	2.215
2018	12.014	26.603	2.214
2019	9.334	20.651	2.212
2020	10.784	23.828	2.210

Table A4.4.7: *NMVOC and CO_2 emissions in 2.D.3.e – Degreasing*

YEAR	NMVOC EMISSIONS	CO_2 EMISSIONS	IEF (CO_2)
	Gg		*t/t of NMVOC*
1990	10.524	20.733	1.970
1991	10.265	20.223	1.970
1992	10.007	19.713	1.970
1993	9.748	19.203	1.970
1994	9.489	18.693	1.970
1995	9.230	18.183	1.970
1996	8.971	17.673	1.970
1997	8.712	17.164	1.970
1998	8.454	16.654	1.970
1999	8.195	16.144	1.970
2000	7.936	14.517	1.829
2001	6.700	12.115	1.808
2002	7.940	14.142	1.781
2003	8.066	14.101	1.748
2004	6.443	12.949	2.010
2005	6.882	14.029	2.038
2006	7.044	14.552	2.066
2007	5.935	12.196	2.055
2008	5.580	11.892	2.131
2009	4.985	10.771	2.161
2010	3.737	7.834	2.096
2011	8.821	19.326	2.191
2012	3.036	6.383	2.102
2013	4.156	8.984	2.162
2014	3.808	8.299	2.180
2015	4.632	10.014	2.162
2016	4.011	8.609	2.146
2017	2.648	5.396	2.038
2018	4.410	9.506	2.156
2019	3.870	8.550	2.209
2020	2.259	4.904	2.171

Table A4.4.8: *NMVOC and CO_2 emissions in 2.D.3.f – Dry cleaning*

YEAR	NMVOC EMISSIONS	CO_2 EMISSIONS	IEF (CO_2)
	Gg		*t/t of NMVOC*
1990	0.064	0.141	2.200
1991	0.063	0.139	2.200
1992	0.062	0.137	2.200
1993	0.061	0.135	2.200
1994	0.060	0.133	2.200
1995	0.059	0.131	2.200
1996	0.059	0.129	2.200
1997	0.058	0.127	2.200
1998	0.057	0.125	2.200
1999	0.056	0.123	2.200
2000	0.055	0.120	2.199
2001	0.054	0.118	2.199

YEAR	NMVOC EMISSIONS	CO_2 EMISSIONS	IEF (CO_2)
	Gg		t/t of NMVOC
2002	0.053	0.116	2.198
2003	0.052	0.114	2.198
2004	0.051	0.039	0.759
2005	0.050	0.110	2.198
2006	0.058	0.049	0.852
2007	0.042	0.092	2.198
2008	0.049	0.107	2.198
2009	0.041	0.022	0.552
2010	0.046	0.100	2.198
2011	0.047	0.030	0.632
2012	0.040	0.027	0.683
2013	0.039	0.087	2.198
2014	0.044	0.030	0.686
2015	0.043	0.029	0.679
2016	0.041	0.028	0.691
2017	0.036	0.025	0.686
2018	0.036	0.079	2.198
2019	0.033	0.021	0.643
2020	0.022	0.014	0.630

Table A4.4.9: *NMVOC and CO_2 emissions in 2.D.3.g - Chemical products*

YEAR	NMVOC EMISSIONS	CO_2 EMISSIONS	IEF (CO_2)
	Gg		t/t of NMVOC
1990	4.214	9.314	2.210
1991	4.065	8.984	2.210
1992	3.915	8.653	2.210
1993	3.766	8.323	2.210
1994	3.616	7.992	2.210
1995	3.467	7.662	2.210
1996	3.317	7.331	2.210
1997	3.168	7.001	2.210
1998	3.018	6.671	2.210
1999	2.869	6.340	2.210
2000	2.719	5.953	2.189
2001	2.570	5.666	2.205
2002	2.420	5.352	2.211
2003	2.271	5.025	2.213
2004	2.121	4.756	2.242
2005	2.752	6.114	2.222
2006	1.660	3.704	2.231
2007	0.848	1.866	2.200
2008	1.040	2.288	2.200
2009	0.625	1.376	2.200
2010	0.629	1.385	2.200
2011	0.714	1.570	2.200
2012	0.717	1.576	2.200
2013	0.687	1.511	2.200
2014	0.709	1.560	2.200
2015	0.589	1.297	2.200

YEAR	NMVOC EMISSIONS	CO_2 EMISSIONS	IEF (CO_2)
	Gg		t/t of NMVOC
2016	0.577	1.270	2.200
2017	0.564	1.240	2.200
2018	0.567	1.248	2.200
2019	0.504	1.110	2.200
2020	0.425	0.936	2.200

Table A4.4.10: *NMVOC and CO_2 emissions in 2.D.3.h – Printing*

YEAR	NMVOC EMISSION	CO_2 EMISSION	IEF (CO_2)
	Gg		t/t of NMVOC
1990	2.178	4.858	2.230
1991	2.108	4.701	2.230
1992	2.038	4.544	2.230
1993	1.968	4.388	2.230
1994	1.897	4.231	2.230
1995	1.827	4.074	2.230
1996	1.757	3.917	2.230
1997	1.686	3.760	2.230
1998	1.616	3.604	2.230
1999	1.546	3.447	2.230
2000	1.475	3.429	2.324
2001	1.405	3.091	2.200
2002	1.335	2.936	2.200
2003	1.264	2.782	2.200
2004	1.194	2.661	2.228
2005	1.418	3.211	2.265
2006	1.334	3.063	2.297
2007	0.942	2.198	2.333
2008	0.699	1.674	2.396
2009	0.597	1.427	2.389
2010	0.525	1.227	2.338
2011	0.513	1.200	2.339
2012	0.680	1.519	2.233
2013	0.490	1.082	2.205
2014	0.529	1.166	2.204
2015	0.560	1.236	2.206
2016	0.558	1.228	2.200
2017	0.602	1.327	2.204
2018	0.522	1.150	2.203
2019	0.362	0.797	2.200
2020	0.642	1.412	2.201

Table A4.4.11: *NMVOC and CO_2 emissions in 2.D.3.i – Other solvent use*

YEAR	NMVOC EMISSIONS	CO_2 EMISSIONS	IEF (CO_2)
	Gg		t/t of NMVOC
1990	0.424	0.933	2.200
1991	0.414	0.911	2.200
1992	0.404	0.889	2.200
1993	0.394	0.867	2.200
1994	0.384	0.845	2.200

YEAR	NMVOC EMISSIONS	CO_2 EMISSIONS	IEF (CO_2)
	Gg		t/t of NMVOC
1995	0.374	0.823	2.200
1996	0.364	0.801	2.200
1997	0.354	0.779	2.200
1998	0.344	0.757	2.200
1999	0.334	0.735	2.200
2000	0.324	0.712	2.197
2001	0.314	0.691	2.200
2002	0.304	0.670	2.200
2003	0.294	0.648	2.200
2004	0.284	0.633	2.224
2005	0.294	0.653	2.221
2006	0.248	0.552	2.225
2007	0.260	0.580	2.231
2008	0.284	0.631	2.223
2009	0.218	0.487	2.228
2010	0.208	0.464	2.224
2011	0.223	0.491	2.202
2012	0.181	0.398	2.200
2013	0.150	0.333	2.218
2014	0.176	0.392	2.224
2015	0.173	0.383	2.215
2016	0.220	0.481	2.191
2017	0.233	0.511	2.196
2018	0.258	0.565	2.190
2019	0.263	0.578	2.192
2020	0.254	0.560	2.199

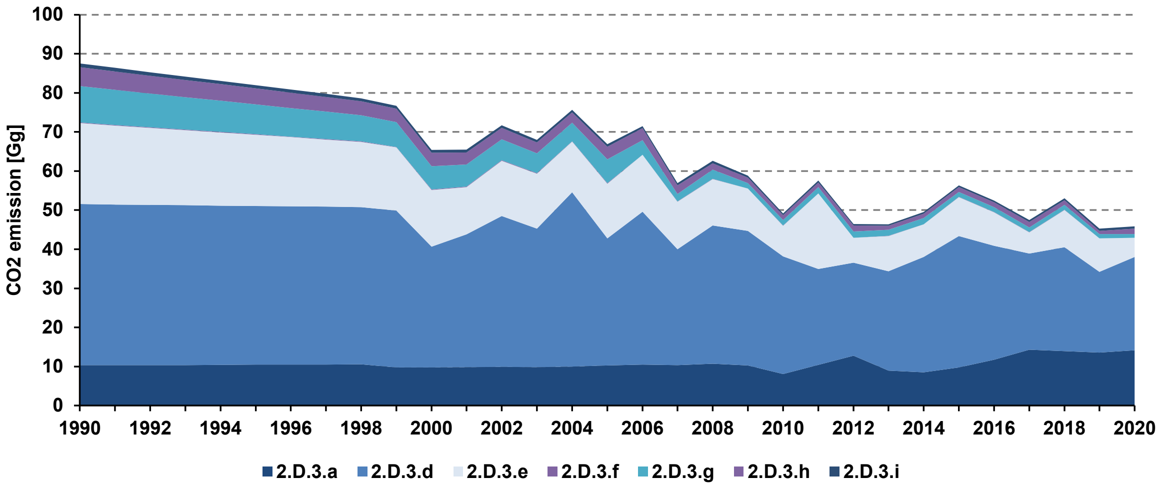
Table A4.4.12: *Comparison of NMVOC and CO_2 emissions (Gg) in 2.D.3 solvent use category in the 2020 and 2021submissions*

YEAR	NMVOC EMISSIONS			CO_2 EMISSIONS		
	SUBMISSION 2020	SUBMISSION 2021	CHANGE	SUBMISSION 2020	SUBMISSION 2021*	CHANGE
1990	67.777	38.386	-43.4%	156.795	87.512	-44.2%
1991	66.749	37.859	-43.3%	154.684	86.393	-44.1%
1992	65.722	37.332	-43.2%	152.572	85.275	-44.1%
1993	64.695	36.806	-43.1%	150.412	84.157	-44.0%
1994	63.681	36.288	-43.0%	146.161	83.059	-43.2%
1995	62.667	35.771	-42.9%	147.470	81.961	-44.4%
1996	61.641	35.246	-42.8%	143.629	80.845	-43.7%
1997	60.615	34.719	-42.7%	141.542	79.728	-43.7%
1998	59.586	34.192	-42.6%	140.646	78.607	-44.1%
1999	58.553	33.300	-43.1%	138.886	76.687	-44.8%
2000	56.319	29.575	-47.5%	136.638	65.382	-52.1%
2001	54.362	28.633	-47.3%	132.781	65.462	-50.7%
2002	56.482	31.726	-43.8%	137.888	71.703	-48.0%
2003	54.234	30.432	-43.9%	131.380	67.934	-48.3%
2004	54.910	32.130	-41.5%	137.682	75.634	-45.1%
2005	47.483	30.708	-35.3%	118.061	66.874	-43.4%
2006	51.139	32.749	-36.0%	129.842	71.499	-44.9%

YEAR	NMVOC EMISSIONS			CO_2 EMISSIONS		
	SUBMISSION 2020	SUBMISSION 2021	CHANGE	SUBMISSION 2020	SUBMISSION 2021*	CHANGE
2007	47.473	26.035	-45.2%	118.634	56.904	-52.0%
2008	51.503	28.432	-44.8%	129.922	62.633	-51.8%
2009	47.097	26.699	-43.3%	119.985	58.799	-51.0%
2010	43.801	22.399	-48.9%	111.298	49.164	-55.8%
2011	45.208	26.125	-42.2%	112.317	57.570	-48.7%
2012	39.791	21.179	-46.8%	99.944	46.446	-53.5%
2013	27.670	21.070	-23.9%	70.572	46.373	-34.3%
2014	24.121	22.486	-6.8%	63.274	49.504	-21.8%
2015	27.690	25.622	-7.5%	73.489	56.297	-23.4%
2016	25.037	23.904	-4.5%	65.797	52.471	-20.3%
2017	21.687	21.705	0.1%	56.569	47.436	-16.1%
2018	22.146	24.132	9.0%	58.176	53.066	-8.8%
2019	-	20.529	-	-	45.261	-

* In the 2021 submission, the CO_2 emissions are reported as indirect emissions.

Figure A4.4.3: *The indirect CO_2 emissions from the 2.D.3 – Other solvent use category*



CHAPTER 5: AGRICULTURE (CRF 3)

Emissions estimation in Agriculture was prepared by the sectoral expert supported by the institutions involved in the National Inventory System of the Slovak Republic among others:

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 Vojtech Brestenský
Slovak Hydrometeorological Institute	3.D Estimation of humid area of the Slovak Republic	Peter Tonhauzer
Slovak Hydrometeorological Institute	sectoral uncertainty analysis	Martin Petraš

The **Agriculture sector** is the fourth largest sector of the GHG emissions inventory of the Slovak Republic with the contribution equal to 7% 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

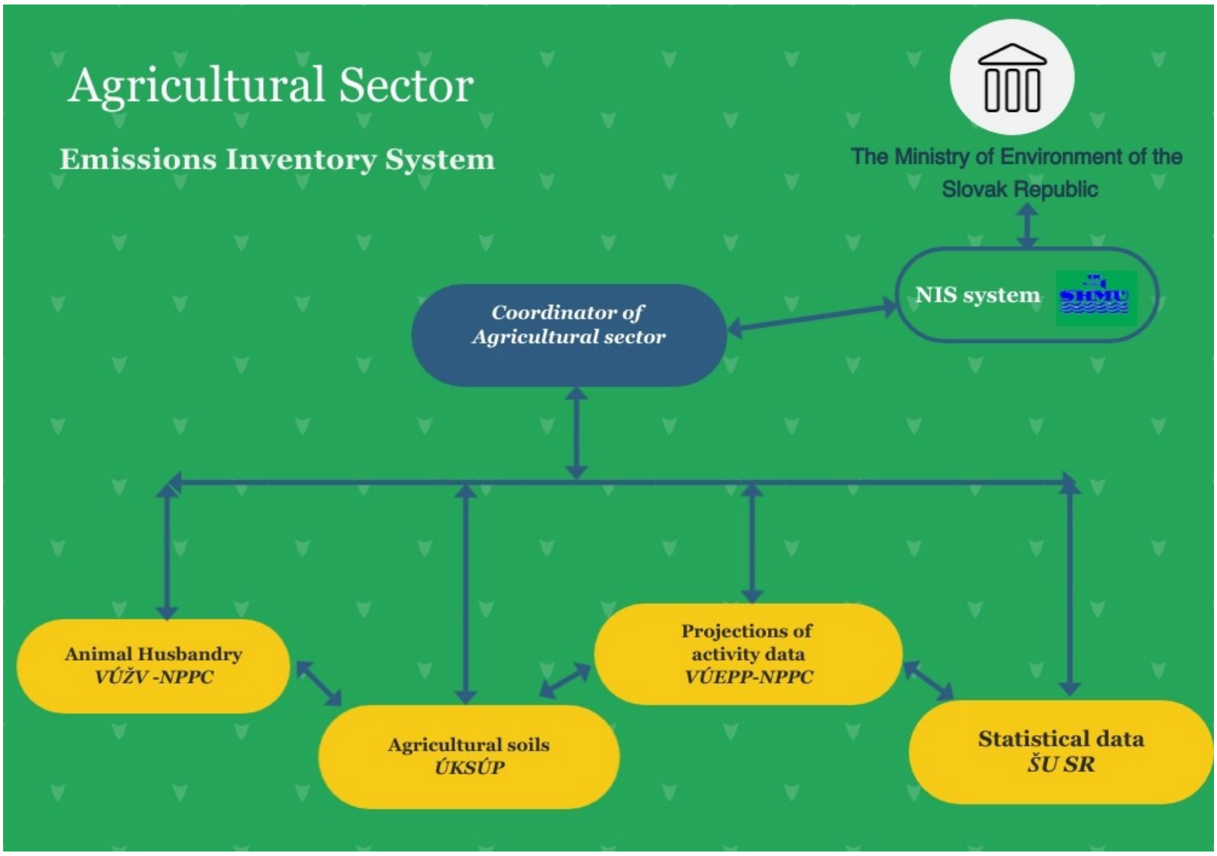
The share of agriculture and food industry in the national economy has decreased in the macro-economic indicators (gross value-added, intermediate consumption, the sectoral employment) in 2020 compared to the 2019 and increased in parameter employee's average wage by 1.5%. Share of foreign agri-food trade in exports and imports decreased by 6.1% from 1.7 billion euro. Agriculture, according to data, achieved a positive economic result in 2020. Due to the animal product decrease, positive economic result, before tax, became smaller by 3.4 mil. EUR (5.1%) Sales of crop products increased. The subsidies from the Common Agricultural Policies (CAP) played the stabilized role of the financial support for Slovak agriculture, which help the majority of the farmers avoid to the negative economic situation. The subsidies from the CAP decreased by 7.4% due to decrease of the EU resources by 8% and national resources of the Slovak Republic (by 5.6%). The faster decrease in funding from direct payments (by 8.7%) and a slower increase of subsidies from the Rural Development Strategy 2014 – 2020 (by 5.6%) influences the decrease of subsidies from the CAP. The structure of gross agricultural output at current prices stagnated inter-annually.

The crop production had the continuing dominant share in economy compared to animal production (63% to 37%). The total production of slaughter animals increased in cattle (0.1%), poultry (1.3%) and decrease in the slaughter sheep (11.6%) and pigs (3.5%). The production of raw products increased compared to the previous year mainly in cattle (1.3%) and sheep milk (0.7%). The small drop was visible in hen eggs (0.3%). (Green Report 2020).

The emissions balance is compiled annually based on the sectoral statistics on animal livestock, animal performance and consumption of organic and inorganic fertilizers, in the recent years on the regional level. The Ministry of Agriculture and Rural Development of the Slovak Republic (MPRV SR) issues annually agricultural statistics in the Green Report, the part of which is dedicated to agriculture and food. Activity data are also available in the Statistical Yearbooks published by the Statistical Office of the Slovak Republic (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 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***.

Figure 5.1: *Emission Inventory System in the Agriculture sector*



The largest share of methane emissions was generated by enteric fermentation of cattle, which produced 34.52 Gg (82%) of methane within the sector in 2020. The major source of N_2O emissions is agricultural soils with a share of 90%, followed by the category 3.B representing 10% on the total N_2O emissions. Regarding N_2O, direct emissions from synthetic fertilization are the most significant emissions source and it produced 2.01 Gg of N_2O (41%) within the sector in 2020.

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 5.2 and ***5.3*** 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 cause 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).

Figure 5.2: *Trend in aggregated emissions (in Gg of CO_2 eq.) by categories within the Agriculture sector in 1990 – 2020*

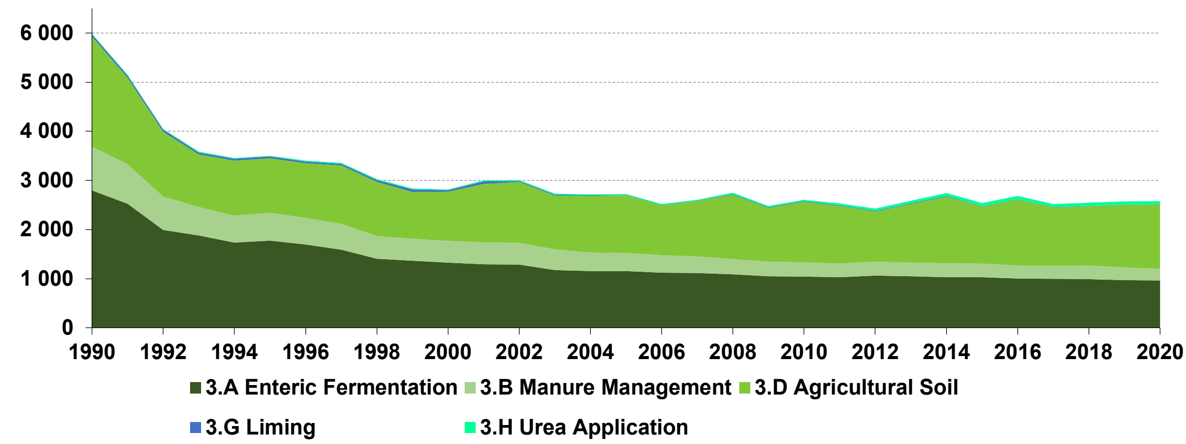


Table 5.1: *Trend of GHG emissions by gases in the Agriculture sector in particular years*

YEARS	CO_2	CH_4	N_2O	NMVOC	NO_X
	Gg				
1990	61.02	129.20	9.05	23.05	13.22
1995	53.29	81.27	4.76	14.36	5.78
2000	46.44	60.64	4.21	11.87	5.92
2005	29.59	52.29	4.66	10.51	6.24
2010	39.17	46.30	4.73	8.60	6.40
2011	54.85	45.48	4.50	8.47	6.99
2012	56.72	46.95	4.02	8.42	6.16
2013	63.94	46.27	4.58	8.23	6.71
2014	69.90	45.47	5.16	8.13	7.06
2015	73.33	45.44	4.46	8.38	6.89
2016	69.85	44.24	5.06	8.07	7.00
2017	66.15	44.02	4.55	8.16	6.83
2018	70.18	43.99	4.61	7.68	7.15
2019	68.25	42.72	4.82	7.49	7.18
2020	72.12	42.13	4.88	7.02	6.98

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.				
1990	2 796.69	890.85	2 238.73	45.73	15.29
1995	1 777.38	565.07	1 108.52	38.00	15.29
2000	1 329.50	439.40	1 001.74	34.34	12.10
2005	1 156.72	366.55	1 173.11	9.28	20.31
2010	1 042.46	294.32	1 231.68	8.23	30.94
2011	1 033.25	274.56	1 171.45	15.14	39.71
2012	1 064.97	284.49	1 021.54	11.30	45.42
2013	1 051.76	275.81	1 194.06	11.95	51.99
2014	1 028.53	282.35	1 363.65	11.96	57.94
2015	1 028.91	278.21	1 157.53	12.41	60.92
2016	1 007.58	261.75	1 343.80	6.77	63.07
2017	998.03	265.31	1 191.58	2.62	63.53
2018	994.12	273.28	1 205.79	4.21	65.97
2019	969.14	261.81	1 273.04	4.71	63.54
2020	966.34	236.78	1 304.47	8.45	63.67

Figure 5.3: *The share of aggregated emissions by main categories within the Agriculture sector in 2020*

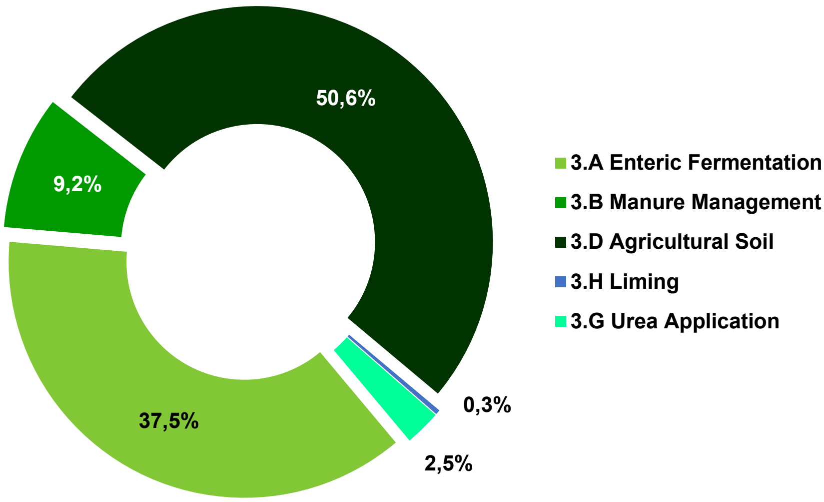


Table 5.3: *Overview of the gases, methodology and tiers reported in the Agriculture sector according to the CRF categories in 2020*

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

CATEGORY (CODE AND NAME)	METHODOLOGY/TIER	GHG GASES REPORTED
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/D	CH_4
3.B.1.4 Horses	T1/D	CH_4
3.B.1.4 Poultry	T1/D	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
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	T1/CS	N_2O
3.B.2.5 Indirect N_2O Emissions	T1/D	N_2O
3.C Rice Cultivation	NO	NO
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	T1/CS	N_2O
3.D.1.5 Mineralization/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 Savannas	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 and based on the discussion, recommendation from the latest UNFCCC review 2021, took place:

- Slovakia reported nitrogen input from straw from bedding material under category 3.D.a.2.a Animal manure applied to soils and straw removals under category 3.D.a.4 Crop residues and revised the estimates. More information is available in the **Chapter 5.12.6**.
- Slovakia implemented description about estimates of the amount of forage consumed by livestock during the 200 days grazing period. More information is available in the **Chapter 5.12.5**.
- Slovakia implemented description on removing burnt lime and other calcareous products not containing limestone during 1990 – 2020. More information is available in the **Chapter 5.15**.

5.3 CATEGORY-SPECIFIC QA/QC AND VERIFICATION

QA/QC procedures in the **Agriculture sector** are linked to the QA/QC manual of the SVK NIS and follow basic QA/QC rules and activities as defined in the IPCC 2006 GL.

The QC checks (i. e. consistency check between CRF data and national statistics) were done during the CRF and NIR compilation by the sectoral experts, general QC questionnaire was filled in and archived by the QA/QC manager of the SVK NIS.

Part of the QA/QC activities is also the comparison of national inventory with the FAO database, which is described in the **Chapter 5.3.1**.

Since 2015, the sectoral expert is participating in the preparation of the Air Pollution Emission Inventory under the Convention on Long-range Transboundary Air Pollution of the United Nations Economic Commission for Europe (UNECE/CLRTAP) (as a Party to the UNECE/LRTAP Convention, the Slovak Republic is required to report annual data on emissions of air-pollutants covered in the Convention). The additional opportunity to crosscheck the activity data and emissions was executed to ensure consistency between these two inventories (nitrogen balance). In the last two years, the QA/QC procedures have been significantly improved.

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 (2021). Experts declared a proactive approach to data harmonization, improved data reporting and methodology is planned for 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 inconsistences was identified (**Table 5.4**).

The quality control comparison of nitrogen was done. Main inconsistencies between the FAOSTAT 2022 database and national inventory (**Table 5.4**) shows huge inconsistency after 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 2020 was not available in the FAOSTAT and IFASTAT at the time of this exercise.

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 2019 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 1993 – 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 2022	FAOSTAT 2022	EUROSTAT 2022	IFASTAT 2022
	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***
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	NA	127 676 520	NA

Table 5.5: *Comparison of national data and the FAOSTAT in livestock population (heads) for the time series 1993 – 2020*

YEAR	DAIRY CATTLE		NON-DIARY CATTLE		GOATS		SHEEP		HORSES		SWINE		POULTRY	
	SVK NIR 2022	FAOSTAT 2022	SVK NIR 2022	FAOSTAT 2022	SVK NIR 2022	FAOSTAT 2022	SVK NIR 2022	FAOSTAT 2022	SVK NIR 2022	FAOSTAT 2022	SVK NIR 2022	FAOSTAT 2022	SVK NIR 2022	FAOSTAT 2022
	heads													
1993	282 274	***429 171***	710 689	***752 489***	24 974	20 278	411 442	571 837	11 188	11 652	2 179 029	2 269 232	12 234 120	***13 084 000***
1994	272 450	***385 949***	643 703	***607 014***	25 010	*24 974*	397 043	*411 442*	10 652	*11 188*	2 037 371	*2 179 029*	14 245 954	***12 057 000***
1995	262 664	***359 348***	666 042	***556 805***	25 046	***27 747***	427 844	*397 043*	10 109	*10 000*	2 076 439	*2 037 370*	13 382 391	***7 852 000***
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 24	320 240	10 589	*35 600*	294 252	294 252	6 099	*NA*	538 310	*538 310*	10 603 624	***10 572 000***

5.4 CATEGORY-SPECIFIC RECALCULATIONS

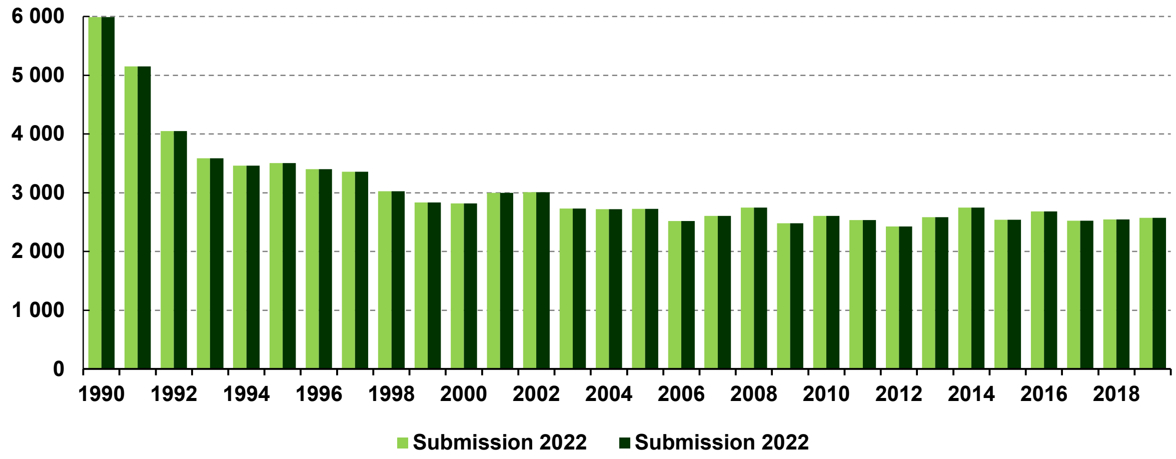
Recalculations made in the **Agriculture sector** were provided and implemented in line with the Improvement and Prioritisation Plan 2021, reflecting recommendations received during previous reviews and the sectoral expert' proposals. ***Table 5.6*** shows an overview of these recalculations and corrections implemented in 2022 submission. The overall impact of recalculations done in the **Agriculture sector** resulted in -7.3% decrease of emissions in 2019 compared to previous submission (2021), which is -202.53 kt of CO_2 eq. Impact on the total emissions is 0.51%. 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.D.1.1 Inorganic N Fertilizers	Revision of nitrogen fertilizers consumption for the years 2000-2011. During March submission 2020 consumption was corrected	**5.12.1**, **5.3.1**
2.	3.D.1.2.a Animal Manure Applied to Soils	Straw-based systems N inputs from deep bedding in the poultry and swine category implemented.	**5.12.2**
3.	3.D.1.2.b Sewage Sludge Applied to Soils	The industrial sludge consumption for agricultural purposes implemented.	**5.12.3**
4.	3.D.1.2.c Other Organic Fertilizers Applied to Soils	The revision of parameters for the estimation of nitrogen content for compost, digestate, green manure implemented.	**5.12.4**
5.	3.D.1.4 Crop Residues	The recalculation of crop residues was done due to the implementation of FracRemove for cereal crops used for bedding purposes.	**5.12.6**
6.	3.D.2 Indirect N_2O Emissions From Managed Soils	The revision of category 3.D.2 was performed due to changes in previous categories. The correction of FracLeach and nitrogen leakage was done.	**5.12**, **5.12.10**
7.	3.G Liming	The revision analysis of activity data since 1998 was performed. The calcium substances containing only CaO, MgO or Ca, Mg were subtracted from activity data.	**5.15.1**, **5.12.2**

Figure 5.4 shows overall trend of recalculated emissions and comparison of 2021 and 2022 submissions.

Figure 5.4: *Comparison of 2021 and 2022 submissions in the Agriculture sector (in Gg of CO_2 eq.)*



Ad 1: The recalculation of N_2O emissions from the application of inorganic fertilizers was performed based on revised input data on the consumption of fertilizers in the soil for the years 2000 – 2011, revision was prepared by the ÚKSÚP. The ŠÚ SR assumed the revised data and prepared resubmission to the EUROSTAT. This change has led to a significant increase in emissions for particular years. The impact on recalculation is visible in ***Table 5.7***.

Table 5.7: *The recalculations of N_2O emissions in 3.D.1.1 – Inorganic N-Fertilizers in 1990 – 2019*

Category	3.D.1.1 INORGANIC N FERTILIZERS		N INPUT FROM INORGANIC N FERTILIZERS TO CROPLAND AND GRASSLAND		INTERANNUAL CHANGE 2021/2022
Submission year	2021	2022	2021	2022	
EFs	*0.01*	*0.01*			
Year	*Gg*		*kg/year*		*%*
2000	1.14	1.33	72 653 000	84 609 000	16%
2001	1.19	1.61	76 032 000	102 423 000	35%
2002	1.39	1.75	88 260 000	111 507 000	26%
2003	1.28	1.54	81 300 000	97 727 000	20%
2004	1.26	1.53	79 911 000	97 151 000	22%
2005	1.28	1.57	81 317 000	99 760 000	23%
2006	1.24	1.52	78 681 120	97 023 000	23%
2007	1.40	1.78	88 935 400	113 298 000	27%
2008	1.38	1.91	87 736 950	121 435 000	38%
2009	1.21	1.51	77 058 450	96 334 000	25%
2010	1.37	1.67	86 873 000	106 513 000	23%
2011	1.46	1.89	92 969 000	120 555 000	30%

Ad 2, **Ad 3**, **Ad 4:** The recalculation of N_2O emissions from animal manure applied to the soils was processed due to the implementation of N inputs from straw-based systems (deep bedding) in the poultry and swine category. The implementation of changes was implemented based on the recommendation raised by the ERT during the 2021 UNFCCC review.

The recalculation of N_2O emissions from the WWTP sludge application was performed. The new database of industrial sludge consumption for agricultural purposes was available. Primary source of data are provided by the ŠÚ SR. Simultaneously, data set used in the emissions estimation is consistent with the data used and presented in the **Waste sector**. These changes caused an increase in N_2O emissions.

The revisions of N_2O emissions from the application of other organic nitrogen fertilizers (compost, digestate, green manure) were prepared with the revision of parameters for the estimation of nitrogen content. Nitrogen content value of 1 tonne of compost = 7 kg of N was replaced by more accurate nitrogen content. More information is available in **Chapter 5.12.4**. Recalculations led to increase of emissions compared to the previous submission by +12.96% in 3.D.1.2 for the year 2019 (***Table 5.8***).

Table 5.8: *The recalculations of N_2O emissions in 3.D.1.2 – Organic N-Fertilizers in 1990 – 2019*

Category	3.D.1.2 ORGANIC N FERTILIZERS		N INPUT FROM ORGANIC N FERTILIZERS TO CROPLAND AND GRASSLAND	
Submission year	2021	2022	2021	2022
EFs	*0.01*	*0.01*		
Year	*Gg*		*kg/year*	
1990	0.99	0.99	62 828 362	63 148 244
1991	0.89	0.89	56 441 009	56 762 647
1992	0.79	0.79	50 214 930	50 435 474

Category	3.D.1.2 ORGANIC N FERTILIZERS		N INPUT FROM ORGANIC N FERTILIZERS TO CROPLAND AND GRASSLAND	
Submission year	2021	2022	2021	2022
EFs	***0.01***	***0.01***		
Year	*Gg*		*kg/year*	
1993	0.70	0.70	44 468 491	44 627 277
1994	0.68	0.69	43 345 303	43 641 383
1995	0.68	0.69	43 484 909	43 685 151
1996	0.66	0.67	42 289 475	42 525 840
1997	0.67	0.68	42 787 186	43 143 961
1998	0.60	0.60	38 233 668	38 494 690
1999	0.58	0.58	36 631 031	36 916 267
2000	0.58	0.59	36 920 337	37 745 411
2001	0.59	0.60	37 496 737	38 189 997
2002	0.57	0.59	36 475 611	37 372 105
2003	0.55	0.57	34 979 553	36 006 038
2004	0.50	0.52	32 082 704	32 969 158
2005	0.50	0.51	31 778 210	32 368 734
2006	0.49	0.49	31 061 790	31 478 259
2007	0.47	0.49	30 018 602	31 086 041
2008	0.44	0.56	27 967 866	35 783 655
2009	0.45	0.53	27 779 375	33 938 190
2010	0.43	0.48	27 320 387	30 723 313
2011	0.41	0.50	26 069 714	32 055 089
2012	0.43	0.47	27 409 660	29 986 590
2013	0.44	0.50	28 244 411	31 709 195
2014	0.47	0.54	29 706 341	34 216 322
2015	0.48	0.54	30 617 177	34 278 529
2016	0.40	0.41	25 412 817	26 218 129
2017	0.40	0.41	25 763 302	25 969 379
2018	0.41	0.42	26 145 389	26 624 594
2019	0.40	0.45	25 308 209	28 588 878
2021/2022 (2019)		**+12.96%**		**+12.96%**

Ad 5: The recalculation of crop residues was done due to the implementation of $Frac_{Remove}$ for cereal crops used for bedding purposes. The revision of methodology was implemented based on the recommendation of the ERT during the 2021 UNFCCC review. Detailed information on recalculations and description of methodological changes are available in the **Chapter 5.12.6**. Recalculations led to decrease of emissions in the category 3.D.1.4 compared to the previous submission by -19.89% in 2019.

Table 5.9: *The recalculations of N_2O emissions in 3.D.1.4 – Crop Residues in 1990 – 2019*

Category	3.D.1.4 CROP RESIDUES		N IN CROP RESIDUES RETURNED TO SOILS	
Submission year	2021	2022	2021	2022
EF	***0.01***	***0.01***		
Year	*Gg*		*kg/year*	
1990	1.05	1.03	66 838 786	65 333 234
1991	1.13	1.10	71 762 496	70 227 717
1992	0.98	0.96	62 625 821	61 280 943
1993	0.88	0.86	55 864 532	54 675 102

Category	3.D.1.4 CROP RESIDUES		N IN CROP RESIDUES RETURNED TO SOILS	
Submission year	**2021**	**2022**	**2021**	**2022**
EF	***0.01***	***0.01***		
Year	*Gg*		*kg/year*	
1994	1.00	0.98	63 886 963	62 406 099
1995	0.96	0.93	60 841 690	59 467 913
1996	0.92	0.90	58 541 078	57 315 336
1997	0.99	0.96	62 701 943	61 345 834
1998	0.93	0.91	59 496 186	58 179 432
1999	0.82	0.80	52 080 517	51 114 948
2000	0.64	0.63	40 891 810	40 017 955
2001	0.89	0.88	56 948 235	55 742 587
2002	0.87	0.85	55 275 732	54 145 339
2003	0.70	0.68	44 299 127	43 425 720
2004	0.97	0.95	61 819 759	60 529 401
2005	0.91	0.89	57 945 239	56 820 571
2006	0.81	0.79	51 320 585	50 363 485
2007	0.77	0.76	49 038 256	48 060 092
2008	1.02	1.00	64 977 238	63 734 344
2009	0.88	0.86	55 710 925	54 700 883
2010	0.71	0.70	45 288 206	44 560 732
2011	0.92	0.91	58 733 474	57 770 548
2012	0.78	0.77	49 618 043	48 804 872
2013	0.89	0.88	56 891 639	55 902 588
2014	1.14	1.12	72 769 674	71 561 386
2015	0.98	0.97	62 624 323	61 417 665
2016	1.19	1.17	75 972 217	74 670 464
2017	0.96	0.94	61 139 304	60 128 443
2018	1.04	1.03	66 315 321	65 258 655
2019	1.31	1.05	83 382 951	66 799 010
2021/2022 (2019)		**-19.89%**		**-19.89%**

Ad 6: Indirect N_2O emissions from agricultural soils were recalculated. The revision of category 3.D.2.1 - Atmospheric Deposition was performed due to changes in category 3.D.1.1 - Inorganic N Fertilizers in 2000 – 2011 and in category 3.D.1.2 - Organic N Fertilizer in 1990 – 2019. The revision of category 3.D.2.2 - Nitrogen Leaching and Run-off was performed due to changes in category 3.D.1.1 - Inorganic N Fertilizers in 2000 – 2011, 3.D.1.2 - Organic N Fertilizer in 1990 – 2019 and 3.D.1.4 - Crop Residues in 1990 – 2019. During 2021 submission, the incorrect value of the fraction and amount of applied organic and inorganic nitrogen that is leached ($Frac_{LEACH-NATIONAL}$ = 24%) was used in all years. In 2022 submission, the values of $Frac_{Leach}$ and leached nitrogen were corrected (***Table 5.10***). Detailed information on recalculations and description of methodological changes are available in the **Chapters 5.12.2**, **5.12.3**, **5.12.4** and **5.12.6**. Recalculations led to a decrease in emissions compared to the previous submission by 11.1% in 2019. Impact of recalculations compared to the previous submission is visible in ***Table 5.10***.

Table 5.10: The recalculations of N_2O emissions in 3.D.2.1 and 3.D.2.2 in 1990 – 2019

Category	3.D.2.1 ATMOSPHERIC DEPOSITION		3.D.2.2 NITROGEN LEACHING AND RUN-OFF		VOLATILIZED N FROM AGRICULTURAL INPUTS OF N		N FROM FERTILIZERS AND OTHER AGRICULTURAL INPUTS THAT IS LOST THROUGH LEACHING AND RUN-OFF	
Submission year	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
EFs	**0.01**	**0.01**	**0.0075**	**0.003**				
Year	*Gg*				*kg N/year*			
1990	0.593	0.594	1.044	1.040	37 733 046	37 797 023	88 543 653	88 257 337
1991	0.451	0.452	0.821	0.803	28 722 973	28 787 301	69 691 115	68 097 965
1992	0.342	0.342	0.616	0.590	21 746 703	21 790 811	52 285 927	50 059 938
1993	0.275	0.276	0.501	0.470	17 526 236	17 557 993	42 504 737	39 867 199
1994	0.275	0.276	0.529	0.486	17 512 727	17 571 943	44 891 515	41 233 197
1995	0.279	0.279	0.525	0.472	17 723 549	17 763 597	44 524 536	40 046 989
1996	0.282	0.282	0.528	0.465	17 925 786	17 973 059	44 804 285	39 478 605
1997	0.296	0.298	0.573	0.494	18 862 961	18 934 316	48 578 579	41 877 962
1998	0.270	0.271	0.531	0.447	17 168 501	17 220 705	45 017 351	37 901 295
1999	0.239	0.240	0.458	0.377	15 209 599	15 266 646	38 881 992	32 015 624
2000	0.252	0.273	0.448	0.376	16 032 299	17 392 914	38 051 761	31 899 650
2001	0.258	0.301	0.504	0.457	16 389 878	19 167 630	42 776 102	38 783 189
2002	0.274	0.314	0.532	0.503	17 457 619	19 961 618	45 141 292	42 676 507
2003	0.259	0.288	0.477	0.443	16 470 904	18 318 901	40 459 704	37 551 708
2004	0.247	0.277	0.514	0.452	15 696 075	17 597 366	43 587 829	38 390 496
2005	0.248	0.279	0.506	0.539	15 772 862	17 735 267	42 917 521	45 728 648
2006	0.241	0.271	0.477	0.176	15 323 281	17 240 763	40 458 055	14 970 056
2007	0.256	0.297	0.498	0.291	16 268 847	18 918 594	42 288 542	24 683 927
2008	0.248	0.325	0.535	0.431	15 765 291	20 698 254	45 382 555	36 594 312
2009	0.231	0.280	0.478	0.323	14 684 334	17 843 652	40 549 171	27 419 995
2010	0.246	0.287	0.476	0.818	15 632 793	18 277 379	40 363 152	69 407 021
2011	0.251	0.313	0.528	0.143	15 978 809	19 934 484	44 762 129	12 092 163
2012	0.270	0.278	0.530	0.143	17 152 330	17 667 716	44 943 688	12 093 118
2013	0.292	0.303	0.589	0.359	18 575 866	19 268 823	49 933 952	30 455 248
2014	0.306	0.320	0.654	0.530	19 465 985	20 367 981	55 498 964	44 989 544
2015	0.302	0.313	0.616	0.070	19 216 322	19 948 592	52 232 529	5 953 850
2016	0.303	0.306	0.671	0.445	19 286 541	19 447 603	56 922 666	37 758 020
2017	0.298	0.298	0.619	0.238	18 943 407	18 984 623	52 479 613	20 209 218
2018	0.311	0.312	0.654	0.064	19 759 816	19 855 657	55 488 005	5 388 277
2019	0.306	0.317	0.698	0.242	19 490 075	20 146 209	59 223 480	20 500 841
2021/2022 (2019)		**+3.37%**		**-65.38%**		**+3.37%**		**-65.38%**

Ad 7: A comprehensive analysis of data since 1998 was performed. The calcium substances containing only CaO were subtracted from activity data, because mentioned substances do not emit CO_2 emissions. A similar analysis was prepared for the application of dolomite to the soil. This change led to the preparation of a new extrapolation analysis up to 1990. The recalculation had an impact on emissions from the 3.G categories.

Detailed information on recalculations and description of methodological changes are available in the **Chapter 5.15**. Recalculations led to a decrease in emissions compared to the previous submission by 41.61% and 81.36% in 2019. Impact of recalculations compared to the previous submission is visible in ***Table 5.11***.

Table 5.11: *The recalculations of N_2O emissions in 3.G.1 and 3.G.2 in 1990 – 2019*

Category	3.G.1 LIMESTONE $CaCO_3$		3.G.2 DOLOMITE $CaMg(CO_3)_2$		AMOUNT APPLIED OF LIMESTONE		AMOUNT APPLIED OF DOLOMITE	
Submission year	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
EFs	***0.12***	***0.12***	***0.13***	***0.13***				
Year	*Gg*				*t/year*			
1990	44.6	43.8	6.4	1.9	101 400	99 515	13 530	4 076
1991	36.0	42.3	6.5	1.9	81 900	96 091	13 678	3 995
1992	27.5	40.8	6.6	1.9	62 400	92 668	13 825	3 913
1993	18.9	39.3	6.7	1.8	42 900	89 245	13 972	3 831
1994	10.3	37.8	6.7	1.8	23 400	85 822	14 120	3 750
1995	63.1	36.3	6.8	1.7	143 520	82 398	14 267	3 668
1996	48.0	34.7	6.9	1.7	109 200	78 975	14 414	3 587
1997	104.1	33.2	6.9	1.7	236 700	75 552	14 561	3 505
1998	140.5	39.1	7.0	1.0	319 280	88 782	14 709	2 092
1999	71.3	49.0	7.1	3.5	162 105	111 323	14 856	7 295
2000	43.7	32.0	7.2	2.3	99 249	72 806	15 003	4 840
2001	65.6	45.1	7.2	3.2	149 170	102 473	15 151	6 713
2002	28.0	19.6	7.3	1.4	63 676	44 569	15 298	2 865
2003	25.2	18.2	7.4	1.2	57 353	41 453	15 445	2 581
2004	11.2	8.9	5.5	0.5	25 380	20 155	11 611	1 142
2005	8.7	8.8	4.5	0.4	19 772	20 087	9 371	922
2006	9.2	7.8	4.6	0.5	20 983	17 737	9 600	944
2007	11.0	7.9	5.5	0.5	25 075	17 893	11 609	1 142
2008	18.6	13.5	10.0	1.0	42 265	30 605	20 925	2 058
2009	17.5	12.5	8.8	0.9	39 792	28 434	18 542	1 824
2010	10.9	7.7	5.3	0.5	24 780	17 533	11 015	1 083
2011	19.7	14.1	10.2	1.0	44 685	32 130	21 430	2 108
2012	14.7	10.6	7.7	0.8	33 311	23 978	16 053	1 579
2013	15.5	11.2	8.0	0.8	35 298	25 362	16 873	1 660
2014	15.7	11.2	7.9	0.8	35 611	25 425	16 529	1 626
2015	16.1	11.6	8.5	0.8	36 503	26 321	17 732	1 744
2016	11.2	5.0	9.1	1.8	25 445	11 288	19 082	3 791
2017	4.5	2.0	3.8	0.7	10 157	4 471	8 025	1 366
2018	8.7	3.3	4.8	0.9	19 720	7 572	10 027	1 845
2019	6.2	3.6	5.8	1.1	14 126	8 248	12 171	2 269
2021/2022 (2019)		**-41.61%**		**-81.36%**		**-41.61%**		**-81.36%**

5.5 NATIONAL CIRCUMSTANCES AND TIME-SERIES CONSISTENCY

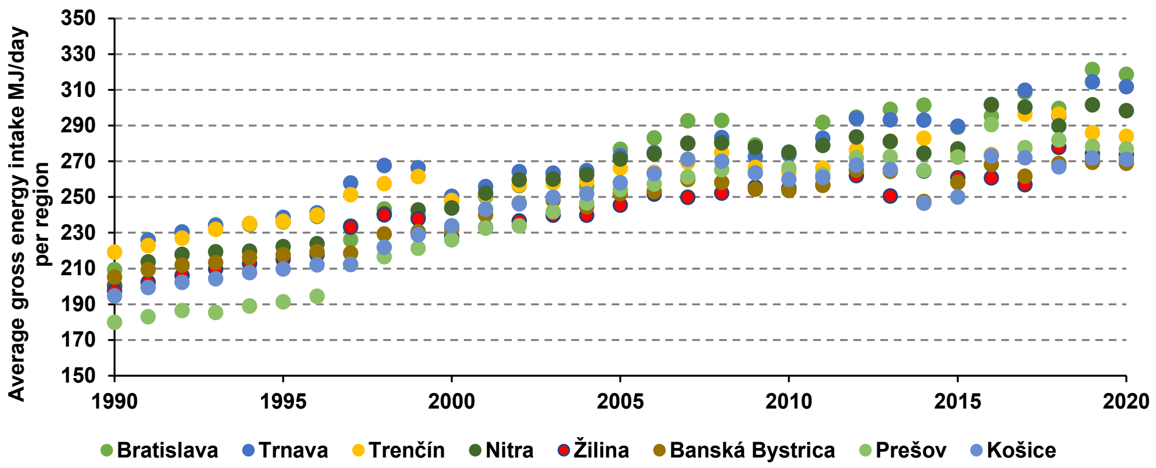
Slovak farmers have been adapted to changes in agriculture after 1990. They invested in the development of their farms to avoid the bankrupt and to be self-competitive in this sector. The EU policy supported the used tools as the base of transformation. The EU policy and measures were transformed into 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 22-25 litres/day. In other regions, milk productivity is 16-18 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 5.5*** and ***5.6***. Highly productive dairy cows (milked 25 litres/day) need to be fed by 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 (286.56 MJ/head/day) (***Table 5.12***).

Table 5.12: *The comparison of the Slovak milk yield with other regions in 2020*

DAIRY COWS	SLOVAKIA[1]	WESTERN EUROPE[2] (AVERAGE)	EASTERN EUROPE[2] (AVERAGE)	NORTH AMERICA[6] (AVERAGE)
	kg/year/head			
Milk yield	7 432	7 465	4 853	10 304

Figure 5.5 *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 70% in 2020 compared to 1990 (***Figure 5.6***). Milk production increased up to 190% in 2020 (***Figure 5.7***) compared to the 1990, 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 per year.

[1] The animal production, sales of primary production and crop balance (in Slovak) www.statistics.sk

[2] Producing Animals (Slaughtered), Milk Production http://www.fao.org/faostat/en/#data/QL

Figure 5.6: *Correlation of milk production (kg/day/head) and nitrogen excretion rate (kg N/year/head)*

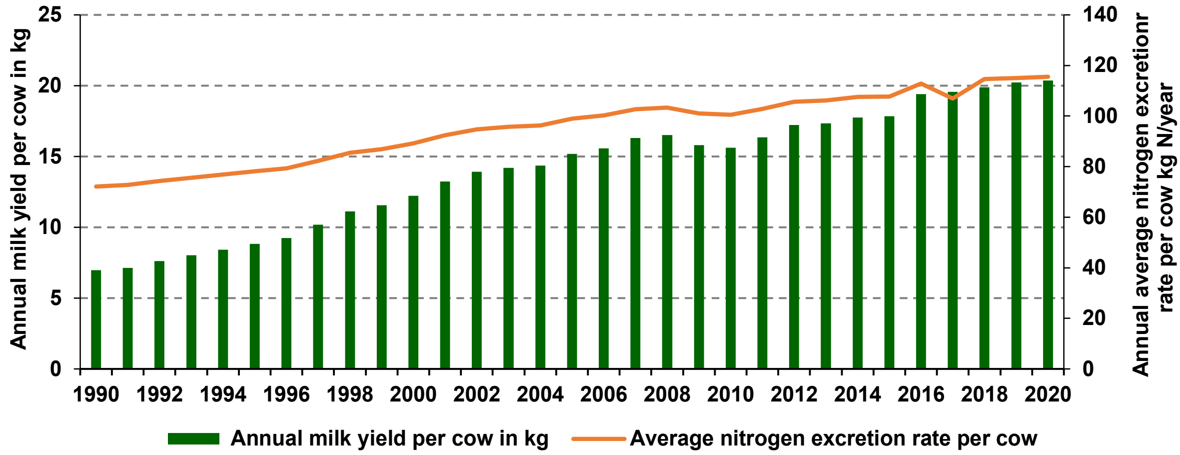
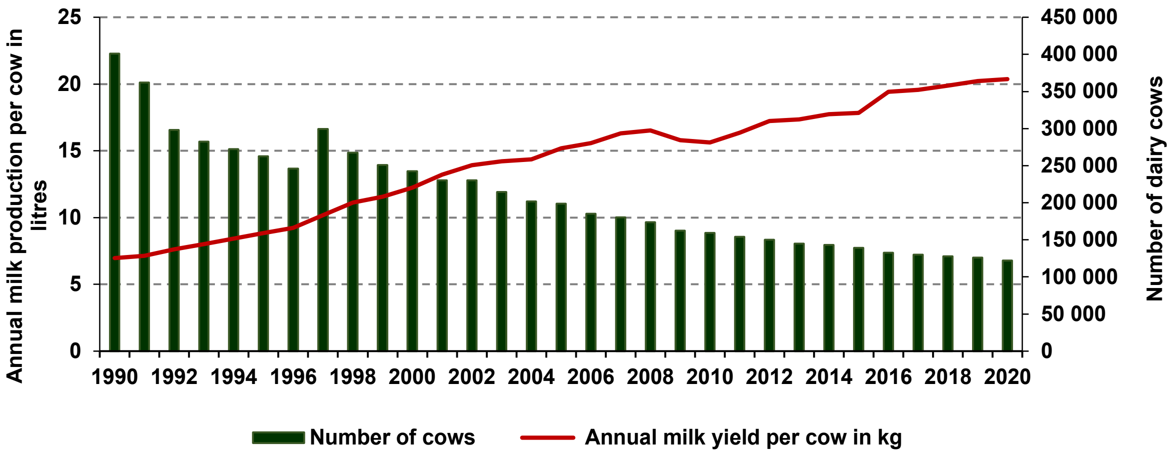
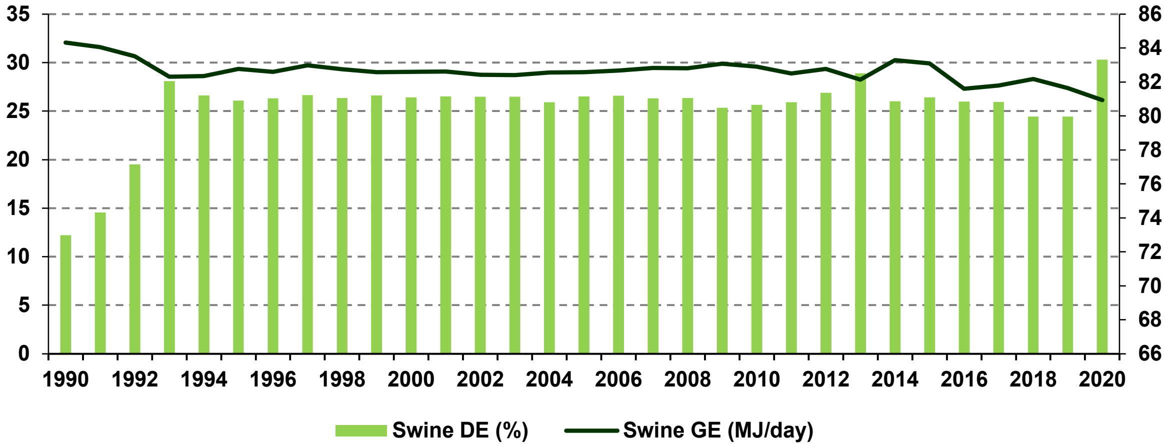


Figure 5.7: *Trend in dairy cattle population and dairy milk production (kg/head/day)*



The pig farming system in the Slovak Republic is divided into two types - breeding and fattening 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 (***Figure 5.8***). 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. In 2020, visible increase of digestibility of feeding doses occurred. This value was estimated by VÚŽV and correlated with increase of pig performance in that year. The opposite trend is visible in the last 4 years mainly in breeding pigs. The decrease in crude proteins, cereals had an impact on the decrease of monitored parameters. Pig breeding in Slovakia has problems mainly due to risk of persistent morbidity - African swine fever and other economic reasons, which lead to decrease numbers of pigs

Figure 5.8: Trend of feed digestibility and gross energy intake of swine in the Slovak Republic



5.6 UNCERTAINTIES

In 2022 submission, comprehended analysis on uncertainties was implemented into agricultural inventory for the first time. 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 latest reviewed year 2019. 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 using for understanding of the impact of risk and uncertainty in prediction and forecasting models. The Monte Carlo analysis was prepared on regional level. The uncertainties of livestock population for 2019 are presented in ***Table 5.13***. Uncertainties were estimated according to an assessment of the SHMÚ team while no information was provided by the ŠÚ SR in this area. 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 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 ±10.124%.

Table 5.13: Uncertainty of animal population data for 2019

CATEGORY	UNIT	AGREGATED UNCERTAINITY OF NUMBER OF LIVESTOCK
Dairy cattle	head	±3 349
Non-dairy cattle	heads	±627
Sheep	heads	±5 632
Goats	heads	±356
Horses	heads	±104
Swine	heads	±20 545
Poultry	heads	±748 224
Overall (weighted mean)	**heads**	**±10.124%**

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 calculated on the value 47.402 Gg of CH_4 (38.65 Gg of CH_4 were estimated in inventory) with uncertainty (-13%, +13%), which represent 95% confidence interval. 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 fermentations for dairy cattle, non-dairy cattle and sheep were based on uncertainties of milk production, wool production and weight listed in ***Tables 5.14-5.17***. 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 5.14: *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*	±2.435	±0.022	± 0.310	±0.246	±0.051	±9.66	±4.950
Activity NE_a	*MJ/day*	±0.160		±0.404	±0.170	-	-	±0.884
Lactation N_{El}	*MJ/day*	±2.853	-	-	-	-	-	-
Work		-	-	-	-	-	±12.94	-
Growth NE_g	*MJ/day*	-	±0.754	±1.570	±1.147	±0.562	-	-
Pregnancy NEp	*MJ/day*	±0.315	-	-	±0.294	-	-	-
REM		±0.019	±0.031	±0.056	±0.035	±0.020	±0.18	±0.060
REG		±0.019	±0.019	±0.032	±0.020	±0.012	±0.11	±0.034
Gross energy	*MJ/head/day*	±16.457	±5.249	±19.627	±16.215	±6.496	±116.613	±32.752
EFs	*kg/head/year*	±46.478	±10.605	±22.746	±29.247	±20.772	±62.545	±31.936

Table 5.15: *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	±0.059	±0.060	±0.123	±0.129	±8.091	±5.040
Activity NE_a	*MJ/day*	±0.433	±0.276	±0.743	±1.011	-	-	-
Lactation N_{El}	*MJ/day*	±0.484	-	-	-	-	-	-
Work		-	-	-	-	-	±9.095	-
Growth NE_g	*MJ/day*		±2.251	±1.242	±1.433	±1.848		-
Pregnancy NEp	*MJ/day*	±0.218			±0.513	-	-	-

PARAMETER*	UNIT	UNCERTAINITY						
		Suckling cows	Calves	Heifers un-pregnant milk breed	Heifers pregnant milk breed	Fattening	Oxen	Breeding bulls
REM		±0.024	±0.070	±0.063	±0.059	±0.064	±0.124	±0.097
REG		±0.013	±0.041	±0.034	±0.032	±0.035	±0.069	±0.054
Gross energy	*MJ/head/day*	±11.020	±16.36	±22.286	±30.906	±24.201	±85.422	±44.504
EFs	*kg/head/year*	±28.427	±16.17	±23.927	±35.179	±25.527	±53.124	±32.729

Table 5.16: *Uncertainties of emission factors in non-key categories in enteric fermentation*

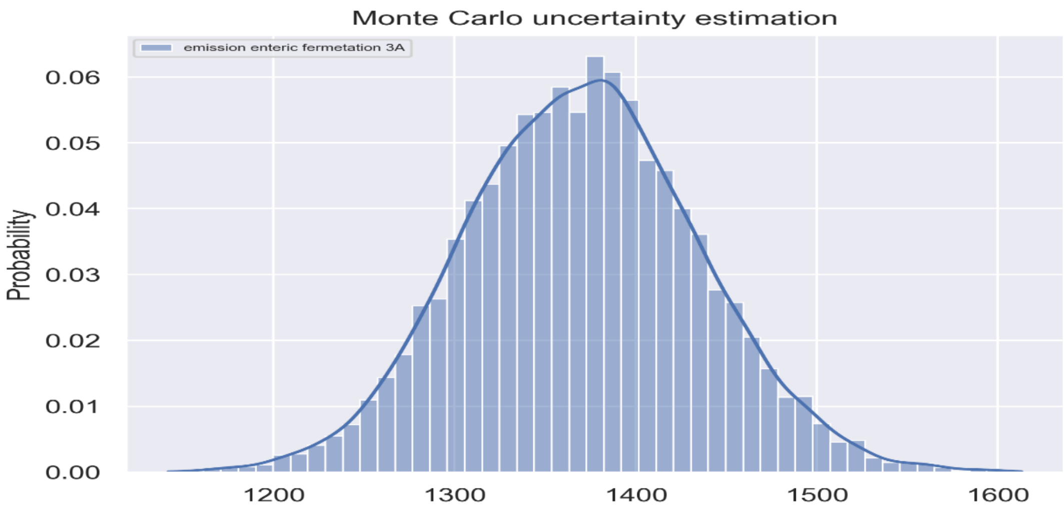
Year	Uncertainty	Animals	Emission factor
2019	0.038173 Gg CH_4	Swine	1.5 kg/head
2019	0.003611 Gg CH_4	Horse	18 kg/head
2019	0.017114 Gg CH_4	Goats	5 kg/head

Table 5.17: *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*	±0.156	±0.606	±0.518	±1.092	±0.162	±0.600	±0.547	±1.140
Activity NE_a	*MJ/day*	±0.060	±0.162	±0.166	±0.150	±0.095	±0.188	±0.235	±0.170
Lactation N_{El}	*MJ/day*	±0.058				±0.077			
Wool production Ne_{wool}	*MJ/day*	±0.005	±0.006	±0.006	±0.005	±0.008	±0.008	±0.014	±0.008
Growth NE_g	*MJ/day*		±0.078	±0.227			±0.176	±0.226	
Pregnancy NEp	*MJ/day*	±0.199		±0.588		±0.315		±0.846	
REM		±0.017	±0.030	±0.023	±0.017	±0.028	±0.049	±0.049	±0.027
REG		±0.009	±0.015	±0.012	±0.009	±0.015	±0.025	±0.024	±0.014
Gross energy	*MJ/head/day*	±1.824	±3.002	±5.018	±4.453	±3.039	±4.501	±8.370	±5.171
EFs	*kg/head/year*	±5.569	±3.802	±8.087	±5.743	±6.192	±4.784	±9.399	±6.262

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 CO_2 eq.)*



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 4.2 Gg of CH_4 (3.48 Gg of CH_4 were estimated in inventory) with uncertainty (-2%, +2%) which represent 95% confidence interval. 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 5.18-5.23***. Data on storage systems and number of livestock is readily available.

Table 5.18: *Uncertainties of parameters used in manure management for cattle and sheep in 2019*

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 5.19: *Uncertainties of parameters used in manure management for swine in 2019*

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 5.20: *Uncertainties of parameters used in manure management for swine in 2019*

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

*B_o for Western Europe was chosen

Figure 5.10: *Probability distribution function for the category 3.B.1 (x-axis in Gg of CO_2 eq.)*

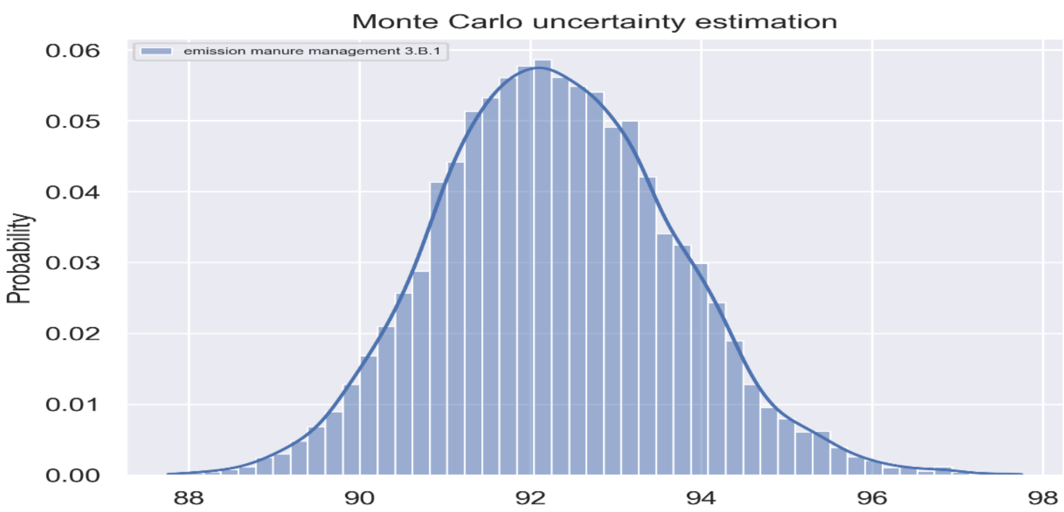


Table 5.21: *Uncertainties of parameters calculated in manure management for sheep in 2019*

ANIMAL		EFs	VSs
		kg VS/day	*kg/head*
DAIRY SHEEP	**Mature ewes**	±0.027	±0.039
	Growing lambs	±0.047	±0.068
	Growing lambs (pregnant)	±0.079	±0.113
	Other mature sheep	±0.094	±0.101
BEEF SHEEP	**Mature ewes**	±0.044	±0.065
	Growing lambs	±0.069	±0.102
	Growing lambs (pregnant)	±0.127	±0.189
	Other mature sheep	±0.110	±0.118

Table 5.22: *Uncertainties of parameters calculated in manure management for swine in 2019*

ANIMAL		VSs	EFs
		kg/head	*kg VS/day*
MILK TYPE	**Dairy cows**	±0.259	±0.499
	Calves in 6. month	±0.444	±0.053
	Heifers	±0.333	±0.289
	Heifers (pregnant)	±0.272	±0.236
	Fattening	±0.104	±0.129
	Oxen	±1.948	±1.715
	Breeding bull	±0.575	±0.444
BEEF TYPE	**Suckler cows**	±0.215	±0.138
	Calves in 6. month	±0.226	±0.159
	Heifer	±0.427	±0.273
	Heifer (pregnant)	±0.609	±0.389
	Fattening	±0.459	±0.730
	Oxen	±1.568	±1.568
	Breeding bull	±0.789	±0.609

Table 5.23: *Uncertainties of parameters calculated in manure management for swine in 2019*

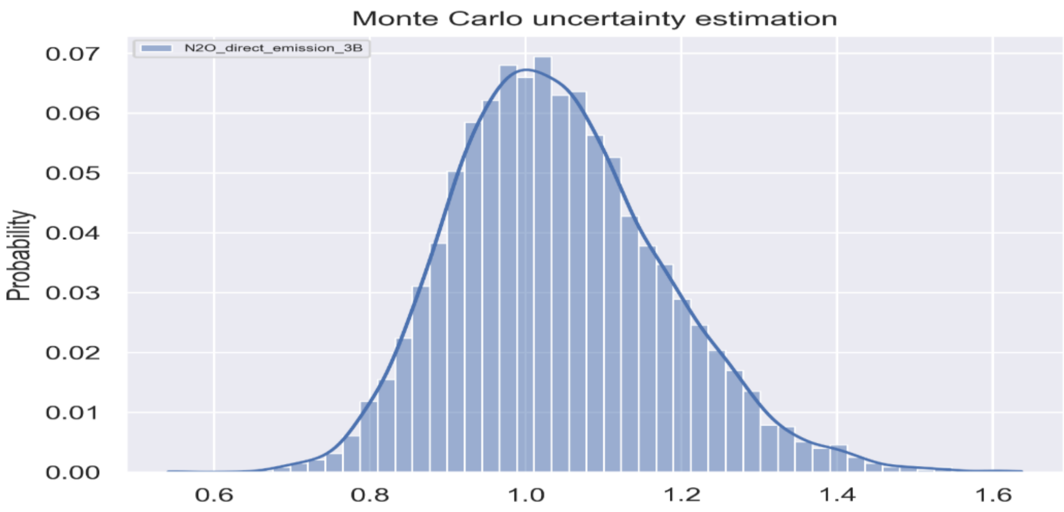
ANIMAL	VSs	GE	ME	EFs
	kg/head	MJ/day	MJ/day	kg/head
Sows	±0.002	±0.136	±0.104	±0.463
Gilts non-pregnant	±0.001	±0.072	±0.056	±0.153
Gilts pregnant	±0.001	±0.081	±0.062	±0.556
Hogs	±0.001	±0.069	±0.053	±0.624
Piglets 20 kg	±0.001	±0.089	±0.068	±0.033
Piglets 21-50kg	±0.001	±0.089	±0.069	±0.062
Fattening to 20 kg	±0.001	±0.080	±0.062	±0.050
Fattening to 21-50 kg	±0.001	±0.076	±0.058	±0.029
Fattening to 50-80 kg	±0.001	±0.067	±0.051	±0.157
Fattening to 80-100 kg	±0.001	±0.067	±0.052	±0.330
Fattening from 110 kg	±0.001	±0.067	±0.051	±0.054

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 1.147 Gg of N_2O (0.50 Gg of N_2O were estimated in inventory) with uncertainty (-2.6%, +2.6%), which represent 95% confidence interval. 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 2006 IPCC 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)

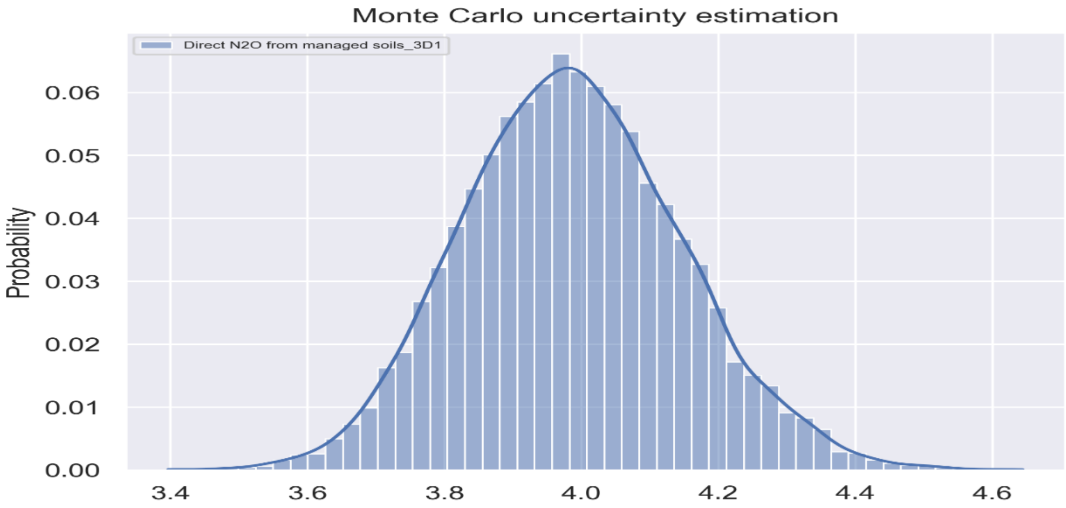
Results of the Monte Carlo simulation for N_2O emissions in the category 3.D.1 – Direct N_2O Emissions from Managed Soils were calculated on the value 3.986 Gg od N_2O (3.73 Gg of N_2O were estimated in inventory) with uncertainty (-7.90%, +7.90%), which represent 95% confidence interval. A probability 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 5.24***). 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 ±7.60%.

Table 5.24: *Uncertainties of activity data in 3.D - Agricultural Soils*

N_2O DIRECT/INDIRECT EMISSION FROM MANAGED SOILS	*UNITS*	UNCERTAINTIES
Animal Manure Applied to Soils	*kg N year*	±13 186 741.46
Urine and Dung deposited by grazing animals	*kg N year*	±2 348 035.73
Crop residues	*kg N year*	±15 196 020.74
Mineralization or Immobilization Associated with Loss or Gain of Soil Organic Matter	%	±0.0
Inorganic N Fertilizers	%	±2
Atmospheric Deposition	%	±12.60
Nitrogen Leaching and Run-off	%	±7.94

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)

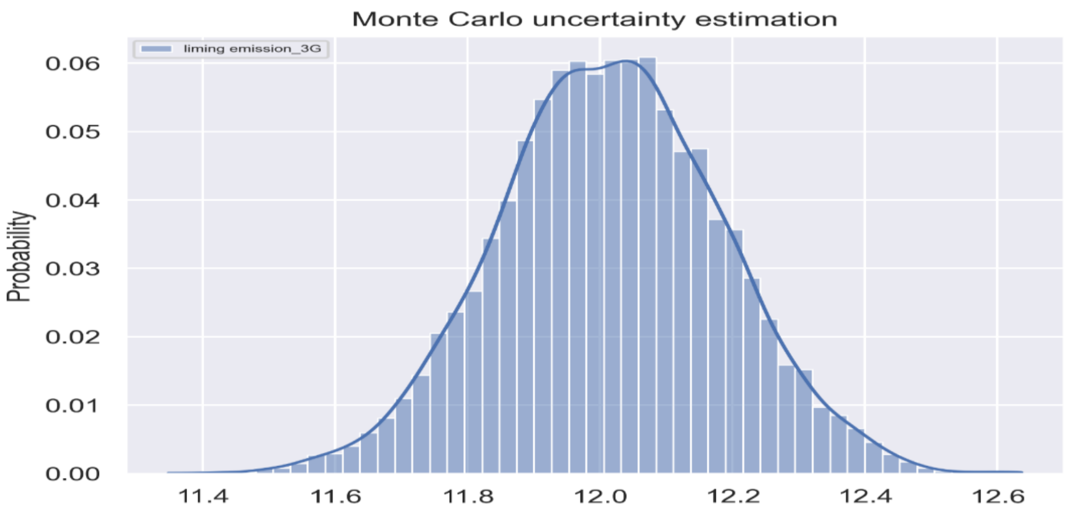
Results of the Monte Carlo simulation for N_2O emissions in the category 3.D.2 – Indirect N_2O Emissions from Managed Soils were calculated on the value 1.784 Gg of N_2O (0.65 Gg of N_2O were estimated in inventory) with uncertainty (-101%, +101%), which represent 95% confidence interval.

The overall uncertainty of indirect N_2O emissions was estimated based on partial uncertainties in emission factors. These uncertainties were combined with the uncertainties in the $Frac_{GASM}$ (±50%) and $Frac_{GASM}$ (±75%). Uncertainties of emission factors in indirect N_2O emissions from soils were calculated at a level of ±151.12%, 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 calculated on the value 12.015 Gg of CO_2 (8.45 Gg of CO_2 were estimated in inventory) with uncertainty (-50.06%, +50.06%), which represent 95% confidence interval. 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.

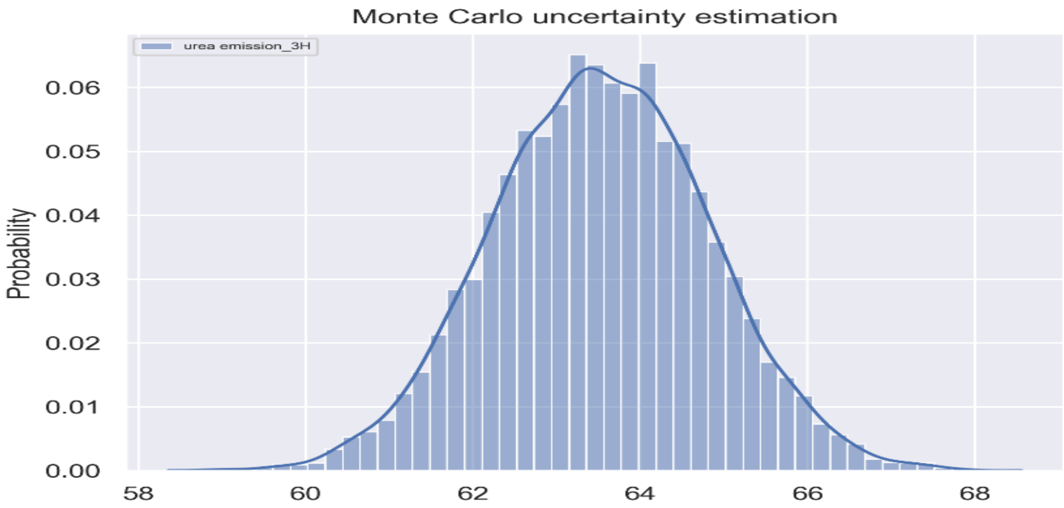
Figure 5.13: *Probability distribution function for the category 3.G (x-axis in Gg of CO_2)*



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 63.538 Gg od CO_2 (63.67 Gg of CO_2 were estimated in inventory) with uncertainty (-50.15%, +50.15%), which represent 95% confidence interval. 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 5.25: *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	±0.6%	±9.30%	±13%
3.B.1 Manure Management	CH_4	±5.40%	±3.00%	±2%
3.B.2 Manure Management	N_2O	±5.20%	±2.60%	±2.6%
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	±9.50%	±7.60%	±7.9%
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	±9.50%	±151.12%	±101%
3.G Liming	CO_2	±2.50%	±50.00%	±50.06%
3.H Urea Application	CO_2	±3.90%	±50.00%	±50.15%

5.7 ENTERIC FERMENTATION (CRF 3.A)

EMITTED GAS: CH_4
METHODS: T1 and T2
EMISSIONS FACTORS: D, CS
KEY SOURCES: YES
SIGNIFICANT SUBCATEGORIES: CATTLE

Among all domestic livestock, 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 in this category. The number of dairy cattle further decreased in 2020 in comparison with 2019 (-3%), non-dairy cattle increased in 2020 in comparison with 2019 (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.

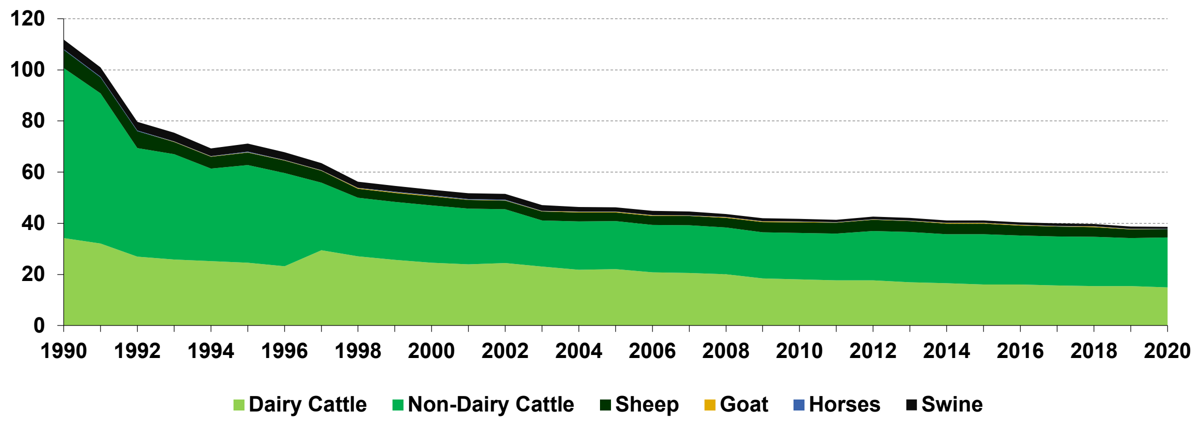
The decline in the number of all species of livestock since the base year is significant mostly in cattle, sheep and horses' categories in the Slovak Republic. The highest decrease was observed in swine (-75%), cattle (-55%) and sheep (-28%) categories compared to the base year. The number of livestock also decreased in goats (-70%), swine (-9%), sheep (-8.7%) horses (-12%) and poultry (-19%) categories in 2020 compared to 2019. The number of cattle increased compared to 2019 by +2%.

Methane emissions from enteric fermentation have the major share on GHG emissions in agriculture. The cattle represents nearly 89.31% of these emissions; from that dairy cattle 38.6% share. Other categories of domestic livestock provide less than 10.69% 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 2019. Total methane emissions from enteric fermentation decreased from 111.87 Gg in 1990 to 38.65 Gg in 2020 (-65%) and decrease by nearly 0.29% compared to the previous year. More information is available in ***Table 5.26*** and on ***Figure 5.15***.

Table 5.26: *Methane emissions from enteric fermentation according to livestock in particular years*

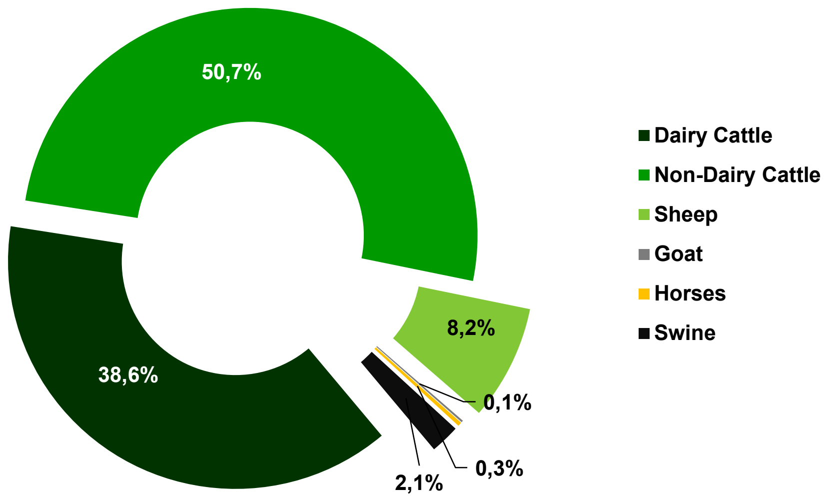
YEAR	DAIRY CATTLE	NON-DAIRY CATTLE	SHEEP	GOAT	HORSES	SWINE
	CH_4 in Gg					
1990	34.173	66.510	7.108	0.052	0.245	3.781
1995	24.509	38.220	4.944	0.125	0.182	3.115
2000	24.538	22.397	3.584	0.257	0.171	2.233
2005	22.088	18.715	3.456	0.198	0.150	1.662
2010	17.999	18.165	4.200	0.176	0.128	1.031
2011	17.659	18.332	4.174	0.170	0.125	0.871
2012	17.719	19.275	4.353	0.174	0.130	0.947
2013	16.966	19.590	4.252	0.177	0.129	0.956
2014	16.527	19.177	4.176	0.176	0.123	0.963
2015	16.113	19.613	4.175	0.182	0.124	0.950
2016	16.000	19.205	3.923	0.182	0.115	0.879
2017	15.683	19.160	3.861	0.185	0.111	0.922
2018	15.475	19.267	3.771	0.185	0.128	0.941
2019	15.428	18.735	3.416	0.178	0.125	0.884
2020	14.911	19.613	3.160	0.053	0.110	0.807

Figure 5.15: Trend in methane emissions (Gg) by animals in enteric fermentation in 1990 – 2020



Methane emissions from dairy and non-dairy cattle represent the significant share of emissions in enteric fermentation (38.6% and 50.74%). More than 8.18% 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 shown on ***Figure 5.16***.

Figure 5.16: The share of aggregated emissions by categories within enteric fermentation in 2020



5.7.1 METHODOLOGICAL ISSUES – METHODS

The intensive 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 5.34)***. The overview is provided in ***Tables 5.27-5.33***. 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 (598.89 kg), share of pregnancy (70.15%)

and share of digestibility of feed (72.71%). 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 5.27: *The overview of used country specific parameters for dairy cattle and suckler cows in 2020*

PARAMETER*	UNIT	DAIRY COWS	SUCKLER COWS	SOURCES OF PARAMETERS**
Body weight	*kg*	598.89	594.90	NPPC-VÚŽV
Milk yield	*l/day*	19.75	6.26	Parameter from the ŠÚ SR
Milk yield	*kg/day*	20.36	6.46	Calculated parameter
Fat milk	*%*	3.79	4.00	Parameter from the ŠÚ SR
DE	*%*	72.71	64.83	Calculated parameter – based on feeding statistics
Ym	*%*	6.50	6.50	Default value from IPCC 2006 GL
Maintenance NEm	*MJ/day*	46.73	42.27	Calculated parameter eq. 10.3 (IPCC 2006 GL)
Activity NEa	*MJ/day*	0.96	8.34	Calculated parameter eq. 10.4 (IPCC 2006 GL)
Lactation N_l	*MJ/day*	60.81	19.82	Calculated parameter eq. 10.8 (IPCC 2006 GL)
Pregnancy NEp	*MJ/day*	3.28	3.05	Calculated parameter eq. 10.13 (IPCC 2006 GL)
Ratio of net energy REM		0.54	0.51	Calculated parameter eq. 10.14 (IPCC 2006 GL)
Ratio of net energy REG		0.34	0.31	Calculated parameter eq. 10.15 (IPCC 2006 GL)
Gross energy	*MJ/head/day*	286.56	220.82	Calculated parameter eq. 10.16 (IPCC 2006 GL)
EFs	*kg/head/year*	122.17	94.14	Calculated parameter eq.10.21 (IPCC 2006 GL)

Table 5.28: *The overview of used country specific parameters for non-dairy cattle milk type in 2020*

PARAMETER*	UNIT	CALVES 6 MONTHS	HEIFER	HEIFER PREGNANT	FATTENING	OXEN	BREEDING BULL
Body weight	*kg*	115.19	372.85	598.78	345.64	700.00	800.00
Daily gain	*kg*	0.84	0.67	0.68	0.80	0.66	-
DE	*%*	81.20	70.45	70.69	71.56	70.44	68.80
Ym	*%*	6.50	6.50	6.50	6.50	6.50	6.50
Maintenance NE_m	*MJ/day*	11.32	27.22	38.86	29.65	50.35	55.66
Draft power Ne_{work}	*MJ/day*	-	-	-	-	25.18	-
Activity NE_a	*MJ/day*	-	1.92	1.12		-	4.94
Growth NE_g	*MJ/day*	12.43	11.36	13.57	11.35	-	-
NE_p	*MJ/day*	-	-	3.89	-	-	-
REM		0.55	0.53	0.53	0.53	0.53	0.53
REG		0.37	0.33	0.34	0.34	0.33	0.33
Gross energy	*MJ/head/day*	66.56	126.53	174.39	124.59	202.40	167.58
EFs	*kg/head/year*	28.38	53.94	74.35	53.19	86.29	71.44

Table 5.29: The overview of used country specific parameters for non-dairy cattle beef type in 2020

PARAMETER*	UNIT	CALVES 6 MONTHS	HEIFER	HEIFER PREGNANT	FATTENING	OXEN	BREEDING BULL
Body weight	*kg*	134.43	393.33	626.81	350.03	700.00	800.00
Daily gain	*kg*	0.95	0.50	0.50	0.72	-	-
DE	*%*	76.28	65.60	64.50	65.88	67.23	68.32
Ym	*%*	6.50	6.50	6.50	6.50	6.50	6.50
Maintenance NE_m	*MJ/day*	12.71	28.44	40.33	29.93	36.16	55.66
Draft power Ne_{work}	*MJ/day*	-	-	-	-	18.08	-
Activity NE_a	*MJ/day*	1.55	5.61	7.96	-	-	4.94
Growth NE_g	*MJ/day*	14.02	9.35	11.24	10.68	-	-
NE_p	*MJ/day*	-	-	4.03	-	-	-
REM		0.54	0.52	0.51	0.52	0.52	0.52
REG		0.36	0.31	0.31	0.31	0.32	0.33
Gross energy	*MJ/head/day*	85.99	146.36	215.41	139.59	154.91	168.39
EFs	*kg/head/year*	19.96	62.40	91.83	59.51	66.04	71.79

*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 2006 GL. Gross energy is the sum of energies calculated by formulas referred to the IPCC 2006 GL 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: $\mathbf{EF} = \left[\frac{GE * \left(\frac{Y_m}{100}\right) * 365}{55.65}\right]$

Where: **EF** = emission factor in kg CH_4/head, **GE** = gross energy intake in MJ/head/day, **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 5.30: 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	85.19	34.17
1995	262.66	8.83	218.87	93.31	24.51
2000	242.50	12.24	237.35	101.19	24.54
2005	198.58	15.18	260.90	111.23	22.09
2010	159.26	15.62	265.09	113.01	18.00
2011	154.11	16.35	268.79	114.59	17.66
2012	150.27	17.22	276.58	117.91	17.72
2013	144.88	17.34	274.69	117.11	16.97
2014	143.08	17.74	270.93	115.50	16.53
2015	139.23	17.85	271.47	115.73	16.11
2016	132.61	19.41	283.01	120.66	16.00
2017	129.86	19.56	283.27	120.77	15.68
2018	127.87	19.89	283.86	121.02	15.47
2019	125.85	20.22	287.56	122.59	15.43
2020	122.05	20.36	286.56	122.17	14.91

Table 5.31: *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	1 161.95	135.73	57.24	66.51
1995	666.04	136.31	57.38	38.22
2000	403.65	130.63	55.49	22.40
2005	329.31	133.98	56.83	18.71
2010	307.87	139.99	59.00	18.16
2011	309.25	140.51	59.28	18.33
2012	320.82	142.88	60.08	19.28
2013	322.95	144.38	60.66	19.59
2014	322.46	135.85	59.47	19.18
2015	318.36	147.63	61.61	19.61
2016	313.50	146.92	61.26	19.20
2017	309.96	147.73	61.81	19.16
2018	310.98	148.16	61.95	19.27
2019	306.41	146.28	61.14	18.73
2020	320.24	146.67	61.24	19.61

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.[3]

Table 5.32: *The overview of used country specific parameters for sheep in 2020*

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	0.27	-	-	-	0.27	-	-	-
Milk yield	kg/day	0.28	-	-	-	0.27	-	-	-
DE of feed	%	60.81	58.95	59.04	58.88	60.82	58.92	59.00	58.62
Ym	%	6.50	5.20	6.50	6.50	6.50	4.90	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*	0.99	0.32	0.91	0.72	1.21	0.47	1.12	0.81
Lactation N_{El}	*MJ/day*	1.30	-	-	-	1.26	-	-	-
Wool production Ne_{wool}	*MJ/day*	0.12	-	0.13	0.12	0.13	-	0.13	0.13
Growth NE_g	*MJ/day*	-	1.20	1.79	-	-	1.64	2.09	-
Pregnancy NEp	*MJ/day*	0.37	-	0.31	-	0.41	-	0.47	-
REM		0.50	0.49	0.49	0.49	0.50	0.49	0.49	0.49
REG		0.28	0.27	0.27	0.27	0.28	0.27	0.27	0.27
Gross energy	*MJ/head/day*	24.95	19.50	31.37	26.46	27.60	26.40	36.62	29.16
EFs	*kg/head/year*	10.64	6.61	13.38	11.28	11.77	8.49	15.61	12.43

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 – 2020. Data were provided including the input parameters (the wool production and the amount of milk for categories ewes). Milk production

[3] Differences in amounts of methane emissions from enteric fermentation from Slovak ewe farming between 2015 and 2016

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 – 2020. 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. 10.20 of the IPCC 2006 GL. Pregnancy coefficient (Cp) for mature ewes and pregnant growing lambs was taken from Table 10.7 of the IPCC 2006 GL. Values reported in 2020 were 100% in pregnant growing lambs and 84.36% in mature ewes.

Table 5.33: *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	28.39	11.84	7.11
1995	427.84	27.55	11.56	4.94
2000	347.98	25.49	10.30	3.58
2005	320.49	26.00	10.78	3.46
2010	394.18	25.88	10.65	4.20
2011	393.93	25.74	10.59	4.17
2012	409.57	25.85	10.63	4.35
2013	399.91	25.80	10.63	4.25
2014	391.15	25.90	10.68	4.18
2015	381.72	25.90	10.94	4.18
2016	368.90	25.81	10.63	3.92
2017	365.34	25.62	10.57	3.86
2018	351.12	26.02	10.74	3.77
2019	320.56	25.80	10.66	3.42
2020	294.25	26.01	10.74	3.16

Goats, horses, and swine – emission factors for goats, horses and swine in enteric fermentation are default (IPCC 2006 GL) constantly used for whole time series. EF for goats is 5 kg/head/year, EF for horses is 18 kg/head/year and EF for swine is 1.5 kg/head/year (***Table 5.34***). 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 5.34: *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	2 520.524	1.500	3.781
1995	25.046	5.000	0.125	10.109	18.000	0.182	2 076.439	1.500	3.115
2000	51.419	5.000	0.257	9.516	18.000	0.171	1 488.441	1.500	2.233
2005	39.566	5.000	0.198	8.328	18.000	0.150	1 108.265	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

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*
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

*IPCC default value for developed countries

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 – 2020 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. 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 5.24***. 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 goats' category (-70%) compared to 1990. The main reason for this decrease is the data gap on self-sufficiency - small household's farmers. The same reason was the cause of the decline of poultry (-19%) and horses (-12%).

Between 2005 and 2020, the production of most agricultural crops showed a declining trend. The decrease was recorded for potatoes by -44.8%, for pulses by -27.2%, for sugar beet by -26.5% and for annual fodder by 1.7%. On the contrary, the production of cereals increased by +27.8% and +oil plants by 57.9% during the given period. Since 2005, livestock numbers have decreased for all farmed species. Between 2005 and 2020, the number of cattle decreased by -16.2%, pigs by -51.4%, poultry by -24.75% and sheep by -8.2%.

Table 5.35: *Animal population (heads) according to categories at regional level for the year 2020*

REGION		**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
DAIRY CATTLE		4 784	20 586	14 047	18 940	20 658	16 201	18 497	8 336
NON-DAIRY CATTLE	Suckling cows	1 605	2 068	4 236	1 407	9 098	16 729	21 994	12 331
	Calves in 6 month (milk sort)	2 340	8 490	5 845	10 525	7 408	5 519	6 439	2 698
	Heifer (milk sort)	1 353	5 985	4 371	6 539	7 344	5 819	7 394	3 079
	Heifer (pregnant) (milk sort)	1 382	5 249	3 381	7 054	5 012	3 774	4 056	1 659
	Fattening (milk sort)	306	11 230	4 288	7 785	4 843	4 229	3 711	2 026
	Oxen (milk sort)	20	5	25	9	258	30	15	11
	Breeding bull (milk sort)	22	97	111	85	316	398	680	258
	Calves in 6 month (beef sort)	785	853	1 762	782	3 263	5 699	7 657	3 990
	Heifer (beef sort)	454	601	1 318	486	3 234	6 009	8 792	4 555
	Heifer (pregnant) (beef sort)	463	527	1019	524	2 207	3 898	4 822	2 455
	Fattening (beef sort)	103	1128	1 293	578	2 135	4 367	4 413	2 996
	Oxen (beef sort)	7	1	7	1	113	31	18	17
	Breeding bull (beef sort)	48	195	222	169	633	795	1359	515
SHEEP	Mature ewes	1 103	1 489	19 613	6 343	52 091	61 702	42 628	19 165
	Growing lambs	0	289	7 942	1 943	14 720	17 397	11 397	4 279
	Growing lambs (pregnant)	410	536	677	735	8 032	7 269	5 877	2 664
	Other mature sheep	29	43	604	183	1 528	1 780	1 224	560
SWINE	Breeding swine	2 886	24 822	7 353	38 223	456	22 300	6 825	2 324
	Fattening swine	20 469	172 357	43 699	111 690	9 617	49 571	43 291	29 960
HORSES	Horses (0-3year)	164	41	167	242	61	107	121	142
	Stallions	37	47	84	104	51	79	42	30
	Mares	489	158	317	365	308	605	416	412
	Castrated stallions	189	85	171	142	236	332	171	184
GOATS	Mature goats	226	212	694	252	1 954	1 767	944	1 180
	Growing goats (pregnant)	19	4	94	370	301	78	301	76
	Other mature goats	91	104	126	84	506	299	382	525

REGION		A	B	C	D	E	F	G	H
POULTRY	Laying hens and cocks	355 616	65 153	291 350	1111469	390 110	533 750	32 210	503 831
	Broilers	297 882	147 674	152 845	428 921	5 547	98 995	69	240 387
	Turkeys	0	6 833	127	106 998	35 963	15	13	1205
	Ducks	5	9 407	4	20	83	226	9	21
	Geese	0	24	3	4	0	40	4	1 585

REGIONS: A: Bratislava, B: Trnava, C: Trenčín, D: Nitra, E: Žilina, F: Banská Bystrica, G: Prešov, H: Košice

5.8 MANURE MANAGEMENT (CRF 3.B.1) – CH_4 EMISSIONS

EMITTED GAS: CH_4
METHODS: TIER 1 and TIER 2
EMISSION FACTORS: CS, D
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 17.33 Gg in 1990 to 3.48 Gg in 2020 due to decrease in livestock number of all categories except goats. 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 80% 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 12.2%, caused by decreased number of cattle, swine and poultry. ***Figure 5.17*** and ***Table 5.37*** 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 approach. Swine are divided into two separate categories – market swine (fattening pigs) and breeding swine (sows, piglet's hogs for breeding purpose). The average annual air temperature provided for different regions is important for selecting the MFCs factors. Data was provided by the SHMÚ. Consistent average temperature used per regions is documented in ***Table 5. 36***.

Table 5.36: *Average temperature per region in 30-years climate normal calculation**

REGION	Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
	°C							
TEMPERATURE	11.8	10.5	9.9	11.0	9.1	8.9	8.9	10.1

*source: SHMÚ - Department of Climate Service

Figure 5.17: *Trend in CH_4 emissions (Gg) by categories within manure management in 1990 – 2020*

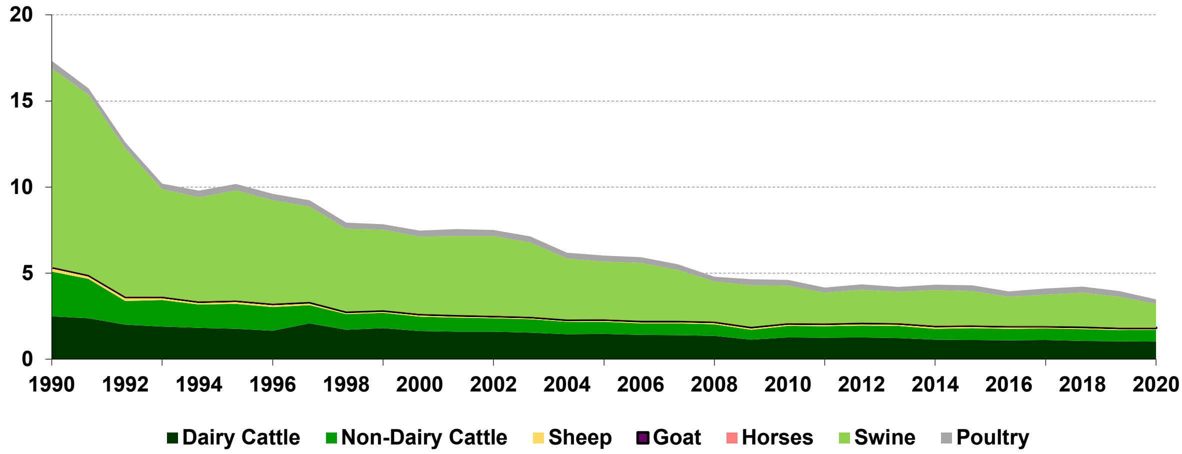
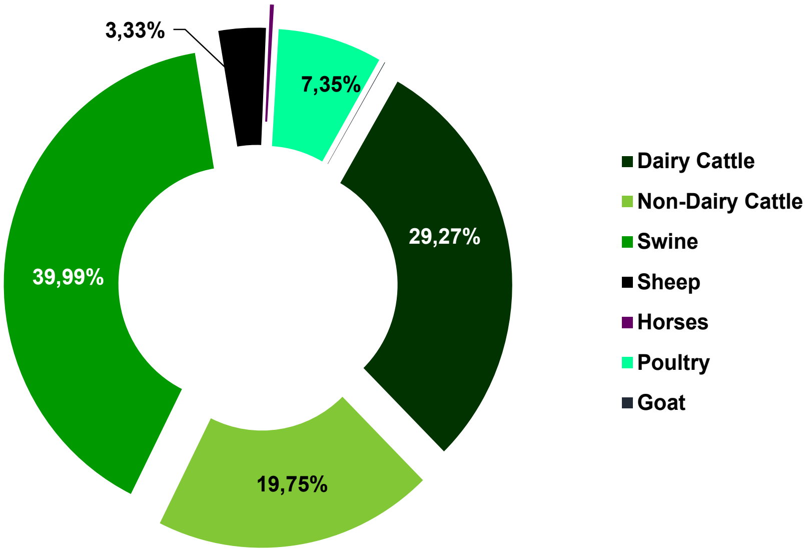


Table 5.37: *CH_4 emissions from manure management according to the animals in particular years*

YEAR	DAIRY CATTLE	NON-DAIRY CATTLE	SWINE	SHEEP	HORSES	POULTRY	GOATS
	CH_4 in Gg						
1990	2.493	2.591	11.526	0.260	0.021	0.439	0.001
1995	1.759	1.455	6.398	0.179	0.016	0.362	0.003
2000	1.635	0.839	4.483	0.135	0.015	0.346	0.007
2005	1.472	0.697	3.352	0.126	0.013	0.352	0.005
2010	1.270	0.653	2.179	0.155	0.011	0.332	0.005
2011	1.245	0.658	1.782	0.154	0.011	0.299	0.004
2012	1.255	0.692	1.913	0.161	0.011	0.310	0.005
2013	1.218	0.708	1.814	0.157	0.011	0.288	0.005
2014	1.133	0.640	2.069	0.154	0.011	0.316	0.005
2015	1.116	0.686	1.987	0.150	0.011	0.328	0.005
2016	1.096	0.672	1.701	0.145	0.010	0.314	0.005
2017	1.107	0.668	1.828	0.142	0.010	0.337	0.005
2018	1.057	0.685	1.970	0.138	0.011	0.355	0.005
2019	1.045	0.652	1.790	0.125	0.011	0.328	0.005
2020	1.017	0.686	1.390	0.116	0.010	0.255	0.001

Figure 5.18 shows the share of individual categories on the production of manure methane emissions. Significant share is represented by swine (39.99%). The important animal categories are also dairy (29.75%) and non-dairy cattle (19.75%).

Figure 5.18: *The share of methane emissions by animals within manure management in 2020*



5.8.1 METHODOLOGICAL ISSUES – METHODS

Cattle, sheep, swine - 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 5.38***- ***5.43***).

$$EF = (VS * 365) * \left[B_o * \frac{0.67\ kg}{m^3} * \sum \frac{MCF}{100} * MS\right]$$

Where: **VS** = daily volatile solid excreted for livestock category, kg DM animal/day, **365** = annual VS production in days/year, $\mathbf{B_o}$ = 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).

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 5.45*** for non-dairy cattle in ***Tables 5.45*** and ***5.46.*** Data for sheep is in ***Tables 5. 47*** and ***5.48***.

Table 5.38: *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*	*m^3/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*	3.592	2.508	0.566	0.722	0.620
Liquid system		10.340	10.340	NO	NO	NO
Solid storage and dry lot		2	2	2	2	2
PRP		1	1	1	1	-
Digesters*		NO	NO	NO	NO	NO

Table 5.39: *Overview of country specific parameters used for cattle and sheep in 2020*

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*	598.89	353,81	64.50	53.85	84.61
Ash content	*%*	8	8	8	8	8
VS daily excretion**	*kg dm/head/day*	4.46	2.59	0.56	0.59	0.62
Liquid system		10,27	10.27	NO	NO	NO
Solid storage and dry lot		2	2	2	2	2
PRP		1	1	1	1	-
Digesters		10	NO	NO	NO	NO

Table 5.40: *Overview of country specific parameters used for breeding swine in 1990*

PARAMETERS	UNIT	A	B	C	D	E	F
B_o*	*m^3/kg VS*	0.45	0.45	0.45	0.45	0.45	0.45
Typical animal mass average	*kg*	200	85	140	145	10.6	35.5
Ash content	*%*	10	10	10	10	10	10
VS daily excretion**	*kg dm/head/day*	0.62	0.46	0.38	0.41	0.12	0.22
Liquid system		10.36	10.36	10.36	10.36	10.36	10.36
Solid storage and dry lot		2	2	2	2	2	2

A: Sows, B: Gilts non-pregnant, C: Gilts pregnant, D: Hogs; E: Piglets up to 20 kg; F: Piglets 21-50 kg

Table 5.41: *Overview of country specific parameters used for breeding swine in 2020*

PARAMETERS	UNIT	A	B	C	D	E	F
B_o*	*m^3/kg VS*	0.45	0.45	0.45	0.45	0.45	0.45
Typical animal mass average	*kg*	200	85	140	145	10.6	35.5
Ash content	*%*	10	10	10	10	10	10
VS daily excretion**	*kg dm/head/day*	0.61	0.50	0.41	0.41	0.13	0.24
Liquid system		10.39	10.39	10.39	10.39	10.39	10.39
Solid storage and dry lot		2	2	2	2	2	2

A: Sows, B: Gilts non-pregnant, C: Gilts pregnant, D: Hogs; E: Piglets up to 20 kg; F: Piglets 21-50 kg

Table 5.42: *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		10.31	10.31	10.31	10.31	10.31
Solid storage and dry lot		2	2	2	2	2
Deep bedding		17.54	17.54	17.54	17.54	17.54

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 5.43: *Overview of country specific parameters used for market swine in 2020*

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

PARAMETERS	UNIT	A	B	C	D	E
Ash content	%	10	10	10	10	10
VS daily excretion**	*kg dm/head/day*	0.10	0.18	0.26	0.45	0.50
Liquid system		10.42	10.42	10.42	10.42	10.42
Solid storage and dry lot		2	2	2	2	2
Deep bedding		17.68	17.68	17.68	17.68	17.68

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;

*B_o for Western Europe was chosen; **VS daily excretion were taken from table 10A-4 in the IPCC 2006 GL

Swine – Due to the lack of specific methodology for GE calculation in the IPCC 2006 GL in swine category, the country specific methodology was implemented in 2020 submission. The VS calculation is consistent with the equation 10.24, p 10.42 (IPCC 2006 GL).

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*[4]. Ash content for pigs was taken from publication the *Strauch, Baader, Tietjen – Waste from agricultural production*[5]. 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 5.49*** and ***5.50***.

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 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, $\mathbf{P_{MAT}}$, $\mathbf{L_{MAT}}$ = 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.

[4] Petrikovič, P., Heger, J., Sommer A., 2005, Nutrition for Pigs, The Research Institute of animal production, ISBN 80-88872-45-6 in Slovak

[5] Strauch, D., Baader, W.,Tietjen, C., 1995 Waste from agricultural production, Ulmer Eugen Verlag, ISBN-978-3800143283 in German

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.): $\mathrm{ME} = \mathrm{ME_m} + \mathrm{ME_P} + \mathrm{ME_L}$

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 and methane 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: $\mathrm{DE} = \frac{\mathrm{ME}}{0.96}$

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: $\mathrm{GE} = \frac{\mathrm{DE}}{\%\mathrm{DE}}$

Where: **GE** = gross energy intake in MJ/kg/head, **DE** = metabolizable energy in MJ/head/kg, %**DE** = digestibility of feed in %.

Table 5.44: *The overview of used VS and EFs for dairy cattle in 2020*

REGION	UNIT	Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
VS excretion per day on a dry organic matter base	*kg VS/day*	4.56	4.57	4.43	4.27	4.56	4.30	4.56	4.42
EFs	*kg/head*	17.98	10.61	8.05	8.49	6.88	7.79	6.18	6.74

Table 5.45: *The overview of used emission factors (kg/head) for non-dairy cattle in 2020*

REGION		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
MILK TYPE	**Calves in 6. month**	0.57	0.62	0.62	0.67	0.74	0.74	0.67	0.64
	Heifers	1.66	1.50	1.59	1.54	2.19	1.98	2.07	2.05
	Heifers (pregnant)	2.44	2.13	2.42	2.26	3.04	2.50	2.93	2.71
	Fattening	3.53	2.65	2.67	2.65	2.66	2.29	2.83	2.20
	Oxen	2.90	2.77	2.76	2.82	3.07	2.60	3.17	2.55
	Breeding bull	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27
BEEF TYPE	**Suckler cows**	2.78	2.72	2.70	2.77	2.74	2.77	2.77	2.75
	Calves in 6. month	0.80	0.68	0.68	0.77	0.70	0.73	0.67	0.69
	Heifer	1.86	1.76	1.75	1.83	1.79	1.82	1.80	1.74
	Heifer (pregnant)	2.66	2.56	2.66	2.63	2.72	2.68	2.82	2.63
	Fattening	5.03	5.35	5.22	5.06	4.86	4.93	4.85	4.62
	Oxen	2.74	2.79	2.43	2.65	2.16	2.26	2.20	2.49
	Breeding bull	2.41	2.42	2.50	2.45	2.59	2.15	2.11	2.46

Tables 5.46: *The overview of used VSs (kg VS/day) for non-dairy cattle in 2020*

REGION		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
MILK TYPE	Calves in 6. month	0.65	0.70	0.71	0.76	0.84	0.84	0.77	0.73
	Heifers	1.90	1.72	1.82	1.77	2.52	2.27	2.38	2.36
	Heifers (pregnant)	1.90	1.72	1.82	1.77	2.52	2.27	2.38	2.36
	Fattening	2.81	2.45	2.79	2.60	3.49	2.88	3.36	3.12
	Oxen	2.58	2.15	2.17	2.07	2.15	1.85	2.30	1.78
	Breeding bull	3.29	3.15	3.13	3.20	3.49	2.95	3.60	2.89
BEEF TYPE	Suckler cows	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94
	Calves in 6. month	4.34	4.26	4.23	4.33	4.29	4.34	4.33	4.30
	Heifer	1.37	1.16	1.16	1.32	1.19	1.24	1.14	1.17
	Heifer (pregnant)	4.16	4.00	4.17	4.12	4.26	4.19	4.41	4.11
	Fattening	2.90	2.75	2.74	2.86	2.80	2.84	2.82	2.73
	Oxen	4.16	4.00	4.17	4.12	4.26	4.19	4.41	4.11
	Breeding bull	2.72	2.89	2.82	2.74	2.63	2.67	2.62	2.50

Tables 5.47: *The overview of used emission factors (kg/head) for sheep in 2020*

REGION		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
DAIRY SHEEP	Mature ewes	0.35	0.41	0.40	0.37	0.38	0.38	0.36	0.36
	Growing lambs	0.33	0.31	0.29	0.29	0.31	0.33	0.27	0.27
	Growing lambs (pregnant)	0.54	0.52	0.47	0.48	0.51	0.54	0.45	0.45
	Other mature sheep	0.52	0.50	0.48	0.58	0.52	0.54	0.48	0.47
BEEF SHEEP	Mature ewes	0.40	0.40	0.40	0.41	0.40	0.40	0.40	0.40
	Growing lambs	0.44	0.41	0.38	0.38	0.41	0.44	0.36	0.36
	Growing lambs (pregnant)	0.61	0.58	0.52	0.53	0.57	0.61	0.50	0.50
	Other mature sheep	0.57	0.55	0.53	0.63	0.57	0.59	0.53	0.51

VS daily excretion for sheep was firstly calculated in 2016 submission. Due to better disaggregation of sheep based on national data into following subcategories: other mature sheep (VS=0.41 kg dm/head/year), growing lambs (VS=0.39 kg dm/head/year) and mature ewes (VS=0.40 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 2006 GL) was used. Allocation of animals into AWMS is described in **Chapter 5.9.4**.

***Tables 5.48:** The overview of used VSs (kg VS/day) for sheep in 2020*

REGION		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
DAIRY SHEEP	Mature ewes	0.50	0.59	0.57	0.53	0.54	0.54	0.52	0.51
	Growing lambs	0.48	0.45	0.41	0.42	0.45	0.48	0.39	0.40
	Growing lambs (pregnant)	0.78	0.74	0.67	0.69	0.74	0.78	0.64	0.65
	Other mature sheep	0.61	0.59	0.57	0.68	0.61	0.63	0.56	0.55
BEEF SHEEP	Mature ewes	0.59	0.60	0.59	0.60	0.59	0.59	0.59	0.60
	Growing lambs	0.65	0.61	0.56	0.56	0.61	0.65	0.53	0.53
	Growing lambs (pregnant)	0.90	0.85	0.77	0.79	0.85	0.90	0.74	0.75
	Other mature sheep	0.67	0.64	0.62	0.74	0.67	0.69	0.62	0.60

***Tables 5.49:** The overview of used emissions factors for swine subcategories in 2020*

REGION	Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
Sows	6.35	5.74	5.73	5.79	4.90	6.20	5.86	5.10
Gilts non-pregnant	5.98	4.65	4.65	5.09	4.65	4.65	4.65	4.65
Gilts pregnant	4.82	3.75	3.75	4.10	3.75	3.75	3.75	3.75
Hogs	4.82	3.75	3.75	4.10	3.75	3.75	3.75	3.75
Piglets 20 kg	1.49	1.16	1.16	1.27	1.16	1.16	1.16	1.16
Piglets 21-50kg	2.81	2.18	2.18	2.39	2.18	2.18	2.18	2.18
Fattening to 20 kg	1.26	0.98	0.98	1.08	0.98	0.98	0.98	0.98
Fattening to 21-50 kg	2.28	1.78	1.78	1.96	1.78	1.78	1.78	1.78
Fattening to 50-80 kg	3.34	2.61	2.61	2.87	2.61	2.61	2.61	2.61
Fattening to 80-100 kg	5.76	4.50	4.50	4.95	4.50	4.50	4.50	4.50
Fattening from 110 kg	6.42	5.02	5.02	5.52	5.02	5.02	5.02	5.02

***Tables 5.50:** The overview of used VSs (kg VS/day) for swine in 2020*

REGION	Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
Sows	0.53	0.62	0.62	0.57	0.53	0.67	0.63	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 20 kg	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Piglets 21-50kg	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24

REGION	Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
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
Fattening to 80-100 kg	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Fattening form 110 kg	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50

Other animals – methodology used for the methane emissions estimation in manure management is based on tier 1 using the default EFs according to the IPCC 2006 GL. Emissions factors are summarized in ***Table 5.51***.

Table 5.51: *Emission factors used for the estimation of CH_4 emissions from manure management*

MANURE MANAGEMENT SYSTEMS	N_2O-N EFs in *kg CH_4/year/head*
Goats	0.13
Horses	1.56
Poultry	
Layers	0.03
Broilers	0.02
Turkey	0.09
Ducks and Geese	0.02

5.8.2 ACTIVITY DATA

The number of animals is consistent with the number of animals described in the **Chapter 5.7.2** (***Table 5.35***).

5.9 MANURE MANAGEMENT (CRF 3.B.2) – N_2O EMISSIONS

EMITTED GAS: N_2O
METHODS: TIER 1 and TIER 2
EMISSION FACTORS: CS, D
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 aqueous 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 pasture range in some periods of the year (200 days per year on average) is a specific management system for sheep, horses, and goats (partly for non-dairy cattle). The input of nitrogen oxide from manure management was 0.50 Gg of N_2O in 2020 and the total decrease was 67% compared to the base year (***Figure 5.19*** and ***Table 5.52)***.

Figure 5.20 shows the share of individual categories on the production of nitrogen from manure. A dominant share represents dairy cattle (37%), non-dairy cattle (31.4%) and swine (14.1%).

Figure 5.19: *Trend in N_2O emissions (Gg) by categories within manure management in 1990 – 2020*

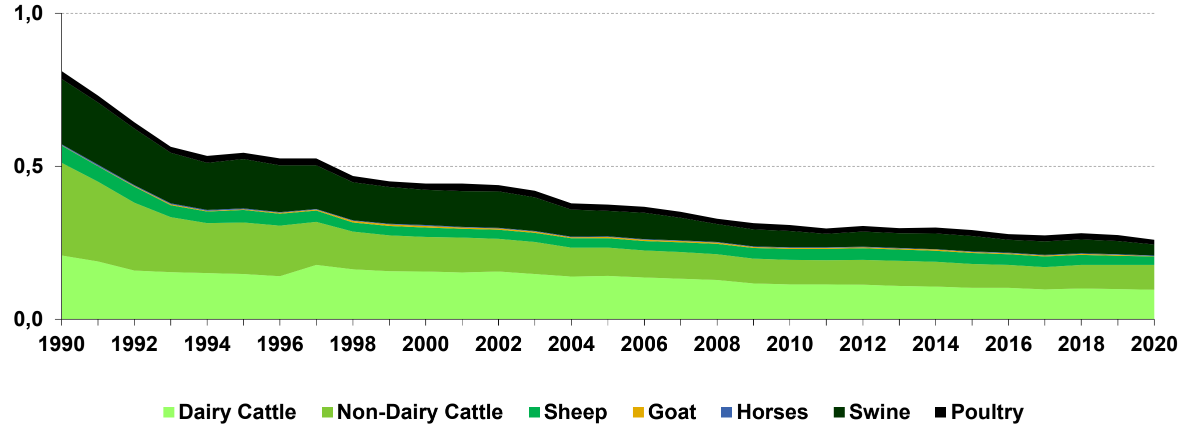
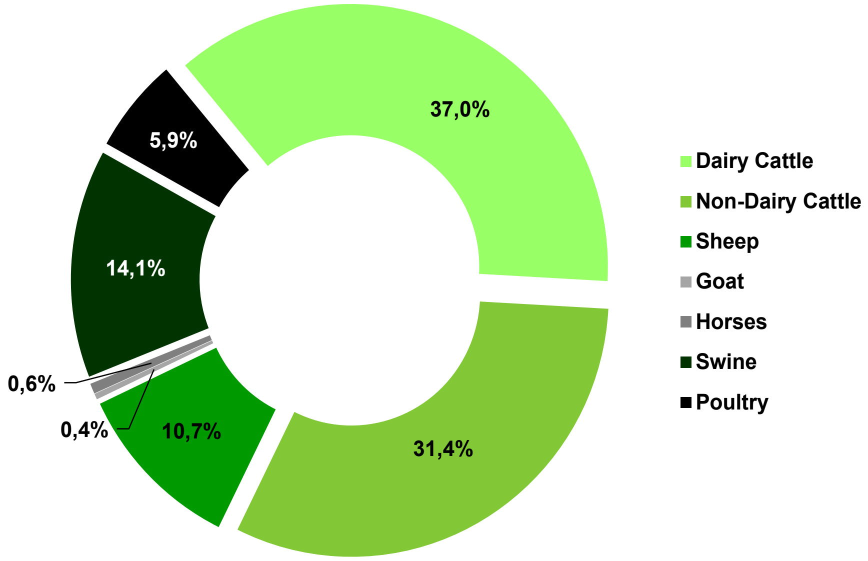


Table 5.52: *N_2O emissions (Gg) in manure management according to the animals in particular years*

YEAR	DAIRY CATTLE	NON-DAIRY CATTLE	SHEEP	GOATS	HORSES	SWINE	POULTRY
1990	0.209	0.303	0.056	0.001	0.004	0.213	0.026
1995	0.148	0.169	0.041	0.002	0.003	0.161	0.021
2000	0.155	0.113	0.031	0.005	0.003	0.115	0.020
2005	0.141	0.093	0.031	0.004	0.002	0.083	0.021
2010	0.114	0.079	0.036	0.003	0.002	0.054	0.020
2011	0.113	0.080	0.036	0.003	0.002	0.044	0.018
2012	0.113	0.081	0.037	0.003	0.002	0.049	0.018
2013	0.109	0.082	0.037	0.003	0.002	0.048	0.017
2014	0.107	0.081	0.036	0.003	0.002	0.052	0.019
2015	0.103	0.078	0.036	0.003	0.002	0.051	0.019
2016	0.103	0.075	0.034	0.003	0.002	0.042	0.019
2017	0.097	0.074	0.034	0.003	0.002	0.044	0.020
2018	0.100	0.077	0.033	0.003	0.002	0.045	0.021
2019	0.098	0.079	0.030	0.003	0.002	0.043	0.020
2020	0.096	0.082	0.028	0.001	0.002	0.036	0.015

Figure 5.20: *The share of N_2O emissions by animals within manure management in 2020*



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. Animal waste management systems will be revised in the next submissions, due to lack of accurate information on abatements in manure management systems.

Allocation according to the climate conditions is 100% for cool climate for all animals based on the IPCC 2006 GL 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 estimates. 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 5.53.***

Table 5.53: *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. Keresteš 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. Keresteš at all.: Biotechnology nutrition and health

NAME OF PARAMETER	PARAMETERS WITH UNITS*	SOURCE
Conversion factor from CP to N	6.25	IPCC 2006 GL 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.*[6] 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:

$$\mathrm{CP_{m-Total}} = \left[(4.93 * \mathrm{H}^{0.75} * \mathrm{U_m}) - \left(\frac{\mathrm{CP_m}}{100} * \mathrm{U_m}\right)\right]$$

$$\mathrm{CP_{l-Total}} = \left[(\mathrm{MY} * \mathrm{CP_l}) - \left(\frac{\mathrm{MY} * 1000}{100 * \mathrm{SP_l}}\right)\right]$$

$$\mathrm{CP_{p-Total}} = \frac{\mathrm{C_{p1}} + \mathrm{C_{p2}}}{100} * \mathrm{U_p}$$

$$\mathrm{Total_{CP}} \frac{\frac{(\mathrm{CP_{m-Total}} + \mathrm{CP_{l-Total}}) * \text{lactation period}}{1000} + \frac{(\mathrm{CP_{m-Total}} + \mathrm{CP_{p-Total}}) * \text{time without milking}}{1000}}{\text{intervening period}} * 365$$

$$\mathrm{N_{intake\,(T)}} = \left(\frac{\frac{\mathrm{Total_{Cp}}}{100}}{6.25}\right)$$

$$\mathrm{NEX_{(T)}} = \mathrm{N_{intake\,(T)}} + \left(\mathrm{N_{intake\,(T)}} * \mathrm{O_N}\right)$$

Non-dairy cattle:

$$\mathrm{CP_{m-Total}} = \left[(4.93 * \mathrm{H}^{0.75} * \mathrm{U_m}) - \left(\frac{\mathrm{CP_m}}{100} * \mathrm{U_m}\right)\right]$$

$$\mathrm{CP_{dg-Total}} = \left[\left(200 + (4.43 * \mathrm{H}^{0.75})\right) * \mathrm{dg}\right] * \mathrm{SP_m}$$

$$\mathrm{Total_{CP}} = \frac{\left(\mathrm{CP_{m-Total}} + \mathrm{CP_{dg-Total}}\right)}{1000} * 365$$

$$\mathrm{N_{intake\,(T)}} = \left(\frac{\frac{\mathrm{Total_{Cp}}}{100}}{6.25}\right)$$

$$\mathrm{NEX_{(T)}} = \mathrm{N_{intake\,(T)}} + \left(\mathrm{N_{intake\,(T)}} * \mathrm{O_N}\right)$$

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

[6] Perikovič, P., Sommer, A., 2002, Nitrition for Cattle, The Research Institute for Animal Production, ISBN: 80-88872-21-9

Nitrogen Excretion rate for swine – a country specific nitrogen excretion rate was used for swine category, based on the tier 2 method from the IPCC 2006 GL. 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 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 the category 3.B.1.3. Data on gross energy intake were calculated according to publication *P. Petrikovič at all: Nutrition for Pigs*. 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 gross energy intake of the swine.

$$N_{\text{intake (T)}} = \frac{GE}{18.45} * \left(\frac{\frac{CP\,\%}{100}}{6.25} \right)$$

Where: **N_{INTAKE} (T)** = daily N consumed per animal of category T, kg N/head/day, **GE** = gross energy intake from feeding ration MJ/animal/day, **18.45** = conversion factor for dietary GE/kg of dry matter MJ/kg, **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 5.54*** - ***5.58***. The results for swine for 2020 were presented in ***Table 5.54*** and ***Table 5.55***. Sheep are also significant contributors to emissions, but data about crude protein were unavailable. The N-excretion rates were calculated according to Equation 10.32 of the IPCC 2006 GL:

$$NEX_{(T)} = N_{intake\ (T)} * (1 - N_{retention})$$

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 2006 GL).

Table 5.54: *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
PIGLETS	*CP (%)*	12.9%	13.3%	13.6%	13.5%	13.5%	14.0%	13.4%	13.4%
	N-intake (kg N animal/day)	0.012	0.013	0.014	0.014	0.014	0.014	0.013	0.013
	N_{EX} (kg N/animal/year)	3.1	3.4	3.5	3.5	3.5	3.6	3.4	3.4

1990		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
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 5.55:** Country specific regional parameters for swine for in 2020*

2020		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)	0.072	0.082	0.081	0.074	0.067	0.087	0.084	0.069
	N_{EX} (kg N/animal/year)	18.5	21.1	20.7	18.9	17.1	22.2	21.4	17.6
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)	0.055	0.057	0.051	0.053	0.055	0.054	0.056	0.052
	N_{EX} (kg N/animal/year)	14.1	14.6	12.9	13.6	14.1	13.8	14.3	13.2
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)	0.045	0.046	0.041	0.043	0.045	0.044	0.045	0.042
	N_{EX} (kg N/animal/year)	11.4	11.7	10.4	10.9	11.4	11.1	11.5	10.7
HOGS	*CP (%)*	15.9%	15.9%	15.9%	15.9%	15.9%	15.9%	15.9%	15.9%
	N-intake (kg N animal/day)	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052
	N_{EX} (kg N/animal/year)	13.3	19.0	19.0	19.0	19.0	19.0	19.0	19.0
PIGLETS	*CP (%)*	13.6%	14.0%	12.4%	13.0%	13.6%	13.3%	13.8%	12.8%
	N-intake (kg N animal/day)	0.014	0.014	0.013	0.013	0.014	0.014	0.014	0.013
	N_{EX} (kg N/animal/year)	3.5	3.6	3.2	3.4	3.5	3.5	3.6	3.3

2020		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
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)	0.026	0.027	0.024	0.025	0.026	0.025	0.026	0.024
	N_{EX} (kg N/animal/year)	6.6	6.8	6.1	6.4	6.6	6.5	6.7	6.2
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)	0.015	0.015	0.014	0.015	0.013	0.015	0.013	0.014
	N_{EX} (kg N/animal/year)	3.7	3.9	3.7	3.8	3.3	3.7	3.3	3.6
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)	0.026	0.028	0.026	0.027	0.023	0.026	0.024	0.025
	N_{EX} (kg N/animal/year)	6.7	7.1	6.7	6.9	6.0	6.7	6.0	6.5
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)	0.039	0.041	0.038	0.039	0.034	0.039	0.034	0.037
	N_{EX} (kg N/animal/year)	9.9	10.4	9.8	10.1	8.7	9.9	8.8	9.5
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)	0.052	0.054	0.051	0.053	0.046	0.052	0.046	0.050
	N_{EX} (kg N/animal/year)	13.2	13.9	13.0	13.4	11.7	13.2	11.7	12.7
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)	0.058	0.061	0.057	0.059	0.051	0.058	0.051	0.055
	N_{EX} (kg N/animal/year)	14.7	15.5	14.5	15.0	13.0	14.7	13.1	14.1

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 2006 GL, Equation 10.30:

$$\mathrm{NEX_T} = \mathrm{N_{rate(T)}} * \frac{\mathrm{TAM}}{1000} * 365$$

Where: **N_{EXT}** = annual N-excretion for each livestock spices respectively category in kg N per animal; **$N_{RATE(T)}$** = default N-excretion rate in kg N (100 kg/animal mass)/day (IPCC 2006 GL), **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: **N_2O_{EM}** = direct N_2O emissions from manure management in kg N_2O; **N** = number of livestock species respectively category, **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 5.56: *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 5.57: *Country specific regional parameters for dairy cattle in 2020*

CATEGORIES	N_{EX}	Body mass	Liquid	Solid	Pasture	Anaerobic digester
	kg N head/year	*kg*	*%*			
Dairy cows Bratislava region	130.43	599	42.874	56.855	0.270	0.000
Dairy cows Trnava region	130.37	599	12.301	72.723	2.515	12.462
Dairy cows Trenčín region	121.00	599	6.582	80.228	5.417	7.773
Dairy cows Nitra region	126.61	599	13.306	83.548	0.700	2.446
Dairy cows Žilina region	102.87	599	5.768	72.771	17.842	3.618
Dairy cows Banská Bystrica region	106.92	599	10.496	75.040	10.172	4.292
Dairy cows Prešov region	105.60	599	4.053	79.391	14.853	1.703
Dairy cows Košice region	105.42	599	2.289	81.153	10.109	6.450

Table 5.58: *N_{EX} and share (%) for different domestic livestock and share in AWMS in 2020*

CATEGORIES		N_{EX}	LIQUID	SOLID	PASTURE	OTHER (LITTER)
		N kg/head	*%*			
NON-DAIRY CATTLE	Suckler cows	47.42	-	45.21	54.79	-
	Calves in 6 month (milk type)	20.19	-	-	100.00	-
	Heifer (milk type)	45.44	-	97.56	2.44	-
	Heifer (pregnant) (milk type)	65.61	-	97.56	2.44	-
	Fattening (milk type)	46.46	10	90	-	-
	Oxen (milk type)	91.74	-	100	-	-
	Breeding bull (milk type)	106.96	-	75.34	24.66	-
	Calves in 6 month (beef type)	22.53	-	40	60.00	-
	Heifer (beef type)	39.75	-	45.21	54.79	-
	Heifer (pregnant) (beef type)	56.37	-	45.21	54.79	-
	Fattening (beef type)	42.19	20	80	-	-
	Oxen (beef type)	67.41	-	100		-
	Breeding bull (beef type)	77.70	-	75.34	24.66	-
	2020*	**43.08**	**2.33**	**72.86**	**24.81**	**-**

CATEGORIES		N_{EX}	LIQUID	SOLID	PASTURE	OTHER (LITTER)
		N kg/head	%			
SHEEP	Mature ewes (milk type)	18.62	-	49.59	50.41	-
	Mature ewes (beef type)	21.72	-	45.20	54.80	-
	2020*	**19.70**	**-**	**48.06**	**51.94**	**-**
	Growing lambs (milk type)	10.80	-	49.59	50.41	-
	Growing lambs pregnant (milk type)	17.60	-	49.59	50.41	-
	Growing lambs (beef type)	14.74	-	45.21	54.79	-
	Growing lambs pregnant (beef type)	20.17	-	45.21	54.79	-
	2020*	**14.16**		**48.23**	**51.77**	**-**
	Rams (milk type)	24.82	-	100.00	-	-
	Rams (beef type)	27.92	-	100.00	-	-
	2020*	**25.88**		**100.00**	**-**	**-**
GOATS	Mature female goats	25.70	-	49.60	50.40	-
	Pregnant goats	22.19	-	49.60	50.40	-
	Other mature goats	10.5	-	49.60	50.40	-
	2020*	**23.65**		**49.60**	**50.40**	**-**
HORSES	Young horses	27.28	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	-
	2020*	**47.13**	**70.00**		**30.00**	**-**
POULTRY	Laying hens + cocks	1.10	-			100.00
	Broilers	0.80	-			100.00
	Turkeys	1.84	-			100.00
	Ducks	1.21	-			100.00
	Geese	1.82	-			100.00
	2020*	**0.95**				**100.00**

*weighted average

The IPCC default emission factors for N_2O emissions estimation per AWMS are based in Table 10.21 of the IPCC 2006 GL (***Table 5.59***).

Table 5.59: *Emission factors for N_2O emissions used in manure management in 2020*

MANURE MANAGEMENT SYSTEMS	EFs (N_2O-N)
	kg N_2O-N/kg N_{EX}
Solid storage and dry lot	0.005
Liquid system	0.005
Anaerobic digesters	0
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)

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.

5.10.1 METHODOLOGICAL ISSUES – METHODS

Tier 1 approach of the IPCC 2006 GL 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:

$$N_{volatilization-MMS} = \sum_{S}\left[\sum_{T}\left[\left(N_T * Nex_T * MS_{T,S}\right) * \left(\frac{Frac_{GasMS}}{100}\right)_{(T,S)}\right]\right]$$

$$N_2O_{MM} = \left(N_{volatilization-MMS} * EF\right) * \frac{44}{28}$$

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 %.

5.10.2 ACTIVITY DATA

Volatilized nitrogen (NH_3 and NO_x) from animal waste was 15 500 t of N, which represents 0.24 Gg of N_2O in 2020. Activity data in this category are consistent with the activity data used in animal manure. ***Table 5.60*** shows the time series of input data and emissions.

Table 5.60: *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	46 094 484	0.02	0.72
1995	31 726 981	0.02	0.50
2000	25 782 315	0.02	0.41
2005	22 300 380	0.02	0.35
2010	18 662 929	0.02	0.29
2011	17 587 704	0.02	0.28
2012	18 170 996	0.02	0.29
2013	17 529 340	0.02	0.28
2014	18 146 196	0.02	0.29
2015	18 019 235	0.02	0.28
2016	17 166 845	0.02	0.27
2017	17 326 168	0.02	0.27
2018	17 932 746	0.02	0.28
2019	17 320 738	0.02	0.27
2020	15 499 638	0.02	0.24

5.10.3 NITROGEN LEACHING AND RUN-OFF FROM MANURE MANAGEMENT SYSTEMS

According to the methodology, the fraction of manure nitrogen that leaches from manure management systems ($Frac_{leachMS}$) is highly uncertain and it has to be developed as a country specific value applied in tier 2 approach. $Frac_{leachMS}$ is not available in the Slovak Republic due to the lack of measures or national survey, therefore the notation key NA is reported in CRF tables for this category.

5.11 RICE CULTIVATION (CRF 3.C)

No emissions from rise cultivation were estimated because this activity did not occur in the Slovak Republic in 1990 – 2020. 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
PARTICULARLY SIGNIFICANT SUBCATEGORIES: SYNTHETIC FERTILIZERS

Direct emissions are the primary source of N_2O in the Slovak inventory. In 2020, 68.8% 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 NO_x. 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 4.38 Gg of N_2O in 2020. The emissions increased by 2% in comparison with 2019 and decreased by 42% in comparison with the base year 1990 (***Table 5.61***). 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***). In, 2020, emissions from agricultural soils increased significantly due to increase of oil plants harvesting area. ***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 5.61: *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	3.493	0.992	0.366	1.027	0.001	0.594	1.040
1995	1.094	0.686	0.252	0.934	0.002	0.279	0.472
2000	1.330	0.593	0.158	0.629	0.003	0.273	0.376
2005	1.568	0.509	0.146	0.893	0.004	0.279	0.539
2010	1.674	0.483	0.167	0.700	0.004	0.287	0.818
2011	1.894	0.504	0.165	0.908	0.004	0.313	0.143
2012	1.587	0.471	0.179	0.767	0.004	0.278	0.143
2013	1.785	0.498	0.180	0.878	0.003	0.303	0.359
2014	1.871	0.538	0.190	1.125	0.003	0.320	0.530
2015	1.804	0.539	0.190	0.965	0.003	0.313	0.070
2016	1.984	0.412	0.187	1.173	0.003	0.306	0.445
2017	1.926	0.408	0.180	0.945	0.003	0.298	0.238
2018	2.027	0.418	0.197	1.025	0.003	0.312	0.064
2019	2.020	0.449	0.193	1.050	0.002	0.317	0.242
2020	2.006	0.414	0.188	1.120	0.002	0.307	0.340

Figure 5.21: *Trend in N_2O emissions (Gg) by subcategories within agricultural soils in 1990 – 2020*

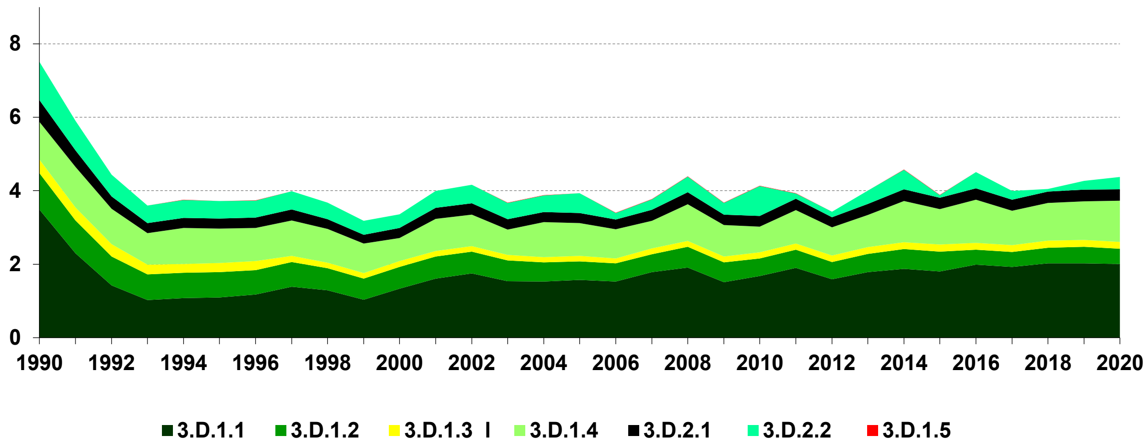
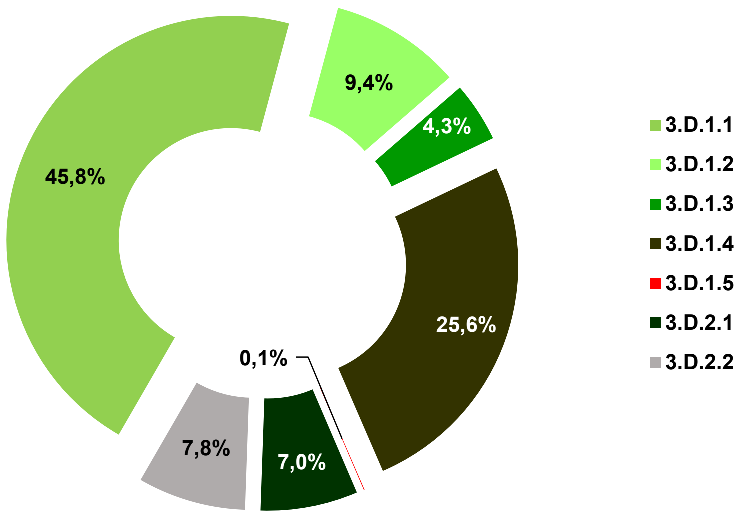


Figure 5.22 shows, that major share of emissions belong to synthetic fertilizers use (46.0%), crop residues (25.4%), organic nitrogen fertilizers (9.4%) and indirect emissions from agricultural soils (14.8%).

Figure 5.22: The share of aggregated emissions by categories within agricultural soils in 2020



5.12.1 INORGANIC N FERTILIZERS (CRF 3.D.1.1)

The applied amounts of synthetic fertilizers into cultivated soils decreased in the last 15 years. In present, 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.

5.12.1.1 Methodological issues - method

Default emission factor was used from the IPCC 2006 GL (0.01 kg N_2O–N/kg N). Total N_2O emissions from using the synthetic fertilizers were 2.01 Gg in 2020. Tier 1 method was applied in combination with the default EF. According to the prioritization plan, Tier 2 approach will be implemented in 2024. Implementation is not processed yet due to missing geographical data on inorganic N fertilizer consumption (including Urea application).

5.12.1.2 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 20th century, from 222 kt in 1990 to 128 kt in 2020 (43%). On the other hand, consumption of the synthetic fertilizers increased by 28% in 2020 compared to 2005 and decreased by almost -0.7% in comparison with the year 2019. Decreasing numbers of domestic livestock caused the demand for inorganic nitrogen. Higher consumption of synthetic fertilizers compensates missing organic nitrogen in soils.

Activity data on N input from the application of inorganic fertilizers to agricultural soils is summarized in ***Table 5.62***.

Table 5.62: *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	0.01	3.493
1995	69 587 000	0.01	1.094
2000	84 609 000	0.01	1.330
2005	99 760 000	0.01	1.568
2010	106 513 000	0.01	1.674
2011	120 555 000	0.01	1.894
2012	101 004 000	0.01	1.587
2013	113 581 390	0.01	1.785
2014	119 036 050	0.01	1.871
2015	114 773 000	0.01	1.804
2016	126 235 768	0.01	1.984
2017	122 541 152	0.01	1.926
2018	128 976 885	0.01	2.027
2019	128 532 971	0.01	2.020
2020	127 676 520	0.01	2.006

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.

5.12.2.1 Methodological issues – method

Managed manure nitrogen, available for application to managed soil (NMMS_Avb) was calculated based on the Equation 10.34 (IPCC 2006 GL).

Losses are defined as losses of following gases N_2, NH_3, NO_x and N_2O. Losses are calculated according to the 2006 IPCC Guideline from the total amount of liquid and solid manure managed in anaerobic digesters. Losses as $Frac_{lossMS}$ used for managed manure as feed, fuel or construction do not occur in Slovakia. Therefore, fractions ($Frac_{FEED}$, $Frac_{FUEL}$, $Frac_{CNST}$) in the Equation 11.4 (IPCC 2006 GL) are considered zero.

Managed manure nitrogen available for application to managed soils (NMMS_Avb) was calculated based on Equation 10.34 (IPCC 2006 GL). 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. The Hungary is neighbouring country with similar climatic and agricultural conditions.

Table 5.63: *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 23 046 t/N/year when the default EF = 0.01 kg N_2O-N/kg N was used. Total amount of N_2O emissions from animal excreta applied to soil was 0.36 Gg in 2020.

Table 5.64: *Input parameters and EFs in the category 3.D.1.2.a - Animal Manure in particular years*

YEAR	TOTAL NITROGEN FROM MM	LOSSES OF NITROGEN	NITROGEN FROM BEDDING MATERIALS (PIGS, POULTRY)	N INPUT FROM MANURE APPLIED TO SOILS	EFS	N_2O EMISSIONS
	kg N/Year				*kg N_2O-N/kg N*	*Gg*
1990	113 655 157	51 853 847	379 168	62 180 478	0.010	0.977
1995	78 173 602	35 549 926	287 981	42 911 657	0.010	0.674
2000	65 362 884	29 334 721	288 187	36 316 350	0.010	0.571
2005	57 154 757	25 479 486	281 710	31 956 981	0.010	0.502
2010	48 192 413	21 218 248	216 462	27 190 628	0.010	0.427
2011	45 684 543	19 996 585	174 135	25 862 093	0.010	0.406
2012	47 094 704	20 611 858	186 155	26 669 001	0.010	0.419
2013	45 544 374	19 873 686	177 416	25 848 104	0.010	0.406
2014	46 938 118	20 508 166	211 133	26 641 085	0.010	0.419
2015	46 411 590	20 242 713	212 388	26 381 266	0.010	0.415
2016	44 377 651	19 282 891	190 327	25 285 087	0.010	0.397
2017	44 693 788	19 484 650	223 181	25 432 320	0.010	0.400
2018	46 041 967	20 199 374	236 875	26 079 468	0.010	0.410
2019	44 550 340	19 545 237	225 305	25 230 408	0.010	0.396
2020	40 477 280	17 640 778	209 149	23 045 651	0.010	0.362

5.12.2.2 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 2006 GL, total nitrogen excretion per liquid (5 333 t/N/year) and solid system (24 540 t/N/year) in manure management were used for the estimation of total nitrogen input of manure applied to soil in 2020.

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.

5.12.3.1 Methodological issues – method

Tier 1 and default emission factor were used (0.01 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 2006 GL.

Emissions were estimated by using these equations:

$\mathrm{N_2O - N_{sewage\ sludge} = N_{sewage\ sludge} * P_N}$ and $\mathrm{N_2O_{sewage\ sludge} = N_2O - N_{sewage\ sludge} * EF * \frac{44}{28}}$

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

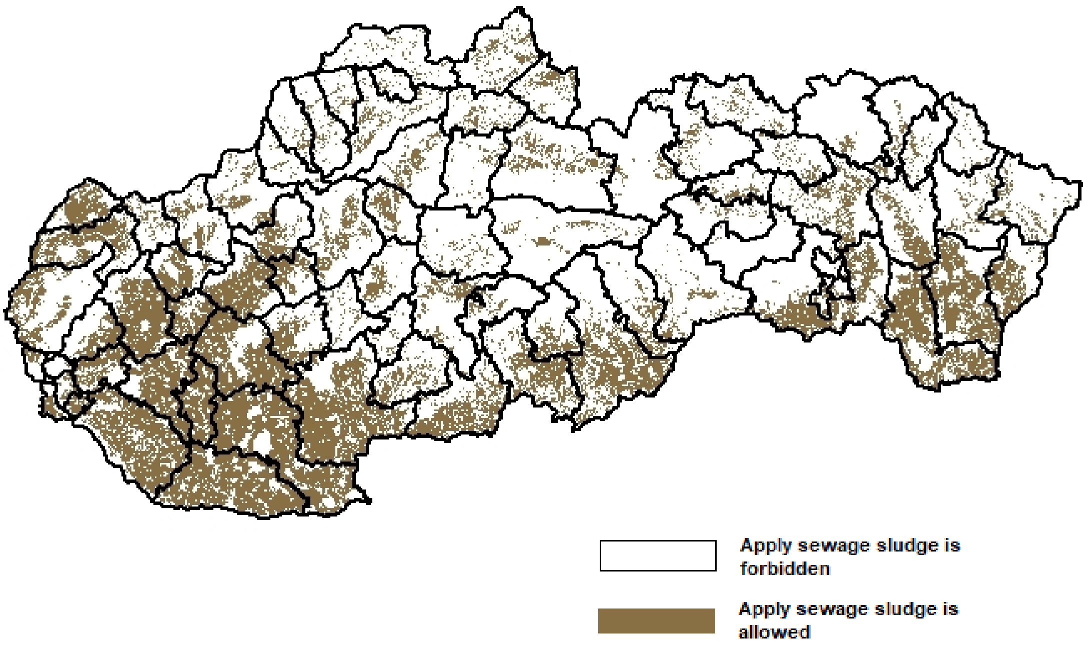
Table 5.65: *Input parameters and EFs used in the category 3.D.1.2.b - Sewage Sludge in particular years*

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	0.0052
1995	4 043	2 251	6 294	208 345	0.0033
2000	1 254	1 342	2 597	85 957	0.0014
2005	5 870	2 231	8 101	268 144	0.0042
2010	923	1102	2 025	67 023	0.0011
2011	358	685	1 043	34 536	0.0005
2012	1 254	478	1 732	57 340	0.0009
2013	518	627	1 145	37 900	0.0006
2014	8	688	696	23 021	0.0004
2015	NO	813	813	26 899	0.0004
2016	NO	1134	1 134	37 523	0.0006
2017	NO	362	362	11 987	0.0002
2018	NO	287	287	9 513	0.0001
2019	NO	49	49	1 620	0.00001
2020	NO	1	1	32	0.0000005

5.12.3.2 Activity data

Activity data on sewage sludge consumption in agriculture (***Table 5.65***) 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 – 2020, 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. Base of presented 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.

5.12.4.1 Methodological issues – method

Tier 1 (IPCC 2006 GL) and default emission factor (0.01 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:

$$\mathrm{N_2O - N_{compost}} = \mathrm{N_{compost}} * \mathrm{P_N};\ \mathrm{N_2O_{compost}} = \mathrm{N_2O - N_{compost}} * \mathrm{EF} * \frac{44}{28}$$

Where: **N_2O-$N_{compost}$** = input of pure nitrogen in compost applied in to the soil in kg, **$N_{compost}$** = amount of compost from composting plant, **P_N** =Share of nitrogen in organic waste, **EF** = 0.01 kg N_2O-N/kg N (default).

Table 5.66: *Share 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[7]	**1**	*ÚKSÚP*
Hay	**8.2**	*https://nasepole.sk/dusikate-hnojenie-po-zbere-obilnin/*
Vitahum (organic - humus fertilizer made from natural substances)[8]	**1**	*ÚKSÚP*
Green fertilizers	**1**	*ÚKSÚP*

5.12.4.2 Activity data

Other organic fertilizers applied to soils include the composted waste, digested slurry from digesters, compost and vitahlum, natural harmony and green fertilizers. The Consumption is provided with total amount of organic waste into soils (**OW**) and the data (***Table 5.67***) is provided by the UKSÚP. The Data are converted into nitrogen content (**NC**).

Data is available from 2000 to 2020. 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 5.67: *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	0	0	33 430	234	0	0	0	0	28 290	283	12 013	120
1991	0	0	34 303	336	0	0	0	0	26 501	265	11 752	118
1992	0	0	35 177	246	0	0	0	0	24 713	247	11 492	115
1993	0	0	36 050	252	0	0	0	0	22 924	229	11 231	112
1994	0	0	36 924	362	0	0	0	0	21 136	211	10 970	110
1995	0	0	37 797	265	0	0	0	0	19 348	193	10 709	107
1996	0	0	38 671	271	0	0	0	0	17 559	176	10 449	104
1997	0	0	39 544	388	0	0	0	0	15 771	158	10 188	102
1998	0	0	40 418	283	0	0	0	0	13 982	140	9 927	99
1999	0	0	41 291	289	0	0	0	0	12 194	122	9 666	97
2000	0	0	74 923	734	0	0	0	0	50 641	506	10 245	102
2001	0	0	40 885	286	0	0	0	0	54 338	543	18 285	183
2002	0	0	36 422	255	0	0	0	0	42 810	428	10 920	109
2003	0	0	34 225	240	0	0	0	0	9 321	93	6 206	62
2004	0	0	42 904	300	0	0	0	0	2 845	28	18 990	190
2005	0	0	7 006	49	0	0	0	0	3 552	36	5 905	59
2006	0	0	13 878	97	0	0	0	0	10 828	108	7 006	70
2007	0	0	21 762	152	0	0	8 868	727	8 758	88	3 540	35
2008	0	0	21 317	149	0	0	90 977	7 460	7 185	72	13 534	135
2009	0	0	25 364	178	0	0	68 637	5 628	195	2	16 642	166
2010	0	0	40 097	281	0	0	36 774	3 015	4 999	50	11 956	120

[7] https://www.biotika.sk/

[8] http://www.eba.sk/substraty-a-vyrobky/volne-lozene-vyrobky/

Year	Fugate		Compost		Natural Harmony		Hay		Vitahum		Green fertilizers	
	OW	NC	OW	NC	OW	NC	OW	NC	OW	NC	OW	NC
	tons											
2011	0	0	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	0	0	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	0	0	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	0	0	0	0	0	0	0	0
2017	32 517	163	46 649	327	0	0	0	0	17 928	36	0	0
2018	28 406	102	43 257	411	0	0	0	0	1 345	23	0	0
2019	776427	3 057	37 618	300	0	0	0	0	0	0	0	0
2020	800393	2 936	43 557	250	0	0	0	0	0	0	34 089	83

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 cattle (not dairy) are mainly grazed during spring, summer and autumn in the small farms. Animals are housed during the winter.

5.12.5.1 Methodological issues – method

The N_2O estimation from pasture is based on default emission factors (0.02 kg N_2O-N/kg N for cattle, 0.01 kg N_2O-N/kg N for other animals). Nitrogen excretions per AWMS were estimated in manure management category. Total nitrogen from pasture was 7 455.9 t/N/year in 2020. Total N_2O emissions from pasture were 0.188 Gg of N_2O in 2020. This category is estimated in conjunction with the category 3.B.2.

Table 5.68: *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	14 709 368	0.02	0.37
1995	10 339 335	0.02	0.25
2000	6 914 661	0.01	0.16
2005	6 427 598	0.01	0.15
2010	7 407 080	0.01	0.17
2011	7 339 829	0.01	0.17
2012	7 849 988	0.01	0.18
2013	7 844 224	0.01	0.18
2014	8 105 558	0.01	0.19
2015	8 077 931	0.01	0.19
2016	7 902 001	0.02	0.19
2017	7 683 159	0.01	0.18
2018	8 165 248	0.02	0.20
2019	7 875 680	0.02	0.19
2020	7 455 857	0.02	0.19

5.12.5.2 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 5.35***. 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 5.69: *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	54 334	65 333 234	0.010	1.027
1995	2 152 852	49 358	59 467 913	0.010	0.934
2000	2 080 004	35 798	40 017 955	0.010	0.629
2005	1 721 125	52 099	56 820 571	0.010	0.893
2010	1 617 786	41 418	44 560 732	0.010	0.700
2011	1 680 333	54 434	57 770 548	0.010	0.908
2012	1 703 613	47 260	48 804 872	0.010	0.767
2013	1 716 326	49 666	55 902 588	0.010	0.878
2014	1 745 299	60 694	71 561 386	0.010	1.125
2015	1 728 043	52 770	61 417 665	0.010	0.965
2016	1 717 480	64 833	74 670 464	0.010	1.173
2017	1 722 049	52 391	60 128 443	0.010	0.945
2018	1 725 424	57 390	65 258 655	0.010	1.025
2019	1 493 401	58 280	66 799 010	0.010	1.050
2020	1 736 499	60 445	71 250 404	0.010	1.120

Total N_2O emission from crop residues represented 1.12 Gg of N_2O from 71 250 404 kg of nitrogen in crop residues returned to soils in 2020. 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 2020, harvested area was 1 736 kha.

5.12.6.1 Methodological issues – method

Tier 1 method was used in this estimation according to the Equation 11.7A (IPCC 2006 GL):

$$F_{Cr} = \sum_T \{Frac_{RENEW} * [(Area_{(T)} - Areaburnt_{(T)} * CF) * AG_{DM(T)} * 1\,000 * N_{AG(T)} * (1 - Frac_{REMOVE(T)}) + Area_{(T)} * (AG_{DM(T)} * 1\,000 + Crop_{(T)}) * R_{BG-BIO(T)} * N_{BG(T)}]\}$$

Where: $\mathbf{F_{Cr}}$ = annual amount of N in crop residues (above and below ground) including N-fixing crops and forage/pasture renewal returned to soils annually in kg N, $\mathbf{Crop_{(T)}}$ = harvested annual dry mater yield for crop T in kg d.m/ha, $\mathbf{Area_{(T)}}$ = total annual area of harvested crop in ha/yr, $\mathbf{Areaburnt_{(T)}}$ = annual area of crop T burnt in ha, **CF** = combustion factor, $\mathbf{Frac_{RENEW}}$ = fraction of total area under crop T that is renewed annually, $\mathbf{N_{AG(T)}}$ = N content of above-ground residues for crop T in kg of N (kg/d.m.), $\mathbf{Frac_{REMOVE(T)}}$ = fraction of above-ground residues of crop T removed annually for purposes such as feed bedding and construction in kg of N, $\mathbf{R_{BG-BIO(T)}}$ = ratio of below-ground residues to harvested yield for crop T in kg/d.m, $\mathbf{N_{BG(T)}}$ = N content of below-ground residues for crop T in kg of N, **T** = crop of forage type, $\mathbf{AG_{DM(T)}}$ = above-ground residue dry matter (Mg/ha).

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. 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 publication *Postharvest residues of sugar beet and their role in the nutrient cycle by Stanislav Torma*, 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 5.70***.

Table 5.70: *Parameters used to estimate emissions from crop residues*

CROP TYPE	$N_{(AG)}$	$N_{(BG)}$	SLOPE	INTERCEPT	$R_{(BG-BIO)}$	DRY MATTER FRACTION OF HARVESTED PRODUCTS	NUTRITION POTENTIAL IN CROP RESIDUES
	kg N (kg d.m.)$^{-1}$						*kg N/ha*
WHEAT	0.006	0.009	1.510	0.520	0.240	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	-
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	0.006	0.007	0.000	0.000	0.220	0.300	-
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	-
ALFALFA	0.027	0.019	0.290	0.000	0.400	0.900	-

Equation 11.7A (IPCC 2006 GL) 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.

Slovak inventory uses a N-flow approach to calculate the emissions from 3.B and 3.D, which is in line with the IPCC 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 by Vojtech Brestenský* and *Storage of agricultural fertilizers 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 by Štefan Gáborík* (in Slovak). In presented 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. Used $Frac_{Remove}$ values are presented in ***Tables 5.71*** and ***5.72***.

Table 5.71: *Parameters used to estimate emissions from crop residues*

TYPE OF CROP	$FRAC_{Renew}$	$FRAC_{Remove}$
WHEAT	1	0.06
RYE	1	0.06
BARLEY	1	0.06
OAT	1	0.06
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
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

Table 5.72: *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	$Frac_{Remove}$ (WHEAT, BARLEY, RYE, OAT)
	kg		%
1990	344 496	5 919 689	5.82%
1991	330 539	5 652 414	5.85%
1992	310 658	5 305 151	5.86%
1993	295 320	5 051 520	5.85%
1994	271 790	4 748 303	5.72%
1995	278 623	4 808 979	5.79%
1996	267 123	4 627 845	5.77%
1997	236 032	4 129 573	5.72%
1998	202 260	3 551 586	5.69%
1999	211 360	3 676 976	5.75%
2000	201 140	3 535 121	5.69%
2001	214 763	3 816 922	5.63%
2002	211 873	3 720 832	5.69%
2003	200 760	3 542 069	5.67%
2004	164 747	2 949 713	5.59%
2005	158 534	2 855 150	5.55%
2006	156 951	2 814 890	5.58%
2007	136 160	2 480 565	5.49%
2008	109 022	2 014 059	5.41%
2009	105 326	2 000 174	5.27%
2010	101 066	1 923 064	5.26%
2011	83 674	1 617 927	5.17%
2012	91 076	1 745 888	5.22%
2013	91 520	1 732 697	5.28%
2014	89 647	1 722 709	5.20%
2015	92 301	1 776 664	5.20%
2016	80 750	1 581 354	5.11%
2017	85 934	1 680 063	5.11%
2018	92 012	1 792 056	5.13%
2019	86 159	1 673 529	5.15%
2020	74 541	1 408 000	5.29%

5.12.6.2 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 (IPCC 2006 GL) 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 2006 GL):

$$\mathrm{Crop}_{(T)} = \mathrm{Yield\ Fresh}_{(T)} * \mathrm{DRY}$$

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 5.73: Growing areas and total nitrogen in crops and legumes in 2020

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	406 821	4 450.0	27 943 037
	Ray	13 556	3 088.8	528 495
	Barley	126 372	4 218.6	7 659 850
	Oat	12 088	2 349.6	386 241
OTHER	Maize	197 244	6 377.1	12 612 959
	Potato	8 191	4 899.4	389 130
	Sugar beet	21 720	0.0	434 400
	Oil plants	671 294	2 375.1	25 007 398
	Tobacco	8	441.0	46
	Maize for silage	75 104	9 000.0	1 040 941
	Meadows	513 592	2 106.0	3 673 198
NITROGEN FIXING CROPS	Peas	4 154	3 676.4	221 115
	Lens	124	1 037.4	2 583
	Beans	99	673.4	1 620
	Other leguminous plants	6 500	1 800.0	228 618
	Soya	47 604	2 238.6	1 717 283
	Clover	8 044	3 996.0	258 651
	Alfalfa	52 180	5 553.0	1 277 387
2020 TOTAL		**2 134 328**	**47 604**	**83 382 951**

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.

5.12.7.1 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 2006 IPCC 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, **$\Delta C_{Mineral, LU}$** = 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 of immobilization of nitrogen is based on default emission factors according to table 11.1 of the 2006 IPCC guideline (0.01 kg N_2O–N/kg N). A default value of 12 for the C:N ratio (R) was applied. Used activity data is consistent with the **LULUCF sector** category 4(III) – Direct N_2O emissions from N mineralization/immobilization.

5.12.7.2 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 5.74: *Activity data and emissions in the category 3.D.1.5 in 1990 – 2020*

YEAR	3.D.1.5 - MINERALIZATION/IMMOBILIZATION ASSOCIATED WITH LOSS/GAIN OF SOIL ORGANIC MATTER	N IN MINERAL SOILS THAT IS MINERALIZED/IMMOBILIZED IN ASSOCIATION WITH LOSS OF SOIL C
	Gg	*kg/year*
1990	0.001	38 450
1995	0.002	128 550
2000	0.003	197 133
2005	0.004	258 592
2010	0.004	260 017
2011	0.004	253 367
2012	0.004	235 550
2013	0.003	220 867
2014	0.003	210 292
2015	0.003	208 783
2016	0.003	200 833
2017	0.003	197 500
2018	0.003	179 692
2019	0.002	151 775
2020	0.002	145 175

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 2020 and is constant in time series. Emissions from this source are below the threshold of significance for all years as documented ***Table 5.75***. 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 5.75: *Activity data, emission factors and emissions from histosols in particular years*

YEAR	AREA	EFs	N_2O EMISSIONS	TOTAL GHG	THRESHOLD	IMPACT
	ha	*kg N_2O-N/ha^{-1}*	*Gg*	*Gg CO_2 eq.*		*%*
1990	450	0.029	0.006	73 463	36.731	0.00011
1995	450	0.029	0.006	52 922	26.461	0.00016
2000	450	0.029	0.006	48 770	24.385	0.00017
2005	450	0.029	0.006	50 565	25.282	0.00016
2010	450	0.029	0.006	45 675	22.838	0.00018
2015	450	0.029	0.006	44 702	22.351	0.00018
2016	450	0.029	0.006	42 285	21.142	0.00020
2017	450	0.029	0.006	41 888	20.944	0.00020
2018	450	0.029	0.006	39 922	19.961	0.00021
2019	450	0.029	0.006	40 641	20.321	0.00020
2020	450	0.029	0.006	41 111	20.555	0.00020

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 0.31 Gg in 2020, which were -48% below compared to 1990 and -3% below compared to previous year.

5.12.9.1 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: **$N_2O_{(ATD)}$** = annual amounts of N_2O emissions from atmospheric deposition of N volatilised from managed soils in kg, **F_{SN}** = annual N amount of synthetic fertilisers applied to soils in regions in kg, **F_{ON}** = annual amount of managed animal manure and sewage sludge applied to soils in kg N, **F_{PRP}** = annual amount of urine and dung N deposited by grazing animals in kg, **$Frac_{GASF}$** = fraction of synthetic fertiliser N that volatilised as NH_3 and NO_x kg volatilised in kg of N applied (added), **$Frac_{GASM}$** = 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-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 applied synthetic fertilizers volatilizes (NH_3 and NO_x) on soil and 20% of nitrogen from manure volatilizes on soils.

5.12.9.2 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 5.76*** shows time series of activity data, emission factors and N_2O emissions in this category.

Table 5.76: *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	37 797 023	0.01	0.59
1995	17 763 597	0.01	0.28
2000	17 392 914	0.01	0.27
2005	17 735 267	0.01	0.28
2010	18 277 379	0.01	0.29
2011	19 934 484	0.01	0.31
2012	17 667 716	0.01	0.28
2013	19 268 823	0.01	0.30
2014	20 367 981	0.01	0.32
2015	19 948 592	0.01	0.31
2016	19 447 603	0.01	0.31
2017	18 984 623	0.01	0.30
2018	19 855 657	0.01	0.31
2019	20 146 209	0.01	0.32
2020	19 521 711	0.01	0.31

5.12.10 NITROGEN LEACHING AND RUN-OFF (CRF 3.D.2.2)

Total losses in soils were 12.4% 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 2021 submission according to continual improvement of emission estimation. In 2020, used methodology was published in the international publication Atmosphere.[9]

[9] 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

Total indirect emissions from nitrogen leaching and run-off were 0.340 Gg, which is more than 67% below as 1990 value and +41% below compared to previous year.

5.12.10.1 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 (0.0075 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 emission through leaching in the 2006 IPCC Guidelines 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, a 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. 77***. 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 94.3% in 2020 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 2020, total irrigated area in Slovakia was 23 441 hectares, representing only 1.7% of agricultural land. The proportion of irrigated areas to the total utilized agricultural areas is given in ***Table 5.77***.

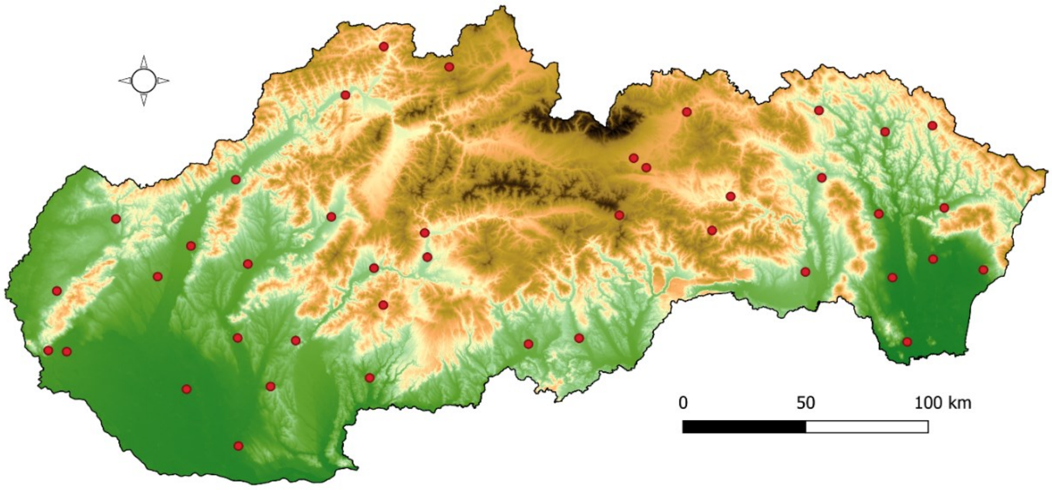
Table 5.77: The proportion of irrigated areas to the total utilized agricultural areas

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%	
1991	394 688	1 483 473	26.6%	
1992	383 238	1 465 662	26.1%	
1993	371 788	1 465 315	25.4%	
1994	360 338	1 471 824	24.5%	
1995	348 888	1 487 714	23.5%	
1996	337 438	1 492 839	22.6%	
1997	325 988	1 500 214	21.7%	
1998	314 538	1 506 461	20.9%	
1999	303 088	1 501 242	20.2%	
2000	291 638	1 507 178	19.3%	
2001	280 188	1 502 051	18.7%	
2002	268 738	1 497 354	17.9 %	
2003	294 202	1 499 323	19.6 %	
2004	220 861	1 501 425	14.7 %	
2005	147 519	1 504 147	9.8 %	
2006	196 749	1 507 400	13.1 %	2.4 %
2007	226 548	1 507 698	15.0 %	
2008	225 436	1 507 278	15.0 %	2.0 %
2009	214 326	1 503 561	14.3 %	
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%	-

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 the automated 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 records 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:

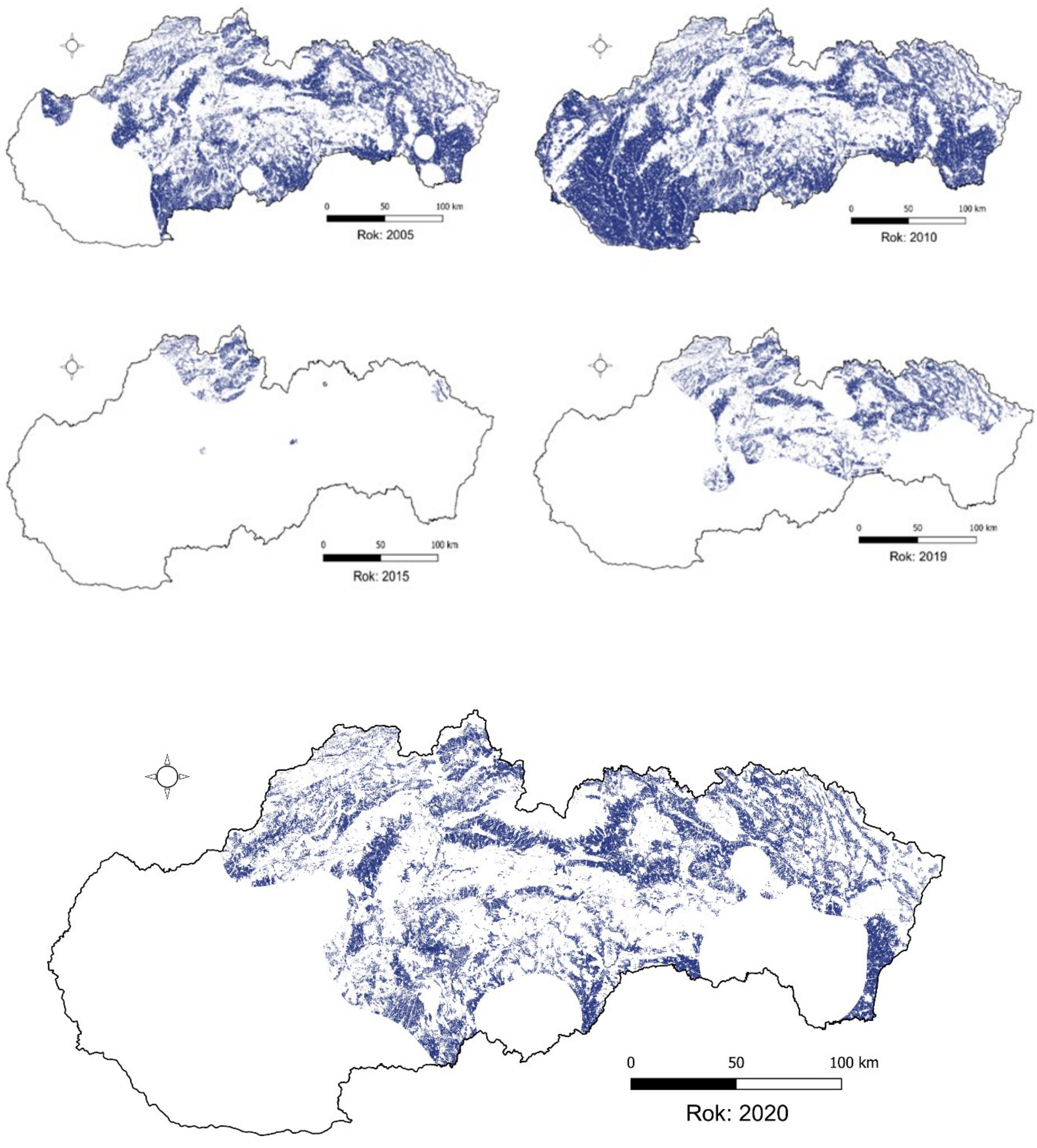
$$\frac{\mathrm{P}}{\mathrm{ET_0}} > 1$$

According to the definition of the $Frac_{LEACH}$ in the 2006 IPCC 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 5.24***), areas with a $\sum P/\sum ET_o \geq 1$ 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 (***Figure 5.25***).

Figure 5.25: *Grassland and arable land where ∑P/∑ETo≥1 for 2005, 2010, 2015, 2019 and 2020*



In 2020, the total humid area was 489 560 ha, which is 25.4% of the total agricultural area registered in LPIS ($Frac_{WET}$). The total irrigated area ($Frac_{IRR}$) in Slovakia 23 441 hectares, representing only 1.7% of agricultural land. To calculate the specific national value for nitrogen losses from agricultural land due to leaching ($Frac_{LEACHNATIONAL}$) we used equation:

$$Frac_{LEACH_{NATIONAL}} = (Frac_{irr} + Frac_{wet}) * Frac_{LEACH}$$

5.12.10.2 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 5.78*** shows the time series of parameters, EFs and N_2O emissions. In 2020, the fraction of nitrogen input to managed soils is 12.4%.

Table 5.78: *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	88 257 337	0.0075	1.04	24%
1995	40 046 989	0.0075	0.47	22%
2000	31 899 650	0.0075	0.38	19%
2005	45 728 648	0.0075	0.54	23%
2010	69 407 021	0.0075	0.82	37%
2011	12 092 163	0.0075	0.14	6%
2012	12 093 118	0.0075	0.14	6%
2013	30 455 248	0.0075	0.36	15%
2014	44 989 544	0.0075	0.53	19%
2015	5 953 850	0.0075	0.07	3%
2016	37 758 020	0.0075	0.45	16%
2017	20 209 218	0.0075	0.24	9%
2018	5 388 277	0.0075	0.06	2%
2019	20 500 841	0.0075	0.24	9%
2020	28 885 778	0.0075	0.34	12%

During 2021 submission, the incorrect value of the fraction of applied organic and inorganic N that is leached ($FracL_{EACH-NATIONAL}$ = 24%) was used in time series. In 2022 submission, the values of FracLeach were corrected based on ***Table 5.10***.

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 LIMINIG (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)

5.15.1.1 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 no implemented. The CO_2 emissions from liming were calculated according to the equation:

$$\mathrm{CO_2\ emissions} = \mathrm{M} * \mathrm{EF} * \frac{44}{12}$$

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 5.79: *Activity data, EFs and estimated CO_2 emissions in 3.G – 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

5.15.1.2 Activity data

The consumption of limestone increased in 2020 compared to 2019 by 72% due to increase in consumption compared to the previous year (2019). This was caused by the starting of subsidies for the purchase of limestone by agricultural enterprises.

Data on liming of agricultural soils (cropland) are provided by the ÚKSUP. For the years 1998 – 2020, 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 contains limestone, which is change compare to previous submission. Other calcareous substances containing only Ca and CaO were subtracted from activity data.

5.15.2 DOLOMITE CONSUMPTION (CRF 3.G.2)

5.15.2.1 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.

5.15.2.2 Activity data

The data on consumption of dolomite was provided by the UKSÚP. Consumption of dolomite increased in 2020 compared to 2019 by 103%. For the years 1998 – 2020, 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 5.80: *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

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 5.81***. CO_2 emissions from urea application were calculated as follows:

$$\mathrm{CO_2\ emissions} = \mathrm{M}_{\mathrm{CO(NH_2)_2}} * \mathrm{EF} * \frac{44}{12}$$

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 5.81: *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
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

5.16.2 ACTIVITY DATA

The ÚKSUP provides data on urea application on agricultural soils (cropland). For the years 1998 – 2018, 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 FE RTILIZERS (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 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 -8 746.54 Gg of CO_2 eq. in 2020 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***.

Figure 6.1: *Emissions and removals (Gg of CO_2 eq.) according to the categories in 1990 – 2020*

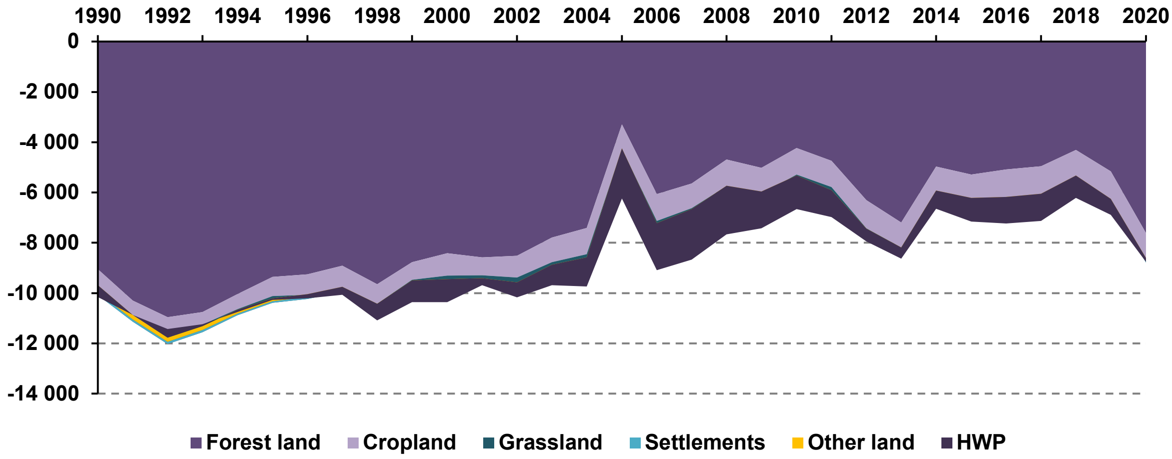


Table 6.1: *Summary of total emissions and removals according to the categories in 2020*

Category	Net CO_2		CH_4	N_2O	NO_x	CO
	Emissions/Removals (Gg)		*Emissions (Gg)*			
4. LULUCF	**NO**	**-8 809.32**	**0.89**	**0.14**	**0.57**	**20.16**
A. Forest Land	NO	-7 645.34	0.89	0.05	0.57	20.16
B. Cropland	NO	-1 094.54	NO	0.04	NO	NO
C. Grassland	NO	-93.17	NO	0.001	NO	NO
D. Wetlands	NO	NO	NO	NO	NO	NO
E. Settlements	78.40	NO	NO	0.02	NO	NO
F. Other Land	92.19	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	-9 060.89	-924.99	-205.65	95.81	281.41	**-10 284.72**	0.40	0.44
1995	-9 372.00	-827.63	-259.60	60.45	102.73	**-10 354.80**	0.28	0.31
2000	-8 459.12	-916.23	-310.74	53.77	103.15	**-10 449.23**	0.98	0.23
2005	-3 333.24	-1 001.07	-209.59	60.87	175.96	**-6 303.52**	0.96	0.17
2010	-4 267.12	-1 068.91	-221.30	99.63	87.32	**-6 704.98**	0.73	0.12
2011	-4 774.91	-1 062.81	-275.17	69.39	79.31	**-7 033.06**	0.87	0.13
2012	-6 371.06	-1 137.68	-216.91	81.00	114.19	**-8 038.87**	1.67	0.17
2013	-7 219.46	-997.17	-204.22	95.74	95.15	**-8 670.39**	0.55	0.11
2014	-4 998.05	-981.18	-184.33	79.99	108.15	**-6 703.81**	0.82	0.13
2015	-5 328.55	-1 024.33	-191.10	84.11	182.43	**-7 218.14**	0.92	0.15
2016	-5 118.95	-1 107.09	-178.79	79.86	97.69	**-7 290.93**	0.76	0.14
2017	-4 992.51	-1 142.66	-165.21	98.63	93.22	**-7 185.57**	0.85	0.14
2018	-4 341.51	-1 147.95	-114.43	80.87	138.71	**-6 273.50**	0.84	0.14
2019	-5 200.75	-1 153.59	-119.03	82.91	79.50	**-6 955.86**	0.98	0.15
2020	-7 645.34	-1 094.54	-93.17	78.40	92.19	**-8 809.32**	0.89	0.14

GHG Inventory submission 2022 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, Ss 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 2022 submission is described in ***Table 6.3***.

Table 6.3: *Reported emissions, methodological tiers and emission factors (EF) in LULUCF in 2020*

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 41.3% 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.

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 2006 IPCC 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 - The Wetlands include artificial reservoirs and dam lakes, natural lakes, rivers and swamps.

Settlements - The Settlements include all developed land, including transportation infrastructure and human settlements of any size.

Other Land - Other Land is 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***.

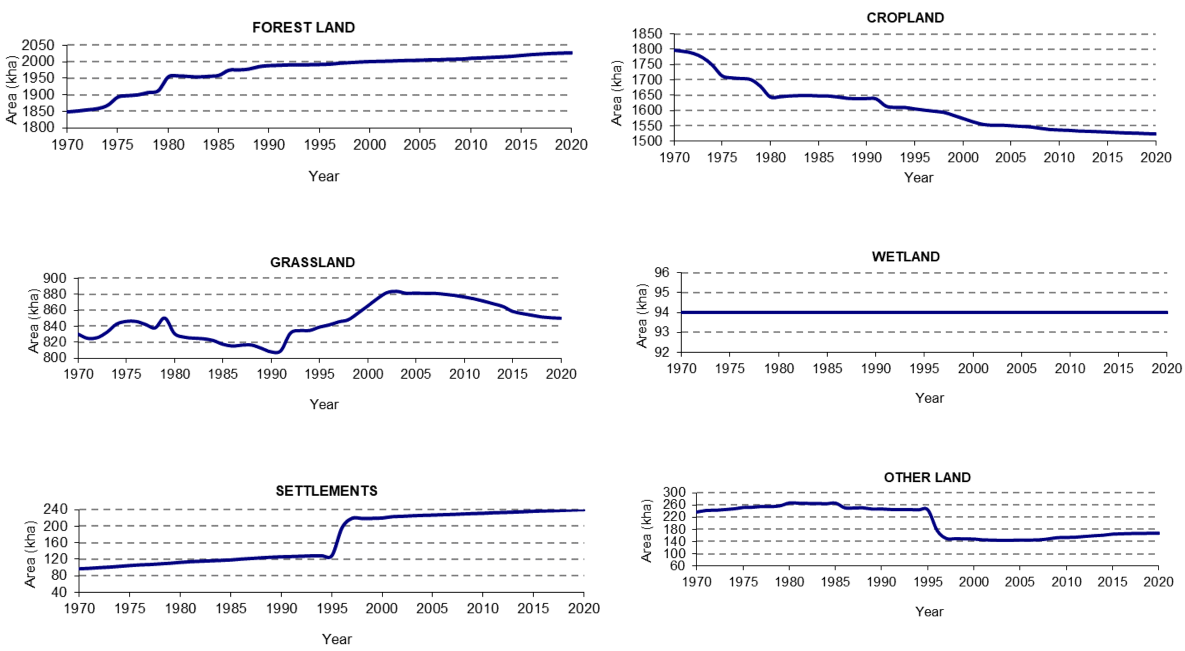
The increasing trend of FL is evident in the Slovak Republic since 1970. The opposite, decreasing trend of Cropland was recorded at the same time. Grassland areas decreased from 1980 to the 1990 and since this year increasing trend was recorded up to 2005. Since 2005, moderately downward trend has been 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. 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). 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 categories remaining in category in particular years*

YEAR	4.A.1	4.B.1	4.C.1	4.E.1	4.F.1
	kha/year				
1990	1 809.15	1 492.15	685.50	94.69	190.37
1995	1 861.77	1 502.19	740.79	102.63	203.45
2000	1 929.76	1 517.42	766.82	109.57	128.14
2005	1 945.13	1 513.92	762.47	116.75	128.01
2010	1 981.89	1 511.70	766.40	116.85	130.80
2011	1 983.77	1 510.36	766.97	117.40	130,65
2012	1 985.11	1 508.36	786.60	117.59	131.46
2013	1 985.74	1 507.23	787.84	117.18	131.36
2014	1 986.15	1 505.97	785.35	117.37	131.13
2015	1 986.73	1 503.58	784.51	117.90	130.04
2016	1 988.25	1 502.40	786.01	184.44	129.49
2017	1 991.52	1 501.95	788.93	206.45	129.33
2018	1 993.56	1 502.51	791.68	206.34	129.57
2019	1 995.57	1 501.94	800.48	206.65	130.00
2020	1 996.76	1 503.21	811.98	207.60	130.41

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 2020 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.

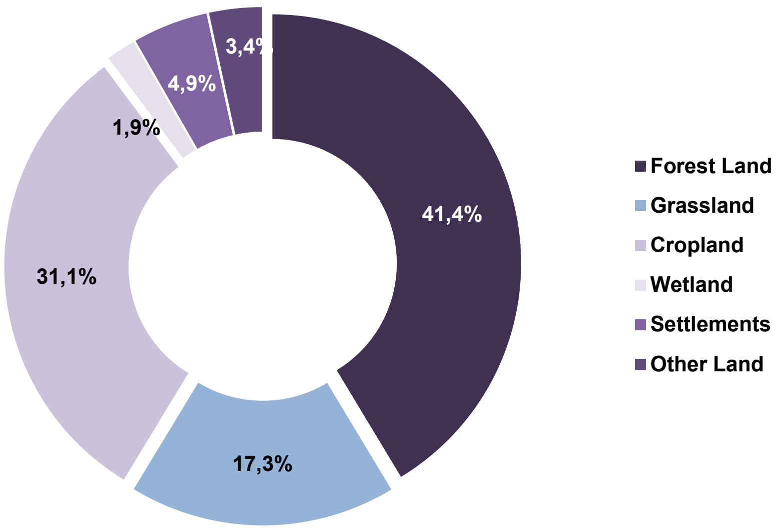
Figure 6.2: *Overall development trends in area of categories from 1970 – 2020 (based on information from the GCCA of the Slovak Republic)*



Land-use matrix identifying annual conversions among the categories for the period 1990 – 2020 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 2020 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 2020*



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 institution 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 in 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 2022 submission is in ***Table 6.5.***

Table 6.5: *Description of recalculations implemented in 2022 submission*

NUMBER/ RECOMME-NDATION	CATEGORY	DESCRIPTION	REFERENCE
1	4.A.1	New calculation of CSC in DW carbon pools Correction of tree species composition value	**Chapter 6.6**
2	4.A.2	New calculation of CSC in DW carbon pools	**Chapter 6.6**
3	4.B.2, 4.C.2, 4.E.2, 4.F.2	The recalculation of CSC in DW carbon pools	**Chapters 6.7, 6.8, 6.10, 6.11**
4	4.B.2	The recalculation of Direct N_2O emissions from N mineralization/immobilization	**Chapter 6.6**

The FL, CL, GL, SE, OL categories within the LULUCF sector were recalculated in 2022 submission. Recalculated values for the whole sector differ from the submission in 2021 by 4.24% to 9.53% in particular years (***Figure 6.4***), the net CO_2 eq. removals increased by 6.30% in average. These changes improved accuracy of the calculations.

Figure 6.4: Comparison of CO_2 eq. (Gg) in the 2021 and 2022 submissions for LULUCF sector

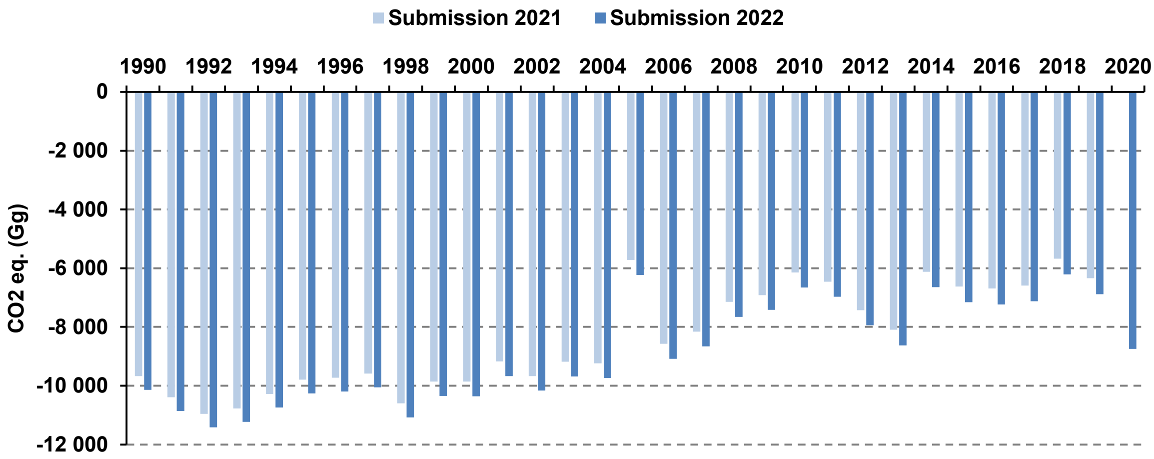
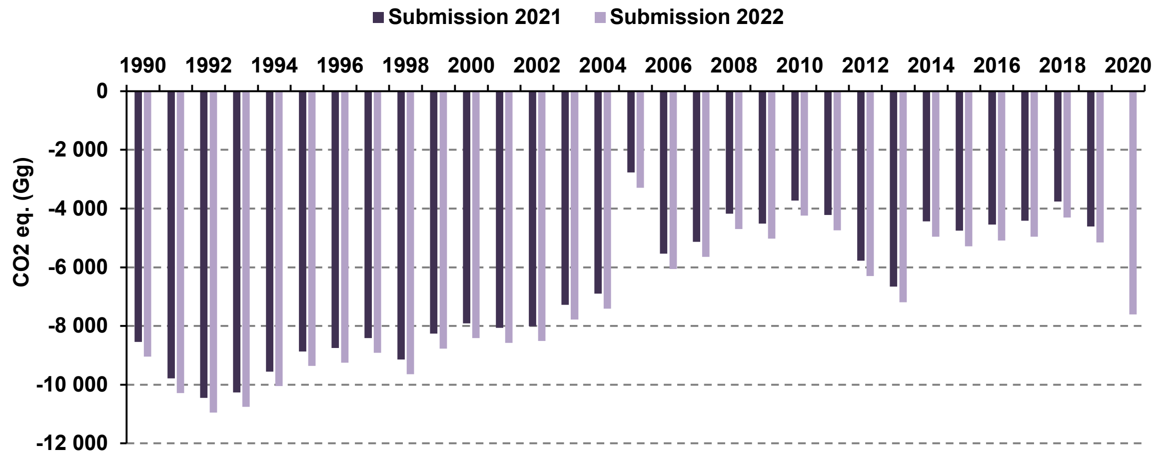


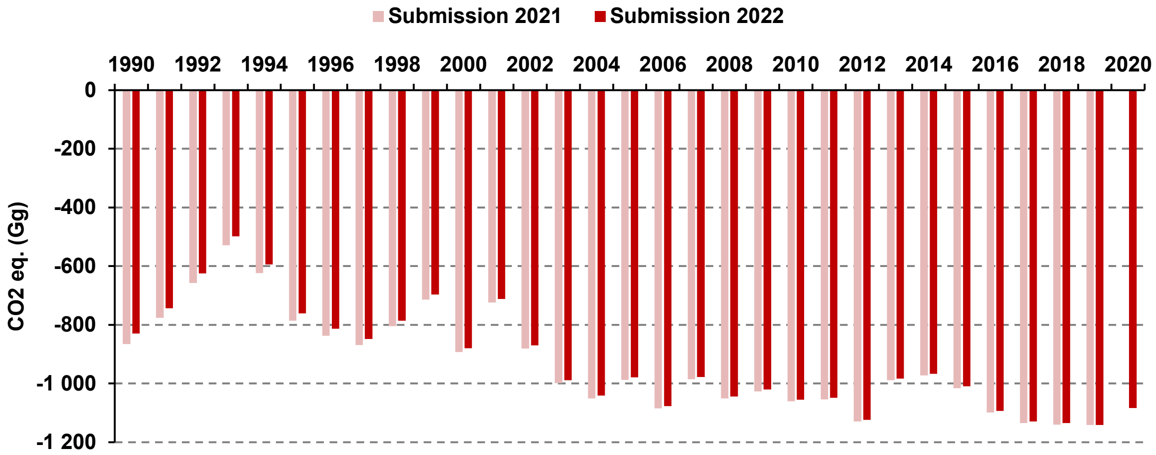
Figure 6.5: Comparison of CO_2 eq. (Gg) in the 2021 and 2022 submissions for Forest Land



In the category 4.A, both subcategories 4.A.1 Forest Land remaining Forest Land and 4.A.2 Land converted to Forest Land was recalculated for the whole period since 1990. The main reason for recalculation in 4.A.1 and 4.A.2 included the calculation of CSC in DW carbon pools following the ERT recommendation. Another reasons of recalculation in 4.A.1 was change and correction of root-to-shoot ratios (using only 0.2 for coniferous and 0.24 for broadleaved; no specific value for oaks following the ERT recommendation. Recalculated values for 4.A category differ from the submission in 2021 by 4.76% to 19.00% in particular years (***Figure 6.5***), the net CO_2 eq. removals increased by 8.92% in average. These changes improved accuracy of the calculations.

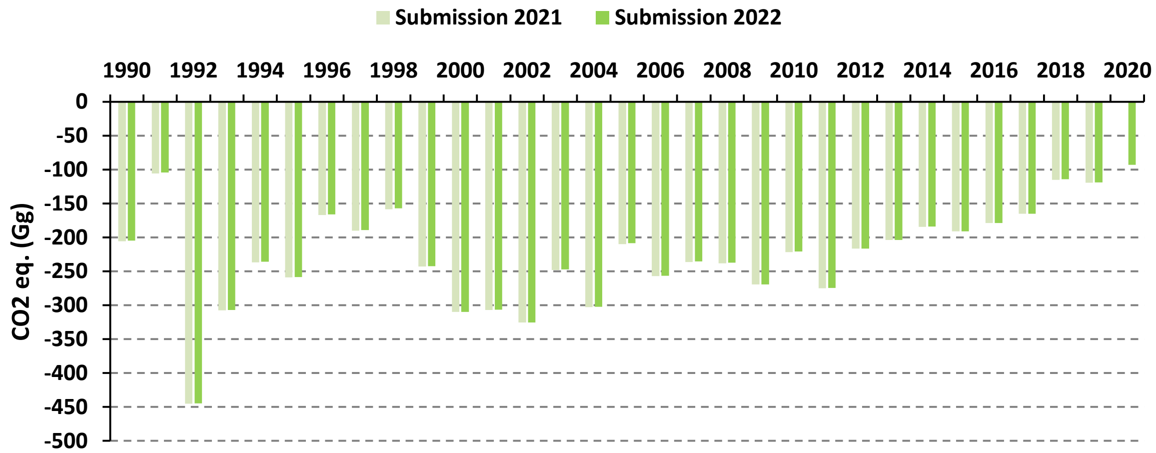
In the category 4.B, subcategory 4.B.2 Land converted to Cropland was recalculated for the whole period since 1990. The main reason for recalculation 4.B.2 category included the recalculation of CSC in DW carbon pools (FL converted to CL) following the ERT recommendation and recalculation of direct N_2O emissions from N mineralization/immobilization. Recalculated values for 4.B category significantly differ from the submission in 2021 by -5.81% to 0.00% in particular years (***Figure 6.6***), the net CO_2 eq. removals decreased by 1.72% in average.

Figure 6.6: *Comparison of CO_2 eq. (Gg) in the 2021 and 2022 submissions for Cropland*



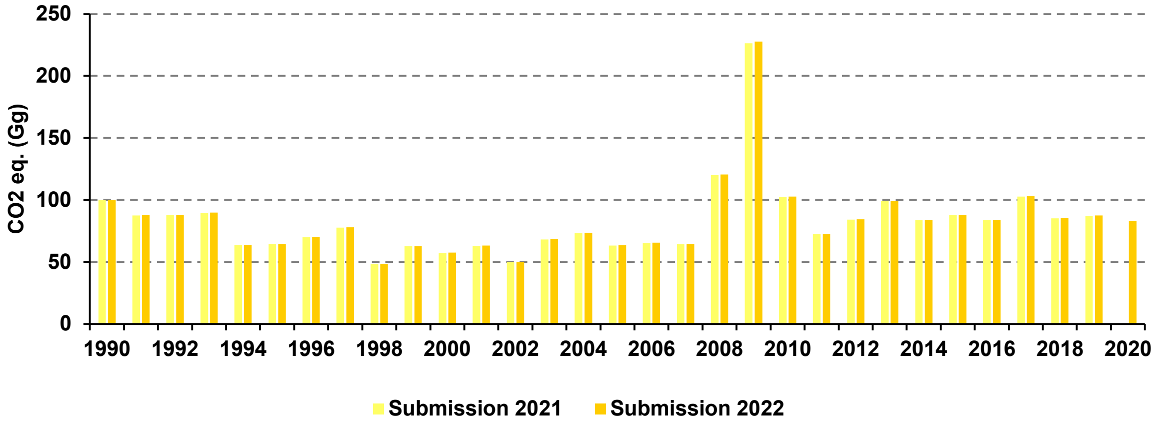
In the category 4.C, subcategory 4.C.2 Land converted to Grassland was recalculated for the whole period since 1990. The reason of recalculations included the recalculation of CSC in DW carbon pools (FL converted to GL) following the ERT recommendation. Recalculated values for 4.C category only slightly differ from the submission in 2021 by -1.42% to -0.03% in particular years (***Figure 6.7***), the net CO_2 eq. removals decreased by 0.29% in average.

Figure 6.7: *Comparison of CO_2 eq. (Gg) in the 2021 and 2022 submissions for Grassland*



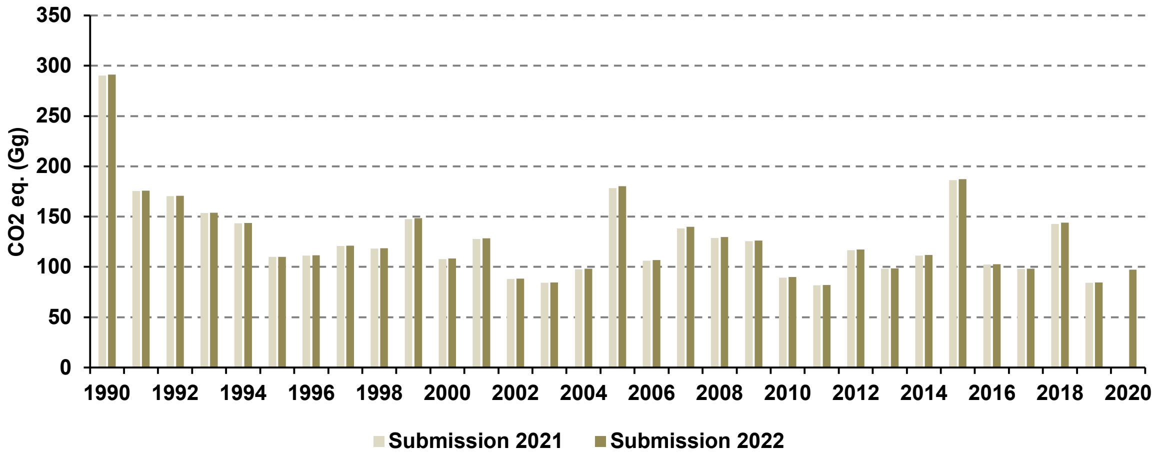
In the category 4.E, subcategory 4.E.2 Land converted to Settlements was recalculated for the whole period since 1990. The reason of recalculations included the recalculation of CSC in DW carbon pools (FL converted to SL) following the ERT recommendation. Recalculated values for 4.E category only slightly differ from the submission in 2021 by 0.00% to 0.58% in particular years (***Figure 6.8***), the net CO_2 eq. emissions increased by 0.27% in average.

Figure 6.8: Comparison of CO_2 eq. (Gg) in the 2021 and 2022 submissions for Settlements



In the category 4.F, subcategory 4.F.2 Land converted to Other Land was recalculated for the whole period since 1990. The reason of recalculations included the recalculation of CSC in DW carbon pools (FL converted to OL) following the ERT recommendation. Recalculated values for 4.F category only slightly differ from the submission in 2021 by 0.14% to 0.97% in particular years (***Figure 6.9***), the net CO_2 eq. emissions increased by 0.43% in average.

Figure 6.9: Comparison of CO_2 eq. (Gg) in the 2021 and 2022 submissions for Other land



6.4 CATEGORY-SPECIFIC IMPROVEMENTS AND IMPLEMENTATION OF RECOMMENDATIONS

Because the official review report from the latest UNFCCC review 2021 was not available during the preparation of the 2022 inventory, this chapter is based on the discussion and recommendations from the UNFCCC review 2019 (SVK ARR 2019), where the following room for improvements was identified:

- ERT recommendation No L.1 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.
- ERT recommendation No L.2 was partially implemented. According to the results from the expert group for uncertainty preparation, the main Monte Carlo simulations for LULUCF categories are already finished. Description is provided in the **Chapter 6.5**.

- ERT recommendation No L.6 was implemented, emissions from the organic soils are below the threshold of significance. Therefore the notation key NE was used. In NIR 2020 and CRF is presented revised estimates of Cropland organic soils, including an analysis demonstrating that emissions are below the significance threshold. Description is provided in the **Chapter 6.7.1.1.4**. Due to the research finalization in December 2021, the analysis is published only in the form of a report. From 2022, analyses and results will be published in the form of scientific professional publications. The status in this Chapter cover also Recommendation L.11.
- ERT recommendation No L.8 working meeting of the experts was held to identify the possibility of including regular pruning of permanent crops in the estimate of annual losses of permanent crops. The outcomes of the discussion include following findings:

  In orchards, methods of breaking out shoots, pruning, bending branches, which aim is to support fruit formation and delay the aging phase, are preferred to biomass fruit production, not support for another biomass production. It is proposed that the loss of regular pruning of permanent crops during the year is zero. In Slovakia, there are currently low areas of orchards and vineyards. Based on these small areas, the amount of trimmed biomass is negligible compared to other countries. The areas of intensive orchards are decreasing.

  The analysis of waste biomass from vineyards showed, that it is also practice to leave the trimmed material in the vineyards or in the intermediate rows. Wood and green waste is returned in the form of mulch back to the soil.

  Experts recommended not including regular pruning of permanent crops (orchards and vineyards) in the estimate of annual losses, mainly due to their low acreage in Slovakia and the absence of historical data on their acreage. In addition, the cut material is left in the rows when they are trimmed. Wood and green waste is returned in the form of mulch back to the soil.

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. The four recalculations (***Table 6.5.)*** were 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 6.6***. More and detailed information is in the SVK NIR 2018, the **Chapter 6.5** (**Annex A6.2** of this Report).

Table 6.6: *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

LULUCF CATEGORY		ACTIVITY DATA	EMISSION FACTOR	EF REFERENCES
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
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 (latest No L.2 SVK ARR 2019, L.10 SVK ARR 2017), 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 the 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 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 – 2021, 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 and 2021. Preliminary results of the application of Monte Carlo simulations are provided in the **Annex A6.2** of this Report. Work will be continuing following the available capacities and sources.

Analyses of uncertainties using Monte Carlo simulations for the main LULUCF categories (including the HWP) and KP activities, 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 34.6% of the area, followed by Norway spruce (21.8%), oaks (10.4%) and pine (6.6%). Broadleaved species represent 63.9% of all tree species found in Slovak forests. Percentage of coniferous species (currently at 36.1%) has been steadily decreasing since 1980; since 2000, their presence fell by 6%. 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, 2021). 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 have increased significantly. This is due to the high extent of forest damage caused by harmful agents and subsequent regeneration of damaged forests (Green Report, 2020). 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 484.5 mil. m^3 (merchantable volume, defined as tree stem and branch volume under bark with minimum diameter threshold of 7 cm) in 2020, an increase of 1.5 mil m^3 compared to 2019. 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; after 2015, the average annual increase in growing stocks was only 1.2 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 249 m^3 in 2020 (Green Report, 2021).

In 2020, the volume of current annual increment (CAI) reached 11.97 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 2021, the carbon stock in forests found in living biomass (aboveground and underground), dead organic mass (deadwood, litter) and forest soils reached a volume of 507.8 mil. tonnes in 2020, with the largest amount stored in soils (270.5 mil. t) and aboveground tree biomass (164.74 mil. t). Compared to 2010, the carbon stock in forests together increased by 3.2%, compared to 2000 by 9.3% and compared to 1990 by 17.1% (Green Report, 2021).

The total volume of harvested timber reached 7.51 mil. m^3 in 2020. Compared to 2019, realized felling decreased by 18.5% (1.71 mil. m^3), and it was lower by 2.3 mil. m^3, as the planned felling calculated using actual fellings possibilities and forest regeneration on urgency. Of the total volume, 53.5% of harvested timber represents the coniferous wood and 46.5% broadleaved wood. Of the total timber volume, 3.53 mil. m^3 (47.1%) was felled due to natural disturbances and pests, of which 78.0% 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 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 9.85 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, 2021).

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 6.10*** shows area changing during years and ***Figure 6.11*** shows map of Forest Land in Slovakia.

Figure 6.10: *Development of activity data (kha) for the category 4.A - FL in the period 1990 – 2020*

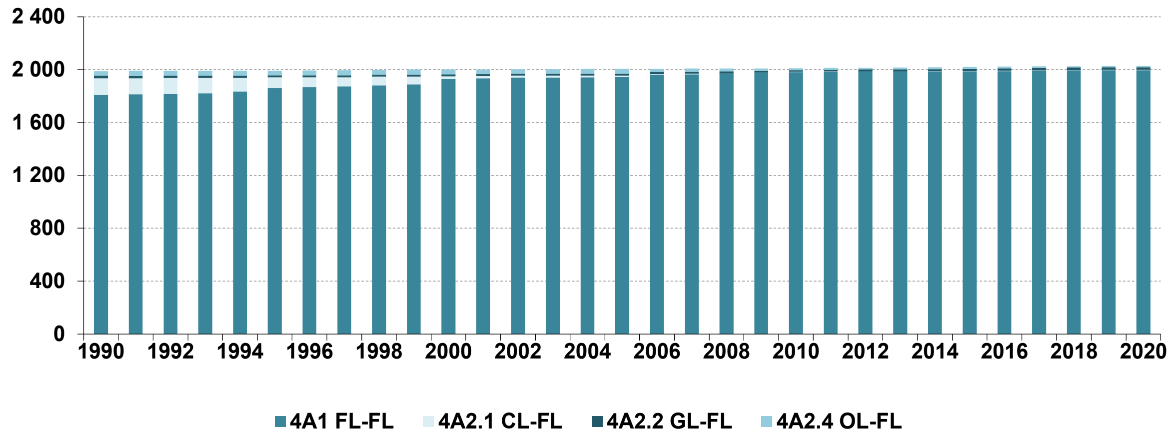
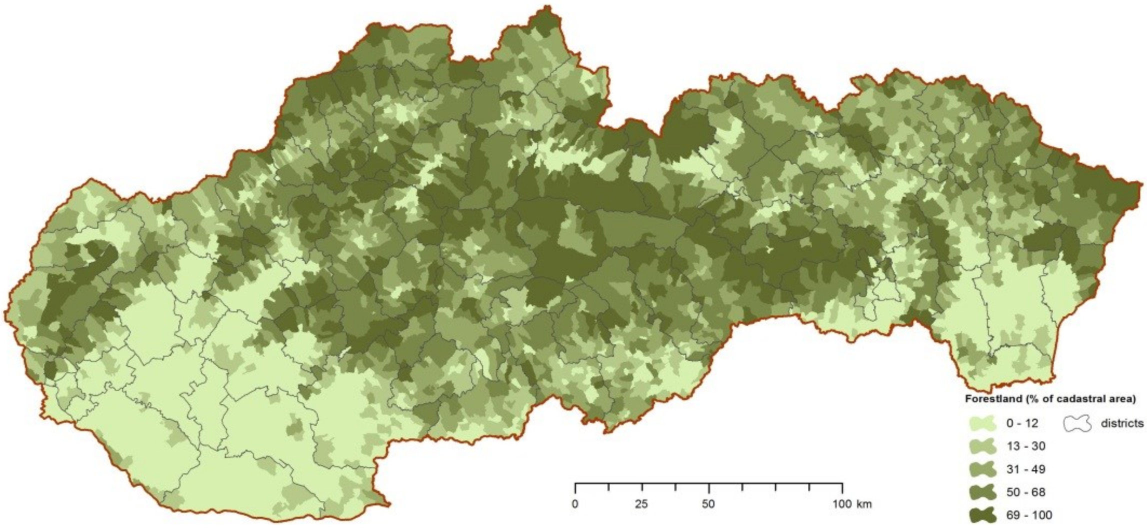


__Figure 6.11:__ Distribution of FL calculated as a spatial share within individual cadastral units



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 2020. 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 1 996.758 kha.

6.6.1.1 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:

- $G_{TOTAL} = G_W * (1 + R)$
- $G_W = I_V * BCEF_I$

According to the ERT recommendation No L.3 of the SVK ARR 2019, root-to-shoot ratio was differentiated according to Table 4.4 of the IPCC 2006 GL (0.2 for coniferous, 0.3 for Quercus species 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 6.7***.

Table 6.7: *Annual biomass increment for individual forest tree species in the Slovak Republic in 2020*

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	**$BCEF_I$**	**GW**	**R**	**G TOTAL**
	m^3/ha/y		*t dm/ha/y*		*t dm/ha/y*
Spruce	8.16	0.45	3.66	0.20	4.39
Fir	7.13	0.45	3.19	0.20	3.83
Pine	6.16	0.67	4.13	0.20	4.95
Larch	6.29	0.80	5.06	0.20	6.07
Other conifer	2.53	0.54	1.36	0.20	1.63
Oak	4.37	0.88	3.81	0.30	4.72
Beech	6.00	0.78	4.65	0.24	5.77
Hornbeam	6.11	0.91	5.57	0.24	6.91
Maple	5.99	0.72	4.30	0.24	5.34
Ash	7.52	0.72	5.40	0.24	6.70
Elm	6.12	0.74	4.54	0.24	5.62
Turkey oak	4.27	0.94	4.01	0.30	4.97
Locust	4.11	0.91	3.75	0.24	4.65
Birch	2.83	0.68	1.94	0.24	2.40
Alder	2.39	0.68	1.63	0.24	2.03
Linden	7.25	0.51	3.72	0.24	4.61
Hybrid poplars	12.13	0.48	5.79	0.24	7.18
Poplar	2.97	0.42	1.24	0.24	1.54
Willow	2.67	0.72	1.91	0.24	2.37
Other broad	1.61	0.68	1.10	0.24	1.37

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 6.7*** 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:

- $\Delta C_{FFG} = \sum (A * G_{TOTAL}) * CF$

According to the ERT recommendation No L.3 of the SVK ARR 2019 (L.11 of the SVK ARR 2017), 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 4 974.49 kt C in 2020 and is shown in ***Table 6.8***.

Table 6.8: *Total carbon uptake increment for individual forest tree species in 2020*

TREE SPECIES	Area of tree species for FL remaining 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/y*	*t C/tdm*	*kt C/y*
Spruce	434.495	4.39	1908.33	0.51	973.25
Fir	80.469	3.83	308.10	0.51	157.13
Pine	131.387	4.95	650.92	0.51	331.97
Larch	52.515	6.07	318.80	0.51	162.59
Other conifer	20.966	1.63	34.13	0.51	17.41
Oak	208.262	4.72	983.40	0.48	472.03
Beech	690.080	5.77	3980.50	0.48	1910.64
Hornbeam	118.807	6.91	821.02	0.48	394.09
Maple	51.516	5.34	274.85	0.48	131.93
Ash	31.149	6.70	208.63	0.48	100.14
Elm	0.599	5.62	3.37	0.48	1.62
Turkey oak	51.317	4.97	254.98	0.48	122.39
Locust	35.742	4.65	166.15	0.48	79.75
Birch	33.945	2.40	81.49	0.48	39.11
Alder	15.175	2.03	30.77	0.48	14.77
Linden	8.386	4.61	38.68	0.48	18.57
Breeding poplars	8.786	7.18	63.09	0.48	30.28
Poplar	8.187	1.54	12.59	0.48	6.05
Willow	1.997	2.37	4.73	0.48	2.27
Other broad	12.979	1.37	17.73	0.48	8.51
TOTAL	**1 996.758**		**10 162.25**		**4 974.49**

The annual decrease in carbon stocks due to biomass loss in FL remaining FL follows Equations 2.12 of the IPCC 2006 GL. According to the ERT recommendation No L.13 of the SVK 2019 ARR, 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 – 2020 in Slovakia are presented on ***Figures 6.12*** and ***6.13***.

Figure 6.12: *The harvesting volume in forest (coniferous and broadleaved) (mil. m^3 volume >7 cm under bark) in 1990 – 2020*

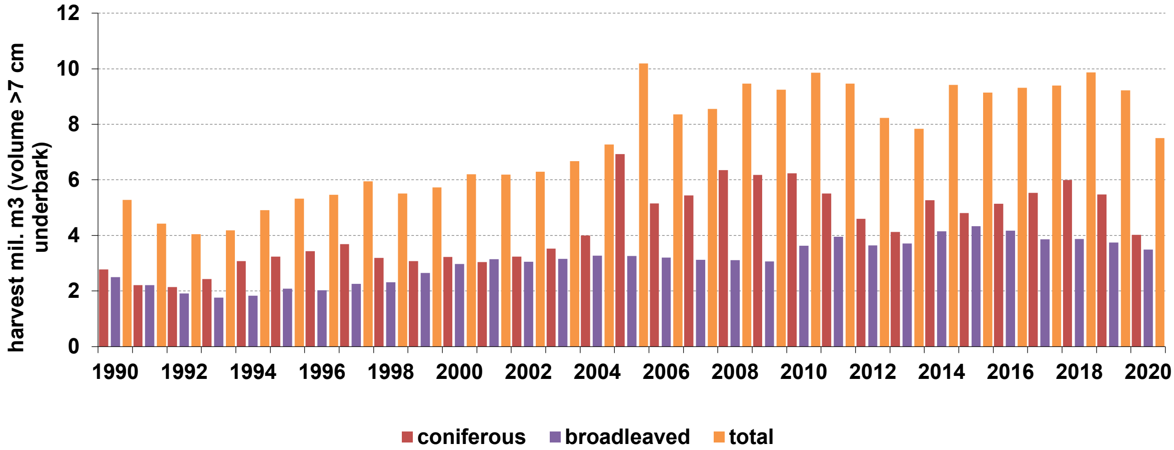
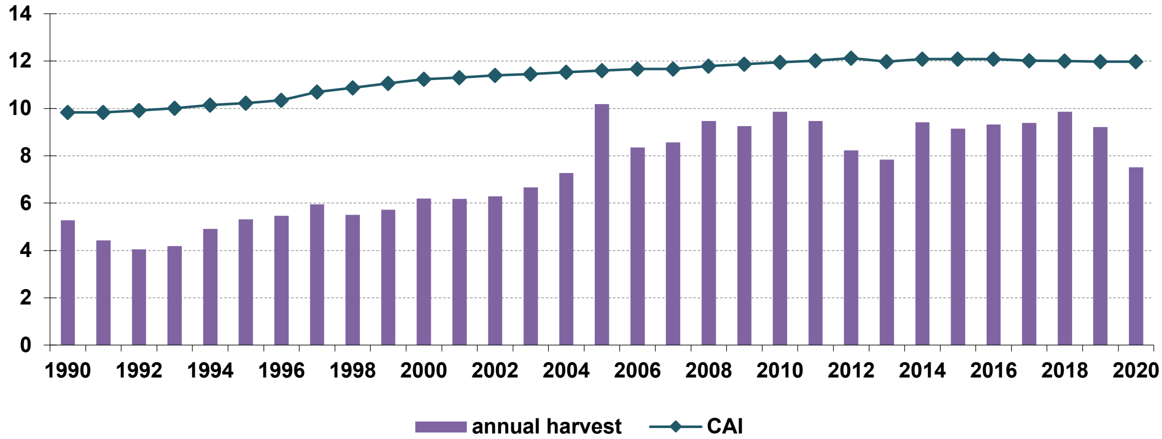


Figure 6.13: *Current annual increment (CAI) and total annual harvest (mil. m^3) in 1990 – 2020*



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, $\mathbf{W_i}$ (Mg) is the dry biomass of component, **V** (m^3) 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. The CF factors used in calculation are described in ***Table 6.9***. 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 3 109.86 kt C in 2020.

Table 6.9: *Activity data and $BCEF_R$ used in calculation of carbon losses in 2020*

TREE SPECIES	Annual wood removal - harvest volume	Biomass conversion/ expansion factor	Annual wood removal - biomass	Ratio of BGB to AGB	Annual wood removal - biomass	Carbon fraction of dry matter	L wood-removals including fuelwood
	H m³/y	*$BCEF_R$*	*t dm/y*	*R*	*t dm/y*	*CF t C/tdm*	*kt C/y*
Spruce	3 297 963	0.626	2 071 254	0.20	2 485 505	0.51	1 267.61
Fir	333 996	0.626	209 763	0.20	251 716	0.51	128.38
Pine	312 996	0.526	164 736	0.20	197 683	0.51	100.82
Larch	59 999	0.526	31 579	0.20	37 895	0.51	19.33
Other conifer	11 000	0.526	5 789	0.20	6 947	0.51	3.54
Oak	653 098	0.832	542 742	0.30	673 000	0.48	323.04
Beech	2 274 342	0.749	1 704 058	0.24	2 113 032	0.48	1 014.26
Hornbeam	193 029	0.749	144 628	0.24	179 338	0.48	86.08
Locust	55 008	0.749	41 215	0.24	51 107	0.48	24.53
Poplar	66 010	0.749	49 458	0.24	61 328	0.48	29.44
Other broad	253 038	0.749	189 590	0.24	235 091	0.48	112.84
TOTAL	**7 510 481**		**5 154 811**		**6 292 641**		**3 109.86**

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 tC/ha for 2005 as well as 7.4 ± 0.7 tC/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.

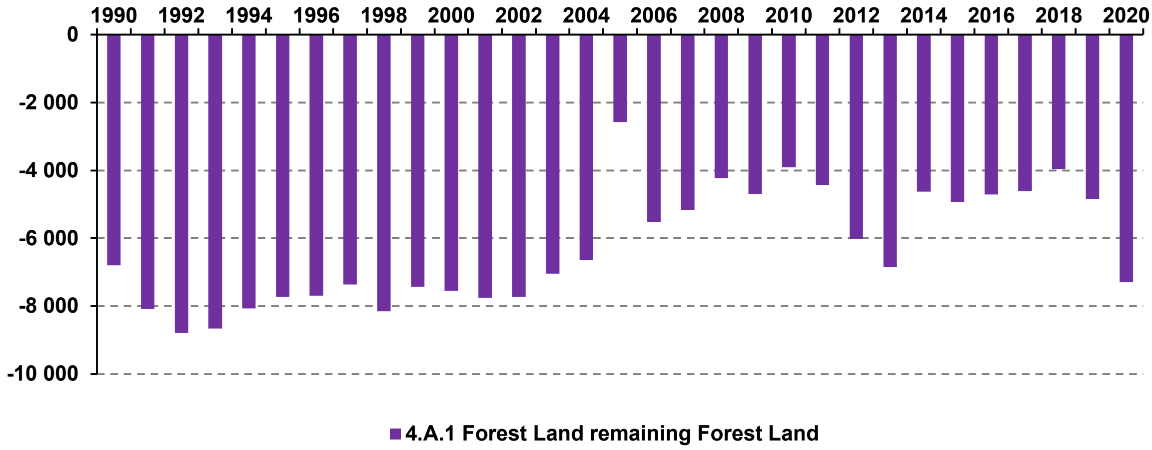
The mean carbon stock in forest litter is 8.3 t C/ha. The value is derived from datasets of the Forest Monitoring System (FMS) and the NFI. The changes of forests management that would dramatically change litter properties and litter carbon changes do not occur, i.e. no significant changes of carbon 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 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 central European conditions, within Forest Land managed according to the principles of sustainable forestry, the mineral soils, litter are not considered a source of net emissions (Pavlenda, 2016). The same assumption was made in countries with similar soils and climatic conditions (Hungary, the Czech Republic).

Figure 6.14 shows that the net CO_2 removals in the FL remaining FL represent -7 645.34 Gg in 2020. 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. In 2020, the net CO_2 removals were higher than in 2019 due to decrease of harvest by 18.5% compared to the year 2019.

Figure 6.14: Summary results of CO_2 removals (Gg) from FL-FL subcategory in 1990 – 2020



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 estimate 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 465.32 ha in 2020. This number increased compared to the previous year 2019, when the total burnt area was 454.87 ha. The average burnt forest area per one fire was 2.2 ha. The largest forest area damaged by fire was 85 ha. The forest fires occurred mostly in spring. According to the ERT recommendation No L.9 from the SVK ARR 2019 (No L.14 from the SVK ARR 2017), the GHG 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 (249 m^3/ha in 2019) 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 6.10*** shows biomass burned in forests with emissions in the same units (the ERT recommendation No L.10 of the SVK ARR 2019, L.15, SVK ARR 2017).

Table 6.10: *Biomass burned in forests, 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	Controlled Burning	Wildfires
	t d.m.	*ha*	*Gg*		*tons*			
1990	94 700.41	208.94	IE	41.60	275.96	124.61	15.27	6.89
1995	81 573.39	65.48	IE	14.13	237.70	42.32	13.15	2.34
2000	119 889.40	892.90	IE	210.40	349.36	630.26	19.33	34.87
2005	195 422.83	511.65	IE	128.53	569.46	385.01	31.50	21.30
2010	198 795.93	189.12	IE	49.65	579.29	148.73	32.05	8.23
2011	191 545.81	396.75	IE	105.09	558.16	314.81	30.88	17.46
2012	114 326.98	1 658.91	IE	444.98	333.15	1332.96	18.43	73.74
2013	115 246.54	266.23	IE	71.98	335.83	215.62	18.58	11.93
2014	229 253.58	188.74	IE	51.08	668.05	153.02	36.96	8.47
2015	219 296.63	346.65	IE	94.27	639.03	282.39	35.35	15.62
2016	213 282.85	171.87	IE	46.97	621.51	140.70	34.38	7.78
2017	208 364.96	292.80	IE	80.06	607.18	239.84	35.59	13.27
2018	218 264.66	244.33	IE	66.89	636.02	200.37	35.18	11.08
2019	207 386.96	454.87	IE	125.17	604.33	374.97	33.43	20.74
2020	171 903.38	465.32	IE	128.15	500.93	383.87	27.71	21.24

*tier 1 approach, CO_2 emissions from controlled burning are included in the total biomass loss associated with harvesting (CRF Table 4.A).

6.6.2.1 Controlled burning

Total methane emissions from controlled burning were 500.93 t and total emissions of N_2O were 27.21 t in 2020. CO_2 emissions from controlled burning are included in the total biomass loss associated with harvesting in CRF Table 4.A.

6.6.2.2 Wildfires

Total methane emissions from wildfires were 383.87 t and total emissions of N_2O were 21.24 t in 2020. CO_2 emissions were 128.15 Gg in 2020.

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 1.882 kha, GL converted to FL 19.711 kha, and OL converted to FL 9.501 kha in 2020. Total FL area was 2 027.852 kha in 2020.

6.6.3.1 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 34% for spruce, 11% for pine, 49% for beech and 6% for oak in 2020.

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), 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 emissions and removals estimation of carbon in dead wood pools follows conversion of land to forest land and the require estimates of the carbon stock just prior to and just following conversion and the estimates of the areas of lands converted during the period. 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 2000 to 2020 is provided in ***Table 6.12***.

The results from the category Land converted to FL are summarized in ***Table 6.11*** and on ***Figure 6.15***.

Table 6.11: *Results for the subcategory Land converted to Forest Land in 2020*

LAND USE CATEGORY	CARBON STOCK CHANGE IN LIVING BIOMASS (Gg C)			NET CARBON STOCK CHANGE IN DOM	NET CARBON STOCK CHANGE IN SOIL	NET CO_2 EMISSIONS/REMOVALS
	gains	*losses*	*net change*	*(Gg C)*	*(Gg C)*	*(Gg CO_2)*
Land - FL	**47.06**	**NO**	**47.06**	**12.90**	**33.30**	**-351.10**
GL - FL	29.83	NO	29.83	9.76	13.88	-196.05
CL - FL	2.85	NO	2.85	0.93	2.72	-23.84
WL - FL	NO	NO	NO	NO	NO	NO
S - FL	NO	NO	NO	NO	NO	NO
OL - FL	14.38	NO	14.38	4.70	16.70	-131.21

The estimated removals for Land converted to Forest Land were -351.10 Gg CO_2 in 2020. In 2020, the net carbon stock change in living biomass, DOM and soil from Land converted to Forest Land represented gains of 33.30, 2.72 and 16.70 Gg of C respectively.

Figure 6.15: *Summary results of CO_2 removals (Gg) in L-FL subcategory in 1990 – 2020*

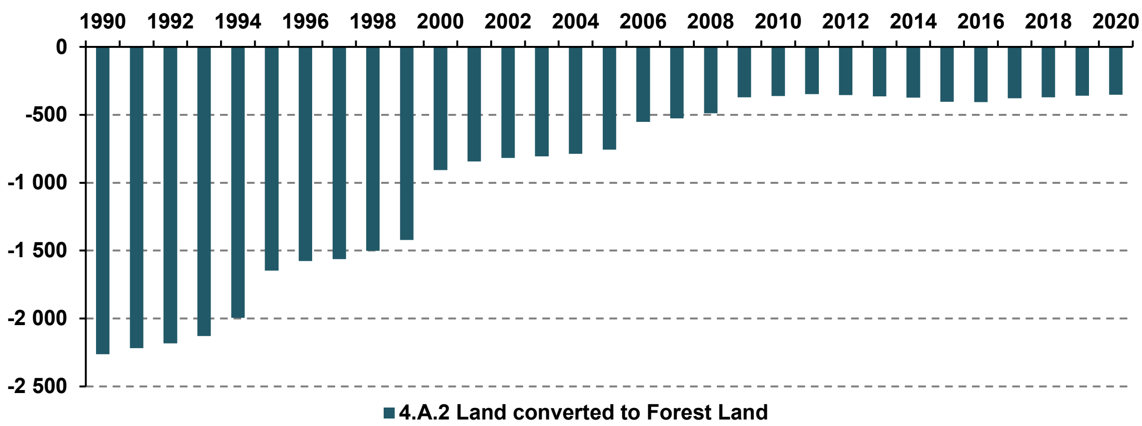


Table 6.12: The land-use matrix from 2000 – 2020

Land use	Forest Land (managed)	Forest Land (unman.)	Cropland annual	Cropland perennial	Grassland (managed)	Grassland (unman.)	Wetland (managed)	Wetland (unman.)	Settlements	Other Land	Total land unman.	Initial area (2000)
Category	*kha*											
Forest Land (managed)	1 995.569	0.000	0.214	0.000	1.419	0.000	0.000	0.000	0.977	1.885	**0.000**	**2 001.253**
Forest Land (unman.)	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	1.882	0.000	1 378.058	0.198	36.644	0.000	0.000	0.000	17.956	15.753	**0.000**	**1 450.491**
Cropland perennial	0.000	0.000	5.418	119.537	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**	**124.955**
Grassland (managed)	19.711	0.000	19.194	0.000	811.978	0.000	0.000	0.000	6.924	7.413	**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	207.603	11.734	**0.000**	**219.337**
Other Land	9.501	0.000	2.380	0.000	0.000	0.000	0.000	0.000	5.972	130.411	**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 (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	**26.599**	**0.000**	**-45.228**	**-5.220**	**-15.193**	**0.000**	**0.000**	**0.000**	**20.110**	**18.932**	**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 6.13***) were calculated according to the Equation 2.27 and Table 2.4 (IPCC 2006 GL) using the default emission factors. According to the ERT recommendation No L.8 of the SVK ARR 2019 (L.13 from the SVK ARR 2017), available mass of fuel for combustion was used according to Table 2.4 (IPCC 2006 GL).

Table 6.13: *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	*tons*		
1990	23.06	911.86	2.73	0.15
1995	4.94	195.15	0.59	0.03
2000	34.35	1358.27	4.07	0.23
2005	16.31	645.00	1.93	0.11
2010	2.84	112.41	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

6.6.4.1 Wildfires

Total methane emissions from wildfires in category 4.A.2 were 0.87 t and total emissions of N_2O were 0.05 t in 2020. Total CO_2 emissions were 291.03 t in 2020. 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 IPCC 2006 GL for AFOLU and national data on area of Cropland and Land converted to Cropland in 2020. The total area of Cropland represented 1 524.998 kha in 2020, 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 1 503.211 kha, of which Annual Cropland remaining Annual Cropland (CLA-CLA) is 1 378.058 kha, Perennial Cropland remaining Perennial Cropland (CLP-CLP) is 119.537 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 5.418 kha. The changes in the Cropland were following: FL converted to CL 0.213 kha, GL converted to CL 19.194 kha and OL converted to the CL 2.380 kha in 2020 as shown on ***Figures 6.16*** and ***6.17***.

Figure 6.16: Development of activity data (kha) for 4.B Cropland in the period 1990 – 2020

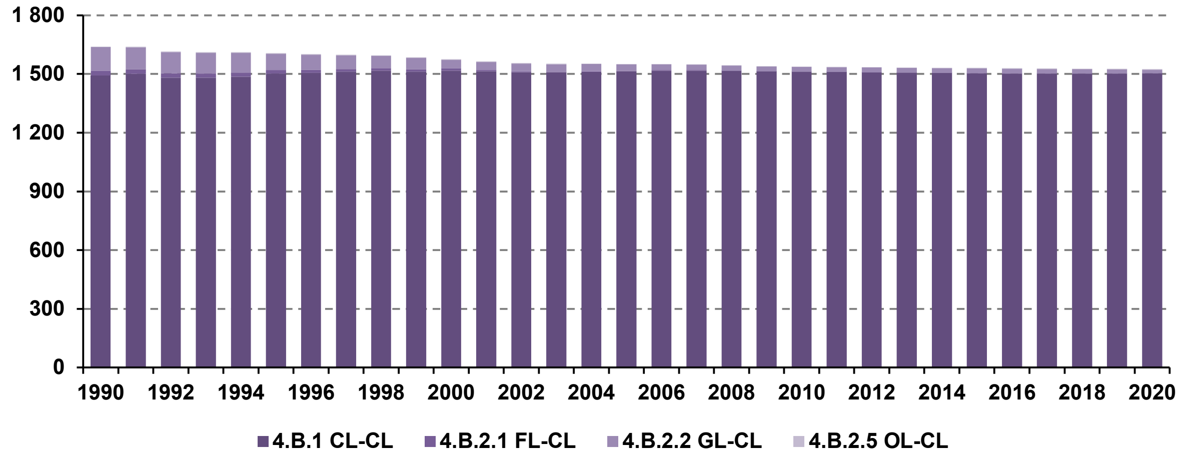
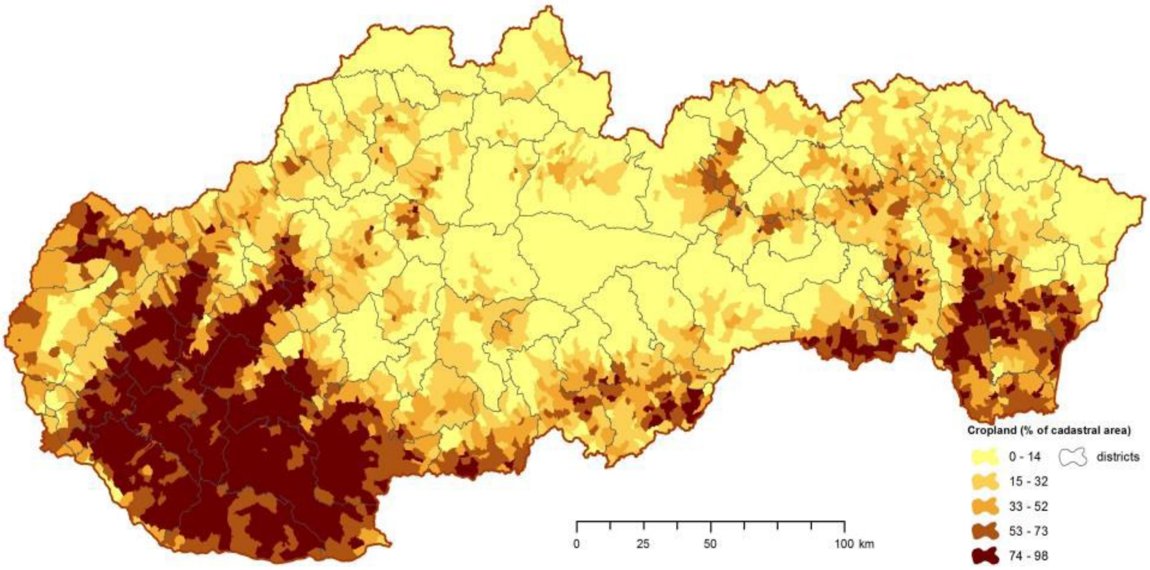


Figure 6.17: Distribution of Cropland in Slovakia – calculated as a spatial share within individual cadastral units



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 1 378.058 kha in 2020. The CLP including vineyards, orchards, hop-gardens and gardens represented 119.537 kha in 2020.

6.7.1.1 Methodological issues – methods, activity data, emission factors and parameters

Change in biomass carbon stocks of Cropland remaining Cropland were estimated by tier 1 approach.

6.7.1.1.1 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). 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).

ERT recommendation No L.16 (SVK ARR 2019) Information on progress is provided in the **Chapter 6.4**. Experts started to investigate the options to include periodic cuttings, including, but not limited to, pruning in the estimation of annual losses in perennial croplands. The investigation includes an analysis of the availability of input data. The survey also involves consultations with other experts, particularly FL experts and relevant experts and institution regarding perennial cropland.

Implementation of the ERT recommendation No L.8 (SVK ARR 2021) proceeded as follows. Information on progress is provided in **Chapters 6.4**. Experts started in 2020 to investigate the options to include periodic cuttings, including, but not limited to, pruning in the estimation of annual losses in perennial croplands. The investigation includes an analysis of the availability of input data. The survey also involves consultations with other experts, particularly FL experts and relevant experts and institution regarding perennial cropland. The ERT considers that the recommendation has not yet been fully addressed because the Party has not reported on the progress or provided the information regarding the expert opinion, which was presented during the review.

Because ERT recommendation L.16 was not fully addressed in the previous NIR, we document the expert opinion in this current version of the NIR.

A working meeting of the experts was held to identify the possibility of including regular pruning of permanent crops in the estimate of annual losses of permanent crops. It was attended by representatives of the Ministry of Agriculture and Rural Development of the Slovak Republic (Plant Production Department), Slovak Hydrometeorological Institute (Department of Emissions and Biofuels), National Agricultural and Food Centre – Soil Science and Conservation Research Institute, representatives of the Union of Winegrowers and Winemakers of Slovakia, representatives of the Fruit Growing Union of the Slovak Republic and representatives of The Central Control and Testing Institute in Agriculture (ÚKSÚP) (Department of Viticulture and Enology, Department of Fruit Growing and Organic Agricultural Production).

The outcomes of the discussion include following findings:

In orchards, methods of breaking out shoots, pruning, bending branches, which aim is to support fruit formation and delay the aging phase, are preferred to biomass fruit production, not support for another biomass production. It is proposed that the loss of regular pruning of permanent crops during the year is zero. In Slovakia, there are currently low areas of orchards and vineyards. Based on these small areas, the amount of trimmed biomass is negligible compared to other countries. The areas of intensive orchards are decreasing.

The analysis of waste biomass from vineyards showed, that it is also practice to leave the trimmed material in the vineyards or in the intermediate rows. Wood and green waste is returned in the form of mulch back to the soil.

Experts recommended not including regular pruning of permanent crops (orchards and vineyards) in the estimate of annual losses, mainly due to their low acreage in Slovakia and the absence of historical data on their acreage. In addition, the cut material is left in the rows when they are trimmed. Wood and green waste is returned in the form of mulch back to the soil.

6.7.1.1.2 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 2020. 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 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).

6.7.1.1.3 Changes of carbon stocks in biomass of Perennial Cropland converted to Annual Cropland

Total land-use change area from CLP converted to CLA was 5.418 kha. The rationale for these estimates and used methods are described in the **Chapter 6.7.1.1.2**. 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 6.7.1.1.2** in more details):

Annual change in biomass = annual area of currently converted land * ($L_{conversion} + \Delta C_{growth}$)

Where:

$\mathbf{L_{conversion}} = C_{after} - C_{before}$;

$\mathbf{C_{after}}$ = carbon stock immediately after conversion is 0;

C_{before} = country specific value of annual change of perennial woody biomass is 3.25 t C/ha/y;

$\mathbf{\Delta C_{growth}}$ = annual growth rate of perennial woody biomass is 2.1 t C/ha/y.

The calculation according to the Austrian methodology was applied.

6.7.1.1.4 Changes of carbon stocks in mineral soils of Annual Cropland remaining Annual Cropland and Perennial Cropland remaining Perennial Cropland

Concerning the ERT recommendation No L.6 The status in this Chapter cover also Recommendation L.11 In terms of recommendation, a new survey was conducted based on a combination of remote sensing, GIS, field survey and laboratory analysis in 2021.The aim of the "Identification of currently existing organic soils, which are managed within the Cropland category on selected representative areas by field research, laboratory analyses, GIS and remote sensing methods" was to identify the current real state of occurrence of organic soils within arable lands - Cropland class in Slovakia. Due to the research finalization in December 2021, the analysis is published only in the form of a report. From 2022, analyses and results will be published in the form of scientific publications.

The reason was not only the calculation and reporting of GHG carbon sinks and emissions for organic soils in the Cropland class presented in the GHG inventory under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (at the same time, it submits an identical report to the European Commission pursuant to Article 7 of EU Regulation 525/2013 (MRD), Article 7 of EU Decision 529/2013 and the relevant articles of EU Regulation 749/2014), but also as knowledge for further practical use and research.

The reported area of organic soils over 2.000 ha (incorrect and out of date) is the result of a simple spatial GIS analysis consisting of overlapping the BPEJ (soil-ecological quality unit (primary soil unit based on information on climate region, soil type and subtype, slope, exposition, depth and texture) layer (no longer current layer, mapping from 60 and 70 years) with the current LPIS layer - only arable land areas and permanent crops. LPIS - Land Parcel Identification System) is an identification system of reference parcels of agricultural areas.

Such an area caused doubts of the authors of the report from the NPPC-VÚPOP, especially for the two reasons listed below, and so we proceeded to re-evaluate and determine the real condition and extent of organic soils.

1. The drainage of these soils in the 50-70 years of the 20th century resulted in the drained former organic soils. After dewatering, the organic carbon content of these soils has decreased due to the mineralization/oxidation of organic matter during more than 60 years of continuous intensive farming. The vast majority of these areas are located in the Danube Plain, especially in the districts of Dunajská Streda and Galanta, which are characterized by very intensive agricultural use for decades.
2. The origin of the BPEJ layer arose at a time when there were no modern technical methods such as GPS field measurement and remote sensing. It was based mainly on a point survey of the Complex Soil Survey (KPP) (laboratory analyses of COx were performed only on selection sample probes, whether it was sparse organic soil mapping network) that covered the area of BPEJ polygons (although there is often no match between soil type of KPP and soil type – HPJ (main soil unit - aggregate soil unit) in BPEJ, which is remarkable). As part of the identification, it was found that only less than 30% of sampling points had a soil type of peat soil/organic

soil/histosols identical between KPP and BPEJ. In addition, the fact that the mapping often did not take place in the field also contributes to the inaccuracies.

Summary of those two reasons is that organic soil is no longer there (reason 1), or has never been (reason 2) on these areas.

The identification of organic soils included:

GIS analysis:

- "Basic / primary" identification of organic soils, overlaps of BPEJ layer with LPIS layer.
- Stratification according to the probability classes of organic soils – strata defined into more homogeneous units / strata according to the assumption of the real COx content in individual strata. Stratification for individual classes is based on visual interpretation of remote sensing and GIS data. Remote sensing experts interpreted the use (especially agricultural), the condition of areas, landscapes and signs of direct waterlogging or wetting. They had at their disposal and used remote sensing, LPIS and cadastre data.
- Selection of KPP probes for field research, laboratory analyses and evaluation of the current state of organic soils within the Cropland category.

Field survey of KPP sampling probes and sampling points on organic soils:

The verification that the organic soil areas, represented by the relevant KPP probes, meet criterion I was realized by specification of the criteria for defining categories by definition of organic soils in the 2006 IPCC Guidelines (Annex 3A.5, Chapter 3, Volume 4). Organic soils are identified based on criteria 1 and 2 or 1 and 3 below (FAO, 1998). Field documentation includes photo documentation (sampling point, surrounding agricultural landscape and mostly soil profile) and orientation of the sampling point with GPS.

Analyses of taken samples (organic carbon COx content):

Forty-seven soil samples were analysed for soil carbon COx content by two different methods. For some KPP probes, the granularity was additionally determined in order to meet the criteria of the second resp. 3rd (FAO, 1998), repeated terrain survey (3 probes) was performed here, supplemented by photo documentation.

The results of laboratory analyses show that the stratification of individual polygons by remote sensing and GIS methods to typical strata was very successful. In strata A, B, B 4 and BM (identical management and land use within agriculture parcels), the results of the weighted average COx content are at the level of more fertile mineral soils (e.g. chernozem).

The use of remote sensing and GIS data in the analysis of land use and its management showing uniformity, identical state on polygons of the layer of "original organic soils" and the surrounding landscape (same sowing, visual state on orthophotomaps) was also verified by field results (absence of organic horizon) and results of laboratory analyses.

Two samples reached a COx content above 20% (26.49 and 23.40). The other three had a COx content over 12%. These were analysed in laboratories for soil texture / granularity analysis. However, one sample did not meet the criteria of the first FAO 1998. Even the original soil type according to KPP - LP - blackberry does not match the soil type Histosols - organic soils according to HPJ (BPEJ). The other two met these criteria and had a COx content of 17.9 and 15.65%.

From the material, financial and personnel point of view, field research and laboratory analyses could not be performed on all more than 1 300 polygons. Therefore, a spatial analysis of the results and interpretation of the results were performed.

Representation of organic soils for strata; A; B; B4 and BM were not calculated as there were no sampling points in these strata that would meet the FAO 1998 criteria for inclusion in organic soils.

Within the strata M and AM, we calculated the area ratio of polygons (e.g. at AM 10.41 ha (17.9% COx), 23.41 ha (15.65% COx) and 24.62 ha (26.46% COx)) - 58.43 ha to the total area of the eight polygons where the collection was taken from the given strata -114.28 ha, this ratio is 51.13%. Similarly, with the strata M on one polygon, the FAO 1998 limits were reached -23.4% -7.87 ha to the total area of eight polygons where the collection was taken from the given strata -34.33 ha, this ratio is 12.93%.

The resulting percentage of 51% of AM strata and 13% of M strata were used to calculate the areas of organic soils within the total strata area (AM 10 -775.66 ha; M -68.93 ha) from the layer of original organic soils.

The result is the calculated acreage of organic land 2020 for the AM strata -395.59 ha and for the M strata 8.96 ha, 404.55 ha of organic land.

Area of organic soils for strata T (technical code indicating areas which do not fall within any known strata for technical reasons) calculated after dividing the area of organic soils determined on the basis of field research and laboratory analyses for AM and M strata -404.55 ha area of the total area of the original layer of organic soils 1 948.98 (after deducting the area of strata T -219.07 ha from the total acreage of organic soils 2 168.05 ha). The resulting area of organic soils within the T strata is 45.457 ha.

The resulting total area of organic soils according to "Identification of currently existing organic soils, which are managed within the Cropland category on selected representative areas by field survey, laboratory analyses, GIS and remote sensing" is 450.01 ha in 2020.

The results confirmed the hypotheses and assumptions that the data on the occurrence and areas of organic soils only based on the overlap of the not actual/recent layer of BPEJ and LPIS arable land are already unrealistic and unsubstantiated. New findings and results of the task "Identification of currently existing organic soils, which are managed within the Cropland category on selected representative areas by field survey, laboratory analysis, GIS and remote sensing" solved in 2020 confirmed the effectiveness of interconnection of remote sensing, GIS, field survey data and laboratory analyses during the task. Each of these components is essential for successful credible and scientifically based current results. Activity data, emission factors, threshold and impact on GHG emissions in particular years are in ***Table 6.14***.

Table 6.14: *Activity data, emission factors, threshold, and impact on GHG emissions in particular years*

YEAR	AREA OF HISTOSOLS	EFs	CO_2 EMISSIONS	GHG TOTAL WITHOUT LULUCF	THRESHOLD	IMPACT ON GHG INVENTORY IN INDIVIDUAL YEARS
	ha	*t CO_2/ha^{-1}*	*Gg*	*Gg CO_2 eq.*		*%*
1990	450	5.0	8.25	73 463	36.731	0.00011
1995	450	5.0	8.25	52 922	26.461	0.00016
2000	450	5.0	8.25	48 770	24.385	0.00017
2005	450	5.0	8.25	50 562	25.281	0.00016
2010	450	5.0	8.25	45 673	22.837	0.00018
2011	450	5.0	8.25	44 700	22.350	0.00018
2012	450	5.0	8.25	42 284	21.142	0.00020
2013	450	5.0	8.25	41 962	20.981	0.00020
2014	450	5.0	8.25	40 009	20.005	0.00021
2015	450	5.0	8.25	40 714	20.357	0.00020
2016	450	5.0	8.25	41 179	20.590	0.00020
2017	450	5.0	8.25	42 263	21.131	0.00020
2018	450	5.0	8.25	42 135	21.067	0.00020

YEAR	AREA OF HISTOSOLS	EFs	CO_2 EMISSIONS	GHG TOTAL WITHOUT LULUCF	THRESHOLD	IMPACT ON GHG INVENTORY IN INDIVIDUAL YEARS
	ha	*t CO_2/ha^{-1}*	*Gg*	*Gg CO_2 eq.*		*%*
2019	450	5.0	8.25	39 822	19.911	0.00021
2020	450	5.0	8.25	37 049	18.524	0.00022

The method used for carbon stock changes in mineral soils followed the Equation 2.25 and relative stock change factors for different activities on Cropland followed Table 5.5 (IPCC 2006 GL). The default relative stock change factors for land use F_{LU} = 0.80 (CLA), 1.00 (CLP), stock change factors for management regime F_{MG} = 1.1 (CLA) and 1.02 (CLP) and stock change factor for input of organic matter F_I = 1.0 were applied. However, country specific value for Cropland soil carbon stock was used (as for other calculation of carbon stock change in mineral soils). The changes in soil carbon stock associated with the annually changing proportion of Cropland areas with different management result in emissions/removals. These are calculated after redistribution of estimated carbon stock change over a 20-year rolling period.

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) is 66.54 t C/ha (0-30 cm).

The ERT recommendation No L.17 (SVK ARR 2019) was implemented in 2020 submission. Slovakia includes the additional information regarding the change of carbon stocks in mineral soils in both CLP remaining CLP and CLA remaining CLA. The relative stock change factor (1.10), corresponding to Table 5.5 of the 2006 IPCC GL, to “no tillage” in annual Cropland, was used, instead e. g. 1.00 corresponding to “full tillage” or 1.02 corresponding to “reduced tillage”, respectively. The reason is that only the area of unused land, not the total area of CLA, is included in the calculation of SOC_{0-T} and SOC_0 from CLA. Unused land represents fallow land and therefore a factor of 1.1 was used. For CLP, a factor of 1.02 is used because full tillage is not possible in CLP.

6.7.1.1.5 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 and was 0.000 kha in the years 2006 – 2017. In the year 2018, the area of CLA converted to CLP increased after several years up to 0.15 kha. Total area of CLA converted to CLP was 0.198 kha in 2020. 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

$\Delta SOC = (SOC_0 – SOC_{0-T})/20 = 0.322$ 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-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 (0.176 kha in 2019, 0.198 kha in 2020), the ΔSOC20 is in 2019 0.05 kt C and in 2020 is 0.06 kt C.

6.7.1.1.6 Changes of carbon stocks in mineral soils of Perennial Cropland converted to Annual Cropland

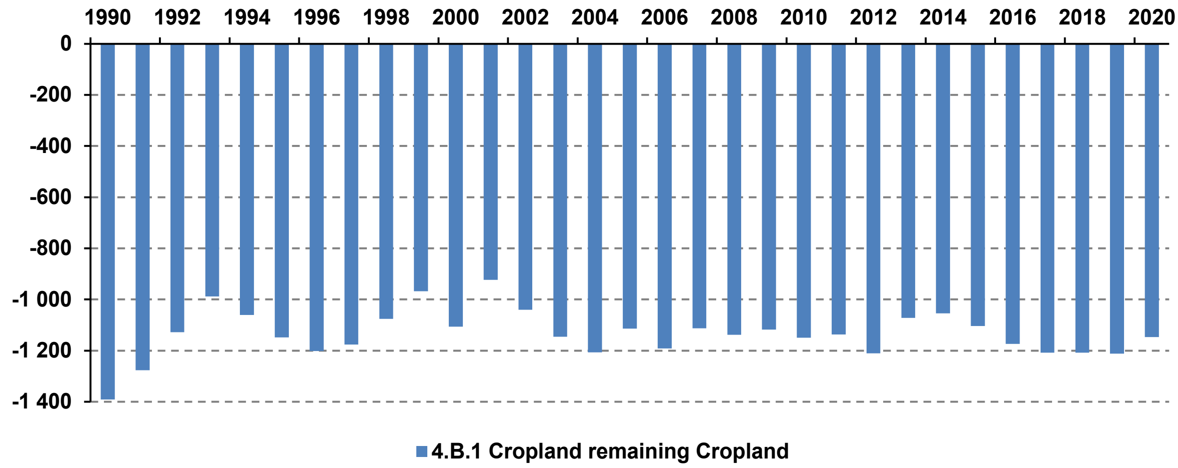
The area of CLP converted to CLA changed from 1.435 kha to 5.418 kha from 1990 to 2020. According to the Equation 2.25 of the 2006 IPCC GL, annual rates of carbon stock change are estimated as the difference in stock at two points in time divided by the time dependence of the stock change factors. Annual change in carbon stock of mineral soils in CLP converted to CLA = ΔSOC_{20} * conversion area for a transition period of 20 years

$\Delta SOC = (SOC_0 – SOC_{0-T})/20 = -0.3215$ 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 (5.418 kha), the ΔSOC_{20} represented -1.74 kt C. ***Figure 6.18*** shows the net CO_2 removals in the category 4.B.1 Cropland remaining Cropland.

Figure 6.18: *Summary results of CO_2 removals (Gg) in CL-CL subcategory in 1990 – 2020*



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.

6.7.2.1 Methodological issues – methods, activity data, emission factors and parameters

Carbon stock changes in biomass were calculated using tier 1 and tier 2 methods (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, $BCEF_R$ (0.602 for conifers and 0.770 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 6.6.3.1** 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 6.6.3.1**). 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

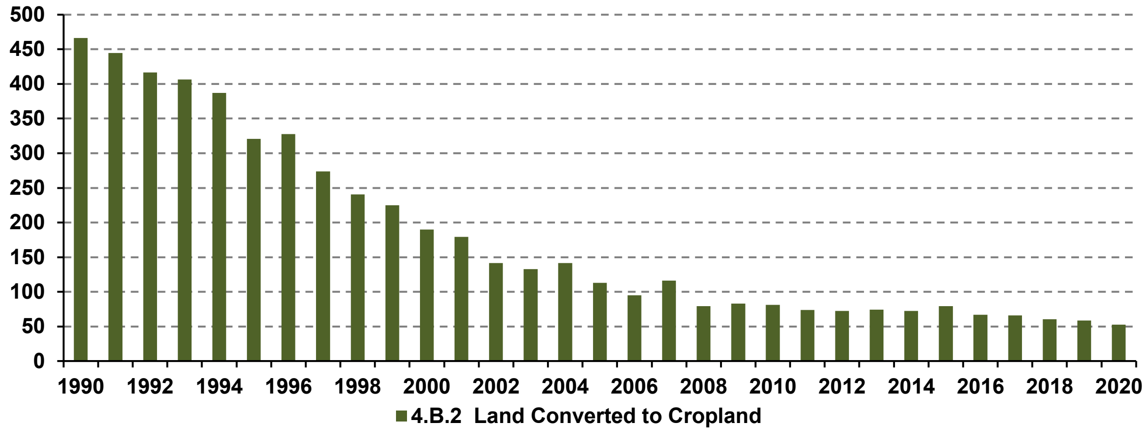
The change in soil carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category associated with Land converted to Cropland. The land-use matrix from 2000 to 2020 is provided in ***Table 6.12***. The results for the subcategory Land converted to Cropland are summarized in ***Table 6.15***, summary of CO_2 emissions are showed in ***Figure 6.19***.

Table 6.15: *Result for the Land converted to Cropland subcategory in 2020*

LAND USE CATEGORY	CARBON STOCK CHANGE IN LIVING BIOMASS *Gg C*			NET CARBON STOCK CHANGE IN DOM	NET CARBON STOCK CHANGE IN SOIL	NET CO_2 EMISSIONS/ REMOVALS
	GAINS	*LOSSES*	*NET CHANGE*	*Gg C*		*Gg CO_2*
LAND-CL	**NO**	**-0.45**	**-0.45**	**-0.06**	**-13.81**	**52.50**
FL-CL	NO	-0.41	-0.41	-0.06	-0.31	2.86
GL-CL	NO	-0.04	-0.04	NA	-14.24	52.37
WL-CL	NO	NO	NO	NO	NO	NO
S-CL	NO	NO	NO	NO	NO	NO
OL-CL	NA	NA	NA	NA	0.74	-2.73

The Land converted to Cropland represents net emissions 52.50 Gg of CO_2 in 2020. In 2020, the net carbon stock change in living biomass, DOM and soil from Land converted to Cropland represented losses of -0.45, -0.06 and -13.81 Gg of C respectively.

Figure 6.19: *Summary of CO_2 emissions (in Gg) in L-CL subcategory in 1990 – 2020*



6.8 GRASSLAND (CRF 4.C)

The GHG emissions and removals in this category were obtained by using the IPCC 2006 GL for LULUCF and national data on Grassland and Land converted to Grassland area in 2020. The total area of Grassland represented 850.027 kha in 2020; 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 6.20*** and ***6.21*** show activity data and map of Grassland area in Slovakia.

Figure 6.20: Development of activity data (kha) for 4.C Grassland in the period 1990 – 2020

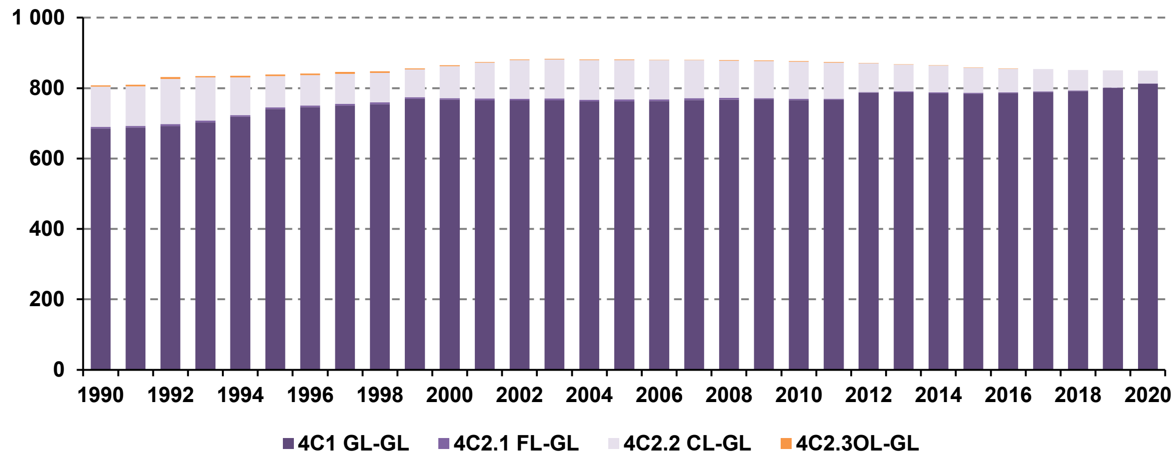
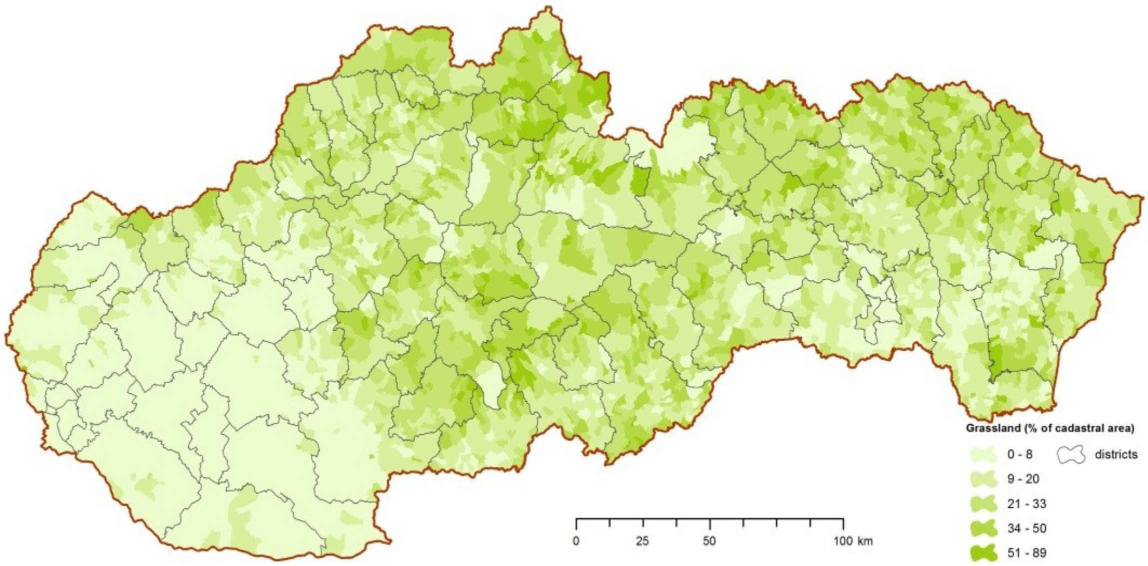


Figure 6.21: Distribution of Grassland in Slovakia – calculated as a spatial share within individual cadastral units



The total area of Grassland remaining Grassland was 811.987 kha in 2020, the changes in Grassland were following: Forest Land converted to Grassland 1.405 kha, Cropland converted to Grassland 36.644 kha, Other Land converted to Grassland "NO" in 2020.

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) 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 categories, disturbance or management regimes within the reporting year. 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. According to the ERT recommendation No L.7 (L.9) from the SVK ARR 2019 (SVK ARR 2017), 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**.

6.8.2.1 Methodological issues – methods, activity data, emission factors and parameters

The annually updated average growing stock volumes, $BCEF_R$ (0.602 for conifers and 0.770 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 6.6.3.1**). 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

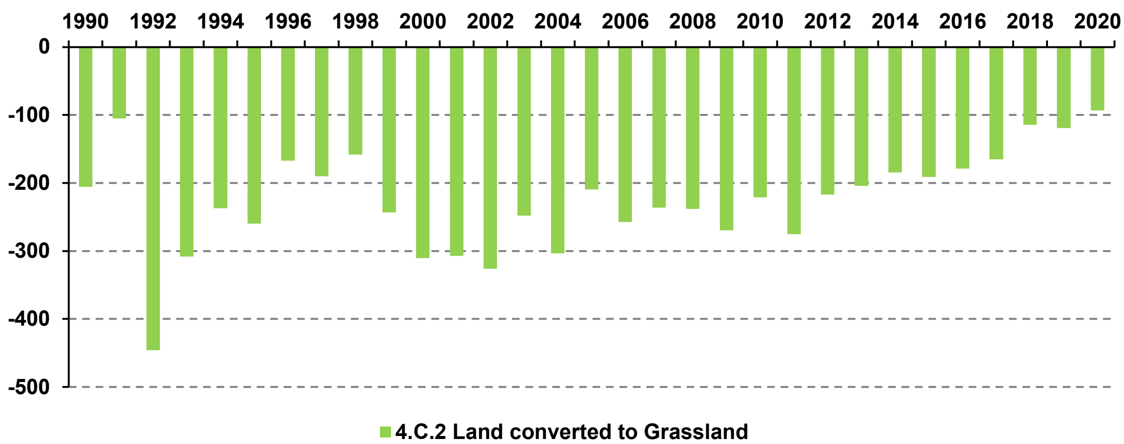
The change in soil carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category associated with Land converted to Grassland. The land-use matrix from 2000 to 2020 is provided in ***Table 6.12***. The results of balance in the Land converted to Grassland subcategory are summarized in ***Table 6.16***.

Table 6.16: *Results for Land converted to Grassland subcategory in 2020*

LAND USE CATEGORY	CARBON STOCK CHANGE IN LIVING BIOMASS *(Gg C)*			NET CARBON STOCK CHANGE IN DOM	NET CARBON STOCK CHANGE IN SOIL	NET CO_2 EMISSIONS/ REMOVALS
	GAINS	*LOSSES*	*NET CHANGE*	*Gg C*		*Gg CO_2*
Land - GL	**0.27**	**-0.92**	**-0.65**	**-0.14**	**26.20**	**-93.17**
FL - GL	NO	-0.92	-0.92	-0.14	-0.99	7.52
CL - GL	0.27	NO	0.27	NO	27.19	-100.69
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 -93.17 Gg CO_2 in 2020. The net carbon stock change in mineral soils for this category represented gains of 26.20 Gg C, but the net carbon stock change in living biomass and DOM from Land converted to Grassland represented the losses of -0.65 and -0.14 Gg C in the reporting year 2020. Summary of CO_2 removals are shown on ***Figure 6.22***.

Figure 6.22: *Summary of CO_2 removals (in Gg) in the L-GL subcategory in 1990 – 2020*



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 239.447 kha in 2020. 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 207.603 kha, the changes in the Settlements were as follows: FL converted to S 0.992 kha, CL converted to S 17.956 kha, GL converted to S 6.924 kha and OL converted to S 5.972 kha in 2020, as described on ***Figures 6.23*** and ***6.24***.

Figure 6.23: *Development of activity data (kha) in the 4.E Settlements in the period 1990 – 2020*

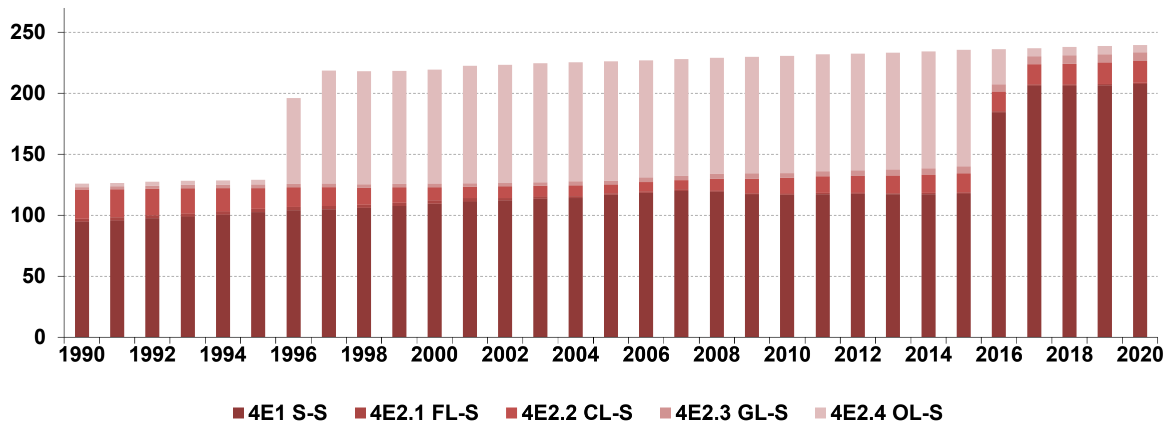
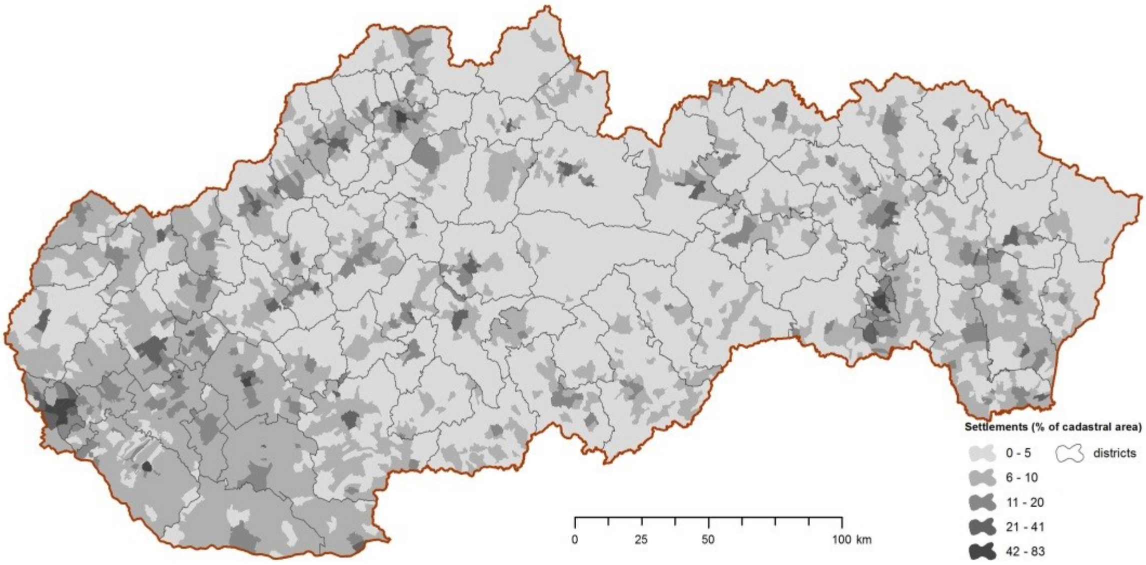


Figure 6.24: Distribution of Settlements in Slovakia – calculated as a spatial share within individual cadastral units



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.

6.10.2.1 Methodological issues – methods, activity data, emission factors and parameters

Tier 1 and tier 2 approaches from the IPCC 2006 GL, Vol. 4 was 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 6.6.3.1** 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

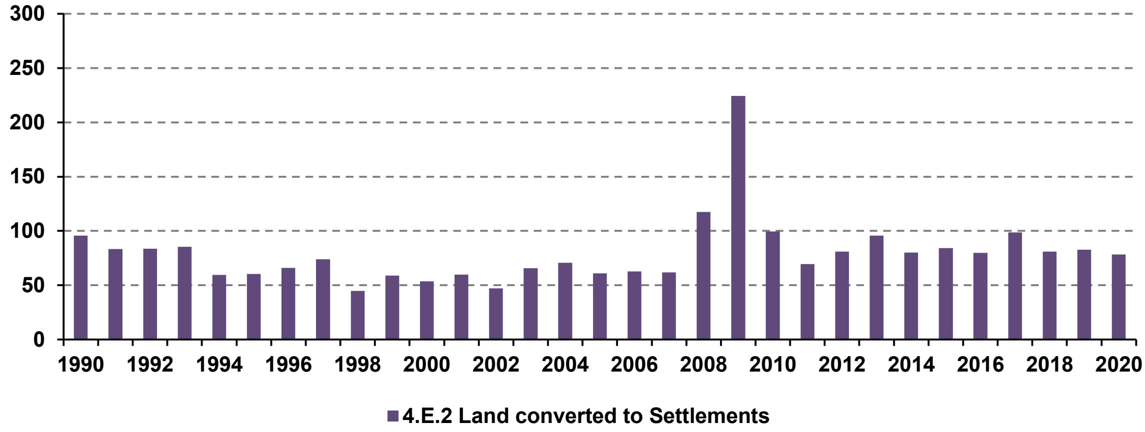
The change in soil carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category associated with Land converted to Settlements. The land-use matrix from 2000 to 2020 is provided in ***Table 6.12***. The results for Land converted to Settlements subcategory are summarized in ***Table 6.17***. Summary of CO_2 removals are shown on ***Figure 6.25***.

Table 6.17: *Results for the subcategory Land converted to Settlements in 2020*

LAND USE CATEGORY	CARBON STOCK CHANGE IN LIVING BIOMASS (Gg C)			NET CARBON STOCK CHANGE IN DOM	NET CARBON STOCK CHANGE IN SOIL	NET CO_2 EMISSIONS/ REMOVALS
	GAINS	*LOSSES*	*NET CHANGE*	*Gg C*		*Gg CO_2*
Land – S	**NO**	**-6.34**	**-6.34**	**-0.37**	**-14.67**	**78.40**
FL – S	NO	-2.34	-2.34	-0.37	-1.74	16.34
CL – S	NO	-3.68	-3.68	NA	-5.62	34.08
GL – S	NO	-0.33	-0.33	NA	-7.30	27.98
WL – S	NO	NO	NO	NO	NO	NO
OL – S	NA	NA	NA	NA	NO	NO

In the reporting year 2020, the total emissions estimated in this category were 78.40 Gg CO_2, the net carbon stock change in living biomass, DOM and soil for this category represented losses of -6.34 Gg C, -0.37 Gg C and -14.67 Gg C respectively.

__Figure 6.25:__ Summary of CO_2 emissions (in Gg) in the subcategory Land-S in 1990 – 2020



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 2020. Total area of Other Land represented 167.196 kha in 2020, 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 130.411 kha, the changes in Other Land were following: FL converted to OL 1.885 kha, CL converted to OL 15.753 kha, GL converted to OL 7.413 kha, S converted to OL 11.734 kha in 2020, as is described on ***Figures 6.26*** and ***6.27***.

__Figure 6.26:__ Development of activity data (kha) for 4.F Other Land in the period 1990 – 2020

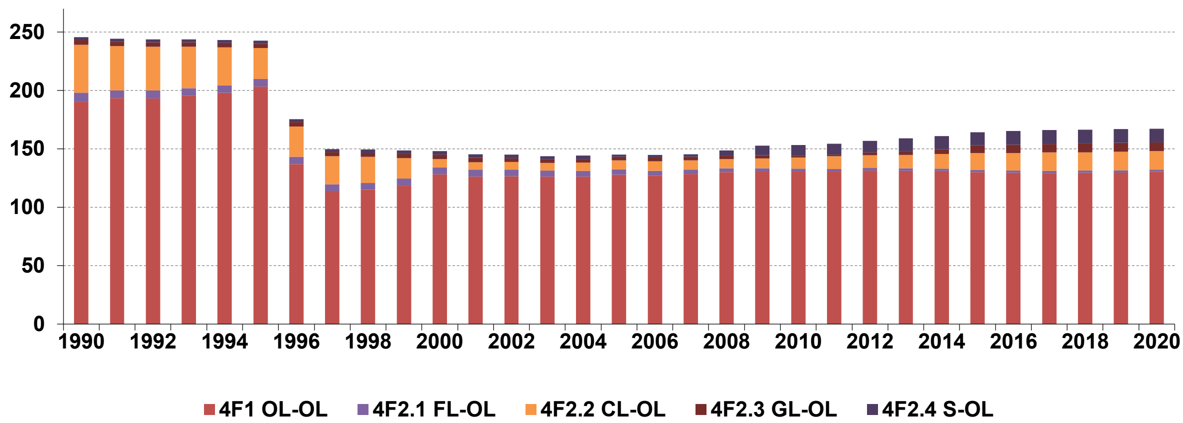
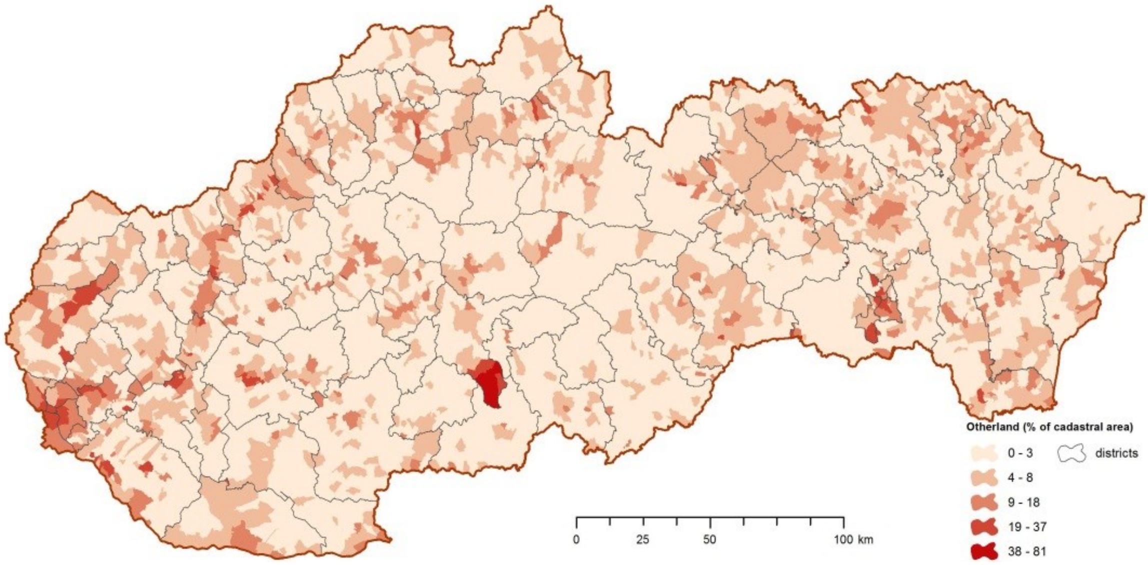


Figure 6.27: Distribution of Other Land in Slovakia – calculated as a spatial share within individual cadastral units



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.

6.11.2.1 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 Mg 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 6.6.3.1** 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

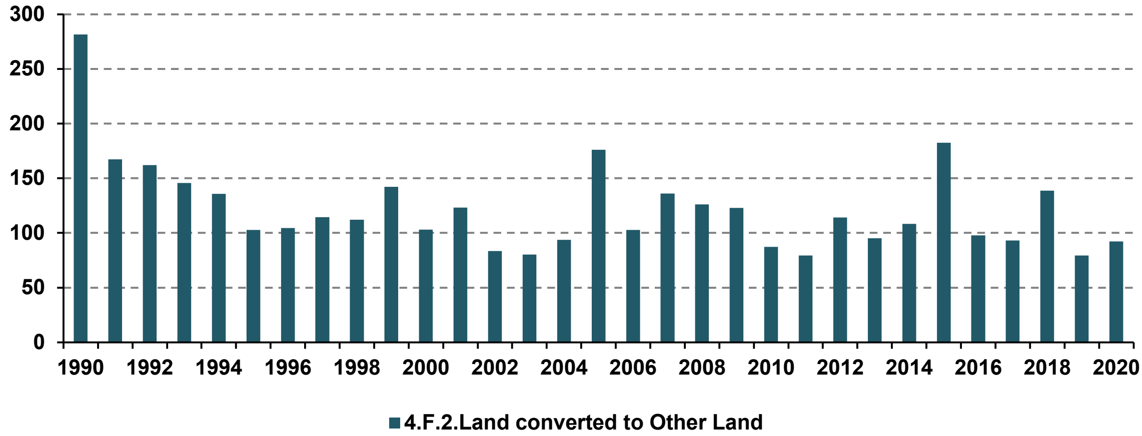
The change in soil carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category associated with Land converted to Other Land. The land-use matrix from 2000 to 2020 is provided in ***Table 6.12***. The results from the subcategory Land converted to Other Land are summarized in ***Table 6.18*** and summary of CO_2 emissions during the years on ***Figure 6.28***.

Table 6.18: *Results for the subcategory Land converted to Other Land in 2020*

LAND USE CATEGORY	CARBON STOCK CHANGE IN LIVING BIOMASS (Gg C)			NET CARBON STOCK CHANGE IN DOM	NET CARBON STOCK CHANGE IN SOIL	NET CO_2 EMISSIONS/ REMOVALS
	GAINS	*LOSSES*	*NET CHANGE*	*Gg C*		*Gg CO_2*
Land - OL	**NO**	**-8.00**	**-8.00**	**-1.08**	**-16.07**	**92.19**
FL – OL	NO	-6.82	-6.82	-1.08	-3.31	41.13
CL – OL	NO	-1.00	-1.00	NA	-4.93	21.73
GL – OL	NO	-0.18	-0.18	NA	-7.82	29.33
WL – OL	NO	NO	NO	NO	NO	NO
S - OL	NO	NO	NA	NO	NO	NO

Total emissions estimated in this category were 92.19 Gg CO_2 in 2020. The net carbon stock change in living biomass, DOM and soil for this category represented losses of -8.00 Gg C, -1.08 Gg C and -16.07 Gg C, respectively.

Figure 6.28: *Summary of CO_2 emissions (Gg) in L-OL subcategory in 1990 – 2020*



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 6.19***.

Table 6.19: *Results for 4(III) – Direct N_2O emissions from N mineralization/immobilization in 2020*

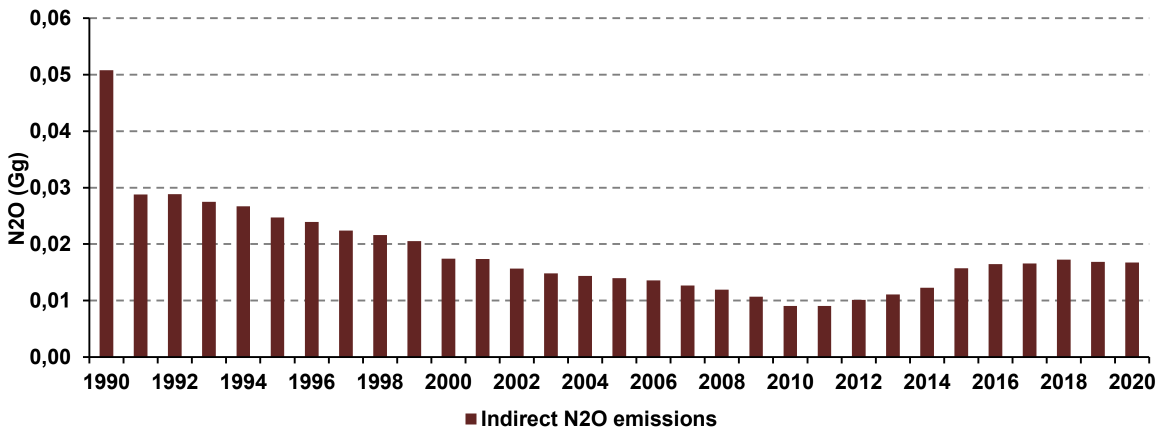
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA	IMPLIED EMISSION FACTORS	EMISSIONS
CATEGORY	Land area converted	N_2O–N emissions per area converted	N_2O
	kha	*kg N_2O–N/ha*	*Gg*
Total all land-use categories	165.74	0.27	0.07
A. Forest land	NO	NO	NO
1. Forest land remaining forest land	NO	NO	NO
2. Lands converted to forest land	NO	NO	NO
B. Cropland	19.41	1.23	0.04
2. Lands converted to cropland	19.41	1.23	0.04
C. Grasslands	1.41	0.47	0.00
1. Grasslands remaining grasslands	NO	NO	NO
2. Lands converted to grasslands	1.41	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	25.87	0.38	0.02
1. Settlements remaining settlements	NO	NO	NO
2. Lands converted to settlements	25.87	0.38	0.02
F. Other land	25.05	0.43	0.02

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 6.29***. Indirect N_2O emissions from Nitrogen Leaching and Run-off represented 0.02 kt in 2020.

Figure 6.29: *Summary of indirect N_2O emissions (in Gg) from managed soils in 1990 – 2020*



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 service life within the country define HWP as the 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 2016 GL: 35 years for sawn wood, 25 years for wood-based panels and 2 years for paper products were used.

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 6.20***.

Table 6.20: *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.

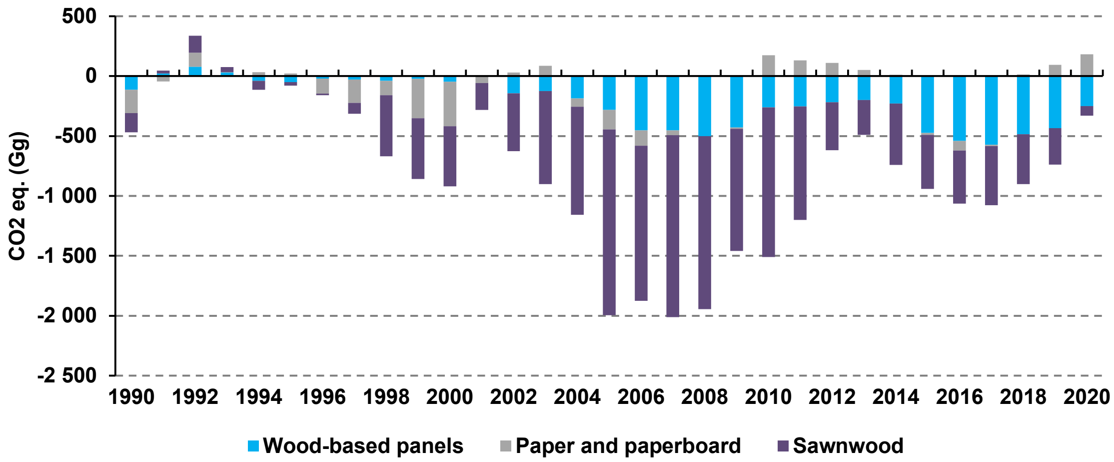
The results of CO_2 gains and losses from domestically produced and used HWP are provided in ***Table 6.21*** and on ***Figure 6.30***.

Table 6.21: *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**	**2014**
	NET EMISSIONS/REMOVALS in Gg of CO_2 eq.					
4.G (UNFCCC)	**-470.4**	**-58.8**	**-920.1**	**-1 996.5**	**-1 334.5**	**-728.4**
gains sawn wood	644.3	528.7	1 027.0	2 144.2	1 972.9	1 287.9
gains wood panels	381.9	327.9	330.0	582.4	619.5	611.2
gains paper	606.8	382.8	1 107.8	993.8	710.3	739.9
losses sawn wood	-482.8	-498.8	-526.2	-593.8	-726.0	-775.9
losses wood panels	-268.6	-277.6	-282.0	-299.0	-357.5	-383.0
losses paper	-411.2	-404.2	-736.5	-831.1	-884.6	-751.7

CO_2 EMISSIONS AND REMOVALS FROM HWP	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
	NET EMISSIONS/REMOVALS in Gg of CO_2 eq.					
4.G (UNFCCC)	**-940.7**	**-1 063.6**	**-1 076.9**	**-889.0**	**-644.9**	**-146.9**
gains sawn wood	1 235.6	1 236.3	1 298.0	1 231.2	1 125.0	904.1
gains wood panels	866.0	948.6	994.7	920.9	882.8	708.4
gains paper	770.2	850.2	795.3	770.8	671.4	533.1
losses sawn wood	-785.4	-794.3	-803.5	-812.6	-819.7	-823.6
losses wood panels	-392.7	-406.8	-422.2	-436.9	-449.6	-459.1
losses paper	-752.9	-770.4	-785.3	-784.4	-765.0	-716.2

Figure 6.30: *CO_2 emissions (positive values) and removals (negative values) from HWP in Slovakia in 1990 – 2020 originating from Forest Land*



ANNEX A6.1: LAND-USE MATRIX

***Table A6.1**: Land-use matrixes identifying annual conversions among the LUC for the period 1990 – 2020, 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**
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**
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**
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**
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**
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**
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**
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**
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 unma-naged 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 unma-naged 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**
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**
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**
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 unma-naged 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**
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 unma-naged 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	**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 unmanaged 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 unmanaged 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**
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**	

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 (without dead wood carbon stock, which is included in NIR for the first time). The methodology of calculations of GHG emissions and removals follows the methods described in the **Chapter 6** of this report. If compared to previous submission, analyses of uncertainties of the GHG emissions and removals in the whole LULUCF sector are provided, as well as for following KP activities – Afforestation, Deforestation and Forest Management.

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. The levels of uncertainties are shown in ***Table A6.2.1.*** The number of iterations was set to 100,000.

Results of the Monte Carlo simulations for the main LULUCF categories (including the HWP) and KP activities, as well as for the whole LULUCF sector, are shown in ***Tables A6.2.2*** – ***A6.2.11*** and on ***Figures A6.2.1*** – ***A6.2.10***.

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

LULUCF category	Data / Factor	Data Type (D – default, N – national)	Uncertainty if known (%)
	Annual growth rate of perennial woody biomass	D	75
	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 2022 (without deadwood)	Results of Monte Carlo simulations						
		Average	Median	Standard deviation	2.5%	97.5%	Percentile 2.5	Percentile 97.5
	Gg CO_2 eq.						%	
2013	-6 614.08	-6 667.41	-6 584.84	2 554.09	-11 926.68	-1 920.27	-78.88	71.20
2014	-4 381.37	-4 428.28	-4 332.90	2 549.10	-9 685.90	316.96	-118.73	107.16
2015	-4 707.53	-4 749.03	-4 660.01	2 539.19	-10 003.40	-38.93	-110.64	99.18
2016	-4 504.09	-4 564.18	-4 480.30	2 544.25	-9 803.79	183.23	-114.80	104.01
2017	-4 373.17	-4 416.84	-4 326.22	2 537.47	-9 655.54	289.04	-118.61	106.54
2018	-3 722.02	-3 777.92	-3 689.29	2 573.89	-9 096.22	1 009.00	-140.77	126.71
2019	-4 574.72	-4 617.34	-4 539.62	2 680.00	-10 096.28	429.09	-118.66	109.29
2020	-7 022.89	-7 068.20	-6 977.57	2 561.75	-12 390.33	-2 313.74	-75.30	67.27

Figure A6.2.1: *Probability distribution function for the category 4.A Forest Land in Gg of CO_2 eq.*

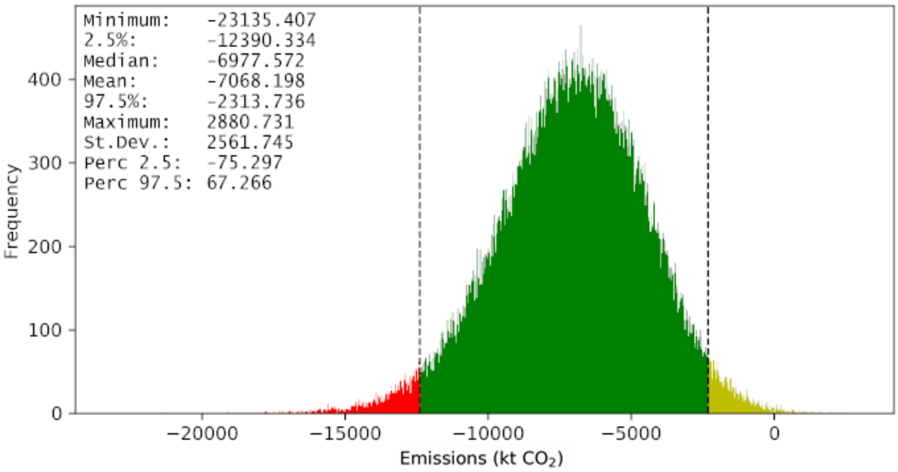


Table A6.2.3. Results of Monte Carlo simulation for category 4.B Cropland (Gg CO_2 eq.)

Year	NIR 2022	Results of Monte Carlo simulations						
		Average	Median	Standard deviation	2.5%	97.5%	Percentile 2.5	Percentile 97.5
	Gg CO_2 eq.						%	
2013	-982.90	-937.96	-937.53	227.09	-1 384.94	-490.76	-47.65	47.68
2014	-966.85	-937.09	-936.67	226.83	-1 383.06	-490.62	-47.59	47.65
2015	-1 009.67	-1 014.41	-10 154.30	226.64	-1 390.04	-488.13	-47.69	47.76
2016	-1 092.79	-1 022.22	-1 022.14	226.44	-1 466.50	-575.91	-43.46	43.66
2017	-1 128.85	-1 053.23	-1 052.98	225.98	-1 497.13	-608.15	-42.15	42.26
2018	-1 134.97	-1 141.69	-1 139.86	380.82	-1 882.37	-409.11	-64.88	64.17
2019	-1 141.04	-1 146.53	-1 145.20	381.19	-1 891.81	-412.13	-65.00	64.05
2020	-1 083.39	-1 087.04	-1 084.51	381.47	-1 829.84	-356.44	-68.33	67.21

Figure A6.2.2: Probability distribution function for the category 4.B Cropland in Gg of CO_2 eq.

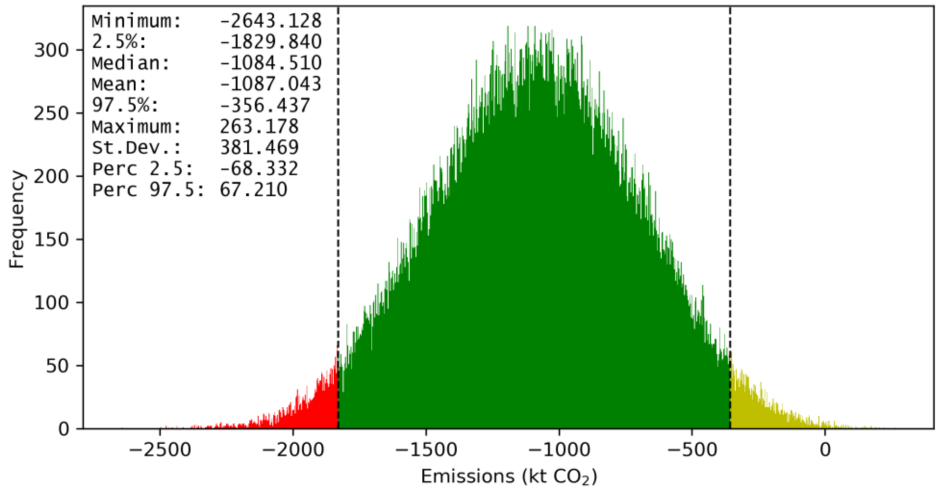


Table A6.2.4. Results of Monte Carlo simulation for category 4.C Grassland (Gg CO_2 eq.)

Year	NIR 2022	Results of Monte Carlo simulations						
		Average	Median	Standard deviation	2.5%	97.5%	Percentile 2.5	Percentile 97.5
	Gg CO_2 eq.						%	
2013	-203.70	-203.32	-203.18	79.90	-361.37	-46.49	-77.74	77.13
2014	-183.84	-183.85	-183.72	79.06	-339.84	-28.63	-84.85	84.43
2015	-190.63	-190.24	-190.09	73.91	-336.24	-44.90	-76.75	76.40
2016	-178.38	-178.02	-177.92	69.93	-316.09	-40.43	-77.56	77.29
2017	-164.84	-164.54	-164.43	65.47	-293.76	-35.66	-78.53	78.33
2018	-114.11	-114.68	-114.50	60.80	-234.48	4.77	-104.46	104.16
2019	-118.71	-119.26	-119.28	50.39	-218.72	-19.42	-83.40	83.72
2020	-92.86	-92.80	-92.74	38.09	-167.88	-17.68	-80.90	80.95

Figure A6.2.3: *Probability distribution function for the category 4.C Grassland in Gg of CO_2 eq.*

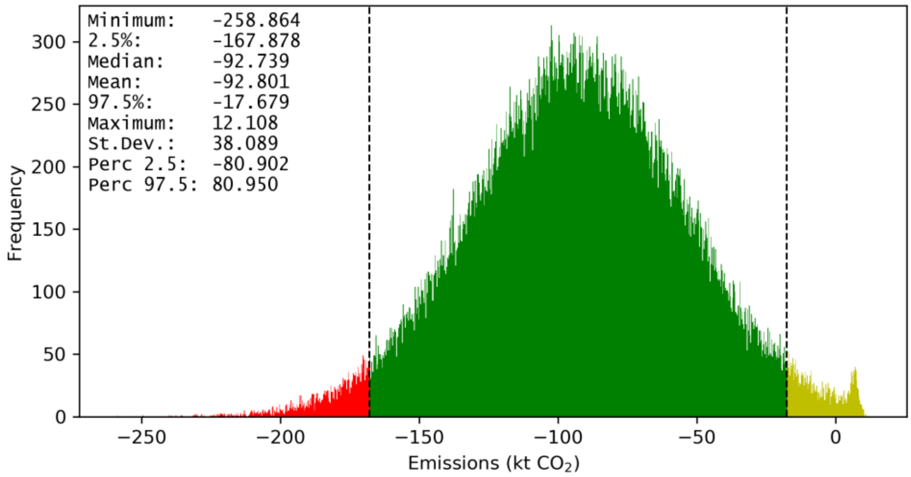


Table A6.2.5. *Results of Monte Carlo simulation for category 4.E Settlements (Gg CO_2 eq.)*

Year	NIR 2022	Results of Monte Carlo simulations						
		Average	Median	Standard deviation	2.5%	97.5%	Percentile 2.5	Percentile 97.5
	Gg CO_2 eq.						*%*	
2013	99.32	99.09	99.09	11.11	77.49	120.96	-21.80	22.07
2014	83.77	83.52	83.52	11.65	60.86	106.45	-27.13	27.46
2015	88.02	87.76	87.75	12.10	64.11	111.64	-26.95	27.21
2016	83.93	83.89	83.88	12.58	59.38	108.66	-29.22	29.52
2017	102.91	102.41	102.40	13.54	76.03	129.02	-25.75	25.99
2018	85.36	85.29	85.28	14.08	57.83	113.00	-32.19	32.50
2019	87.48	87.20	87.16	14.38	59.17	115.55	-32.14	32.52
2020	82.98	83.00	82.92	14.25	55.29	111.09	-33.39	33.83

Figure A6.2.4: *Probability distribution function for the category 4.E Settlements in Gg of CO_2 eq.*

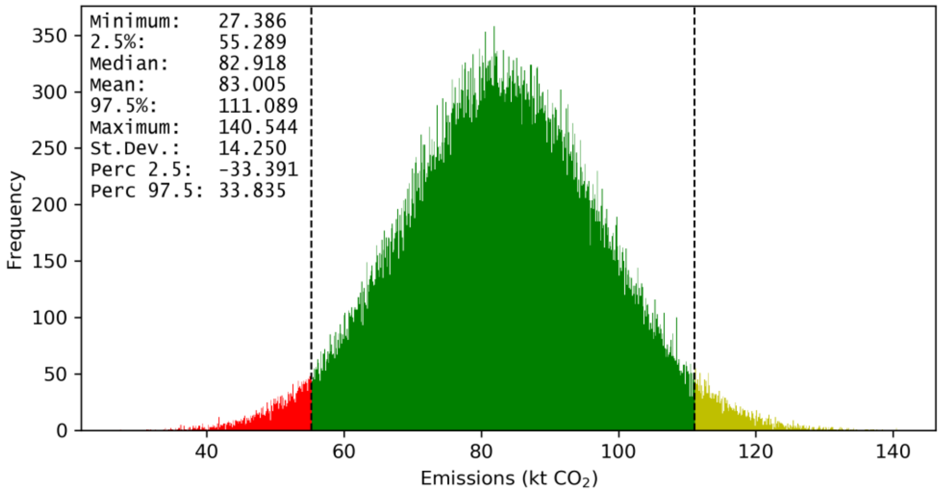


Table A6.2.6. Results of Monte Carlo simulation for category 4.F Other Land (Gg CO_2 eq.)

Year	NIR 2022	Results of Monte Carlo simulations						
		Average	Median	Standard deviation	2.5%	97.5%	Percentile 2.5	Percentile 97.5
	Gg CO_2 eq.						%	
2013	98.46	98.03	98.02	9.66	79.10	117.09	-19.31	19.45
2014	111.83	111.28	111.26	10.81	90.16	132.59	-18.98	19.15
2015	187.14	186.35	186.31	14.79	157.27	215.55	-15.61	15.67
2016	102.61	102.20	102.15	14.65	73.59	130.90	-28.00	28.09
2017	98.18	97.58	97.56	14.81	68.65	126.65	-29.65	29.79
2018	143.88	142.47	142.43	16.30	110.78	174.70	-22.25	22.62
2019	84.55	84.17	84.11	15.03	54.91	113.77	-34.76	35.18
2020	97.21	97.27	97.27	15.14	67.56	126.89	-30.55	30.44

Figure A6.2.5: Probability distribution function for the category 4.F Other Land in Gg of CO_2 eq.

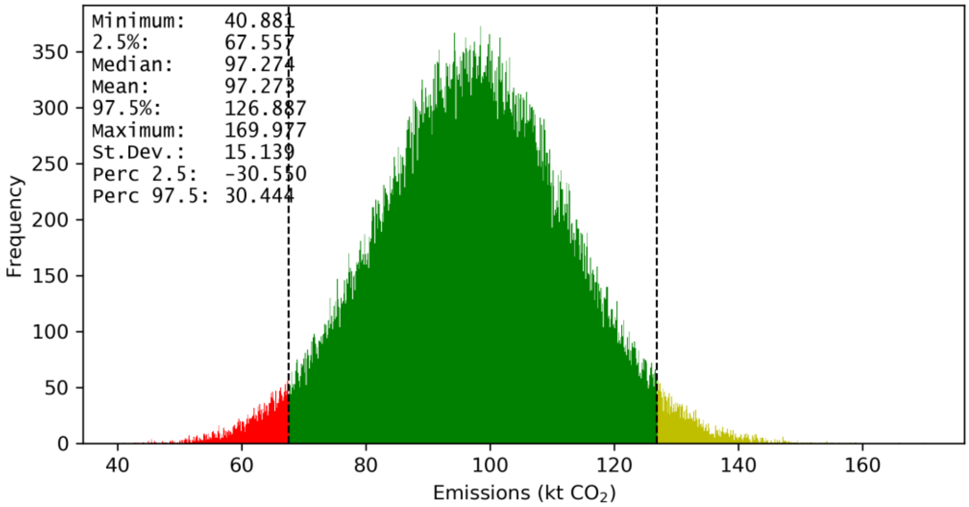


Table A6.2.7. Results of Monte Carlo simulation for category 4.G HWP (Gg CO_2 eq.)

Year	NIR 2022	Results of Monte Carlo simulations						
		Average	Median	Standard deviation	2.5%	97.5%	Percentile 2.5	Percentile 97.5
	Gg CO_2 eq.						%	
2013	-440.42	-303.48	-366.44	435.42	-860.04	608.70	-183.39	300.57
2014	-728.40	-625.72	-674.48	352.26	-1 125.72	166.54	-79.91	126.62
2015	-940.70	-854.92	-900.96	327.88	-1 329.77	-101.95	-55.54	88.08
2016	-1 063.66	-986.15	-1 030.04	314.58	-1 446.68	-252.82	-46.70	74.36
2017	-1 077.04	-1 004.25	-1 046.89	305.06	-1 460.27	-291.56	-45.41	70.97
2018	-889.19	-820.87	-861.42	294.13	-1 263.69	-126.88	-53.95	84.54
2019	-644.91	-491.51	-562.60	627.45	-1 098.55	474.55	-123.50	196.55
2020	-146.86	1.36	-64.48	479.22	-587.08	959.12	-43 336.5	70 536.12

Figure A6.2.6: *Probability distribution function for the category 4.G HWP in Gg of CO_2 eq.*

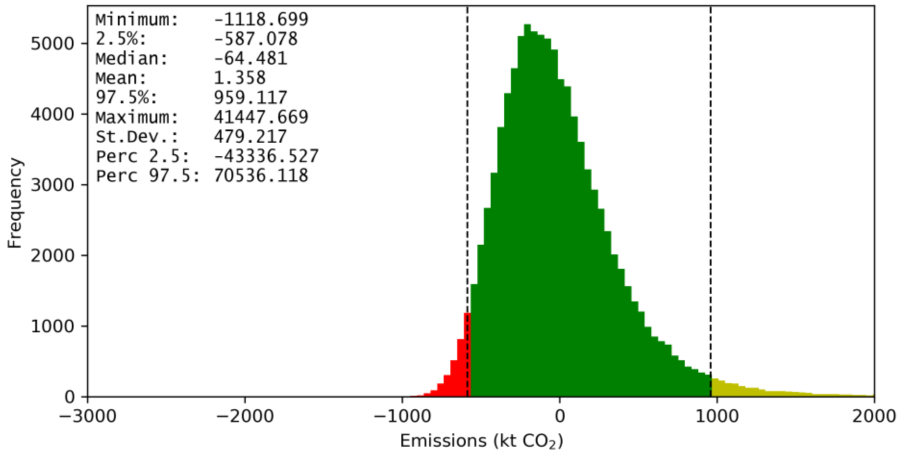
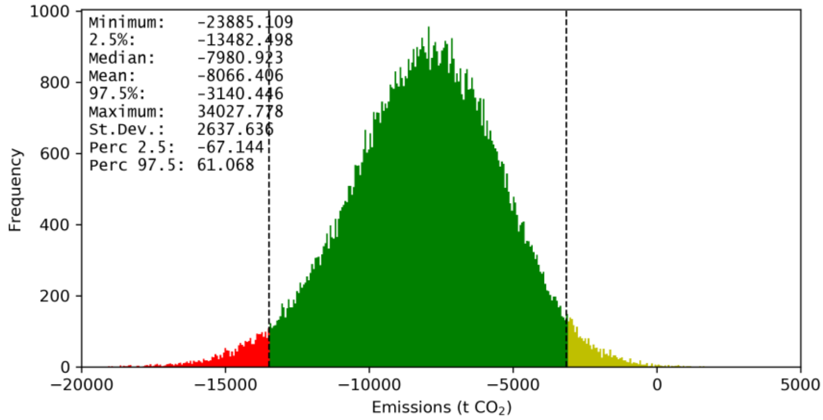


Table A6.2.8. *Results of Monte Carlo simulation for LULUCF sector (Gg CO_2 eq.)*

Year	NIR 2022 (without deadwood)	Results of Monte Carlo simulations						
		Average	Median	Standard deviation	2.5%	97.5%	Percentile 2.5	Percentile 97.5
	Gg CO_2 eq.						*%*	
2013	-8 040.03	-7 915.05	-7 835.49	2 602.97	-13 246.43	-3 080.70	-67.36	61.08
2014	-6 061.20	-5 980.15	-5 897.13	2 585.11	-11 316.12	-1 139.06	-89.23	80.95
2015	-6 568.67	-6 454.49	-6 369.06	2 574.10	-11 762.72	-1 671.83	-82.24	74.10
2016	-6 647.48	-6 564.48	-6 483.32	2 574.90	-11 875.33	-1 754.25	-80.90	73.28
2017	-6 537.86	-6 438.88	-6 346.68	2 568.05	-11 729.69	-1 659.40	-82.17	74.23
2018	-5 625.90	-5 627.39	-5 545.09	2 622.92	-11 035.80	-723.77	-96.11	87.14
2019	-6 302.33	-6 203.28	-6 132.01	2 777.68	-11 822.88	-1 004.27	-90.59	83.81
2020	-8 160.82	-8 066.41	-7 980.92	2 637.64	-13 482.50	-3 140.45	-67.14	61.07

Figure A6.2.7: *Probability distribution function for LULUCF sector in Gg of CO_2 eq.*



KP ACTIVITIES

Table A6.2.9. Results of Monte Carlo simulation for activity KP. A.1 Afforestation (Gg CO_2 eq.)

Year	NIR 2022	Results of Monte Carlo simulations						
		Average	Median	Standard deviation	2.5%	97.5%	Percentile 2.5	Percentile 97.5
	Gg CO_2 eq.						%	
2013	-454.30	-443.26	-443.23	22.58	-487.63	-398.84	-10.01	10.20
2014	-474.49	-462.89	-462.89	23.72	-509.55	-416.22	-10.08	10.80
2015	-509.65	-497.13	-497.13	25.61	-547.48	-446.76	-10.13	10.13
2016	-536.47	-523.22	-523.22	26.91	-576.48	-469.90	-10.18	10.19
2017	-557.71	-543.89	-543.88	28.29	-599.49	-488.24	-10.22	10.23
2018	-579.55	-565.17	-565.16	29.44	-623.01	-507.26	-10.24	10.25
2019	-591.12	-576.39	-576.37	30.14	-635.62	-517.13	-10.28	10.28
2020	-600.42	-585.44	-585.43	30.65	-645.69	-525.17	-10.29	10.30

Figure A6.2.8: Probability distribution function for activity KP. A.1 Afforestation in Gg of CO_2 eq.

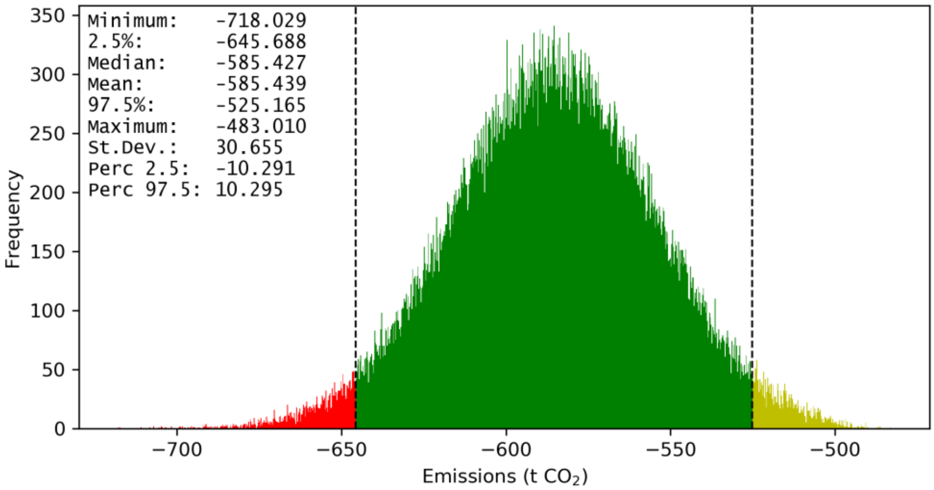


Table A6.2.10. Results of Monte Carlo simulation for activity KP. A.2 Deforestation (Gg CO_2 eq.)

Year	NIR 2022	Results of Monte Carlo simulations						
		Average	Median	Standard deviation	2.5%	97.5%	Percentile 2.5	Percentile 97.5
	Gg CO_2 eq.						%	
2013	42.87	42.01	41.91	3.88	34.74	49.91	-17.31	18.80
2014	62.63	61.25	61.02	6.11	49.89	73.82	-18.55	20.53
2015	60.53	59.27	59.10	5.78	48.48	71.15	-18.20	20.04
2016	28.28	27.69	27.61	2.61	22.84	33.00	-17.51	19.17
2017	56.20	54.96	54.82	5.50	45.50	65.26	-17.22	18.73
2018	111.57	109.08	108.78	10.29	89.76	130.16	-17.71	19.32
2019	39.24	38.29	38.18	3.66	31.45	45.78	-17.87	19.54
2020	45.16	45.22	45.09	4.23	37.29	53.92	-17.53	19.25

Figure A6.2.9: Probability distribution function for activity KP. A.2 Deforestation in Gg of CO_2 eq.

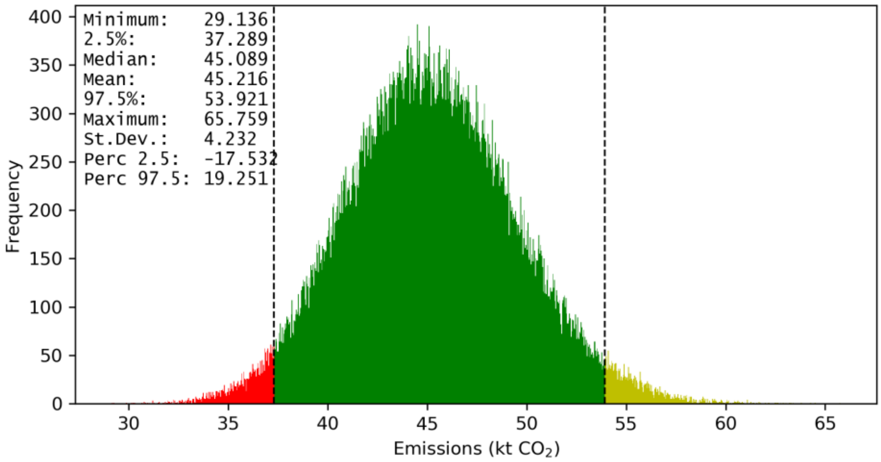
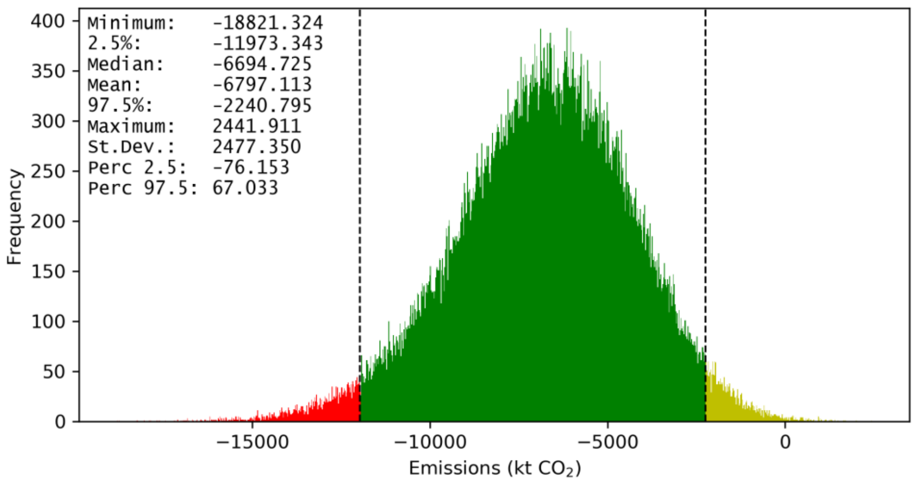


Table A6.2.11. Results of Monte Carlo simulation for activity KP. B Forest Management (Gg CO_2 eq.)

Year	NIR 2022 (without deadwood)	Results of Monte Carlo simulations						
		Average	Median	Standard deviation	2.5%	97.5%	Percentile 2.5	Percentile 97.5
	Gg CO_2 eq.						%	
2013	-6 750.43	-6 666.08	-6 585.69	2 575.07	-11 942.45	-1 853.46	-79.15	72.20
2014	-4 796.72	-4 725.09	-4 626.66	2 579.83	-10 042.17	65.77	-112.53	101.39
2015	-5 345.35	-5 279.24	-5 186.46	2 551.82	-10 533.76	-520.06	-99.53	90.15
2016	-5 167.17	-5 111.03	-5 025.53	2 549.89	-10 398.06	-355.32	-103.44	93.05
2017	-5 105.38	-5 052.25	-4 954.77	2 566.22	-10 344.83	-278.25	-104.76	94.49
2018	-4 287.25	-4 234.81	-4 133.73	2 601.68	-9 613.37	580.42	-127.01	113.71
2019	-4 891.84	-4 829.24	-4 736.72	2 564.40	-10 157.05	-41.93	-110.32	99.13
2020	-6 841.02	-6 797.11	-6 694.72	2 477.35	-11 973.34	-2 240.79	-76.15	67.03

Figure A6.2.10: Probability distribution function for activity KP. B Forest Management in Gg of CO_2 eq.



CHAPTER 7: WASTE (CRF 5)

This Chapter was prepared by the sectoral experts and institutions involved in the National Inventory System of the Slovak Republic (NIS SR):

INSTITUTE	CHAPTER	SECTORAL EXPERT
Geosofting, s.r.o.	**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 2020 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).

Total emissions from the **Waste sector** are relatively stable over the entire period 1990 – 2020 as is shown on ***Figure 7.1***. Total aggregated emissions from the **Waste sector** were 1 684.65 Gg of CO_2 eq. in 2020 and they increased by 1% compared to the previous year, due to an increase of the amount of composting waste responsible for slight increase in methane and N_2O emissions. Compared to the reference year 1990, total GHG emissions increased by 20%. The increase of emissions in biological treatment was compensated by the decrease of emissions from SWDS. 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 – 2020. Emissions from industrial landfilled waste (ISW) have been steadily declining since 2008 (-16%). The growth of emissions from municipal landfilled waste (MSW) slowed down after 2011 and there was already a decrease of the second year in time series (albeit minimal) in 2020. New methane emissions from landfilled waste in 2020 are slightly lower than in 2019 by -1.0%.

Emissions from biological treatment (5.B) do not vary significantly, but there is an increase in the last years (2011 – 2020) due to increasing amounts of waste sent for composting.

Emissions from waste incineration without energy recovery (5.C) were recalculated due to reconsideration of the source of activity data. 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 decreasing due to the modernisation of wastewater treatment plants.

Figure 7.1: *Waste sector emissions (Gg of CO_2 eq.) by trends 1990 – 2020*

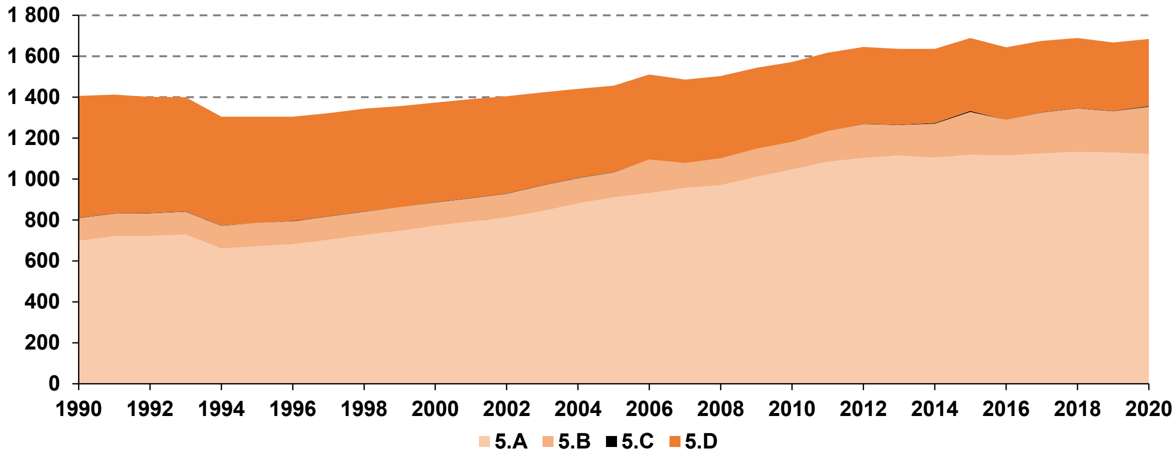
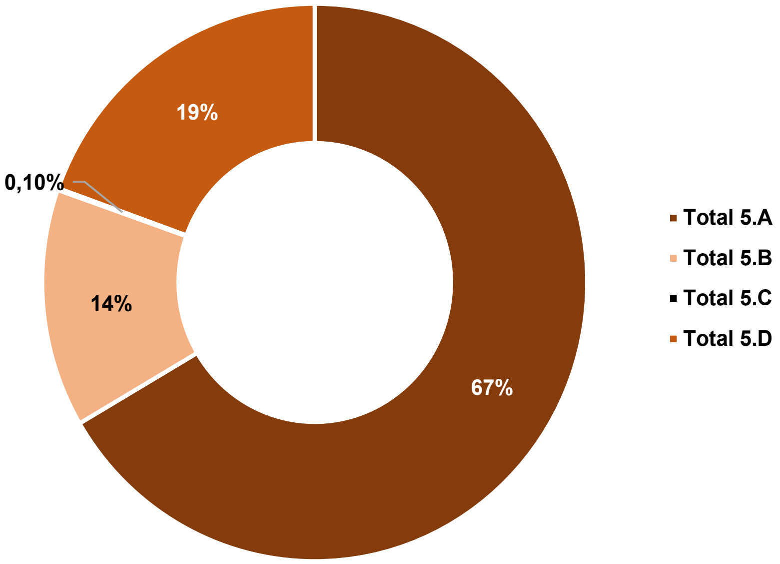


Figure 7.2 bellow shows that the most important source of GHG emissions is solid waste disposal (67%), followed by wastewater treatment (19%), biological treatment (14%) and incineration of waste without energy recovery (0.1%). The **Waste sector** contributed 4.55% to total GHG emissions in 2020.

Figure 7.2: *The share of categories in waste sector in 2020*

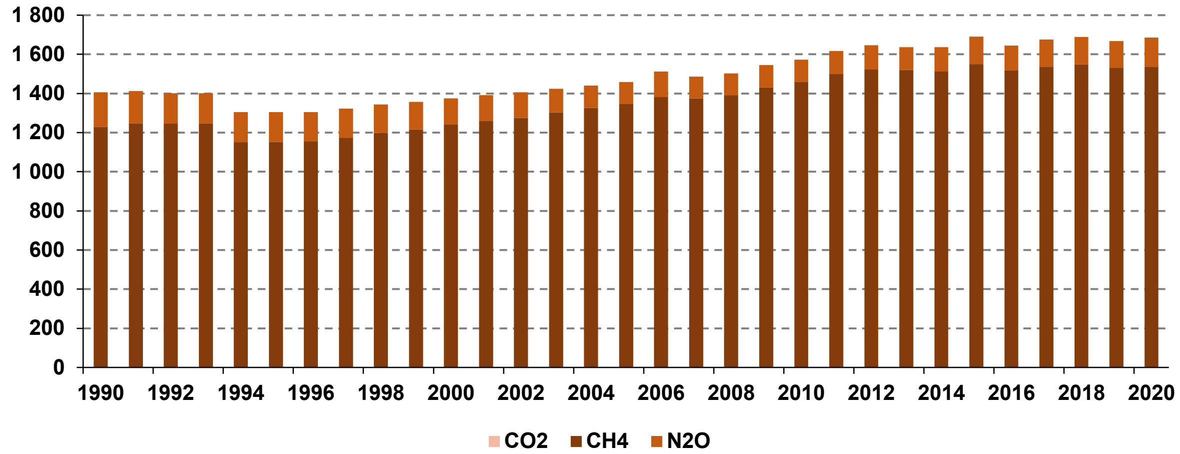


The majority of GHG emissions from the **Waste sector** are in form of CH_4 with 91.4% share followed by 8.6% of N_2O and 0.04% of CO_2 as shows in ***Table 7.1*** and on ***Figure 7.3***.

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			*Gg of CO_2 eq.*				
1990	1.01	49.16	0.59	1 406.35	698.02	111.33	1.39	595.61
1995	1.00	46.08	0.51	1 304.78	671.31	113.98	1.38	518.11
2000	1.08	49.62	0.45	1 374.46	772.57	114.13	1.50	486.26
2005	0.80	53.78	0.38	1 457.54	911.79	121.32	1.11	423.32
2010	0.47	58.39	0.38	1 572.40	1 046.62	135.02	0.65	390.11
2011	0.46	59.94	0.40	1 617.27	1 084.24	150.53	0.64	381.86
2012	0.59	60.89	0.41	1 646.31	1 103.87	165.59	1.19	375.66
2013	0.77	60.79	0.39	1 635.89	1 116.49	148.14	1.65	369.61
2014	1.23	60.50	0.41	1 636.01	1 105.31	165.41	3.29	362.00
2015	1.36	61.93	0.47	1 690.10	1 119.42	209.63	3.74	357.30
2016	0.35	60.71	0.42	1 643.80	1 115.98	173.66	0.55	353.62
2017	0.37	61.48	0.46	1 674.94	1 125.24	200.83	0.52	348.35
2018	0.61	61.87	0.48	1 689.23	1 132.73	213.47	1.24	341.79
2019	0.69	61.26	0.45	1 667.33	1 129.44	201.97	1.57	334.36
2020	0.71	61.43	0.50	1 684.65	1 121.42	232.88	1.70	328.66

Figure 7.3: *Trend in aggregated emissions by gases within the waste in 1990 – 2020 (Gg of CO_2 eq.)*



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 2020*

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.
			CS emission factors not available.
5.C Incineration and Open Burning	CH_4, N_2O	T2/CS, D	Plant specific data not available.
			CS data on waste available.

EMISSION CATEGORY	GAS/TIER USED		NOTE (RESPONSES TO DECISION TREE)
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 2020, 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 2020*

CATEGORY	TOTAL WASTE	RECOVERY, REUSE					DISPOSAL			STORA -GE
		A	B	C	D	E	F	G	H	
	t	%								
SR Total	**12 407 669**	**16.6%**	**3.6%**	**8.8%**	**5.4%**	**5.3%**	**23.1%**	**0.8%**	**2.9%**	**33.7%**
01 Wastes resulting from exploration, mining, quarrying, physical and chemical treatment of minerals	**245 954**	29%	0%	0%	3%	0%	27%	0%	0%	42%
02 Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing	**598 607**	42%	5%	23%	0%	1%	1%	0%	9%	19%
03 Wastes from wood processing and the production of panels and furniture, pulp, paper and cardboard	**431 434**	0%	43%	20%	0%	14%	5%	0%	0%	18%
04 Wastes from the leather, fur and textile industries	**7 609**	1%	0%	3%	0%	7%	23%	0%	0%	66%
05 Wastes from petroleum refining, natural gas purification and pyrolytic treatment of coal	**6 084**	0%	2%	0%	0%	5%	11%	13%	12%	57%
06 Wastes from inorganic chemical processes	**3 835**	12%	0%	38%	0%	2%	1%	0%	29%	19%
07 Wastes from organic chemical processes	**54 112**	2%	1%	29%	0%	14%	10%	2%	1%	42%
08 Wastes from the manufacture, formulation, supply and use (MFSU) of coatings (paints, varnishes and vitreous enamels), adhesives, sealants and printing inks	**16 402**	5%	1%	0%	0%	8%	10%	0%	12%	64%
09 Wastes from the photographic industry	**235**	15%	0%	0%	0%	2%	0%	0%	13%	70%
10 Wastes from thermal processes	**1 165 359**	6%	0%	1%	1%	1%	83%	0%	4%	4%

CATEGORY	TOTAL WASTE	RECOVERY, REUSE					DISPOSAL			STORA -GE
		A	B	C	D	E	F	G	H	
	t	%								
11 Wastes from chemical surface treatment and coating of metals and other materials; non-ferrous hydro-metallurgy	**36 813**	20%	0%	4%	0%	6%	3%	0%	31%	35%
12 Wastes from shaping and physical and mechanical surface treatment of metals and plastics	**735 128**	58%	0%	0%	0%	11%	0%	0%	1%	29%
13 Oil wastes and wastes of liquid fuels (except edible oils, 05 and 12)	**35 811**	11%	11%	1%	0%	16%	1%	0%	25%	35%
14 Waste organic solvents, refrigerants and propellants (except 07 and 08)	**2 676**	33%	6%	0%	0%	1%	0%	0%	1%	59%
15 Waste packaging; absorbents, wiping cloths, filter materials and protective clothing not otherwise specified	**415 789**	1%	2%	12%	0%	23%	9%	0%	1%	53%
16 Wastes not otherwise specified in the list	**341 523**	15%	0%	2%	0%	8%	4%	0%	31%	40%
17 Construction and demolition wastes (including excavated soil from contaminated sites)	**4 389 359**	9%	0%	0%	14%	6%	7%	0%	0%	64%
18 Wastes from human or animal health care and/or related research (except kitchen and restaurant wastes not arising from immediate health care)	**13 480**	0%	14%	2%	0%	4%	5%	29%	18%	29%
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	**1 537 733**	16%	6%	22%	2%	6%	16%	0%	7%	25%
20 Municipal waste (household waste and similar commercial, industrial and institutional wastes) including separately collected fractions	**2 369 725**	22%	5%	19%	0%	0%	51%	4%	0%	0%

A=material, B=energy, C=compost, D=backfilling, E=other, F=landfilling, G=incineration, H=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, 2021. 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 – 2020, 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 – 2020) 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 **Chapters 7.5.1.3** and **7.5.2.3**.

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 7.5.1.1**). 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 2006 Guidelines. Because dry matter content is not monitored by the Slovak incinerators, 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 only in January year X-2, therefore the latest inventory year (2020) is estimated as preliminary and the final value for 2019 is updated in this submission. 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 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. Actual decrease in N_2O emissions is due to the decreasing industrial production in this specific field and decreasing volume of generated wastewater (due to increase of pollution payments) as well as for restrictions during COVID-19 measures.

7.3 CATEGORY-SPECIFIC RECALCULATIONS

Due to several recommendations made to the Slovak waste inventory during the latest UNFCCC review 2019, the National Inventory System of the Slovak Republic was strengthen for capacity in the categories SWDS (5.A) and Wastewater (5.D). New sectoral experts started revision of the methodological approaches and used activity data. After analysis, several improvements introduced in this submission led to recalculation or reallocation of data from these categories. This work will be continued and it is expected, that several recalculations will be implemented also in the next inventory.

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 2022, 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 2022 submission*

RECOMME-NDATION NO.	CATEGORY	DESCRIPTION	REFERENCE
1.	5.A.1	Based on the new available data, activity data on ISW landfilling was revised for the years 1990 – 2019.	**Chapter 7.5.1.3**
2.	5.B	The recalculation of activity data and emissions was processed since 1993 due to the implementation of composted sewage sludge from the municipal wastewater treatment plant. The Source of data is the Water Research Institute.	**Chapter 7.6**
3.	5.C.1	Emissions of CO_2, CH_4 and N_2O and for the category Waste Incineration – industrial waste were recalculated in this submission since the base year due to the addition of industrial and sewage sludge incineration into the calculation. Activity data of industrial and sewage sludge incineration without energy recovery were added to the calculation to comply with data from wastewater treatment plants presented in category 5.D.	**Chapter 7.7**
4.	5.D.1	Protein consumption was updated for the year 2018 and 2019 based on new statistical data provided by the ŠÚ SR	**Chapter 7.8**

Ad 1: Based on the new available data, activity data on ISW landfilling was revised for the years 1990 – 2019. Real data on landfilling of ISW for the groups 01-19 from the EWC with the DOC higher than 0 were used. Resulting methane emissions generating from the six groups of ISW (02, 03, 04, 15, 17 and

19) were summarised according to the biodegradable share of Food, Wood, Paper, Textile, C + D waste, Mix_Package and Sludge. Sludge is a common category with both municipal sludge and industrial sludge counted together (***Table 7.5***). More information on recalculations and changes in SWDS categories is described in **Chapter 7.5**.

Table 7.5: *Recalculations and changes in the methane emissions (Gg) caused by recalculations of the activity data in the 5.A.1 category*

YEAR	5.A.1.a		5.A.1.b		TOTAL		
	2021	2022	2021	2022	2021	2022	%
1990	NO	NO	27.921	27.921	27.921	27.921	0.00%
1991	NO	NO	28.748	28.789	28.748	28.789	0.14%
1992	NO	NO	28.799	28.878	28.799	28.878	0.27%
1993	NO	NO	29.079	29.194	29.079	29.194	0.40%
1994	NO	NO	26.321	26.455	26.321	26.455	0.51%
1995	NO	NO	26.686	26.853	26.686	26.853	0.62%
1996	NO	NO	27.023	27.226	27.023	27.226	0.75%
1997	NO	NO	27.863	28.104	27.863	28.104	0.86%
1998	NO	NO	28.756	29.039	28.756	29.039	0.98%
1999	NO	NO	29.557	29.892	29.557	29.892	1.13%
2000	NO	NO	30.505	30.903	30.505	30.903	1.30%
2001	NO	NO	31.236	31.711	31.236	31.711	1.52%
2002	NO	NO	31.947	32.515	31.947	32.515	1.78%
2003	NO	NO	33.103	33.783	33.103	33.783	2.05%
2004	NO	NO	34.416	35.230	34.416	35.230	2.37%
2005	NO	NO	35.496	36.472	35.496	36.472	2.75%
2006	NO	NO	36.372	37.275	36.372	37.275	2.48%
2007	NO	NO	37.416	38.263	37.416	38.263	2.26%
2008	NO	NO	38.079	38.842	38.079	38.842	2.00%
2009	NO	NO	39.584	40.465	39.584	40.465	2.23%
2010	41.081	41.865	NO	NO	41.081	41.865	1.91%
2011	42.704	43.369	NO	NO	42.704	43.369	1.56%
2012	43.539	44.155	NO	NO	43.539	44.155	1.41%
2013	44.102	44.660	NO	NO	44.102	44.660	1.26%
2014	43.734	44.212	NO	NO	43.734	44.212	1.09%
2015	44.361	44.777	NO	NO	44.361	44.777	0.94%
2016	44.284	44.639	NO	NO	44.284	44.639	0.80%
2017	44.666	45.010	NO	NO	44.666	45.010	0.77%
2018	44.991	45.309	NO	NO	44.991	45.309	0.71%
2019	44.887	45.178	NO	NO	44.887	45.178	0.65%

Ad 2: This recalculation is connected with the correction of activity data in sewage sludge and is particularly focused on the utilisation of the sewage sludge produced in the WWTP and then distributed between the landfilling, incineration and composting. Previously, sewage sludge composting was not included in the inventory. ***Table 7.6*** is showing changes led to increase of emissions in this category.

Table 7.6: *Recalculations of the 5.B.1.a category and comparison of the submissions*

YEAR	5.B.1.a - CH_4 emissions			5.B.1.a - N_2O emissions		
	2021	2022	CHANGE	2021	2022	CHANGE
1993	0.086	0.086	-0.19%	0.005	0.005	0.99%
1994	0.076	0.076	0.37%	0.005	0.005	-0.50%
1995	0.142	0.142	-0.11%	0.009	0.009	0.12%
1996	0.126	0.126	-0.29%	0.008	0.008	0.51%
1997	0.155	0.155	0.10%	0.009	0.009	0.10%
1998	0.152	0.152	0.05%	0.009	0.009	0.27%
1999	0.157	0.157	0.23%	0.009	0.009	0.44%
2000	0.145	0.145	0.28%	0.009	0.009	0.28%
2001	0.138	0.138	-0.06%	0.008	0.008	-0.30%
2002	0.157	0.157	0.28%	0.009	0.009	0.49%
2003	0.163	0.384	135.28%	0.010	0.023	134.80%
2004	0.164	0.468	185.32%	0.010	0.028	186.49%
2005	0.180	0.513	184.72%	0.011	0.031	184.72%
2006	0.206	0.600	191.44%	0.012	0.036	190.50%
2007	0.304	0.728	139.31%	0.018	0.044	138.53%
2008	0.321	0.704	119.43%	0.019	0.042	120.11%
2009	0.356	0.826	132.09%	0.021	0.050	132.74%
2010	0.363	0.834	129.83%	0.022	0.050	129.62%
2011	0.399	0.900	125.68%	0.024	0.054	125.12%
2012	0.491	0.956	94.60%	0.030	0.057	94.34%
2013	0.523	0.975	86.48%	0.031	0.059	86.36%
2014	0.580	0.946	63.05%	0.035	0.057	63.05%
2015	0.802	1.149	43.25%	0.048	0.069	43.31%
2016	0.850	1.197	40.81%	0.051	0.072	40.81%
2017	1.269	1.614	27.16%	0.076	0.097	27.06%
2018	1.514	1.844	21.78%	0.091	0.111	21.78%
2019	1.770	2.090	18.06%	0.106	0.125	18.06%

Ad 3: Emissions of all GHG for the category Waste Incineration were recalculated in this submission due to double-counting discovered in the activity data. Therefore, the revision of activity data of waste incinerated without energy recovery was performed. Data from three waste incineration facilities were reported under the **Energy** as well as under the **Waste category**. These activity data are significantly lower than previously reported and in consistency with the data used in air pollutants' inventory. Revised data on GHG emissions and comparison is provided in the ***Table 7.7***. Emissions with energy utilization are reported in the **Energy sector** where revision took place in this submission.

Table 7.7: *Recalculations of the 5.C category and comparison of the submissions*

YEAR	2021	2022	2021	2022	CHANGE
	Biogenic industrial and clinical waste *(Gg of CO_2 eq./year)*		***Non-biogenic industrial and clinical waste*** *(Gg of CO_2 eq./year)*		*%*
1990	11.344	13.554	0.865	1.034	19.49
1991	11.327	13.534	0.864	1.032	19.49
1992	11.299	13.501	0.862	1.029	19.49
1993	11.367	13.582	0.867	1.036	19.49
1994	11.369	13.585	0.867	1.036	19.49
1995	11.226	13.414	0.856	1.023	19.49
1996	11.367	13.582	0.867	1.036	19.49
1997	11.571	13.826	0.882	1.054	19.49

YEAR	2021	2022	2021	2022	CHANGE
	Biogenic industrial and clinical waste (Gg of CO_2 eq./year)		**Non-biogenic industrial and clinical waste** (Gg of CO_2 eq./year)		%
1998	11.092	13.253	0.846	1.011	19.49
1999	11.138	13.308	0.849	1.015	19.49
2000	12.202	14.580	0.930	1.112	19.49
2001	11.863	14.931	0.905	1.139	25.87
2002	17.173	23.448	1.310	1.788	36.54
2003	11.292	14.207	0.861	1.083	25.81
2004	12.078	16.204	0.921	1.236	34.15
2005	8.637	10.788	0.659	0.823	24.91
2006	5.545	10.161	0.423	0.775	83.26
2007	3.264	4.417	0.249	0.337	35.34
2008	2.682	5.334	0.205	0.407	98.88
2009	4.424	5.867	0.337	0.447	32.61
2010	4.403	6.330	0.336	0.483	43.75
2011	4.977	6.254	0.380	0.477	25.66
2012	4.345	8.328	0.331	0.635	91.65
2013	5.169	10.914	0.394	0.832	111.12
2014	4.925	18.040	0.376	1.376	266.28
2015	4.323	20.090	0.330	1.532	364.76
2016	4.272	4.792	0.326	0.365	12.18
2017	5.026	5.026	0.383	0.383	0.00
2018	4.789	8.559	0.365	0.653	78.73
2019	4.463	9.884	0.340	0.754	121.49

Ad 4: New data on protein consumption provided by the Statistical Office of the Slovak Republic for the year 2018 and 2019 led to the recalculation of N_2O emissions and nitrogen in effluents and retention tanks for domestic wastewater. Available data and results are provided in **Chapter 7.8** of this Report. The explanation for protein data being corrected each year is that data on protein consumption are published annually by the ŠÚ SR, however only in January year X-2, therefore the latest inventory year (2020) is estimated as preliminary and the final value for 2019 is updated in this submission.

Table 7.8: *Recalculations and changes in protein consumption and N in effluents and retention tanks for the years 2018 and 2019*

YEAR	2021	2022	CHANGE 2022/2021
	Gg of N_2O		%
2019	0.1581	0.1637	3.54%
Gg of N in effluents and retention tanks			
2018	21.68	21.73	0.23%
2019	20.11	20.84	3.63%

7.4 CATEGORY-SPECIFIC IMPROVEMENTS AND IMPLEMENTATION OF RECOMMENDATIONS

During the inventory preparation and based on the discussion, the recommendation from the latest ESD review 2020 took place:

- Recommendation SK-5A-2020-0003 – Implemented, oxidation factor 0.1 (10%) for CH_4 was used since 1994.

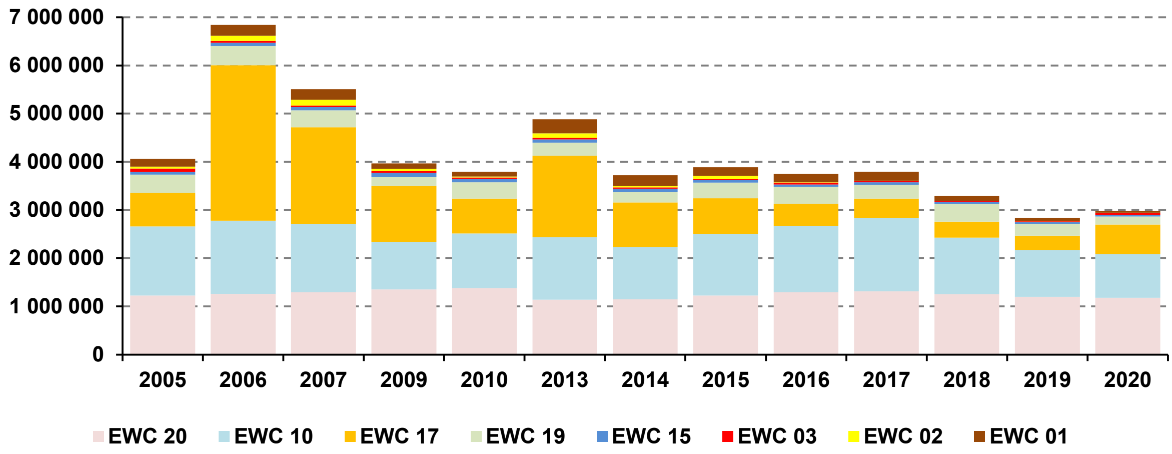
7.5 SOLID WASTE DISPOSAL (CRF 5.A)

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 44.86 Gg (1 121.42 Gg of CO_2 eq.) in 2020 as is shown in ***Table 7.9*** and they are almost on the same level compared to the previous year, however amount of landfilled waste is decreasing. Emissions from solid waste disposal increased in comparison with the base year by 62.25% due to improvement of disposal practices and increase of the amount of disposed waste.

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 7.9***. 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).

Figure 7.4: *Major groups of landfilled solid waste in tons in Slovakia in recent years*



The correlation between municipal waste production and economic grow is described on ***Figure 7.5*** where X-axis is GDP in $ per capita for the years 2005 – 2020. Y-axis depicted total municipal waste production in tons according to the Statistical Office of the Slovak Republic. As it is visible, economic growth after 2004 with the HDP inter-annual increase by 10% led to an increase in MSW production. On the other hand, the recession after 2009 decreased also MSW production resisted until 2013. In recent years, HDP growth on the level of 4-5% correlates with the MSW production with the 8-9% growth (inter-annual). A similar trend is visible also in industrial waste.

Figure 7.5: *Correlation of the MSW production in tons and HFC (Households Final Consumption)*

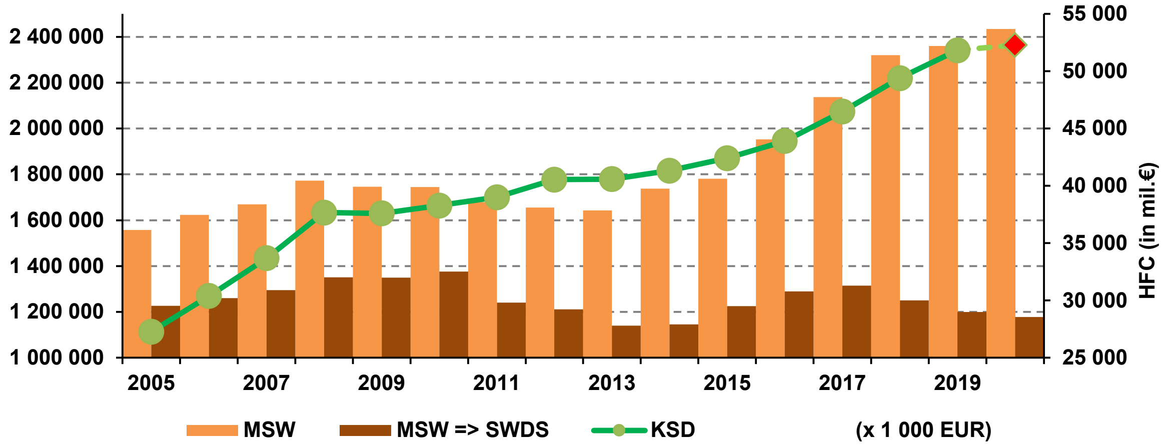


Table 7.9: *Activity data from the total SWDS in Slovakia (MSW + ISW) in particular years*

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%

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. There has been a year-on-year increase in the rate of sorted municipal waste collection (from 37% in 2019 to 40.5% in 2020).

Decreasing trend in landfilling is visible in the last decade, however the total municipal waste production is increasing and represents more than 434 kg/capita/year. Also, the share of MSW ending on landfills is decreasing compared to about 80% in 1995, represents 48.4% in 2020 according to EUROSTAT data (***Figure 7.6***). However, Slovakia is one of the EU Member States with the highest share of landfilling. The share of recycling increased only negligible from 38.1% to 39% between 2018 and 2019. New legislation on this field will be in place since the 2022 (***Figure 7.7***).

Figure 7.6: *Comparison of total MSW generated and landfilled in tons (y-axis)*

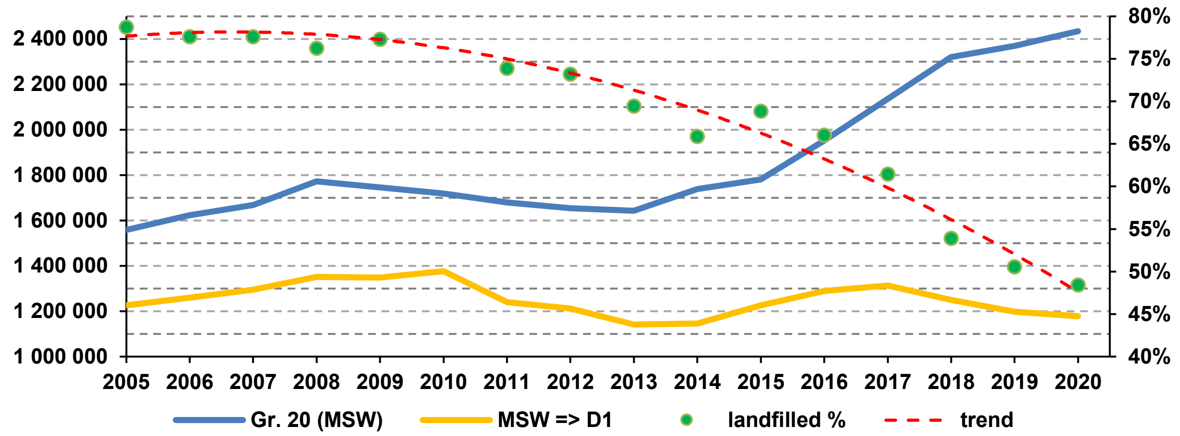
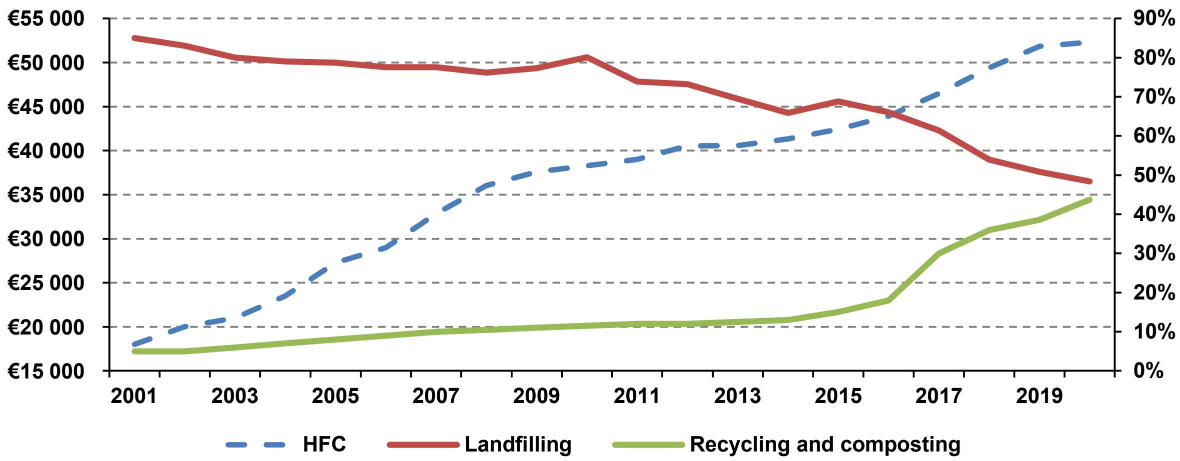


Figure 7.7: *Correlation of the MSW landfilling and recycling/composting with the HFC in tons (y-axis)*



At the time, there are almost 90 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 11 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 in dumps.

The State Geological Institute (Štátny Geologický Ústav Dionýza Štúra (ŠGÚ DŠ)) published inventory of more than 5 000 disposal sites and landfills, which were analysed in order to obtain characteristics of past practices in disposal, with a focus on division of disposal sites according to:

- Depth for identification of MCF;
- Altitude for defining typical MAP/PET;
- Year of closing for identification of transition period towards controlled disposal.

Results of this analysis are presented in **Chapter 7.5.1.1**. 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 in this Chapter are presented as disaggregated to the MSW and ISW (***Table 7.9***).

7.5.1.1 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 7.10***. 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 50%). 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).

Table 7.10: *Development of the DOC in the MSW disposal*

Year	1960	1970	1980	1990	1995	2000	2005	2010	2015	2017	2018-2020
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 7.11***).

Table 7.11: *Development of the Methane Correction Factor (MCF)*

Year	1950	1960	1970	1980	1990	1995	2000	2005	2010	2015	2020
MCF	0.54	0.54	0.54	0.56	0.56	0.61	0.74	0.86	1.0	1.0	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 5.A.1.a since 2011. Increase of methane recovery from landfilling is not expected in the next years due to lowering of subsidies for energy recovery LFG.

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 7.12***).

Table 7.12: *Correction of the LFG calculation based on the ÚRSO data for the years 2011 – 2020*

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

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 stationairy 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 7.13***.

The differences between the "real" data and the calculated values for the years 2016 to 2020 range from 0.8% to 11.4%, which we consider to be 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.

Table 7.13: *Correction of the LFG calculation based on the ÚRSO data for the years 2011 – 2020*

YEARS	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

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 – 2020 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 7.14***. 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 7.14: *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

YEAR	POPULATION	IRW*/HFC**	MSW	MSW/CAP	MSW TO SWDS	MSW TO SWDS
		GDP/capita	kt	kt/capita/year	%	kt
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

IRW = income real wage, since the year 2000 not relevant, HFC = household final consumption (EUR) – only year 2005 – 2020, correlation MSW/HFC = 0.86

7.5.1.2 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 7.15***).

Table 7.15: *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 – 2019
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)

7.5.1.3 Source-specific recalculations

Recalculations in this category are described in **Chapter 7.3** and **Chapter 7.5.2** of this Report. Comparison of recalculated data can be found in ***Table 7.5***.

In Slovakia, there are not sufficiently reliable data on the MSW composition in the exact breakdown into biodegradable components according to the IPCC 2006 methodology (food/wood/paper /textile/garden). The MŽP SR adopted and published a methodology for analysing the types of individual waste streams represented in mixed waste and their quantities in August 2020. Previous analyses of municipal waste in the most cases distinguished only the so-called bio-waste + paper, some also textiles and rarely wood. When analysing the success of separate collection, the surveys focus more on recyclable components (metals, glass, plastics, paper), which, however, does not help to refine the calculation of DOC in accordance with the IPCC 2006 GL methodology.

In the current submission, a recalculation has been carried out for municipal waste for the period 1990 to 2018, taking into account available data on the composition of MSW in the past. The composition of MSW deposited in landfills was retrospectively modelled based on the following data:

- until 1995: based on publication "Zloženie MSW v roku 1995" (in Stratégia obmedzovania ukladania BRO na skládky, table18, MŽP SR X/2010);

- until 2000: based on the 2019 Refinement to the 2006 IPCC GL - Waste default compositions: Eastern Europe - table 2A.2;
- after 2010: based on the published articles according to the average MSW composition in the years 2004 – 2010.[1]

Composition of the MSW in Slovakia is completely different in comparison with the default published by the IPCC 2006 Guidelines data (and also in 2019 IPCC Refinements). The differences occurred in the share of food and garden waste and partly in paper share. Share of wood and textiles is almost identical. Improvements in MSW composition and DOC calculation will be introduced in the next submissions. Corrected calculation and revised data for time series will be verified and published in the next submissions.

7.5.2 NON-MUNICIPAL DISPOSAL SITES (INDUSTRIAL)

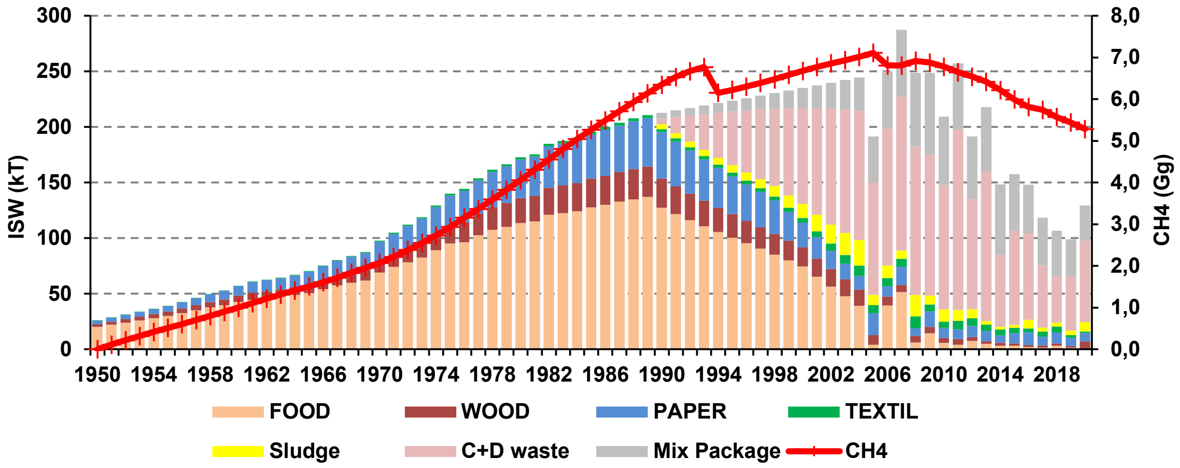
In the past, industrial waste was landfilled together with municipal waste in common landfills. It was not until 1991, when the First Waste Act was passed, that some large industrial companies built their own landfills to store their industrial waste. After 2001 (the Second Waste Act), there are three 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. 90), 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 Ministry of the Environment of the Slovak Republic (IS Odpady) show that there is a change in the composition of landfills for industrial waste. Compared to previous years, the share of food and paper is significantly decreasing. On the contrary, the share of landfilled sludge has been growing since 2005. In terms of weight, however, the most significant landfilled share is mixed Construction and Demolition waste (C + D) and mixed packaging waste (Mix_Package).

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 can be find on ***Figure 7.8***.

[1] see References

Figure 7.8: *ISW production in kt according to the composition and methane emissions*



7.5.2.1 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. New data on sectoral final energy consumption allowed a new analysis of correlation of ISW volume.

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.

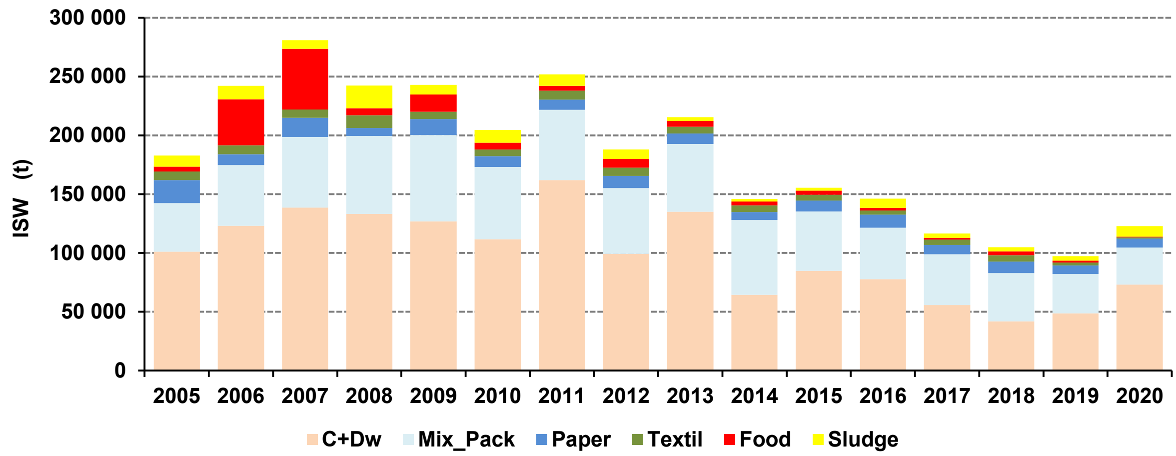
Consistency of time series is ensured by using continuous time series of sectoral growth indicators since 1950. Activity data were completely recalculated in this submission. Time series consistency was maintained by replacing data obtained by waste classification used in 1990 – 2005 using extrapolations 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 $W_i < 0.2\% \Sigma W_i$. 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 proportion was very low (approximately 500 to 1 000 t/y). An overview of individual types of landfilled ISW is provided in ***Table 7.16*** and on ***Figure 7.9***.

Table 7.16: 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

Figure 7.9: An overview of individual types of landfilled ISW in tons in 2005 – 2020



7.5.2.2 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 reached 3% and did not have a significant impact on the estimation.

Periods 1950 – 1990, 1991 – 2004 and 2005 – 2020 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 7.9 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 7.17***).

Table 7.17: *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 – 2019
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
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

7.5.2.3 Source-specific recalculations

Recalculations in this category are described in **Chapter 7.3** and **Table 7.5** of this Report. Based on the new available data, activity data on ISW landfilling was revised for the years 1990 – 2019. Real data on landfilling of ISW for the groups 01-19 from the EWC with the DOC higher than 0 were used. Resulting methane emissions generating from the six groups of ISW (02, 03, 04, 15, 17 and 19) were summarised according to the biodegradable share of Food, Wood, Paper, Textile, C + D waste, Mix_Package and Sludge.

In the previous version, the amount of sludge was based on the data from the ŠÚ SR and represented the amount of landfilled sludge in its natural state (wett). In the revised version reported in this submission, the data from the VÚVH was used, where the amount of landfilled sludge is already converted to dry weight (**Chapter 7.8**). Therefore, it was also necessary to adjust the DOC parameter for sludge. Compared to the original value of DOC = 0.05, the new value was identified by calculating the weighted average of the weight of landfilled municipal and industrial sludge.

The new value DOC is 0.355.

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 7.18*** 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 59 kg per capita of biologically degradable waste was recycled in 2020 in comparison with 2005, representing an increase of more than 100% to the 2005 and an increase by 20% compared to the previous year.

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 7.18: *The overview of municipal and industrial composting in 1990 – 2020*

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	8.000	0.080	0.005	251.600	2.516	0.151
1995	14.184	0.142	0.009	251.600	2.516	0.151
2000	14.540	0.145	0.009	251.600	2.516	0.151
2005	51.250	0.513	0.031	231.660	2.317	0.139
2010	83.428	0.834	0.050	231.416	2.314	0.139
2011	90.047	0.900	0.054	261.020	2.610	0.157
2012	95.550	0.956	0.057	290.624	2.906	0.174
2013	97.529	0.975	0.059	247.940	2.479	0.149
2014	94.568	0.946	0.057	291.244	2.912	0.175
2015	114.885	1.149	0.069	373.996	3.740	0.224
2016	119.687	1.197	0.072	285.304	2.853	0.171
2017	161.364	1.614	0.097	306.952	3.070	0.184
2018	184.405	1.844	0.111	313.424	3.134	0.188
2019	208.966	2.090	0.125	262.039	2.620	0.157
2020	227.301	2.273	0.136	315.775	3.158	0.190

7.6.1 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. Emissions from anaerobic treatment were not estimated. The technology is not occurring in the Slovak Republic.

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 2020. 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.

7.6.2 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 7.19***. The highest uncertainty come from CH_4 and N_2O emission factors.

Table 7.19: *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)

7.6.3 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 sewage sludge from the municipal waste WTP. The Water Research Institute is the source of activity data. In the previous submissions, the municipal sewage sludge used for composting were not considered. Recalculations increased CH_4 and N_2O emissions in this category for time series since the year 1993. In 2020, 36 562 tons of sewage sludge from municipal wastewater treatment plants and 3.893 tons of industrial sludge were composted. The values are consistent with the data in ***Tables 7.27*** and ***7.28*** (**Chapter 7.8**). Sewage sludge applied on agricultural land (soils) is estimated in **Agriculture sector**.

Table 7.20: *Recalculations of the GHG emissions in the category 5.B.1.a*

YEAR	CH_4 EMISSIONS			N_2O EMISSIONS			WASTE TREATED		
	Gg		Change	*Gg*		Change	*kt (dm)*		Change
	2021	2022		2021	2022		2021	2022	
1993	0.086	0.086	99.81%	0.005	0.005	100.99%	8.584	8.584	100.00%
1994	0.076	0.076	100.37%	0.005	0.005	99.50%	7.628	7.628	100.00%
1995	0.142	0.142	99.89%	0.009	0.009	100.12%	14.184	14.184	100.00%
1996	0.126	0.126	99.71%	0.008	0.008	100.51%	12.564	12.564	100.00%
1997	0.155	0.155	100.10%	0.009	0.009	100.10%	15.516	15.516	100.00%
1998	0.152	0.152	100.05%	0.009	0.009	100.27%	15.208	15.208	100.00%
1999	0.157	0.157	100.23%	0.009	0.009	100.44%	15.736	15.736	100.00%
2000	0.145	0.145	100.28%	0.009	0.009	100.28%	14.540	14.540	100.00%

YEAR	CH_4 EMISSIONS			N_2O EMISSIONS			WASTE TREATED		
	Gg		Change	*Gg*		Change	*kt (dm)*		Change
	2021	2022		2021	2022		2021	2022	
2001	0.138	0.138	99.94%	0.008	0.008	99.70%	13.792	13.792	100.00%
2002	0.157	0.157	100.28%	0.009	0.009	100.49%	15.744	15.744	100.00%
2003	0.163	0.384	235.28%	0.010	0.023	234.80%	16.264	38.350	235.80%
2004	0.164	0.468	285.32%	0.010	0.028	286.49%	16.356	46.793	286.09%
2005	0.180	0.513	284.72%	0.011	0.031	284.72%	18.000	51.250	284.72%
2006	0.206	0.600	291.44%	0.012	0.036	290.50%	20.632	60.037	290.99%
2007	0.304	0.728	239.31%	0.018	0.044	238.53%	30.436	72.751	239.03%
2008	0.321	0.704	219.43%	0.019	0.042	220.11%	32.068	70.436	219.65%
2009	0.356	0.826	232.09%	0.021	0.050	232.74%	35.568	82.624	232.30%
2010	0.363	0.834	229.83%	0.022	0.050	229.62%	36.288	83.428	229.91%
2011	0.399	0.900	225.68%	0.024	0.054	225.12%	39.936	90.047	225.48%
2012	0.491	0.956	194.60%	0.030	0.057	194.34%	49.104	95.550	194.59%
2013	0.523	0.975	186.48%	0.031	0.059	186.36%	52.268	97.529	186.59%
2014	0.580	0.946	163.05%	0.035	0.057	163.05%	58.044	94.568	162.92%
2015	0.802	1.149	143.25%	0.048	0.069	143.31%	80.196	114.885	143.26%
2016	0.850	1.197	140.81%	0.051	0.072	140.81%	84.992	119.687	140.82%
2017	1.269	1.614	127.16%	0.076	0.097	127.06%	126.948	161.364	127.11%
2018	1.514	1.844	121.80%	0.091	0.111	121.78%	151.423	184.405	121.78%
2019	1.770	2.090	118.06%	0.106	0.125	118.06%	176.998	208.966	118.06%

Industrial waste composting was not recalculated. According to the previous ERT recommendation, ***Table 7.21*** shows the overview of the type of industrial waste composting in 2020.

Table 7.21: *The overview of type industrial composted waste in 2020*

Code of Industrial Waste	Percentage share of waste
Wastes from geological exploration, extraction, treatment and further processing of minerals and stone	0.01%
Wastes from agriculture, horticulture, forestry, hunting and fishing, aquaculture and food production and processing	14.84%
Wastes from wood processing and from the production of paper, board, pulp, lumber and furniture	11.05%
Wastes from the leather, fur and textile industries	0.42%
Wastes from organic chemical processes	1.48%
Wastes from MFSU of paints, varnishes and enamels, adhesives, sealants and printing inks	0.00%
Wastes from inorganic chemical processes	0.18%
Wastes from the photographic industry	0.00%
Wastes from thermal processes	1.41%
Wastes from chemical surface treatment of metals and coating of metals and other materials; wastes from non - ferrous hydrometallurgical processes	0.23%
Wastes from shaping, physical and mechanical treatment of metal and plastic surfaces	0.00%
Wastes from oils and liquid fuels other than edible oils	0.00%
Waste organic solvents, coolants and propellants	0.00%
Waste packaging, absorbents, cleaning cloths, filter material and protective clothing not otherwise specified	32.44%
Wastes not otherwise specified in this catalog	0.75%
Construction and demolition wastes, including excavated soil from contaminated sites	0.84%
Wastes from health or veterinary care or related research other than catering and restaurant wastes not arising from direct medical care	0.04%
Wastes from off-site treatment plants, off-site waste water treatment plants and drinking water and industrial water treatment plants	36.31%

Notation key for the category 5.B.2 – Anaerobic Digestion at Biogas Facilities previously reported as "NO" was changed to the "IE", emissions from biogas facilities are included in the **Energy sector**, category 1.A.5 – Other since the base.

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 the waste incineration, ones that are more modern replaced smaller and non-compliant facilities.

Following facilities for waste incineration were in operation in 2020 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 temporary out of order);
- One incinerator of rendering plant residues;
- Five facilities co-incinerating ISW (cement and lime kilns).

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 cement, lime and chemical industry 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 0.71 Gg of CO_2 eq. in 2020. Major share of emissions in this category originated from the biogenic waste incineration (9.31 Gg of bio-CO_2). Disaggregation of other waste (non-MSW, clinic and other) to biogenic and non-biogenic waste is shown in ***Table 7.22***.

***Table 7.22:** 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	8.00	13.20	0.0048	0.0008	0.61	1.01	0.00037	0.00006
1995	7.91	13.06	0.0047	0.0008	0.60	1.00	0.00036	0.00006
2000	8.60	14.19	0.0052	0.0009	0.66	1.08	0.00039	0.00007
2005	6.37	10.50	0.0038	0.0006	0.49	0.80	0.00029	0.00005
2010	3.73	6.16	0.0022	0.0004	0.28	0.47	0.00017	0.00003
2011	3.69	6.09	0.0022	0.0004	0.28	0.46	0.00017	0.00003
2012	4.71	7.77	0.0028	0.0016	0.36	0.59	0.00022	0.00012
2013	6.12	10.10	0.0037	0.0024	0.47	0.77	0.00028	0.00019
2014	9.77	16.13	0.0059	0.0059	0.75	1.23	0.00045	0.00045
2015	10.84	17.88	0.0065	0.0069	0.83	1.36	0.00050	0.00052
2016	2.79	4.61	0.0017	0.0005	0.21	0.35	0.00013	0.00004
2017	2.97	4.89	0.0018	0.0003	0.23	0.37	0.00014	0.00002
2018	4.83	7.97	0.0029	0.0017	0.37	0.61	0.00022	0.00013
2019	5.50	9.07	0.0033	0.0024	0.42	0.69	0.00025	0.00019
2020	5.64	9.31	0.0034	0.0028	0.43	0.71	0.00026	0.00021

7.7.1.1 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 in 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 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.

7.7.1.1.1 Uncertainties

The default IPPC uncertainties for activity data consistent with the **Energy sector** were used.

7.7.1.1.2 Source-specific recalculations

Please see **Chapter 7.7.1.2.3** for recalculations.

7.7.1.2 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 municipal and industrial waste treatment was reported in this category for the first time in this submission back to year 2012. Amounts of various types of incinerated waste included in this category are in ***Table 7.23***.

Table 7.23: *Activity data of included types of waste from waste incineration without energy recovery reported in the waste sector in particular years*

YEAR	IND. WASTE (without sludge)	IND. SLUDGE (from WWT)	HAZARDOUS WASTE	CLINICAL WASTE	SEWAGE SLUDGE (from WWT)	TOTAL	BIOGENIC	NON-BIOGENIC
UNIT	*kt*							
1990	6.0363	NE	0.3879	2.1832	NE	8.6074	7.9975	0.5666
1995	5.9739	NE	0.3838	2.1606	NE	8.5183	7.9148	0.5608
2000	6.4930	NE	0.4172	2.3483	NE	9.2585	8.6025	0.6095
2005	1.1274	1.5005	1.9410	2.2818	NE	6.8507	6.3653	0.4510
2010	NO	1.2234	1.6638	1.1325	NE	4.0197	3.7349	0.2646
2011	NO	0.8109	1.5811	1.5796	NE	3.9717	3.6903	0.2615
2012	NO	0.7521	2.0897	0.6696	1.5577	5.0691	4.7100	0.3337
2013	NO	0.8443	2.6242	0.6585	2.4578	6.5848	6.1183	0.4335
2014	NO	0.7322	2.4766	0.6510	6.6593	10.5191	9.7738	0.6925
2015	NO	1.1469	2.2185	0.5266	7.7726	11.6646	10.8382	0.7679
2016	NO	0.0457	2.4485	0.2642	0.2497	3.0080	2.7949	0.1980
2017	NO	NO	3.0785	0.1130	NO	3.1914	2.9653	0.2101
2018	NO	0.4763	2.7749	0.2662	1.6816	5.1990	4.8306	0.3423
2019	NO	0.5262	2.6759	0.1598	2.5552	5.9172	5.4980	0.3895
2020	NO	0.3361	2.6841	0.0534	2.9964	6.0700	5.6400	0.3996

7.7.1.2.1 Methodological issues

Emissions from non-MSW are estimated by the IPCC 2006 GL, tier 2 approach. Calculations were made for the total amount of incinerated waste to estimate the total amount of CO_2, CH_4 and N_2O emissions. Then the calculations were repeated for selected waste groups containing non-biogenic waste to estimate emissions of non-biogenic waste origin. Emissions of biogenic origin were estimated as a difference between total and non-biogenic emissions. Similarly, the available data indicate that about 0.5 kt of waste from the health sector are incinerated in 2020. Currently, clinical waste incineration is included in the non-MSW incineration.

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 impact of air pollution on the forests. Data for sewage sludge incinerated are available from the year 2012 and are collected by VÚVH (Water Management Research Institute). 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 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. Same activity data were used for GHG inventory and Air pollutants inventory. Consistency of time series was ensured by using the same activity data source for the whole time series.

7.7.1.2.2 Uncertainties

The default IPPC uncertainties for activity data were used. The total uncertainty of emissions from incineration of waste was estimated to ±45%.

Table 7.24: *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%

7.7.1.2.3 Category-specific recalculations

Emissions of CO_2, CH_4 and N_2O for the category industrial waste Incineration were recalculated in this submission since the base year due to the addition of industrial and sewage sludge incineration into the calculation. Activity data of industrial and sewage sludge incineration without energy recovery were added to the calculation to comply with data from wastewater treatment plants presented in category 5.D.

In 2020, 2.21 kt of sewage sludge and 0.49 kt of industrial sludge were incinerated without energy recovery. These numbers, together with sewage sludge incineration with energy recovery are displayed in ***Tables 7.27*** and ***7.28*** in **Chapter 7.8**. Sewage sludge incineration with energy recovery is included in the **Energy sector**, category 1.A.1.a.

Table 7.25: *Recalculations of AD and GHG emissions in the category 5.C.1.1.b and 5.C.1.2.b*

YEAR	CO_2 EMISSIONS BIOGENIC			CH_4 EMISSIONS BIOGENIC			N_2O EMISSIONS BIOGENIC		
	Gg		Change	*Gg*		Change	*Gg*		Change
	2021	2022		2021	2022		2021	2022	
1990	11.044	13.196	119%	0.0040	0.0048	119%	0.00067	0.00080	119%
1991	11.027	13.176	119%	0.0040	0.0048	119%	0.00067	0.00080	119%
1992	11.000	13.144	119%	0.0040	0.0048	119%	0.00067	0.00080	119%
1993	11.066	13.223	119%	0.0040	0.0048	119%	0.00067	0.00080	119%
1994	11.068	13.225	119%	0.0040	0.0048	119%	0.00067	0.00080	119%
1995	10.930	13.059	119%	0.0040	0.0047	119%	0.00066	0.00079	119%
1996	11.066	13.223	119%	0.0040	0.0048	119%	0.00067	0.00080	119%
1997	11.265	13.460	119%	0.0041	0.0049	119%	0.00068	0.00082	119%
1998	10.798	12.903	119%	0.0039	0.0047	119%	0.00065	0.00078	119%
1999	10.843	12.957	119%	0.0039	0.0047	119%	0.00066	0.00079	119%
2000	11.879	14.194	119%	0.0043	0.0052	119%	0.00072	0.00086	119%
2001	11.549	14.536	126%	0.0042	0.0053	126%	0.00070	0.00088	126%
2002	16.719	22.828	137%	0.0061	0.0083	137%	0.00101	0.00138	137%
2003	10.993	13.831	126%	0.0040	0.0050	126%	0.00067	0.00084	126%
2004	11.759	15.775	134%	0.0043	0.0057	134%	0.00071	0.00096	134%
2005	8.408	10.503	125%	0.0031	0.0038	125%	0.00051	0.00064	125%
2006	5.398	9.892	183%	0.0020	0.0036	183%	0.00033	0.00060	183%
2007	3.177	4.300	135%	0.0012	0.0016	135%	0.00019	0.00026	135%
2008	2.611	5.193	199%	0.0009	0.0019	199%	0.00016	0.00031	199%

YEAR	CO_2 EMISSIONS BIOGENIC			CH_4 EMISSIONS BIOGENIC			N_2O EMISSIONS BIOGENIC		
	Gg		Change	*Gg*		Change	*Gg*		Change
	2021	2022		2021	2022		2021	2022	
2009	4.307	5.711	133%	0.0016	0.0021	133%	0.00026	0.00035	133%
2010	4.287	6.163	144%	0.0016	0.0022	144%	0.00026	0.00037	144%
2011	4.846	6.089	126%	0.0018	0.0022	126%	0.00029	0.00037	126%
2012	4.230	7.771	184%	0.0015	0.0028	184%	0.00026	0.00163	635%
2013	5.033	10.095	201%	0.0018	0.0037	201%	0.00031	0.00244	800%
2014	4.795	16.127	336%	0.0017	0.0059	336%	0.00029	0.00593	2040%
2015	4.208	17.883	425%	0.0015	0.0065	425%	0.00026	0.00686	2690%
2016	4.159	4.612	111%	0.0015	0.0017	111%	0.00025	0.00047	185%
2017	4.893	4.893	100%	0.0018	0.0018	100%	0.00030	0.00030	100%
2018	4.662	7.971	171%	0.0017	0.0029	171%	0.00028	0.00173	613%
2019	4.345	9.072	209%	0.0016	0.0033	209%	0.00026	0.00245	930%

YEAR	CO_2 EMISSIONS NON-BIOGENIC			CH_4 EMISSIONS NON-BIOGENIC			N_2O EMISSIONS NON-BIOGENIC		
	Gg		Change	*Gg*		Change	*Gg*		Change
	2021	2022		2021	2022		2021	2022	
1990	0.842	1.006	119%	0.00031	0.00037	119%	5.104E-05	6.098E-05	119%
1991	0.841	1.005	119%	0.00031	0.00037	119%	5.096E-05	6.089E-05	119%
1992	0.839	1.002	119%	0.00031	0.00036	119%	5.084E-05	6.074E-05	119%
1993	0.844	1.008	119%	0.00031	0.00037	119%	5.114E-05	6.111E-05	119%
1994	0.844	1.008	119%	0.00031	0.00037	119%	5.115E-05	6.112E-05	119%
1995	0.833	0.996	119%	0.00030	0.00036	119%	5.051E-05	6.035E-05	119%
1996	0.844	1.008	119%	0.00031	0.00037	119%	5.114E-05	6.111E-05	119%
1997	0.859	1.026	119%	0.00031	0.00037	119%	5.206E-05	6.220E-05	119%
1998	0.823	0.984	119%	0.00030	0.00036	119%	4.990E-05	5.963E-05	119%
1999	0.827	0.988	119%	0.00030	0.00036	119%	5.011E-05	5.988E-05	119%
2000	0.906	1.082	119%	0.00033	0.00039	119%	5.490E-05	6.560E-05	119%
2001	0.881	1.108	126%	0.00032	0.00040	126%	5.337E-05	6.718E-05	126%
2002	1.275	1.741	137%	0.00046	0.00063	137%	7.727E-05	1.055E-04	137%
2003	0.838	1.055	126%	0.00030	0.00038	126%	5.080E-05	6.392E-05	126%
2004	0.897	1.203	134%	0.00033	0.00044	134%	5.434E-05	7.290E-05	134%
2005	0.641	0.801	125%	0.00023	0.00029	125%	3.886E-05	4.854E-05	125%
2006	0.412	0.754	183%	0.00015	0.00027	183%	2.495E-05	4.572E-05	183%
2007	0.242	0.328	135%	0.00009	0.00012	135%	1.468E-05	1.987E-05	135%
2008	0.199	0.396	199%	0.00007	0.00014	199%	1.207E-05	2.400E-05	199%
2009	0.328	0.436	133%	0.00012	0.00016	133%	1.990E-05	2.639E-05	133%
2010	0.327	0.470	144%	0.00012	0.00017	144%	1.981E-05	2.848E-05	144%
2011	0.370	0.464	126%	0.00013	0.00017	126%	2.239E-05	2.814E-05	126%
2012	0.323	0.593	184%	0.00012	0.00022	184%	1.955E-05	1.242E-04	635%
2013	0.384	0.770	201%	0.00014	0.00028	201%	2.326E-05	1.860E-04	800%
2014	0.366	1.230	336%	0.00013	0.00045	336%	2.216E-05	4.520E-04	2040%
2015	0.321	1.364	425%	0.00012	0.00050	425%	1.945E-05	5.232E-04	2690%
2016	0.317	0.352	111%	0.00012	0.00013	111%	1.922E-05	3.546E-05	185%
2017	0.373	0.373	100%	0.00014	0.00014	100%	2.261E-05	2.261E-05	100%
2018	0.356	0.608	171%	0.00013	0.00022	171%	2.155E-05	1.321E-04	613%
2019	0.331	0.692	209%	0.00012	0.00025	209%	2.008E-05	1.868E-04	930%

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. In the line with the 2006 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.

Total methane emissions from wastewater treatment were 11.14 Gg in 2020 and this value was produced dominantly from domestic WW (98.5%). Compared to the previous years, methane emissions continue slowly to decrease, which is caused mainly by lower amounts of the population connected to septic tanks, which are the dominant producer of methane from wastewater.

Total N_2O emissions from wastewater treatment were 0.17 Gg in 2020, which represents almost identical emissions in the comparison with 2019. In the industrial WWTPs relatively very small but a continuously degreasing trend of N_2O emissions is recorded in all monitored years. The emission value of N_2O from domestic WW was recalculated due to an additional change in the value of protein consumption in year 2018 and 2019. ***Table 7.26*** shows trends of emissions from domestic and industrial wastewater during the last years.

Table 7.26: *GHG emissions in individual categories in wastewater handling in 1990 – 2020*

YEAR	DOMESTIC WASTEWATER				INDUSTRIAL WASTEWATER			
	BOD IN EFFLUENT AND RET, TANKS	CH_4	N IN EFFLUENT AND RET, TANKS	N_2O	COD IN EFFLUENT	CH_4	N IN EFFLUENT	N_2O
	Gg							
1990	108.76	17.471	50.92	0.4001	46.75	1.169	4.435	0.035
1995	79.65	15.719	40.76	0.3202	33.81	0.845	3.669	0.029
2000	73.13	15.322	33.42	0.2626	29.4	0.726	2.905	0.023
2005	59.2	14.05	24.37	0.1915	16.88	0.422	1.902	0.015
2010	51.41	13.04	22.13	0.1739	13.39	0.335	1.671	0.013
2011	49.09	12.792	22.17	0.1742	10.75	0.269	1.463	0.012
2012	47.99	12.617	21.75	0.1709	10.8	0.252	1.283	0.010
2013	46.61	12.424	21.51	0.1690	9.92	0.248	1.041	0.008
2014	44.63	12.198	21.10	0.1658	9.07	0.227	0.836	0.007
2015	43.81	12.041	20.93	0.1645	8.81	0.220	0.745	0.006
2016	41.53	11.795	21.89	0.1720	8.90	0.222	0.829	0.007
2017	39.55	11.568	22.20	0.1745	8.48	0.212	0.788	0.006
2018	38.54	11.399	21.73	0.1707	7.18	0.180	0.624	0.005
2019	37.66	11.181	20.84	0.1637	7.48	0.187	0.595	0.005
2020	37.04	10.978	20.86	0.1639	6.59	0.165	0.536	0.004

The typical balance of wastewater pathways for domestic and industrial wastewater in Slovakia is presented on ***Figure 7.10***.

Figure 7.10: *The typical balance of wastewater pathways for domestic and industrial wastewater in Slovakia*

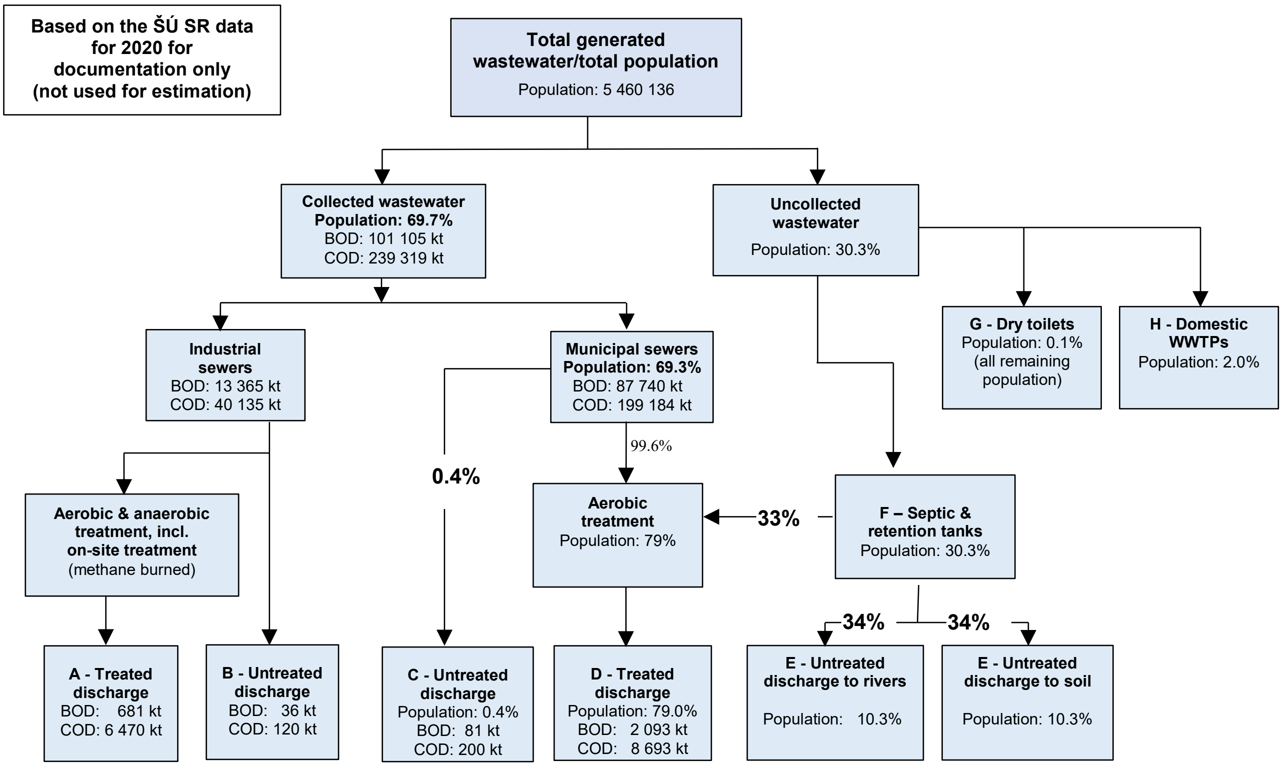


Figure 7.11: *Distribution of methane emissions (in Gg) according to the wastewater pathways*

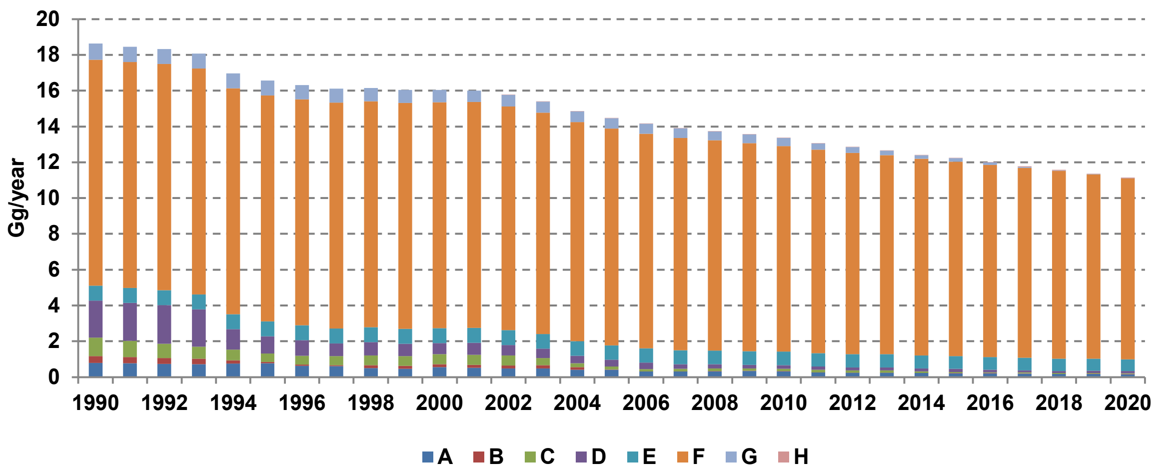


Figure 7.12: *Distribution of the N_2O emissions (in Gg) from the municipal wastewater*

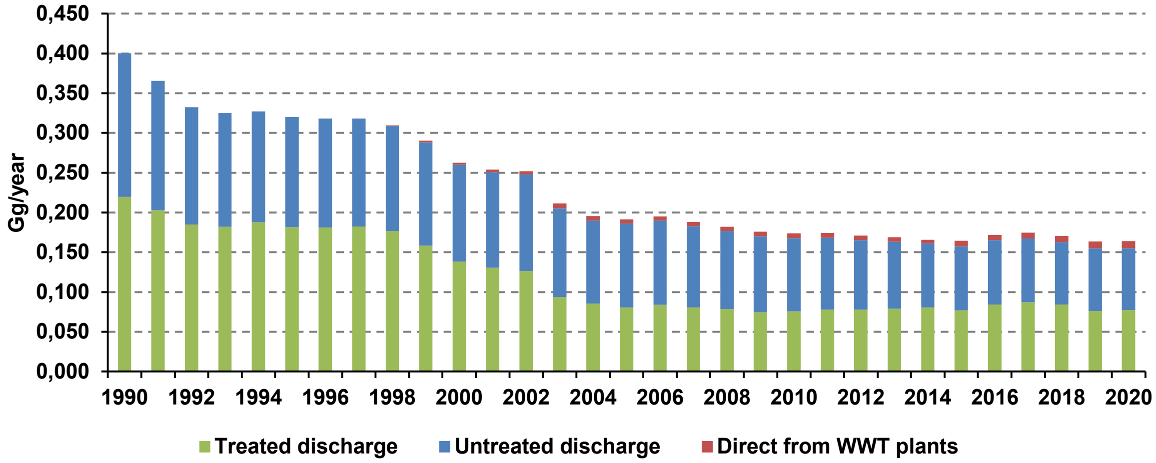
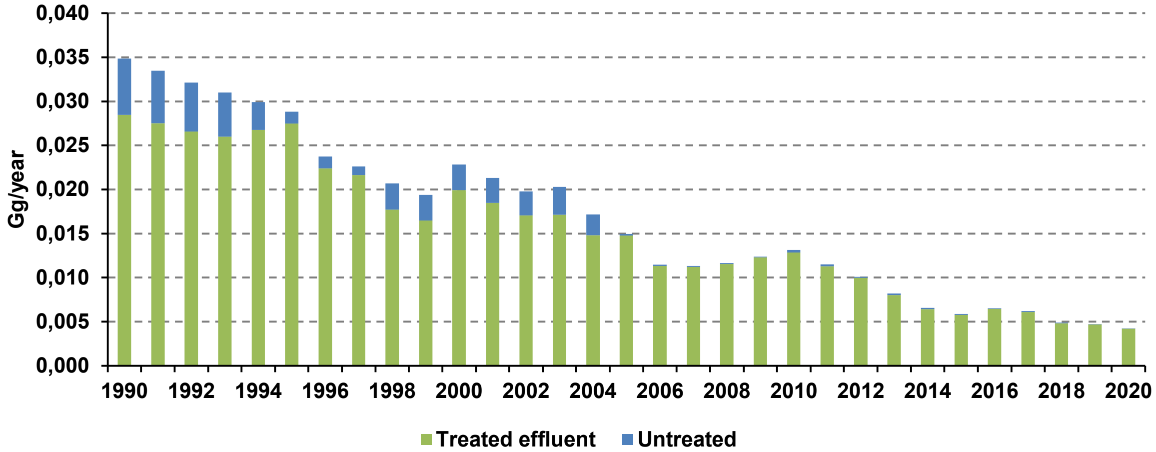


Figure 7.13: *Distribution of the N_2O emissions (in Gg) from the industrial wastewater*



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 7.27*** and ***7.28*** provides information on the data sources regarding the share of the distribution of domestic and industrial sludge treatment.

Table 7.27: *WWT distribution of the domestic sludge*

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
2013	57 433	50 787	518	45 261	5 008	1 666	4 980

YEAR	TOTAL GENERATED	TOTAL USE	DIRECT AGR. LAND APPLIC.	COMPOSTED	INCINER.	LANDFILLED	TEMPORARY STORED ON-SITE
	tons						
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

Table 7.28: *WWT distribution of the industrial treatment sludge since 2005*

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

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)

Generally, more than two-thirds of the population are discharging wastewater through sewers (3 805 330) and the rest is using retention tanks or individual treatment systems. Wastewater collection and treatment in Slovakia is developing toward modern, advanced WWTPs with the removal of nitrogen and phosphorus. The largest domestic WWTPs (52 WWTPs each with a capacity of more than 10 000 p.e.) create 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 10.98 Gg in 2020. The main contribution to these emissions have retention tanks with 10.11 Gg in 2020, which represents about 94% of methane emissions (***Table 7.29***).

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 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.

Table 7.29: *Summary of methane emissions from the domestic and commercial WW by pathways in particular years*

PATHWAY	DOMESTIC AND COMMERCIAL WW UNTREATED	DOMESTIC AND COMMERCIAL WW TREATED	UNTREATED DISCHARGE FROM SEPTIC TANKS	SEPTIC AND RETENTION TANKS	REST/ UNCATEGORI-SED	DOMESTIC WWTPs
	C	*D*	*E*	*F*	*G*	H
MFC	***0.1***	***0.1***	***0.1***	***0.5***	***0.1***	***0.1***
YEAR	*CH_4 in Gg*					
1990	1.042	2.055	0.834	12.639	0.900	0
1995	0.477	0.957	0.834	12.632	0.819	0
2000	0.551	0.625	0.833	12.625	0.687	0
2005	0.171	0.372	0.800	12.122	0.578	0.007
2010	0.129	0.195	0.759	11.495	0.445	0.016
2011	0.143	0.179	0.750	11.370	0.332	0.018
2012	0.124	0.164	0.742	11.245	0.323	0.019
2013	0.119	0.175	0.734	11.119	0.258	0.020
2014	0.087	0.164	0.726	10.994	0.206	0.022
2015	0.064	0.173	0.717	10.868	0.195	0.023
2016	0.047	0.14	0.709	10.743	0.132	0.024
2017	0.046	0.122	0.701	10.618	0.056	0.026
2018	0.041	0.117	0.692	10.492	0.029	0.027
2019	0.038	0.123	0.680	10.301	0.011	0.028
2020	0.038	0.126	0.667	10.110	0.008	0.029

Total N_2O emissions from domestic wastewater treatment were 0.16 Gg. The majority of N_2O emissions is generated both from WWTPs untreated (0.0776 Gg) and treated discharges (0.0775 Gg) (***Table 7.30***). As already stated in the previous text, due to the additional change in protein consumption for 2019, N_2O emissions for 2019 were also adjusted.

Table 7.30: *Summary of N_2O emissions from the domestic and commercial WW by pathways in particular years*

YEAR	UNTREATED DISCHARGE AND RETENTION TANKS	DIRECT FROM WWT PLANTS	TREATED DISCHARGE	TOTAL
	N_2O in Gg			
1990	0.1803	0.0000	0.2198	**0.4001**
1995	0.1385	0.0000	0.1818	**0.3202**
2000	0.1220	0.0027	0.1379	**0.2626**
2005	0.1053	0.0056	0.0806	**0.1915**
2010	0.0920	0.0068	0.0751	**0.1739**
2011	0.0904	0.0070	0.0768	**0.1742**
2012	0.0876	0.0071	0.0762	**0.1709**
2013	0.0843	0.0073	0.0774	**0.1690**
2014	0.0805	0.0076	0.0777	**0.1658**

YEAR	UNTREATED DISCHARGE AND RETENTION TANKS	DIRECT FROM WWT PLANTS	TREATED DISCHARGE	TOTAL
	N_2O in Gg			
2015	0.0807	0.0082	0.0755	**0.1645**
2016	0.0811	0.0068	0.0841	**0.1720**
2017	0.0797	0.0073	0.0874	**0.1745**
2018	0.0783	0.0080	0.0845	**0.1707**
2019	0.0789	0.0087	0.0762	**0.1637**
2020	0.0776	0.0088	0.0775	**0.1639**

7.8.1.1 Methodological issues

The IPCC 2006 GL method was accommodated to reflect available data and observed trends in wastewater management. Known influent and effluent BOD from all individual domestic WWTPs (evidence data 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 (S). 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 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)
- Domestic WWTPs discharge (H)

N_2O emissions estimation is based on the IPCC 2006 GL, but due to the increased number of advanced WWT plants, nitrogen removal by nitrification/denitrification had to be included in the estimation. The effectiveness of N removal in advanced WWT plants was estimated to be 82%, based on data published by the ŠÚ SR and SHMÚ. According to the information from the VÚVH, measurements of nitrogen content in sludge was provided also in 2020. The average nitrogen concentration in sludge was 44.6 g/kg.

Default parameters and emission factors from the IPCC 2006 GL 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 0.1 for methane correction factor (MCF) was used for all pathways except for retention tanks where MCF=0.5 was applied.

A comparison of the calculated TOW (based on the connected population multiply by the BOD) and the real measured values of domestic sewage loads provided in the SHMÚ database is performed on annual basis. This assessment estimates a proportion of industrial contribution in sewage i.e. real I-value. This I-value is estimated only for internal use (QA/QC process) annually; however the CH_4 emissions estimation is based on the real measured BOD values, where I-value is not used.

Identification of wastewater pathways is based on population using individual pathways. Estimation of CH_4 emissions from domestic wastewater is based on BOD data on 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).

7.8.1.2 Uncertainties

The default uncertainties based on the IPCC 2006 GL 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 7.31***. 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 7.31: *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 real 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)

7.8.1.3 Category-specific recalculations

The Statistical Office of the Slovak Republic provided new data on protein consumption for the year 2019, which led to the recalculation of N_2O emissions in the domestic wastewater. These recalculations were introduced in ***Table 7.8***. Due to late statistical publication data for the year 2020 will be updated in the next submission. For this submission, expert judgement was used.

The uncertainty calculations for 2019, which were defined as extremely high, were also re-assessed. High uncertainties were also noted in the 2020 submission.

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. This decrease can be explained by the general modernisation of Slovak industries and stricter standards for the discharge of industrial wastewater to public sewers or to water courses. The decrease in pollution in 2020 was probably also due to the decrease in industrial production due to the COVID pandemic situation.

Total methane emissions were estimated to be 0.165 Gg and total N_2O emissions were 0.004 Gg from industrial wastewater treatment in 2020. The pathways A and B (***Figure 7.10***) are included in the estimation of methane emissions. ***Table 7.32*** 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 2019, removed sludge was reported as "NE" in the CRF table 5.D.2. In the reflection of the discussion during the UNFCCC review 2019, new data about sludge production and disposal ways from industrial wastewater treatment 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 7.32: *GHG emissions from wastewater treatment in particular years*

YEAR	TOTAL ORGANIC PRODUCT	N IN EFFLUENT	CH_4	N_2O
	kt DC - COD	*Gg*		
1990	46.75	4.435	1.169	0.0348
1995	33.81	3.669	0.845	0.0288
2000	29.04	2.905	0.726	0.0228
2005	16.88	1.902	0.422	0.0149
2010	13.39	1.671	0.335	0.0131
2011	10.75	1.463	0.269	0.0115
2012	10.08	1.283	0.252	0.0101
2013	9.92	1.041	0.248	0.0082
2014	9.07	0.836	0.227	0.0066
2015	8.81	0.745	0.220	0.0059
2016	8.90	0.829	0.222	0.0065
2017	8.48	0.788	0.212	0.0062
2018	7.18	0.624	0.180	0.0049
2019	7.48	0.594	0.187	0.0047
2020	6.59	0.536	0.165	0.0042

7.8.2.1 Methodological issues

The methodology recommended by the 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 6.2.3.3 of the IPCC 2006 GL. Only 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. 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).

The IPCC 2006 GL do not provide a specific methodology for the estimation of N_2O emissions from industrial wastewater. Slovakia currently collects information on 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 2006 GL were used. Default value 0.25 kg CH_4/kg COD of maximum CH_4 producing capacity (B_O) was used. Default value 0.1 of methane correction factor (MCF) for both pathways was used. Default value 0.005 kg N_2O-N/kg N was used. COD data are available for the entire time series. A full balance of COD was prepared covering generated pollution, pollution discharged as treated effluent and pollution discharged as untreated effluent. Data on discharged nitrogen are available for the period 2009 – 2020. A good correlation (0.92) was identified between the discharged N_2O and COD. COD was used for extrapolation of missing N_2O activity data in the period 1990 – 2008. Extrapolations were done separately for treated and untreated discharge.

7.8.2.2 Uncertainties

The default uncertainties based on 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 N_{total}) at the effluent of 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 7.33***. 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 discussions, a value of ±10% was defined as the overall uncertainty for methane emissions and a value of ±20% 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	
<u>For methane calculation:</u>	
EF_j (kg CH_4/kg COD) = 0.25 (default value)	±0%
MCF for treated and untreated system = 0.1 (default value)	±10%
<u>For N_2O calculation:</u>	
N_2O Emission factor effluent = 0.005 (default value)	±10%
Activity data	
<u>For methane calculation:</u>	
TOW from real industrial WWTPs effluent (SHMÚ data)	±10% (sampling and analytical errors)
<u>For N_2O calculation:</u>	
N_{eff} from real WWTPs influent and effluent (SHMÚ data)	±10% (sampling and analytical errors)

7.8.2.3 Source-specific recalculations

No recalculations in this category for 2022 submission.

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 7.34***, 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 7.34: *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

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 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, INCLUDING FOR KP-LULUCF INVENTORY

The main driver for recalculations in the 2022 greenhouse gas inventory submission of the Slovak Republic has been the implementation of the methodologies and categories given in the IPCC 2006 GL and further planned improvements. The preliminary recommendations (no ARR 2021 is available) from the previous UNFCCC (2021) and EU ESD inventory reviews (2021) have been taken into account to the extent they are applicable taking into account the implementation of the revised UNFCCC reporting guidelines and the IPCC 2006 GL. 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. The recalculations made since the previous inventory submission (2021) are described also in the appropriate sectoral Chapters 3-7. The list of the major recalculations with the short descriptions made in the 2022 submission is summarized in ***Tables 10.3*** and ***10.4***.

10.2 IMPLICATIONS FOR EMISSION LEVELS

Reflecting the QA/QC activities for improving the emission inventory of GHG and recommendations provided by the experts during the review process for inventory submissions under the UNFCCC and under the EU MMR, 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 road transportation, solid waste disposal sites, energy consumption in households and agricultural activities), updated statistical information (e.g. in the **Waste** and **Energy** sectors) 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 2022, version 4 against previous inventory submission from April 14, 2021 version 4 with and without the **LULUCF sector**. ***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 decreased after recalculations made in 2022 submission: for the year 1990 by 0.02%, and for the year 2019 by 0.43% (***Table 10.1***). Regarding total GHG emissions with LULUCF, GHG emissions decrease in 2022 submission by 2.13% for the year 2019 (***Table 10.2***).

Table 10.1: *Comparison of the GHG emissions trend without LULUCF in 2021 and 2022 submissions*

NATIONAL GHG INVENTORY WITHOUT LULUCF			
YEAR	Submission 2021 v4	Submission 2022 v4	2022 v4/2021 v4
	Gg of CO_2 eq.		%
1990	73 386.16	73 374.79	99.98%
1991	63 926.60	63 918.51	99.99%
1992	58 212.79	58 210.71	100.00%
1993	54 796.04	54 800.77	100.01%
1994	52 323.03	52 331.01	100.02%
1995	52 888.94	52 840.35	99.91%
1996	52 723.11	52 686.83	99.93%
1997	52 634.99	52 537.20	99.81%
1998	51 948.77	51 818.95	99.75%
1999	50 561.42	50 517.05	99.91%
2000	48 669.91	48 704.17	100.07%
2001	50 925.39	51 033.18	100.21%
2002	49 526.70	49 638.08	100.22%
2003	49 680.81	49 770.51	100.18%
2004	50 409.47	50 505.50	100.19%
2005	50 357.19	50 495.10	100.27%
2006	50 267.53	50 304.74	100.07%
2007	48 477.95	48 574.31	100.20%
2008	48 898.52	49 101.03	100.41%
2009	44 706.18	44 813.94	100.24%
2010	45 363.93	45 624.02	100.57%
2011	44 555.47	44 642.64	100.20%

NATIONAL GHG INVENTORY WITHOUT LULUCF			
YEAR	Submission 2021 v4	Submission 2022 v4	2022 v4/2021 v4
	Gg of CO_2 eq.		%
2012	42 309.22	42 237.69	99.83%
2013	41 862.56	41 915.27	100.13%
2014	39 862.99	39 959.82	100.24%
2015	40 712.46	40 657.98	99.87%
2016	41 112.12	41 126.85	100.04%
2017	42 226.70	42 215.29	99.97%
2018	42 159.13	42 081.77	99.82%
2019	39 948.33	39 776.35	99.57%

Figure 10.1: *Comparison of the recalculated GHG emissions trend without LULUCF in 2021 and 2022 submissions for 1990 – 2019 in Gg of CO_2 eq.*

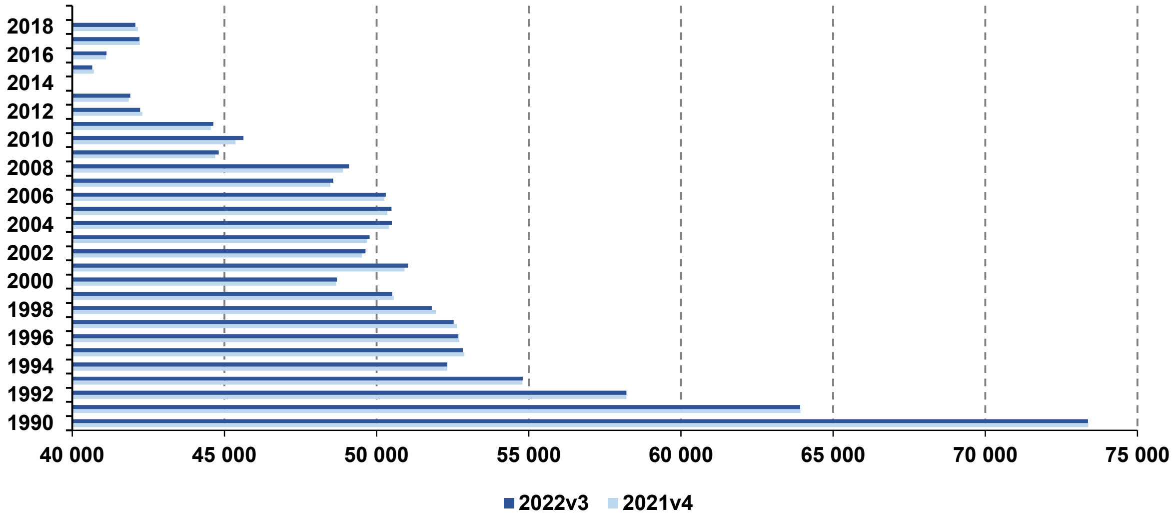
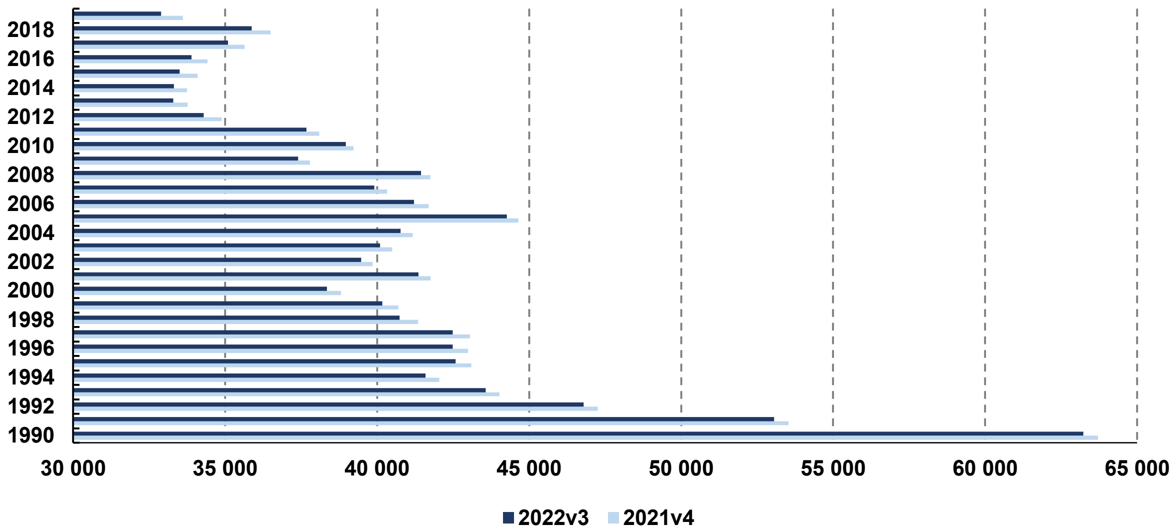


Table 10.2: *Comparison of the GHG emissions trend with LULUCF in 2021 and 2022 submissions*

NATIONAL GHG INVENTORY WITH LULUCF			
YEAR	Submission 2021 v4	Submission 2022 v4	2022 v3/2021 v4
	Gg of CO_2 eq.		%
1990	63 710.11	63 232.47	99.25%
1991	53 529.41	53 056.30	99.12%
1992	47 258.68	46 792.55	99.01%
1993	44 025.42	43 568.08	98.96%
1994	42 043.10	41 589.76	98.92%
1995	43 100.61	42 583.90	98.80%
1996	42 993.26	42 489.03	98.83%
1997	43 053.30	42 481.03	98.67%
1998	41 348.06	40 738.86	98.53%
1999	40 698.43	40 168.14	98.70%
2000	38 809.34	38 347.79	98.81%
2001	41 755.95	41 359.75	99.05%
2002	39 857.74	39 476.97	99.04%
2003	40 497.75	40 091.76	99.00%
2004	41 174.28	40 771.99	99.02%
2005	44 641.26	44 265.31	99.16%
2006	41 693.18	41 215.80	98.86%

NATIONAL GHG INVENTORY WITH LULUCF			
YEAR	Submission 2021 v4	Submission 2022 v4	2022 v3/2021 v4
	Gg of CO_2 eq.		%
2007	40 322.48	39 909.52	98.98%
2008	41 751.07	41 441.77	99.26%
2009	37 789.11	37 396.60	98.96%
2010	39 216.03	38 972.81	99.38%
2011	38 094.80	37 669.33	98.88%
2012	34 885.38	34 292.31	98.30%
2013	33 766.20	33 292.75	98.60%
2014	33 744.53	33 316.01	98.73%
2015	34 095.80	33 506.53	98.27%
2016	34 421.01	33 896.15	98.48%
2017	35 641.70	35 093.23	98.46%
2018	36 488.75	35 871.09	98.31%
2019	33 605.57	32 888.65	97.87%

Figure 10.2: *Comparison of the GHG emissions trend with LULUCF in 2021 and 2022 submissions for 1990 – 2019 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 desk review during the week from 20th – 25th September 2021. Until the date of this submission, Slovakia only received informal document "List of the Provisional and Main Finding" for which we have send the comments with proposal to change or delete some of the recommendation. The answers of ERT to comments made by Slovakia and Annual Review Report were not delivered, therefore some of the potential recommendations were not implemented in this submission.

The status of implementation for those recommendations for which we did not send the comments or proposals for change is descripted in ***Table A4.3.***

EU ESD review: The requirements for the Union review of the national inventory data submitted by Member States are set out in Article 19 of the MMR. The details concerning the review process, such as the timing and steps of conducting of the annual and comprehensive reviews are set out in Chapter III and Annex XVI of the Commission Implementing regulations (EU) No 749/2014. The comprehensive review 2021 concerning Member States' inventories for the year 2019 was carried out as planned during the spring 2021. Second step of the review of Slovakia was necessary in the review cycle 2021 due to one issue in the **Waste sector**. Therefore, Final Review Report 2021 of national greenhouse gas inventory data pursuant to Article 19(2) of Regulation (EU) No 525/2013 was provided by the June 30, 2021. The reviewers raised 13 issues during the first and the second steps of the 2021 ESD review which leads to no recommendation.

Recalculations: In term to further improvements of the GHG emissions inventory, the NIS SR made recalculations for the 2022 submission. These recalculations are listed in ***Table 10.3*** below. Focus is on the main issues highlighted in the regular UNFCCC and ESD reviews performed in the years 2020 and 2021. 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).

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 10.3: *List of recalculations in the April 15, 2022 submission (version 4) against the April 15, 2021 submission (version 4) with short explanation*

RECALCULATED CATEGORY		YEARS	GHG	EXPLANATION
1. ENERGY SECTOR				
1.A.1.a.iv	Public Electricity and Heat Production – Other for Other fuels and Biomass	2019	CO_2, CH_4, N_2O	An issue with incorrect municipal waste consumption in one MSW incinerator was identified. In current submission the consumption was corrected.
1.A.3.b	Road Transportation – diesel oil, gasoline, biomass, LPG and CNG	2013-2019	CO_2, CH_4, N_2O	Recalculations of road transportation using new version of model COPERT model.
1.A.5.a	Other – Stationary	2008-2019	CO_2, CH_4, N_2O	An improvement in LFG consumption was included in current submission. The activity data were modified for the years 2008 – 2019.
1.B.1.b	Solid Fuel Transformation - Charcoal	2019	CH_4	Charcoal production in Slovakia for the year 2019 was revised by FAO STAT.
1.B.2.a.2	Oil and Natural Gas and Other Emissions from Energy Production – Oil Production	2010-2019	CO_2, CH_4	Crude oil production for the years 2010 – 2019 was provided directly by companies. There were significant differences between statistical data and real data provided by companies. Slovakia in this NIR started to use real data. The difference was between - 53% and 4%. Between years 2010 and 2013 there is a small rise in crude oil production and afterwards the real production was significantly lower than statistical data. These data are measured directly by the wells and are connected to direct measurements of fugitive emission changed reported in Chapter 3.5.4.2 and Chapter 3.5.4.3
1.B.2.b.2	Oil and Natural Gas and Other Emissions from Energy Production – Natural Gas Production	2010-2019	CO_2, CH_4	Natural gas production for the years 2010 – 2019 was provided directly by companies. There were significant differences between statistical data and real data provided by companies. Slovakia in this NIR started to use real data. The difference was between -4% and -40%, which correspond to decrease in NG production between 4.11 to 59.30 million m^3. This data also affected emissions of NG processing.
1.B.2.b.3	Oil and Natural Gas and Other Emissions from Energy Production – Natural Gas Processing	2010-2019	CO_2, CH_4	See above.
1.B.2.b.4	Oil and Natural Gas and Other Emissions from Energy Production – Transmission and storage	2014-2019	CO_2, CH_4	In the category 1.B.2.b.4 was, in the NIR 2021, used incorrect constant, which resulted in incorrect methane emissions.
1.B.2.b.6	Oil and Natural Gas and Other Emissions from Energy Production – Natural Gas Other/Storage	2010-2019	CO_2, CH_4	Natural gas storage data for the years 2010 – 2019 were also provided by the companies operating NG reservoirs for the Slovak Republic. These data were cross-checked by the national expert with statistical data. After this cross-check it was found out that there was a difference in the methodology of companies and the Statistical Office of the Slovak Republic. Companies reported NG that flowed through the reservoirs throughout the year and the Statistical office reported only the balance of the reservoirs in the end of the year. Thus Slovakia decided to move to plant specific activity data. These data significantly increased and varied between years according of the needs of sector using NG.
2. INDUSTRIAL PROCESSES SECTOR				
2.D.3	Urea Catalytic Converters	2013 – 2019	CO_2	Recalculations of emissions from urea catalysts connected with the recalculations made in road transportation.

RECALCULATED CATEGORY		YEARS	GHG	EXPLANATION
3. AGRICULTURE				
3.D.1.1	Inorganic N Fertilizers	2000-2011	N_2O	Revision of nitrogen inorganic fertilizers consumption for the years 2000 – 2011.
3.D.1.2.a	Animal Manure Applied to Soils	1990-2019	N_2O	Straw-based system N inputs from deep bedding in the poultry and swine categories was implemented.
3.D.1.2.b	Sewage Sludge Applied to Soils	1990-2019	N_2O	The industrial sludge consumption for agricultural purposes was completed into inventory and revisions were implemented.
3.D.1.2.c	Other Organic Fertilizers Applied to Soils	1990-2019	N_2O	The revision of parameters for the estimation of nitrogen content for compost, digestate and green manure were implemented.
3.D.1.4	Crop Residues	1990-2019	N_2O	The recalculation of crop residues was performed due to the implementation of $Frac_{Remove}$ for cereal crops used for bedding purposes.
3.D.2.1	Atmospheric Deposition	1990-2019	N_2O	The revision of category 3.D.2.1 was performed due to changes in category 3.D.1.1 - Inorganic N Fertilizers from 2000 to 2011 and category 3.D.1.2 - Organic N Fertilizer in all time-series
3.D.2.2	Nitrogen Leaching and Run-off	1990-2019	N_2O	The revision of category 3.D.2.1 was performed due to changes in category 3.D.1.1 - Inorganic N Fertilizers in 2000 to 2011, 3.D.1.2 - Organic N Fertilizer in all time-series and 3.D.1.4 - Crop Residues. Correction of used $Frac_{Leach}$ was implemented.
3.G.1	Liming Limestone $CaCO_3$	1990-2019	CO_2	The revision of activity data since 1998 was performed. The calcium substances containing only CaO or Ca were subtracted from activity data, due to mentioned substances do not emit CO_2 emissions. Based on new activity data since the year 1998, extrapolation was performed back to base year.
3.G.2	Liming Dolomite $CaMg(CO_3)_2$	1990-2019	CO_2	The revision analysis of activity data since 1998. The substances contain magnesium oxide and magnesium were subtracted from activity data (no CO_2 emissions). Based on new activity data since the year 1998, extrapolation was performed back to base year.
4. LULUCF				
4.A.1	Forest Land Remaining Forest Land	1990-2019	CO_2	The categories 4.A.1 Forest Land remaining Forest Land and 4.A.2 Land converted to Forest Land were recalculated for the whole time period since 1990. The main reason for recalculation in 4.A.1 and 4.A.2 included the calculation of CSC in DW carbon pools following the ERT recommendation. Another reasons of recalculation in 4.A.1 was change and correction of root-to-shoot ratios (using only 0.2 for coniferous and 0.24 for broadleaved; no specific value for oaks following the ERT recommendation.
4.A.2	Land Converted to Forest Land	1990-2019	CO_2	See explanation in 4.A.1.
4.B.2	Land Converted to Cropland	1990-2019	CO_2	The category 4.B.2 Land converted to Cropland was recalculated for the whole time period since 1990. The main reason for recalculation 4.B.2 category included the recalculation of CSC in DW carbon pools (FL converted to CL) following the ERT recommendation.
4.C.2	Land Converted to Grassland	1990-2019	CO_2	The category 4.C.2 Land converted to Grassland was recalculated for the whole time period since 1990. The reason of recalculations included the recalculation of CSC in DW carbon pools (FL converted to GL) following the ERT recommendation.

RECALCULATED CATEGORY		YEARS	GHG	EXPLANATION
4.E.2	Land Converted to Settlements	1990-2019	CO_2	The category 4.E.2 Land converted to Settlements was recalculated for the whole time period since 1990. The reason of recalculations included the recalculation of CSC in DW carbon pools (FL converted to SL) following the ERT recommendation.
4.F.2	Land Converted to Other Land	1990-2019	CO_2	The category 4.F.2 Land converted to Other land was recalculated for the whole time period since 1990. The reason of recalculations included the recalculation of CSC in DW carbon pools (FL converted to OL) following the ERT recommendation.
5. WASTE				
5.A.1	5.A.1.a – Anaerobic Managed Waste Disposal Sites 5.A.1.b – Semi-aerobic Managed Waste Disposal Sites	1990-2019	CH_4	Based on the new available data, activity data on ISW landfilling was revised for the years 1990 – 2019. Real data on landfilling of ISW for the groups 01-19 from the EWC with the DOC higher than 0 were used. Resulting methane emissions generating from the six groups of ISW (02, 03, 04, 15, 17 and 19) were summarised according to the biodegradable share of Food, Wood, Paper, Textile, C + D waste, Mix_Package and Sludge.
5.B.1.a	Biological treatment of solid waste – Municipal Solid Waste	1993-2019	CH_4, N_2O	The recalculation of activity data and emissions was processed due to the implementation of composted sewage sludge from the municipal wastewater treatment plant. The Source of data is the Water Research Institute.
5.C.1	5.C.1.1.b – Other Waste Incineration Biogenic 5.C.1.2.b – Other Non-Biogenic	1990-2019	CO_2, CH_4, N_2O	Emissions of CO_2, CH_4 and N_2O for the category Waste Incineration – industrial waste were recalculated in this submission due to the addition of industrial and sewage sludge incineration into the calculation. Activity data of industrial and sewage sludge incineration without energy recovery were added to the calculation to comply with data from wastewater treatment plants presented in category 5.D.
5.D.1	Wastewater Treatment - Protein Consumption	2019	N_2O	Protein consumption for the year 2019 was updated based on the statistics reported by the ŠÚ SR.
7. KP LULUCF				
3.3 ARD	Afforestation and Reforestation and Deforestation	2013-2019	CO_2	The emissions/removals for ARD activities were recalculated in 2022 submission since the year 2013. The main reason for recalculation in AR activities included the new calculation of CSC in DW carbon pools following the ERT recommendation and recalculations in D activities included the recalculation of CSC in DW carbon pools.

CHAPTER 11: KP-LULUCF

Summary information on emissions and removals accounted under Article 3.3 and 3.4 is provided in ***Table ES.1***, **Chapter ES.4** of this Report.

11.1 GENERAL INFORMATION

The information provided in this Chapter follows the content and the structure specified in the “Guidelines for the preparation of the information required under Article 7 of the Kyoto Protocol” (Annex to decision 15/CMP.1, FCCC/KP/CMP/2005/8/Add.2 page 56) and “Information on land use, land-use change and forestry activities under Article 3, paragraphs 3 and 4, of the Kyoto Protocol in annual greenhouse gas inventories” (Annex II to decision 2/CMP.8, FCCC/KP/CMP/2012/13/Add.1).

11.1.1 DEFINITION OF FOREST AND ANY OTHER CRITERIA

The Slovak Republic has selected as threshold values for the forest definition for reporting under the Article 3.3 (ARD activities: afforestation, reforestation and deforestation) the following: Forest Land includes the land with minimum tree crown cover of 20% for trees capable to reach minimum height of 5 m in situ. The minimum area for forest is 0.3 ha. Temporarily unstocked areas are included (forest regeneration areas). For linear formations, a minimum width of 20 m is applied.

Table 11.1: *Selected parameters defining forest in the Slovak Republic for reporting under the KP*

PARAMETER	RANGE	SELECTED VALUE
Minimum Land Area	0.05-1 ha	0.3 ha
Minimum Crown Cover	10 - 30%	20%
Minimum Height	2 - 5 m	5 m

The selected threshold values are consistent over the first and second commitment periods (CP), as well as with the values used in the reporting to the Food and Agriculture Organisation of the United Nations (the GFRA 2005), the National Forest Inventory, and the MCPFE criteria and indicators of sustainable forest management).

11.1.2 ELECTED ACTIVITIES UNDER ARTICLE 3, PARAGRAPH 4, OF THE KYOTO PROTOCOL

The Slovak Republic was reporting and accounting on the mandatory activities under Article 3.3 (afforestation and reforestation; deforestation, also referred as ARD in the further text) for the first (CP1) as well as for the second commitment period (CP2).

The Slovak Republic has decided not to elect any voluntary activity under the Article 3.4 (Cropland Management, Grazing Land Management, Revegetation or Wetland Drainage and Rewetting) for meeting its commitment under the CP2 of the Kyoto Protocol. For the CP2, the Slovak Republic reports also on the activity Forest Management under Article 3.4 (FM) as it became mandatory.

11.1.3 DESCRIPTION OF HOW THE DEFINITIONS OF EACH ACTIVITY UNDER ARTICLE 3.3 AND EACH ELECTED ACTIVITY UNDER ARTICLE 3.4 HAVE BEEN IMPLEMENTED AND APPLIED CONSISTENTLY OVER TIME

The linkage between the ARD activities and the reported land use changes from and to forest in the UNFCCC GHG inventory is as follows:

- Afforestation and Reforestation activities represent all land conversions to Forest Land (from Cropland, Grassland or Other Land). Deforestation activity represents the conversion of Forest Land to any other land use category (Cropland, Grassland, Settlements or Other Land).

The information about areas of ARD and FM activities is based on the data from the Geodesy, Cartography and Cadastre Authority of the Slovak Republic (GCCA). The GCCA issues annually the Statistical Yearbook of the Soil Resources in the Slovak Republic. The yearbook provides consistently updated cadastral information annually, not only on land use areas but also the information about the areas which were afforested/reforested and deforested. The Cadastral information is complemented by the data from the national program: "Afforestation of the land unsuitable for agricultural production". This program was running from 1995 to 1999 and was guaranteed by the Government of the Slovak Republic. All land use change from and to forest is considered to be human induced in the Slovak Republic. AR activities are reported together. Forest is managed in the Slovak Republic, thus Forest Land remaining Forest Land is considered as subject to the Forest Management activity under Article 3.4. Other activities under the Article 3.4 were not elected.

11.1.4 DESCRIPTION OF PRECEDENCE CONDITIONS AND/OR HIERARCHY AMONG ARTICLE 3.4 ACTIVITIES, AND HOW THEY HAVE BEEN CONSISTENTLY APPLIED IN DETERMINING HOW LAND WAS CLASSIFIED

The Slovak Republic has not elected any voluntary activity under the Article 3.4 (Cropland Management, Grazing Land Management, Revegetation or Wetland Drainage and Rewetting). Since only FM, as mandatory activity, is reported, no preceding conditions and/or hierarchy among the Article 3.4 activities are applicable.

11.2 LAND-RELATED INFORMATION

11.2.1 SPATIAL ASSESSMENT UNIT USED FOR DETERMINING THE AREA OF THE UNITS OF LAND UNDER ARTICLE 3.3 AND ARTICLE 3.4

The identification of all lands and associated carbon pools subject to decision 2/CMP.7, Annex, paragraph 37, including the georeferenced location and year of conversion, is described in **Chapter 11**. To meet the reporting requirements of the Marrakesh Accords, general information on activities under the Article 3.3 must include the geographical boundaries of areas encompassing units of land subject to the mandatory and elected activities.

To achieve this, method 1 was chosen, see Chapter 2.2.2 (Figure 2.2.1) of the IPCC 2013 KP Supplement. The method entails delineating areas that include multiple land units subject to the Article 3.3 activities by using legal and administrative boundaries. The data published in the Statistical Yearbook of the Soil Resources in the Slovak Republic permit spatial assessment and identification of AR, D and FM activities at the district level. The national system has the attributes of both approach 2 and approach 3. The Statistical Yearbook provides information on eight self-government districts since 1996 and three districts in the period from 1990 to 1995 (***Figures 11.1*** and ***11.2***). Geographical boundaries of these regions are georeferenced by means of the S – JTSK Krovak system. All maps used in the Slovak Republic are made in the coordinate system of uniform trigonometric cadastral network (S – JTSK).

More detailed localisation is possible using cadastral spatial layers, which contain information on every land parcel in Slovakia at the end of the calendar year (8 244 308 parcels by the end of 2020). To identify each parcel where AR and D activities occurred, it is necessary to intersect layers from two consecutive years. The results of this computationally demanding analyses, summarized according to cadastral units for better visualisation, is presented on ***Figures 11.3*** and ***11.4***. These detailed spatial analyses are possible since 2012, when all land parcels in GCCA system have been vectorised and information stored in geodatabase.

Figure 11.1: *The eight Slovak regional districts established in 1996 (until present)*

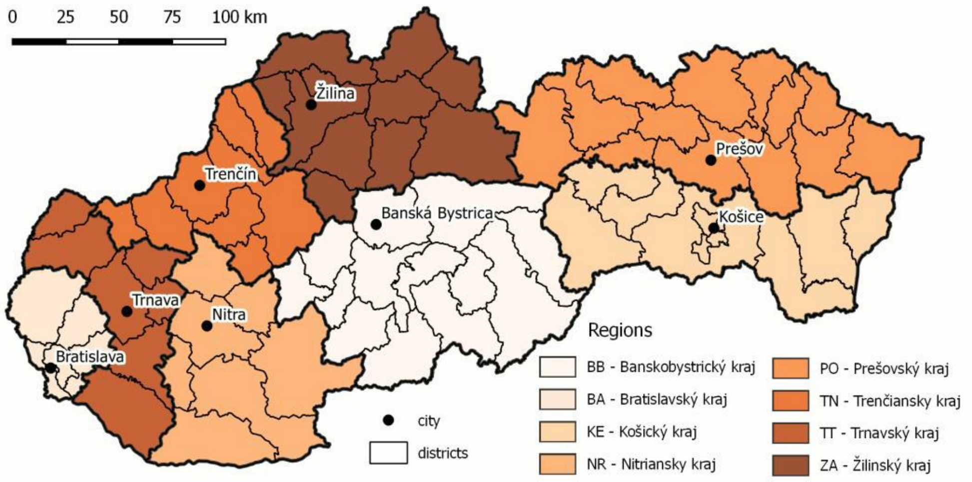
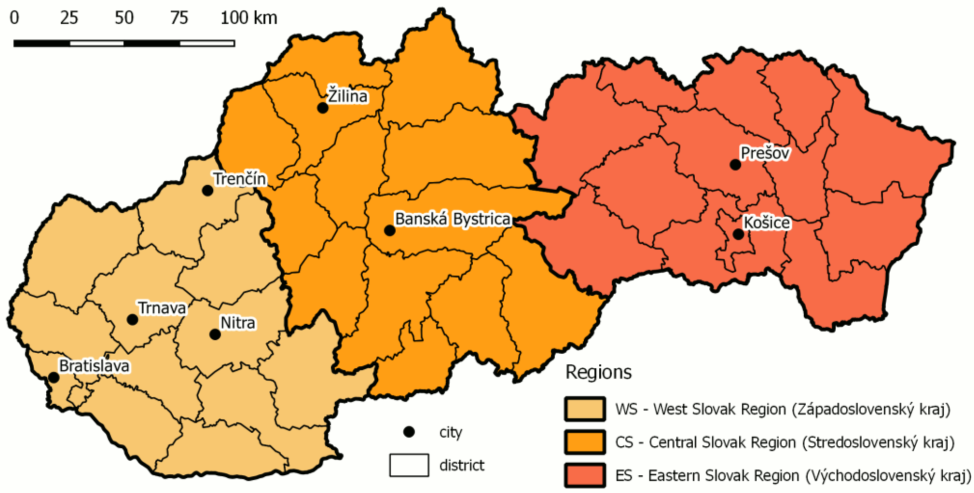


Figure 11.2: *The three Slovak regional districts used for the assessment of ARD activities since 1990*



Considering a small area of the country and its specific conditions, there is no applicable stratification that would justify reporting on a smaller unit than the country-level unit. Total areas of ARD activities in different years are small, not more than 3 800 ha (AR) or 988 ha (D) for the whole country. Following ***Tables 11.2-11.4*** provide an overview of the spatial extent of ARD activities in each district in Slovakia.

Table 11.2: *Area of ARD activities at the district and national level (**Figure 11.2**) in 1990 – 1995*

A/R	SK	WS	CS	ES	DEF	SK	WS	CS	ES
	kha					*kha*			
1990	3.770	0.314	2.538	0.918	**1990**	0.809	0.083	0.313	0.413
1991	1.963	0.097	1.654	0.185	**1991**	0.988	0.068	0.179	0.741
1992	1.467	0.384	0.386	0.697	**1992**	0.324	0.114	0.167	0.043
1993	0.722	0.311	0.249	0.162	**1993**	0.366	0.099	0.027	0.240
1994	0.559	0.223	0.145	0.191	**1994**	0.351	0.058	0.075	0.218
1995	0.721	0.015	0.573	0.133	**1995**	0.135	0.051	0.018	0.066

SK = the Slovak Republic, WS = Western Slovak Region, CS = Central Slovak Region, ES = Eastern Slovak Region

Table 11.3: *Area of A/R activities at the district and national level (**Figure 11.1**) in 1996 – 2020*

AFF/REF	SK	BA	TT	TN	NR	ZA	BB	PO	KE
	kha								
1996	1.577	0.001	0.004	0.011	0.004	0.207	0.803	0.353	0.195
1997	3.395	0.059	0.214	0.018	0.000	1.498	0.155	1.427	0.024
1998	2.288	0.000	0.068	0.005	0.000	0.844	0.865	0.495	0.012
1999	2.102	0.000	0.120	0.139	0.091	0.470	0.447	0.344	0.490
2000	1.292	0.003	0.000	0.010	0.022	0.698	0.159	0.356	0.044
2001	1.178	0.003	0.011	0.121	0.024	0.636	0.013	0.121	0.250
2002	0.793	0.029	0.008	0.074	0.003	0.449	0.103	0.020	0.109
2003	1.648	0.008	0.008	0.124	0.060	0.718	0.351	0.046	0.332
2004	0.992	0.001	0.023	0.244	0.002	0.257	0.076	0.297	0.091
2005	0.842	0.008	0.076	0.012	0.003	0.600	0.082	0.057	0.003
2006	1.945	0.076	0.023	0.066	0.154	0.726	0.016	0.825	0.059
2007	0.656	0.030	0.011	0.040	0.093	0.017	0.208	0.217	0.040
2008	1.438	0.010	0.013	0.459	0.200	0.159	0.244	0.184	0.170
2009	1.048	0.018	0.012	0.089	0.031	0.023	0.235	0.504	0.136
2010	2.732	0.099	0.013	0.441	0.108	0.029	1.162	0.650	0.230
2011	1.174	0.041	0.027	0.204	0.038	0.317	0.222	0.096	0.229
2012	1.845	0.078	0.021	0.191	0.205	0.235	0.376	0.393	0.346
2013	1.407	0.019	0.091	0.025	0.034	0.141	0.638	0.151	0.307
2014	1.886	0.005	0.055	0.066	0.131	0.741	0.479	0.187	0.068
2015	3.145	0.008	0.009	0.155	0.245	0.648	1.168	0.634	0.278
2016	2.467	0.000	0.002	0.020	0.062	0.963	0.377	0.645	0.398
2017	1.978	0.001	0.119	0.029	0.012	0.747	0.170	0.642	0.258
2018	1.902	0.000	0.002	0.049	0.008	0.368	0.373	0.886	0.215
2019	1.162	0.001	0.002	0.089	0.032	0.079	0.318	0.574	0.068
2020	0.856	0.000	0.000	0.038	0.000	0.048	0.143	0.346	0.281

__Figure 11.3:__ The cadastral units with afforestation activity in Slovakia (2020)

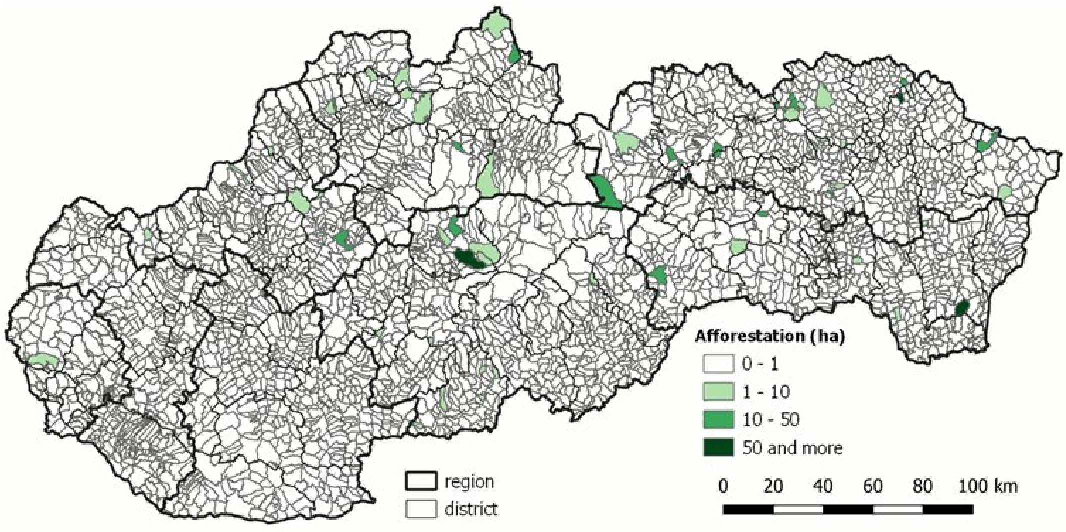


__Table 11.4:__ Area of the D activities at the district and national level (__Figure 11.4__) in 1996 – 2020

DEF	SK	BA	TT	TN	NR	ZA	BB	PO	KE
	kha								
1996	0.468	0.015	0.039	0.017	0.033	0.043	0.029	0.197	0.095
1997	0.388	0.034	0.029	0.087	0.019	0.015	0.046	0.013	0.145
1998	0.378	0.006	0.016	0.011	0.035	0.009	0.040	0.143	0.118
1999	0.297	0.014	0.026	0.073	0.026	0.032	0.016	0.096	0.014
2000	0.127	0.010	0.007	0.024	0.010	0.020	0.016	0.030	0.010
2001	0.302	0.057	0.006	0.015	0.027	0.076	0.029	0.031	0.061
2002	0.149	0.019	0.026	0.005	0.022	0.008	0.022	0.041	0.006
2003	0.321	0.040	0.021	0.130	0.009	0.051	0.026	0.016	0.028
2004	0.166	0.015	0.002	0.016	0.006	0.074	0.012	0.036	0.005
2005	0.534	0.209	0.021	0.187	0.017	0.012	0.037	0.035	0.016
2006	0.239	0.018	0.008	0.026	0.010	0.004	0.035	0.121	0.017
2007	0.454	0.026	0.052	0.047	0.066	0.061	0.023	0.161	0.018
2008	0.323	0.026	0.029	0.033	0.017	0.059	0.091	0.026	0.041
2009	0.462	0.199	0.023	0.053	0.044	0.049	0.010	0.043	0.041
2010	0.326	0.034	0.018	0.027	0.006	0.087	0.025	0.091	0.038
2011	0.087	0.008	0.005	0.008	0.011	0.014	0.020	0.012	0.009
2012	0.122	0.007	0.027	0.006	0.003	0.019	0.030	0.013	0.017
2013	0.098	0.013	0.002	0.001	0.015	0.014	0.017	0.021	0.015
2014	0.149	0.005	0.004	0.004	0.065	0.014	0.014	0.039	0.004
2015	0.134	0.002	0.011	0.044	0.038	0.008	0.016	0.004	0.011
2016	0.061	0.007	0.001	0.013	0.001	0.003	0.002	0.003	0.010
2017	0.126	0.023	0.004	0.006	0.009	0.016	0.041	0.022	0.005
2018	0.249	0.001	0.080	0.013	0.007	0.121	0.013	0.012	0.002
2019	0.090	0.008	0.003	0.002	0.005	0.005	0.011	0.044	0.012
2020	0.103	0.005	0.020	0.012	0.010	0.008	0.015	0.026	0.007

SK = the Slovak Republic, BA = Bratislava District, TT = Trnava District, TN = Trenčín District, NR = Nitra District, ZA = Žilina District, BB = Banská Bystrica District, PO = Prešov District, KE = Košice District

Figure 11.4: *The cadastral units with the deforestation activity in Slovakia (2020)*

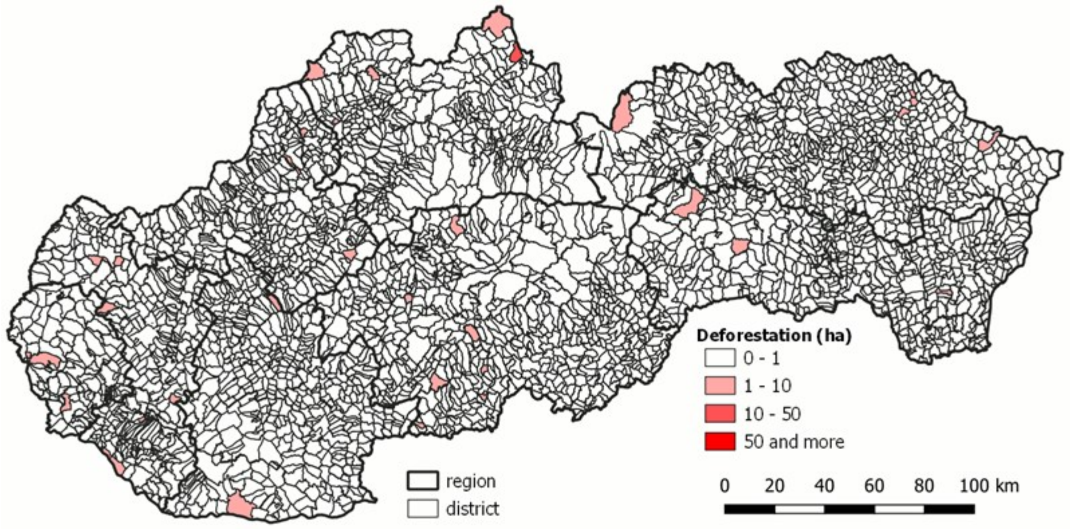


Table 11.5 presents an example of percentage of areas with realized AR activities from total area of individual districts. The values fluctuated between 0.0003% and 0.2207%.

Table 11.5: *The percentage of the area of the AR activities at district and national level in 1996 – 2020*

AFF/REF	SK	BA	TT	TN	NR	ZA	BB	PO	KE
	%								
1996	0.03	0.00	0.00	0.00	0.00	0.03	0.08	0.04	0.03
1997	0.07	0.03	0.05	0.00	0.00	0.22	0.02	0.16	0.00
1998	0.05	0.00	0.02	0.00	0.00	0.12	0.09	0.06	0.00
1999	0.04	0.00	0.03	0.03	0.01	0.07	0.05	0.04	0.07
2000	0.03	0.00	0.00	0.00	0.00	0.10	0.02	0.04	0.01
2001	0.02	0.00	0.00	0.03	0.00	0.09	0.00	0.01	0.04
2002	0.02	0.01	0.00	0.02	0.00	0.07	0.01	0.00	0.02
2003	0.03	0.00	0.00	0.03	0.01	0.11	0.04	0.01	0.05
2004	0.02	0.00	0.01	0.05	0.00	0.04	0.01	0.03	0.01
2005	0.02	0.00	0.02	0.00	0.00	0.09	0.01	0.01	0.00
2006	0.04	0.04	0.01	0.01	0.02	0.11	0.00	0.09	0.01
2007	0.01	0.01	0.00	0.01	0.01	0.00	0.02	0.02	0.01
2008	0.03	0.00	0.00	0.10	0.03	0.02	0.03	0.02	0.03
2009	0.02	0.01	0.00	0.02	0.00	0.00	0.02	0.06	0.02
2010	0.06	0.05	0.00	0.10	0.02	0.00	0.12	0.07	0.03
2011	0.02	0.02	0.01	0.05	0.01	0.05	0.02	0.01	0.03
2012	0.04	0.04	0.01	0.04	0.03	0.03	0.04	0.04	0.05
2013	0.03	0.01	0.02	0.01	0.01	0.02	0.07	0.02	0.04
2014	0.04	0.00	0.01	0.01	0.02	0.11	0.05	0.02	0.01
2015	0.06	0.00	0.00	0.03	0.04	0.10	0.12	0.07	0.04
2016	0.05	0.00	0.00	0.00	0.01	0.14	0.04	0.07	0.06
2017	0.04	0.00	0.03	0.01	0.00	0.11	0.02	0.07	0.04
2018	0.04	0.00	0.00	0.01	0.00	0.05	0.04	0.10	0.03
2019	0.02	0.00	0.00	0.02	0.00	0.01	0.03	0.06	0.01
2020	0.02	0.00	0.00	0.01	0.00	0.01	0.02	0.04	0.04

SK = the Slovak Republic, BA = Bratislava District, TT = Trnava District, TN = Trenčín District, NR = Nitra District, ZA = Žilina District, BB = Banská Bystrica District, PO = Prešov District, KE = Košice District

11.2.2 METHODOLOGY USED TO DEVELOP THE LAND TRANSITION MATRIX

The land transition matrix is based on the results of land use changes from and to forest derived from the database of GCCA. This authority annually updates the cadastral information on the areas which have been afforested/reforested and deforested, as well as the information on the areas remaining in the same land use category. The AR area represented 50.950 kha in total and 1.644 kha yearly in average in Slovak conditions from 1990 to 2020. In the same time period the total deforestation area reached 9.126 kha in total resp. 0.294 kha in average. The differences between AR and D correspond to the net increment of cadastral Forest Land between 0.202 and 3.011 kha (***Table 11.6***).

Table 11.6: *The differences between the AR and DEF activities during 1990 – 2020*

YEAR	Afforestation/Reforestation				Deforestation					DIFF.
	C to FL	G to FL	OL - FL	Total	FL to C	FL to G	FL to S	FL - OL	Total	
	kha									
1990	0.088	1.421	2.261	**3.770**	0.010	0.353	0.028	0.418	**0.809**	**2.961**
1991	0.012	0.325	1.626	**1.963**	0.045	0.678	0.075	0.190	**0.988**	**0.975**
1992	0.202	0.196	1.069	**1.467**	0.002	0.146	0.063	0.113	**0.324**	**1.143**
1993	0.008	0.227	0.487	**0.722**	0.002	0.175	0.071	0.118	**0.366**	**0.356**
1994	0.019	0.308	0.232	**0.559**	0.014	0.186	0.025	0.126	**0.351**	**0.208**
1995	0.028	0.556	0.137	**0.721**	0.002	0.063	0.023	0.047	**0.135**	**0.586**
1996	0.107	1.113	0.357	**1.577**	0.098	0.280	0.032	0.058	**0.468**	**1.109**
1997	0.130	0.311	2.954	**3.395**	0.026	0.203	0.065	0.094	**0.388**	**3.007**
1998	0.067	0.845	1.376	**2.288**	0.004	0.294	0.000	0.080	**0.378**	**1.910**
1999	0.067	0.831	1.204	**2.102**	0.009	0.086	0.029	0.173	**0.297**	**1.805**
2000	0.096	0.693	0.503	**1.292**	0.005	0.023	0.008	0.091	**0.127**	**1.165**
2001	0.013	0.422	0.743	**1.178**	0.039	0.101	0.040	0.122	**0.302**	**0.876**
2002	0.008	0.509	0.276	**0.793**	0.006	0.064	0.021	0.058	**0.149**	**0.644**
2003	0.050	1.110	0.488	**1.648**	0.009	0.185	0.065	0.062	**0.321**	**1.327**
2004	0.086	0.815	0.091	**0.992**	0.005	0.020	0.050	0.091	**0.166**	**0.826**
2005	0.023	0.455	0.364	**0.842**	0.015	0.219	0.038	0.262	**0.534**	**0.308**
2006	0.044	0.504	1.397	**1.945**	0.000	0.109	0.024	0.106	**0.239**	**1.706**
2007	0.065	0.365	0.226	**0.656**	0.068	0.144	0.047	0.195	**0.454**	**0.202**
2008	0.084	0.847	0.507	**1.438**	0.010	0.119	0.058	0.136	**0.323**	**1.115**
2009	0.044	0.472	0.532	**1.048**	0.014	0.050	0.262	0.136	**0.462**	**0.586**
2010	0.035	1.218	1.479	**2.732**	0.022	0.156	0.066	0.082	**0.326**	**2.406**
2011	0.115	0.933	0.126	**1.174**	0.000	0.013	0.023	0.051	**0.087**	**1.087**
2012	0.274	1.044	0.527	**1.845**	0.002	0.011	0.037	0.072	**0.122**	**1.723**
2013	0.057	0.800	0.550	**1.407**	0.006	0.010	0.036	0.046	**0.098**	**1.309**
2014	0.168	1.582	0.136	**1.886**	0.004	0.052	0.037	0.056	**0.149**	**1.737**
2015	0.273	2.302	0.570	**3.145**	0.008	0.006	0.039	0.081	**0.134**	**3.011**
2016	0.090	1.908	0.469	**2.467**	0.000	0.007	0.014	0.040	**0.061**	**2.406**
2017	0.271	1.506	0.201	**1.978**	0.000	0.010	0.060	0.056	**0.126**	**1.852**
2018	0.136	1.118	0.648	**1.902**	0.000	0.094	0.018	0.137	**0.249**	**1.653**
2019	0.000	1.162	0.000	**1.162**	0.001	0.026	0.034	0.029	**0.090**	**1.072**
2020	0.046	0.639	0.171	**0.856**	0.040	0.090	0.023	0.067	**0.103**	**0.753**
Total 90-20	**2.706**	**26.537**	**21.707**	**50.950**	**0.466**	**3.973**	**1.411**	**3.393**	**9.126**	**41.824**
Aver. 90-20	**0.087**	**0.856**	**0.700**	**1.644**	**0.015**	**0.128**	**0.046**	**0.109**	**0.294**	**1.349**

The areas of AR activities represent land use changes (kha/year) from Cropland (C), Grassland (G), and Other Land (OL) to Forest Land (FL), and areas of D activities represent land use changes from Forest Land (FL) to following land use categories Cropland (C), Grassland (G), Settlements (S) and Other Land (OL) from 1990 to 2018

The identified land-use change from Cropland, Grassland or Other Land converted to Forest Land, were categorized as ARF/REF (kha/year) and land use change from the Forest Land to Cropland, Grassland, Settlements or Other Land represent DEF (kha/year) in Slovak conditions for the period 1990 – 2020. The FM area represents the total forest area minus the AR areas. Comparison of ARD and FM areas reported under KP and areas of FL remaining FL and LUC to/from forest reported under UNFCCC (kha) is included in ***Table 11.7***. The equal areas under both reporting schemes have appeared for year 2009 (20 years of transition).

Table 11.7: *Comparison of the FL remaining FL and LUC to/from forest reported under the UNFCCC and ARD and FM areas reported under the KP (kha)*

YEAR	KP REPORTING					REPORTING UNDER CONVENTION		
	Annual AR	Total AR since 1990	Annual D	Total D since 1990	Total FM	4.A.1 FL remaining FL	4.A.2 LUC to forests 20yr transition period	4.B.2 – 4.F.2 LUC from forests 20yr transition period
	kha							
1990	3.770	3.770	0.809	0.809	1 985.219	1 809.147	179.842	38.684
1991	1.963	5.733	0.988	1.797	1 984.231	1 813.805	176.159	36.752
1992	1.467	7.200	0.324	2.121	1 983.907	1 817.647	173.460	36.504
1993	0.722	7.922	0.366	2.487	1 983.541	1 822.293	169.170	35.574
1994	0.559	8.481	0.351	2.838	1 983.190	1 833.676	157.995	34.575
1995	0.721	9.202	0.135	2.973	1 983.055	1 861.769	130.488	31.334
1996	1.577	10.779	0.468	3.441	1 982.587	1 868.438	124.928	28.971
1997	3.395	14.174	0.388	3.829	1 982.199	1 873.390	122.983	26.429
1998	2.288	16.462	0.378	4.207	1 981.821	1 881.172	117.111	25.726
1999	2.102	18.564	0.297	4.504	1 981.524	1 887.294	112.794	25.108
2000	1.292	19.856	0.127	4.631	1 981.397	1 929.759	71.494	24.789
2001	1.178	21.034	0.302	4.933	1 981.095	1 935.707	66.422	21.794
2002	0.793	21.827	0.149	5.082	1 980.946	1 938.383	64.390	17.533
2003	1.648	23.475	0.321	5.403	1 980.625	1 939.252	64.848	15.191
2004	0.992	24.467	0.166	5.569	1 980.459	1 941.977	62.949	14.497
2005	0.842	25.309	0.534	6.103	1 979.925	1 945.133	60.101	13.965
2006	1.945	27.254	0.239	6.342	1 979.686	1 961.945	44.995	12.921
2007	0.656	27.910	0.454	6.796	1 979.232	1 963.896	43.246	11.961
2008	1.438	29.348	0.323	7.119	1 978.909	1 968.266	39.991	10.211
2009	1.048	30.396	0.462	7.581	1 978.447	1 978.447	30.396	7.581
2010	2.732	33.128	0.326	7.907	1 978.121	1 981.891	29.358	7.098
2011	1.174	34.302	0.087	7.994	1 978.034	1 983.767	28.569	6.197
2012	1.845	36.147	0.122	8.116	1 977.912	1 985.112	28.947	5.995
2013	1.407	37.554	0.098	8.214	1 977.814	1 985.736	29.632	5.727
2014	1.886	39.440	0.149	8.363	1 977.665	1 986.146	30.959	5.525
2015	3.145	42.585	0.134	8.497	1 977.531	1 986.733	33.383	5.524
2016	2.467	45.052	0.061	8.558	1 977.470	1 988.249	34.273	5.117
2017	1.978	47.030	0.126	8.684	1 977.344	1 991.518	32.856	4.855
2018	1.902	48.932	0.249	8.933	1 977.095	1 993.557	32.470	4.726
2019	1.162	50.094	0.090	9.023	1 977.005	1 995.569	31.530	4.519
2020	0.856	50.950	0.103	9.126	1 976.902	1 996.758	31.094	4.495

11.2.3 MAPS AND/OR DATABASE TO IDENTIFY THE GEOGRAPHICAL LOCATIONS, AND THE SYSTEM OF IDENTIFICATION CODES FOR THE GEOGRAPHICAL LOCATIONS

Each cadastral unit is a part of the Slovak Cadastral system. Maps in digital format are available online. Beside this since 1st February 2004 a Cadastral Portal (KAPOR) has been established. The KAPOR establishment was supported by Decree of the Slovak Government No. 540/2002 Coll., which has enacted the publication of real estate cadastre data on the Internet. KAPOR operation has been supported also by the European Union within the framework of PHARE project. KAPOR enables the access of users to the real estate cadastre data.

11.3 ACTIVITY-SPECIFIC INFORMATION

11.3.1 METHODS FOR CARBON STOCK CHANGE AND GHG EMISSION AND REMOVAL ESTIMATES

11.3.1.1 Description of the methodologies and the underlying assumptions used

Summary of the emissions, methodologies and emission factors applied is given in ***Table 11.8***.

Table 11.8: *Reported emissions, tiers and emission factors (EFs) in the KP LULUCF sector in 2020*

CATEGORY		CO_2		CH_4		N_2O	
		METHOD APPLIED	EF	METHOD APPLIED	EF	METHOD APPLIED	EF
KP A.1	**Afforestation and Reforestation**						
KP A.1	Afforestation and Reforestation	T1, T2	CS, D	T2	CS, D	T2	CS, D
4 (KP-II) 4	Biomass Burning	T1, T2	CS, D	T2	CS, D	T2	CS, D
KP A.2	**Deforestation**						
KP A.2	Deforestation	T1, T2	CS, D	-	-	-	-
KP B.1	**Forest Management**						
KP B.1	Forest Management	T1, T2	CS, D	-	-	-	--
4 (KP-II) 4	Biomass Burning	T1, T2	CS, D	T2	CS, D	T2	CS, D
4 (KP-II) C	Carbon stock changes in the harvested wood products (HWP) pool	T2	CS, D	-	-	-	-

The estimations of emissions and/or removals of CO_2 are quantified for changes in five ecosystems carbon pools, namely above-ground biomass, below-ground biomass, dead wood, litter and soil organic matter in the KP LULUCF reporting. Methods of carbon stock changes calculations for ARD and FM activities are divided into three sub-sections: Change in Carbon Stocks in Living Biomass, Change in Carbon Stocks in Dead Organic Matter, Change in Carbon Stocks in Soils. More detail on the methods used can be found in the **Chapter 6** of this Report.

- Change in Carbon Stocks in Living Biomass for Afforestation/Reforestation:

Annual changes in carbon stocks in living biomass were estimated following tier 1 and tier 2 approaches and Equation 2.7 (IPCC 2006 GL). The annual increase in biomass carbon stock is estimated using Equation 2.9 (IPCC 2006 GL). Changes in carbon stocks in living biomass on Land converted to Forest Land through artificial regeneration were estimated as the annual increase in carbon stock in living biomass, the annual increment of tree species in young stages was derived from the specific research activities oriented to the biomass quantification in initial stages of forest stands.

Annual change in carbon stocks in living biomass in afforested land: $\Delta C_{LFLB} = \Delta C_{LFGROWTH} - \Delta C_{LFLOSS}$

Where: $\mathbf{\Delta C_{LFLB}}$ - annual change in carbon stocks in living biomass in afforested land, t C/y; $\mathbf{\Delta C_{LFGROWTH}}$ - annual increase in carbon stocks in living biomass due to growth in Land converted to Forest Land, t C/y; $\mathbf{\Delta C_{LFLOSS}}$ - annual decrease in carbon stocks in living biomass due to losses from harvesting, fuel wood gathering and disturbances in Land converted to Forest Land, t C/y.

- Annual Increase in Carbon Stocks in Living Biomass:

The method follows Equation 2.9 (IPCC 2006 GL).

Annual increase in carbon stocks in living biomass in Land converted to Forest Land: $\Delta C_G = (\sum A \bullet G_{TOTAL}) \bullet CF$

Where: $\mathbf{\Delta C_G}$ - annual increase in carbon stocks in living biomass due to growth in Land converted to Forest Land, t C/y; **A** - area of Land converted to Forest Land (including plantations), ha; $\mathbf{G_{Total}}$ - annual growth rate of biomass in forest (including plantations), t dm/ha/y; **CF** = carbon fraction of dry matter (default = 0.5), t C /(t dm).

The carbon increment is proportional to the extent of afforested/reforested areas and the biomass increment per hectare and year. The new afforested areas were obtained from cadastral database. The annual increment of the above-ground and below-ground tree biomass for four main tree species including Norway spruce, Scotch pine, European beech and Sessile oak in young forest plantations were selected from experimental database of the National Forest Centre. These data were published by Priwitzer et al. (2008), Priwitzer et al. (2009) and Pajtík et al. (2011). The annual increment of the above-ground tree biomass for the four main tree species included in the inventory are following: spruce 2.74 t dm/ha/y, pine 3.17 t dm/ha/y, beech 2.32 t dm/ha/y, oak 1.23 t dm/ha/y. These values are lower than used for FM within activities under Article 3.4. An average increment of the above-ground biomass (and merchantable volume as well) in Central-European forest stands peaks at an age of 30-40 years (Halaj & Petráš 1998, Pajtík et al. 2017). Moreover, yield tables of neighbouring countries (e.g. Austria, Czechia, Hungary and Germany, as well as the United Kingdom of Great Britain and Northern Ireland) indicate that biomass current annual increment or mean annual increment of above-ground biomass reaches maximum growth after 30–50 years since the beginning of afforestation. The activity data come from representative experimental plots, 7 plots per each tree species were established. Then, whole-tree samples including foliage, branches, stem and coarse roots were taken, oven-dried and weighed. We constructed allometric relationships for all tree compartments using tree height and/or diameter at stem base as independent variables. The tree biomass at the sites was measured and calculated by different compartments (stem, branches, roots and foliage) from the measured data 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. Biomass allocation into the tree compartments changed with stand size, also, some inter-specific differences were found. Most probably, carbon accumulated in the soil prevailed over carbon fixed in the biomass.

Table 11.9: *Proportion of the main tree species of the total artificial reforestation areas (%)*

YEAR	SPRUCE (PICEA SP.)	PINE (PINUS SP.)	BEECH (FAGUS SYLVATICA)	OAKS (QUERCUS SP.)
2013	46	22	29	3
2014	55	9	33	3
2015	45	21	30	4
2016	36	14	45	5
2017	35	12	48	5
2018	36	11	47	6
2019	36	11	48	5
2020	34	11	48	6

The annual increment of the below-ground biomass for the four main tree species included in the inventory are following: spruce 0.56 t dm/ha/y, pine 0.40 t dm/ha/y, beech 0.90 t dm/ha/y and oak 0.57 t dm/ha/y. The proportion of main tree species of total artificial reforestation areas for accounting years was selected from database of the Statistical Office of the Slovak Republic and shown in ***Table 11.9***.

- Annual Decrease in Carbon Stocks in Living Biomass Due to Losses:

In case of harvesting, fuel wood gathering and disturbances can be attributed to Land converted to Forest Land, annual losses in biomass should be estimated with use of Equation 2.11 (IPCC 2006 GL):

Annual decrease in carbon stocks in living biomass due to losses in Land converted to Forest Land: $\Delta C_L = L_{fellings} + L_{fuelwood} + L_{other\ losses}$

Where: ΔC_L - annual decrease in carbon stocks in living biomass due to losses in Land converted to Forest Land, t C/y; **$L_{fellings}$** - biomass loss due to harvest of industrial wood and saw logs in Land converted to Forest Land, t C y^{-1}; **$L_{fuelwood}$** - biomass loss due to fuelwood gathering in Land converted to Forest Land, t C/y; **$L_{other\ losses}$** - biomass loss due to fires and other disturbances in Land converted to Forest Land, t C/y.

The carbon loss connected with living biomass (caused by silvicultural cuttings) in the afforested/reforested land was assumed to be insignificant (zero). First argument for such approach is that the first thinning (with removing the biomass from forests) occurs in older age forest stands in the conditions of Slovakia. Second, is that in case of clearings the wood is not extracted from forest. It means that no losses of living biomass have occurred on AR areas in Slovakia. Beside this, the data on the amount of living biomass felled in forests till to the extraction of merchantable dimensions of wood are not available in the Slovak conditions and in general are considered to be zero.

- Change in Carbon Stocks in Living Biomass for Deforestation:

The method requires the estimates of carbon in living biomass stocks prior to deforestation, based on the estimates of the areas of land deforested during the period between land-use surveys. Because of deforestation, it is assumed that the dominant vegetation is removed entirely, resulting in no carbon remaining in living biomass after deforestation. The difference between initial and final living biomass carbon pools is used to calculate change in carbon stocks due to deforestation (Equation 2.16, IPCC 2006 GL).

The average change in carbon stocks estimated on a per area basis is to be equal to the change in carbon stocks due to the removal of living biomass from initial forests. Given the definition of the deforestation, the default assumption is that carbon stock after this activity is zero.

Annual change in carbon stocks in living biomass in Land converted to Other Land:

$$\Delta C_{Conv.} = A_{Conv.} \bullet (B_{After} - B_{Before}) \bullet CF$$

Where: $\Delta C_{Conv.}$ - annual change in carbon stocks in living biomass in Land converted to Other Land, t C/y; **$A_{Conv.}$** - area of annually deforested land from some initial land uses, ha/y; **B_{After}** - amount of living biomass immediately after deforestation, t d.m./ha; **B_{Before}** - amount of living biomass immediately before deforestation, t d.m./ha; **CF** = carbon fraction of dry matter (default = 0.5), t C/(t d.m.).

Tier 1 and tier 2 methods were used for calculation. It follows the approach in the Section 2.3.1.2 (IPCC 2006 GL) for Land converted to a new land use category, where the amount of aboveground biomass that is removed is estimated by multiplying the forest area deforested annually to other land by the average annual carbon content of biomass in the land prior to deforestation. It is assumed that the entire biomass is removed in the year of deforestation. The default assumption for the tier 1 method is that all carbon in biomass is released to the atmosphere through decay processes either on- or off-site.

For calculation of above ground biomass carbon stocks on Forest Land prior conversion, the annually updated average growing stock volumes, BCEFs (0.603 for conifers and 0.769 for broadleaves in 2020) and default carbon content (0.51 for conifers, 0.48 for broadleaves) were used. The average growing stock (m^3/ha) was estimated on the basis of forest taxation data in the Forest Management Plans (FMP), differently for the individual Slovak districts.

The default coefficients for the root/shoot ratio (R) - 0.20 for coniferous above-ground biomass 150 t/ha and 0.24 for broadleaves above-ground biomass 150 t/ha, were used for calculation of below-ground biomass stocks, Table 4.4 (IPCC 2006 GL). The average biomass stocks per ha for 8 different Slovak regions is from 132 to 183 t dm/ha for coniferous (mean 153) and from 153 to 194 t dm/ha (mean 178) for broadleaves. The cadastral data source demonstrates deforested area for individual regions.

- Change in Carbon Stocks in Living Biomass for Forest Management:

The carbon stock change in living biomass was estimated using a Gain-Loss method according to the Equation 2.7 (IPCC 2006 GL). This method is based on separate estimation of increments, removals and their 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 (IPCC 2006 GL). The methodologies as well as data used to estimate emissions/removals from FM activities were similar to those used for the FL remaining FL category (**Chapter 6.6**). However, the different areas of the activities compared to the UNFCCC category are considered in the estimates (**Chapter 11.2.2**).

- Change in Carbon Stocks in Dead Organic Matter for ARD and FM:

Methods to quantify emissions and removals of carbon in dead organic matter pools (deadwood and litter) following conversion of Land to Forest Land (Afforestation/Reforestation) or Forest Land to another type of land use (Deforestation) require estimates of the carbon stocks just prior to and just following conversion, and the estimates of the areas of lands converted during the period. Most of the land use categories (Cropland, Grassland, Settlements, Other Land) does not produce deadwood or litter (Grassland is producing litter, but this data does not exist in Slovakia), so that corresponding carbon pools prior to afforestation/reforestation can be taken as zero, as a default assumption.

The deadwood carbon pool consists of standing dead trees, stumps, coarse lying deadwood and small-sized lying deadwood not included in the litter or soil carbon pools in Slovak conditions. Quantification of deadwood was, unlike abroad, performed in such a way that all its components were determined in the same volume units (m^3 outside 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, while the diameter at the top of the cut area D and the stump height H represent input variables. The volume of the lying deadwood 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 IP or a sub-plot using the Smalian equation (Šmelko 2000). The volume of small-sized lying deadwood (having diameter from 1 to 7 cm) was estimated by the original method, where the volume of small-sized lying deadwood (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 deadwood multiplied by the area of IP, estimated coverage of small-sized lying deadwood, and tree species proportion (Šmelko et al. 2008). 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 on the basis of 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 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. The mean net annual accumulation of dead wood over 10 years period is 0.08 t C/ha/y. Following equation was used for calculation:

Annual changes in DW C stocks for ARD = net annual accumulation of DW (t C/ha/y) x converted area (kha).

Litter includes all non-living biomass with a size less than the minimum diameter chosen for dead wood (e.g., 0 cm) in Slovak conditions. This includes the surface organic layer (horizons L, F, H) as usually defined in soil typologies. 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 from it empirically. The small-sized lying deadwood (diameter between 0 and 7 cm), in various states of decomposition above the mineral soil are not a part of litter, because they are included to deadwood in Slovak conditions. This definition is similar to the definition of surface soil organic layer in forests which comprises all humus sublayers or sub-horizons (L, F, H – if present) including all non-living parts of biomass (foliage, seeds, buds, flowers). 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 including these humus layers.

The total carbon stock in litter represents 16.66 Mt C (mean value per area unit is 8.3 t C/ha). These values are derived from similar datasets of the Forest Monitoring System (FMS) and the National Forest Inventory (NFI) as a part of soil inventory.

The net carbon stock change in litter was estimated using the country specific tier 2 method. 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 of 8.3 t C/ha for C stocks in litter (representing surface organic layer) as well as 0.415 t C/ha/y as a net annual accumulation of litter over length of transition period were used for calculation of net carbon stock change in litter. Following equation was used for calculation:

Annual changes in litter C stocks for ARD = net annual accumulation of litter (t C/ha/y) x converted area (kha).

Litter stock under the new land use category was set to zero and transition period to one year to apply instant oxidation. The change in litter carbon stock in each year was calculated as the sum of annual changes in C stocks for each category of land use associated with ARD.

- Change in Carbon Stocks in Soils for ARD and FM:

Carbon stock changes in mineral soils are calculated based on the data from the soil inventory with the default assumption of 20 years period for carbon stock equilibrium in „new land use“ conditions (**Chapter 6** - Land converted to Forest Land for AR activity and Forest Land converted to Other Land-use categories for D activity). Calculations of carbon stock changes in mineral soils as a result of ARD activities follow the IPCC 2006 GL. The net carbon stock change in mineral soils was estimated using the country specific tier 2 method described in detail in **Chapter 6**. The average soil carbon stock per hectare, noted above (4.A.2 - Land converted to Forest Land), was used for estimation of net carbon stock change in mineral soil. These values are based on updated existing data sets from soil inventories and published information with the default assumption of 20 years period for carbon stock equilibrium in „new land use“ conditions.

Since the SVK NIR 2013, approach for soil organic carbon stocks in soil as for the soil depth calculation has been changed. In order to have results that are more precise and to improve the methodological comparability for different land-use, the soil carbon stocks to the depth 30 cm (not 100 cm as in previous years) was estimated. As was expected, the significant changes in soil carbon caused by land-use change during decades are only in topsoil (soil layers near the soil surface) and information sources about soil carbon stocks in deeper layers is limited, the bias is the data sets is lowered.

Results from the latest soil survey on agricultural soil have been used for calculation (Barančíková, Makovníková, 2013). In addition, pedotransfer function for soil bulk density estimation calibrated at national level was used to get more precise results of soil carbon stock change.

For respective land use categories following values were used in calculations of carbon stock changes in mineral soils (0-30 cm):

- Forest Land 89.02 t C/ha
- Cropland 60.11 t C/ha
- Grassland 74.95 t C/ha
- Other Land 53.85 t C/ha

The average annual C stock change in mineral soil for ARD was calculated as:

Annual changes in mineral soil C stocks for ARD = average annual change of SOC (t C/ha/y) x converted area (kha) and Average annual change of SOC = (mean SOC stock of FL – mean SOC stock of land converted to FL)/20.

The following values of mean annual soil carbon stock change were calculated for different types of conversion:

- A/R of Cropland +1.446 t C/ha/y
- A/R of Grassland +0.704 t C/ha/y
- A/R of Other Land +1.758 t C/ha/y
- D to Cropland -1.446 t C/ha/y
- D to Grassland -0.704 t C/ha/y
- D to Settlements and Other Land -1.758 t C/ha/y

The change in soil carbon stock in each year was calculated as the sum of annual changes in C stocks for each category of land use associated with land converted to forest or from forest in selected districts.

- N_2O emissions from disturbance associated with deforestation:

The emissions of N_2O (the annual release of N_2O from soils due to mineralization of soil organic matter after disturbance) were calculated by default tier 1 method using Equations 11.8 (IPCC 2006 GL). N_2O emissions were estimated on the basis of the detected changes in mineral soils on respective areas of FL converted to CL, GL, S and OL. Total emissions from disturbance associated with deforestation were 0.00713 Gg N_2O in 2020.

- GHG emissions from wildfires associated with Afforestation/Reforestation activities:

The emissions of greenhouse gases from wildfires were calculated on the basis of known areas burnt annually and the average biomass stock in forests according to the Equation 2.27 (IPCC 2006 GL). The burnt area connected to A/R activities was estimated as percentage of total burnt area. This percentage was calculated from areas of FM and areas of A/R activities in corresponding year. Total CH_4, N_2O emissions on AR and FM areas from wildfires are shown in ***Table 11.10***.

Table 11.10: *Total CH_4 and N_2O emissions on A/R and FM areas from wildfires*

YEAR	A/R		FM	
	t CH_4	*t N_2O*	*t CH_4*	*t N_2O*
2013	0.596	0.033	214.805	11.883
2014	0.444	0.025	152.406	8.431
2015	0.880	0.049	281.156	15.553
2016	0.461	0.026	139.974	7.743
2017	0.819	0.045	238.195	13.177
2018	0.710	0.039	198.770	10.996
2019	1.353	0.075	371.570	20.555
2020	1.407	0.078	380.144	21.029

11.3.1.2 Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected activities under Article 3.4

No carbon pool is omitted for activities under Article 3.3 . Net carbon stock changes in litter were reported separately as individual carbon pool. There is no practice of biomass burning, lime application and N fertilization at ARD areas in Slovakia. The calculation of N_2O emissions from disturbance associated with land use conversion to cropland was realized firstly in 2013 submission. Slovakia provides the estimation of GHG emissions from wildfires on A/R lands since 2014 on the basis of the recommendations of the ERT.

Slovakia has provided following justification for omitting the soil and inherently the litter C pools from the reporting under FM. Slovakia assumed that under the conditions of current forestry practices at the country level, forest soils and litter do not represent a net source of CO_2 emissions. This assumption was confirmed by soil data analysis (Slovak ICP forests data) during which the soil carbon stocks were estimated for two time levels in 1993 and 2006 (***Table 11.11***). The results of statistical analysis have not confirmed the changes of soil C stocks on FM areas. A similar conclusion was obtained from comparison of carbon stocks in litter. The litter C stock in 2006 was even found slightly higher compared to the first evaluation (1993).

In Central European conditions, within forest management according to the principles of sustainable forestry, the mineral soils and litter are not considered to be a source of net emissions (Pavlenda, 2016). The same assumption was made in countries with similar soils and climatic conditions (Hungary, Czech Republic).

The statistically representative empirical data from two Slovak NFIs, which would confirm this assumption, are under the evaluation. Slovakia analysed these values of carbon content by different types of soils and site conditions, and plans to report on this in the next submission.

Table 11.11: *Average litter and mineral soil C stocks on the FM areas*

YEAR	LITTER		MINERAL SOIL	
	Average	**Standard Deviation**	**Average**	**Standard Deviation**
	t C/ha		*t C/ha*	
1993	7.81	6.02	70.40	27.0
2006	7.87	6.53	68.67	28.3

11.3.1.3 Information on whether or not indirect and natural GHG emissions and removals have been factored out

The indirect and natural GHG emissions/removals have not been factored out.

11.3.1.4 Changes in data and methods since the previous submission

The emissions/removals for ARD activities were recalculated in 2022 submission. The whole time series were recalculated. The main reason for recalculation in AR included the new calculation of CSC in DW carbon pools following the ERT recommendation and in D included the recalculation of CSC in DW carbon pools. Recalculated CO_2 removals for AR activity differ from the submission in 2021 by 2.49% to 2.55% in particular years, the CO_2 removals increased by 2.52% in average. Recalculated CO_2 emissions for D activity differ from the submission in 2021 by -0.25% to 2.05% in particular years, the CO_2 emissions increased by 1.40% in average. All these changes improved the accuracy of the calculations.

The emissions/removals for FM activities were recalculated in 2022 submission. The whole time series were recalculated. The main reason for recalculation in FM included the calculation of CSC in DW carbon pools following the ERT recommendation. Another reason of recalculation in FM was change and correction of root-to-shoot ratios (using only 0.2 for coniferous and 0.24 for broadleaved; no specific value for oaks following the ERT recommendation. Recalculated CO_2 removals for FM activity differ from the submission in 2021 by 3.85% to 5.79% in particular years, the CO_2 removals increased by 4.76% in average. These changes improved the accuracy of the calculations.

11.3.1.5 Uncertainty analysis

In a reflection to the ERT recommendations made in previous reviews (latest No L.2 SVK ARR 2019, L.10 SVK ARR 2017), the NIS SR has started preparation work on improvement of uncertainty analyses of the key categories inside the **LULUCF sector**. During the years 2018 – 2021, work on the improvement of uncertainty analyses for the LULUCF categories was ongoing. The work on the Monte Carlo simulation started in the second half of 2018 and it has continued also during 2021. The KP activities were included in these analyses.

The uncertainties of activity data and EFs in individual C pools and KP activities analysis for KP A.1, KP A.2 and KP B.1 categories are in ***Table 11.12.***

Table 11.12: *Uncertainties of activity data and EFs in individual C pools and KP activities*

IPCC CATEGORY		ACTIVITY DATA	EMISSION FACTOR	EF REFERENCES
		%		
KP A.1	Afforestation and Reforestation - living biomass	3	40.61	IPCC 2006 GL
KP A.1	Afforestation and Reforestation - DOM (litter)	3	75.00	expert judgement
KP A.1	Afforestation and Reforestation - mineral soil	3	75.00	expert judgement
KP A.2	Deforestation - living biomass	3	107.98	IPCC 2006 GL (tab. 5.1, 6.4), Šmelko et al. 2003
KP A.2	Deforestation – DOM (DW/litter)	3	75.24	SVK NFI, expert judgement
KP A.2	Deforestation - mineral soil	3	75.00	expert judgement
KP B.1	Forest Management - living biomass	3	82.84	IPCC 2006 GL

The values of activity data and emission factors were used for estimation uncertainty in individual C pools and LU categories: default uncertainty values (IPCC 2006 GL) - areas of land use 3%, amount of harvest 20%, carbon fraction in dry wood mass 2%, root/shoot factor 30%, extracted volume of roundwood 20%. According to the expert estimation and based on statistical approach for the published estimation of wood stocks in the Slovak forests (Šmelko et al., 2003) the uncertainty interval is in the range ±15-20%. The uncertainty of current annual increment (CAI) can fluctuate from ±30 up to 60% (Šmelko et al., 2003) for individual forest stand. The uncertainty applicable to BCEF was 25%, which was derived from the work of Lehtonen et al. (2007). According to the expert estimation and based on statistical approach for the published estimation of wood stocks in the Slovak forests (Šmelko et al., 2003) the uncertainty interval is in the range ±15-20%.

The accuracy of tree biomass (dry mass) annual increment on new afforested areas represented by standard deviation was following: spruce ±1.56 t/ha/y, pine ±1.61 t/ha/y, beech ±2.04 t/ha/y and oak ±1.05 t/ha/y. The accuracy of below ground biomass annual increment on new afforested areas represented by standard deviation was following: spruce ±0.22 t dm/ha/y, pine ± 0.12 t dm/ha/y, beech ±0.55 t dm/ha/y and oak ±0.24 t dm/ha/y.

Accuracy of dead wood volume for different parts of DW and tree species was published by Šmelko et al. (2008). Concerning variability of soil carbon stocks in different site condition and different land use as well as expected differences in time for new soil organic matter equilibrium compared with the default 20-year period, the total uncertainty of C emission/removal for land use change of mineral soils can be estimated ±75%.

The results of the application of Monte Carlo simulations are provided in the **Annex A6.2** of this Report. Work will be continuing following the available capacities and sources.

11.3.1.6 Information on whether or not indirect and natural GHG emissions and removals have been factored out

Due to a lack of available methods in the IPCC 2006 GL and elsewhere, indirect and natural GHG emissions/removals have not been factored out.

11.3.1.7 Information on other methodological issues

No other information is available.

11.3.1.8 The year of the onset of an activity, if after 2013

Not relevant.

11.4 ARTICLE 3.3

11.4.1 INFORMATION THAT DEMONSTRATES THAT ACTIVITIES UNDER ARTICLE 3.3 BEGAN ON/OR AFTER 1ST JANUARY 1990 AND BEFORE 31ST DECEMBER 2012 AND ARE DIRECT HUMAN-INDUCED

Reporting under the Article 3.3 is based on the cadastral information provided by the Geodesy, Cartography and Cadastre Authority of the Slovak Republic (GCCA) on annual base. This is an official state institution and it is managed in accordance with the national legislation. The change of land-use classification is always initiated by landowners in the Slovak Republic, if the owners have interest to make the ARD activity. A special plan for undertaken Afforestation is needed. Deforestation activities require official administrative decisions in agreement with the Forest Act. Due these circumstances, all activities under the Article 3.3 are considered as direct human-induced.

11.4.2 INFORMATION ON HOW HARVESTING OR FOREST DISTURBANCE THAT IS FOLLOWED BY THE RE-ESTABLISHMENT OF FOREST IS DISTINGUISHED FROM DEFORESTATION

The temporarily (no more than 2 years) unstocked areas (e.g. harvested area, disturbances) are still considered as forest area and are not accounted as deforestation. According to the cadastral law deforestation means that the category of Forest Land was definitely and permanently changed to another land use category. It is strictly prohibited by law to make conversion from Forest Land into another category without official administrative decision and therefore all permanent deforestations are reflected in the cadastral database.

11.4.3 INFORMATION ON THE SIZE AND GEOGRAPHICAL LOCATION OF FOREST AREAS THAT HAVE LOST FOREST COVER BUT WHICH ARE NOT YET CLASSIFIED AS DEFORESTED

This is not possible to recognize from actually available data in the Slovak Republic.

With respect to the ERT recommendation No KL.12 (SVK ARR 2019), Slovakia explained that all temporarily unstocked areas (e.g. harvested area, disturbances) remain forests and are not accounted for as deforestation. Temporarily unstocked areas following forest management measures or forests with biotic and abiotic reduction of their crown coverage (e.g. windthrows, forest fire, pest outbreaks) maintain the natural succession of forest vegetation and site conditions and therefore remain part of the forest. Slovakia also emphasized that the National Forest Act obliges landowners to afforest the temporarily unstocked Forest Land and ensure the regeneration of forest areas without sufficient crown cover within a defined time span. On the other hand, deforestation represents a permanent and irreversible change of Forest Land to a different land-use category in Slovakia. The Slovak Forest Act obliges landowners or managers to officially apply to the appropriate forestry authorities for permanent deforestation, implying a long and administratively demanding process, captured in the inventories.

11.4.4 INFORMATION ON ESTIMATED EMISSIONS AND REMOVALS OF ACTIVITIES UNDER ARTICLE 3.3

The afforestation/reforestation activities represented the total net removals of -1 968.51 Gg of CO_2 eq. for the first commitment period. In 2013 – 2020, total net removals represented -3 301.98 Gg of CO_2 eq.

The deforestation activities represented the total net emissions of 401.32 Gg of CO_2 eq. in the period 2013 – 2020.

Detailed description of the methodological approaches used for calculation is given in **Chapter 6.5** of this Report. The estimated removals from ARD activities in the second commitment period are provided in ***Table 11.13***. Details are noted in corresponding CRF tables for the KP LULUCF.

Table 11.13: *Emissions and removals from the activities under the Article 3.3*

YEAR	Afforestation/Reforestation	Deforestation	Total
	CO_2 eq. (Gg)	*CO_2 eq. (Gg)*	*CO_2 eq. (Gg)*
2013	-454.30	42.87	-411.43
2014	-474.49	62.63	-411.86
2015	-509.65	60.53	-449.13
2016	-536.47	28.28	-508.18
2017	-557.71	56.20	-501.51
2018	-579.55	111.57	-467.98
2019	-591.12	39.24	-551.88
2020	-600.42	45.17	-555.25
Total	-3703.29	401.32	-3301.98

11.4.5 INFORMATION ON HARVESTED WOOD PRODUCTS UNDER ARTICLE 3.3

The HWP removals and emissions for activities under Article 3.3 were not considered for AR as wood from AR areas is not yet extracted for commercial use. The share corresponding to DEFf activities is not subject of HWP balance; it is subject of instantaneous oxidation.

A default method described in the IPCC 2013 KP Supplement has been applied to allocate the carbon stock changes to the particular forest activities under the Article 3.3 and 3.4 as follows:

$fj(i) = harvestj(i) / harvestTotal(i)$;

Where: fj(i) is a share of harvest originating from the particular activity j in year i, j is an activity FM or D in year i.

The share of DEF in particular years was as follows: 0.0030 in 2013, 0.0036 in 2014, 0.0036 in 2015, 0.0017 in 2016, 0.0033 in 2017, 0.0065 in 2018, 0.0023 in 2019 and 0.0032 in 2020.

11.5 ARTICLE 3.4

11.5.1 INFORMATION THAT DEMONSTRATES THAT ACTIVITIES UNDER ARTICLE 3.4 HAVE OCCURRED SINCE 1 JANUARY 1990 AND ARE HUMAN-INDUCED

The total forest area of Slovakia is managed and forest management is a planned activity (all forests have a forest management plan renewed every 10 years) covering regeneration and afforestation, clearing, regular thinning, logging (timber felling, skidding and hauling) and forest protection. According to Slovak Act on Forest it is mandatory to regenerate all areas that have been clear-cut within two years. State authorities regularly inspect all forest management activities. The forestry sector of Slovakia is regulated by several acts, which have been issued by the Government since 2005 and implemented by the Ministry of Agriculture and Rural Development of the Slovak Republic. These include Act No 360/2007 Coll., which has direct or indirect impacts on emissions in the **LULUCF sector**. It provides a basic framework for the conservation of forest soils, forest management, sustainable harvesting and the exploitation of forests. For all mentioned reasons all Forest Land is considered as managed and FM activities are human-induced.

The CO_2 removals from FM were related to the changes in ABG and BLG biomass and in DW C pools. The net removals in this activity were -7 420.92 Gg CO_2 in 2020. The emissions from biomass burning are associated with FM as well. The emissions of CH_4 and N_2O were 0.88 Gg CH_4 and 0.05 Gg N_2O in 2020. The net CO_2 eq. removals were -7 384.36 Gg in 2020. The values for the period 2013 – 2020 are shown in ***Table 11.14*** and in CRF KP tables.

The area reported under FM in the Article 3.4 is lower than the area reported in LULUCF in Forest Land remaining Forest Land (FL remaining FL). The reason is that under LULUCF, areas afforested prior to 1990 have been included in FL remaining FL since 2010, whereas lands under the Afforestation remained under Afforestation and did not move to the FM.

Table 11.14: *The FM area and the net GHG emissions from the Forest Management*

YEAR	AREA	CO_2	CH_4	N_2O	GHGs
	kha	*Gg*			*Gg CO_2 eq.*
2013	1 977.814	-7 330.59	0.55	0.03	-7 307.75
2014	1 977.665	-5 376.84	0.82	0.05	-5 342.80
2015	1 977.531	-5 925.42	0.92	0.05	-5 887.25
2016	1 977.470	-5 747.22	0.76	0.04	-5 715.63
2017	1 977.344	-5 685.39	0.85	0.05	-5 650.32
2018	1 977.095	-4 867.20	0.83	0.05	-4 832.57
2019	1 977.005	-5 471.76	0.98	0.05	-5 431.28
2020	1 976.902	-7 420.92	0.88	0.05	-7 384.36

11.5.2 INFORMATION RELATING TO FOREST MANAGEMENT

11.5.2.1 Conversion of natural forest to planted forest

Emissions arising from the conversion of natural forests to planted forests are not considered. All natural forests in Slovakia are included to National parks and are protected by specific laws. The conversion of natural forest to planted forest is for this reason impossible and does not occur.

11.5.2.2 Forest Management Reference Level (FMRL)

Slovakia is one of the Member States of the European Union (EU) for which the Joint Research Centre (JRC) of the European Commission developed projections in collaboration with two EU modelling groups. The models, G4M (Global Forestry Model) from the International Institute for Applied Systems Analysis and EFISCEN (European Forest Information Scenario Model) from the European Forest Institute, project annual estimates of emissions and removals for forest management until 2020 for the living (above- and below-ground) biomass carbon pool. To estimate the FMRL, the emissions and removals estimated by the models for the period 2000 to 2020 were calibrated/adjusted using historical data from the country for the period 2000 – 2008. Slovakia has not selected forest management for the first commitment period of the Kyoto Protocol and, therefore, the reference level is constructed for the area defined as Forest Land remaining Forest Land under the Convention. Historical data for 1900 – 1992 were assessed based on the averages of the earliest available five years (1993 – 1997). All models involved in the construction of the FMRL using the harvesting rate as input value use the same source of information (the FAOSTAT database).

The contribution of HWP to the reference level of Slovakia amounts to -1.415 Mt CO_2. The information on the methodological approach used to estimate the contribution of HWP was added. It was calculated using the C-HWP-Model, which estimates delayed emissions based on the annual stock change of semi-finished wood products as outlined in the IPCC 2006 GL (Rüter, 2011). The estimation uses the product categories, half-lives and methodologies as suggested in para 27, page 31 of the FCCC/KP/AWG/2010/CRP.4/Rev.4. The activity data (production and trade of sawn wood, wood based panels and paper and paperboard) were derived from the TIMBER database (UNECE 2011) (time series 1993 – 2009).

Forest Management Reference Level (FMRL) of Slovakia inscribed in the appendix to the annex to Decision 2/CMP.7 amounts to +358 Gg of CO_2 eq. per year assuming instant oxidation of HWP and -1 084 Gg of CO_2 eq. applying the first-order decay function for HWP.

11.5.2.3 Technical corrections of the FMRL

Slovakia follows the ERT recommendations published in the Report of the Technical Assessment of the Forest Management Reference Level submission of Slovakia submitted in 2011 and the ERT recommendation No KL.1 (SVK ARR 2017) to ensure methodological consistency between the FMRL and reporting for Forest Management during the CP2 and has applied a technical correction to the FMRL using the assistance from JRC.

During the LULUCF workshop organized by the Joint Research Centre (JRC) that took place in a virtual format in June 7 - 8 2021, Slovakia declared the need of support by JRC to perform the final technical correction (TC) of the forest management reference level (FMRL). This TC of the FMRL is needed to ensure a methodologically consistent accounting of forest management activities at the end of the second commitment period of the Kyoto Protocol in 2022.

At the request of the JRC, Slovakia provided following relevant information to assess how the TC would need to be implemented.

Methodological consistency between the FMRL and reporting for Forest Management during the CP2 was controlled by analysis of all methodological improvements and recalculations of reported GHG emissions since 2011. Because Slovakia has not selected forest management during CP1 and the emissions/removals under KP 3.4 in CP2 are calculated in the same methodological way as UNFCCC category 4.A.1 FL remaining FL, analysis was done for this category.

Identified changes included:

- 2012 – area of FL remaining FL category, current annual increment – CAI.
- 2013 – $BCEF_I$, $BCEF_R$, factor for the fraction of biomass left to decay in forest (fBL); root to shoot ratio and wood density (instead of the condensed BCEFs).
- 2014 – factor for the fraction of biomass left to decay in forest (fBL), BEF1 for some tree species.
- 2018 – biomass expansion factor for increment ($BCEF_I$), below-ground biomass to above-ground biomass ratio (R).
- 2019 – carbon fraction of dry matter.
- 2020 – new calculation of CSC in DW carbon pools, correction of tree species composition value.

Recalculations in category 4.A.1 FL remaining FL in particular years:

2012: The category FL remaining FL was recalculated for whole time period since 1990. The main reasons were the recalculation of land areas due to incorrect determination of the length of the transition period (21 years instead of 20 years) and the recalculation of current annual biomass increments (CAI) for all tree species. Recalculation of CAI seems to be the most important change leading to the higher GHG removals. Before 2012, CAI was calculated by the National Forest Centre using different methods in particular years (1990 – 1992 using old yield tables leading to underestimation, in 1993 – 2002 using combination of the old and new yield tables and since 2003 according to the new tables only). Since NIR 2012, calculation of CAI values is unified. CAI value is calculated as an increment of the total volume production, i.e., it is a “gross” value and it includes also the increment of trees which died due to the natural mortality.

2013: The FL remaining FL category was recalculated for the whole time period since 1990. The main reason was the application of a new national biomass expansion factor (BCEFs) in FL remaining FL category. The $BCEF_I$ (used to convert merchantable increment to total aboveground increment) and $BCEF_R$ (used to convert merchantable volume of harvest to total aboveground volume) were derived as recommended by ERT during the 2012 review. Furthermore, the factor for the fraction of biomass left to decay in forest (fBL) was included to the calculation of living biomass losses. The recalculation affected the amount of gains (8-20% decreasing in individual years) and losses (18-25% decreasing in individual years) in living biomass carbon pool. These changes improved comparability of LULUCF inventory by including the disaggregated values of root-shoot ratio, BEFs and wood density instead of the condensed “biomass expansion/conversion factors” in the NIR.

2014: The FL remaining FL category was recalculated for whole time period since 1990. The main reason was correction of the factor for the fraction of biomass left to decay in forest (fBL) used for calculation of annual carbon loss due to commercial felling. This factor had been changed from 0.1 to 0, following the recommendation of ERT. Also the BEF1 for breeding poplars and willows were corrected (from 0.95 to 1.28). The recalculation affected the amount of gains (1% increasing individual years) and losses (10% increasing in individual years) in living biomass carbon pool.

2018: Category FL remaining FL was recalculated since 1990. The main reason for recalculation in 4.A.1 was the change of biomass expansion factor for increment (BEFI) and values of below-ground biomass to above-ground biomass ratio (R). Recalculated values for 4.A category differ from the submission in 2017 by -5.75% to 4.03% in particular years

2019: Category FL remaining FL was recalculated since 1990. The main reason was the change of carbon fraction of dry matter, for coniferous 0.51 and for broadleaves 0.48, following the ERT recommendation. Recalculated values for the 4.A category differ from the 2018 submission by -5.97% to -0.62% in particular years, the net CO_2 eq. removals decreased by 1.87% in average.

2020: Category FL remaining FL was recalculated since 1990. The main reason for recalculation in 4.A.1 included the calculation of CSC in DW carbon pools following the ERT recommendation. Another reasons of recalculation in 4.A.1 was change and correction of root-to-shoot ratios (using only 0.2 for coniferous and 0.24 for broadleaved; no specific value for oaks following the ERT recommendation. Recalculated values for 4.A category differ from the 2021 submission by 4.76% to 19.00% in particular years, the net CO_2 eq. removals increased by 8.92% in average.

Comparison of input data used for estimation of FMRL with the data used for actually reported in GHG inventory:

Area of Forest Land remaining Forest Land:

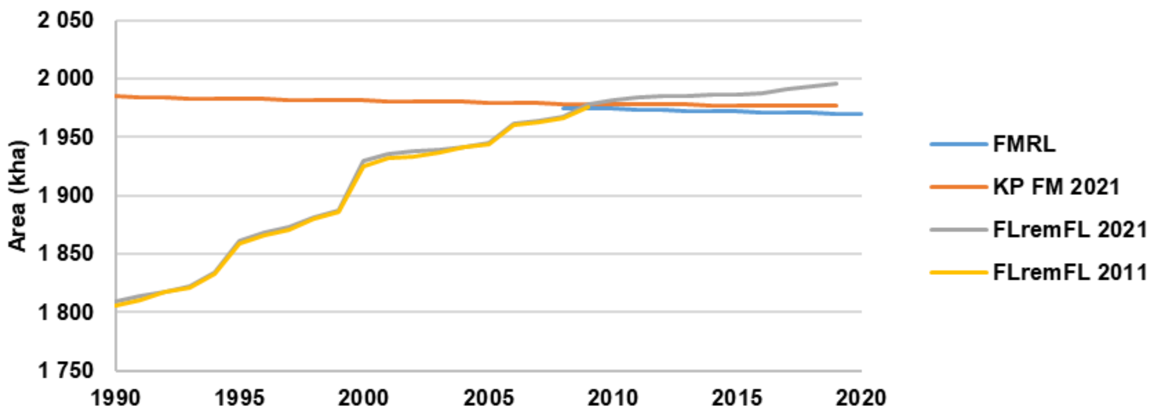
The area of forest management (FM) used in the construction of the FMRL was based on the area under FL remaining FL as a proxy (SVK had not selected the FM for 1 CP). There are only several very small changes (0.03-0.24%; 0.12% in average) in the areas under FL remaining FL between submission 2011 (used for the calculation FMRL) and submission 2021 (used for calculation TC) (***Table 11.15***).

Table 11.15: *Comparison of the area of FL remaining FL in submissions 2011 and 2021*

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008
	kha								
sub 2011	1 925.145	1 932.410	1 933.733	1 936.589	1 941.258	1 944.208	1 960.803	1 962.623	1 966.334
sub2021	1 929.759	1 935.707	1 938.383	1 939.383	1 939.252	1 941.977	1 945.133	1 961.945	1 968.266
diff. (%)	0.24	0.17	0.23	0.14	0.04	0.05	0.06	0.07	0.10

According to the "Report of the technical assessment of the FMRL submission of Slovakia submitted in 2011", in the run of models, the initial area under forest management is 1 975.000 kha and the projection shows almost no change in the Forest management area from 2008 and 2020 (slight decrease to 1 970.000 kha). The trend is in line with submission 2021 (***Figure 11.5***). No inconsistencies were identified in the areas of FL remaining FL category used for FMRL calculation (submission 2011) and used for GHGs inventory (submission 2021).

Figure 11.5: *Comparison of the development of FL/FL area in sub 2011 and sub 2021 and KP Forest Management – sub 2021, FMRL – area used by models for the estimation of FMRL*



Age structure:

No changes were found in the activity data for the age structure. Current data on the area (***Figure 11.6***) and volume by tree species (***Figure 11.7***) and age classes are the same as data used for modelling (initial year 2000).

Figure 11.6: *Comparison of data on the area of forest land structured by 10-years wide age classes*

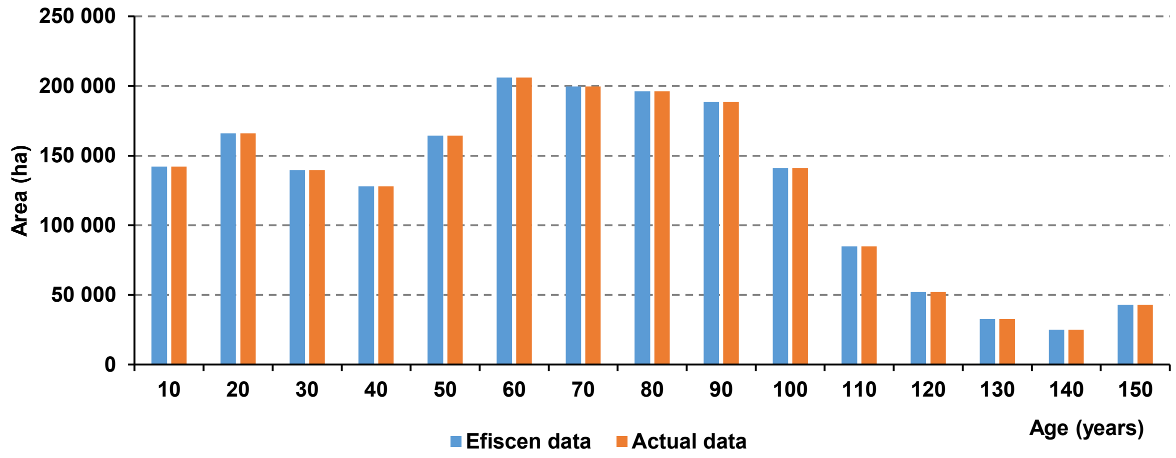
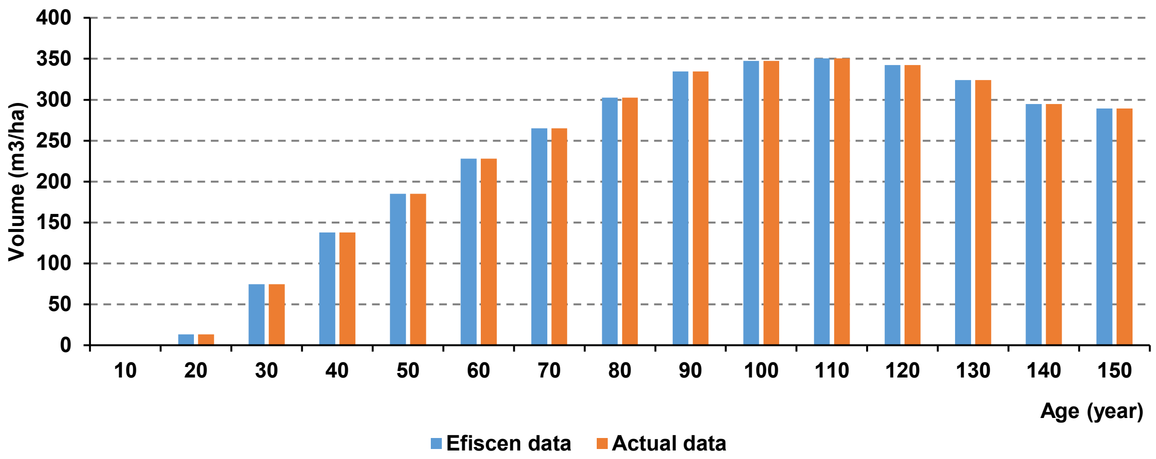


Figure 11.7: *Comparison of data on the volume per ha structured by 10-years wide age classes*

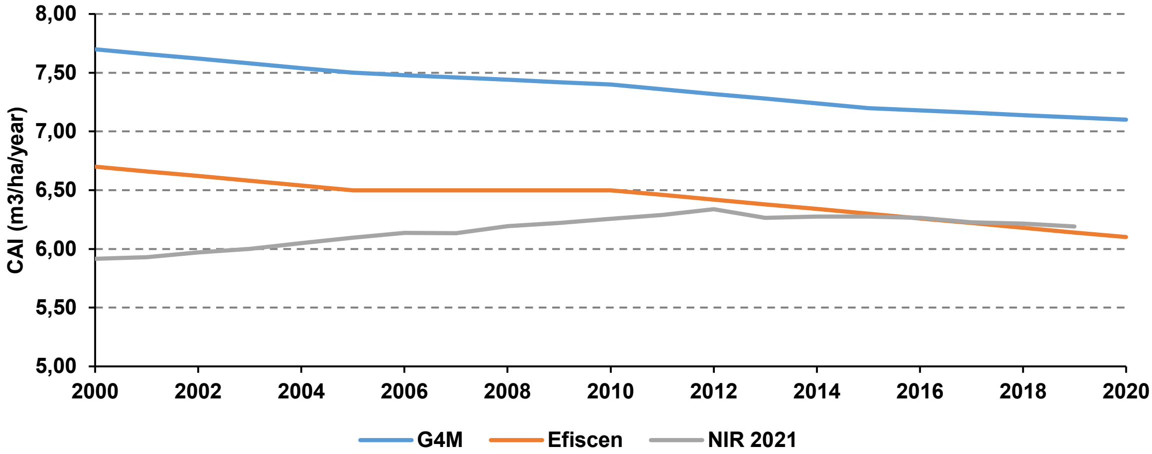


No inconsistencies were identified in the age structure used for the modelling by Efiscen and age structure based on current data.

Current annual increment:

The data on current annual increment (CAI, in m^3/ha/y) are the same in submissions 2011 and 2021, with the exception on hybrid poplars where the value increased due to the usage of new yield tables. However, this tree species covers only 0.5% of FL/FL area in Slovakia.

Figure 11.8: *Comparison of CAI (average value for FL/FL) used by the models (G4M, Efiscen) and SVK submission 2021*

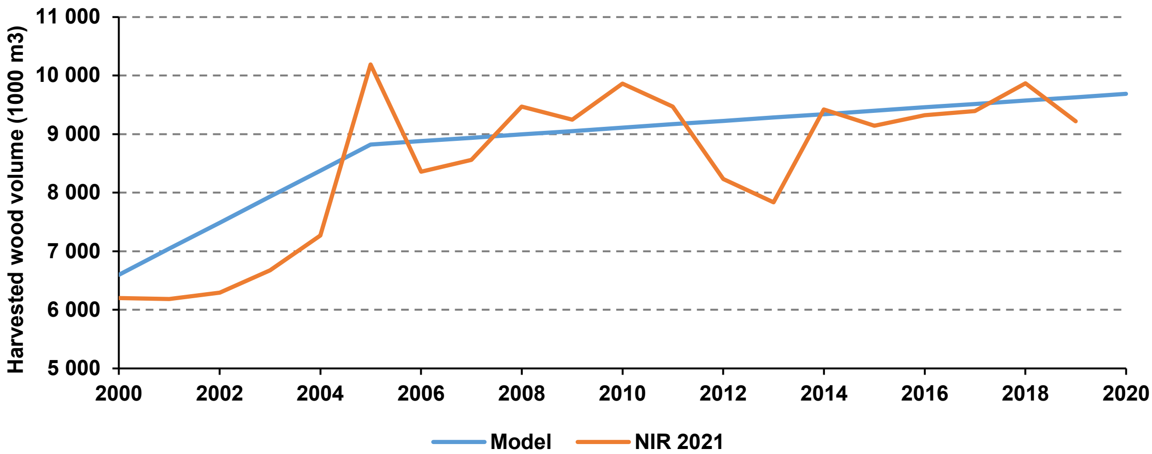


Comparison of average value of CAI for the whole forest area with the values used by G4M and Efiscen models for estimation of FMRL (***Figure 11.8***) shows that the real trend of CAI values was different in the period 2000 - 2011. Since that time, decreasing trend is in line with the values projected for the second commitment period and the real CAI values are almost exactly the same as values used by the Efiscen model.

Harvested volume and harvest rate:

Real harvest shows good coincidence with the model estimation (***Figure 11.9***). No inconsistencies were found regarding harvested wood volumes and harvest rate.

Figure 11.9: *Comparison of real harvested volumes with the model estimation*



Based on this information, the JRC provided to Slovakia official following statement concerning to assistance with Technical Correction (TC) of FMRL: “Based on your document where no inconsistencies have been found between the current inventory data and the model´s inputs used to estimate the FMRL, we do not see either the need for a new run of the models. In this case, as it was discussed during the meeting held on September 7, 2021, Slovakia could implement a recalibration approach to derive the Technical Correction that will ensure a consistent accounting of the KP activity FM during the CP2.”

The tool (MS Excel file) provided by the JRC was used for the calculation of TC of FMRL. This tool is able to modify simulation results of both models using ratio of originally reported values of emissions/removals for the reference period to the newly reported values, resulting in recalculation of FMRL (without HWP). Data from the same reference period (2000 to 2008) but reported in 2022 submission were used to calculate TC of FMRL. The tool (MS Excel file) provided by the JRC was used for the correction. This tool is able to modify simulation results of both models using ratio of originally reported values of emissions/removals for the reference period to the newly reported values, resulting in recalculation of FMRL (without HWP). The value of removals by HWP was kept constant (-1 442 Gg CO_2 eq.) and added to the modified FMRL without HWP. The change of carbon stock in dead wood was taken into account as well.

The difference between the original and the modified FMRL represents the value of the technical correction. The updated FMRL without HWP was set at -3 365 Gg CO_2 eq., i.e., the so-called the technical correction to be added to the original FMRL is -3 723 Gg CO_2 eq. FMRL, including harvested wood products, after technical correction is -4 807 Gg CO_2 eq.

No inconsistencies in input data for FMRL setting were found and methodological issues related to the changes in emissions/removals calculations were solved using recalibration approach to the estimation the TC of FMRL.

Accounted quantity (AQ = FM - FMRL) is a result of the deviations in different harvesting rates used for FMRL modelling and the real harvested data used for GHG inventory (***Figure 11.9***). The difference between the mean carbon balance of FL/FL over the period 2013 – 2020 (-5 196 Gg CO_2 eq.) and the corrected FMRL (-3 723 Gg CO_2 eq.) amounts to 1 473 Gg CO_2 eq.

Information on the implementation of the relevant PAMs listed in the Annex II (EU-level policies) to the submission on the FMRL can be find in the Fourth Biennial Report of Slovakia to the UNFCCC in the Chapter 4 https://unfccc.int/documents/230929. Updated information can be find in the 2021 submission of Slovakia under the Governance of the Energy Union and Climate Action regulation (EU) 2018/1999 and Commission Implementing Regulation (EU) 2020/1208, Article 18 on Policies and Measures. Further information can be find here https://reportnet.europa.eu/public/country/SK. Slovakia does not expect the direct impact of implementing these EU-level policies on the FMRL.

All energy policies implemented at the EU and national levels are taken by the PRIMES model as input values for the estimation of wood fuel demand driven by these policies. The output of PRIMES is further used as input for next step models. Forest management policies are not directly taken by models as input parameters but the impact of forest management policies is integrated into the projection process through increment and harvesting rates, and changes in age-class structure.

Furthermore, Slovakia confirms that no domestic policies other than those included by PRIMES have been taken into account when estimating the reference level.

According to the policy expert's judgment, there is no direct impact of policies adopted before 2009 on the future harvest rate in Slovakia. Impact on future harvest rates is caused by the age structure with an excess of older forests and also by the climate change causing the relative high sanitary fellings in older forest stands (mainly Norway spruce stands after bark beetle attacks or windthrows damage).

11.5.2.4 Information related to the natural disturbances provision under Article 3.4

According to Paragraph 33 (a) of the Annex to the decision 2.CPM 7, Slovakia does not intend to apply the provision to exclude emissions from natural disturbances for the accounting for afforestation and reforestation under Article 3, paragraph 3, of the Kyoto Protocol and/or Forest Management under Article 3, paragraph 4, of the Kyoto Protocol during the second commitment period.

11.5.2.5 Information on Harvested Wood Products under Article 3.4

Half-lives used in estimating emissions/removals for the HWP categories used:

- For the assessment, the half-lives were applied according to Table 2.8.2 in IPCC 2013 KP Supplements: 35 years for sawn wood, 25 years for wood-based panels and 2 years for paper products.

In the CP1, Slovakia reported only ARD activities. Emissions from HWP originating from management of forests have been included in the accounting since FM activity became mandatory (CP2).

Emissions from the HWP pool were not accounted for in the CP1. Emissions from HWP in SWDS are limited due to separation of waste. Wood harvested for energy purposes is complementary component to the HWP and is considered in AGB and BGB pools.

For HWP, the production approach was applied, based on domestic harvest. FAO database on forestry production and trade was used to derive production data from 1961 to 2020. Harvest from deforestation was separated and excluded from calculations to apply instant oxidation. ***Table 11.17*** shows domestic production of sawn wood, wood based panels and paper (including paper board) as used for HWP stocks changes. ***Table 11.16*** shows changes in C stock (Gg C) and net CO_2 emissions/removals (Gg CO_2 eq.) for HWP from the Article 3.4 activity (FM) in particular years.

Table 11.16: *Change in C stock and net CO_2 emissions/removals for HWP according to the Article 3.4 (FM) in particular years*

YEAR	2013	2014	2015	2016	2017	2018	2019	2020
	Gg CO_2 eq.							
Net CO_2 emissions/removals	**-440.40**	**-728.39**	**-940.67**	**-1 063.62**	**-1 076.92**	**-889.05**	**-644.90**	**-146.86**
Change in C stock	*Gg C*							
gains sawn wood	288.90	351.25	336.97	337.17	353.99	335.78	306.82	246.57
gains wood panels	157.46	166.69	236.17	258.72	271.28	251.16	240.78	193.21
gains paper	193.90	201.78	210.06	231.86	216.90	210.21	183.11	145.40
losses sawn wood	-209.44	-211.61	-214.21	-216.62	-219.15	-221.61	-223.57	-224.61
losses wood panels	-102.83	-104.45	-107.10	-110.94	-115.16	-119.15	-122.62	-125.20
losses paper	-207.89	-205.01	-205.35	-210.11	-214.16	-213.93	-208.64	-195.33

The uncertainty analysis of HWP category was guided by tier 1 method using the Equation 3.1 (Volume 1, Chapter 3, IPCC 2006 GL). For the input data, following information on relative uncertainty was used: round wood harvest: ±5% (national activity data from reporting of forest managers), sawn wood, wood panels, paper: ±10% (statistical survey). Conversion factors are as follows: wood density: ±25% (default from IPCC 2006 GL), carbon contents in wood products: ±10% (assessment of carbon content in wood). Emission factors (half-life estimates): ±50% (IPCC 2006 GL). The total relative uncertainty of carbon losses and gains in the HWP category was 58% in 2020.

Table 11.17: *Domestic production of sawn wood, wood based panels and paper (including paper board) as used for the HWP stocks changes in 1990 – 2020*

YEAR	SAWN WOOD	WOOD BASED PANELS	PAPER AND PAPERBOARD
	m^3		*t*
1990	792 651	399 986	449 039
1991	602 475	275 842	375 466
1992	440 916	208 231	237 645
1993	550 000	253 000	303 000
1994	700 000	328 000	299 000

YEAR	SAWN WOOD	WOOD BASED PANELS	PAPER AND PAPERBOARD
	m^3		t
1995	646 000	341 000	327 000
1996	629 000	312 000	467 000
1997	767 000	339 000	525 500
1998	1 265 000	339 000	597 400
1999	1 265 000	321 000	803 000
2000	1 265 000	346 000	925 000
2001	1 265 000	392 400	988 000
2002	1 265 000	449 000	710 000
2003	1 651 000	438 000	674 000
2004	1 837 000	508 000	798 000
2005	2 621 000	606 000	858 000
2006	2 440 000	827 000	888 000
2007	2 781 000	846 000	915 000
2008	2 841 520	952 020	921 445
2009	2 253 965	866 400	920 977
2010	2 575 740	688 500	780 356
2011	2 204 000	683 000	748 361
2012	1 560 000	675 000	736 000
2013	1 430 000	663 500	723 000
2014	1 750 000	707 000	793 000
2015	1 600 000	954 647	812 214
2016	1 580 000	1 032 100	858 900
2017	1 737 500	1 133 538	832 392
2018	1 730 000	1 101 596	839 264
2019	1 653 000	1 104 295	805 849
2020	1 522 000	1 015 256	762 737

11.5.3 INFORMATION RELATING TO CROPLAND MANAGEMENT, GRAZING LAND MANAGEMENT AND REVEGETATION, WETLAND DRAINAGE AND REWETTING IF ELECTED, FOR THE BASE YEAR

Slovakia not elected these activities for the second commitment period.

11.6 OTHER INFORMATION

11.6.1 KEY CATEGORY ANALYSIS FOR ARTICLE 3.3 ACTIVITIES, FOREST MANAGEMENT AND ANY ELECTED ACTIVITIES UNDER ARTICLE 3.4

Key categories are defined as the sources or removals of emissions that have a significant influence 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 2019 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 (**Chapter 1.2** and **Annex 1** of this Report). According to key category analysis, all activities under Article 3.3 (Afforestation, Reforestation and Deforestation) as well as under Article 3.4 (Forest Management) are considered as key categories.

11.7 INFORMATION RELATING TO ARTICLE 6

There are no activities connected to Article 6 in the Slovak Republic.

CHAPTER 12: INFORMATION ON ACCOUNTING OF KYOTO UNITS

12.1 BACKGROUND INFORMATION FOR THE SECOND COMMITMENT PERIOD

12.1.1 IDENTIFICATION OF BASE YEARS OF SLOVAKIA FOR THE SECOND COMMITMENT PERIOD

Base year for CO_2, N_2O and CH_4:

- For carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) the Slovak Republic use the year 1990 as base year with the following exceptions:
  - Base year for hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride and the identification of its selected base year for nitrogen trifluoride in accordance with Article 3, paragraph 8 of the Kyoto Protocol and 8bis:
  - For hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride, the choice of base year for the Slovak Republic remains as in the first commitment period the year 1990. According to Annex I of the Doha amendment to the Kyoto Protocol nitrogen trifluoride (NF_3) shall be included as a new gas in the second commitment period. The base year choices of the Slovak Republic related to NF_3 is 2010.

12.1.2 AGREEMENT UNDER ARTICLE 4 OF THE KYOTO PROTOCOL FOR THE SECOND COMMITMENT PERIOD

The Kyoto Protocol, under Article 4, provides the option for Parties to fulfil their commitments under Article 3 jointly, acting in the framework of and together with a regional economic integration organisation. For the first commitment period, the agreement of the European Union and its Member States to fulfil their respective commitments under Article 3, paragraph 1 of the Kyoto Protocol jointly (the joint fulfilment agreement) established quantified emission limitation and reduction commitments for the Union and its Member States. For the second commitment period, upon adoption of the Doha amendment to the Kyoto Protocol, the European Union and its Member States stated that the European Union and its Member States again intend to fulfil their reduction targets under the second commitment period jointly.[1] Moreover, the European Union and its Member States also expressed their intention to fulfil their commitments in the second commitment period of the Kyoto Protocol jointly with Iceland.

Table 12.1: *Emissions level of the Slovak Republic set out in the terms of the joint fulfilment for the second commitment period under the Kyoto Protocol*

SLOVAKIA	EMISSIONS LEVEL
	tons of CO_2 eq.
	202 268 939

[1] Declaration made in footnote to Annex B of the Doha Amendment.

12.1.3 CALCULATION OF THE ASSIGNED AMOUNT PURSUANT TO ARTICLE 3, PARAGRAPHS 7BIS, 8 AND 8BIS

The base year emissions of the Slovak Republic are aggregated in the same way as the annual greenhouse gas inventory of the Slovak Republic, while taking account of the appropriate base year for HFCs, PFCs, SF_6 and NF_3. ***Table12.2*** presents the base year emissions as well as the emissions in 1990 due to deforestation in 1990 that shall be included in the base year emissions for those countries for whom LULUCF constituted a net source of greenhouse gas emissions in 1990 in accordance with Article 3(7bis) of the Kyoto Protocol.

Table 12.2: *Base year emissions of the Slovak Republic, calculated pursuant to Article 3(7bis)*

SLOVAKIA	BASE YEAR EMISSIONS	NET EMISSIONS IN 1990 DUE TO DEFORESTATION WHERE LULUCF SECTOR IS A NET SOURCE OF EMISSIONS	FINAL BASE YEAR EMISSIONS, AFTER APPLICATION OF ART. 3(7BIS)
	t of CO_2 eq.		
	75 533 161	0	75 533 161

Pursuant to Article 3, paragraphs 7bis, 8 and 8bis of the Kyoto Protocol, the assigned amount for the second commitment period is equal to the percentage inscribed in the third column of Annex B of the Annex to the Doha amendment of the aggregate anthropogenic carbon dioxide equivalent emissions of greenhouse gases in the base year multiplied by eight, taking into account Article 3 (7bis) of the Kyoto Protocol.

This method of calculation is only applied to the calculation of the joint assigned amount of the European Union, its Member States and Iceland. It does not apply to the calculation of the individual assigned amounts for the Union, the Member States individually, or Iceland. Thus, the calculations of the base year emissions do not play a role in the calculation of their individual assigned amounts, which are instead determined pursuant to the joint fulfilment agreement which sets an assigned amount of 202 268 939 t of CO_2 eq. for the Slovak Republic.

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:

According to Article 3 (7ter) of the Doha Amendment of the Kyoto Protocol, any positive difference between the assigned amount of the second commitment period and the average annual emissions for the first three years of the preceding commitment period multiplied by eight shall be transferred to the cancellation account.

Table 12.3: *Assigned amount for the second commitment period and average emissions for the first three years of the preceding commitment period*

ASSIGNED AMOUNT FOR THE SECOND COMMITMENT PERIOD	202 268 939
AVERAGE ANNUAL EMISSIONS FOR 2008 TO 2010 MULTIPLIED BY EIGHT	380 416 187

The assigned amount for the second commitment period, is lower than average annual emissions for the period 2008 – 2010 multiplied by eight as indicated in ***Table 12.3***. Thus, no positive difference occurs and no cancellation needs to be performed.

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 2021 in format respecting both first and second commitment period (RREG1_SK_2021_1_2.xlsx and RREG1_SK_2021_2_2.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. The R-2 to R-5 reports (RREG2_SK_2021_1.xlsx, RREG3_SK_2021_1.xlsx, RREG4_SK_2021_1.xlsx and RREG5_SK_2021_1.xlsx) have been filled automatically respecting all requirements on format and are included in the submission.

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.

CALCULATION OF THE COMMITMENT PERIOD RESERVE (CPR)

Parties are required by decision 11/CMP.1 and paragraph 18 of decision 1/CMP.8 to establish and maintain a commitment period reserve as part of their responsibility to manage and account for their assigned amount. The commitment period reserve equals the lower of either 90% of a Party's assigned amount pursuant to Article 3, paragraphs 7bis, 8 and 8bis or 100% of its most recently reviewed inventory (2018), multiplied by 8. ***Table 12.4*** provides a calculation using both methods to calculate the commitment period reserve. The last column presents the commitment period reserve applicable for the second commitment period for Slovakia based on the lower value resulting from the two methods.

Table 12.4: *Commitment period reserve of the Slovak Republic (*submission 2021 v4)*

SLOVAKIA	ASSIGNED AMOUNT FOR SECOND COMMITMENT PERIOD	90% OF ASSIGNED AMOUNT	100% OF MOST RECENTLY REVIEWED INVENTORY MULTIPLIED BY 8	COMMITMENT PERIOD RESERVE
	t of CO_2 eq.			
	202 268 939	182 042 046	318 210 795*	182 042 046

CHAPTER 13: INFORMATION ON CHANGES IN NATIONAL SYSTEM

There were no significant changes in the arrangement of the National Inventory System of the Slovak Republic during inventory preparation year 2021. National Inventory System description is provided in **Chapter 1.2**.

However, several changes occurred during the year 2021. 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). In addition, new internal (SHMÚ) expert on emission projections was included and continuing of harmonization process between the air pollutants and GHG inventories is still ongoing. 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 change of name or contact occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	There was a change in the cooperation arrangement during the reported period as the United Kingdom of Great Britain and Northern Ireland no longer operate their registry in a consolidated manner within the Consolidated System of EU registries.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	There has been 6 new EUCR releases (versions 12.4, 13.0.2, 13.2.1, 13.3.3 , 13.5.1 and 13.5.2) after version 11.5 (the production version at the time of the last Chapter 14 submission). No changes were applied to the database, whose model is provided in Annex A. No change was required to the application backup plan or to the disaster recovery plan. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	The changes that have been introduced with versions 12.4, 13.0.2, 13.2.1, 13.3.3, 13.5.1 and 13.5.2 compared with version 11.5 of the national registry are presented in Annex B. It is to be noted that each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and are carried out prior to the relevant major release of the version to Production (see Annex B). No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	No changes regarding security were introduced.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No change to the list of publicly available information occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change 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 are 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.

Adopted Legislative Measures:

a) Fiscal Policy Instruments

Fiscal policy instruments are deemed to be an efficient instrument to correct existing environmentally related price distortions. The Slovak Republic maintains excise taxes on fossil fuels, electricity and mineral oils. The budgetary situation in the aftermath of the COVID-19 pandemic has been complicated and the government had to adopt numerous measures to deal with its economic and social consequences. Even though there will be an increased pressure to improve the general government budget balance in the upcoming years, elements of a green tax reform are being considered. As a part of the 2017 Spending Review, there was a proposal to scrap socially motivated tax exemptions on energy excise taxes. However, the decision was eventually not made. On the other hand, an increase in landfilling fees is believed to bring about a significant GHG and pollutants emissions decrease. This is especially significant as landfilling is responsible for the vast majority of GHG emissions associated with waste management. No impact on any third countries with respect to measures is expected from already implemented fiscal policies and therefore no specific policies to offset any negative effects have been considered.

b) Biofuels Policy

Biofuels policy has been in place to meet the targets required by EU legislation. Increased demand and subsequently also the production of biofuels has not only been reflected by rising commodity prices but also induced land use changes resulting from the reduction of the supply of commodities in direct competition with those used for biofuels world-wide. Therefore, international trade represents the key channel through which the potential negative economic, social and environmental impacts[2] might be transmitted towards developing countries. Taking into account the low quantities of biofuels in use in the Slovak Republic and domestic production of raw materials for their production, we do not expect any negative effects on neither forests destruction nor contribution to the rising world prices of agricultural

[2] Implied excessive land use changes, food shortages or compromised food security.

commodities.[3] In accordance with EU legislation, Slovakia accepts only the sustainable biofuels for fulfilment of the targets and their minimum share in motor fuels, monitors the production of raw materials for so-called ILUC biofuels, have established a cap for biofuels from food and feed materials, and we support the production of biofuels from waste and residues as well as the production of advanced biofuels. The data show, that the import of biofuels and raw materials for their production from developing countries is very negligible. In 2020, 3.5% of all the biofuels placed on the Slovak market was from developing countries. This value is connected to the biofuels made from raw materials, not from used cooking oil.

c) GHG Reduction Policies

The key policy option was a development of emerging carbon market with resulting carbon price. Among the complementary policies, targets have been adopted to increase the share of renewable energy resources, increase energy efficiency as well as the new legislation, which sets more stringent quality standards for fuels and personal cars.

Adopted policies could have had some implications for third countries through either the underlying carbon market price mechanisms or requirements to comply with new and tighter environmental regulations. CO_2 emission trading (either EU ETS or Kyoto Protocol emission trading) and increasingly stringent fuel quality standards might have some impact. The major example of its direct impact on the third countries is the integration of the aviation sector into the trading scheme. Among indirect effects, the major example is the concern about a possible carbon leakage. Most of the impacts of carbon leakage (shifts of industrial activity to the countries without any GHG emission reduction commitments, potential downward pressure on oil prices, etc.) on the third countries would in fact be rather positive for them.[4] Measures in place to minimize a potential carbon leakage include the provision to enlist the economic sectors facing immediate threat of carbon leakage, which under given conditions continue will receiving their CO_2 allowances free. Additionally, a carbon border adjustment mechanism, presented in July 2021, represents a mechanism for addressing greenhouse gas emissions embedded in goods produced in third countries and imported into the customs territory of the European Union, which ultimate goal is to reduce the carbon footprint in particular goods and ultimately reduce the emission intensity of the production at global level. As the proposal was presented in 2021, the negotiations were kicked-off swiftly and the envisaged deal on a mechanism is expected in the following year with a launch of the transitional period from 1 January 2023.

As far as GHG reduction policies is concern, no new or additional policies were introduced, Slovakia expects that following new EU reduction targets presented in the climate-energy package Fit for 55 related to the year 2030 (and subsequently to year 2050), these policies will impact on the third countries and will be assessed in this respect. For completing information in year 2021, Slovakia is channelling its Official Development Assistance (ODA) to third countries through projects, where climate change component as a cross-sectoral issue is incorporated. Climate change is then reflected in the projects oriented to food safety and agriculture, infrastructure and sustainable use of resources (e.g. strengthening food security building resilience of local communities to affect climate change in agriculture). Other projects aim to improve the health of the population with special emphasis on children and mothers, by making them accessible quality health and preventive care, what refers also to the illness caused by climate change impacts. Referring to the projects to reduce youth unemployment, improving access to quality education and acquisition practical skills, climate component is taken in consideration, even though in limited scale.

[3] Please note that the different conclusion might be drawn when considering the implications of the overall EU biofuel policies. Similarly, this would also apply in considering the existing agricultural policies within the EU Common Agricultural Policy.

[4] In some specific cases, where the polluting entity seeking a location in developing country causing an increase of local pollution, increased environmental damage might outweigh economic benefits.

Furthermore, increasingly stringent fuel quality standards, proposed increased CO_2 emission standards for cars and vans, and deployment of infrastructure for net-zero emission transport means in Europe might in fact turn out to be positive impact because it might trigger increase of investments in the fuel processing industries in third countries. Rising fuel prices in Europe due to the carbon price (or tax) and quality increase might counter play the rising oil prices particularly due to increasing scarcity of this commodity. Such effects might on the one hand negatively affect revenues of the oil exporting countries, which can be on the other hand still balanced by rising demand from the rest of the world. The final net impact will depend on the benefits derived from expansion of industrial production and costs needed to clean up higher levels of pollution including addressing its consequences.

Apart to emission trading, no other Kyoto Protocol flexible instruments have been used to meet the GHG emission reduction targets by the Slovak Republic, therefore no impact on third countries in this respect is reported. However, outcomes of COP26 held in November 2021, particularly completing the Katowice "Rulebook" represent a deal with an international significance for emission trading. Especially, an agreement on Article 6 of the Paris Agreement, including accounting rules for bilateral transfers between parties, a mechanism to replace the CDM, or provisions to no carryover of units from 2030 onwards, entails the opportunity to launch a robust and transparent framework for global emission trading.

Activities considered within the preparation of the adaptation strategy to climate change or the National recovery and resilience plan with a substantive climate importance have a local character without any implications to third countries.

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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 2020 according to Approach 1 and Approach 2 (including uncertainties) (IPCC 2006 GL) was performed with and without LULUCF by level and trend assessments. The results are presented in ***Tables A1.1 - A1.4***.

Analysis for the base year 1990 was performed by Approach 1 and 30 key categories with LULUCF and 26 without LULUCF were identified by level assessment. The results are presented in ***Table A1.5*** and ***Table A1.6***.

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 with LULUCF in 2020*

IPCC Category Code	IPCC Category	Gas	Emissions/ removals 2020	Level Assessment L1	Cumulative Total	Key in level analysis
2.F.1	Refrigeration and Air conditioning	F-gases	645.665	1.394	1.394	YES
1.A.1	Fuel combustion - Energy Industries - Liquid Fuels	CO_2	1 289.826	2.785	4.250	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	2 707.931	5.846	10.096	YES
1.A.1	Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	2 242.839	4.842	14.938	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	239.492	0.517	15.808	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	3 136.303	6.771	22.579	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	2 168.483	4.681	27.260	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	337.840	0.729	27.990	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	6 743.785	14.559	42.550	YES
1.A.3.e	Fuel combustion - Other Transportation	CO_2	167.827	0.362	43.081	YES
1.A.4	Fuel combustion - Other Sectors - Liquid Fuels	CO_2	286.895	0.619	43.700	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CO_2	457.468	0.988	44.688	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	3 634.768	7.847	52.535	YES
2.A.1	Mineral Industry - Cement Production	CO_2	1 443.145	3.116	55.826	YES
2.A.2	Mineral Industry - Lime Production	CO_2	430.648	0.930	56.755	YES
2.A.4	Mineral Industry - Other Process Uses of Carbonates	CO_2	326.545	0.705	57.500	YES
2.B.1	Chemical Industry - Ammonia Production	CO_2	703.092	1.518	59.018	YES
2.B.8	Chemical Industry - Petrochemical and Carbon Black Production	CO_2	381.655	0.824	59.941	YES
2.B.10	Chemical Industry - Other	CO_2	306.642	0.662	60.603	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	3 145.818	6.791	67.394	YES
2.C.3	Metal Industry - Aluminium Production	CO_2	238.708	0.515	68.373	YES
4.A.1	Forest Land - Forest Land Remaining Forest Land	CO_2	-7 294.533	15.748	84.341	YES
4.A.2	Forest Land - Land Converted to Forest Land	CO_2	-350.811	0.757	85.098	YES
4.B.1	Cropland - Cropland Remaining Cropland	CO_2	-1 147.040	2.476	87.574	YES
4.G	Harvested Wood Products	CO_2	-146.862	0.317	88.574	YES
1.B	Fugitive emissions from fuels - Solid Fuels	CH_4	7.142	0.385	89.521	YES
1.B.2.b	Fugitive emissions from fuels - oil, NG and Other - Natural gas	CH_4	7.002	0.378	89.916	YES
1.B.2.c	Fugitive emissions from fuels - oil, NG and Other - Venting and flaring	CH_4	2.007	0.108	90.024	YES
3.A	Enteric Fermentation	CH_4	38.654	2.086	92.114	YES
5.A	Solid Waste Disposal	CH_4	44.857	2.421	94.770	YES
5.D	Wastewater Treatment and Discharge	CH_4	11.143	0.601	95.665	YES
3.D.1	Direct N_2O Emissions From Managed Soils	N_2O	3.730	2.400	99.127	YES
3.D.2	Indirect N_2O Emissions From Managed Soils	N_2O	0.647	0.416	99.543	YES
1.A.1	Fuel combustion - Energy Industries - Liquid Fuels	CO_2	1 289.826	0.007	0.010	YES

Table A1.1: *Key categories identified using Approach 1 and Approach 2 by level assessment with LULUCF in 2020 – cont.*

IPCC Category Code	IPCC Category	Gas	Emissions/ removals 2020	Level Assessment L1	Cumulative Total	Key in level analysis
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	2 707.931	0.011	0.021	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	3 136.303	0.017	0.048	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	2 168.483	0.007	0.056	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	6 743.785	0.032	0.090	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	3 634.768	0.013	0.108	YES
2.B.8	Chemical Industry - Petrochemical and Carbon Black Production	CO_2	381.655	0.009	0.129	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	3 145.818	0.022	0.152	YES
2.D	Non-energy Products from Fuels and Solvent Use	CO_2	29.849	0.004	0.158	YES
4.A.1	Forest Land - Forest Land Remaining Forest Land	CO_2	-7 294.533	0.578	0.739	YES
4.A.2	Forest Land - Land Converted to Forest Land	CO_2	-350.811	0.019	0.758	YES
4.B.1	Cropland - Cropland Remaining Cropland	CO_2	-1 147.040	0.080	0.838	YES
4.C.2	Grassland - Land Converted to Grassland	CO_2	-93.170	0.007	0.849	YES
4.F.2	Other land - Land Converted to Other Land	CO_2	92.190	0.007	0.863	YES
4.G	Harvested Wood Products	CO_2	-146.862	0.007	0.870	YES
3.A	Enteric Fermentation	CH_4	38.654	0.008	0.892	YES
5.A	Solid Waste Disposal	CH_4	44.857	0.028	0.921	YES
5.D	Wastewater Treatment and Discharge	CH_4	11.143	0.008	0.937	YES
3.B	Manure Management	N_2O	0.503	0.001	0.947	YES
3.D.1	Direct N_2O Emissions From Managed Soils	N_2O	3.730	0.013	0.960	YES
3.D.2	Indirect N_2O Emissions From Managed Soils	N_2O	0.647	0.027	0.987	YES
5.B	Biological Treatment of Solid Waste	N_2O	0.326	0.008	0.998	YES

Table A1.2: *Key categories identified using Approach 1 and Approach 2 by level assessment without LULUCF in 2020*

IPCC Category Code	IPCC Category	Gas	Emissions/ removals 2020	Level Assessment L1	Cumulative Total	Key in level analysis
2.F.1	Refrigeration and Air conditioning	F-gases	645.665	1.745	1.745	YES
1.A.1	Fuel combustion - Energy Industries - Liquid Fuels	CO_2	1 289.826	3.486	5.320	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	2 707.931	7.318	12.639	YES
1.A.1	Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	2 242.839	6.061	18.700	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	3 136.303	8.476	28.265	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	2 168.483	5.860	34.125	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	337.840	0.913	35.038	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	6 743.785	18.225	53.266	YES
1.A.3.e	Fuel combustion - Other Transportation	CO_2	167.827	0.454	53.930	YES
1.A.4	Fuel combustion - Other Sectors - Liquid Fuels	CO_2	286.895	0.775	54.705	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CO_2	457.468	1.236	55.941	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	3 634.768	9.823	65.764	YES
2.A.1	Mineral Industry - Cement Production	CO_2	1 443.145	3.900	69.884	YES
2.A.2	Mineral Industry - Lime Production	CO_2	430.648	1.164	71.048	YES
2.A.4	Mineral Industry - Other Process Uses of Carbonates	CO_2	326.545	0.882	71.980	YES
2.B.1	Chemical Industry - Ammonia Production	CO_2	703.092	1.900	73.880	YES
2.B.8	Chemical Industry - Petrochemical and Carbon Black Production	CO_2	381.655	1.031	75.036	YES
2.B.10	Chemical Industry - Other	CO_2	306.642	0.829	75.864	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	3 145.818	8.502	84.366	YES
2.C.3	Metal Industry - Aluminium Production	CO_2	238.708	0.645	85.591	YES
1.B.1	Fugitive emissions from fuels - Solid Fuels	CH_4	7.142	0.483	87.051	YES
1.B.2.b	Fugitive emissions from fuels - oil, NG and Other - Natural gas	CH_4	7.002	0.473	87.546	YES
1.B.2.c	Fugitive emissions from fuels - oil, NG and Other - Venting and flaring	CH_4	2.007	0.136	87.682	YES
3.A	Enteric Fermentation	CH_4	38.654	2.612	90.297	YES
5.A	Solid Waste Disposal	CH_4	44.857	3.031	93.563	YES
5.D	Wastewater Treatment and Discharge	CH_4	11.143	0.753	94.683	YES
3.D.1	Direct N_2O Emissions From Managed Soils	N_2O	3.730	3.004	99.017	YES
3.D.2	Indirect N_2O Emissions From Managed Soils	N_2O	0.647	0.521	99.538	YES

Table A1.2: *Key categories identified using Approach 1 and Approach 2 by level assessment without LULUCF in 2020 – cont.*

IPCC Category Code	IPCC Category	Gas	Emissions/ removals 2020	Level Assessment L2	Cumulative Total	Key in level analysis
1.A.1	Fuel combustion - Energy Industries - Liquid Fuels	CO_2	1 289.826	0.019	0.025	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	2 707.931	0.028	0.053	YES
1.A.1	Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	2 242.839	0.020	0.073	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	3 136.303	0.042	0.121	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	2 168.483	0.019	0.140	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	6 743.785	0.081	0.226	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	3 634.768	0.032	0.272	YES
2.B.1	Chemical Industry - Ammonia Production	CO_2	703.092	0.012	0.300	YES
2.B.8	Chemical Industry - Petrochemical and Carbon Black Production	CO_2	381.655	0.023	0.325	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	3 145.818	0.055	0.382	YES
2.D	Non-energy Products from Fuels and Solvent Use	CO_2	29.849	0.009	0.397	YES
1.A.4	Fuel combustion - Other Sectors - Biomass	CH_4	7.824	0.023	0.427	YES
1.B.2.b	Fugitive emissions from fuels - oil, NG and Other - Natural gas	CH_4	7.002	0.002	0.433	YES
3.A	Enteric Fermentation	CH_4	38.654	0.046	0.480	YES
3.B	Manure Management	CH_4	3.475	0.009	0.489	YES
5.A	Solid Waste Disposal	CH_4	44.857	0.070	0.559	YES
5.B	Biological Treatment of Solid Waste	CH_4	5.431	0.020	0.579	YES
5.D	Wastewater Treatment and Discharge	CH_4	11.143	0.021	0.600	YES
3.B	Manure Management	N_2O	0.503	0.035	0.659	YES
3.D.1	Direct N_2O Emissions From Managed Soils	N_2O	3.730	0.268	0.928	YES
3.D.2	Indirect N_2O Emissions From Managed Soils	N_2O	0.647	0.047	0.974	YES
5.B	Biological Treatment of Solid Waste	N_2O	0.326	0.021	0.996	YES

Table A1.3: *Key categories identified using Approach 1 and Approach 2 by trend assessment with LULUCF in 2020*

IPCC Category Code	IPCC Category	Gas	Trend Assessment T1	Contribution to trend %	Cumulative Total	Key in trend analysis
2.F.1	Refrigeration and Air conditioning	F-gases	0.01	1.88	1.88	YES
1.A.1	Fuel combustion - Energy Industries - Liquid Fuels	CO_2	0.00	1.21	3.19	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	0.04	8.85	12.04	YES
1.A.1	Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	0.01	3.70	15.74	YES
1.A.1	Fuel combustion - Energy Industries - Other Fossil Fuels	CO_2	0.00	0.43	16.17	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	0.01	3.03	19.20	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	0.01	2.61	21.81	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	0.00	0.72	23.74	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	0.06	13.78	37.51	YES
1.A.3.c	Fuel combustion - Railways	CO_2	0.00	0.27	37.79	YES
1.A.3.e	Fuel combustion - Other Transportation	CO_2	0.01	1.87	39.67	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CO_2	0.03	7.58	47.34	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	0.02	5.85	53.19	YES
2.A.1	Mineral Industry - Cement Production	CO_2	0.01	2.30	55.92	YES
2.B.1	Chemical Industry - Ammonia Production	CO_2	0.01	1.62	58.17	YES
2.B.8	Chemical Industry - Petrochemical and Carbon Black Production	CO_2	0.00	0.55	58.86	YES
2.B.10	Chemical Industry - Other	CO_2	0.00	0.74	59.60	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	0.02	3.74	63.33	YES
2.C.3	Metal Industry - Aluminium Production	CO_2	0.00	0.54	64.11	YES
4.A.1	Forest Land - Forest Land Remaining Forest Land	CO_2	0.04	9.50	73.83	YES
4.A.2	Forest Land - Land Converted to Forest Land	CO_2	0.04	9.21	83.04	YES
4.B.1	Cropland - Cropland Remaining Cropland	CO_2	0.01	2.95	85.99	YES
4.B.2	Cropland - Land Converted to Cropland	CO_2	0.00	0.45	86.45	YES
4.C.2	Grassland - Land Converted to Grassland	CO_2	0.00	0.66	87.11	YES
4.G	Harvested Wood Products	CO_2	0.01	1.70	89.01	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CH_4	0.00	0.39	89.50	YES
1.B.1	Fugitive emissions from fuels - Solid Fuels	CH_4	0.00	0.36	90.41	YES
1.B.2.b	Fugitive emissions from fuels - oil, NG and Other - Natural gas	CH_4	0.00	0.93	91.34	YES
3.A	Enteric Fermentation	CH_4	0.00	0.83	92.79	YES
3.B	Manure Management	CH_4	0.00	0.31	93.10	YES
5.A	Solid Waste Disposal	CH_4	0.01	2.36	95.51	YES
2.B.2	Chemical Industry - Nitric Acid Production	N_2O	0.01	1.26	97.81	YES
2.C.3	Metal Industry - Aluminium Production	PFCs	0.00	0.39	99.95	YES

Table A1.3: *Key categories identified using Approach 1 and Approach 2 by trend assessment with LULUCF in 2020 – cont.*

IPCC Category Code	IPCC Category	Gas	Trend Assessment T2	Contribution to trend %	Cumulative Total	Key in trend analysis
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	0.16	1.63	2.31	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	0.08	0.79	3.80	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	0.28	2.96	7.80	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CO_2	0.20	2.05	10.33	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	0.11	1.18	14.15	YES
4.A.1	Forest Land - Forest Land Remaining Forest Land	CO_2	3.25	34.12	48.99	YES
4.A.2	Forest Land - Land Converted to Forest Land	CO_2	2.14	22.47	71.46	YES
4.B.1	Cropland - Cropland Remaining Cropland	CO_2	0.89	9.34	80.80	YES
4.B.2	Cropland - Land Converted to Cropland	CO_2	0.15	1.60	82.40	YES
4.C.2	Grassland - Land Converted to Grassland	CO_2	0.22	2.32	84.72	YES
4.G	Harvested Wood Products	CO_2	0.35	3.65	89.10	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CH_4	0.08	0.83	90.10	YES
3.A	Enteric Fermentation	CH_4	0.03	0.32	92.02	YES
3.B	Manure Management	CH_4	0.01	0.08	92.10	YES
5.A	Solid Waste Disposal	CH_4	0.25	2.65	94.77	YES
3.B	Manure Management	N_2O	0.00	0.04	97.34	YES

Table A1.4: *Key categories identified using Approach 1 and Approach 2 by trend assessment without LULUCF in 2020*

IPCC Category Code	IPCC Category	Gas	Trend Assessment T1	Contribution to trend %	Cumulative Total	Key in trend analysis
2.F.1	Refrigeration and Air conditioning	F-gases	0.01	2.39	2.39	YES
1.A.1	Fuel combustion - Energy Industries - Liquid Fuels	CO_2	0.01	2.36	4.87	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	0.05	14.00	18.87	YES
1.A.1	Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	0.02	4.24	23.12	YES
1.A.1	Fuel combustion - Energy Industries - Other Fossil Fuels	CO_2	0.00	0.54	23.66	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	0.02	4.47	28.13	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	0.02	5.25	33.38	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	0.00	0.88	34.95	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	0.06	16.58	51.52	YES
1.A.3.c	Fuel combustion - Railways	CO_2	0.00	0.43	51.95	YES
1.A.3.e	Fuel combustion - Other Transportation	CO_2	0.01	2.77	54.74	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CO_2	0.04	11.11	65.87	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	0.02	6.68	72.55	YES
2.A.1	Mineral Industry - Cement Production	CO_2	0.01	2.61	75.81	YES
2.A.4	Mineral Industry - Other Process Uses of Carbonates	CO_2	0.00	0.38	76.35	YES
2.B.1	Chemical Industry - Ammonia Production	CO_2	0.01	1.99	78.34	YES
2.B.8	Chemical Industry - Petrochemical and Carbon Black Production	CO_2	0.00	0.61	79.12	YES
2.B.10	Chemical Industry - Other	CO_2	0.00	0.92	80.04	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	0.01	3.87	83.91	YES
2.C.3	Metal Industry - Aluminium Production	CO_2	0.00	0.66	84.80	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CH_4	0.00	0.57	85.80	YES
1.A.4	Fuel combustion - Other Sectors - Biomass	CH_4	0.00	0.66	86.47	YES
1.B.1	Fugitive emissions from fuels - Solid Fuels	CH_4	0.00	0.61	87.08	YES
1.B.2.b	Fugitive emissions from fuels - oil, NG and Other - Natural gas	CH_4	0.01	1.41	88.50	YES
1.B.2.c	Fugitive emissions from fuels - oil, NG and Other - Venting and flaring	CH_4	0.00	0.92	89.41	YES
3.A	Enteric Fermentation	CH_4	0.01	1.65	91.06	YES
3.B	Manure Management	CH_4	0.00	0.49	91.55	YES
5.A	Solid Waste Disposal	CH_4	0.01	2.85	94.40	YES
2.B.2	Chemical Industry - Nitric Acid Production	N_2O	0.01	1.85	97.48	YES
2.C.3	Metal Industry - Aluminium Production	PFCs	0.00	0.57	99.94	YES

Table A1.4: *Key categories identified using Approach 1 and Approach 2 by trend assessment without LULUCF in 2020 – cont.*

IPCC Category Code	IPCC Category	Gas	Trend Assessment T2	Contribution to trend %	Cumulative Total	Key in trend analysis
2.F.1	Refrigeration and Air conditioning	F-gases	0.03	0.88	0.88	YES
1.A.1	Fuel combustion - Energy Industries - Liquid Fuels	CO_2	0.05	1.58	2.76	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	0.23	6.67	9.43	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	0.10	3.00	14.56	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	0.11	3.27	17.83	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	0.02	0.67	18.78	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	0.31	9.19	27.98	YES
1.A.3.e	Fuel combustion - Other Transportation	CO_2	0.05	1.54	29.76	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CO_2	0.26	7.74	37.52	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	0.09	2.70	40.22	YES
2.B.1	Chemical Industry - Ammonia Production	CO_2	0.05	1.53	43.18	YES
2.B.8	Chemical Industry - Petrochemical and Carbon Black Production	CO_2	0.06	1.75	45.14	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	0.11	3.15	48.57	YES
2.D	Non-energy Products from Fuels and Solvent Use	CO_2	0.01	0.23	49.34	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CH_4	0.11	3.11	53.19	YES
1.A.4	Fuel combustion - Other Sectors - Biomass	CH_4	0.12	3.58	56.78	YES
1.B.1	Fugitive emissions from fuels - Solid Fuels	CH_4	0.02	0.57	57.36	YES
3.A	Enteric Fermentation	CH_4	0.12	3.62	62.36	YES
3.B	Manure Management	CH_4	0.08	2.39	64.75	YES
5.A	Solid Waste Disposal	CH_4	0.28	8.28	73.03	YES
5.B	Biological Treatment of Solid Waste	CH_4	0.09	2.61	75.64	YES
1.A.3.b	Fuel combustion - Road Transportation	N_2O	0.03	0.74	78.35	YES
2.B.2	Chemical Industry - Nitric Acid Production	N_2O	0.04	1.23	81.12	YES
3.B	Manure Management	N_2O	0.11	3.27	84.46	YES
3.D.1	Direct N_2O Emissions From Managed Soils	N_2O	0.32	9.48	93.94	YES
5.B	Biological Treatment of Solid Waste	N_2O	0.09	2.78	98.92	YES
2.C.3	Metal Industry - Aluminium Production	PFCs	0.03	0.82	99.97	YES

Table A1.5: *Key categories identified using Approach 1 and Approach 2 by level assessment 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	3 819.212	4.467	4.467	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	12 861.048	15.044	19.512	YES
1.A.1	Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	2 176.697	2.546	22.058	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	2 867.639	3.354	25.454	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	9 028.534	10.561	36.015	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	3 930.584	4.598	40.613	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	4 503.024	5.267	46.119	YES
1.A.3.e	Fuel combustion - Other Transportation	CO_2	1 813.955	2.122	48.676	YES
1.A.4	Fuel combustion - Other Sectors - Liquid Fuels	CO_2	580.736	0.679	49.356	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CO_2	6 852.155	8.015	57.371	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	3 634.428	4.251	61.622	YES
2.A.1	Mineral Industry - Cement Production	CO_2	1 464.497	1.713	63.920	YES
2.A.2	Mineral Industry - Lime Production	CO_2	794.915	0.930	64.850	YES
2.A.4	Mineral Industry - Other Process Uses of Carbonates	CO_2	446.730	0.523	65.382	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	4 167.975	4.875	71.284	YES
4.A.1	Forest Land - Forest Land Remaining Forest Land	CO_2	-6 797.845	7.952	79.855	YES
4.A.2	Forest Land - Land Converted to Forest Land	CO_2	-2 263.043	2.647	82.502	YES
4.B.1	Cropland - Cropland Remaining Cropland	CO_2	-1 391.220	1.627	84.129	YES
4.B.2	Cropland - Land Converted to Cropland	CO_2	466.230	0.545	84.675	YES
4.G	Harvested Wood Products	CO_2	-470.409	0.550	85.907	YES
1.B.1	Fugitive emissions from fuels - Solid Fuels	CH_4	27.198	0.795	87.234	YES
1.B.2.b	Fugitive emissions from fuels - oil, NG and Other - Natural gas	CH_4	44.139	1.291	88.542	YES
1.B.2.c	Fugitive emissions from fuels - oil, NG and Other - Venting and flaring	CH_4	23.607	0.690	89.232	YES
3.A	Enteric Fermentation	CH_4	111.868	3.271	92.504	YES
3.B	Manure Management	CH_4	17.332	0.507	93.011	YES
5.A	Solid Waste Disposal	CH_4	27.921	0.817	93.839	YES
5.D	Wastewater Treatment and Discharge	CH_4	18.640	0.545	94.460	YES
2.B.2	Chemical Industry - Nitric Acid Production	N_2O	3.831	1.335	96.097	YES
3.B	Manure Management	N_2O	1.535	0.535	96.652	YES
3.D.1	Direct N_2O Emissions From Managed Soils	N_2O	5.878	2.049	98.701	YES

Table A1.5: *Key categories identified using Approach 1 and Approach 2 by level assessment with LULUCF in 1990 – cont.*

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	3 819.212	0.016	0.016	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	12 861.048	0.037	0.053	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	2 867.639	0.012	0.070	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	9 028.534	0.034	0.104	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	4 503.024	0.015	0.130	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CO_2	6 852.155	0.029	0.169	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	4167.975	0.021	0.215	YES
2.D	Non-energy Products from Fuels and Solvent Use	CO_2	50.487	0.004	0.221	YES
4.A.1	Forest Land - Forest Land Remaining Forest Land	CO_2	-6 797.845	0.383	0.606	YES
4.A.2	Forest Land - Land Converted to Forest Land	CO_2	-2 263.043	0.087	0.693	YES
4.B.1	Cropland - Cropland Remaining Cropland	CO_2	-1 391.220	0.069	0.762	YES
4.B.2	Cropland - Land Converted to Cropland	CO_2	466.230	0.026	0.788	YES
4.C.2	Grassland - Land Converted to Grassland	CO_2	-205.648	0.011	0.799	YES
4.F.2	Other land - Land Converted to Other Land	CO_2	281.410	0.016	0.821	YES
4.G	Harvested Wood Products	CO_2	-470.409	0.016	0.837	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CH_4	13.720	0.011	0.849	YES
3.A	Enteric Fermentation	CH_4	111.868	0.017	0.878	YES
3.B	Manure Management	CH_4	17.332	0.002	0.879	YES
5.A	Solid Waste Disposal	CH_4	27.921	0.012	0.892	YES
3.B	Manure Management	N_2O	1.535	0.002	0.919	YES
3.D.1	Direct N_2O Emissions From Managed Soils	N_2O	5.878	0.014	0.933	YES
3.D.2	Indirect N_2O Emissions From Managed Soils	N_2O	1.634	0.049	0.982	YES

Table A1.6: *Key categories identified using Approach 1 and Approach 2 by level assessment 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	3 819.212	5.205	5.205	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	12 861.048	17.528	22.733	YES
1.A.1	Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	2 176.697	2.967	25.700	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	2 867.639	3.908	29.656	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	9 028.534	12.305	41.961	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	3 930.584	5.357	47.318	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	4 503.024	6.137	53.733	YES
1.A.3.e	Fuel combustion - Other Transportation	CO_2	1 813.955	2.472	56.713	YES
1.A.4	Fuel combustion - Other Sectors - Liquid Fuels	CO_2	580.736	0.791	57.504	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CO_2	6 852.155	9.339	66.843	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	3 634.428	4.953	71.796	YES
2.A.1	Mineral Industry - Cement Production	CO_2	1 464.497	1.996	74.473	YES
2.A.2	Mineral Industry - Lime Production	CO_2	794.915	1.083	75.557	YES
2.A.4	Mineral Industry - Other Process Uses of Carbonates	CO_2	446.730	0.609	76.176	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	4 167.975	5.680	83.053	YES
1.B.1	Fugitive emissions from fuels - Solid Fuels	CH_4	27.198	0.927	85.320	YES
1.B.2.b	Fugitive emissions from fuels - oil, NG and Other - Natural gas	CH_4	44.139	1.504	86.844	YES
1.B.2.c	Fugitive emissions from fuels - oil, NG and Other - Venting and flaring	CH_4	23.607	0.804	87.648	YES
3.A	Enteric Fermentation	CH_4	111.868	3.812	91.460	YES
3.B	Manure Management	CH_4	17.332	0.591	92.051	YES
5.A	Solid Waste Disposal	CH_4	27.921	0.951	93.002	YES
5.D	Wastewater Treatment and Discharge	CH_4	18.640	0.635	93.726	YES
2.B.2	Chemical Industry - Nitric Acid Production	N_2O	3.831	1.556	95.633	YES
3.B	Manure Management	N_2O	1.535	0.624	96.279	YES
3.D.1	Direct N_2O Emissions From Managed Soils	N_2O	5.878	2.387	98.667	YES
3.D.2	Indirect N_2O Emissions From Managed Soils	N_2O	1.634	0.664	99.331	YES

Table A1.6: *Key categories identified using Approach 1 and Approach 2 by level assessment without LULUCF in 1990 – cont.*

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	3 819.212	0.030	0.030	YES
1.A.1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	12 861.048	0.071	0.101	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	2 867.639	0.022	0.133	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	9 028.534	0.065	0.199	YES
1.A.2	Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	3 930.584	0.018	0.217	YES
1.A.3.b	Fuel combustion - Road Transportation	CO_2	4 503.024	0.029	0.248	YES
1.A.3.e	Fuel combustion - Other Transportation	CO_2	1 813.955	0.012	0.262	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CO_2	6 852.155	0.055	0.322	YES
1.A.4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	3 634.428	0.017	0.339	YES
2.B.8	Chemical Industry - Petrochemical and Carbon Black Production	CO_2	428.801	0.014	0.370	YES
2.C.1	Metal Industry - Iron and Steel Production	CO_2	4 167.975	0.039	0.410	YES
2.D	Non-energy Products from Fuels and Solvent Use	CO_2	50.487	0.008	0.422	YES
1.A.4	Fuel combustion - Other Sectors - Solid Fuels	CH_4	13.720	0.022	0.446	YES
3.A	Enteric Fermentation	CH_4	111.868	0.071	0.539	YES
3.B	Manure Management	CH_4	17.332	0.025	0.563	YES
5.A	Solid Waste Disposal	CH_4	27.921	0.023	0.587	YES
5.D	Wastewater Treatment and Discharge	CH_4	18.640	0.019	0.611	YES
3.B	Manure Management	N_2O	1.535	0.058	0.693	YES
3.D.1	Direct N_2O Emissions From Managed Soils	N_2O	5.878	0.228	0.921	YES
3.D.2	Indirect N_2O Emissions From Managed Soils	N_2O	1.634	0.063	0.984	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 (2022).

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				Other Fossil Fuels	NO	NO	NO
1. A.1. Energy industries				Peat	NO	NO	NO
Peat	NO	NO	NO	Biomass	NO	NO	NO
a. Public electricity and heat production[7]				**1.A.2 Manufacturing industries and construction**			
Peat	NO	NO	NO	a. Iron and steel			
1.A.1.a.i Electricity Generation				Other fossil fuels	NO	NO	NO
Liquid Fuels	NO	NO	NO	Peat	NO	NO	NO
Solid Fuels	NO	NO	NO	b. Non-ferrous metals			
Other Fossil Fuels	NO	NO	NO	Other fossil fuels	NO	NO	NO
Peat	NO	NO	NO	Peat	NO	NO	NO
1.A.1.a.ii Combined heat and power generation				c. Chemicals			
Other Fossil Fuels	NO	NO	NO	Peat	NO	NO	NO
Peat	NO	NO	NO	d. Pulp, paper and print			
1.A.1.a.iii Heat plants				Other fossil fuels	NO	NO	NO
Other Fossil Fuels	NO	NO	NO	Peat	NO	NO	NO
Peat	NO	NO	NO	e. Food processing, beverages and tobacco			
1.A.1.a.iv Other (please specify)				Other fossil fuels	NO	NO	NO
Methane Cogeneration (Mining)	NO	NO	NO	Peat	NO	NO	NO
Other Fossil Fuels	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	Other Fossil Fuels	NO	NO	NO
Biomass	NO	NO	NO	Peat	NO	NO	NO
1.A.1.c.ii Oil and gas extraction				1.A.2.g.v Construction			

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
Other Fossil Fuels	NO	NO	NO	Gaseous fuels	NO	NO	NO
Peat	NO	NO	NO	Other fossil fuels	NO	NO	NO
1.A.2.g.vi Textile and leather				Biomass	NO	NO	NO
Other Fossil Fuels	NO	NO	NO	e. Other transportation			
Peat	NO	NO	NO	Liquid fuels	NO	NO	NO
1.A.2.g.viii Other (please specify)				Solid fuels	NO	NO	NO
Other Fossil Fuels	NO	NO	NO	Other fossil fuels	NO	NO	NO
Peat	NO	NO	NO	Biomass	NO	NO	NO
1.A.3 Transport				i. Pipeline transport			
Solid fuels	NO	NO	NO	Liquid fuels	NO	NO	NO
a. Domestic aviation				Solid fuels	NO	NO	NO
Biomass	NO	NO	NO	Other fossil fuels	NO	NO	NO
b. Road transportation				Biomass	NO	NO	NO
Other liquid fuels	NO	NO	NO	ii. Other	NO	NO	NO
ii. Light duty trucks				**1.A.4 Other sectors**			
Liquefied petroleum gases (LPG)	NO	NO	NO	Other fossil fuels	NO	NO	NO
Other liquid fuels	NO	NO	NO	Peat	NO	NO	NO
Gaseous fuels	NO	NO	NO	a. Commercial/institutional			
iii. Heavy duty trucks and buses				Other fossil fuels	NO	NO	NO
Liquefied petroleum gases (LPG)	NO	NO	NO	Peat	NO	NO	NO
Other liquid fuels	NO	NO	NO	1.A.4.a.i Stationary combustion			
iv. Motorcycles				Other Fossil Fuels	NO	NO	NO
Liquefied petroleum gases (LPG)	NO	NO	NO	Peat	NO	NO	NO
Other liquid fuels	NO	NO	NO	b. Residential			
Gaseous fuels	NO	NO	NO	Other fossil fuels	NO	NO	NO
v. Other		NO	NO	Peat	NO	NO	NO
Urea-based catalysts		NO	NO	1.A.4.b.i Stationary combustion			
Diesel Oil		NO	NO	Other Fossil Fuels	NO	NO	NO
c. Railways				Peat	NO	NO	NO
Solid fuels	NO	NO	NO	c. Agriculture/forestry/fishing			
Gaseous fuels	NO	NO	NO	Other fossil fuels	NO	NO	NO
Other fossil fuels	NO	NO	NO	Peat	NO	NO	NO
d. Domestic Navigation				i. Stationary			
Residual fuel oil	NO	NO	NO	Other fossil fuels	NO	NO	NO
Gasoline	NO	NO	NO	Peat	NO	NO	NO
Other liquid fuels	NO	NO	NO	ii. Off-road vehicles and other machinery			

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS		
	CO_2	CH_4	N_2O
Liquefied petroleum gases (LPG)	NO	NO	NO
Other liquid fuels	NO	NO	NO
Gaseous fuels	NO	NO	NO
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
Other fossil fuels (*please specify)*	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
International aviation (aviation bunkers)			
Biomass	NO	NO	NO
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

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		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	

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS			COMMENT
	CH_4		CO_2	
	Recovery/Flaring	Emissions	Emissions	
Post-mining activities	NO	NO	NO	
1.B.1.b Solid Fuel Transformation	NO		NO	
1.B.1.c Other		NO	NO	

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS				COMMENT
	CO_2		CH_4	N_2O	
	Emissions	Amount captured			
1.B.2.a Oil		NO, NE		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		NO	Emissions not occurring in this subcategory
3. Transport		NO			Emissions not occurring in this subcategory
4. Refining/storage	NE	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)
5. Distribution of oil products	NE	NO		NE	This activity is occurring in Slovakia but no EFs are available in the IPCC 2006 GL (NA for EFs)
6. Other	NO	NO	NO		No other source exists
1.B.2.b Natural Gas		NO			
1. Exploration	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			

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS				COMMENT
	CO_2		CH_4	N_2O	
	Emissions	Amount captured			
ii. Gas		NO			
iii. Combined	NO	NO	NO	NO	This activity is not occurring in Slovakia
1 B.2.d Other	NO		NO	NO	

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.
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			
Diesel Oil	IE			
1. B. 2. a. Oil				
4. Refining/storage	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)
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)

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

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	COMMENT
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	
1. Iron and steel production		NA,NO,IE						No CH_4 are reported because of the used methodology, sinter and pellet production are included in steel production
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	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
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	NO	These types of gas are not used
1. Refrigeration and air conditioning					NO	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

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	COMMENT
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	No available activity data (rabbits, fur animals, etc.)
B Manure Management				
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 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 for CO_2 emissions in this subcategory.
J Other	NO	NO	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	No uncategorised sites
B Biological Treatment of Solid Waste				No CO_2 emissions are reported in waste treatment.
2. Anaerobic digestion at biogas facilities		IE	IE	All sources are operated with energy use, emissions are included in Energy sector.
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.
D Wastewater Treatment and Discharge				No CO_2 emissions are reported in wastewater treatment.
3. Other *(as specified in table 6.B)*		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 and the KP 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.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Net CO_2 emissions/ removals	CH_4	N_2O	COMMENT
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.
Article 3.3 activities				
A.2. Deforestation		NO	NO	CH_4 and N_2O emissions biomass burning not occurring in Slovakia, Direct and indirect N_2O emissions from N fertilization not occurring in Slovakia, CH_4 and N_2O emissions from drained and rewetted organic soils not occurring in Slovakia

ANNEX 3: ASSESSMENT OF UNCERTAINTY

Chapter 3 of the IPCC 2006 GL 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 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 the next submissions for calculation of total uncertainty of the inventory.

Table A3.1: *Approach 1 uncertainty with LULUCF assessment in 2020 (emissions in Gg of CO_2 eq., uncertainty in %)*

CRF	IPCC Category	GAS	BASE YEAR EMISSIONS OR REMOVALS	YEAR 2020 EMISSIONS OR REMOVALS	ACTIVITY DATA UNCERTAINTY	EMISSION FACTOR UNCERTAINTY	COMBINED UNCERTAINTY	CONTRIBUTION TO VARIANCE BY CATEGORY IN YEAR 2018	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	645.66	3.40	0.00	3.40	0.01	0.01	0.01	0.00	0.05	0.00
2F2	Foam Blowing Agents	F-gases	0.00	1.93	11.65	0.00	11.65	0.00	0.00	0.00	0.00	0.00	0.00
2F3	Fire Protection	F-gases	0.00	22.15	22.77	0.00	22.77	0.00	0.00	0.00	0.00	0.01	0.00
2F4	Aerosols	F-gases	0.00	9.13	21.39	0.00	21.39	0.00	0.00	0.00	0.00	0.00	0.00
1A1	Fuel combustion - Energy Industries - Liquid Fuels	CO_2	3819.21	1289.83	5.00	3.60	6.16	0.08	-0.01	0.02	-0.02	0.14	0.02
1A1	Fuel combustion - Energy Industries - Solid Fuels	CO_2	12861.05	2707.93	2.50	3.60	4.38	0.18	-0.05	0.04	-0.17	0.15	0.05
1A1	Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	2176.70	2242.84	2.50	2.75	3.72	0.09	0.02	0.04	0.06	0.13	0.02
1A1	Fuel combustion - Energy Industries - Other Fossil Fuels	CO_2	35.61	163.47	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	CO_2	2867.64	239.49	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	CO_2	9028.53	3136.30	5.00	2.80	5.73	0.40	-0.01	0.05	-0.04	0.35	0.12
1A2	Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	3930.58	2168.48	2.50	2.75	3.72	0.08	0.01	0.03	0.02	0.12	0.02
1A2	Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	200.34	337.84	5.00	5.00	7.07	0.01	0.00	0.01	0.02	0.04	0.00
1A2	Fuel combustion - Manufacturing Industries and Construction - Peat	CO_2	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	CO_2	3.74	0.88	1.00	5.00	5.10	0.00	0.00	0.00	0.00	0.00	0.00

CRF	IPCC Category	GAS	BASE YEAR EMISSIONS OR REMOVALS	YEAR 2020 EMISSIONS OR REMOVALS	ACTIVITY DATA UNCERTAINTY	EMISSION FACTOR UNCERTAINTY	COMBINED UNCERTAINTY	CONTRIBUTION TO VARIANCE BY CATEGORY IN YEAR 2018	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
1A3b	Fuel combustion - Road Transportation	CO_2	4503.02	6743.79	1.00	5.00	5.10	1.48	0.07	0.11	0.37	0.15	0.16
1A3c	Fuel combustion - Railways	CO_2	372.29	72.53	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	CO_2	0.02	5.35	1.00	5.00	5.10	0.00	0.00	0.00	0.00	0.00	0.00
1A3e	Fuel combustion - Other Transportation	CO_2	1813.95	167.83	1.00	5.00	5.10	0.00	-0.01	0.00	-0.05	0.00	0.00
1A4	Fuel combustion - Other Sectors - Liquid Fuels	CO_2	580.74	286.89	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	CO_2	6852.15	457.47	5.00	4.00	6.40	0.01	-0.04	0.01	-0.16	0.05	0.03
1A4	Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	3634.43	3634.77	2.50	2.75	3.72	0.23	0.03	0.06	0.09	0.20	0.05
1A5	Fuel combustion - Other (Not specified elsewhere) - Stationary - Liquid Fuels	CO_2	34.99	1.40	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	CO_2	216.08	1.47	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	CO_2	154.75	54.46	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	CO_2	70.04	10.84	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	CO_2	19.01	12.26	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	CO_2	0.03	0.01	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	CO_2	0.58	0.33	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	CO_2	4.57	0.57	5.00	7.00	8.60	0.00	0.00	0.00	0.00	0.00	0.00
2A1	Mineral Industry - Cement Production	CO_2	1464.50	1443.15	2.88	0.00	2.88	0.02	0.01	0.02	0.00	0.09	0.01
2A2	Mineral Industry - Lime Production	CO_2	794.92	430.65	3.99	0.00	3.99	0.00	0.00	0.01	0.00	0.04	0.00
2A3	Mineral Industry - Glass Production	CO_2	7.88	18.39	0.78	0.00	0.78	0.00	0.00	0.00	0.00	0.00	0.00
2A4	Mineral Industry - Other Process Uses of Carbonates	CO_2	446.73	326.55	3.44	0.00	3.44	0.00	0.00	0.01	0.00	0.03	0.00
2B1	Chemical Industry - Ammonia Production	CO_2	331.77	703.09	5.00	5.00	7.07	0.03	0.01	0.01	0.04	0.08	0.01
2B5	Chemical Industry - Carbide Production	CO_2	0.00	45.83	11.61	0.00	11.61	0.00	0.00	0.00	0.00	0.01	0.00
2B8	Chemical Industry - Petrochemical and Carbon Black Production	CO_2	428.80	381.66	26.19	0.00	26.19	0.13	0.00	0.01	0.00	0.22	0.05

CRF	IPCC Category	GAS	BASE YEAR EMISSIONS OR REMOVALS	YEAR 2020 EMISSIONS OR REMOVALS	ACTIVITY DATA UNCERTAINTY	EMISSION FACTOR UNCERTAINTY	COMBINED UNCERTAINTY	CONTRIBUTION TO VARIANCE BY CATEGORY IN YEAR 2018	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
2B10	Chemical Industry - Other	CO_2	116.99	306.64	2.00	2.00	2.83	0.00	0.00	0.00	0.01	0.01	0.00
2C1	Metal Industry - Iron and Steel Production	CO_2	4167.97	3145.82	7.49	0.00	7.49	0.70	0.02	0.05	0.00	0.53	0.28
2C2	Metal Industry - Ferroalloys Production	CO_2	296.74	214.52	3.00	5.00	5.83	0.00	0.00	0.00	0.01	0.01	0.00
2C3	Metal Industry - Aluminium Production	CO_2	121.32	238.71	2.00	5.00	5.39	0.00	0.00	0.00	0.01	0.01	0.00
2C5	Metal Industry - Lead Production	CO_2	0.00	0.03	20.16	0.00	20.16	0.00	0.00	0.00	0.00	0.00	0.00
2D	Non-energy Products from Fuels and Solvent Use	CO_2	50.49	29.85	130.94	0.00	130.94	0.02	0.00	0.00	0.00	0.09	0.01
3G	Liming	CO_2	45.73	8.45	2.50	50.00	50.06	0.00	0.00	0.00	-0.01	0.00	0.00
3H	Urea Application	CO_2	15.29	63.67	3.90	50.00	50.15	0.01	0.00	0.00	0.04	0.01	0.00
4A1	Forest Land - Forest Land Remaining Forest Land	CO_2	-6797.85	-7294.53	20.00	82.84	85.22	118.34	-0.07	0.12	-5.58	3.26	41.81
4A2	Forest Land - Land Converted to Forest Land	CO_2	-2263.04	-350.81	3.00	57.81	57.88	0.52	0.01	0.01	0.60	0.02	0.37
4B1	Cropland - Cropland Remaining Cropland	CO_2	-1391.22	-1147.04	3.00	75.00	75.06	9.28	-0.01	0.02	-0.62	0.08	0.39
4B2	Cropland - Land Converted to Cropland	CO_2	466.23	52.50	3.00	83.58	83.63	0.02	0.00	0.00	-0.21	0.00	0.04
4C2	Grassland - Land Converted to Grassland	CO_2	-205.65	-93.17	3.00	83.58	83.63	0.08	0.00	0.00	0.00	0.01	0.00
4E2	Settlements - Land Converted to Settlements	CO_2	95.81	78.40	3.00	86.07	86.13	0.06	0.00	0.00	0.05	0.01	0.00
4F2	Other land - Land Converted to Other Land	CO_2	281.41	92.19	3.00	86.07	86.13	0.08	0.00	0.00	-0.05	0.01	0.00
4G	Harvested Wood Products	CO_2	-470.41	-146.86	10.00	50.00	50.99	0.07	0.00	0.00	0.05	0.03	0.00
5C	Incineration and Open Burning of Waste	CO_2	1.01	0.71	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	CH_4	3.42	1.09	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	CH_4	3.18	0.57	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	CH_4	0.98	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	CH_4	0.28	1.51	5.00	50.00	50.25	0.00	0.00	0.00	0.00	0.00	0.00
1A1	Fuel combustion - Energy Industries - Biomass	CH_4	0.57	9.50	3.00	50.00	50.09	0.00	0.00	0.00	0.01	0.00	0.00

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1A2	Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CH_4	2.79	0.17	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	CH_4	16.27	4.13	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	CH_4	1.75	0.97	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	CH_4	1.60	2.58	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	CH_4	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	CH_4	2.72	8.98	3.00	50.00	50.09	0.00	0.00	0.00	0.01	0.00	0.00
1A3a	Fuel combustion - Domestic Aviation	CH_4	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	CH_4	29.14	4.23	3.00	5.00	5.83	0.00	0.00	0.00	0.00	0.00	0.00
1A3c	Fuel combustion - Railways	CH_4	0.52	0.11	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	CH_4	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	CH_4	0.80	0.08	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	CH_4	1.25	0.90	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00
1A4	Fuel combustion - Other Sectors - Solid Fuels	CH_4	343.00	18.98	3.00	50.00	50.09	0.00	0.00	0.00	-0.11	0.00	0.01
1A4	Fuel combustion - Other Sectors - Gaseous Fuels	CH_4	8.14	8.15	3.00	5.00	5.83	0.00	0.00	0.00	0.00	0.00	0.00
1A4	Fuel combustion - Other Sectors - Biomass	CH_4	36.13	195.59	3.00	50.00	50.09	0.12	0.00	0.00	0.14	0.01	0.02
1A5	Fuel combustion - Other (Not specified elsewhere) - Stationary - Liquid Fuels	CH_4	0.03	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	CH_4	0.05	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	CH_4	0.34	0.12	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	CH_4	0.00	0.40	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	CH_4	0.19	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	CH_4	679.94	178.56	5.00	7.00	8.60	0.00	0.00	0.00	-0.01	0.02	0.00

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1B2a	Fugitive emissions from fuels - oil, NG and Other - Oil	CH_4	14.79	8.13	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	CH_4	1103.48	175.05	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	CH_4	590.18	50.18	2.00	5.00	5.39	0.00	0.00	0.00	-0.02	0.00	0.00
2B1	Chemical Industry - Ammonia Production	CH_4	0.27	0.40	2.00	10.00	10.20	0.00	0.00	0.00	0.00	0.00	0.00
2B10	Chemical Industry - Other	CH_4	0.05	0.14	2.00	10.00	10.20	0.00	0.00	0.00	0.00	0.00	0.00
2C2	Metal Industry - Ferroalloys Production	CH_4	0.00	0.93	2.00	10.00	10.20	0.00	0.00	0.00	0.00	0.00	0.00
3A	Enteric Fermentation	CH_4	2796.69	966.34	0.60	9.30	9.32	0.10	0.00	0.02	-0.04	0.01	0.00
3B	Manure Management	CH_4	433.31	86.88	5.40	3.00	6.18	0.00	0.00	0.00	-0.01	0.01	0.00
4A1	Forest Land - Forest Land Remaining Forest Land	CH_4	10.01	22.12	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	CH_4	0.07	0.02	5.00	5.00	7.07	0.00	0.00	0.00	0.00	0.00	0.00
5A	Solid Waste Disposal	CH_4	698.02	1121.42	17.35	20.31	26.71	1.12	0.01	0.02	0.26	0.44	0.26
5B	Biological Treatment of Solid Waste	CH_4	64.90	135.77	8.42	62.23	62.80	0.09	0.00	0.00	0.11	0.03	0.01
5C	Incineration and Open Burning of Waste	CH_4	0.13	0.09	5.00	50.00	50.25	0.00	0.00	0.00	0.00	0.00	0.00
5D	Wastewater Treatment and Discharge	CH_4	466.00	278.56	4.44	31.44	31.75	0.10	0.00	0.00	0.03	0.03	0.00
1A1	Fuel combustion - Energy Industries - Liquid Fuels	N_2O	7.92	2.17	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	N_2O	54.11	8.20	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	N_2O	1.17	1.20	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	N_2O	0.44	2.40	3.00	50.00	50.09	0.00	0.00	0.00	0.00	0.00	0.00
1A1	Fuel combustion - Energy Industries - Biomass	N_2O	0.90	15.09	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	N_2O	6.81	0.40	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	N_2O	28.72	7.21	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	N_2O	2.09	1.16	3.00	5.00	5.83	0.00	0.00	0.00	0.00	0.00	0.00

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1A2	Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	N_2O	2.54	4.09	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	N_2O	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	N_2O	4.32	20.89	3.00	50.00	50.09	0.00	0.00	0.00	0.01	0.00	0.00
1A3a	Fuel combustion - Domestic Aviation	N_2O	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	N_2O	56.48	65.29	1.00	50.00	50.01	0.01	0.00	0.00	0.03	0.00	0.00
1A3c	Fuel combustion - Railways	N_2O	42.82	8.97	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	N_2O	0.00	0.04	1.00	50.00	50.01	0.00	0.00	0.00	0.00	0.00	0.00
1A3e	Fuel combustion - Other Transportation	N_2O	0.95	0.09	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	N_2O	9.99	25.86	3.00	50.00	50.09	0.00	0.00	0.00	0.02	0.00	0.00
1A4	Fuel combustion - Other Sectors - Solid Fuels	N_2O	27.65	2.02	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	N_2O	1.94	1.94	3.00	5.00	5.83	0.00	0.00	0.00	0.00	0.00	0.00
1A4	Fuel combustion - Other Sectors - Biomass	N_2O	6.26	33.04	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	N_2O	0.08	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	N_2O	0.90	0.01	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	N_2O	0.08	0.03	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	N_2O	0.00	0.07	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	N_2O	1.66	0.26	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	N_2O	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	N_2O	0.32	0.47	2.00	10.00	10.20	0.00	0.00	0.00	0.00	0.00	0.00
2B2	Chemical Industry - Nitric Acid Production	N_2O	1141.53	75.95	6.09	0.00	6.09	0.00	-0.01	0.00	0.00	0.01	0.00
2B10	Chemical Industry - Other	N_2O	0.06	0.16	2.00	10.00	10.20	0.00	0.00	0.00	0.00	0.00	0.00
2G3	Other Product Manufacture and Use	N_2O	16.39	65.23	2.80	0.00	2.80	0.00	0.00	0.00	0.00	0.00	0.00

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3B	Manure Management	N_2O	457.54	149.90	5.20	2.60	5.81	0.00	0.00	0.00	0.00	0.02	0.00
3D1	Direct N2O Emissions From Managed Soils	N_2O	1751.76	1111.60	9.50	7.60	12.17	0.23	0.01	0.02	0.04	0.24	0.06
3D2	Indirect N2O Emissions From Managed Soils	N_2O	486.97	192.87	9.50	151.12	151.42	1.07	0.00	0.00	-0.06	0.04	0.01
4A1	Forest Land - Forest Land Remaining Forest Land	N_2O	6.60	14.59	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	N_2O	0.05	0.01	5.00	5.00	7.07	0.00	0.00	0.00	0.00	0.00	0.00
4B2	Cropland - Land Converted to Cropland	N_2O	95.67	11.15	75.00	100.00	125.00	0.00	0.00	0.00	-0.05	0.02	0.00
4C2	Grassland - Land Converted to Grassland	N_2O	0.96	0.31	75.00	100.00	125.00	0.00	0.00	0.00	0.00	0.00	0.00
4E2	Settlements - Land Converted to Settlements	N_2O	4.29	4.58	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	N_2O	9.61	5.02	75.00	100.00	125.00	0.00	0.00	0.00	0.00	0.01	0.00
4(IV)	Nitrogen leaching and run-off	N_2O	15.14	4.99	58.70	0.00	58.70	0.00	0.00	0.00	0.00	0.01	0.00
5B	Biological Treatment of Soild Waste	N_2O	46.43	97.11	8.42	93.34	93.72	0.10	0.00	0.00	0.11	0.02	0.01
5C	Incineration and Open Burning of Waste	N_2O	0.26	0.90	5.00	100.00	100.12	0.00	0.00	0.00	0.00	0.00	0.00
5D	Wastewater Treatment and Discharge	N_2O	129.61	50.09	6.74	31.44	32.16	0.00	0.00	0.00	0.00	0.01	0.00
2C3	Metal Industry - Aluminium Production	PFCs	314.86	5.61	7.50	11.00	13.31	0.00	0.00	0.00	-0.02	0.00	0.00
2G1	Electrical equipment	SF6	0.06	17.20	4.63	0.00	4.63	0.00	0.00	0.00	0.00	0.00	0.00

ANNEX 4: QUALITY ASSURANCE/QUALITY CONTROL PLAN

Table A4.1: *The Quality Assurance/Quality Control Plan 2022 - Internal*

ACTIVITY		WHO	CHECK-IN	TIME SCHEDULE	RECORD
1.	Evaluation of Improvement plans for the year 2022	Sectoral experts NIS coordinator Deputy of NIS coordinator	Quality manager MŽP SR – NFP	15. 01. 2022	Improvement plan for the year 2022 for every sector
2.	Tasks and financial plan of NIS – preparation for the year 2022.	NIS coordinator Deputy of NIS coordinator	MŽP SR – NFP Quality manager Head of the SHMÚ	12. 02. 2022	Information on budget, capacity (personal, external, internal), training plan, meetings and business trips plan, plan of QA/QC activities for the inventory year 2020.
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. 2022	Responsibilities matrix for 2022 Description of work activities
4.	Work assignment and contracts signing for each sector for the year 2022	NIS coordinator Deputy of NIS coordinator	MŽP SR - NFP Head of the SHMÚ	31. 03. 2022	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. 2022	Description QA/QC activities in each sectoral chapters for the year 2022
6.	Key sources and uncertainty management for each sector for the inventory year 2020	Sectoral expert for uncertainty Sectoral experts NIS coordinator	Deputy of NIS coordinator Quality manager	15. 03. 2022	Report on key sources and uncertainty evaluation for year 2020 Template for the key sources and uncertainty evaluation for year 2020
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. 2022	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 2023	Sectoral experts NIS coordinator Deputy of NIS coordinator	MŽP SR – NFP Quality manager	April 2022 September 2022 December 2022	Report from the meeting
9.	Completeness check of emission inventory for the year 2022	Sectoral experts	NIS coordinator Deputy of NIS	30. 09. 2022	Report from completeness check

ACTIVITY		WHO	CHECK-IN	TIME SCHEDULE	RECORD
			coordinator Quality manager MŽP SR – NFP		
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. 2022	Report of emission for each sector, for inventory year 2021
11.	Sectoral final reports delivery	Sectoral experts	NIS coordinator Deputy of NIS coordinator Quality manager	30. 11. 2022	Delivery protocols Drafts of sectoral reports for the inventory year 2021
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 2022 - External*

ACTIVITY		WHO	CHECK-IN	TIME SCHEDULE	RECORD
1.	Annual Report submission according to the Regulation EU 525/2013, Article 7: - Preliminary Emission GHG inventory for years 1990-2020; - Indicators for the year 2020; - Preliminary National Inventory Report information for year 2022, SEF tables for the year 2021	NIS coordinator Sectoral experts National administrator	Ministry of Environment of the Slovak Republic – NFP Deputy of NIS coordinator	15. 01. 2022	Annual Report SVK 2022 Elements of NIR SVK 2022 CRF tables 1990 - 2020 SEF tables for the years 2018, 2019, 2020, 2021
2.	Revised Annual Report submission according to the Regulation 2018/1999/EU, Article 26 and Implementing regulation 2020/1208/EU, Article 8-24: - GHG emissions inventory for year 2020;	NIS coordinator Sectoral experts National administrator	Ministry of Environment of the Slovak Republic – NFP Deputy of NIS coordinator	15. 03. 2022	Indicators 1990 - 2020 CRF tables 1990 - 2020 KP CRF tables 2008 – 2020 for UNFCCC NIR SVK 2022 KP CRF tables for the years 1990 a 2013 - 2020 for cropland and grazing land management for the EU.

ACTIVITY		WHO	CHECK-IN	TIME SCHEDULE	RECORD
	- Indicators for the year 2020; - National Inventory Report for year 2022; SEF tables for the year 2021.				
3.	Submission of the report according to the Article 3 under decision 529/2013/EU	NIS coordinator Ministry of Environment of the Slovak Republic Ministry of Agriculture and Rural Development of the Slovak Republic (National Forest Centre, Soil Science and Conservation Research Institute)	European Commission	15. 03. 2022	Initial, preliminary and non-binding annual estimates of emissions and removals from cropland management and grazing land management
4.	ESD annual review 2022	NIS coordinator Deputy of NIS coordinator Sectoral experts	Technical Expert Review Team	15. 02.-20. 04. 2022	Report from the ESD review until 30. 6. 2022 (depending on the findings and their solution)
5.	Nomination letters for the sectoral experts – update for the year 2022.	Ministry of Environment of the Slovak Republic – NFP	Deputy of NIS coordinator	15. 04. 2022	Nomination Letters List of nominated sectoral experts for the year 2022.
6.	Draft of the Improvement Plan for the GHG emissions inventory based on the SVK ARR 2020.	NIS coordinator Deputy of NIS coordinator Sectoral experts Ministry of Environment of the Slovak Republic – NFP	Independent review from the secretariat UNFCCC	15. 04. 2022	NIR SVK 2022 ARR 2020 Preliminary findings ERT 2021
7.	National Inventory Report NIR SVK 2022 submission to the secretariat UNFCCC: - Emission GHG inventory for the years 1990-2020; - National Inventory Report NIR SVK 2022; - KP-LULUCF tables for the years 2008-2020; Information from the National Registry for the year 2022.	NIS coordinator Sectoral experts National Registry	Deputy of NIS coordinator Ministry of Environment of the Slovak Republic – NFP	15. 04. 2022	CRF tables 1990-2020 KP CRF tables 2008-2020 SEF 2019, 2020, 2021 NIR SVK 2022 published on the official web of the UNFCCC
8.	Publicity of the SVK NIR 2022 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. 05. 2022	Update of data on https://oeab.shmu.sk/en/
9.	Revision of the NIR SVK 2022 on the basis of Initial Assessment by the UNFCCC and ESD review.	NIS coordinator Sectoral experts	Deputy of NIS coordinator Ministry of	15. 05. 2022	Re-submission of the emissions GHG inventory and NIR SVK 2022 submission (if relevant)

ACTIVITY		WHO	CHECK-IN	TIME SCHEDULE	RECORD
			Environment of the Slovak Republic – NFP		
10.	Audit of the status of the preparation of the GHG emissions inventory for the year 2021 – supervising milestones.	NIS coordinator Sectoral experts	Deputy of NIS coordinator Ministry of Environment of the Slovak Republic – NFP	30. 06. 2022 30. 09. 2022	Report from the coordination meetings of the NIS
11.	Proxy GHG emissions inventory 2021 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. 2022	Proxy inventory of GHG emissions
12.	Submission of the 8th National Report of the Slovak Republic on Climate Change (8NC) and 5th Biennial report (5BR)	NIS coordinator Ministry of Environment of the Slovak Republic	Ministry of Environment of the Slovak Republic	September 2022 December 2022	Draft of the 8NC and 5BR Final 8NC and 5BR
13.	International in-country review of the inventory years 2013 - 2020 coordinated by the secretariat UNFCCC.	NIS coordinator Deputy of NIS coordinator Sectoral experts Ministry of Environment of the Slovak Republic – NFP	Expert Review Team coordinated by the secretariat UNFCCC	September-October 2022	Preliminary Report from the International review of the NIR SVK 2022
14.	Data delivering to the Statistical Office of the Slovak Republic. Distribution of the SVK NIR 2022 to the relevant institutions.	NIS coordinator Sectoral experts	Deputy of NIS coordinator Ministry of Environment of the Slovak Republic – NFP	31. 10. 2022	Statistical record Emission GHG inventory for the years 1990-2020
15.	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 2022.	Sectoral experts Deputy of NIS coordinator	NIS coordinator Ministry of Environment of the Slovak Republic – NFP	30. 11. 2022	Report and Improvement plan for the year 2023.

Table A4.3: *List of UNFCCC main findings and recommendations, and status of implementation (ESD recommendations are included in MMR Table Article 9)*

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION	CHAPTER/SECTION IN THE NIR
LULUCF - Accuracy	General: Continue the ongoing technical research in order to provide reliable data for estimating CSC in living biomass, dead organic matter and soil organic matter.	L.1 List of the provisional main findings 2021	Deleting/changing recommendation was proposed (not implemented in 2022)	
LULUCF - Adherence to the UNFCCC Annex I inventory reporting guidelines	General: When using default uncertainty values for parameters, use default values from the 2006 IPCC Guidelines and not from the IPCC good practice guidance for LULUCF, and reference the source of those values.	L.2 List of the provisional main findings 2021	Implemented. According to the results from the expert group for uncertainty preparation, the main Monte Carlo simulations for LULUCF categories are already finished.	More information was added in the SVK NIR 2022, Chapter 6.5
LULUCF - Completeness	4.B.1: Report the area and associated stock changes of carbon in organic soils for cropland in CRF table 4.B, replacing the “NO” currently reported.	L.6 List of the provisional main findings 2021	Implemented, emissions from the organic soils are below the threshold of significance. Therefore the notation key NE was used. In NIR and CRF 2020 is presented revised estimates of Cropland organic soils, including an analysis demonstrating that emissions are below the significance threshold.	NIR SVK 2022, Chapter 6.7.1.1.4
LULUCF - Accuracy	4.B.1: Investigate the options to include periodic cuttings, including, but not limited to, pruning and thinning, in the estimation of annual losses in perennial croplands and report on progress in its next submission.	L.8 List of the provisional main findings 2021	A working meeting of the experts was held to identify the possibility of including regular pruning of permanent crops in the estimate of annual losses of permanent crops. It was attended by representatives of the Ministry of Agriculture and Rural Development of the Slovak Republic (Plant Production Department), Slovak Hydrometeorological Institute (Department of Emissions and Biofuels), National Agricultural and Food Centre – Soil Science and Conservation Research Institute, representatives of the Union of Winegrowers and Winemakers of Slovakia, representatives of the Fruit Growing Union of the Slovak Republic and representatives of The Central Control and Testing Institute in Agriculture (ÚKSÚP) (Department of Viticulture and Enology, Department of Fruit Growing and Organic Agricultural Production). The outcomes of the discussion include following findings: In orchards, methods of breaking out	NIR SVK 2022, Chapter 6.7.1.1.1

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION	CHAPTER/SECTION IN THE NIR
			shoots, pruning, bending branches, which aim is to support fruit formation and delay the aging phase, are preferred to biomass fruit production, not support for another biomass production. It is proposed that the loss of regular pruning of permanent crops during the year is zero. In Slovakia, there are currently low areas of orchards and vineyards. Based on these small areas, the amount of trimmed biomass is negligible compared to other countries. The areas of intensive orchards are decreasing. The analysis of waste biomass from vineyards showed, that it is also practice to leave the trimmed material in the vineyards or in the intermediate rows. Wood and green waste is returned in the form of mulch back to the soil. Experts recommended not including regular pruning of permanent crops (orchards and vineyards) in the estimate of annual losses, mainly due to their low acreage in Slovakia and the absence of historical data on their acreage. In addition, the cut material is left in the rows when they are trimmed. Wood and green waste is returned in the form of mulch back to the soil.	
LULUCF - Transparency	Land representation: the ERT recommends again that Slovakia provide an explanation for the cause of this abrupt increase in the areas of Settlements and Other land occurring around 1995 in the NIR of its next annual submission and also in future submissions. The ERT further encourages the Party to check that figures presented in the NIR are correct and complete.	L.10 List of the provisional main findings 2021	Implemented	This information was added in the SVK NIR 2022, Chapter 6.1
LULUCF - Completeness	4. general: The ERT recommends that the Party reviews its estimates of the area of organic soils, also in the light of literature values suggesting 26 kha (Fazekašová et al. 2021, https://doi.org/10.3390/plants10071290, 35kha (Table 1 in Montanarella et al. 2006, http://www.mires-and-	L.11 List of the provisional main findings 2021	Deleting/changing recommendation was proposed (not implemented in 2022)	

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION	CHAPTER/SECTION IN THE NIR
	peat.net/pages/volumes/map01/map0101.php and 60kha (Table 1 in Tanneberger et al. 2017, http://www.mires-and-peat.net/pages/volumes/map19/map1922.php. The ERT further recommends that the Party presents revised estimates and ensures that it reports on the entire area, and includes an analysis demonstrating that emissions are below the significance threshold or, alternatively, reports estimates.			
LULUCF - Accuracy	4.A.1: The ERT recommends that Slovakia justifies for the conversion of dead wood volume to biomass and carbon, the use and applicability of reduction factors for dead wood in different decomposition stages used by the Czech Republic. The ERT further recommends that Slovakia presents its methodology for the conversion and the use of the reduction factors from the Czech Republic more clearly and consistently in the relevant categories.	L.12 List of the provisional main findings 2021	Implemented. Slovakia provides estimate for the dead wood pool under FL.	This information was added in the SVK NIR 2022, Chapter 6.6
LULUCF - Adherence to the UNFCCC Annex I inventory reporting guidelines	4. General: The ERT recommends that the Party ensures that CRF Table9 is complete and contains all relevant documentation as required by the reporting guidelines. The ERT encourages the Party to consult with the secretariat in case of problems with the CRF reporter.	L.13 List of the provisional main findings 2021	CRF Table 9 is generated automatically, so we do not guarantee the completeness of included information there. Table A2.7 will be updated and completed in the SVK NIR 2022 (April submission). This Table was included into NIR due to often technical constrains with the CRF Reporter software.	Table A2.7 was updated and completed in the SVK NIR 2022.
LULUCF - Adherence to the UNFCCC Annex I inventory reporting guidelines	4.A.2: The ERT recommends that the Party to further investigate whether the affected categories are significant, and to consider implementing a higher tier approach, if appropriate after considering the available data and the significance of the subcategory. In case of applying a tier1 approach, the ERT recommends to provide a more detailed justification of the assumption that biomass on land prior to conversion to FL is not removed.	L.14 List of the provisional main findings 2021	Deleting/changing recommendation was proposed (not implemented in 2022)	
KP LULUCF - Accuracy	FM: Explain the main factors responsible for the reporting of a greater sink during the commitment period compared with the FMRL, with the aim of showing that the accounting	KL.4 List of the provisional main findings 2021	Implemented	This information was added in the SVK NIR 2022, Chapter 11.

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION	CHAPTER/SECTION IN THE NIR
	quantity can be explained by deviations in policy assumptions compared with those included in the FMRL, rather than differences in the factors/parameters, including increments, used in the FMRL and in the actual estimates of emissions and removals, as requested in the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol.			
KP LULUCF - Accuracy	FM: Report the correct FM cap (20 796.023 Gg CO_2 eq.) in the CRF accounting table.	KL.5 List of the provisional main findings 2021	Implemented	The correct values was edited into CRF Reporter
KP LULUCF- Transparency	FM: Continue to analyse the values of carbon content by different types of soils and site conditions, characterizing different types of forests, and report on this in the NIR. Provide in the NIR further evidence that the deadwood pool is not a source under FM	KL.7 List of the provisional main findings 2021	Deleting/changing recommendation was proposed (not implemented in 2022)	
KP LULUCF- Transparency	FM: The ERT recommends that the Party revises its justification and removes incorrect statements and further develops its justification by evaluating the NFI data on dead wood from the two inventories (see also #KL.7).	KL.8 List of the provisional main findings 2021	Implemented. Slovakia provides estimate for the dead wood pool under FM.	This information was added in the SVK NIR 2022, Chapter 11.3.1.1.
KP LULUCF- Transparency	FM: The ERT recommends that the Party ensures that descriptions of recalculations in FM reflect the recalculations made in that submission.	KL.9 List of the provisional main findings 2021	Implemented	This information was corrected in the SVK NIR 2022, Chapter 11.3.1.4.
KP LULUCF- Transparency	AR: The ERT recommends that the Party either uses the notation key 'NE' including an appropriate justification while considering that AR is a key category or attempts to provide estimates for the dead wood pool under AR.	KL.10 List of the provisional main findings 2021	Implemented. Slovakia provides estimate for the dead wood pool under AR.	This information was added in the SVK NIR 2022, Chapter 11.3.1.1.
KP LULUCF - Accuracy	General: The ERT recommend using root to shoot ratios for broadleaves and conifers for both FM and D to ensure consistency. The ERT also recommends that the Party considers in the selection of default root to shoot ratios the size of the above-ground biomass pool which is given in Table 4.4 in Vol. 4 of the 2006 IPCC guidelines and which	KL.11 List of the provisional main findings 2021	Implemented	Slovakia used root to shoot ratios for broadleaves and conifers for both FM and D to ensure consistency.

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION	CHAPTER/SECTION IN THE NIR
	was the focus of the recommendation for root to shoot ratios under Deforestation in the 2017 review			
KP LULUCF - Convention reporting adherence	FM: The ERT recommends that the Party reports in its next NIR submission, i.e. the year of accounting for the 2nd commitment period of the Kyoto Protocol on the technical correction by considering the relevant guidance in the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol and the relevant decision texts 2/CMP.7, 2/CMP.8, 6/CMP.9 and 4/CMP.11, including but not limited to demonstrating that the method/model used to calculate FMRLcorr is capable to reproduce the historical data of FM or FL-FL used for the construction of the FMRL, as reported in the FMRL submission, or a justification, if it is not the case.	KL.12 List of the provisional main findings 2021	Implemented	This information was added in the SVK NIR 2022, Chapter 11.5.2.3.
KP LULUCF - Convention reporting adherence	FM: The ERT recommends that the Party ensures that in next submission and in the context of the technical correction it demonstrates methodological consistency between the reference level and reporting for FM during the second commitment period, including in the area accounted for, in the treatment of harvested wood products, and in the accounting of any emissions from natural disturbances.	KL.13 List of the provisional main findings 2021	Implemented	This information was added in the SVK NIR 2022, Chapter 11.5.2.3.
KP LULUCF - Convention reporting adherence	FM: The ERT recommends that the Party to ensure that this information on how the EU-level policies are being implemented at the national level and the expected impact on the FMRL is provided.	KL.14 List of the provisional main findings 2021	Implemented	This information was added in the SVK NIR 2022, Chapter 11.
KP LULUCF - Convention reporting adherence	FM: The ERT recommends that the Party ensures that this information is provided in the next submission when the Party is accounting for the 2^{nd} CP of the Kyoto Protocol.	KL.15 List of the provisional main findings 2021	Implemented	This information was added in the SVK NIR 2022, Chapter 11.

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION	CHAPTER/SECTION IN THE NIR
General - Transparency	Article 3.14: Report in the NIR, in accordance with paragraph 25 of the annex to decision 15/CMP.1, on the changes in the information provided regarding the minimization of adverse impacts in accordance with Article 3, paragraph 14, of the Kyoto Protocol since its last submission, including, for example, any changes in fiscal and emission reduction policies, maintaining the sustainability of biofuel production and use, and incorporating climate-related issues into its official development assistance to developing countries.	G.1 List of the provisional main findings 2021	Implemented	SVK NIR 2022, Chapter 15
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. This could best be done by providing the results in the format of table 3.2 of the 2006 IPCC Guidelines.	G.4 List of the provisional main findings 2021	Table A3.1 of the NIR is updated in accordance with the Table 3.2 of the IPCC 2006 Guidelines completed with the full names of the categories.	SVK NIR 2022, Annex 3
General - Transparency	Uncertainty analysis: Include in the NIR the information on effort prioritization, inventory improvements and methodological choice that it provided during the review, that is, that the results of the uncertainty assessment are reflected in the annual improvement plan, where the actions for specific sectors and categories are prioritized based on the level of their importance for the inventory, and that continuous improvement of the inventory methodology for significant categories are carried out on the basis of the outcomes of the uncertainty analysis. Provide the description of underlying assumptions used for the estimation of uncertainties in line with paragraph 42 of the UNFCCC Annex I inventory reporting guidelines	G.5 List of the provisional main findings 2021	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. Please refer also sectoral chapters of the SVK NIR 2021 where more detail information are specifically provided.	SVK NIR 2022, Chapter 1.2.4.6
Energy - Transparency	1.A.1.c: Explain in the NIR the high value of the CO_2 IEF for this category and how it was obtained.	E.3 List of the provisional main findings 2021	IEF for CO_2 is so high because blast furnace gas, which has a high carbon content, represented more than 70 % of total fuels in this category. Information about fuel mix, AD, EF in CRF category 1.A1.c was included into NIR.	Detail information can be found in the NIR SVK 2022, Chapter 3.2.5

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION	CHAPTER/SECTION IN THE NIR
Energy - Accuracy	1.A.4: 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, and if this is not practical, explain in the NIR any national circumstances that may affect this issue.	E.6 List of the provisional main findings 2021	Based on improvement plan, activity data estimation and the calculation of CO_2 emissions is prioritized. The change of tier (to T2) is currently postponed.	Detail information can be found in the NIR SVK 2022, Chapter 3.2.5
Energy - Consistency	1.A.5.b: Use expert judgment and/or one of the recalculation techniques included in the 2006 IPCC Guidelines, volume 1, section 5.3.3, to estimate the emissions of CO_2, CH4 and N_2O from this category for gasoline (1990 – 2014), diesel (1990 – 2014) and biomass (2007 – 2014) and explain in the NIR the methods used.	E.7 List of the provisional main findings 2021	Implemented/Method used to estimated historical data was explained (linear regression)	SVK NIR 2022, Chapter 3.2.10.1
Energy - Transparency	1.B.2.b: The ERT recommends that the Party improve the transparency of the description of the methodology used to estimate 1.B.2.b.4 and 1.B.2.c.1.ii emissions in the NIR, by including information on the sources of emissions in these categories (e.g. valves, compressors), the method of measurement or estimation (e.g. infrared cameras, Bacharach HiFlow instrument, specific emission factors), the method of back-calculation of emissions pre 2013 (e.g. the extrapolation approach or proxy used, or alternative method), and the verification of the results.	E.10 List of the provisional main findings 2021	Deleting/changing recommendation was proposed (not implemented in 2022)	
Energy - Transparency	1.B.1.a: The ERT recommends that the Party ensure the consistency of the coal production data provided in the NIR and the CRF, and increase the transparency of the description for the method of estimating CO_2 emissions from 1.B.1.a coal mining and handling in the NIR, by providing more details on HBP, a.s.' measurements, verification, and the application of these estimates to other mines.	E.11 List of the provisional main findings 2021	Deleting/changing recommendation was proposed (not implemented in 2022)	
Energy - Transparency	1.A.5.a: The ERT recommends that the Party clearly describe in the NIR the methods, data and parameters used for emissions calculations of LFG and sludge gas in 1.A.1.a and 1.A.5.a, the links with the waste sector reporting.	E.13 List of the provisional main findings 2021	Detail analysis of LFG consumption was performed. Based on this analysis biomass consumption was recalculated.	Detail information can be found in the NIR SVK 2022, Chapter 3.2.4

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION	CHAPTER/SECTION IN THE NIR
IPPU - Transparency	2.D.3:Report the AD used in the estimation of CO_2 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 explain in the NIR how those CO_2 emissions are estimated.	I.3 List of the provisional main findings 2021	Deleting/changing recommendation was proposed (not implemented in 2022)	
IPPU - Transparency	2.A.3: The ERT recommends that the Party to include in the NIR a comparison of country-specific emission factor with the Tier 1 default value from 2006 IPCC Guidelines and explain the large difference between the country-specific emission factor with the Tier 1 default value in accordance with the 2006 IPCC Guidelines QC procedure.	I.8 List of the provisional main findings 2021	Deleting/changing recommendation was proposed (not implemented in 2022)	
IPPU - Transparency	2.B.1: The ERT recommends the Party to include the explanation in the NIR on why the country-specific emission factor is outside the interval of default values of emission factors recommended in the 2006 IPCC Guidelines (EF between 1.694 to 3.273 t CO_2/ t NH_3 produced)	I.9 List of the provisional main findings 2021	Implemented	NIR SVK 2022, Chapter 4.8.1.2
IPPU - Transparency	2.A.1: The ERT recommends the Party to include the estimated values in table 4.7 with notation explaining how these values were estimated. The ERT also recommends the Party to adopt different designations (symbols) for CaO content aggregated and CaO content in the cement clink.	I.11 List of the provisional main findings 2021	Implemented	NIR SVK 2022, Chapter 4.7.2.1 and Tables 4.5 and 4.6
Agriculture - Transparency	3.D.a.4: Revise the methodology description in its 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 (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.	A.4 List of the provisional main findings 2021	Deleting/changing recommendation was proposed (not implemented in 2022)	
Agriculture - Accuracy	3.D.a.4: Investigate how to consistently report nitrogen input from straw in animal manure applied to soils (currently reported under category 3.D.a.2.a) and straw removals under	A.5 List of the provisional main findings 2021	Deleting/changing recommendation was proposed (not implemented in 2022)	

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION	CHAPTER/SECTION IN THE NIR
	category 3.D.a.4 crop residues and revise its estimates accordingly			
Agriculture - Consistency	3.G: Ensure the consistency of the time series by investigating whether burnt lime is excluded from liming products for 1990 – 2013, and if this is the case, modify the AD to exclude burnt lime. Clarify in the NIR for which years burnt lime is excluded from liming products reported as AD for this category.	A.7 List of the provisional main findings 2021	Deleting/changing recommendation was proposed (not implemented in 2022)	
Agriculture - Accuracy	3.D.a.4: The ERT recommends that the Party estimate the amount of forage consumed by livestock during the 200 days grazing period and assess how this affects crop residue returns to the soil and DE. The ERT noted that this is not in accordance with [the 2006 IPCC Guidelines (vol. 4, chap. 11, equation 11.6)] because the omission FRACRemove factor implies an overestimation of N in crop residues.	A.8 List of the provisional main findings 2021	Deleting/changing recommendation was proposed (not implemented in 2022)	
Waste - Convention reporting adherence	General: Improve the QC procedures to ensure that the waste sector recalculations are correctly reflected in the NIR.	W.1 List of the provisional main findings 2021	Deleting/changing recommendation was proposed (not implemented in 2022)	
Waste - Transparency	General: Provide information about sludge treatment in the appropriate sections of Chapter 7 of the NIR	W.2 List of the provisional main findings 2021	Information about sludge treatment are implemented and reported in appropriate sections.	NIR SVK 2022, Chapter 7
Waste - Convention reporting adherence	5.D.2: Correct the erroneous reference to CH4 emissions in NIR chapter 7.8.2.2. Provide in the NIR additional information about the reason why there is such a high uncertainty of N2O emissions due to the N2O EF from industrial wastewater treatment.	W.6 List of the provisional main findings 2021	Information about recalculation of uncertainty of N_2O emissions from industrial wastewater are implemented and reported in appropriate sections.	NIR SVK 2022, Chapter 7.8.2.2.
Waste - Transparency	5.A.1: The ERT recommends the Party to correct the erroneous references in which the burning of LFG is allocated on the waste sector in the same chapter and to clearly indicate the amounts of gas burned and its	W.8 List of the provisional main findings 2021	Emissions from the combustion of landfill gas (LFG) in cogeneration units for electricity generation are reported in the energy sector. Methane, which makes up 50% of landfill gas and which enters the CHP unit as fuel, is reported	NIR SVK 2022, Chapter 7.5.1.1

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION	CHAPTER/SECTION IN THE NIR
	characteristics in the relevant sections of the NIR in next submissions.		in the waste sector as recovery methane.	
Waste - Transparency	5.D.1: The ERT recommends the Party to correct the reference to the sources of information regarding protein consumption in the relevant sections of the NIR.	W.9 List of the provisional main findings 2021	Deleting/changing recommendation was proposed (not implemented in 2022)	
Waste - Consistency	5.D.1: The ERT recommends the Party to include the explanation on how the protein consumption values are estimated in the relevant sections of the NIR to guarantee that they are consistent with the remaining time series.	W.10 List of the provisional main findings 2021	Explanation and recalculation are implemented in appropriate section.	SVK NIR 2022, Chapter 7.8.

ANNEX 5: ENERGY BALANCE OF THE ŠÚ SR FOR THE YEAR 2020

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	-	-	-	11 268	-	-	-	-	-	-	-
Import	3 597	56 320	12 271	5 582	6 637	781	196	-	-	-	-
Export	-	-	-	-	1 921	-	-	1 340	-	-	-
Stock Changes	574	710	719	2 424	-3 050	20	-	-	-	-	-
Gross Inland Consumption	**4 171**	**57 030**	**12 990**	**19 274**	**1 666**	**801**	**196**	**-1 340**	**-**	**-**	**-**
Transformation Input	**2 190**	**57 030**	**4 313**	**18 310**	**36 606**	**-**	**-**	**-**	**679**	**858**	**213**
Electricity Production - Thermal Equipment	2 190	-	4 313	18 287	-	-	-	-	679	853	199
of which: Public	2 190	-	2 824	18 264	-	-	-	-	-	-	-
Autoproducers	-	-	1 489	23	-	-	-	-	679	853	199
Nuclear Plants	-	-	-	-	-	-	-	-	-	-	-
Coke Ovens	-	45 257	-	-	-	-	-	-	-	-	-
Blast Furnaces	-	11 773	-	-	36 606	-	-	-	-	-	-
Refineries	-	-	-	-	-	-	-	-	-	-	-
Heat Production	-	-	-	23	-	-	-	-	-	5	14
Transformation Output	**-**	**-**	**-**	**-**	**39 487**	**-**	**-**	**1 340**	**8 763**	**13 526**	**2 361**
Electricity Production - Thermal Equipment	-	-	-	-	-	-	-	-	-	-	-
of which: Public	-	-	-	-	-	-	-	-	-	-	-
Autoproducers	-	-	-	-	-	-	-	-	-	-	-
Nuclear Plants	-	-	-	-	-	-	-	-	-	-	-
Coke Ovens	-	-	-	-	39 487	-	-	1 340	8 763	-	-
Blast Furnaces	-	-	-	-	-	-	-	-	-	13 526	2 361
Refineries	-	-	-	-	-	-	-	-	-	-	-
Heat Production	-	-	-	-	-	-	-	-	-	-	-
Exchanges and Transfers, Backflows	**-**	**-**	-	**-**	-	**-**	**-**	**-**	-	-	-
Product Transferred	**-**	**-**	-	-	-	-	-	-	-	-	-
Backflows from Petrochemical Sector	**-**	**-**	-	-	-	-	-	-	-	-	-
Consumption of the Energy Sector	**-**	**-**	**-**	**11**	**-**	**-**	**-**	**-**	**2 692**	**7 808**	**-**
Distribution Losses	**-**	**-**	**-**	**11**	**-**	**-**	**-**	**-**	**114**	**272**	**421**

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	**1 981**	**-**	**8 677**	**942**	**4 547**	**801**	**196**	**-**	**5 278**	**4 588**	**1 727**
Final Non - Energy Consumption	**860**	**-**	**-**	**-**	**1 158**	**-**	**-**	**-**	**-**	**-**	**-**
of which: Chemical Industry	-	-	-	-	-	-	-	-	-	-	-
Final Energy Consumption	**1 121**	**-**	**8 677**	**942**	**3 389**	**801**	**196**	**-**	**5 278**	**4 588**	**1 727**
Industry	**1 121**	**-**	**7 240**	**402**	**2 146**	**-**	**-**	**-**	**5 278**	**4 588**	**1 727**
of which: Iron and steel	991	-	6 033	-	1 186	-	-	-	5 274	4 588	1 727
Non - ferrous metals	-	-	-	-	141	-	-	-	-	-	-
Chemical	-	-	-	-	-	-	-	-	-	-	-
Non - metallic minerals	130	-	1 207	11	734	-	-	-	4	-	-
Mining and quarrying	-	-	-	23	-	-	-	-	-	-	-
Food, beverages and tobacco	-	-	-	299	85	-	-	-	-	-	-
Textile and leather	-	-	-	-	-	-	-	-	-	-	-
Pulp, paper and print	-	-	-	-	-	-	-	-	-	-	-
Mach. and transport equipment	-	-	-	69	-	-	-	-	-	-	-
Not elsewhere specified	-	-	-	-	-	-	-	-	-	-	-
Transport	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Other Sectors	**-**	**-**	**1 437**	**540**	**1 243**	**801**	**196**	**-**	**-**	**-**	**-**
of which: Households	-	-	1 078	437	28	681	-	-	-	-	-
Agriculture	-	-	-	11	-	-	-	-	-	-	-
Commercial and public services	-	-	359	92	1 215	120	196	-	-	-	-

2nd continuation

ACTIVITY/FUELS	Natural Gas	Crude Oil and NGL	Refinery Feedstock1/	Refinery Gas	LPG	Naphtha	Gasoline	Kerosene
UNITS	*TJ*							
Primary Production	2 294	168	6 923	-	-	-	-	-
Import	150 716	237 510	688	-	4 324	440	8 303	260
Export	-	84	-	-	2 944	528	34 135	476
Stock Changes	18 162	-3 360	-	-	46	220	220	-
Gross Inland Consumption	**171 172**	**234 234**	**7 611**	**-**	**1 426**	**132**	**-25 612**	**-216**
Transformation Input	**40 610**	**234 234**	**29 878**	**251**	**-**	**-**	**-**	**-**
Electricity Production - Thermal Equipment	32 255	-	-	251	-	-	-	-
of which: Public	30 059	-	-	-	-	-	-	-
Autoproducers	2 196	-	-	251	-	-	-	-
Nuclear Plants	-	-	-	-	-	-	-	-
Coke Ovens	-	-	-	-	-	-	-	-
Blast Furnaces	-	-	-	-	-	-	-	-
Refineries	-	234 234	29 878	-	-	-	-	-
Heat Production	8 355	-	-	-	-	-	-	-
Transformation Output	**-**	**-**	**-**	**14 062**	**6 302**	**23 496**	**48 984**	**1 429**
Electricity Production - Thermal Equipment	-	-	-	-	-	-	-	-
of which: Public	-	-	-	-	-	-	-	-
Autoproducers	-	-	-	-	-	-	-	-
Nuclear Plants	-	-	-	-	-	-	-	-
Coke Ovens	-	-	-	-	-	-	-	-
Blast Furnaces	-	-	-	-	-	-	-	-
Refineries	-	-	-	14 062	6 302	23 496	48 984	1 429
Heat Production	-	-	-	-	-	-	-	-
Exchanges and Transfers, Backflows	**-6 286**	**-**	**22 267**	**-**	**-2 530**	**-5 896**	**-**	**-**
Product Transferred	-6 286	-	13 841	-	-	-	-	-
Backflows from Petrochemical Sector	-	-	8 426	-	-2 530	-5 896	-	-
Consumption of the Energy Sector	**5 989**	**-**	**-**	**10 351**	**-**	**-**	**-**	**-**
Distribution Losses	**3 560**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

3rd continuation

ACTIVITY/FUELS	Natural Gas	Crude Oil and NGL	Refinery Feedstock1/	Refinery Gas	LPG	Naphtha	Gasoline	Kerosene
UNITS	*TJ*							
Final Consumption	**114 727**	**-**	**-**	**3 460**	**5 198**	**17 732**	**23 372**	**1 213**
Final Non - Energy Consumption	**16 257**	**-**	**-**	**-**	**3 128**	**17 732**	**-**	**-**
of which: Chemical Industry	16 257	-	-	-	3 128	17 732	-	-
Final Energy Consumption	**98 470**	**-**	**-**	**3 460**	**2 070**	**-**	**23 372**	**1 213**
Industry	**34 395**	**-**	**-**	**3 460**	**184**	**-**	**44**	**-**
of which: Iron and steel	5 832	-	-	-	-	-	-	-
Non - ferrous metals	1 338	-	-	-	-	-	-	-
Chemical	4 648	-	-	3 460	-	-	-	-
Non - metallic minerals	4 189	-	-	-	92	-	-	-
Mining and quarrying	1 737	-	-	-	-	-	-	-
Food, beverages and tobacco	3 640	-	-	-	-	-	-	-
Textile and leather	407	-	-	-	-	-	-	-
Pulp, paper and print	1 871	-	-	-	-	-	-	-
Mach. and transport equipment	6 071	-	-	-	46	-	44	-
Not elsewhere specified	4 662	-	-	-	46	-	-	-
Transport	**315**	**-**	**-**	**-**	**1 426**	**-**	**23 328**	**1 213**
Other Sectors	**63 760**	**-**	**-**	**-**	**460**	**-**	**-**	**-**
of which: Households	47 872	-	-	-	276	-	-	-
Agriculture	995	-	-	-	92	-	-	-
Commercial and public services	14 893	-	-	-	92	-	-	-

4th continuation

ACTIVITY/FUELS	Natural Gas	Crude Oil and NGL	Refinery Feedstock[1]	Refinery Gas	LPG	Naphtha	Gasoline	Kerosene
UNITS	*mil. m^3*	*1 000 t*	*1 000 t*	*1 000 t*	*1 000 t*	*1 000 t*	*1 000 t*	*1 000 t*
Final Consumption	**3 273**	**-**	**-**	**124**	**113**	**403**	**532**	**28**
Final Non - Energy Consumption	**465**	**-**	**-**	**-**	**68**	**403**	**-**	**-**
of which: Chemical Industry	465	-	-	-	68	403	-	-
Final Energy Consumption	**2 808**	**-**	**-**	**124**	**45**	**-**	**532**	**28**
Industry	**984**	**-**	**-**	**124**	**4**	**-**	**1**	**-**
of which: Iron and steel	167	-	-	-	-	-	-	-
Non - ferrous metals	38	-	-	-	-	-	-	-
Chemical	133	-	-	124	-	-	-	-
Non - metallic minerals	120	-	-	-	2	-	-	-
Mining and quarrying	50	-	-	-	-	-	-	-
Food, beverages and tobacco	104	-	-	-	-	-	-	-
Textile and leather	12	-	-	-	-	-	-	-
Pulp, paper and print	53	-	-	-	-	-	-	-
Mach. and transport equipment	174	-	-	-	1	-	1	-
Not elsewhere specified	133	-	-	-	1	-	-	-
Transport	**9**	**-**	**-**	**-**	**31**	**-**	**531**	**28**
Other Sectors	**1815**	**-**	**-**	**-**	**10**	**-**	**-**	**-**
of which: Households	1368	-	-	-	6	-	-	-
Agriculture	28	-	-	-	2	-	-	-
Commercial and public services	419	-	-	-	2	-	-	-

[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	35 142	568	242	808	473	2 265	5 527	173	4 011	5 081
Export	74 871	4 547	5 131	11 756	473	965	121	-	-	17 403
Stock Changes	84	-	-81	-323	-	-	-	-	35	-
Gross Inland Consumption	**-39 645**	**-3 979**	**-4 970**	**-11 271**	**0**	**1 300**	**5 406**	**173**	**4 046**	**-12 322**
Transformation Input	**-**	**-**	**121**	**2 303**	**-**	**-**	**-**	**-**	**-**	**-**
Electricity Production - Thermal Equipment	-	-	121	2 303	-	-	-	-	-	-
of which: Public	-	-	121	-	-	-	-	-	-	-
Autoproducers	-	-	-	2 303	-	-	-	-	-	-
Nuclear Plants	-	-	-	-	-	-	-	-	-	-
Coke Ovens	-	-	-	-	-	-	-	-	-	-
Blast Furnaces	-	-	-	-	-	-	-	-	-	-
Refineries	-	-	-	-	-	-	-	-	-	-
Heat Production	-	-	-	-	-	-	-	-	-	-
Transformation Output	**118 177**	**4 710**	**5 131**	**19 836**	**-**	**-**	**-**	**-**	**1 695**	**14 862**
Electricity Production - Thermal Equipment	-	-	-	-	-	-	-	-	-	-
of which: Public	-	-	-	-	-	-	-	-	-	-
Autoproducers	-	-	-	-	-	-	-	-	-	-
Nuclear Plants	-	-	-	-	-	-	-	-	-	-
Coke Ovens	-	-	-	-	-	-	-	-	-	-
Blast Furnaces	-	-	-	-	-	-	-	-	-	-
Refineries	118 177	4 710	5 131	19 836	-	-	-	-	1 695	14 862
Heat Production	-	-	-	-	-	-	-	-	-	-
Exchanges and Transfers, Backflows	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Product Transferred	-	-	-	-	-	-	-	-	-	-
Backflows from Petrochemical Sector	-	-	-	-	-	-	-	-	-	-
Consumption of the Energy Sector	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1 695**	**-**
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	**78 532**	**731**	**40**	**6 262**	**-**	**1 300**	**5 406**	**173**	**4 046**	**2 540**
Final Non - Energy Consumption	**-**	**609**	**-**	**-**	**-**	**1 300**	**5 406**	**173**	**2 006**	**2 540**
of which: Chemical Industry	-	609	-	-	-	-	-	-	-	2 540
Final Energy Consumption	**78 532**	**122**	**40**	**6 262**	**-**	**-**	**-**	**-**	**2 040**	**-**
Industry	**547**	**-**	**40**	**6 262**	**-**	**-**	**-**	**-**	**2 040**	**-**
of which: Iron and steel	-	-	-	-	-	-	-	-	-	-
Non - ferrous metals	-	-	-	-	-	-	-	-	-	-
Chemical	-	-	-	6 262	-	-	-	-	-	-
Non - metallic minerals	42	-	-	-	-	-	-	-	2 040	-
Mining and quarrying	168	-	-	-	-	-	-	-	-	-
Food, beverages and tobacco	-	-	-	-	-	-	-	-	-	-
Textile and leather	-	-	-	-	-	-	-	-	-	-
Pulp, paper and print	-	-	40	-	-	-	-	-	-	-
Mach. and transport equipment	42	-	-	-	-	-	-	-	-	-
Not elsewhere specified	295	-	-	-	-	-	-	-	-	-
Transport	**75 586**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Other Sectors	**2 399**	**122**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
of which: Households	-	-	-	-	-	-	-	-	-	-
Agriculture	2 399	-	-	-	-	-	-	-	-	-
Commercial and public services	-	122	-	-	-	-	-	-	-	-

7th continuation

ACTIVITY/FUELS	Nuclear Heat	Solar Heat	Geoth. Heat	Ambient heat	Heat	Wood and Charcol.	MSW	Bio-gas	ISW	Wind energy	Hydro Energy	Solar Electricity	EE	Liquid Bio-fuels	Total
UNITS	*TJ*														
Primary Production	165 112	338	392	2 159	-	55 312	2 523	5 479	8 289	14	16 261	2 387	-	7 469	286 388
Import	-	-	-	-	69	64	-	-	392	-	-	-	47 840	4 412	594 692
Export	-	-	-	-	-	393	-	-	-	-	-	-	46 692	4 286	208 066
Stock Changes	-	-	-	-	-	37	-	-	-39	-	-	-	-	-40	16 358
Gross Inland Consumption	**165 112**	**338**	**392**	**2 159**	**69**	**55 020**	**2 523**	**5 479**	**8 642**	**14**	16 261	2 387	**1 148**	**7 555**	**689 372**
Transformation Input	**163 264**	**-**	**362**	**-**	**-**	**17 403**	**1 510**	**4 473**	**134**	**-**	**-**	**-**	**-**	**-**	**614 742**
Electricity Production - Thermal Equipment	-	-	-	-	-	15 212	1 510	4 340	50	-	-	-	-	-	82 563
of which: Public	-	-	-	-	-	7 650	-	1 372	-	-	-	-	-	-	62 480
Autoproducers	-	-	-	-	-	7 562	1 510	2 968	50	-	-	-	-	-	20 083
Nuclear Plants	163 264	-	-	-	-	-	-	-	-	-	-	-	-	-	163 264
Coke Ovens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	45 257
Blast Furnaces	-	-	-	-	-	-	-	-	-	-	-	-	-	-	48 379
Refineries	-	-	-	-	-	-	-	-	-	-	-	-	-	-	264 112
Heat Production	-	-	362	-	-	2 191	-	133	84	-	-	-	-	-	11 167
Transformation Output	**-**	**-**	**-**	**-**	**28 892**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**84 139**	**-**	**437 192**
Electricity Production - Thermal Equipment	-	-	-	-	19 172	-	-	-	-	-	-	-	28 541	-	47 713
of which: Public	-	-	-	-	16 463	-	-	-	-	-	-	-	19 566	-	36 029
Autoproducers	-	-	-	-	2 709	-	-	-	-	-	-	-	8 975	-	11 684
Nuclear Plants	-	-	-	-	-	-	-	-	-	-	-	-	55 598	-	55 598
Coke Ovens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	49 590
Blast Furnaces	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15 887
Refineries	-	-	-	-	-	-	-	-	-	-	-	-	-	-	258 684
Heat Production	-	-	-	-	9 720	-	-	-	-	-	-	-	-	-	9 720
Exchanges and Transfers, Backflows	**-1 848**	**-2**	**-**	**-2 159**	**4 009**	**-**	**-**	**-**	**-**	**-14**	-16 261	**-2 387**	**18 662**	**-7 555**	**0**
Product Transferred	-1 848	-2	-	-2 159	4 009	-	-	-	-	-14	-16 261	-2 387	18 662	-7 555	0

ACTIVITY/FUELS	Nuclear Heat	Solar Heat	Geoth. Heat	Ambient heat	Heat	Wood and Charcol.	MSW	Bio-gas	ISW	Wind energy	Hydro Energy	Solar Electricity	EE	Liquid Bio-fuels	Total
UNITS	*TJ*														
Backflows from Petrochemical Sector	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Consumption of the Energy Sector	**-**	**2**	**-**	**-**	**3 882**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**12 503**	**-**	**44 933**
Distribution Losses	**-**	**-**	**-**	**-**	**4 067**	**25**	**-**	**-**	**-**	**-**	**-**	**-**	**5 720**	**-**	**14 190**

8th continuation

ACTIVITY/FUELS	Nuclear Heat	Solar Heat	Geoth. Heat	Ambient heat	Heat	Wood and Charcol.	MSW	Bio-gas	ISW	Wind energy	Hydro Energy	Solar Electricity	EE	Liquid Bio-fuels	Total
UNITS	*TJ*														
Final Consumption	**-**	**334**	**30**	**-**	**25 021**	**37 592**	**1 013**	**1 006**	**8 508**	**-**	**-**	**-**	**85 726**	**-**	**452 699**
Final Non - Energy Consumption	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**51 169**
of which: Chemical Industry	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40 266
Final Energy Consumption	**-**	**334**	**30**	**-**	**25 021**	**37 592**	**1 013**	**1 006**	**8 508**	**-**	**-**	**-**	**85 726**	**-**	**401 530**
Industry	**-**	**-**	**-**	**-**	**2 710**	**12 536**	**-**	**3**	**8 508**	**-**	**-**	**-**	**37 803**	**-**	**131 034**
of which: Iron and steel	-	-	-	-	26	237	-	-	-	-	-	-	5 407	-	31 301
Non - ferrous metals	-	-	-	-	90	1	-	-	-	-	-	-	8 446	-	10 016
Chemical	-	-	-	-	382	2	-	-	847	-	-	-	3 708	-	19 309
Non - metallic minerals	-	-	-	-	182	6	-	-	7 625	-	-	-	2 639	-	18 901
Mining and quarrying	-	-	-	-	2	2	-	-	-	-	-	-	216	-	2 148
Food, beverages and tobacco	-	-	-	-	155	276	-	-	-	-	-	-	1 735	-	6 190
Textile and leather	-	-	-	-	34	3	-	-	-	-	-	-	374	-	818
Pulp, paper and print	-	-	-	-	1299	10 424	-	3	-	-	-	-	2 941	-	16 578
Mach. and transport equipment	-	-	-	-	377	209	-	-	36	-	-	-	8 118	-	15 012
Not elsewhere specified	-	-	-	-	163	1 376	-	-	-	-	-	-	4 219	-	10 761
Transport	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1 818**	**-**	**103 686**
Other Sectors	**-**	**334**	**30**	**-**	**22 311**	**25 056**	**1 013**	**1003**	**-**	**-**	**-**	**-**	**46 105**	**-**	**166 810**
of which: Households	-	303	-	-	18 702	24 359	-	-	-	-	-	-	21 146	-	114 882
Agriculture	-	-	30	-	32	338	-	724	-	-	-	-	896	-	5 517
Commercial and public services	-	31	-	-	3 577	359	1 013	279	-	-	-	-	24 063	-	46 411

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Authors:	JANKA SZEMESOVÁ (CHAPTERS 1, 2, 8, 9, 10, 12, 13) 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) MARTIN PETRAŠ (CHAPTER 5) MIROSLAV HROBÁK (CHAPTER 14) JOZEF ŠKULTÉTY (CHAPTER 15)
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