SLOVAK REPUBLIC

NATIONAL INVENTORY REPORT 2017

Submission under the UNFCCC
and under the Kyoto Protocol

SHMÚ

Slovak Hydrometeorological Institute

MINISTERSTVO ŽIVOTNÉHO PROSTREDIA SLOVENSKEJ REPUBLIKY

Ministry of Environment of the Slovak Republic

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PREFACE

TITLE OF REPORT	**NATIONAL GREENHOUSE GAS INVENTORY REPORT 1990 – 2015 TO THE UNFCCC AND THE KYOTO PROTOCOL**
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In 2017, the Slovak Republic made an inventory submission under the UNFCCC and under the Kyoto Protocol.

The 2017 national inventory submission contains the following parts:

- Part 1: Slovakia's national greenhouse gas emission inventory report (NIR) 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. Other relevant decisions under the Kyoto Protocol (19/CMP.1, 2/CMP.7, 4/CMP.7 and 6/CMP.9) are also followed.
- Part 2: CRF (Common Reporting Format) data tables showing Slovakia's greenhouse gas emissions for the years 1990 – 2015 including KP-LULUCF data tables for the years 2013 – 2015. The CFR tables were compiled using the CRF Reporter Inventory software (version 6.0.1.1) accompanied by the xml file.
- Part 3: 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, 31.12.2016, and transfers of the units during 2016. In accordance with para.1 of annex II to decision 3/CMP.11 SVK SEF tables for the reported year 2015. Further to this, para. 4 of decision 10/CMP.11, the SVK SEF information for the reported years 2013 – 2016 are included.

The Slovakia inventory report as well as the CRF tables can be downloaded from the following address: http://ghg-inventory.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.

EXECUTIVE SUMMARY

ES.1 BACKGROUND INFORMATION ON GREENHOUSE GAS INVENTORIES AND CLIMATE CHANGE

Climate change has become one of the biggest, if not the biggest challenges of the environmental policy in the 21st century. The World Economic Forum Global Risks 2013 Report[1], which regularly assesses 50 biggest global risks according to their impacts, possibility and inter-connections with other issues identified this phenomenon as one of the top 5 risks that the world faces in 2013. The report criticises the lack of financial interest to solve environmental challenges such as climate change.

Although the impact of the climate change is different in different regions of the world, its socio-economic and environmental impact always needs 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 point for any policy making for 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 mankind. 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.

The World Meteorological Organization's Greenhouse Gas Bulletin says that between 1990 and 2014 there was a 36% increase in radiative forcing – the warming effect on our climate – because of long-lived greenhouse gases such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) from industrial, agricultural and domestic activities. Atmospheric concentrations of CO_2 – the most important long-lived greenhouse gas – reached 397.7 parts per million (ppm) in 2014. In the Northern hemisphere CO_2 concentrations crossed the symbolically significant 400 ppm level in 2014 spring, when CO_2 is most abundant. In spring 2015, the global average concentration of CO_2 crossed the 400 ppm barrier.

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 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 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 Slovak Republic committed itself to an 8% reduction of

[1] http://www.weforum.org/reports/global-risks-2013-eighth-edition

emissions compared to the base year 1990. The Slovak Republic and the former 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, its Member States and Iceland agreed to a 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.

In 2010, the EU submitted a pledge to reduce its GHG emissions by 2020 by 20% compared to 1990 levels (UNFCCC, 2014a). As this target under the convention has only been submitted by EU-28 and not by each of its Member States (MS), there are no specified convention targets for single MS. Due to this, Slovakia as part of the EU-28, takes on a quantified economy-wide emission reduction target jointly with all Member States.

With the 2020 climate and energy package the EU has set internal rules which underpin the implementation of the target under the Convention. The 2020 climate and energy package introduced a clear approach to achieving the 20% reduction of total GHG emissions from 1990 levels, which is equivalent to a 14% reduction compared to 2005 levels. This 14% reduction objective is divided between two sub-targets, equivalent to a split of the reduction effort between ETS and non-ETS sectors (the Effort Sharing Decision = ESD emissions). Under the revised EU ETS Directive[3], one single EU ETS cap covers the EU Member States and the three participating non-EU Member States (Norway, Iceland and Liechtenstein), i.e. there are no further differentiated caps by country. For allowances allocated to the EU ETS sectors, annual caps have been set for the period from 2013 to 2020; these decrease by 1.74% annually, starting from the average level of allowances issued by Member States for the second trading period (2008 – 2012). The annual caps imply interim targets for emission reductions in sectors covered by the EU ETS for each year until 2020. While the EU ETS target is to be achieved by the EU as a whole, the ESD target was divided into national targets to be achieved individually by each Member State. In the Effort Sharing Decision national emission targets for 2020 are set, expressed as percentage changes from 2005 levels. For Slovakia, this percentage changes from 2005 levels are +13%.

The Paris Agreement is a historic step forward, with almost 200 countries committing to action which they will be held to account on 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 action is being taken to tackle climate change and limit global temperature rises to below 2°C, and pursue efforts for 1.5°C; and countries strive to prepare long-term low GHG emission development strategies.

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. More detailed information can be found in the Standard Electronic Tables (SEF) that are part of Slovakia's inventory submission.

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

[3] Directive 2009/29/EC of the European Parliament and of the Council amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community

ES.2 SUMMARY OF NATIONAL EMISSION AND REMOVAL TRENDS

The GHG emissions presented in the National Inventory Report 2017 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. According to the recommendations of the ERT from the last centralised review (2016), several recalculations and reallocations were performed and reflected in the 2017 submission with the impacts on the previous inventory years 1991 – 2014 and the base year 1990. Recommendations provided in the EU internal review cycle 2016 and partly 2017 under the Effort Sharing Decision were implemented in this 2017 submission.

Total GHG emissions were 41 269.49 Gg of CO_2 equivalents in 2015 (without LULUCF). This represents a reduction by 44.6% against the base year 1990. In comparison with 2014, the emissions increased by 1.45%. The increase in total emissions of 2015 compared to 2014 was due to increase in energy, industrial processes and waste sectors in the reaction to increasing economy growth in Slovakia. This trend was slightly corrected with the interannual increase of removals in the LULUCF sector.

Latest OECD Environmental Performance Review of the Slovak Republic summarised results in GHG emission reductions since 1990 as follow:

„Significantly reduced CO_2 emissions, combined with strong GDP growth and low population growth rate, resulted in a sharp drop of the economy's carbon intensity as measured by CO_2 emissions per unit of GDP (using purchasing power parities). This was the sharpest decline in any OECD country".[4]

Similarly, ETC/ACM Technical paper states that:

"*The fall in emission per GDP observed in Slovakia during 2003 – 2008 is the highest decline of all EU-27 Member States, as result of a small fall in emissions despite a large increase in GDP. Slovakia project further decoupling of emissions and GDP but at a slower rate than the impressive rate observed during 2003 – 2008. Based on the trend observed in other Member States, it is fair to assume that Slovakia's emissions per GDP may not continue to fall at the same impressive rate observed in historic years.*[5]

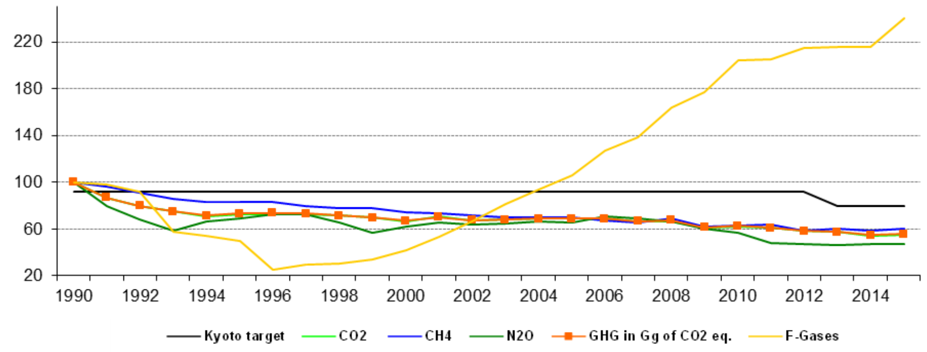
The major changes in the national inventory in the 2017 submission are caused by recalculations in transport, agriculture and waste sectors for whole time series.

The emissions without LULUCF in 2015 slightly increase compared with 2014. During the whole following period 1991 – 2015, 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 – 2015, the total greenhouse gas emissions expressed in CO_2 equivalents in the Slovak Republic did not exceed the level of the base year 1990. ***Figure ES.1*** shows trends 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 with increasing trend since 1990 (despite decrease of PFCs gases from aluminium production).

[4] OECD Environmental Performance Reviews, Slovak Republic, 2011

[5] Assessment of the member States` projections submitted under the EU Monitoring Mechanism in 2014, ETC/ACM Technical paper 2011/2, February 2012

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



GHG emissions in % to base years without LULUCF; emissions are determined as of 15.04.2017

Slovakia has decreased its emissions by around 18% between 2008 and 2015. According to 2015 projections, Slovakia is on track to overachieve 2020 target, with a 17% margin between the projected emissions and its target, as compared to 2005.

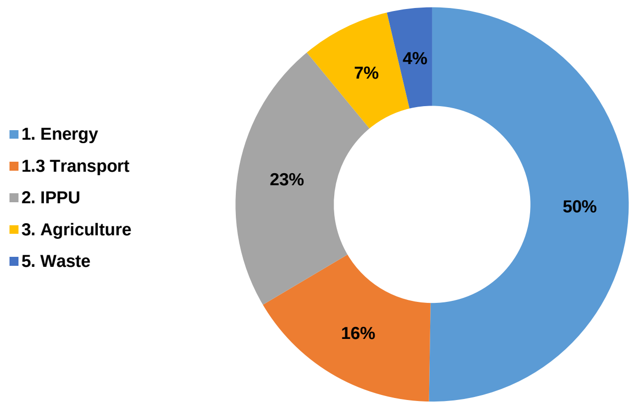
Reduction of emissions in Slovakia is conjunction of different impacts starting from impressive industrial and technological restructuring connected with the fuel switching of fossil fuels from coal and oil to the natural gas (air pollution legislation since 1991 was the main driving force), economy 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 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 sector.

In Slovakia, the trends observed in primary energy intensity could be partly explained by the economic crisis. In addition, 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 and which 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 2005 – 2008. The policy package as well needs significant improvements across sectors.

ES.3 OVERVIEW OF SOURCE AND SINK CATEGORY

The energy sector (including transport) with the share of 66.5% was the main contributor to total GHG emissions in 2015. Within this sector, transport with 16% share contributes significantly to the GHG emissions. The transport sector in total emissions has increase by 3.25% in comparison with previous year (2014). 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. Sector industrial processes and product use was the second important sector in 2015 with its 22.5% 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. Their level is influenced mostly by the production volume in industrial processes. 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 2015, the share of agriculture sector on total GHG emissions was 7.3% 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. Waste sector contributed by 3.7% to total GHG emissions in 2015. 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, to a large extent, on applied methodology to evaluate landfills and also 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 and decreased share of stationary sources of pollution in energy sector are noticeable. Combustion of fossil fuels, which account for about 75% of the total CO_2 emissions in the Slovak Republic (without LULUCF), represent the most important anthropogenic source of CO_2 emissions (***Figure ES.2***, ***Table ES.4***).

Figure ES.2: *GHG emissions share by sectors in 2015 (%) in the Slovak Republic*



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

According to the *"Report on the estimation of assigned amount units under the Kyoto Protocol-revised version according to the IRR from July, 2007"* the Slovak Republic has officially declared 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 also 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 Organisation 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.1 shows total CO_2 removals from afforestation/reforestation activities were -400.65 Gg of CO_2 eq. (changes in 39.44 kha to the end of 2015). Total CO_2 emissions from deforestation were 62.80 Gg of CO_2 eq. (changes in 8.36 kha to the end of 2015). In 2015, total removals under the Article 3.3 of the KP were -379.01 Gg of CO_2 eq. with the changed area of 47.80 kha. Net removals from FM activity were -5 158.64 Gg of CO_2 eq. with the changes on the area at the end of 2015 – 1 977.67 kha.

Table ES.1: *Emissions and removals (Gg of CO_2 eq.) in 2013, 2014 and 2015 resulting from activities under the Articles 3.3 and 3.4 of the Kyoto Protocol*

ACTIVITIES	2013	2014	2015	TOTAL
Total 3.3 and 3.4	**-7 189.47**	**-5 224.27**	**-5 559.29**	**-17 973.03**
A. Article 3.3 activities	**-400.03**	**-379.01**	**-400.65**	**-1 179.69**
A.1 Afforestation/ Reforestation	-443.07	-441.81	-465.10	-1 349.98
A.2 Deforestation	43.04	62.80	64.45	170.29
B. Article 3.4 activities	-6 789.44	-4 845.26	-5 158.64	-16 793.34
B.1 Forest Management	-6 789.44	-4 845.26	-5 158.64	-16 793.34

Table ES.2: *Summary of the GHG emissions in 2014 and 2015 according to the gases and sectors*

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2015					
	CO_2 eq. (Gg)					
	CO_2	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**
1. Energy	25 416.78	1 826.75	201.56	NO	NO	NO
2. Industrial Processes	8 317.13	1.77	208.56	734.88	8.50	14.31
3. Agriculture	75.91	1 141.95	1 796.60	NO	NO	NO
4. LULUCF	-6 474.21	16.80	28.62	NO	NO	NO
5. Waste	6.97	1 381.86	135.84	NO	NO	NO
KP LULUCF	-5 587.17	0.67	0.04	NO	NO	NO
Memo Items - International Transport	166.28	0.09	1.35	NO	NO	NO
Total (including LULUCF)	**27 342.58**	**4 369.24**	**2 371.18**	**734.88**	**8.50**	**14.31**
Total (excluding LULUCF)	**33 816.79**	**4 352.44**	**2 342.56**	**734.88**	**8.50**	**14.31**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2014					
	CO_2 eq.(Gg)					
	CO_2	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**
1. Energy	25 203.74	1 694.32	191.21	NO	NO	NO
2. Industrial Processes	8 158.30	1.71	225.26	653.84	11.15	14.17
3. Agriculture	73.57	1 169.11	1 804.44	NO	NO	NO
4. LULUCF	-6 166.40	17.15	27.50	NO	NO	NO
5. Waste	6.85	1 350.81	119.30	NO	NO	NO
KP LULUCF	-5 252.73	0.69	0.04	NO	NO	NO
Memo Items - International Transport	132.70	0.06	1.07	NO	NO	NO
Total (including LULUCF)	**27 276.06**	**4 233.11**	**2 367.71**	**653.84**	**11.15**	**14.17**
Total (excluding LULUCF)	**33 442.47**	**4 215.96**	**2 340.21**	**653.84**	**11.15**	**14.17**

Table ES.3: *Summary of the GHG emissions in 1990 – 2013 according to the gases*

GREENHOUSE GAS EMISSIONS	Base year 1990	1991	1992	1993	1994	1995	1996	1997
	CO_2 eq.(Gg)							
CO_2 emissions including net CO_2 from LULUCF	61 935.05	53 549.31	49 082.55	46 569.29	43 740.36	44 779.18	45 081.93	45 136.91
CO_2 emissions excluding net CO_2 from LULUCF	52 856.70	43 743.15	38 572.93	36 045.91	33 911.17	35 430.48	35 776.40	35 951.53
CH_4 emissions including CH_4 from LULUCF	7 198.63	6 914.50	6 567.88	6 151.45	5 957.92	6 010.81	5 984.05	5 722.56
CH_4 emissions excluding CH_4 from LULUCF	7 206.07	6 920.43	6 573.89	6 159.18	5 963.30	6 016.92	5 990.99	5 729.68
N_2O emissions including N_2O from LULUCF	5 011.74	4 009.18	3 400.35	2 922.63	3 312.83	3 465.49	3 647.49	3 621.51
N_2O emissions excluding N_2O from LULUCF	5 091.40	4 083.12	3 472.63	2 994.22	3 379.80	3 523.95	3 702.67	3 671.94
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 (including LULUCF)	**74 460.34**	**64 782.75**	**59 339.06**	**55 823.78**	**53 182.16**	**54 411.60**	**54 793.75**	**54 573.82**
Total (excluding LULUCF)	**65 469.09**	**55 056.46**	**48 907.73**	**45 379.72**	**43 425.32**	**45 127.47**	**45 550.33**	**45 445.99**

GREENHOUSE GAS EMISSIONS	1998	1999	2000	2001	2002	2003	2004	2005
	CO_2 eq. (Gg)							
CO_2 emissions including net CO_2 from LULUCF	44 115.61	43 283.29	41 265.80	43 573.57	41 736.23	42 200.62	42 733.00	42 747.51
CO_2 emissions excluding net CO_2 from LULUCF	33 884.00	33 218.71	31 495.57	34 661.89	32 233.33	32 941.00	33 775.27	37 097.84
CH_4 emissions including CH_4 from LULUCF	5 621.28	5 577.13	5 355.32	5 262.45	5 144.28	5 040.82	5 024.42	5 024.37
CH_4 emissions excluding CH_4 from LULUCF	5 628.29	5 590.82	5 366.21	5 271.47	5 154.26	5 053.80	5 035.14	5 039.83
N_2O emissions including N_2O from LULUCF	3 267.95	2 844.95	3 108.95	3 273.85	3 203.92	3 234.95	3 341.54	3 290.21
N_2O emissions excluding N_2O from LULUCF	3 314.50	2 893.70	3 149.39	3 309.31	3 232.68	3 264.47	3 369.62	3 319.47
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)	**53 101.20**	**51 811.57**	**49 863.07**	**52 278.00**	**50 294.85**	**50 731.42**	**51 392.40**	**51 395.62**
Total (including LULUCF)	**42 923.14**	**41 809.43**	**40 144.17**	**43 410.81**	**40 830.68**	**41 514.29**	**42 473.47**	**45 790.67**

GREENHOUSE GAS EMISSIONS	2006	2007	2008	2009	2010	2011	2012	2013
	CO_2 eq. (Gg)							
CO_2 emissions including net CO_2 from LULUCF	42 486.48	40 879.31	41 384.89	37 590.29	38 536.13	37 811.21	36 001.10	35 543.38
CO_2 emissions excluding net CO_2 from LULUCF	34 111.80	32 776.01	34 399.93	30 724.01	32 483.97	31 362.70	28 343.95	27 441.49
CH_4 emissions including CH_4 from LULUCF	4 836.77	4 708.28	4 962.84	4 491.87	4 531.00	4 603.57	4 224.88	4 367.75
CH_4 emissions excluding CH_4 from LULUCF	4 848.96	4 721.98	4 976.48	4 506.26	4 545.93	4 618.46	4 237.12	4 376.77
N_2O emissions including N_2O from LULUCF	3 547.42	3 450.42	3 315.85	3 012.08	2 850.69	2 394.87	2 350.33	2 295.53
N_2O emissions excluding N_2O from LULUCF	3 573.32	3 476.40	3 341.06	3 037.22	2 875.30	2 419.41	2 373.56	2 317.11
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)	**51 271.33**	**49 473.09**	**50 179.67**	**45 651.68**	**46 559.69**	**45 455.58**	**43 251.41**	**42 885.65**
Total (including LULUCF)	**42 934.74**	**41 409.46**	**43 233.55**	**38 824.93**	**40 547.07**	**39 046.50**	**35 629.74**	**34 814.36**

Table ES.4: *Summary of the GHG emissions in 1990 – 2013 according to the sectors*

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997
	CO_2 eq.(Gg)							
1. Energy	56 667.66	50 115.38	45 887.39	41 993.22	39 345.17	39 567.82	39 729.95	39 523.12
2. Industrial Processes	9 813.05	7 604.19	7 226.74	8 243.04	8 457.31	9 383.33	9 695.95	9 733.40
4. Agriculture	6 587.01	5 673.13	4 846.84	4 215.04	4 034.36	4 121.87	4 032.85	3 976.12
5. Land Use, Land-Use Change and Forestry	-8 991.25	-9 726.29	-10 431.33	-10 444.06	-9 756.84	-9 284.13	-9 243.42	-9 127.82
6. Waste	1 392.62	1 390.06	1 378.10	1 372.49	1 345.32	1 338.58	1 335.00	1 341.17

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1998	1999	2000	2001	2002	2003	2004	2005
	CO_2 eq.(Gg)							
1. Energy	38 210.90	37 585.12	36 539.52	38 759.52	35 710.47	36 691.32	36 296.84	36 759.25
2. Industrial Processes	9 875.36	9 490.25	8 594.17	8 765.51	9 810.85	9 411.98	10 701.28	10 257.56
4. Agriculture	3 665.83	3 388.21	3 378.74	3 398.24	3 417.03	3 273.44	3 036.22	3 021.66
5. Land Use, Land-Use Change and Forestry	-10 178.05	-10 002.14	-9 718.90	-8 867.19	-9 464.16	-9 217.13	-8 918.93	-5 604.95
6. Waste	1 349.10	1 347.99	1 350.64	1 354.73	1 356.49	1 354.69	1 358.06	1 357.15

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2006	2007	2008	2009	2010	2011	2012	2013
	CO_2 eq.(Gg)							
1. Energy	35 785.45	34 122.64	35 040.80	32 173.39	32 741.10	32 022.32	29 779.31	29 621.67
2. Industrial Processes	11 136.95	10 978.20	10 850.00	9 292.97	9 609.94	9 200.01	9 123.09	8 846.91
4. Agriculture	2 951.14	3 014.18	2 904.63	2 798.28	2 813.38	2 806.24	2 890.52	2 970.82
5. Land Use, Land-Use Change and Forestry	-8 336.59	-8 063.63	-6 946.12	-6 826.76	-6 012.61	-6 409.08	-7 621.67	-8 071.29
6. Waste	1 397.78	1 358.07	1 384.23	1 387.05	1 395.27	1 427.02	1 458.49	1 446.26

Total aggregated GHGs emission, emissions are determined as of 15.04.2017, no indirect emissions are reported in the 2017 submission.

ES.5 INDIRECT EMISSIONS AND PRECURSORS OF GREENHOUSE GASES

The Slovak Republic is providing emissions of CO, NO_x, SO_2 and NMVOC for the year 2015 as required in the UNFCCC reporting Guidelines 2013. This information is included in the CRF tables 1990 – 2015 generated by the CRF Reporter software version 6.0.1.1 as a part of annual GHG inventory submitted on 15th April 2017.

In general, the national totals of CO, NO_x, SO_X and NMVOC emissions are below the national emission ceilings from 2010 that were determined in Directive 2001/81/EC. The new Directive 2284/2016/EU repeals and replaces Directive 2001/81/EC, the National Emission Ceilings Directive (NEC Directive) and ensure that the emission ceilings for 2010 set in that Directive shall apply until 2020. Directive 2016/2284 also transposes the reduction commitments for 2020 taken by the EU and its Member States under the revised Gothenburg Protocol and sets more ambitious reduction commitments for 2030 so as to cut the health impacts of air pollution by half compared with 2005.[6]

The CO, NO_x, SO_X and NMVOC emissions have decreasing trend as a result of the intensive air protection policy in the Slovak Republic. Although the decline of CO and SO_X emissions is more dramatic throughout the entire time series compare to NO_x and NMVOC. However, SO_X emissions has strongly increased inter-annually (2014/2015) due to the reconstructions of particular heating plant which used the unabated granulated coal boilers. The overview NO_X, CO, NMVOC and SO_2 emissions for the year 2015 is shown in the Table of the Annex II (Article 7) of the Commission Implementing Regulation (EU) No 749/2014 provided in this submission.

Several recalculations were done in reporting under NECD. The general revision of used methodologies in Slovak emission inventory is still ongoing and the first results were applied in NECD submission in submission 2016 and continued on submission 15th January 2017. The major changes are visible in NMVOC emissions. These recalculations were performed as the result of the QA/QC activity in improving process of transparency, accuracy and consistency of the emission inventory.

- The revision of methodology in solvents, energy, transport and industry was performed. The final values are slightly different compare to the previous reports due to modelling of activity data and emissions. Modelling of emissions was performed back up to 1990. Revise of EMEP/EEA Guidebook 2016 had also influence to recalculation of emissions.
- Emissions from Agriculture for 3.B category were recalculated due to change in activity data. The Statistical Office of The Slovak Republic provided very detailed data about number of livestock up to 1990 year. According to this improvement, the more accurate estimates of all emissions from all animal species we prepared. New NEX, which was calculated in GHG inventory was implemented. The discrepancy of the NH_3 emissions in 3B Manure management found during the last year caused the overestimation of emissions in 2016 submission. In 2017 submission, we prepared the revise of NH_3 estimate. The Revision of EMEP/EEA Guidebook had also influence onto recalculation of emissions. We prepare new estimate of NMVOC emissions for cattle category. New detailed information about number of livestock, ratio data and new estimate of NH_3 emissions was available and these implementations had influence at total amount of NMVOC emissions.

Submission for the years 1990-2015 was uploaded via the EIONET Central Data Repository tool on webpage: http://cdr.eionet.europa.eu/sk/eu/nec_revised/inventories/envwmmbxa/ during the February 2016 as preliminary version. On 15th March 2017 the data were updated as final version. Relevant, more detailed and updated methodological information on indirect gases such as NOx, SO_2 and NMVOC are available in the Informative Inventory Report of the Slovak Republic under the Convention on Long-rage Transboundary Air Pollution on 15th March 2016 submission.

[6] http://ec.europa.eu/environment/air/pollutants/ceilings.htm

According to the preliminary analyses there are no larger inconsistencies (+/- 5%) in the reporting under NECD (submitted on 15/3/2015) and the GHG inventory (submitted on 15/4/2016). 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 in the GHG inventory (indirect N_2O emissions are calculated based on NOx emissions in the category 3.B.2 – manure management).

Comparison and analyses are described in the Annex table to this submission pursuant to Article 7(1)(b) of Regulation (EU) No 525/2013.

Table ES.5: *Summary of the indirect GHG emissions in 2015 according to the gases and sectors*

EMISSIONS	TOTAL	ENERGY	INDUSTRY	AGRICULTURE	LULUCF	WASTE
	Gg					
NOx	**63.79**	56.11	0.85	6.38	0.43	0.02
CO	**231.06**	214.67	1.09	NE,NA,NO	15.30	0.00
NMVOC	**93.82**	27.83	50.17	9.15	NE,NA,NO	6.67
SO_2	**71.21**	70.76	0.44	NA,NO	NE	0.00

Emissions of basic pollutants are available in public database: DATAcube: http://datacube.statistics.sk/TM1Web/TM1WebLogin.aspx. Public available are also Air Emissions Accounts:

- SOSR website – Air Emission Accounts data are available in the STATdat database. Data are updated annually.
- SHMU website – Air Emission Accounts preliminary data 2016 are available as the aggregates in format of separate PDF files for particular years – 2008, 2009, 2010, 2011, 2012, 2013, 2014.

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.

Carbon dioxide (CO_2) accounted for about 83% of the total increase in radiative forcing by long-lived greenhouse gases over the past decade. The pre-industrial level of about 278 ppm represented a balance between the atmosphere, the oceans and the biosphere. Human activities such as the burning of fossil fuels has altered the natural balance and in 2014, globally averaged levels were 143% of pre-industrial levels. In 2014, global annual average concentration of CO_2 concentrations reached 397.7 ppm with annual increase close to the 10 year averaged. The global annual average is likely to pass 400 ppm in 2016.

Methane CH_4 is the second most important long-lived greenhouse gas. 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. Atmospheric methane reached a new high of about 1 833 parts per billion (ppb) in 2014 and now is 254% of the pre-industrial level.

Nitrous oxide (N_2O) is emitted into the atmosphere from both natural (about 60%) and anthropogenic sources (approximately 40%), including oceans, soil, biomass burning, fertilizer use, and various industrial processes. Its atmospheric concentration in 2014 was about 327.1 parts per billion. This is 121% of pre-industrial levels. Its impact on climate, over a 100-year period, is 298 times greater than equal emissions of carbon dioxide. It also plays an important role in the destruction of the stratospheric ozone layer which protects us from the harmful ultraviolet rays of the sun.[7]

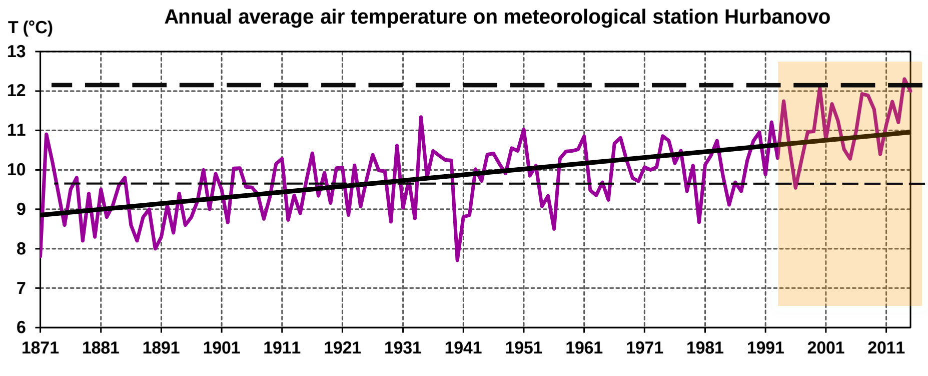
[7] World Data Centre for Greenhouse Gases (WDCGG) at the Japan Meteorological Agency (http://ds.data.jma.go.jp/gmd/wdcgg

According to 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.

During the period 1881 – 2015 (good quality of meteorological observations at several stations and precipitation totals at 203 stations), significant increase of annual air temperature by 1.8°C and insignificant decrease of annual precipitation totals by 1.3% were recorded on average in Slovakia. 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 decrease up to 5% in the south-west and snow cover decrease up to altitude 800 m were recorded (moderate snow cover increase in the highlands, above 1 000 m a.s.l.). There is the evidence of gradual desertification, particularly in the south of the country (increase of potential evaporation and decrease of soil moisture), but the year 2010 and the cold half-year 2012/2013 were the wettest since 1 881. Significant increase in regional and flash floods has been recorded since 1995. Sun radiation characteristics changed insignificantly, except the temporal decrease in 1965 – 1985. Heavy and intense precipitation events play very important role in flash flood events, evidence of such cases is based on measurements at about 700 station since 1949 and decreasing number of stations since 1881 (more than 200 stations in Slovakia in 1900). An increase of such events can be seen since 1994, but in 1949 – 1970 there were as many or even more numbers of heavy rains than in the last 20 years (36 events/stations on June 29, 1958).[8]

The climate scenarios for impacts of anthropogenic activities on average temperature in the Central Europe show significant increase. These results were recorded also by measurements in Slovakia. Years 2014 and 2015 were the warmest since the beginning of meteorological measurements in Slovakia (***Figure 1.1***). Higher air temperature increases water evaporation and higher precipitation. The precipitation in summer is irregularly distributed in time and space and in winter increase of liquid precipitation was recorded. The share of liquid or mixed precipitation is increasing. Loss of snow cover in winter mostly in lowlands caused acceleration of temperature increase and risk of desertification. These circumstances shift our climate in complex to the less stable one.

Figure 1.1: *Trend in annual average air temperature in Slovakia since 1871*



[8] The Sixth National Communication of the Slovak Republic on Climate Change, 2013

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 sectoral tables (IPPU and agriculture). The indirect CO_2 emissions have been evaluated and included in the sector Industrial Processes and Other Product Use sector consistent with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Indirect N_2O emissions resulting from a deposition of nitrogen due to emissions of nitrogen oxides (NOx) and ammonia (NH_3) are estimated and indirect N_2O emissions from agricultural sources are included in the national total emissions consistent with the UNFCCC reporting guidelines in the Annex to Decision 24/CP.19 (UNFCCC 2013).

The SVK NIR 2017 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 2000 (see Chapter ES.5).

The emission 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 in the Common Reporting Format (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 (UNFCCC 2013). According to the emission inventory submitted in March 15, 2017, the Slovak Republic total anthropogenic emissions of greenhouse gasses expressed as CO_2 equivalent decreased by 44.6% without LULUCF, compared to the base year 1990. This achievement is the result of impacts of several processes and factors, mainly:

- 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 (except for metallurgy).
- 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.
- Implementation of strict policies and measures in climate change and international agreements up to 2030.

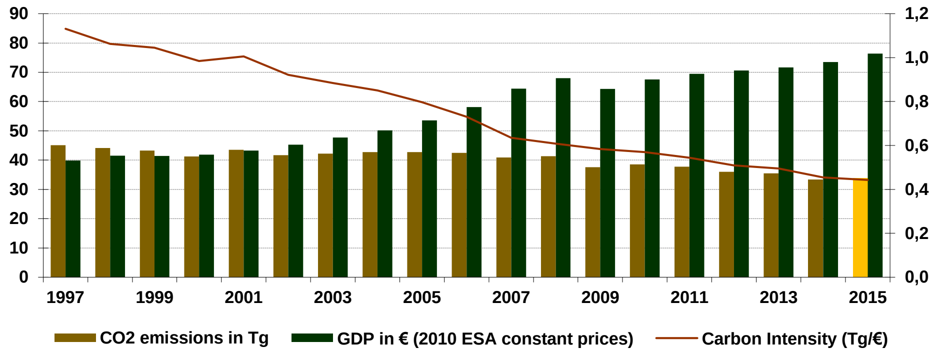
In May 2004, the Slovak Republic joined the European Union. Relevant European legislation has brought additional positive direct and indirect effects to the reduction of GHG emissions, mainly in energy sector. The introduction of emission trading scheme will allow the implementation of further reduction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

Table 1.1 and ***Figure 1.2*** show the most significant trend indicator of GDP and GHG emissions decoupling which was achieved in Slovakia in past years. Also development in the last inventory year (2014) is an evidence of continuation of decoupling process started in the 1997 and continuing also 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 1.1: *Decrease of carbon intensity per GDP in the Slovak Republic since 2000*

YEAR	2000	2001	2002	2003	2004	2005	2006	2007
CO_2 emission in Tg	41.24	43.55	41.71	42.19	42.71	42.74	42.47	40.87
GDP in Bio € at ESA 2010 prices	41.89	43.28	45.24	47.69	50.20	53.59	58.12	64.40
Carbon Intensity (Tg/GDP)	0.98	1.01	0.92	0.88	0.85	0.80	0.73	0.63
YEAR	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
CO_2 emission in Tg	41.38	37.59	38.51	37.80	36.00	35.53	33.42	33.79
GDP in Bio € at ESA 2010 prices	68.02	64.33	67.58	69.48	70.63	71.69	73.53	76.35
Carbon Intensity (Tg/GDP)	0.61	0.58	0.57	0.54	0.51	0.50	0.45	0.44

Figure 1.2: *Comparison of CO_2 emissions per GDP (carbon intensity)*



The Statistical Office of the Slovak Republic, Dpt. of National Accounts. Within the revision of annual national accounts, ESA 2010 methodology was implemented and reference year was changed from 2005 to 2010 constant prices.

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 23rd, 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 emission inventory on annual basis.

In 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, taking into account 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. More information can be found in the Initial Report of Slovakia under the First Commitment Period.[9]

The Slovak Republic and the former EU Member States ratified the Kyoto Protocol on 31st May 2002.[10] 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.[11]

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 Climate and Energy 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 this SVK NIR 2017 is reported the first three years (2013, 2014 and 2015) of the second commitment period of the Doha Amendment of the Kyoto Protocol.

The European Union and Slovakia aimed for ambitious, fair and long-lasting agreement in COP 21 in Paris (December 2015). Slovakia welcomes the adopted agreement as it fulfils most of our requirements and expectations. We signed the agreement at the signing ceremony on April 22, 2016 in New York and we started with the ratification process.

Ratification of the Paris Agreement will be subject to the approval of the National Council of the Slovak Republic. The formal document has to be first submitted to the Government and then to the Parliament. The whole process will take minimum of 6 to 9 months. Ministry of the Environment, together with the Ministry of Foreign Affairs, is responsible for the process.

However, before submitting the proposal for ratification to the Government and the National Council we need to prepare some modelling of possible scenarios and analyses of the trends in Slovakia.

The ratification may be finalised in 2018 at the earliest.

EU context - After joining the European Union (May 1st, 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.[12] The Slovak Republic submits the preliminary data on GHG emission inventory for the year X-2 in required scope by January 15th each year (Annual Report), according to Regulation No 525/2013/EU (the MMR) repealing Decision No 280/2004/EC of the European Parliament and of the Council concerning a mechanism for monitoring Community GHG emissions and for implementing the Kyoto Protocol and Doha Amendment.

[9] http://unfccc.int/national_reports/initial_reports_under_the_kyoto_protocol/items/3765.php

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

[11] http://unfccc.int/kyoto_protocol/reporting/true-up_period_reports_under_the_kyoto_protocol/items/9049.php

[12] New environmental action program: Environment 2010 Our Future, Our Choice

Basic objectives of the Regulation are:[13]

- Monitoring of all anthropogenic emissions of GHGs in the EU Member States.
- Ensure the progress in fulfilling the reduction targets under the UNFCCC and the Kyoto Protocol.
- Implement the Convention and the Kyoto Protocol in view of national programs, GHGs inventory, national systems and register of the EU and the Member States.
- Ensure completeness, transparency, consistency, accuracy, comparability and the timing in the EC reporting.

In view of urgency and need to solve problems of climate change, energy efficiency and security, the heads of states and governments adopted a political decision regarding middle-term objectives for EU in March 2007, as follows:

- Unilateral 20% reduction of GHG emissions by 2020 compared to 1990, or the reduction by 30% in case of achieving a new international agreement.
- Increase in energy efficiency by 20% by 2020.
- Achieving 20% share of renewable resources on final energy consumption, including, 10% share of biofuels in gasoline and diesel oil consumption by 2020.

Integrated Climate and Energy Package (CEP) is a principal, comprehensive and ambitious solution, which will influence significantly the economic development of the Slovak Republic within the middle-term horizon. By its approval in December 2009, the legal framework of the issue was distinctly strengthened. The CEP is an important impulse for more active perception of climate change and adaptation at the level of the Government of the Slovak Republic and general public, together with international negotiations on future cooperation of countries in this agenda after the year 2012.

Several non-legislative activities were introduced in the Slovak Republic in 2013. Among others The Adaptation Strategy of the Slovak Republic has been already prepared, approved by the Slovak Government and published. The preparation of the Low Carbon Strategy of the Slovak Republic is on the agenda of the High Level Committee for Coordination of Climate Change Policy and its working group of experts.

In addition to the already mentioned EU policy, the European Union has approved Climate and Energy Framework for the period 2020 – 2030 with the set of measures preparing for legislation after 2020. The European Commission will be assessing various options for enhancing flexibility mechanisms, including compliance aspects for the EU ETS emissions, ESD emissions (non-EU ETS) and LULUCF emissions/removals.

In the present period, the EU MMR 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 Climate and Energy package, 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, and 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 these 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.

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[13] 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. Both, the conceptual documents as well as legislative proposals are always annotated by all ministries and other relevant bodies. 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 and to monitor progress of Slovakia to meet all commitments and obligations of climate change and adaptation policy.

According to the Governmental Resolution No 821/2011 Coll. from 19th December 2011, the inter-ministerial High Level Committee on Coordination of Climate Change Policy was established. This Committee is created at the state secretary level and replaced previous coordinating body, i.e. the High Level Committee on Climate-Energy Package established in August 2008. Committee is chaired by the State Secretary of the Ministry of Environment, other members are 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.

Main objective of the Coordination Committee is 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 is 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"), annually 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[14], another in April 2013,[15] in April 2014,[16] in April 2015[17] , in April 2016 [18] and in April 2017[19].

Special working group within the Coordination Committee was established at the second meeting of the Inter-ministerial High Level Committee on the Coordination of the Climate Change in November 16, 2012. The working group comprises the representatives of the relevant institutions and coordinates the following tasks:

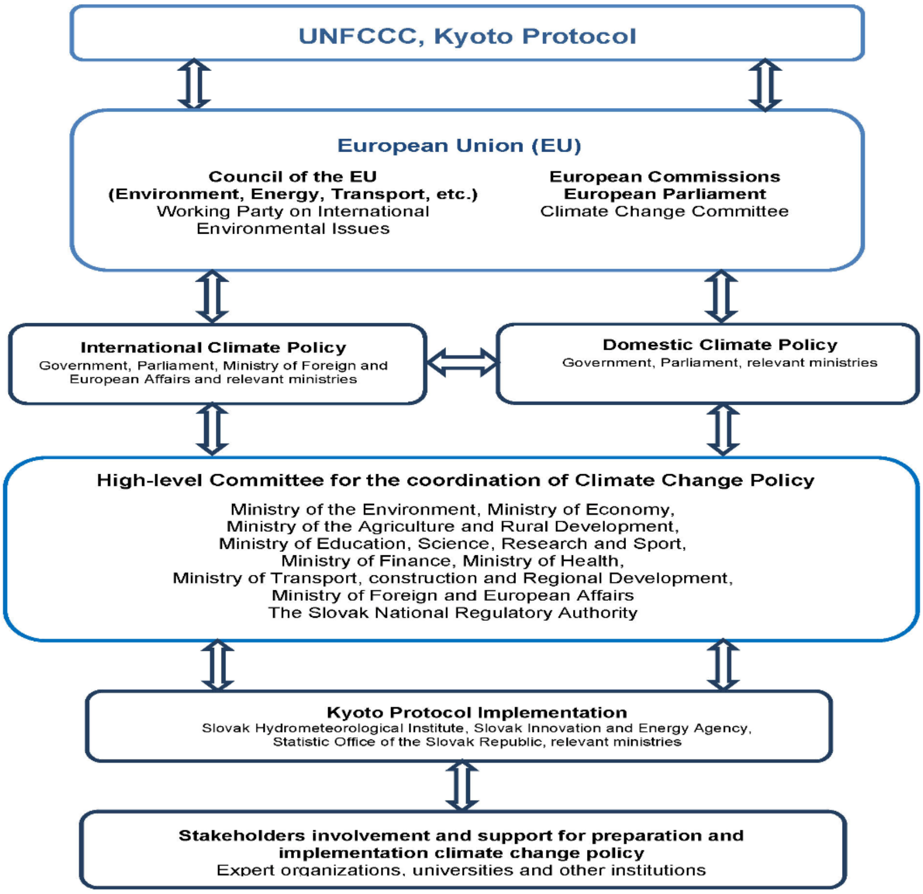
- reviewing and providing comments to the emission indicators calculated as obligatory part of the Annual Report 2015 prepared according to the Article 7 of the Regulation EU 525/2013 (January 2015),
- providing documents for relevant strategies, policies and measures to prepare 7th National Communication on Climate Change,
- drafting the Low Carbon Strategy of the Slovak Republic up to 2030.

[14] http://www.rokovania.sk/Rokovanie.aspx/BodRokovaniaDetail?idMaterial=21144
[15] http://www.rokovania.sk/Rokovanie.aspx/BodRokovaniaDetail?idMaterial=22264
[16] http://www.rokovanie.sk/Rokovanie.aspx/BodRokovaniaDetail?idMaterial=23392
[17] http://www.rokovanie.sk/Rokovanie.aspx/BodRokovaniaDetail?idMaterial=24429
[18] http://www.rokovanie.sk/Rokovanie.aspx/BodRokovaniaDetail?idMaterial=25426
[19] http://www.rokovania.sk/Rokovanie.aspx/BodRokovaniaDetail?idMaterial=26360 (No.151/2017)

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 Coordination Committee in 2012. These expert groups include experts from other relevant ministries, academic and university positions and other expert institutions. The Adaptation Strategy was adopted in January 2014.[20]

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

Figure 1.3: *Institutional arrangements concerning climate change policy and its implementation*



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 (NIS) which enables continual monitoring of greenhouse gases emissions is given by Article 5, paragraph 1 of the Kyoto Protocol.

[20] http://www.rokovania.sk/File.aspx/ViewDocumentHtml/Mater-Dokum-163003?prefixFile=m

Setting up the National Inventory System (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 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 also 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 (http://ghg-inventory.shmu.sk/) has been 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.[21] In agreement with paragraph 30(f) of Annex to Decision 19/CMP.1 which gives the definitions of all qualitative parameters for the national inventory systems, the description of quality assurance and quality control plan according to Article 5, paragraph 1 is also required. The revised report of the National Inventory System 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 National Inventory System with all qualitative and quantitative indicators is provided in the National Inventory Reports and was also provided in the Sixth National Communication of the SR on Climate Change, published in December 2013.

1.2.1.1 The role of responsible ministries in the national system

The Ministry of Environment of the Slovak Republic (the MZP 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 8 regional and 46 district administration offices. Inspection and enforcement activities are carried out by the 4 inspectorates of the Slovak Environmental Inspection. 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 MZP 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 Ministry of Environment of the Slovak Republic 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

[21] "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

details of the SHMÚ activities are described in the Plan of Main Tasks. The plan, commented by all stakeholders is published after approval at the website of the SHMÚ http://www.shmu.sk/File/Kontrakt_SHMU/Kontrakt_SHMU_2016.pdf. Deadline for the approval of this plan by the ministry is 31st December each year.

Organisational changes occurred in the 1.1.2017 at the SHMÚ (the new structure of SHMÚ is presented at http://www.shmu.sk//File/Org_Struktura_SHMU/Struktura_bezVO_1_1_2017.pdf. They resulted in establishment of the Department of Emissions and Biofuels (OEaB). The OEaB has two main tasks: emission inventories (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 (https://www.air.sk). 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 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 in the official document.[18] 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 National Inventory System of the SR (the NIS SR). It currently comprises 3.5 experts working on inventory tasks as a full time job. Composition of the SNE is: NIS coordinator, deputy NIS coordinator and data manager, energy expert and agricultural expert. Permanent staff of the SNE is complemented to the NIS SR by several institutions and external experts from relevant sectors working on contracts updated as necessary and partly also other experts of the OEaB (***Figure 1.4***). On this figure is a new structure of the NIS, where the Committee on CCP is intergovernmental body responsible for climate change policy implementation on cross-ministerial level. On the ***Table 1.2*** is updated list of internal experts within SHMU and a list of external experts and institutions within NIS SR.

1.2.1.3 Responsibilities of expert organisations

Contracts with the external institutions and 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 MZP 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;
- National Forest Centre – Ministry of Agriculture and Rural Development;
- Research Institute on Soil Protection Bratislava - Ministry of Agriculture and Rural Development.

Supporting institutions, founded by the Ministry of Environment to perform specific tasks linked to the inventory activities, play an important role. These include the Slovak Hydrometeorological Institute, the Water Research Institute, and the Slovak Environmental Agency. Academic and research institutions, the non-governmental organizations, and associations of interested groups the Profing company, the Ecosys company, the National Forest Centre Zvolen (the NLC) with the cooperation of the Ministry of Agriculture and Rural Development of the Slovak Republic (the MPRV SR), the Transport Research Institute Žilina with the cooperation of the Ministry of Transport and of the Slovak Republic (the MDVRR SR), the Research Institute on Soil Protection Bratislava with the cooperation of the MPRV SR, the Department of Chemical and Environmental Engineering of the Faculty of Chemical Technology of the Slovak Technical University Bratislava, the Faculty of Mathematics, Physics & Informatics of the Comenius University Bratislava, the Slovak Environmental Agency, the Statistical Office of the Slovak Republic (the SU SR), the Slovak Cooling and Air Conditions Association, the SPIRIT Information Systems and the Waste Management Centre Bratislava and Ministry of Finance of the Slovak Republic (the MF SR). There are also other relevant subjects for data providing, which are listed in the sectoral chapters (***Table 1.2***).

Figure 1.4: *Structure and responsibilities of the National Inventory System of the Slovak Republic*

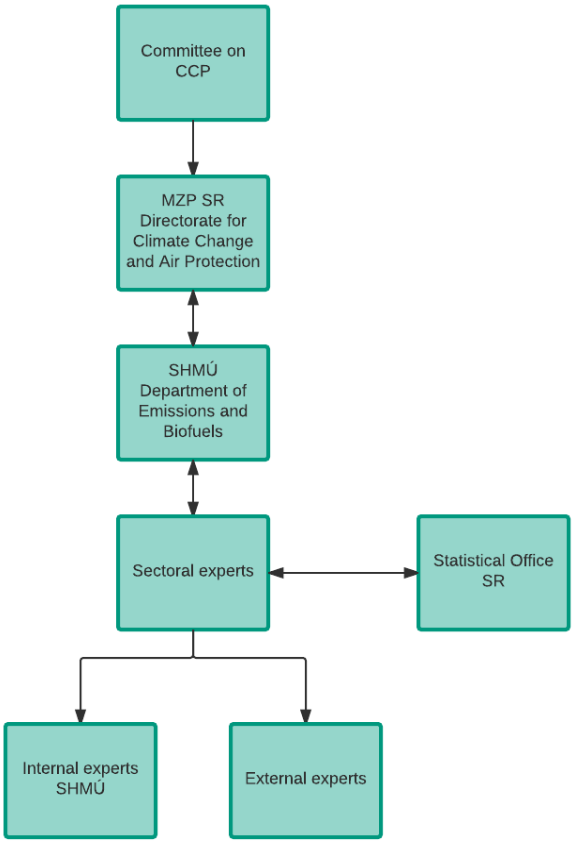


Table 1.2: *List of sectoral experts in the National Inventory System of the Slovak Republic*

INTERNAL EXPERTS - SHMÚ		
INSTITUTION	**NAME**	**RESPONSIBILITY**
Dept. of Emissions and Air Quality Monitoring - SNE	Ms. Janka Szemesová	NIS coordinator
Dept. of Emissions and Air Quality Monitoring - SNE	Ms. Lenka Zetochová	Deputy of NIS coordinator and data manager
Dept. of Emissions and Air Quality Monitoring - SNE	Mr. Ján Horváth	Energy expert
Dept. of Emissions and Air Quality Monitoring	Mr. Marcel Zemko	Emission projections expert
Dept. of Emissions and Air Quality Monitoring	Ms. Ivana Ďuricová	Other pollutant expert

INTERNAL EXPERTS - SHMÚ		
INSTITUTION	**NAME**	**RESPONSIBILITY**
Dept. of Emissions and Air Quality Monitoring	Ms. Kristina Tonhauzer	Agricultural expert
Dept. of Emissions and Air Quality Monitoring	Ms. Monika Jalšovská	NEIS expert
Dept. of Water Quality	Ms. Lea Mrafková	GHG inventory in wastewater sector

EXTERNAL INSTITUTIONS/EXPERTS		
INSTITUTION	**NAME**	**RESPONSIBILITY**
Profing – company for environmental services in GHG	Mr. Jan Judák	Reference approach and fugitive emission 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. Pavel Pavenda	GHG inventory in Forest Land and KP LULUCF
Geodesy, Cartography and Cadaster Authority of Slovak Republic	Mr. Peter Katona	Cadastral data provider in AFOLU sector
Motran Research – company for transport research	Mr. Jiří Dufek	GHG inventory in transport sector
Transport Research Institute Žilina	Ms. Ingrid Dorčíková	Data provider in transport sector
Animal Production Research Centre	Ms. Zuzana Palkovičová Mr. Vojtech Brestenský	GHG inventory in agriculture – animal production
Research Institute on Soil Protection Bratislava National Agricultural and Food Institute	Ms. Beáta Houšková Ms. Zuzana Tarasovičová	Data provider in agriculture sector – soils, LULUCF Cropland and fertilisers
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
Faculty of Mathematics, Physics & Informatics of the Comenius University Bratislava	Mr. Martin Gera	Uncertainty analyses, QA activity
veQ – company for waste management research	Mr. Juraj Farkaš	GHG inventory in waste – solid waste
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). Slovak national registry was successfully connected to ITL with other EU countries in October 2008 and it has been fully functional since. More information on changes in the national registry is provided in Chapters 12 and 14 of this report.

Table 1.3: *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:	Unit Manager (Emission Registry)
E-mail address:	miroslav.hrobak@icz.sk

1.2.3 INVENTORY PLANNING, PREPARATION AND MANAGEMENT

The preparation of emission inventories within the National Inventory System for GHG emissions is decentralized according to the definition of Article 5.1 of the KP. Individual sectors are fully under the responsibilities of 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 NIS and approved by the MZP 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 VERIFICATION PLANS

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

1.2.4.1 Quality management

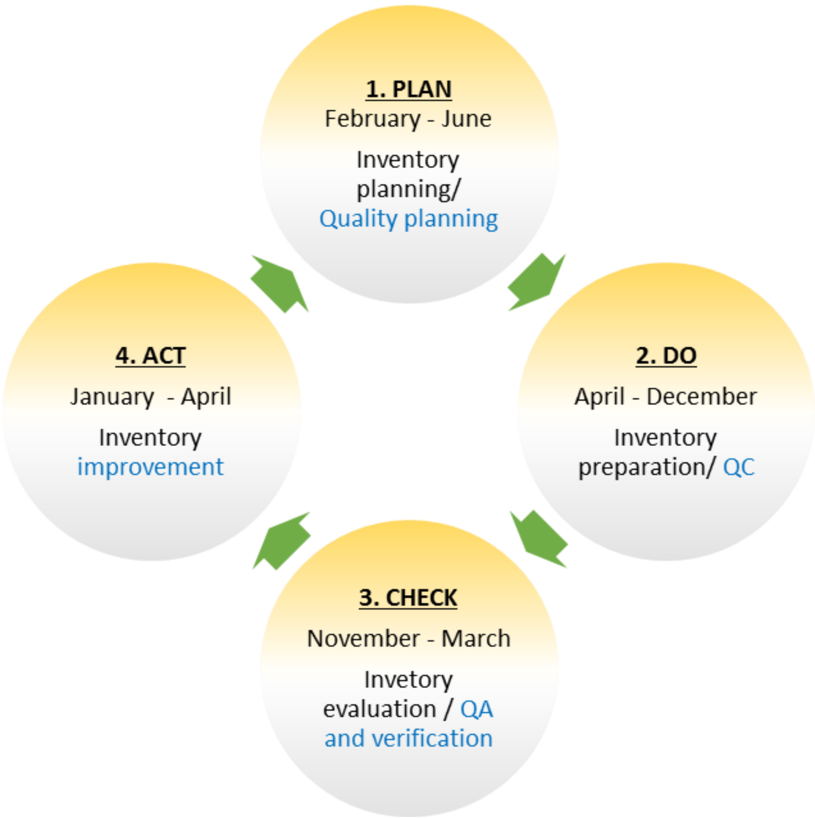
The Slovak Hydrometeorological Institute has built and introduced the quality management system (QMS) according to the requirements of EN ISO 9001:2008 standard of conformity. In the frame of introduction of the QMS for the SHMU as a global standard, the certification itself proceeds according to the partial processes inside of the SHMU 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 National Inventory System (NIS) is to produce high-quality GHG inventories. In the context of GHG inventories, high quality provides that both the structures of the national system (i.e. all institutional, legal and procedural arrangements) for estimating GHG emissions and removals and the inventory submissions (i.e. outputs, products) comply with the requirements, principles and elements arising from UNFCCC, the *Kyoto Protocol*, the IPCC guidelines and the EU GHG monitoring mechanism (Regulation No 525/2013/ of the European Parliament and of the Council).

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 activities and verification procedures.

Figure 1.5: *PDCA cycle (Plan, Do, Check, Act)*



1. Inventory planning/Quality planning
- Setting roles and responsibilities
- Elaboration of QA/QC and verification plan
- Specifying necessary processes and resources
- Selecting methods and emission factors

2. Inventory preparation/Quality control
- Collecting activity data
- Estimating GHG emissions and removals
- Implementing QC checks

Uncertainty estimation, calculations, compile CRF tables

3. Inventory evaluation/QA and verification
- Implementing QA
- Verification
- Final QC
- NIR preparation

Documenting and archiving inventory material

4. Inventory improvement
- reviews
- addressing comments and errors
- assessing the effectiveness

Conclusions for future actions

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 sent to sectoral experts of the SVK NIS. 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.

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 national inventory system 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 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:

1. Continuous improvement

- ✓ Treatment of review feedback is systematic
- ✓ Improvements promised in the NIR are introduced
- ✓ Improvement of the inventory is systematic
- ✓ QC procedures meet the requirements and QA is appropriate

2. Transparency

- ✓ Archiving of the inventory is systematic and complete
- ✓ Internal documentation of calculations supports emission and removal estimates
- ✓ CRF Tables and the NIR include transparent and appropriate descriptions of emission and removal estimates and of their preparation.

3. Consistency

- ✓ The time series are consistent
- ✓ Data have been used in a consistent manner in the inventory.

4. Comparability

- ✓ The methodologies and formats used in the inventory meet comparability requirements.

5. <u>Completeness</u>

- ✓ The inventory covers all the emission sources, sinks and gases

6. <u>Accuracy</u>

- ✓ The estimates are systematically neither greater nor less than the actual emissions or removals
- ✓ The calculation is correct
- ✓ Inventory uncertainties are estimated

7. <u>Timeliness</u>

- ✓ High-quality inventory reports reach their recipient (EU/UNFCCC) within the set time.

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 are updated and evaluated annually by the quality manager of the NIS and approved by the MZP SR.

1.2.4.3 Quality control procedures (DO)

The general and category – specific QC procedures are performed by the experts during inventory calculation and compilation.

General quality control includes routine checks, 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 are in different levels, include basic reviews of the draft report, general public review, external peer review, internal audit, EU and UNFCCC reviews.

With uploading to the website of SHMÚ, printing and distribution of the final inventory document we can have feedback from general public. Sectoral experts and the members of inventory team during the year are participating in various seminars, meetings, conferences and sector-specific workshops, where are reported the activities of inventory members and results of national inventory emission. A broader range of researchers and practitioners in non-government organizations, industry and academia, trade associations as well as the general public have the opportunity to contribute to the final document. The comments received during these processes are reviewed and, as appropriate, incorporated into the Inventory Report or reflected in the inventory estimates.

When checking the quality of data of each sector, the NIS coordinator, quality manager of NIS, data manager of the 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 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 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 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 SHMU and the Czech Hydrometeorological Institute (CHMI) met to exchange information and experience relating to the preparation of GHG inventory. The main points in last meeting which took place in July 2016 were:

- QA/QC processes - QA/QC system in Czech Republic, steps, cooperation with experts;
- Agriculture – key categories, NEX, Ym factor;
- Review – ESD evaluation, discussion about conclusions;
- Estimating emission of charcoal, F-gases;
- Feedstock and other non-energy use of fuels.

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 are checked regularly. Completeness checks are undertaken, new and previous estimates are compared every time. Data entry into the database is checked many times by the sector expert for uncertainty. 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 EU28, and analyse its relevance for Slovakia.

Confidential information is provided to the NIS experts based on the bilateral agreements but cannot be reported separately (only as national total).

1.2.4.6 Inventory improvement (ACT)

The main aim of QA/QC process is continuous improvement of the quality of inventory. In the reflection of the ERT request No G.3 of the SVK 2016 ARR, 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 and improvement plans are updated annually after the regular UNFCCC and EU compliance reviews takes place. As the Slovakia is one of the Member States of the European Union, the separate review regime is undertaken under the EU Monitoring Mechanism Regulation EU No 525/2013 and the Effort Sharing Decision (ESD) in spring every year. These outcomes and recommendations are included in the improvement plan, too. Prioritisation process is based on problems and recommendation raised during reviews and also based on expert's consultations. Results of prioritisation are included in the improvement plans. Detailed recommendation list and improvement plan are prepared by 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.

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. Last year the priority was a revision and implementation methodological changes and national parameters in emissions inventory of agricultural sector. This process was not completely implemented in 2016 submission and will continue also this year. For this NIR top priority have problems and recommendation which were identified in the 3 previous reviews - chapters LULUCF, Transport and Energy. High priority have items which identified in the previous review chapters – General and Agriculture and newly identified recommendations in chapters IPPU, Waste and KP LULUCF.

1.2.5 CHANGES IN THE NATIONAL INVENTORY ARRANGEMENTS

There were no significant changes in the arrangement of the National Inventory System during inventory year 2016. More information can be found in Chapter 13 of this report.

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 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 National Inventory System http://ghg-inventory.shmu.sk/ and by the sectoral experts and NIS coordinator. The most important source of activity data is the Statistical Office of the Slovak Republic and the sectoral statistics of the ministries. The NEIS database is also important reference source of emission data on fuels and other characteristics of stationary air pollution sources. The NEIS is operated by the OEaB of the SHMU. Other important sources are listed in the ***Table 1.4*** below.

Table 1.4: *List of important information sources for inventory preparation*

SECTOR	SOURCE OF INPUT DATA
Energy	Energy Statistics of the SR, www.statistics.sk, NEIS - www.air.sk, www.spp.sk, www.transpetrol.sk, EU ETS Reports, Reports of verifiers
Industrial Processes and Product Use	Association of cement and lime producers, Association of refrigeration and air conditioning engineers, Association of paper producers; Association for coating and adhesives, solvent distributors, Research institute for crude oil, www.vurup.sk.
Agriculture	Green Report of the Ministry of Agriculture of the SR - Agriculture, Institute for Fertilisers Research, http://www.mpsr.sk/sk/index.php?navID=122
LULUCF	Green Report of the Ministry of Agriculture of the SR - Forest, Cadastral Office, http://www.mpsr.sk/sk/index.php?navID=123
Waste	Dbase RISO http://www.sazp.sk/slovak/struktura/COH/oim/data/index.htm, dbase of the industrial wastewater of the SHMU, Waste Statistics of the SU SR

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 waste sector, etc.).

Archiving of inventory documents and database is in the competence of the quality and data managers of the NIS SR. Archiving of database is in the competence of 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 National Inventory System. The access to sensitive documents is through the user name and password. Statistics and calculations are archived at the level of external institutions and managed by sectoral experts. All other relevant documents, papers and reports are stored in electronic and printed forms at the OEaB.

The archiving is controlled by rules for archiving systems in organizations at the SHMU level. The documents are archived in electronic and printed forms. Electronic archiving of sectoral reports, inventory submissions and other specific documents (ERT reports, ARR, National Reports etc.) is at webpage http://ghg-inventory.shmu.sk/, 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 SHMU (intranet). Printed documents are archived in central archive of the SHMU 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.

All information used to create the inventory is archived in a single location in both electronic and/or hard copy (paper) storage so that future inventory managers can reference all relevant files to respond to reviewer feedback including questions about methodologies. 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 the information about archiving is recorded in form Archiving System.

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 IPCC 2006 GL. Detailed descriptions of used methodologies can be found as sector specific ones in Chapters 3 to 7. Regarding the tier methods used in the SVK NIS, the detailed information can be found in the 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 agriculture, industry and energy sectors. Additional sources of activity data for major sectors are as follows:

Energy:

- *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:

- *SLOVNAFT a.s. Bratislava*: Production and selling of gasoline and diesel fuel.
- *The Statistical Office of the Slovak Republic:* Import and export of gasoline and diesel fuel from the EU Member States.
- *The Customs Directorate of the Slovak Republic:* Import and export of gasoline and diesel fuel from the countries outside the EU.
- *Probugas a.s. Bratislava, Progas s.r.o. Bratislava, Flaga Slovplyn s.r.o. Pezinok, Flavia s.r.o. Vranov n/Topľou, Slovnaft a.s. Bratislava, 1. SPS, Autoplyn Danka Chovancová, Žilina:* Selling of LPG gas for road vehicles delivered into net of gas stations.
- *Slovak Gas Trading Company SPP Inc.:* Selling of compressed natural gas at gas stations.
- *SAD, a.s. Zvolen, SAD a.s. Nitra, SAD a.s. Michalovce, DP mesta Košice a.s. Košice, DPMB a.s. Bratislava:* Bus transportation companies provide data concerning of CNG consumption of gas driven busses.
- *Presidium of the Police Force of the Slovak Republic, the Department of Documents and Registration of the Presidium:* Data concerning numbers of new registrations, changes in the registration and deregistration of road vehicles at the end of the year in relation to the emission inventory.
- *The Association of Car Industry of the Slovak Republic:* Detailed data concerning structure of all type of cars sold in the Slovak Republic during actual year.

Data concerning GHG emissions inventory produced by railway traffic are provided by:

- *Železničná spoločnosť Slovensko, a. s.:* It provides fuel consumption data and selected operation capacity of combustion engine driven locomotives in personnel railway transport.

- *Železničná spoločnosť Cargo Slovakia, a. s.:* It provides fuel consumption data and selected operation capacity of combustion engine driven locomotives in railway freight service.

Data concerning GHG emissions inventory produced by water-borne transport are provided by:

- *State water-borne administration Bratislava*: It provides data concerning numbers of driving ships on the Slovak section of the Danube.
- *Slovak navigation and harbours Inc. Bratislava*: It provides data about selling of diesel oil from custom storage to navigation companies in Slovak harbours.

Data concerning GHG emissions inventory produced by aviation sector are provided by:

- *Aero servis Košice, ESSO Bratislava and Bratislava airport:* They provide data about sales of aviation fuels to airlines at important airports in the Slovak Republic.
- *Bratislava Airport, Košice Airport, Poprad – Tatry, Sliač Airport, Piešťany Airport and Žilina Airport:* They provide total numbers of LTO cycles at particular airports. These data are partially used as additional data for the national GHG inventory compilation. The data are used to determine the air pollution from the airports.

Waste:

- *COHEM SAZP (Waste Management Centre of the Slovak Environmental Agency):* Industrial solid waste data.
- *Terrasystems Banska Bystrica:* 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 2015 and the trend in emissions for the year 2015 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 2015 and the trend in emissions for the year 2015 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 2015, the Slovak Republic determined using the Approach 1 by the level assessment, 33 key categories with LULUCF and 24 key categories without LULUCF. In 2015, the Slovak Republic determined using the Approach 2 by the level assessment, 21 key categories with LULUCF and 19 key categories without LULUCF.

In 2015, the Slovak Republic determined using the Approach 1 by the trend assessment, 33 key categories with LULUCF and 30 key categories without LULUCF. In 2015, the Slovak Republic determined using the Approach 2 by the trend assessment, 19 key categories with LULUCF and 26 key categories without LULUCF.

List of key categories is almost identical for the base year 1990 and for the latest inventory year. The level assessment determined using Approach 1 methodology 32 key categories with LULUCF in 1990 and 26 key categories without LULUCF in 1990.

The level assessment determined using Approach 2 methodology 21 key categories with LULUCF in 1990 and 18 key categories without LULUCF in 1990.

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 (for more information see Chapter 2.3.1.

1.2.9 GENERAL UNCERTAINTY EVALUATION

The uncertainty assessment by Approach 1 is enclosed in an 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 estimated the 10.67% level uncertainty and the 3.46% trend uncertainty in 2015.

The uncertainty assessment by using the more sophisticated tier 2 Monte Carlo method was prepared with cooperation with the Faculty of Mathematics, Physics & Informatics.

The tier 2 uncertainty analyses for fuel combustion in energy sector (including transport) according to the fuels classification was estimated in the range of confidence interval (-2.38%; +3.12%) in 2015.

The tier 2 uncertainty analyses for industrial processes and product use sector including solvent and other product use sector 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[22,23] and detailed description is in Chapters 3 and 4 of this report.

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

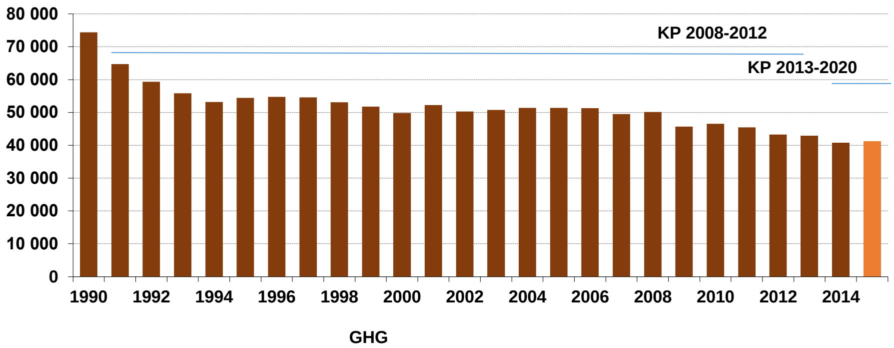
[23] Szemesová J., Gera M. Uncertainty analysis for estimation of landfill emissions and data sensitivity for the input variation, Climatic Change DOI 10.1007/s10584-010-9919-1, 2010

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 2017 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 41 269.49 Gg CO_2 eq. in 2015 (without LULUCF). This represents a reduction by 44.6% in comparison with the reference (base) year 1990. In comparison with 2014, the emissions increased by 1.45%. Total GHG emissions in the Slovak Republic increased in 2015 in comparison with the previous year, which was probably influence by increase in energy, industrial processes and subsequently in waste sectors as a result of increasing of economical productivity in Slovakia. Total GHG emissions excluding LULUCF sector have been decreasing continually from the base year with the more stable trend in the recent years. 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 – 2015, 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 target (%)*



Aggregated GHG emissions without LULUCF; emissions are determined as of 15.04.2017

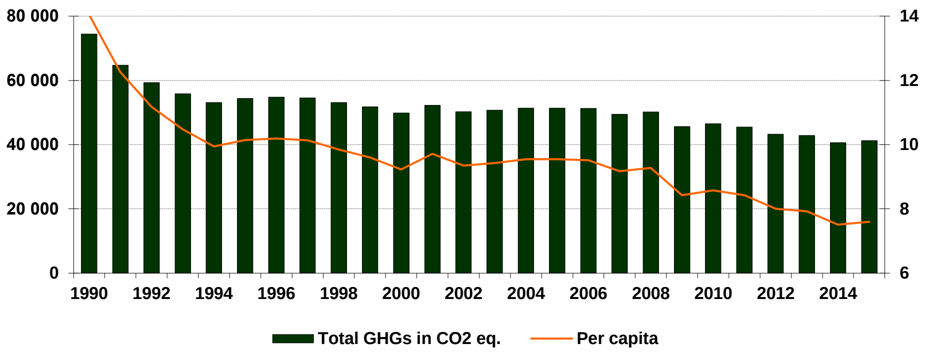
This important reduction of emissions has resulted above all from the strong although temporary decrease in economy activities, followed by restructuring of economy joined with implementing new and more effective technologies, reducing the share of the intensive energy industry and increasing share of 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 – 2015 are depicted in the ***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 dynamics 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.

Continuous pressure is being put on formulating the effective strategy and policy to achieve further reduction of the emissions. 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. But 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.

Figure 2.2: *Total GHG emissions in Gg of* CO_2 *eq. per capita in 1990 – 2015*



2.2 DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS BY GAS

Population of the Slovak Republic as of December 31, 2015 was 5 426 252. Average residential density is 110.7 inhabitants per km². The population is concentrated in towns in lowlands and the main basins. Mountain areas are randomly populated. Employment rate in the Slovak Republic is 64.2% in average during 2015 (according to the OECD statistics). The largest city is Bratislava with 422 932 inhabitants (as of 31st December 2015). It is the capital of the Slovak Republic.

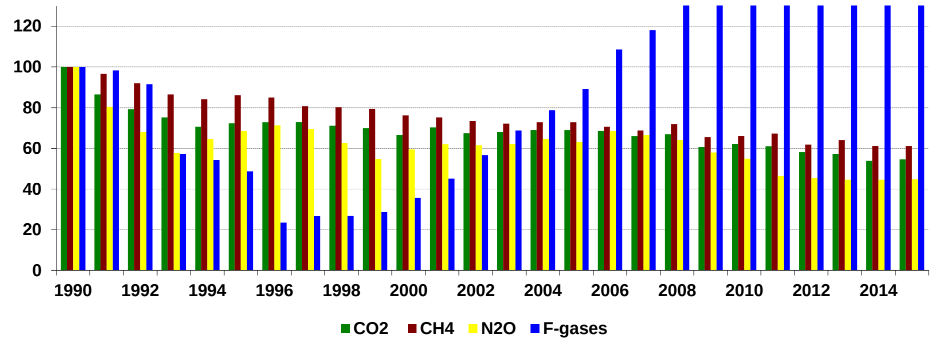
Total anthropogenic emissions of carbon dioxide excluding LULUCF have decreased by 45.4% in 2015 compared to the base year (1990). Nowadays the amount is 33 816.79 Gg of CO_2. Compared to the previous inventory year 2014, the increase is 1%. The reason for the increase in CO_2 emissions in 2015 is caused mainly by increasing CO_2 emissions in energy, industrial processes and waste sectors due to increase in economy and productivity in Slovakia. In 2015, CO_2 emissions including LULUCF sector are almost at the same level compared to the previous year and decreased by 48% compared to the base year.

Total anthropogenic emissions of methane without LULUCF decreased compared to the base year (1990) by 39.5% and currently the emissions are 4 352.44 Gg of CO_2 equivalents. In absolute value, CH_4 emissions were 174.10 Gg without LULUCF. Methane emissions from LULUCF sector are 0.67 Gg of CH_4 caused by forest fires. The trend has been relatively stable during the last years with a slight increase in the year 2014 due to the emission increase from agriculture. Methane emissions peaked in 2002 due to the implementation of new waste legislation and increasing emissions from solid waste disposal sites in the Slovak Republic.

Total anthropogenic emissions of N_2O without LULUCF decreased compared to the base year (1990) by 53.3% and currently the emissions are 2 342.56 Gg of CO_2 equivalents. Emissions of N_2O in absolute value were 7.86 Gg without LULUCF. Emissions of N_2O from LULUCF sector are 0.1 Gg. Emissions decreased compared to the previous year 2014 by less than 1% due to the decrease in energy and industrial processes sectors. The trend depends on the nitric acid production. Overall decreasing trend is mainly driven by the decrease in agriculture due to declining number of animals and making use of fertilizers.

Total anthropogenic emissions of F-gases were 734.88 Gg of HFCs, 8.5 Gg of PFCs and 14.31 Gg of SF_6 in CO_2 equivalents. Emissions of HFCs have increased since 1995 due to the increase in consumption and the replacement of PFCs and HFCs substances. Emission trend of PFCs is decreasing and emissions of SF_6 are slightly increasing due to the increasing consumption in industry.

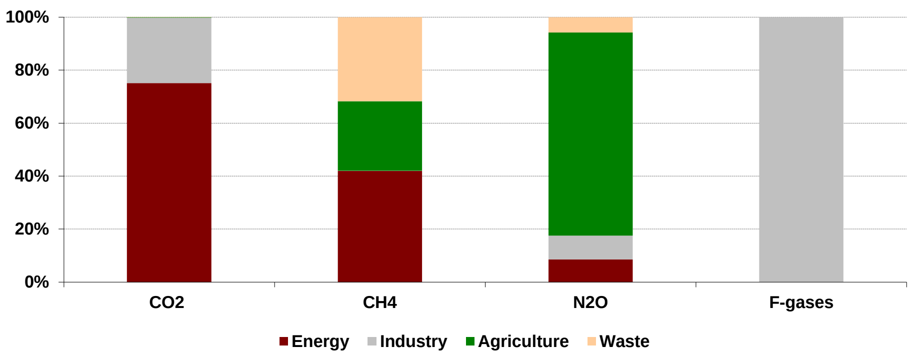
Figure 2.3: *Emission trends by gas for the years 2000 – 2015 relative to the 1990 level (relative in %)*



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 75% share from the total carbon dioxide emissions in 2015 inventory, 25% of CO_2 is produced in industrial processes and product use sector and negligible amount is produced in agriculture (0.22%) and waste (0.02%) sectors. The energy related CO_2 emissions from waste incineration are included in energy sector. The 32% of CH_4 emissions is produced in waste sector (SWDS), 42% of methane emissions is produced in energy sector and 26% in agriculture sector. More than 75% of N_2O emissions is produced in agriculture sector (nitrogen from soils), 9% in industrial processes sector (nitric acid production), 6% in waste sector and 9% in energy sector. F-gases are produced exclusively in sector industrial processes (***Figure 2.4***).

Figure 2.4: *Emission trends by gas in sectors in 2015*



Aggregated GHG emissions from energy sector based on sectoral approach data in 2015 were estimated to be 27 445.21 Gg of CO_2 eq. including transport emissions (6 704.75 Gg of CO_2 eq.), which represent the decrease by 52% compared to the base year and 1% increase in comparison with

2014. Transport sub-sector increased by 3% compared to 2014 and in comparison with the base year it declined by 2%.

Total emissions from industrial processes and product use sector were 9 285.16 Gg of CO_2 equivalents in 2015, which was decreased by 5% compared to the base year and the increased by 2% compared to the previous year. This sector covers also emissions from solvents use.

Emissions from agriculture sector were estimated to be 3 014.46 Gg of CO_2 equivalents. It is 54% decrease in comparison with the base year and 1% decrease in comparison to the previous year. 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.

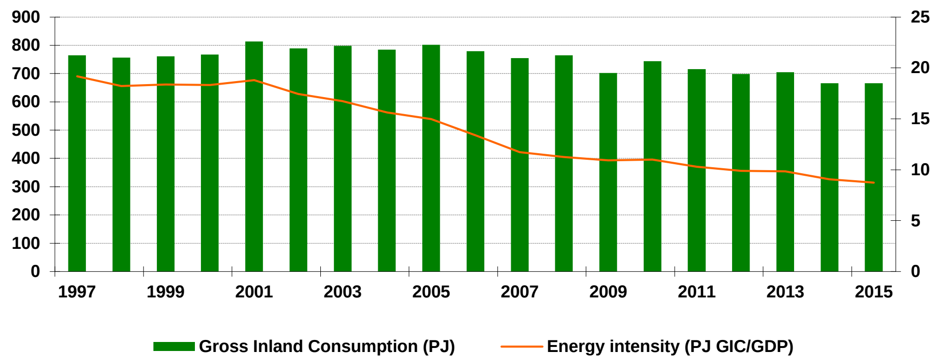
Emissions from waste sector were estimated to be 1 524.67 Gg of CO_2 equivalents. The increase is 3% compared to the previous inventory year and the time series are stable for last years. Compared to the base year, the increase was more than 9%, because of increased methane emissions from solid waste disposal sites. The emissions from waste incineration with energy use are included into energy sector, category 1.A.1.a – energy industries, other fuels.

Structural changes in energy sector and the implementation of economic instruments have played an important role in achieving the current 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 also 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 sectors in the years 1990 – 2015 are depicted in the ***Table ES.3*** in this report.

According to the statistical information from the Statistical Office of the Slovak Republic – information database Slovstat, energy industry (production and distribution of electricity, natural gas and water) reached 12% share in total GDP of the Slovak Republic in 2013. Energy intensity is still higher than the average in the EU-15 (member states before 2004 enlargement), in spite of its continual decrease. Reason for that is the adversely high share of energy intensive industry in GDP. This trend can be illustrated also by the indicator comparing the gross inland consumption (GIC) of energy resources with the GDP growth. Energy intensity is expressed in PJ/Bio Euro. The significant decrease in gross inland consumption was the result of gas crises from the beginning of 2009 and followed by the lack of resources in energy and iron and steel industry (coke production).

Figure 2.5: *The trend of energy intensity (right y axis) in the period 1997 – 2015 (estimated by the revised statistical approach NACErev.2)*



Transport is a significant source of emissions in energy sector, with 8% share in total GDP 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 V version 1.0. GHG emissions from non-road transport are balanced by the use of EMEP/EEA 2010 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 is increasing rapidly, especially due to the increasing activity of low cost airlines.

Fugitive methane emissions from the extraction (only 0.4% share in total GDP) and distribution of fossil fuels are 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.

Industrial processes sector includes all GHG emissions generated from technological processes producing raw materials and products with the 23% 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 emission inventory is based on the balance of non-methane volatile organic compounds (NMVOC) according to EMEP/EEA 2010 methodology. Emissions are recalculated according to the stoichiometric coefficients to CO_2 emissions.

Agriculture sector with 4% share 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 emission balance is compiled annually on the basis of sectoral statistics and in recent years on the basis of 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.

The area of forest land in the Slovak Republic covers 40% of the territory and wood harvesting is historically an important economic activity. Since 1990, sinks from sector LULUCF have remained at the level of 8-10% of 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.

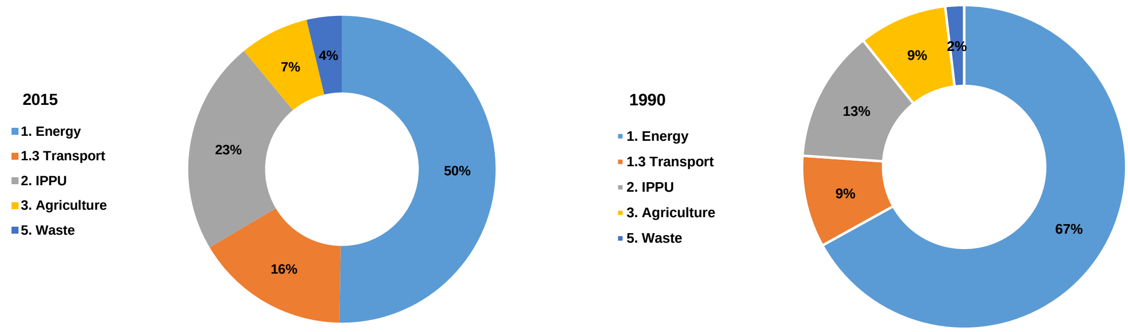
Several significant changes and re-evaluations of the applied methods have been carried out in sector waste, followed by recalculations in all categories of waste treatment. Methane emissions from solid waste disposal sites (SWDS) have the largest share in total emissions from the sector. Waste balance 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 increasing depending on the adopted values for parameters of municipal waste landfills. A more detailed description of the methodology as well as with the Monte Carlo uncertainty analysis is described in the references.[24] 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 energy sector, sub-category 1.A.1.a (other fuels). The emissions from waste incineration without energy utilisation are reported within waste sector.

[24] 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

The comparison of the 2015 sectors share with the base year is shown on the following ***Figure 2.6***. The significant decrease is visible in energy sector (without transport) and increase in waste, IPPU and transport sectors. 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 reached 167.72 Gg of CO_2 equivalents in 2015. Emissions from international aviation have more than 95% share.

Figure 2.6: *The share of individual sectors in total GHG emissions in 1990 and 2015*



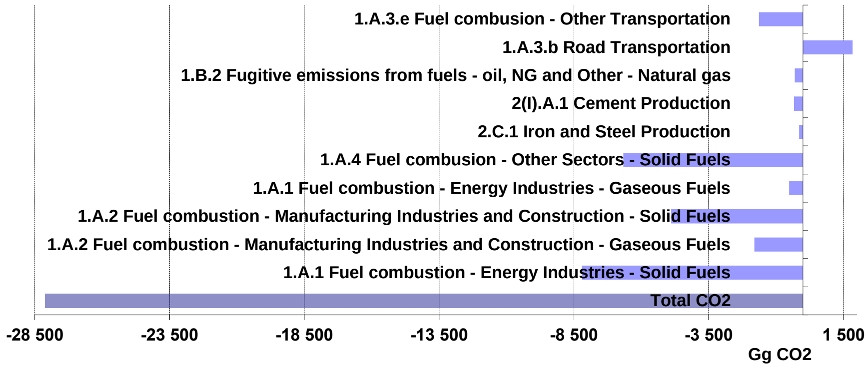
2.3.1 CHANGE IN EMISSIONS FROM KEY CATEGORIES

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 2015 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 LULUCF sector (more see Chapter 1.2.12 and Annex 1 of this report).

CO_2 emissions from the category 1.A.3.b - Road Transportation – diesel fuel are the largest key source accounting for 19% of total CO_2 emissions without LULUCF in 2015. Between 1990 and 2015, CO_2 emissions in road transportation increased by 1.8 Mt of CO_2, which is 19% increase due to an increase in fossil fuel consumption 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 Fuel combustion - Energy Industries is the second largest key category without LULUCF (14%) and the decrease (64%) is between 1990 and 2015. The main explanatory factors of emissions decrease is in improvements in energy efficiency and (fossil) fuel switching from coal to gas. A shift from solid and liquid fuels to mainly natural gas took place and an increase of biomass and other fuels has been recorded.

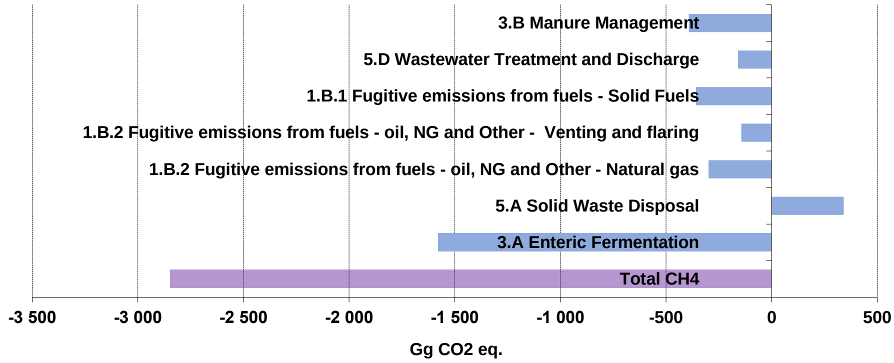
CO_2 emissions from fuels in the category 2.C.1 - Iron and Steel Production are the largest key category without LULUCF in the IPPU sector, accounting for 12% of total CO_2 emissions in 2015. CO_2 emissions from the category 1.A.2 in energy sector are the third largest key source in the Slovak Republic, accounting for 12.3% of total GHG emissions in 2015. Between 1990 and 2015, emissions from this category showed the decrease by 54%.

Figure 2.7: *Absolute change of CO_2 emissions by large key categories 1990 to 2015*



Methane emissions account for 11% of total GHG emissions in 2015 and decreased by 40% since 1990 to 174.10 Gg CH_4 in 2015. The two largest key sources (5.A Solid Waste Disposal at 23% and 3.A Enteric Fermentation at 22% of total CH_4 emissions in 2015) account for 50% of CH_4 emissions in 2015. ***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 category 3.A and 3.B and increase in 5.A waste sector caused by the change of IPCC methodology used for solid waste disposal sites which considers time layer since 1960.

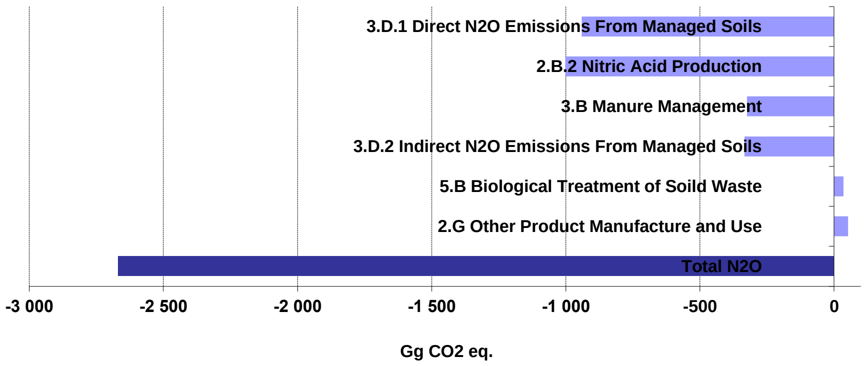
Figure 2.8: *Absolute change of CH_4 emissions by large key categories 1990 to 2015*



N_2O emissions are responsible for 5.7% of total GHG emissions and decreased by 53% to 7.86 Gg of N_2O in 2015 (***Figure 2.9***). The two largest key sources causing this trend – 3.D.1 Direct N_2O Emissions from Managed Soils 53% and 3.D.2 Indirect N_2O Emissions from Managed Soils at 16% of total N_2O emissions in 2015. 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 increased was caused by increase of operationalise and production.

Fluorinated gas emissions account for 1.84% of total GHG emissions. In 2015, emissions were 757.69 Gg CO_2 equivalents, which was 141% above 1990 levels. The largest key source is 2.F.1 Refrigeration and Air Conditioning and accounts for 93% of fluorinated gas emissions in 2015. HFC emissions from the consumption of halocarbons showed large increases between 1990 and 2015. 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. The decrease has started in 1996 and was the strongest in 1999 and 2000.

Figure 2.9: *Absolute change of N_2O emissions by large key categories 1990 to 2015*



2.3.2 MAIN REASONS FOR EMISSION CHANGES IN 2014 – 2015

Total GHG emissions in the Slovak Republic significantly increased by 1.45% in 2015 in comparison with the previous year, which was influenced by the decrease in energy sector due to the higher share of renewables and increase in energy efficiency. Total GHG emissions excluding LULUCF sector have been decreasing continually from the base year with the almost stable trend in the recent years. 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 2014 – 2015 were as follows:

- CO_2 emissions increase in energy industry (500 Gg of CO_2) caused by increase in liquid, solid and also gaseous fuels.
- CO_2 emissions increase in the transport category (200 Gg of CO_2) mainly caused by the increasing of driven operations in passenger and light and heavy duty vehicles.
- CH_4 increase (200 Gg of CO_2 eq.) in fugitive emissions from oil and natural gas mainly caused by international trade.
- CO_2 increase (200 Gg of CO_2 eq.) in chemical industry caused by higher productivity in this industry.
- F-gases (100 Gg of CO_2 eq.) increase due to increasing industrial productivity.
- Increase in biological treatment of solid waste by 50 Gg of CO_2 eq.
- Relative cold winter in 2014 – 2015.

2.3.3 KEY DRIVERS AFFECTING EMISSION TRENDS IN LULUCF

The increasing trend of forest land-use category is evident in the Slovak Republic since 1970. The opposite, decreasing trend of cropland land-use category was recorded at the same time. Grassland areas decreased from 1980 to beginning of 1990 and since this year increasing trend 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 to be constant, not involving any land use conversions.

The LULUCF sector with net removals -6 428.79 Gg of CO_2 equivalents in 2015 is very important sector and comprises from several key categories. The major share represents CO_2 removals with the contributions of following categories: Forest Land with net removals of -4 998.12 Gg CO_2, Cropland with net removals of -830.21 Gg CO_2, Grassland with net removals of -191.10 Gg CO_2, Settlements with the emissions of 84.15 Gg CO_2 and Other Land with the emissions of 182.51 Gg CO_2. Total methane emissions were 0.67 Gg and total N_2O emissions were 0.096 Gg from LULUCF sector in 2015. N_2O emissions from the disturbance associated with the land-use conversion to Cropland, Grassland, Settlements and Other Land were reported in this submission. Also 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 0.43 Gg and the estimated amount of CO emissions was 15.30 Gg in 2015 (***Table 2.1***).

Table 2.1: *Summary of total emissions and removals according to the categories in 2015*

CATEGORY	Net CO_2		CH_4	N_2O	NO_x	CO
	EMISSIONS/REMOVALS (Gg)		EMISSIONS (Gg)			
4. LULUCF	**NO**	**-6 474.21**	**0.67**	**0.096**	**0.43**	**15.30**
A. Forest Land	NO	-4 998.12	0.67	0.04	0.43	15.30
B. Cropland	NO	-830.21	NO	0.03	NO	NO
C. Grassland	NO	-191.10	NO	0.002	NO	NO
D. Wetlands	NO	NO	NO	NO	NO	NO
E. Settlements	84.15	NO	NO	0.01	NO	NO
F. Other Land	182.51	NO	NO	0.02	NO	NO

2.4 DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS FOR INDIRECT GHG AND SO_2

Information can be found in the chapter ES.5 of this report.

CHAPTER 3: ENERGY (CRF 1)..47

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
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Motrans – consultation company in transport	Chapter 3.2.8	Jiří Dufek

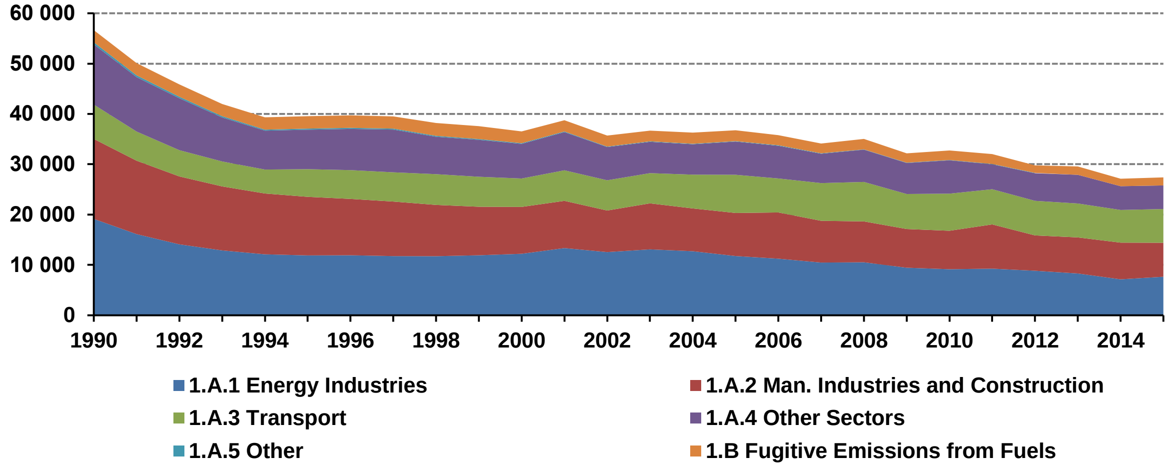
3.1 OVERVIEW OF THE SECTOR

Energy sector covers emissions from fossil fuels combustion (CRF 1.AA) 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 (NOx, CO, NMVOCs) GHG emissions, as well SO_2 emissions. Point sources, transport and other fuel 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 calculated into national total.

A significant decline in energy intensity was recorded in the previous year in Slovakia. The gross domestic energy consumption decreased by more than 24% in the last 10 years. This decrease is associated with a decrease in solid and liquid fuels consumption for heating and also 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 21%, nuclear fuel 22%, coal 19%, crude oil 29% and renewable sources (RES) 9%. Based on the National Energy Strategy up to 2030, increase of nuclear and RES share on the total energy consumption is expected. Natural gas consumption slight increase is projected in transport fuels consumption up to 2030. Based on the information provided by the Ministry of Economy, total share of carbon-free energy on total energy production in 2015 was 11.6% in Slovakia (excluding nuclear).

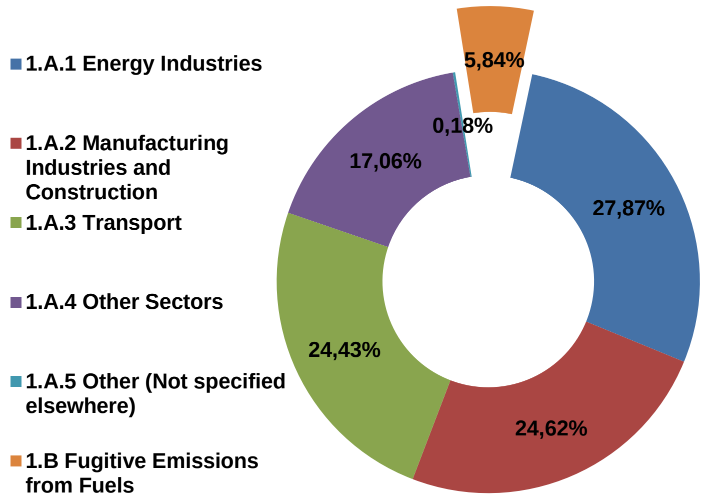
The most indicative decoupling trend in GHG emissions and GDP is visible directly in sector energy (fossil fuel consumption). The decrease in the consumption of solid fuels is more than 71% in comparison with the base year 1990. The consumption of liquid fuels decreased more than 32% and the decline in gaseous fuels is 33%. By comparison, the consumption of biomass was 3.6 times higher in 2015 than in 1990. General trend in total consumption of fossil fuels is declining due to the increase in energy efficiency. ***Figure 3.1*** shows this trend by categories for time series. Basic key categories 1.A.1 – Energy Industry, 1.A.2 – Manufacturing Industries and Construction and 1.A.4 – Other Sectors (services and households) have the most significant influence on the overall decreasing emission trends.

__Figure 3.1__: Trend in aggregated emissions by categories within energy sector in 1990 – 2015 (Gg of CO_2 eq.)



Energy sector is the main contributor to overall GHG emissions with its share of 66.5% and 27 445.21 Gg of CO_2 eq. in 2015. Within this sector, ***Figure 3.2*** shows significant contributors (and key categories) to the emissions as follow: transport with its share of 24.4%, fuel combustion in the large (share 28%) and medium stationary sources of pollution (share 25%), pollution from small sources of residential heating systems (share 17%) and fugitive methane emissions from transmission/transport /distribution, processing and storage of oil and natural gas (share 6%).

__Figure 3.2__: The share of aggregated GHG emissions by categories within energy sector in 2015

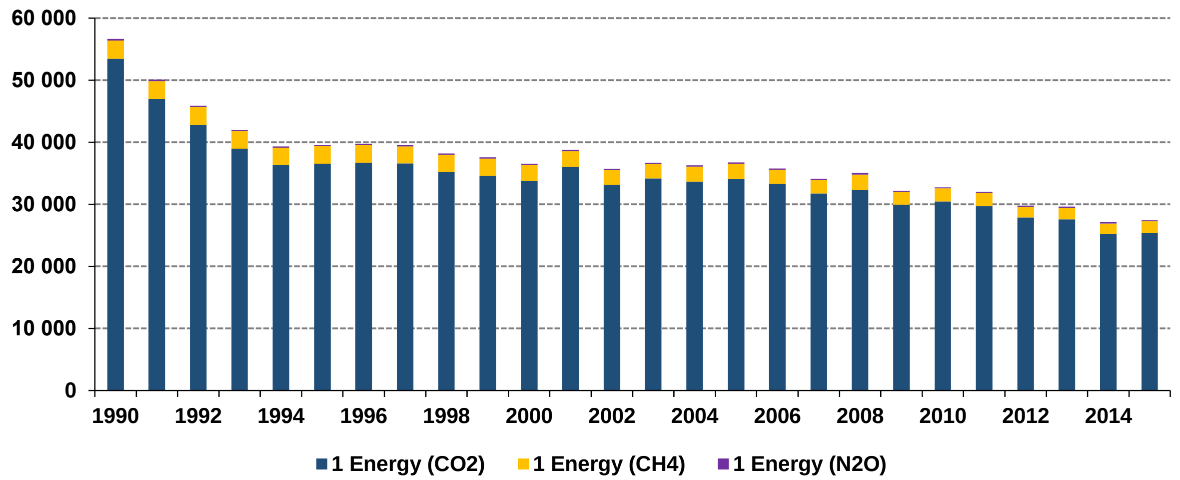


Following ***Table 3.1*** and ***Figure 3.3*** show overall emissions trends since base year 1990 according to gases and major categories. The majority of emissions is reported in the category 1.AA – Fuels Combustion (more than 90% in all years) and major gas is carbon dioxide (more than 90% in all years).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

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

YEAR	CO_2 EMISSIONS			CH_4 EMISSIONS			N_2O EMISSIONS		
	(Gg)								
	Energy	1.AA	1.B	Energy	1.AA	1.B	Energy	1.AA	1.B
1990	53 468	53 445	24.18	116.94	21.41	95.54	0.92	0.92	0.000067
1995	36 573	36 547	26.41	112.14	14.58	97.56	0.64	0.64	0.000063
2000	33 751	33 726	25.18	104.15	11.33	92.82	0.62	0.62	0.000046
2005	34 090	34 066	23.24	98.36	12.58	85.78	0.71	0.71	0.000027
2010	30 462	30 440	21.21	84.01	8.99	75.02	0.60	0.60	0.000013
2011	29 666	29 646	20.05	86.85	9.05	77.80	0.62	0.62	0.000015
2012	27 864	27 845	19.05	69.07	9.96	59.11	0.63	0.63	0.000014
2013	27 554	27 534	19.63	75.18	9.48	65.69	0.63	0.63	0.000012
2014	25 204	25 176	27.68	67.78	9.59	58.19	0.64	0.64	0.000012
2015	25 417	25 396	20.79	73.07	9.79	63.28	0.68	0.68	0.000012

Figure 3.3: *Trend in aggregated emissions by gases within energy sector in 1990 – 2015 (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 published by the Statistical Office of the Slovak Republic. Sectoral approach is compared with the reference approach based on top-down data from the Statistical Office of the Slovak Republic in the National Energy Balance. 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 by the Statistical Office of the SR.

Fugitive GHG emissions in the period 1990 – 2015 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 and the Ministry of Economy of the Slovak Republic.

The overview of sub-sectors and IPCC categories according to the IPCC 2006 Guidelines relevant for the Slovak Republic in energy sector is listed in the ***Table 3.2***.

Table 3.2: *Reported emissions and methodological tiers in energy sector in 2015*

CATEGORY		DESCRIPTION / EMISSIONS / METHODOLOGICAL TIERS					
1.A.1 Energy industry							
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,T3	**CH_4**	T1	**N_2O**	T1
1.A.1.a.ii	*Combined heat and power generation*	**CO_2**	T2,T3	**CH_4**	T1	**N_2O**	T1
1.A.1.a.iii	*Heat plants*	**CO_2**	T2,T3	**CH_4**	T1	**N_2O**	T1
1.A.1.a.iv	*Other (waste incineration, methane cogeneration)*	**CO_2**	T2	**CH_4**	T1,T2	**N_2O**	T1,T2
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**	T1	**CH_4**	T1	**N_2O**	T1
1.A.3.b	Road transportation						
1.A.3.b.i	*Cars*	**CO_2**	M	**CH_4**	M	**N_2O**	M
1.A.3.b.ii	*Light duty trucks*	**CO_2**	M	**CH_4**	M	**N_2O**	M
1.A.3.b.iii	*Heavy duty trucks and buses*	**CO_2**	M	**CH_4**	M	**N_2O**	M

CATEGORY		DESCRIPTION / EMISSIONS / METHODOLOGICAL TIERS					
1.A.3.b.iv	*Motorcycles*	CO_2	M	CH_4	M	N_2O	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.3.e.ii	*Other/Urea Based Catalysts*	CO_2	M				
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	T1		
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	T1		
1.B.2.b.3	*Processing*	CO_2	T1	CH_4	T1		
1.B.2.b.4	*Transmission and storage*	CO_2	T1	CH_4	T1		
1.B.2.b.5	*Distribution*	CO_2	T1	CH_4	T1		
1.B.2.b.6	*Other*	CO_2	T1	CH_4	T1		
1.B.2.c	Venting and flaring						
1.B.2.c.1	Venting						
1.B.2.c.1.i	*Oil*	CO_2	T1	CH_4	T1		
1.B.2.c.1.ii	*Gas*	CO_2	T1	CH_4	T1		
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

3.2 FUEL COMBUSTION (CRF 1.AA)

3.2.1 OVERVIEW OF FUEL COMBUSTION (CRF 1.AA)

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 more than 63% 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 residential sector (block of flats and dwellings), public and services buildings and other objects of non-productive sector.

Total aggregated emissions from fuel combustion, including transport, based on sectoral approach represented 25 842.32 Gg of CO_2 eq. in 2015. ***Table 3.3*** shows trend in GHG emissions by categories within the sectoral approach in particular years indicated the significant decrease in emissions followed decrease in fuel consumption and switch of fuels´ share (decreasing of solid, liquid and gaseous and increase of biomass) which is showed on ***Figure 3.4*** and ***Figure 3.5***.

Table 3.3: *GHG emissions by categories in 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.				
1990	19 159.93	15 890.35	6 823.77	11 966.46	414.56
1995	11 900.68	11 640.72	5 495.29	7 845.32	220.37
2000	12 218.46	9 313.75	5 649.36	6 879.95	132.31
2005	11 765.44	8 556.54	7 587.93	6 602.94	78.51
2010	9 141.57	7 645.83	7 376.83	6 624.55	55.63
2011	9 257.38	8 788.82	6 995.83	4 947.18	68.10
2012	8 838.59	7 024.82	6 872.10	5 479.11	66.86
2013	8 299.26	7 166.20	6 742.04	5 696.51	54.77
2014	7 136.78	7 289.66	6 493.46	4 634.19	52.70
2015	7 652.16	6 755.27	6 704.75	4 681.86	48.28

Figure 3.4: *Trend in fuels consumption within 1.AA category in TJ in 1990 – 2015*

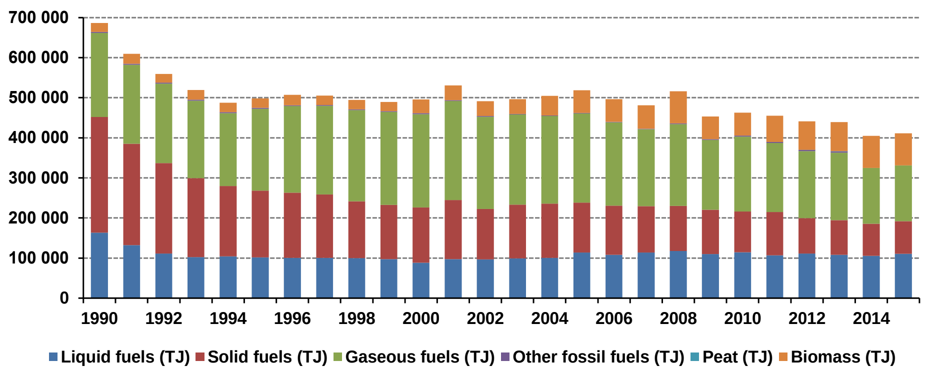
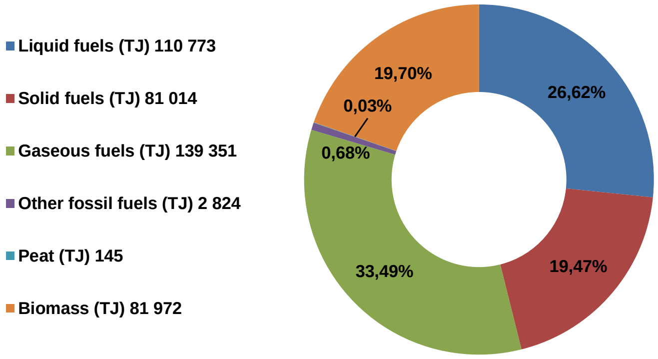


Figure 3.5: *The share of fuels´ consumption within category 1.AA in 2015*



High level dependency on import of primary energy sources (PES) is a limiting factor for the energy sector and subsequently for the whole economic (mostly industrial) development in Slovakia. Net imports of PES are covered by almost 90%, together with nuclear fuel, from the Russian Federation as the exclusive supplier. The share of fossil fuels in the PES is relatively high, reaching more than 80%.

The energy intensity of the Slovak economy 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.

In 2001, the Slovak Republic started transformation and privatization of regional distribution companies. In 2002, the biggest producer of electricity, Slovenské elektrárne – a member of ENEL group was transformed and split up (http://www.seas.sk/en). Since then, the Slovak electricity transmission system, Plc. (Slovenská elektrizačná prenosová sústava, a.s.) has been registered and it acts as the transmission system operator including also the energy dispatch (http://www.sepsas.sk/seps/en_index.asp).

Energy industries (CRF 1.AA.1), Manufacturing industries and construction (CRF 1.AA.2), Transport (CRF 1.AA.3), Other sectors (CRF 1.AA.4) and Other (CRF 1.AA.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 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.					
1990	14 959.17	2 881.44	1 319.32	2 689.97	1 262.24	2 636.38
1995	8 562.32	2 034.49	1 303.87	2 454.58	534.77	3 041.57
2000	9 034.71	1 934.78	1 248.97	2 782.68	287.52	1 641.42
2005	8 681.21	1 735.36	1 348.87	3 398.16	188.49	854.31
2010	6 232.31	1 600.65	1 308.62	3 752.86	199.52	542.48
2011	6 391.55	1 588.65	1 277.18	4 787.85	247.28	574.43
2012	6 099.34	1 463.39	1 275.27	3 363.26	226.87	538.44
2013	5 639.51	1 473.31	1 186.44	3 182.86	187.65	555.31
2014	4 666.82	1 218.92	1 251.05	3 197.09	150.11	503.05
2015	4 910.50	1 451.55	1 290.11	2 875.16	139.28	468.84

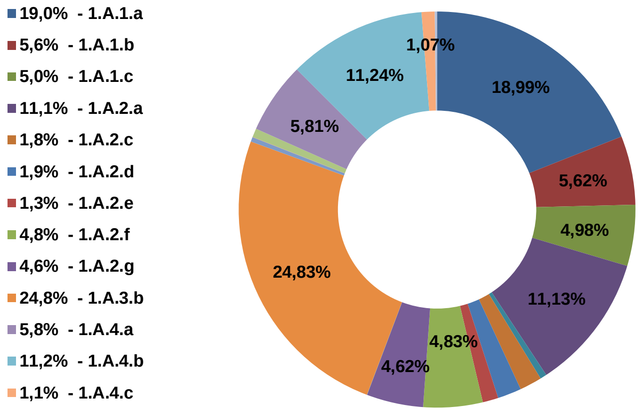
YEAR	1.A.2 MANUFACTURING INDUSTRIES AND CONSTRUCTION				1.A.3 TRANSPORT		
	1.A.2.d	1.A.2.e	1.A.2.f	1.A.2.g	1.A.3.a	1.A.3.b	1.A.3.c
	Gg of CO_2 eq.						
1990	2 341.71	1 144.23	3 251.84	2 563.97	3.77	4 588.64	415.63
1995	1 215.24	761.53	1 695.28	1 937.75	2.68	4 114.55	222.81
2000	705.41	570.10	1 403.41	1 923.21	2.67	4 068.32	172.13
2005	548.88	436.91	1 389.92	1 739.86	7.86	6 134.09	116.74
2010	421.01	306.53	1 181.91	1 241.51	5.18	6 453.68	92.35
2011	403.28	312.56	1 223.31	1 240.09	4.28	5 991.44	88.58
2012	329.10	296.35	1 152.21	1 118.58	3.95	6 387.67	75.16
2013	447.39	310.14	1 244.84	1 238.02	3.42	6 162.20	91.66
2014	500.04	326.87	1 381.43	1 231.08	3.47	6 221.41	86.21
2015	500.97	329.65	1248.62	1192.76	3.69	6 415.34	94.86

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.						
1990	0.02	1 815.70	4 166.53	7 643.24	156.69	407.31	7.25
1995	0.02	1 155.23	2 433.72	5 242.74	168.87	213.73	6.64
2000	0.02	1 406.21	1 569.94	5 091.06	218.95	130.57	1.74
2005	0.04	1 329.25	2 259.35	4 022.11	321.48	76.58	1.93
2010	0.33	825.29	2 571.58	3 748.18	304.79	54.04	1.59
2011	0.84	910.68	1 566.33	3 100.91	279.93	66.45	1.64
2012	1.11	405.20	1 871.54	3 323.30	284.28	65.38	1.48
2013	3.44	482.32	2 102.97	3 287.37	306.16	53.33	1.44
2014	4.42	177.96	1 482.54	2 850.75	300.90	51.30	1.40
2015	6.28	184.58	1 501.47	2 904.51	275.88	46.54	1.75

The share of fuels on total fuel consumption in energy sector of the categories 1.AA.1, 1.AA.2, 1.AA.4 and 1.AA.5 was almost 76% in 2015 (without transport). The highest share of GHG emissions represents 1.AA.1.a – Public Electricity and Heat Production (19%) followed by the 1.AA.2.a – Iron and Steel (11%) and 1.AA.4.b – Residential (11%) (***Figure 3.6***). According to the detail analyses of the subcategories, the major share of emissions has 1.AA.3.b Road Transportation (25%) which is the most important key category with the one of the highest share on emissions in energy sector. There is a significant decrease in CO_2 emissions in the category 1.AA.2.c. This is caused by the decrease of the solid fuels consumption. This decrease is significant and continuous during the period 1990 – 2015. However, the sharpest decrease occurred between 2001 and 2002. In 2001 there were only five plants in Slovak Republic, 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 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 in categories 1.AA.4.a and 1.AA.4.b. This decrease is caused mainly by reduction of combustion of solid fuels. The reduction of CO_2 emission from combustion of solid fuels is more than 85 % percent in 1.AA.4.a and 95 % in 1.AA.4.b in comparison with base year. On the other hand, there is a slightly increase of emission from combustion of natural gas in category 1.AA.4.b.

Figure 3.6: *The share of emissions in CO_2 eq. on different subcategories within 1.AA in 2015*



3.2.2 UNCERTAINTY ANALYSES OF THE FUEL COMBUSTION (CRF 1.AA)

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 IPCC default methodology and default emission factors consistent with previous reporting. For emission uncertainty assessment AD, caloric value, EFs and their uncertainties are available in the energy sector.

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 dependency, therefore Approach 1 and Approach 2 are well comparable. Approach 2 offers more reliable statistical results, it shows us more information about statistical structure of analysed uncertainty.

With Approach 2 the category´ uncertainty is constructed by Monte Carlo method and consecutive aggregated uncertainty is computed for Energy sector 1.AA (except 1.B).

From our knowledge and experiences, the most difficult part of uncertainty analysis is the constructing of the PDF (or CDF) for AD and EF. In the some cases the construction of empirical form of PDF are necessary to satisfy the expert statistical criterions (to keep mean value and confidence interval). For this reason special software packages have been developed. The work with wide collection of analytical PDF is supported by this software. The following statistical distributions are implemented: Gumbel, Exponential, Weibull, Lognormal, Uniform, Triangular, Beta, Binomial, Negative binomial, Chi-square, Noncentral chi-square, F, Noncentral F, Gamma, T, Noncentral T, Normal and Poisson.

Despite this fact the empirical distribution has to be constructed in some situations. The methodology of empirical function creation is based upon four equations with N-4 degree of freedom (N represents the number of values of data sets). These free parameters are applied for the construction of PDF (shape, kurtosis). These equations contain information about the requirements for mean value and confidence interval.

Aggregated uncertainty is computed from partial uncertainties. For energy sector (combustion of fuel) the combination of AD, EF and caloric values are utilized. Emission for specific source is computed:

$Em_i=AD_i*NCV_i*EF_i*(44/12)/1\,000$ (1)

where Em_i represents the emissions from source (i) marked as subscript, AD_i are activity data, EF_i are emission factors and NCV_i represent caloric values. Including uncertainty the previous formula is extended to the form:

$Em_{ni}=(AD_i+a\delta_i)*(NCV_i+n\delta_i)*(EF_i+e\delta_i)*(44/12)/1\,000$ (2)

where $a\delta_i$ represents uncertainty of AD, $e\delta_i$ represents uncertainty of EF and $n\delta_i$ represents uncertainty for caloric value.

From theory it is known, that direct computation of aggregate uncertainty is difficult to compute in many cases. For this reason, a statistical approach has been chosen. The Monte Carlo method has been utilizes. It induces the construction of PDF for all input parameters. We create the probability density function for variables $a\delta_i$, $e\delta_i$ and $n\delta_i$. In some cases the absence of direct measurement were solved by expert contributions. Mean value and confidence interval have usually background in measured data or in empirical relations. On the other hand, uncertainty shapes of input parameters are usually estimated by expert impressions. For this reason, we followed suggestions and we started to play with normal, triangular and lognormal analytical distributions at the beginning. An input data empirical PDF has been applied only in the problematic cases.

Consecutive, the aggregated uncertainty is computed as the sum of partial emission uncertainties.

$\mathbf{E} = \sum_{i=1}^{Z} Emn_i$ (3)

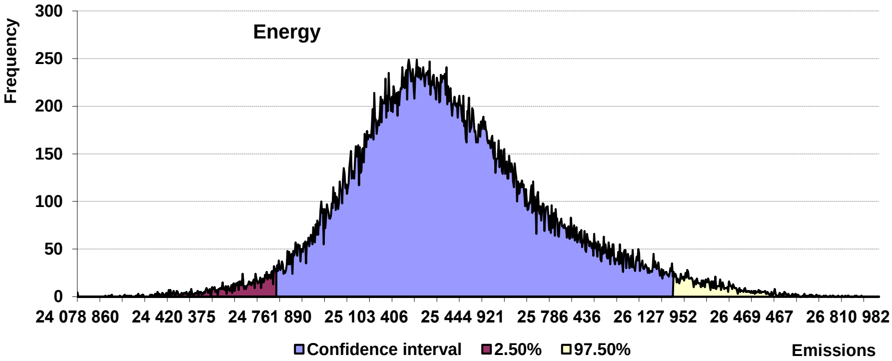
where Z represents the number of source inputs. The results for every category are generated from 60 000 trials, with random number generator of random numbers for adequate PDF.

From presented results obtained by Monte Carlo simulation (60 000 trials) it seems that the average value is 25 398 Gg of CO_2 while the estimated value is 25 394 Gg of CO_2 in 2015. Confidence interval (95%) is within the range: <24 079; 26 925>, which represents the uncertainty by relative values to the mean value: -2.38%; +3.12%. The following tables and graphs described calculated results of uncertainty analyses.

Table 3.5: *Selected statistical characteristics for energy sector, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in Gg of CO_2)*

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
25 359.557	**25 398.276**	34.612	24 078.860	26 924.821	-2.38%	3.12%

Figure 3.7: *Probability density function for energy sector – sectoral approach in tons of CO_2*



Comparison of tier 1 and tier 2 approaches for uncertainty estimation described above, can be finding in the following tables.

Table 3.6: *Comparison of approach 2 and approach 1, emissions are in Gg per year*

APPROACH	ENERGY	1.A.1.a	1.A.1.b	1.A.1.c	1.A.2.a
Approach 2	25 398.28	4 845.82	1 448.17	1 291.76	2 867.29
Approach 1	25 393.54	4 845.62	1 448.15	1 289.55	2 866.94
Deviation Approach 2-Approach 1	4.73	0.19	0.02	2.21	0.35

APPROACH	1.A.2.b	1.A.2.c	1.A.2.d	1.A.2.e	1.A.2.f
Approach 2	137.19	467.72	475.71	329.06	1 234.67
Approach 1	137.18	467.70	475.66	329.01	1 234.63
Deviation Approach 2-Approach 1	0.01	0.02	0.05	0.05	0.04

APPROACH	1.A.2.g	1.A.3.a	1.A.3.b	1.A.3.c	1.A.3.d
Approach 2	1 186.67	3.66	6 344.22	84.33	6.21
Approach 1	1 186.58	3.66	6 342.97	84.33	6.22
Deviation Approach 2-Approach 1	0.09	0.00	1.25	0.00	0.00

APPROACH	1.A.3.e	1.A.4.a	1.A.4.b	1.A.4.c	1.A.5
Approach 2	184.40	1 487.12	2 703.53	253.37	47.38
Approach 1	184.40	1 487.04	2 703.17	253.35	47.38
Deviation Approach 2-Approach 1	0.00	0.08	0.37	0.02	0.00

3.2.3 CATEGORY-SPECIFIC QA/QC AND VERIFICATION PROCESS

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 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.

Emissions balance in energy sector was prepared in the model taking into consideration also fuel balance in transport and industrial processes sectors. The sector specific QC activities were performed directly during calculation when checking several data sources and including the QC for the emissions factors and other parameters.

Activity data verification is processing by the consultations with the SU SR, the NEIS experts and operators (or verifiers). As it was already mentioned, the main source of activity data (and also NCVs and EFs) in current submission are verified EU ETS reports and disaggregated data provided by the Statistical Office of the Slovak Republic. In the category 1.A.1 more than 90.7% of emissions are cover by the EU ETS reports. If a plant is included in the EU ETS, its activity data are compared against two independent sources: the NEIS database and disaggregated fuel consumptions provided by the SU SR. New database system developed for fuels and emissions balance in the GHG inventory allows to perform several QC check more or less automatically.

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 to national statistics or EUROSTAT data;
- Comparison of data across similar sites in individual CRF categories;
- Review significant changes in year-over-year estimates for individual plants, categories and sub-categories;
- 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 SU SR is compared and validated with the NEIS database. The NEIS database is reference 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 Slovak hydrometeorological institute (SHMÚ), the Department of Emissions and Air Quality Monitoring. The process of data verification in the NEIS database must be completed by the end of July year X-1.

After closing the QC activities, the verification process is returning back to the operators of installations. They receive decisions issued according to effective legislation on basic pollutants fees. The verification process is based on cross-checking of the input data from the NEIS database and its comparison with the sectoral statistical indicators from the Ministry of Economy and the Statistical Office of the Slovak Republic. The background documents are archived by sectoral experts and in central archiving system of SNE at SHMÚ.

In line with the national rules applied in the EU ETS, annual publication of emission factors and NCVs used in sectoral and reference approach of the GHG emissions inventory is published on the webpage: http://www.minzp.sk/files/oblasti/politika-zmeny-klimy/ets/svk_ef_ncv_2013-2014_22-02-2015.pdf.

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 and reallocations made in Energy sector were provided and implemented in the line with the Improvement and Prioritisation Plan reflecting recommendations made during previous reviews.

Table 3.7: *Summary of the recalculations and changes in 1.AA*

NUMBER	CATEGORY	DESCRIPTION	REFERENCE
1.	1.AA.1.a.iv - other	New model of MWS composition, recalculations connected with the recalculations described in the Waste sector for time series.	According to the recommendation from the ESD comprehensive review (W.14), change in the oxidation factor from 0.9 to 1.0, more information see in Chapter Waste.
2.	1.AA.2.f	Refinement in industrial waste incineration used in cement plants for the year 2014.	
3.	1.AA.4.a	Change in gaseous fuels for the year 2014 caused by change in Energy Statistics.	Statistical Yearbook - Energy 2015 ENERGY 2015, Statistical Office of the Slovak Republic, ISBN 978-80-8121-481-3

NUMBER	CATEGORY	DESCRIPTION	REFERENCE
4.	1.AA.4.c	Reallocation of emissions between 1.AA.4.c.i and 1.AA.1.c.ii for time series.	SVK ARR 2016, E.25
5.	1.AA.4.c.ii	Recalculation in off-road transportation.	Chapter 3.2.8
6.	1.AA.5	Reallocation of fuels from pipelines into category 1.AA.3.e.i	Chapter 3.2.8

Ad. 1: A new model of MSW composition was developed for the use of the IPCC Waste model. The MSW composition model is estimating share of MSW fractions, depending on share of population using natural gas as heating media and amount of MSW fractions removed from mixed MSW by separate collection.

Parallel to estimating emissions from MSW disposal, emissions from MSW incineration were estimated using MSW composition cited from Waste Management Plan of Slovakia, which was constant over the entire period. This can be characterised as using two different characteristics for the same activity data. With the aim to remove this discrepancy, the MSW incineration model was changed to variable MSW composition, as used in IPCC Waste model. More information about the modification of EFs can be found in chapter 7 of this report.

Ad. 2: Several important recalculations were performed in previous submission. In current submission minor refinements in industrial waste incineration with energy use in category 1.AA.2.f was performed. Model of industrial waste incineration taking place in cement plants (1.AA.2.f) was modified. In previous submission only fossil part of waste was reported. In current submission a biogenic part of waste was included to balance.

Industrial waste incineration taking place in cement plants (there are 4 cement plants in Slovakia with waste incineration reported in the EU ETS reports). According to the IPCC methodology, these emissions shall be allocated in the energy sector in the appropriate subcategory. There are also emissions from industrials waste incineration without energy use, which are reported in waste sector.

Due to the national circumstances, industrial waste for cement plants in imported into Slovakia since 2000. The imported volume of waste is collected by the Ministry of the Environment of the Slovak Republic – Department of Waste. We expected, that before the year 2000, no waste for industrial incineration was imported into Slovakia. Therefore industrial waste for the years 1990 – 1999 is reported in waste sector without energy use.

According to the QA/QC, volume of the industrial waste incinerated is compared with the information from the SU SR. Time series 1990 – 1999 is completely following energy balance of the SU SR. Time series 2000 – 2014 is based on the data reported directly by sources in the NEIS database and the information provided in the EU ETS reports (since 2005). Both data sources are compared with the data published by the SU SR. There is a good consistency between sources and the SU SR database.

EU ETS reports prepared by the cement plants provide information on the Refused Derived Fuels (RDS) factor. These allow to separate C-fossil and biogenic parts of industrial waste incinerated.

Only C-fossil industrial waste incinerated in cement plants are reported here in the subcategory 1.AA.2.f.iv – other solid fuels. NCV for quantity of C-fossil fuels are based on the EU ETS reports. Total C-fossil CO_2 was 284.55 Gg, CH_4 was 0.098 and N_2O was 0.0013 in 2015 and total biogenic CO_2 (reported under biomass) was 201.55 Gg, CH_4 was 0.068 and N_2O was 0.00907 in 2015.

Ad. 3: In sector 1.AA.4.a the gaseous fuel was recalculated. The reason for this reallocation was modification of energy balance provided by the Statistical Office of the Slovak republic. This correction of natural gas consumption was published in Statistical Yearbook – Energy 2015. Mentioned correction was performed only for year 2014. The information in energy balance is modified only in occasional cases. If the SU SR implements modifications/refinements in the energy balance, these changes are published next year in the appendix of Statistical Yearbook year+1. Moreover these modifications are forwarded to SHMI and to sectoral experts. If a modification in inventory is required, this improvements are performed during preparations of actual NIR. Especially in this case a problem with estimation of NG losses and NG consumption in services was discovered and modified.

Ad.4: During ERT review an inconsistency of categorization of emission in sector 1.A.1.c was identified. The main sour of emission in this category is from coke production. In accordance with the 2006 IPCC Guidelines (and based on ERT **recommendation SVK ARR 2016 E-25**), own-energy use emissions from coal mines, oil and gas companies were disaggregated from 1.AA.1.c.i and now are reported under 1.AA.1.c.ii. The emission from coke production are reported under 1.AA.1.c.i. In previous submission all of these emissions were reported under 1.A.1.c.i. Mentioned reallocation has no impact on total emissions in given category. The reallocation was done based on disaggregated energy balance provided by Statistical office of Slovak republic and NEIS database.

Ad. 5: Recalculations in off-road transportation included in the subcategory 1.AA.4.c.ii was implemented due to a systematic error occurred in the previous estimation.

Ad. 6: The recalculation occurred in this subcategory is connected with the reallocation of natural gas consumption used for pipeline transport, which was previously reported under 1.AA.5. In accordance with the IPCC 2006 GL this source is now reported under subcategory 1.AA.3.e.i.

Recalculations taking place in the transport category are described in the chapter 3.2.8.4.

3.2.5 CATEGORY-SPECIFIC IMPROVEMENTS AND IMPLEMENTATION OF RECOMMENDATIONS

During the inventory preparation following room for improvements was identified:

- Co-incineration of industrial waste in energy and industry – improvements in collection and verification of activity data, improvements in allocation of emissions from waste incineration between energy and waste sectors.
- Harmonisation of solid fuels categories between different data sources, including increasing of cooperation between different subjects and bodies.
- Improvements in verification of models used in refinery and iron and steel industry.
- Further improvements in country and plant specific EFs and NCVs.
- Whereas, the Statistical Office of the Slovak Republic provides data on fuels used in households, it is planned to improve data collection from households particularly as regards solid fuels. Therefore it is planned to apply for Eurostat grant in the frame of the Air emissions accounts (AEA) data collection as requested by the Regulation (EU) 691/2011, in collaboration with the Statistical Office of the Slovak Republic.

Improvements are implemented in line with the Improvement and Prioritization Plan for the year 2017.

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, it is also described in this chapter.

Public Electricity and Heat Production (1.A.1.a) - this allocates GHG emissions form the power installations for the production of electricity and heat and the combined heat-power installations (CHP). Total volume of fuels reported in this subcategory was 82 650.83 TJ in 2015. The most significant gas reported here was carbon dioxide, which was represented by 4 847.92Gg of CO_2 in 2015. After significant decrease in 2013 the production of emission was stabilized and in 2015 a slightly increase was expected. The increase in CO_2 emissions in the comparison with the year 2014 is 5.23%.On the other hand, the increase in biomass consumption is not as sharped as in previous years. Total CH_4 emissions were 0.73 Gg and total N_2O emissions were 0.15 Gg.

In accordance with the IPCC 2006 GL, GHG emissions in the 1.A.1.a were disaggregated into new introduced subcategories (Electricity Generation, Combined Heat and Power Generation, Heat Plants and Other). This approach was applied in this submission for the first time and was based on information provided by the SU SR (modules ENERG 719 – ENERG 721).

In 1.A.1.a also the “other fuels” are reported. In this group were included following emission sources:

- Methane combusted by cogeneration of gases from mines (1.B.1.A Coal Mining and Handling);
- Municipal solid waste incineration with energy use (6.C.2 Municipal Waste Burning);
- Industrial solid waste incineration with energy use (6.C.2 Industrial Waste Incineration).

These gases are used for electricity and heat production and were reallocated from the waste sector. The measurements of methane content in cogeneration gas are not representative and well documented and therefore the country specific emission factor and NCV was used for emissions estimation. Activity data for industrial waste incineration are included in 6.C.2 (Waste sector) due to unavailability of the specific NCV of the industrial waste (which contains different materials). Methane emissions from waste incineration with energy use are not reported in the category 6.C - Incineration and open burning of waste.

Petroleum Refining (1.A.1.b) - GHG emissions from the refineries are allocated in 1.A.1.b. Refineries process crude oil into a variety of hydrocarbon products. The biggest refinery SLOVNAFT Plc is the only petroleum refining company operating in Slovakia, processing approximately 5.9 million tons of crude oil a year. The company is the most important supplier of petrol and diesel fuels in Slovakia. 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). The fuels are allocated to liquid and gaseous fuels categories. No solid fuel is combusted in this subcategory.

Total volume of fuels allocated in 1.A.1.b expressed in energy units represented 21 249.19 TJ in 2015. Total CO_2 emissions were 1 448.15 Gg. There is an increase in CO_2 emissions, which is proportional to the increase of crude oil processed (increase of crude oil was 13.5% in comparison with year 2014). Total CH_4 emissions were 0.0458 Gg and total N_2O emissions were 0.0075 Gg.

Manufacture of Solid Fuels and Other Energy Industries (1.A.1.c) - Total volume of fuels allocated in the 1.A.1.c – Manufacture of Solid Fuels and Other Energy Industries expressed in energy units represented 7 418.12 TJ in 2015. Total CO_2 emissions were 1 289.70 Gg in 2015 and increase by 3.0% compared with the previous year. Total CH_4 emissions were 0.007 Gg and total N_2O emissions were 0.0008 Gg.

3.2.6.1 Methodological issues

Tier 2 or/and tier 3 methods are used for the majority of CO_2 combustion source categories 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 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 in 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 two primary sources for activity data: verified reports of operators included in the EU ETS and disaggregated data on economical subjects in details provided by the Statistical Office of the Slovak Republic (the SU SR). The share of emission sources covered by the EU ETS is large in these subcategories (90.7% of all CO_2 emissions in 1.A.1 and 84.3% in 1.A.2) and the remaining sources allocated here are balanced by the using data from the SU SR. After verification of the ETS reports by accredited verifiers, the ETS reports (in NIMs[2] formats) are released to the NIS team of experts. In the first step, the ETS reports are processed and transferred into internal database system (May, year-1). Activity data from the most plants are directly linked to the specific IPCC categories based on the NACE rev.2 classification (provided by the SU SR), which is a pan-European classification system of economic activities. In chemical industry, petroleum industry or iron and 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 annexes and in the chapter 4 of this report). This approach is used also for proxy inventory for the year-1. As in May, the official data from the SU SR are not available; the ETS reports are validated against the SU SR and the NEIS data from previous year, to check the time series consistency and trends. After releasing official data from the SU SR and the NEIS (October, 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 (regional 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 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.

Then the emissions balance is calculated directly by the sectoral experts. The CO_2 emissions estimate on source level are in the final step cross-checked with the emissions estimate calculated based on the activity data provided by the SU SR and the NEIS.

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 Statistical Office of the Slovak Republic.[3] Official (verified) data from the SU SR are released to SHMÚ in October 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. These data completed the EU ETS data and were used for the sectoral approach balance in 1.A.1, 1.A.2, 1.A.4 and 1.A.5. The major

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 NIMs – National Implementation Measures

3 These data are officially provided from the year 2012 based on agreement between the MZP SR, the SHMU and the Statistical Office of the Slovak Republic

improvement implemented in this submission is the new approach in preparation of the fuel and emission balance in connection with the IPPU sector.

The emissions balance in the 1.A.1, 1.A.2, 1.A.4 and 1.A.5 is done by combination and summation of activity from the EU ETS reports and the Statistical Office database provided on plant level. This procedure is performed automatically by our internal database system. This system contains unmodified information about the fuel consumption. 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. Information from the EU ETS reports has higher priority (due to more levels of verifications and more details) and therefore in final balance the activity data from the EU ETS reports replacing disaggregated energy balance data on plant level provided by the SU SR.

There are only few exceptions like chemical industry, petroleum refining and iron and steel production, where material and emissions data flow is too complicated to automate the splitting of technological and combustion emissions. Therefore in these sources 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 SU SR) are replaced by the activity data calculated by the models. The background information for preparing such a models are obtained directly from the plant operators or the EU ETS verifiers. Such a 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, underestimation emissions or discrepancies with the IPCC guidelines. Based on the recent improvement in the EU ETS reporting (using more advance format for 2014 data - NIMS), the automatic check tool for the data reported in the EU ETS tables with disaggregated energy balance data on plant level provided by the SU SR was prepared and tested in current submission. The comparisons were made for the apparent consumption of different fuels on plant (installation) level and for the allocation of production categories and harmonization with NACE rev.2 classification of installations.

For an illustration, ***Table 3.8*** compares the share of GHG emissions in the individual IPPC categories estimated based on the EU ETS data and the SU SR database. Very interesting is also comparison of the number of plants which belongs to the one IPPC category.

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

CATEGORY	CO_2 EMISSIONS (%)		NUMBER OF ENTITIES	
	EU ETS	SU SR	EU ETS	SU SR
1.A.1 Energy Industries	90.70	9.30	38	192
1.A.2 Manufacturing Industries and Construction	84.30	15.70	64	1 727
1.A.4 Other Sectors	1.60	98.40	7	671
1.A.5 Other (Not specified elsewhere)	0.00	100.00	0	56.00

Based on the information provided in the ***Table 3.8*** is visible, that the EU ETS share of CO_2 emissions in 1.A.1 is higher than 90% and in 1.A.2 more than 84%. Due to high “EU ETS CO_2 emissions” share it is possible to compare the activity data between three independent sources (EU ETS, SU SR and NEIS).

For fuel combustion in 1.A.1.b - Petroleum Refining, a plant specific tier 3 bottom-up method was used. For calculation of GHG emissions, activity data was obtained directly from the SLOVNAFT Plc (data on the amount of fuel combusted in individual sources, plant specific emission factors). The activity data were compared with the information provided by the SU SR and the NEIS database.

In 1.A.1.b bottom-up tier 3 method of IPCC was used (emission factors for liquid fuels are plant specific). The emission estimation is based on the material and energy balance provided to us by operator. This information is formed by monthly consumption of individual fuel types 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 Inc).

Based on the IPCC 2006 GL, the highest available tier is used and the combustion data are preferred. Activity data were provided directly by the operator. They include the monthly (or yearly) average consumptions of fuels by the individual sources of emissions in refinery. 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 Statistical Office of the Slovak Republic, 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 as 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 EU-EST. Therefore there is good (practically absolute) correlation between emission reported under EU-ETS and NIR. This approach was introduced in submission 2013. In submission 2014 the emission estimation was slightly modified. The methodology remains the same, however based on the 2006 IPCC GL and recommendations provided by the ERT, the emissions from 1.A.1.b were split and reallocated into three new categories. 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 used to estimate the emissions 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 for other fuels. No emissions from the municipal solid waste incineration are reported in 5.C.2 Municipal Waste Burning in Waste sector due to the fact that all incineration of the MSW is with energy use in the Slovak Republic. Therefore notation key "IE" is used in the 5.C.2 subcategory.

Municipal solid waste (MSW) incineration is used as fuel for electricity and heat production. MSW is combusted in two large stationary combustion plants in Bratislava and Kosice. Statistically negligible volume of MSW is incinerated outside of these two large plants.

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 Kosice produce electricity for own consumption and partly also selling to public grid;

3. Bratislava incinerator is not producing heat for own consumption. Incinerator in Kosice is producing heat for heating plant TEKO Kosice, which is allocated in 1.A.1.a.

Volume of MSW incinerated and reported is comparable with the volume reported by the SU SR (and EUROSTAT) and was 191.43 kt (1 885.60 GJ) in 2015. Following ***Table 3.9*** shows the comparison of the MSW volume reported by the operators in the SU SR publication "Waste" and EUROSTAT in the period 2002 – 2015.

Table 3.9: *Comparison of MSW incinerated with energy use reported by the EUROSTAT and the Publication "Waste" of the SU SR with the biogenic and C-fossil share*

MSW INCINERATED	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
EUROSTAT in GJ														
biogenic	87	537	602	730	880	805	1 035	1 052	901	736	775	653	485	625
C-fossil	86	537	600	731	880	805	876	826	705	667	629	454	1 235	1 043
SU SR PUBLICATION "WASTE" in GJ														
biogenic	1 180	1 227	1 392	1 394	1 450	1 385	1 210	1 373	1 423	1 446	1 319	1 361	1 489	1 504
C-fossil	361	374	421	408	421	390	339	378	383	381	336	350	382	382

Incinerated MSW was divided into C-fossil and biogenic fraction using composition of waste generated in municipalities and presented in chapter 7 of this report.

There is not consistent approach in reporting C-fossil and biogenic share in energy units (TJ) in the energy balance of the SU SR and the amount reported by the operators. The reasons are, that the SU SR includes part of MSW into industrial solid waste incinerated and used different waste composition. There is a good agreement in the amount of MSW incinerated between the EU ETS and the data from operators. Average NCV based on statistical information 9.850 TJ/t was used for reporting requirement in the GHG inventory.[4]

Appropriate CO_2, CH_4 and N_2O emissions were estimated for C-fossil and biogenic fractions of the MSW incinerated and reported in the "solid fuel" and "biomass" items of 1.A.1.a.iv – Other. Total C-fossil CO_2 was 21.94 Gg, CH_4 was 0.011 Gg and N_2O was 0.0015 Gg in 2015 and total biogenic CO_2 was 86.41 Gg, CH_4 was 0.0451 Gg and N_2O was 0.00601 Gg in 2015.

3.2.6.2 Emission factors and NCVs

The country specific calorific values of the fuels are announced by the SU SR annually. The variations depend on fuel characteristics, which are published in the Statistical Yearbook annually. If an operator used the plant specific calorific values, it is an obligation to provide supported measurements to the NEIS database and inform relevant competent authority (the Ministry of Environment of the Slovak Republic). The plant specific data and results of measurements can be found also in the EU ETS reports. The inventory experts used the NCVs from the SU SR and the EU ETS reports 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 SU 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.

[4] http://enviroportal.sk/ovzdusie/zoznam-spalovni-a-zariadeni-na-spoluspalovanie

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, Profing Ltd., sectoral expert, plant 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 since 2000, for coal since 2000, for brown coal according to the source of origin (Slovak, Ukraine, the Czech Republic) since 2000, for coke since 2000 and for 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 Slovak Gas Industry, Ltd, the Slovak Energy Industry, LtD., refinery plant Slovnaft, Ltd. (liquid fuels), and the U.S. Steel Company for iron and steel production. These EFs are in use for the installations under the EU ETS and for the reporting requirements of the Ministry of Environment of the Slovak Republic. 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 (of the Russian origin) is based on precise measurements and calculations published every month by the Slovak Gas Industry Ltd. since January 1, 2000. Nowadays, these EFs are used for the installations covered by the EU ETS. The emission factors are published monthly online[5] (***Tables 3.10 - 3.12***). Weighted averages are calculated based on monthly consumption announced by the Slovak Gas Industry Ltd. Despite the fact, that the Slovak Gas Industry, Ltd. 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 Slovak Gas Industry Ltd. – Distribution Company.

The annual EU ETS reports are an important source of activity-specific and company specific data on CO_2 emissions, fuel use and emission factors for major combustion sources (and industrial processes sources) in the national GHG emissions inventory. The EU ETS covers 135 installations with the total CO_2 emissions of 21 181 Gg in 2015.

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).

Default CO_2 emission factors from the IPCC 2006 Guidelines are used only for biomass, which almost invariably refers to wood, wood wastes and biogas. The list of actually used EFs is presented in the ***Table 3.17***. The CO_2 emission factor of natural gas (55.72 t CO_2/TJ) is lower than the IPCC default

[5] http://www.spp.sk/sk/velki-zakaznici/zemny-plyn/o-zemnom-plyne/emisie

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.

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 0.6% of the total GHG emissions (expressed in CO_2 eq.), in energy sector (CO_2: 7 099.47 Gg; CH_4: 18.45 Gg; N_2O: 44.20 Gg). These emissions are dependent on a large number of factors, including fuel type, equipment design, and emission control technology. It is, therefore, inherently more complex and more uncertain than CO_2 emissions estimation. The non-CO_2 EFs are default based on the IPCC 2006 GL.

Table 3.10: *Composition of natural gas in 2015 published on-line by the Slovak Gas Industry*

2015	NATURAL GAS (mol %)									
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
I.	96.0234	2.1802	0.5573	0.0897	0.0913	0.0197	0.0144	0.0213	0.2686	0.7334
II.	96.1087	2.0975	0.5552	0.0891	0.0915	0.0201	0.0149	0.0234	0.2583	0.7410
III.	96.1236	2.1570	0.5535	0.0929	0.0920	0.0198	0.0143	0.0209	0.2415	0.6841
IV.	95.9399	2.1752	0.6449	0.1056	0.1082	0.0238	0.0177	0.0232	0.2387	0.7227
V.	95.3170	2.6530	0.8344	0.1383	0.1379	0.0288	0.0205	0.0206	0.2204	0.6286
VI.	94.3941	3.2281	1.0593	0.1743	0.1751	0.0367	0.0266	0.0293	0.2614	0.6146
VII.	93.9374	3.3274	1.0317	0.1604	0.1705	0.0373	0.0274	0.0355	0.4782	0.7937
VIII.	93.6415	3.4218	1.0167	0.1544	0.1695	0.0390	0.0288	0.0416	0.6127	0.8733
IX.	94.0029	3.1892	0.9456	0.1417	0.1563	0.0357	0.0263	0.0361	0.5901	0.8753
X.	95.3621	2.5014	0.7585	0.1190	0.1248	0.0264	0.0194	0.0221	0.3141	0.7516
XI.	95.5887	2.4310	0.6563	0.1044	0.1059	0.0226	0.0162	0.0201	0.3295	0.7243
XII.	95.0214	2.7219	0.7441	0.1145	0.1223	0.0269	0.0198	0.0273	0.4253	0.7754
AVERAGE	**95.1220**	**2.6740**	**0.7800**	**0.1240**	**0.1290**	**0.0280**	**0.0210**	**0.0270**	**0.3530**	**0.7430**

Table 3.11: *Overview of the EFs and NCVs for natural gas in 2015 [15°C; 101.325 kPa] published on-line by the Slovak Gas Industry*

2015	NATURAL GAS						
MONTH	RELATIVE DENSITY	DENSITY	NCV	COMBUSTION HEAT	WOBBE NUMBER	SULPHUR CONTENT	EF CO_2
	(mol %)	(kg.m^{-3})	(kWh.m^{-3})	(kWh.m^{-3})	(kWh.m^{-3})	(mg.m^{-3})	(tCO_2/TJ)
I.	0.5804	0.7112	9.655	10.701	14.05	0.0368	55.54
II.	0.5799	0.7107	9.649	10.695	14.05	0.0298	55.53
III.	0.5798	0.7105	9.660	10.708	14.06	0.0629	55.53
IV.	0.5815	0.7126	9.681	10.730	14.07	0.0431	55.57
V.	0.5861	0.7183	9.770	10.822	14.14	0.0626	55.69
VI.	0.5931	0.7268	9.867	10.918	14.19	0.0242	55.89
VII.	0.5960	0.7305	9.832	10.887	14.11	0.0868	56.01
VIII.	0.5981	0.7330	9.818	10.871	14.06	0.1650	56.09
IX.	0.5954	0.7297	9.783	10.833	14.04	0.3500	56.01
X.	0.5854	0.7175	9.720	10.770	14.08	0.2111	55.69
XI.	0.5836	0.7152	9.690	10.739	14.06	0.0719	55.65
XII.	0.5877	0.7203	9.722	10.772	14.05	0.0297	55.78
AVERAGE	**0.5870**	**0.7200**	**9.737**	**10.787**	**14.08**	**0.0978**	**55.75**

Table 3.12: *Overview of the CO_2 country or plant specific emission factors in 1.A.1 in 2015*

1.A.1.a	WEIGHTED EF CO_2 (t/TJ)	FUEL TYPE	EF C (t/TJ)	EF CO_2 (t/TJ)
LIQUID	78.15	Gas/Diesel oil	20.21	74.10
		Residual fuel oil	21.54	79.00
		Liquefied petroleum gases	17.22	63.15

1.A.1.a	WEIGHTED EF CO_2 (t/TJ)	FUEL TYPE	EF C (t/TJ)	EF CO_2 (t/TJ)
SOLID	101.38	Anthracite	0.00	0.00
		Other bituminous coal	26.48	97.08
		Lignite	28.01	102.70
GASEOUS	55.72	Natural gas	15.20	55.68
BIOMASS	98.00	Other biogas	14.90	54.63
		Sludge gas	14.90	54.63
		Other primary solid biomass	26.48	97.08
		Wood/Wood waste	27.30	100.10
1.A.1.b	**WEIGHTED EF (CO_2) t/TJ**	**FUEL TYPE**	**EF C (t/TJ)**	**EF CO_2 (t/TJ)**
LIQUID	71.31	Residual fuel oil	21.54	78.92
		Petroleum coke	26.61	97.50
		Refinery gas	15.17	55.57
GASEOUS	55.72	Natural gas	15.20	55.68
1.A.1.c	**WEIGHTED EF (CO_2) t/TJ**	**FUEL TYPE**	**EF C (t/TJ)**	**EF CO_2 (t/TJ)**
LIQUID	74.95	Gas/Diesel oil	20.44	74.95
		Liquefied petroleum gases	17.22	63.15
SOLID	191.16	Lignite	27.91	102.32
		Coke oven gas	11.53	42.28
		Blast furnace gas	71.24	261.21
GASEOUS	55.72	Natural gas	15.20	55.72
BIOMASS	54.63	Other biogas	14.90	54.63

3.2.6.3 Uncertainties and time-series consistency

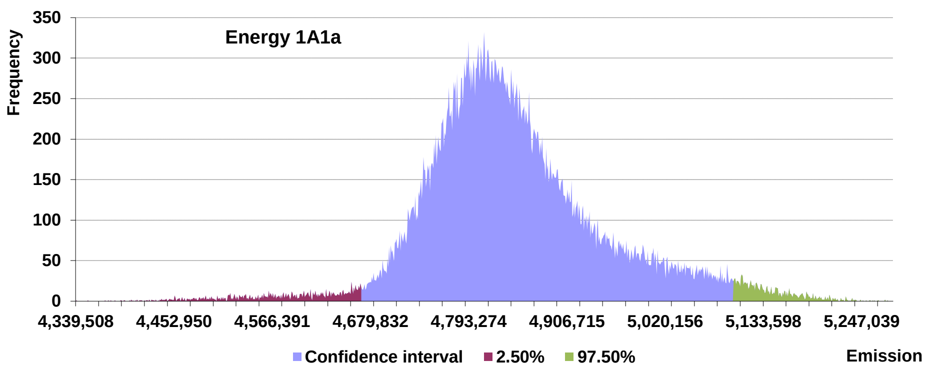
Time series is consistent in all aspects (methodological approach, country specific EFs and oxidation factor used, fuel characteristics, etc.) to the detailed level of disaggregation (on plant specific level).

The average mean value of GHG emissions for the 1.A.1.a obtained by the Monte Carlo simulation is 4 846 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 4 847 Gg. Confidence interval (95%) is within the range: <4 340; 5 285>, which represents the uncertainty by relative values to the mean value: -3.66%; +5.23%. The following table and graph described calculated results of uncertainty analyses.

Table 3.13: *Selected statistical characteristics for 1.A.1.a, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in Gg of CO_2)*

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
4 830.70	**4 845.82**	106.16	4 339.51	5 284.85	-3.66%	5.23%

Figure 3.8: *Probability density function for 1.A.1.a in tons of CO_2*

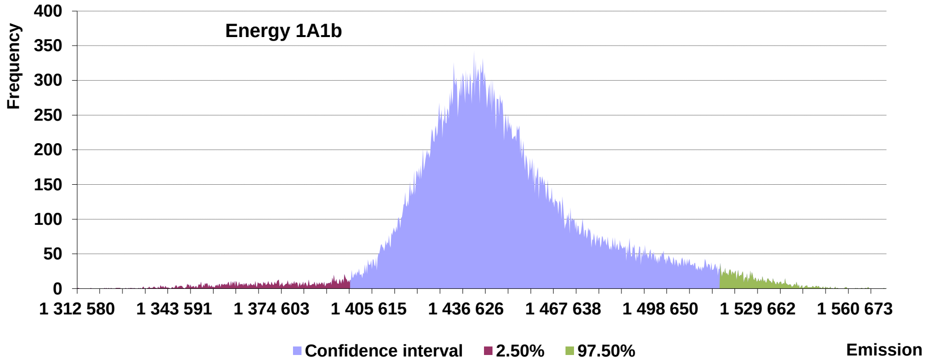


The average mean value of CO_2 emissions for the 1.A.1.b obtained by the Monte Carlo simulation is 1 448 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 1 448 Gg. Confidence interval (95%) is within the range: <1 313; 1 571>, which represents the uncertainty by relative values to the mean value: -3.38%; +4.79%. The following table and graph described calculated results of uncertainty analyses.

Table 3.14: *Selected statistical characteristics for 1.A.1.b, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in Gg of CO_2)*

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
1 443.79	**1 448.17**	29.25	1 312.58	1 571.01	-3.38%	4.79%

Figure 3.9: *Probability density function for 1.A.1.b in tons of CO_2*

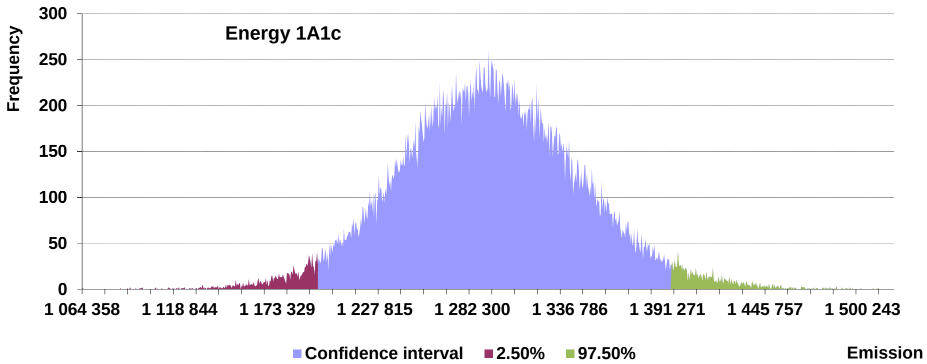


The average mean value of CO_2 emissions for the 1.A.1.c obtained by the Monte Carlo simulation is 1 292 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 1 290 Gg. Confidence interval (95%) is within the range: <1 196; 1 393>, which represents the uncertainty by relative values to the mean value: -7.39%; +7.86%. The following table and graph described calculated results of uncertainty analyses.

Table 3.15: *Selected statistical characteristics for 1.A.1.c, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in Gg of CO_2)*

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
1 290.89	**1 291.76**	49.95	1 064.36	1 518.40	-7.39%	7.86%

Figure 3.10: *Probability density function for 1.A.1.c in tons of CO_2*



3.2.7 MANUFACTURING INDUSTRIES AND CONSTRUCTION (CRF 1.A.2)

Category 1.A.2 includes CO_2 emissions allocated in the subcategories: 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 from the category 1.A.2 include industrial emissions originating to a large extent from energy and heat production in raw materials and semi-manufactured goods production. These emissions are related to fuel combustion, only. Consumption of fuels used as feedstock and reduction medium is not included in this category, but 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 23 368.27 TJ in 2015. Total CO_2 emissions were 2 866.95 Gg. Total CH_4 emissions were 0.12 Gg and total N_2O emissions were 0.02 Gg.

Non-ferrous metals (1.A.2.b) - This source covers combustion-related emissions from non-ferrous metal industry. Total volume of fuels allocated in this subcategory expressed in energy units was 2 786.19 TJ in 2015. Total CO_2 emissions were 137.18 Gg, total CH_4 emissions were 0.03 Gg and total N_2O emissions were 0.004 Gg.

Chemicals (1.A.2.c) - includes emissions from fuel 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 11 use more than 65% of the energy according to the available activity data. Total volume of fuels expressed in energy units allocated in this subcategory was 7 893.25 TJ in 2015. The decline of natural gas consumption was caused by the termination of operation of one company with relatively high fuel consumption. Total CO_2 emissions were 467.73 Gg, total CH_4 emissions were 0.02 Gg and total N_2O emissions were 0.002 Gg.

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 this subcategory expressed in energy units was 27 472.11 TJ in 2015. The fuel consumption remains practical on the same level as in previous year. Total CO_2 emissions were 475.66 Gg, total CH_4 emissions were 0.26 Gg and total N_2O emissions were 0.06 Gg.

Food processing, beverage and tobacco (1.A.2.e) - Total volume of fuels allocated in this subcategory expressed in energy units represented 5 526.95 TJ in 2015. Total CO_2 emissions were 329.01 Gg, total CH_4 emissions were 0.010 Gg and total N_2O emissions were 0.001 Gg. The fuels are allocated among solid, liquid, gaseous and biomass fuels.

Non-metallic minerals (1.A.2.f) - Total volume of fuels allocated in this subcategory expressed in energy units represented 18 581.71 TJ in 2015. Total CO_2 emissions were 1 234.63 Gg, total CH_4 emissions were 0.21 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 fuel combustion in industry were allocated in this subcategory. Total volume of fuels in this category expressed in energy units represented 20 890.45 TJ in 2015. Total CO_2 emissions were 1 186.67 Gg, total CH_4 emissions were 0.10 Gg and total N_2O emissions were 0.01 Gg. Based on the IPCC 2006 Guidelines, this subcategory 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 in this subcategory is depicted on the next ***Table 3.16***.

Table 3.16: *Disaggregation of CO_2 emissions across the subcategory 1.A.2.g*

SUBCATEGORY	CO_2 EMISSIONS (Gg)	SHARE
1.A.2.g.i Man. of machinery	164.64	13.87%
1.A.2.g.ii Man. of transport equipment	166.18	14.00%
1.A.2.g.iii Mining and quarrying	12.13	1.02%
1.A.2.g.iv Wood and wood products	16.20	1.37%
1.A.2.g.v Construction	40.62	3.42%
1.A.2.g.vi Textile and leather	36.32	3.06%
1.A.2.g.viii Other	750.59	63.25%

3.2.7.1 Methodological issues

Detail general description of the methodological issues 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 year after consultation with company focusing on energy issues (Profing, LtD.) and in cooperation with the IPPU sectoral expert. 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). Methodology for emissions estimation in this subcategory 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 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

Mainly country-specific or plant-specific emission factors are used in the category 1.A.2, although IPCC default emission factors are used for some fuels with less importance. 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 subcategory specific (estimated as weighted average of sources allocated in this subcategory). The list of actually used EFs is presented in the ***Table 3.17***.

Table 3.17: *Overview of the country or plant specific CO_2 emission factors in 1.A.2 in 2015*

1.AA.2.a	WEIGHTED EF CO_2 (t/TJ)	FUEL TYPE	EF C (t/TJ)	EF CO_2 (t/TJ)
Liquid	63.17	Residual Fuel Oil	20.66	75.77
		Liquefied Petroleum Gases	17.22	63.15
Solid	128.79	Gas Coke	29.13	106.82
		Other Bituminous Coal	26.64	97.69
		Coke Oven Gas	11.53	42.28
		Blast Furnace Gas	71.24	261.21
Gaseous	55.72	Natural Gas	15.20	55.72
Biomass	111.83	Wood/Wood Waste	30.50	111.83
1.AA.2.b	**WEIGHTED EF CO_2 (t/TJ)**	**FUEL TYPE**	**EF C (t/TJ)**	**EF CO_2 (t/TJ)**
Liquid	90.23	Gas/Diesel Oil	20.44	74.95
		Petroleum Coke	24.83	91.06
		Liquefied Petroleum Gases	17.22	63.15
Solid	99.57	Other Bituminous Coal	26.52	97.25
		Gas Coke	29.13	106.82
Gaseous	55.72	Natural Gas	15.20	55.72
Biomass	111.83	Wood/Wood Waste	30.50	111.83
1.AA.2.c	**WEIGHTED EF CO_2 (t/TJ)**	**FUEL TYPE**	**EF C (t/TJ)**	**EF CO_2 (t/TJ)**
Liquid	74.27	Residual Fuel Oil	20.66	75.77
		Gas/Diesel Oil	20.44	74.95
		Liquefied Petroleum Gases	17.22	63.15
Solid	103.27	Anthracite	28.56	104.72
		Coking Coal	25.72	94.30
		Lignite	27.91	102.32
		Other Bituminous Coal	26.45	96.98
Gaseous	55.72	Natural Gas	15.20	55.72
Biomass	94.87	Wood/Wood Waste	30.50	111.83

		Other Primary Solid Biomass	27.30	100.10
		Other Biogas	14.90	54.63
1.AA.2.d	**WEIGHTED EF CO_2 (t/TJ)**	**FUEL TYPE**	**EF C (t/TJ)**	**EF CO_2 (t/TJ)**
Liquid	74.88	Residual Fuel Oil	20.66	75.77
		Liquefied Petroleum Gases	17.22	63.15
Solid	99.52	Other Bituminous Coal	26.45	96.98
		Lignite	27.87	102.21
Gaseous	55.72	Natural Gas	15.20	55.72
Other	105.97	Peat	28.90	105.97
Biomass	98.58	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.AA.2.e	**WEIGHTED EF CO_2 (t/TJ)**	**FUEL TYPE**	**EF C (t/TJ)**	**EF CO_2 (t/TJ)**
Liquid	63.15	Liquefied Petroleum Gases	17.22	63.15
		Gas/Diesel Oil	20.44	74.95
Solid	102.50	Anthracite	28.56	104.72
		Lignite	27.87	102.21
		Gas Coke	29.13	106.82
Gaseous	55.72	Natural Gas	15.20	55.72
Biomass	71.83	Other Primary Solid Biomass	27.30	100.10
		Sludge Gas	14.90	54.63
		Wood/Wood Waste	30.50	111.83
1.AA.2.f	**WEIGHTED EF CO_2 (t/TJ)**	**FUEL TYPE**	**EF C (t/TJ)**	**EF CO_2 (t/TJ)**
Liquid	92.33	Residual Fuel Oil	20.66	75.77
		Petroleum Coke	25.53	93.61
		Liquefied Petroleum Gases	17.22	63.15
		Gas/Diesel Oil	0.00	0.00
Solid	98.22	Anthracite	28.56	104.72
		Other Bituminous Coal	26.45	96.98
		Lignite	27.87	102.21
		Gas Coke	29.13	106.82
Gaseous	55.72	Natural Gas	15.20	55.72
Other	88.54	Municipal and Industrial Wastes	24.15	88.55
		Waste Oil	20.00	73.33
Biomass	88.60	Wood/Wood Waste	30.50	111.83
		Waste (biogenic)	24.15	88.55
1.AA.2.g	**WEIGHTED EF CO_2 (t/TJ)**	**FUEL TYPE**	**EF C (t/TJ)**	**EF CO_2 (t/TJ)**
Liquid	64.23	Gas/Diesel Oil	20.21	74.10
		LPG	17.22	63.15
		Residual Fuel Oil	20.66	75.77
		Other Petroleum Products	20.01	73.35
Solid	92.24	Blast Furnace Gas	71.24	261.21
		Coke oven Gas	11.53	42.28
		Lignite	27.87	102.21
		Other bituminous coal	26.45	96.98
Gaseous	55.72	Natural Gas	15.20	55.72
Biomass	111.82	Other primary solid biomass	27.30	100.10
		Wood/Wood waste	30.50	111.83

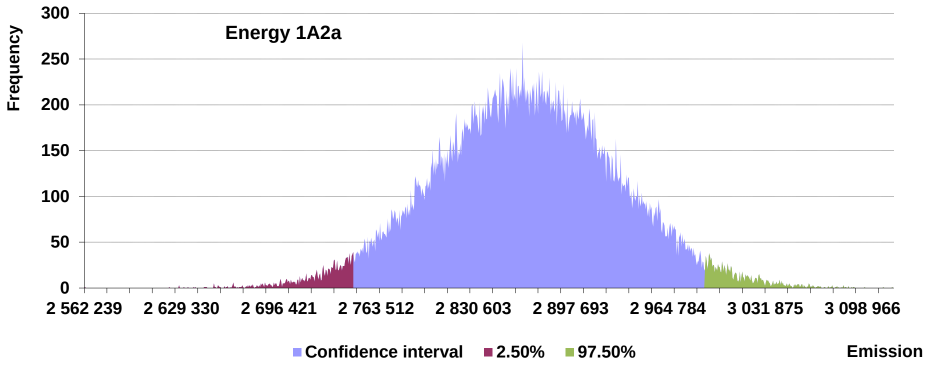
3.2.7.3 Uncertainties and time-series consistency

The average mean value of CO_2 emissions for the 1.A.2.a obtained by the Monte Carlo simulation is 2 867 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 2 867 Gg. Confidence interval (95%) is within the range: <2 746; 2 990>, which represents the uncertainty by relative values to the mean value: -4.22%; +4.28%. The following table and graph described calculated results of uncertainty analyses.

Table 3.18: *Selected statistical characteristics for 1.A.2.a, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in Gg of CO_2)*

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
2 866.92	**2 867.29**	62.18	2 562.24	3 121.33	-4.22%	4.28%

Figure 3.11: *Probability density function for 1.A.2.a in tons of CO_2*

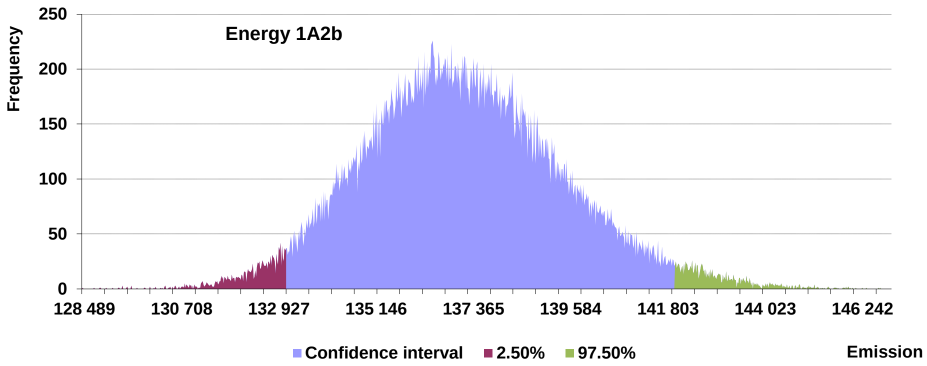


The average mean value of GHG emissions for the 1.A.2.b obtained by the Monte Carlo simulation is 137 Gg per year. The average mean value is with the same as the real result of the CO_2 emissions, which is 137 Gg. Confidence interval (95%) is within the range: <133; 142>, which represents the uncertainty by relative values to the mean value: -3.02%; +3.51%. The following table and graph described calculated results of uncertainty analyses.

Table 3.19: *Selected statistical characteristics for 1.A.2.b, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in Gg of CO_2)*

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
137.08	**137.19**	2.27	128.49	146.98	-3.02%	3.51%

Figure 3.12: *Probability density function for 1.A.2.b in tons of CO_2*

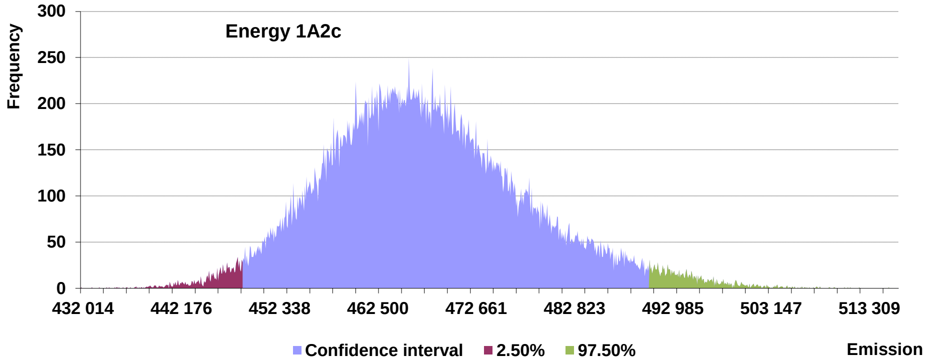


The average mean value of GHG emissions for the 1.A.2.c obtained by the Monte Carlo simulation is 468 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 468 Gg. Confidence interval (95%) is within the range: <450; 491>, which represents the uncertainty by relative values to the mean value: -3.87%; +4.94%. The following table and graph described calculated results of uncertainty analyses.

Table 3.20: *Selected statistical characteristics for 1.A.2.c, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in Gg of CO_2)*

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
466.86	**467.72**	10.33	432.01	516.70	-3.87%	4.94%

Figure 3.13: *Probability density function for 1.A.2.c in tons of CO_2*

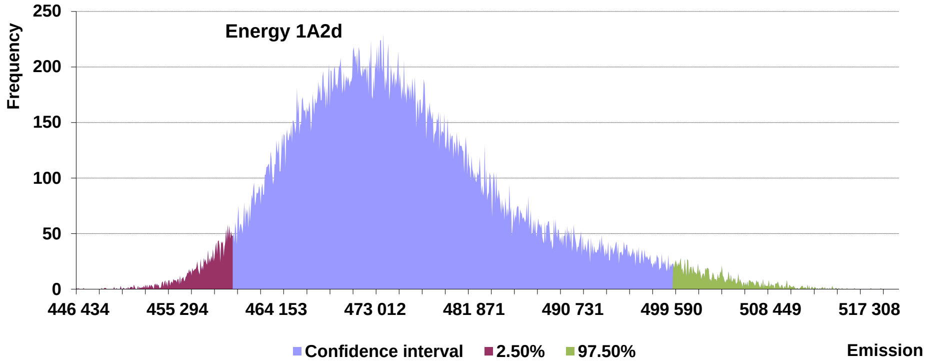


The average mean value of CO_2 emissions for the 1.A.2.d obtained by the Monte Carlo simulation is 476 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 476 Gg. Confidence interval (95%) is within the range: <460; 500>, which represents the uncertainty by relative values to the mean value: -3.36%; +5.08%. The following table and graph described calculated results of uncertainty analyses.

Table 3.21: *Selected statistical characteristics for 1.A.2.d, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in Gg of CO_2)*

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
474.25	**475.71**	10.11	446.43	520.26	-3.36%	5.08%

Figure 3.14: *Probability density function for 1.A.2.d in tons of CO_2*

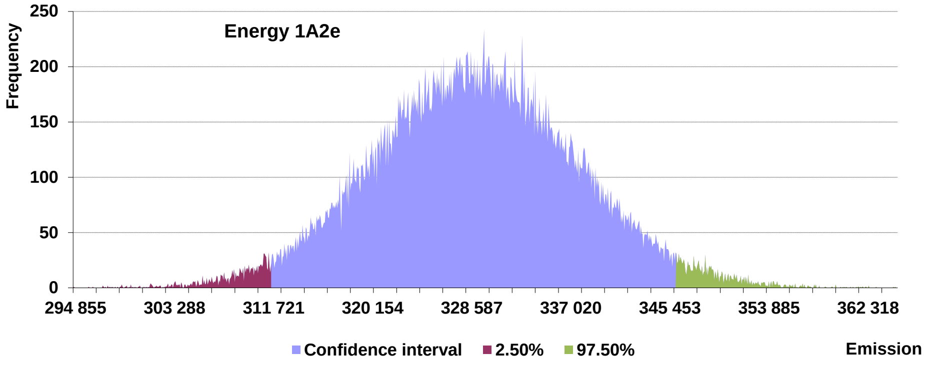


The average mean value of CO_2 emissions for the 1.A.2.e obtained by the Monte Carlo simulation is 329 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 329 Gg. Confidence interval (95%) is within the range: <312; 346>, which represents the uncertainty by relative values to the mean value: -5.10%; +5.20%. The following table and graph described calculated results of uncertainty analyses.

Table 3.22: *Selected statistical characteristics for 1.A.2.e, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in Gg of CO_2)*

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
328.99	**329.06**	8.65	294.86	365.13	-5.10%	5.20%

Figure 3.15: *Probability density function for 1.A.2.e in tons of CO_2*

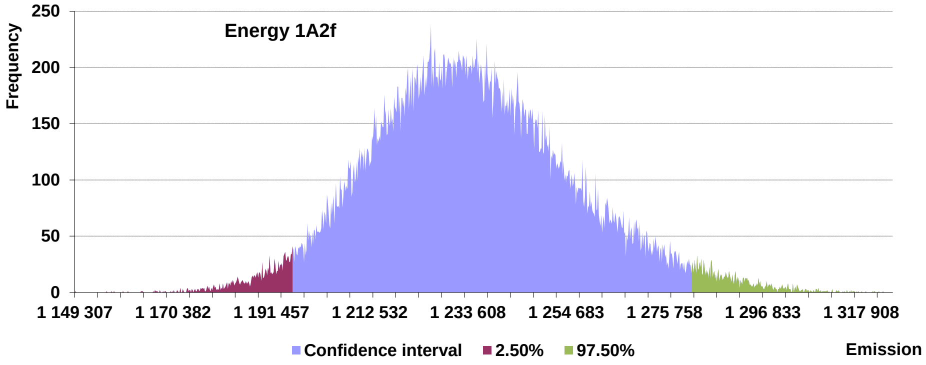


The average mean value of CO_2 emissions for the 1.A.2.f obtained by the Monte Carlo simulation is 1 235 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 1 235 Gg. Confidence interval (95%) is within the range: <1 196; 1 282>, which represents the uncertainty by relative values to the mean value: -3.15%; +3.80%. The following table and graph described calculated results of uncertainty analyses.

Table 3.23: *Selected statistical characteristics for 1.A.2.f, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in Gg of CO_2)*

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
1 233.25	**1 234.67**	21.59	1 149.31	1 324.93	-3.15%	3.80%

Figure 3.16: *Probability density function for 1.A.2.f in tons of CO_2*

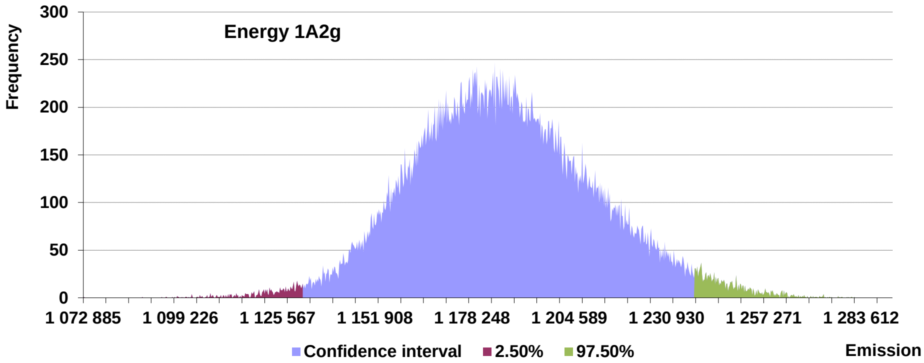


The average mean value of CO_2 emissions for the 1.A.2.g obtained by the Monte Carlo simulation is 1 187 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 1 187 Gg. Confidence interval (95%) is within the range: <1 141; 1 239>, which represents the uncertainty by relative values to the mean value: -3.81%; +4.37%. The following table and graph described calculated results of uncertainty analyses.

Table 3.24: *Selected statistical characteristics for 1.A.2.g, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in Gg of CO_2)*

Median	Average	St. dev	Min	Max	Per_2.5	Per_97.5
1 185.35	**1 186.67**	24.74	1 072.89	1 292.39	-3.81%	4.37%

Figure 3.17: *Probability density function for 1.A.2.g in tons of CO_2*



3.2.8 TRANSPORT (CRF 1.A.3)

Transport has very special position in the energy sector, as it is not included in the EU ETS or other legislative regulations, thus emissions in this category are very difficult to regulate. The emissions from category 1.A.3 Transport 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). During recent years, the shift from a public transportation to individual passenger cars has been observed. The level of transit transport (HDV) has been increased at the same time. The consumption of fuels in railways is decreasing continuously, while the consumption of fuels in road transportation is sharply increasing. Total aggregated GHG emissions in transport decreased slightly against the base year, although emissions in road transportation have increased by 36% in comparison with the base year and emissions in pipeline transport decreased accordingly. More information can be find below.

The emissions from road and non-road transport were calculated by using models, default methodologies and the consistent data series from 1990 – 2015 are presented in the CRF Tables. Total GHG emissions in the category transport were 6 704.60 Gg of CO_2 eq. in 2015. The CO_2 emissions were 6 421.57 Gg, which represent the 98.76% share on total transport emissions, the CH_4 emissions were 15.04 Gg of CO_2 eq. with the 0.22% share and N_2O emissions were 68.15 Gg of CO_2 eq. with the 1.02% share on total transport GHG emissions.

The share of road transportation was 95.68%, pipeline transport 2.75%, railways 1.41%, domestic aviation represents 0.05% and domestic navigation 0.09% from the total emissions reported in transport category (in CO_2 eq.). Total energy consumption was 97 540.36 TJ of fuels in 2015. Among fuels, the most important are liquid fuels (***Figure 3.18***) and gaseous fuels with 3.87 %. No solid fuels are used in transport category. The time series of GHG emissions are presented in the ***Table 3.25***.

Figure 3.18: *The share of fuels on different categories within transport in 2015*

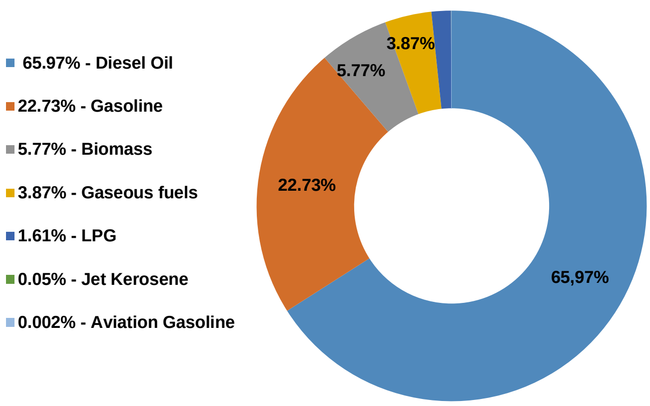


Table 3.25: *Fuel consumption and GHG emissions in transport by subcategories in particular years*

Year	1.A.3.a DOMESTIC AVIATION				1.A.3.b ROAD TRANSPORTATION			
	FUEL (TJ)	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)	FUEL (TJ)	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)
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	54 574.15	3 989.01	0.9586	0.1852
2005	107.14	7.79	0.000158	0.000212	82 603.22	6 045.33	0.9352	0.2189
2010	70.59	5.13	0.000095	0.000140	91 385.19	6 382.01	0.7196	0.1797
2011	58.43	4.25	0.000076	0.000116	85 317.71	5 923.48	0.6311	0.1746
2012	53.96	3.92	0.000072	0.000107	90 804.83	6 316.04	0.6165	0.1882
2013	46.72	3.40	0.000062	0.000092	87 880.26	6 091.87	0.6230	0.1832
2014	47.29	3.44	0.000066	0.000093	89 990.51	6 153.47	0.6318	0.1745
2015	50.31	3.66	0.000069	0.000099	92 876.71	6 342.97	0.5926	0.1927

Year	1.A.3.c RAILWAYS				1.A.3.d DOMESTIC NAVIGATION			
	FUEL (TJ)	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)	FUEL (TJ)	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)
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	4.41	0.33	0.0000309	0.0000088
2011	1 121.86	78.90	0.0047	0.0321	11.20	0.83	0.0000784	0.0000224
2012	949.73	66.97	0.0039	0.0272	14.87	1.10	0.0001041	0.0000297
2013	1 164.27	81.62	0.0048	0.0333	45.93	3.40	0.0003215	0.0000919
2014	1 106.37	76.66	0.0046	0.0316	59.00	4.37	0.0004130	0.0001180
2015	1 220.28	84.33	0.0051	0.0349	83.87	6.22	0.0005871	0.0001677

Year	1.A.3.e.i PIPELINE TRANSPORT			
	FUEL (TJ)	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)
1990	31 844.87	1 813.95	0.0318	0.0032
1995	20 644.81	1 154.10	0.0206	0.0021
2000	25 523.75	1 404.81	0.0255	0.0026
2005	24 168.60	1 327.92	0.0242	0.0024
2010	1 4961.55	824.47	0.0150	0.0015
2011	16 506.95	909.78	0.0165	0.0017
2012	7 328.28	404.80	0.0073	0.0007
2013	8 669.94	481.84	0.0087	0.0009
2014	3 190.47	177.78	0.0032	0.0003
2015	3 309.18	184.40	0.0033	0.0003

Domestic Aviation (CRF 1.A.3.a) - The inventory evaluation of GHG emissions in the category domestic aviation was performed for all GHGs, precursors as well as 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 method as it is not a key category for Slovak Republic) for the years 1990 – 2004. The estimation of GHG emissions was based on the fuel sold at the important Slovak airports (Bratislava, Kosice, Poprad, Sliac, Piestany and Zilina). The airports are managed by the Slovak Management of Airports, except for the airport in Zilina, where exercises with light aircrafts of the Zilina University predominate. Other smaller civil airports (Nitra, Prievidza, Ružomberok, 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 – 2015 was used EUROCONTROL data on the number of flights, fuel consumption and share of domestic and international flights.

The fuel consumption decreased compared to the base year 1990 by 2%. The total consumption of jet kerosene was 48.20 TJ and the consumption of aviation gasoline was 2.11 TJ allocated in domestic aviation in 2015. Total GHG emissions from domestic aviation represented 3.69 Gg of CO_2 eq. in 2015. There was a visible increase of emissions in years 2002 – 2008 (***Table 3.26***). Since 2002, air transport in the Slovak Republic has been positively affected by the entry of low cost companies to the market, like SkyEurope Airlines, Seagle Air and Danube Wings to the Slovak market. The important objectives which influence this category are, 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 3.26: *The quantity of fuels and GHG emissions for national flights in particular years*

YEAR	AVIATION GASOLINE				JET KEROSENE			
	CONSUMPTION	EMISSIONS (t)			CONSUMPTION	EMISSIONS (t)		
	(TJ)	CO_2	CH_4	N_2O	(TJ)	CO_2	CH_4	N_2O
1990	3.35	236.985	0.002	0.007	48.13	3 501.22	0.068	0.095
1995	2.22	156.820	0.001	0.004	34.36	2 499.39	0.049	0.068
2000	2.56	180.670	0.002	0.005	33.94	2 469.37	0.048	0.067
2005	0.95	67.234	0.001	0.002	106.19	7 725.42	0.158	0.210
2010	1.85	130.636	0.001	0.004	68.75	5 001.21	0.094	0.136
2011	1.86	131.191	0.001	0.004	56.57	4 115.68	0.075	0.112
2012	2.44	172.269	0.001	0.005	51.52	3 747.87	0.070	0.102
2013	1.66	117.414	0.001	0.003	45.05	3 277.65	0.061	0.089
2014	1.38	97.365	0.001	0.003	45.91	3 340.00	0.065	0.091
2015	2.11	149.268	0.001	0.004	48.20	3 506.73	0.068	0.095

Road Transportation (CRF 1.A.3.b) - Short distance passenger transport is an important part of road transport. It is the most exploited type of transport in the Slovak Republic due to a high density of roads, the quality of road network and interconnection of all municipalities. In recent 12 years, road transport has expanded significantly in the transport of goods and persons. In 2015, the transport network included 463 km of highways, 264 km of motorways and 3 302 km of the category 1^{st} class roads. Total roads network represented 18 019 km of roads in the Slovak Republic in 2015. Road transportation is the most important and key category within transport with the highest share of emissions and continually increasing trend in fuel consumption. Total aggregated emissions from road transportation reached 6 415.20 Gg of CO_2 eq. in 2015. The increase in emissions compared to 2014 is 3.12%, and compared to the base year, the increase is 39.81%. The major share belongs to heavy duty vehicles and passenger cars (***Table 3.27***). Total blended CO_2 emissions were 6 804.18 Gg in 2015. After separation of biomass content, the final CO_2 balance was 6 342.97 Gg. The biomass content is increasing and actually represents 461.21 Gg of bio-CO_2. The most of the emissions come from the city traffic (***Table 3.28***).

Table 3.27: *Overview of total GHG emissions according to the type of vehicles without separation of fossil and biomass contents in fuels in 2015*

CATEGORY OF ROAD VEHICLES	EMISSIONS (t)			CATEGORY OF ROAD VEHICLES	EMISSIONS (t)		
	CO_2	CH_4	N_2O		CO_2	CH_4	N_2O
Passenger cars	**3 374 609**	**296.57**	**102.44**	diesel >32 t	71 944	4.26	1.70
gasoline <1.4 l	815 819	148.58	22.31	diesel 14-20 t	220 343	18.68	6.88
gasoline 1.4 l–2.0 l	448 041	70.03	10.70	diesel 20-28 t	188 047	11.02	4.64
gasoline >2.0 l	220 389	26.95	4.02	diesel 28-34 t	99 225	6.27	3.36
diesel <2.0 l	1 374 418	27.26	50.45	diesel 34-40 t	129 522	3.61	3.74

CATEGORY OF ROAD VEHICLES	EMISSIONS (t)			CATEGORY OF ROAD VEHICLES	EMISSIONS (t)		
	CO_2	CH_4	N_2O		CO_2	CH_4	N_2O
diesel >2.0 l	413 215	6.31	11.42	**Buses**	**360 706**	**98.42**	**3.50**
LPG	102 728	17.45	3.54	City buses CNG	26 155	73.55	0.01
CNG, E85, Hybrid	0.00	0.00	0.00	City buses Midi <=15t	19 727	1.80	0.24
Two stroke engine	0.00	0.00	0.00	City buses Stand. 15-18t	107 035	7.48	0.96
Light duty vehicles	**637 990**	**20.56**	**20.05**	City buses >18t	60 487	3.36	0.44
gasoline <3.5 t	148 534	14.60	8.03	Long-line buses	147 303	12.23	1.86
diesel <3.5 t	489 456	5.96	12.02	**Motorcycles**	**10 830**	**9.03**	**0.23**
Heavy duty vehicles	**2 420 047**	**167.99**	**66.43**	<50 cm3 (mopeds)	1 823	0.85	0.03
diesel <=7.5 t	577 146	45.09	21.59	Two stroke engine >50 cm3	4 646	4.55	0.11
diesel 7.5-12 t	119 298	5.91	2.28	Four stroke engine <250 cm3	990	1.29	0.03
diesel 12- 4 t	69 238	3.14	1.92	Four stroke engine 250-750 cm3	1 335	1.35	0.03
diesel 14-20 t	308 364	26.36	7.08	Four stroke engine >750 cm3	2 035	0.99	0.03
diesel 20-26 t	321 254	24.95	6.08	**Total road transport**	**6 804 184**	**592.58**	**192.66**
diesel 26-28 t	99 259	6.26	2.01	**Total fossil emissions**	**6 342 970**	**592.58**	**192.66**
diesel 28-32 t	216 405	12.45	5.14				

Table 3.28: *Results from COPERT in distribution for agglomeration mode (CO_2 emissions are from blended fuels with bio-component) in 2015*

TRAFFIC	EMISSIONS (t)		
	CO_2	CH_4	N_2O
City	2 820 281.4	396.9	84.7
Road	2 975 969.7	169.8	86.1
Highway	1 007 932.6	25.9	21.9
Total SR	**6 804 183.6**	**592.6**	**192.7**

Railways (CRF 1.A.3.c) - Railways is the second most important source of emissions in transport (except of pipeline transport), despite the decreasing character of this transport mode. Railways and rail transport are modernised 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 2015, the length of managed railways was 3 626 km of which the length of electric railways was 1 587 km. Total emissions from railways transport reached 94.86 Gg of CO_2 eq. in 2015 and they increased by 10.03% compared to 2014 (***Table 3.29***) and decreased several times compared to the base year. The decrease of fuels consumption was caused by the improvements of technical parameters (new locomotives and wagons and electrification of railways).

Table 3.29: *Overview of GHG emissions in railways of fossil fuels in particular years*

YEAR	FUEL CONSUMPTION	EMISSIONS (Gg)		
	TJ	CO_2	CH_4	N_2O
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	1 110.930	82.319	0.005	0.032
2011	1064.819	78.903	0.005	0.032
2012	903.712	66.965	0.004	0.027

[6] Annual Report of Slovak Railway 2015, p.11, http://www.zsr.sk/buxus/docs/vyrSpravy/VyrocnaSprava2015.pdf

YEAR	FUEL CONSUMPTION	EMISSIONS (Gg)		
	TJ	CO_2	CH_4	N_2O
2013	1 101.423	81.615	0.005	0.033
2014	1034.574	76.661	0.005	0.031
2015	1138.080	84.331	0.005	0.034

Domestic Navigation (CRF 1.A.3.d) - The major share of emissions from inland shipping in Slovakia are realized as transit on Danube River. Therefore, emissions from this transport are included in the subcategory 1.D.1.b Memo Items/ International Bunkers/ International Navigations (chapter 3.6.2). Based on the information from the State Navigation Administration (the SNA), there are movements realized between the Gabcikovo and Komarno ports on the Slovak territory (national transport). Due to the international character of shipping transportation on the Danube River, the 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 national movements between the ports on Slovak Territory is included in the national emissions. Detailed information was based on statistics made by the SNA and the company Slovak Shipping and Ports. The share of "national fuel consumption" is available since 2005 and therefore emissions were recalculated since this year. The experts from the Slovak Shipping and Ports Company confirmed that before 2005, negligible number of movements was between the Slovak ports registered. Inland shipping transportation on small lakes for tourist purposes was also estimated and added to the total emissions in this category.

Total aggregated emissions from inland shipping excluding international navigations (on Danube River) reached 6.28 Gg of CO_2 eq. in 2015. The increasing trend was recognized compared to the previous years and compared to the base year (***Table. 3.30***) due to increase of touristic activities in Slovakia.

Table 3.30: *Overview of GHG emissions in national navigation in 1990 – 2015*

YEAR	TOTAL CONSUMPTION	EMISSIONS (Gg)		
	TJ	CO_2	CH_4	N_2O
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	4.411	0.327	0.000031	0.000009
2011	11.198	0.830	0.000078	0.000022
2012	14.871	1.102	0.000104	0.000030
2013	45.934	3.404	0.000322	0.000092
2014	58.997	4.372	0.000413	0.000118
2015	83.874	6.215	0.000587	0.000168

Pipeline Transport (CRF 1.A.3.e.i) - The total volume of fuels in this subcategory expressed in energy units represented 3 309.18 TJ and total GHG emissions represented 184.58 Gg of CO_2 eq. in 2015. The share of this category on total transport emissions is 2.75% in 2015. There is a significant decrease of fuel consumption in recent years and this trend is related to decrease of natural gas transit through the Slovak Republic. The fuel consumption and emissions are shown in the ***Table 3.4***.

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 methodology for emission estimation in domestic aviation, both for aviation gasoline and jet kerosene was used for time series 1990 – 2004. Tier 1 methodology 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 revised (in line with the UNFCCC recommendations E.11 and E.21 from the SVK ARR 2016). The share for national and international aviation activities for the period 1990 – 2004 was improved based on the real number used for time series 2005 – 2015. The share is constant value. Real share of national and international activities for the period 2005 – 2015 was taken from the EUROCONTROL database directly. More data and revision is provided in the ***Table 3.31***.

Table 3.31: *The share of fuel consumption in domestic aviation and international bunkers for the period 1990 – 2015*

FUELS	DOMESTIC AVIATION		INTERNATIONAL BUNKER	
	PREVIOUS SUBMISSIONS	CURRENT SUBMISSION	PREVIOUS SUBMISSIONS	CURRENT SUBMISSION
PERIOD 1990 - 2015				
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 were calculated as average from available the EUROCONTROL data for 2005 – 2015. These average emission factors for all gases were used for the years 1990 – 2004 in current submissions in domestic aviation and international bunkers and time series were recalculated.

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 (***Table 3.32***).

From the year 2005 onwards, Slovakia decided to use the EUROCONTROL data. The decision was made 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 methodology applying the Advanced Emissions Model (AEM). Following data were taken from the EUROCONTROL data published in 2016 into national inventory (***Table 3.32***):

- 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 3.32: *Average emission factors for the GHG emissions in civil aviation according to tier 1 method based on fuel consumption*

PARAMETER	EMISSIONS FACTORS (kg/TJ of fuel)	
	INTERNATIONAL FLIGHTS	NATIONAL FLIGHTS
Emissions	Jet kerosene	
CO_2	72 748	72 748
CH_4	0.692	1.145
N_2O	1.977	1.977
Emissions	Aviation gasoline	
CO_2	7 700	7 700
CH_4	0.474	0.651

PARAMETER	EMISSIONS FACTORS (kg/TJ of fuel)	
	INTERNATIONAL FLIGHTS	NATIONAL FLIGHTS
N_2O	1.984	1.984
NCV		
Aviation Gasoline	TJ/Gg	43.14
Jet Kerosene	TJ/Gg	43.30

Road Transportation (1.A.3.b) - COPERT IV model (version 9.0) was used for estimation of emissions in road transportation for the years 1990 – 2009 and for the years 2010 – 2015 COPERT V model was used. The version V of the model distinguishes vehicle categories and emission factors reflecting the recent development and research. Due to capacity reasons and lack of input data, the years 1990 – 2009 were not recalculated yet. This is planned for the next submission and it is also included in the Improvement Plan for the year 2017.

The methodology is often referred to the name of program (methodology "COPERT"). The fuel based approach is used for the calculation of CO_2 emissions. This approach is based on the fuel consumption and others variables such as H/C ratio and carbon content. According to the UNFCCC recommendation E.27 (SVK ARR 2016), the country specific H/C ratio and NCVs were used in this calculation. The H/C ratio of the fuels were provided by Slovnaft refinery (***Table 3.33***). The NCVs of the fuels and bio-components were obtained from the Statistical Office of the Slovak Republic and are shown in the ***Table 3.34*** for the years 1990 – 2015.[7]

Table 3.33: *H/C ratio for the fuel type provided by Slovnaft refinery in 2015*

FUEL	GASOLINE	DIESEL OIL	LPG	CNG	BIOETHANOL	ETBE	ESTERS
H/C Ratio	1.852	1.946	2.589	NA	3.000	NA	1.857

Table 3.34: *Net calorific values (NCVs) for the fuel type obtained by the SU SR for particular years*

Year	Gasoline blended	Diesel Oil Blended	LPG	CNG	Bioethanol	ETBE	Esters
	TJ/Gg	TJ/Gg	TJ/Gg	TJ/Gg	TJ/Gg	TJ/Gg	TJ/Gg
1990	43.206	42.511	NA	NA	NA	NA	NA
1995	43.388	42.076	46.000	NA	NA	NA	NA
2000	43.316	42.588	46.000	48.814	NA	NA	NA
2005	43.800	42.208	46.000	48.767	NA	NA	NA
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

Statistically recorded fuel consumption and fuel consumption calculated through COPERT methodology shall be equal or the difference shall not be more than 2%. The COPERT V defined new vehicle´ categories for the calculation of CH_4 and N_2O emissions, with the disaggregation into 6 base categories and 275 subcategories. Further disaggregation was applied according to the operation of road vehicles in the agglomeration, road and highway traffic mode. In COPERT V, buses were divided into 8 sub-districts and 2 subgroups (urban and coaches). Heavy duty vehicles are divided into 2 basic groups (rigid and articulated). Rigid vehicles are further divided by weight into 8 subgroups and articulated into 6 subgroups. COPERT IV and COPERT V model versions have almost the same methodology, which

[7] This approach is used as a result of recommendation from ESD reviews 2016 and 2017. The country-specific EF(CO_2) is calculated from the H/C ratio in the COPERT model as it was recommended.

is described below. This methodology used technical parameters of different vehicle types and country characteristics, such as the composition of car fleet, the age of the cars, the parameters of operation and fuels or climate conditions.

The estimation is provided for the main 5 groups of input data:

- Total fuel consumption;
- Composition of vehicles fleet;
- Driving mode;
- Driving speed;
- Emission factors.

Based on these input parameters the emissions can be estimated. Information about the vehicle fleet is based on database operated by the Police Presidium of the Slovak Republic. The SHMU has access to the database and can download the necessary information directly from the IS EVO (Information System for Vehicle Evidence) website http://www.minv.sk/?statisticke-prehlady-agendy-vozidiel.

The EFs values for CH_4 and N_2O in COPERT V model are defined separately for the different types of fuels, types of vehicles and the different technological level of vehicles. 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 V model (***Table 3.35***). Particularly kilometres (km) travelled are not available in Slovakia and therefore these AD are estimated according to the recommendations provided within the framework of the COPERT V model, including consistency with fuel consumption. Main source of activity data such as intensity on urban, rural and highways is the Traffic Census of Slovakia, conducted every five years (2000, 2005, 2010 and 2015[8]).

Table 3.35: *Overview of input data used in COPERT V model in 2015*

CATEGORY OF ROAD VEHICLES	ACTIVITY DATA		
	Number of vehicles	**Average of fuel consumption (l/100 km)**	**Average mileage (km/veh)**
Passenger cars	**2 034 381**	**7.28**	**8 328.94**
gasoline < 1.4 l	742 699	7.21	6 049.49
gasoline 1.4-2.0 l	337 003	8.36	5 695.16
gasoline > 2.0 l	73 416	10.13	10 469.52
diesel < 2.0 l	686 049	6.19	10 497.52
diesel > 2.0 l	151 135	7.98	12 908.28
LPG	43 989	10.00	13 882.42
CNG, E85, Hybrid	0	10.90	3 650.00
two stroke engine	90	10.79	0.00
Light duty vehicles	**185 781**	**21.13**	**13 615.18**
gasoline < 3.5 t	46 228	9.36	12 526.84
diesel < 3.5 t	139 553	25.03	13 975.70
Heavy duty vehicles	**150 313**	**23.39**	**30 870.32**
diesel <= 7.5 t	66 211	19.05	26 884.14
diesel 7.5-12 t	9 516	20.54	26 100.06

[8] Data were published in 2016 but not used in the 2017 submission, http://www.ssc.sk/sk/cinnosti/rozvoj-cestnej-siete/dopravne-inzinierstvo.ssc

CATEGORY OF ROAD VEHICLES	ACTIVITY DATA		
	Number of vehicles	Average of fuel consumption (l/100 km)	Average mileage (km/veh)
diesel 12-14 t	5 008	23.72	26 949.48
diesel 14-20 t	17 061	26.28	30 347.16
diesel 20-26 t	11 293	27.90	39 560.45
diesel 26-28 t	3 764	32.02	37 708.53
diesel 28-32 t	5 646	30.65	46 951.88
diesel > 32 t	1 882	21.80	46 290.59
diesel 14-20 t	15 564	26.71	26 296.08
diesel 20-28 t	7 483	27.65	39 037.38
diesel 28-34 t	3 592	30.82	39 260.75
diesel 34-40 t	3 293	32.93	53 381.68
Buses	**8 865**	**21.73**	**46 657.00**
City buses CNG	243	21.95	79 698.45
City buses Midi <=15 t	862	29.40	36 892.20
City buses Stand. 15-18 t	3 017	37.83	44 831.73
City buses >18 t	1 294	26.46	44 571.22
Long Line buses	3 449	3.93	49 148.75
Motorcycles	**87 201**	**4.57**	**1 461.99**
< 50 cm^3 (mopeds)	27 756	3.74	974.61
Two stroke engine > 50 cm^3	43 194	3.63	1 294.34
Four stroke engine < 250 cm^3	6 219	4.21	2 301.34
Four stroke engine 250-750 cm^3	4 798	5.49	2 924.35
Four stroke engine > 750 cm^3	5 234	16.27	3 092.19
Total road transportation	**2 466 540**		**9 995.78**

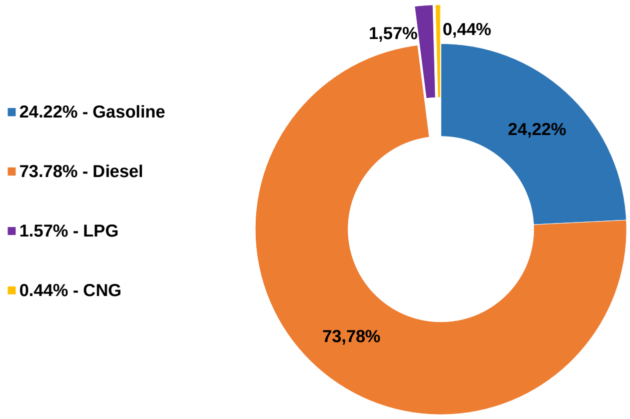
Regarding non-CO_2 emissions, the values used for setting and calculating the emission factors and the corresponding emissions in the COPERT model were verified and discussed in the previous years. The results of a comparative assessment for CH_4 and N_2O emissions showed that the emission estimates made in Slovakia is comparable with other European countries and therefore the use of emission factors in the COPERT model are fully in agreement with the national circumstances. Also the IEF used in COPERT model are regularly updated and verified (as outcomes of experimental studies).

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 neither be used 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 passenger cars for CNG. Hence, their emissions performance may vary significantly. Therefore, CNG buses also need to fulfil a specific emissions standard (Euro II, Euro III, etc.). Due to the low NOx 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 emission 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.

Important information about the import, production, distribution and sale of gasoline and diesel oil were received from domestic producer Slovnaft Ltd. Bratislava refinery, from the Customs Directory of the Slovak Republic and the Statistical Office of the Slovak Republic. The bottom-up data from the distribution stations in the Slovak Republic are known also from the NEIS database. Data about LPG and CNG distribution and sale were obtained from exclusive dealers and the Slovak Gas Industry, Ltd. All documents are in Slovak language and they are official and available for the national inventory experts. According to the statistical information, the diesel oil represents 73.8% share on fuel balance, followed by gasoline with 24.2% share, then LPG (1.6%) and CNG (0.4%) (***Figure 3.19***).

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). The information about fuels quality is provided by the Ministry of Economy of the Slovak Republic 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 3.36***). Because ETBE bio-component is only in 47% (bio) by volume and activity data are available only in mass units, bio-ETBE was considered also 47% by weight in calculation of total bio-components in fuel. Since the COPERT model do not estimate emissions from bio-components yet, they were calculated additionally as a share of emissions from blended fuels. The percentage of emissions from biomass in fuels is the same as the percentage of biomass in fuels, including the bio-component of ETBE.

Figure 3.19: *Fuels balance in road transportation in 2015*



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. The report is prepared by the Ministry of Economy of the Slovak Republic with the cooperation of the Customs Administration Offices and the Ministry of Environment of the Slovak Republic.

Table 3.36: *Estimated activity data and share of biomass for the time series 2007 – 2015*

GASOLINE	**2007**	**2008**	**2009**	**2010**	**2011**
Biomass share % (energy)	2.25%	1.22%	2.51%	2.89%	2.90%
Biomass (TJ)	652.261	358.172	706.723	779.130	715.872
DIESEL OIL	**2007**	**2008**	**2009**	**2010**	**2011**
Biomass share % (energy)	3.50%	4.06%	4.35%	4.46%	5.08%
Biomass (TJ)	2 025.029	2 437.576	2 383.580	2 798.753	3 025.806
GASOLINE	**2012**	**2013**	**2014**	**2015**	
Biomass share % (energy)	2.93	2.91	3.15	4.64	
Biomass (TJ)	716.583	711.351	727.558	1 007.164	
DIESEL OIL	**2012**	**2013**	**2014**	**2015**	
Biomass share % (energy)	5.12	4.88	5.32	6.30	
Biomass (TJ)	3 176.525	3 121.695	3 311.932	4 122.693	

The CO_2 emissions from urea based catalysts were estimated using COPERT V model for categories “heavy duty trucks Euro V 2008 Standards” and “passenger cars diesel PC Euro VI up to 2016”. These vehicles occurred in Slovakia since 2010 and therefore, time series 2010 – 2015 was reported in this submission. As the number of vehicles with 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 is allocated in the IPPU sector 2.D.3 (chapter 4.5). This is according to the UNFCCC recommendation E.29 (SVK ARR 2016).

Railways (1.A.3.c) – GHG emissions from railways were calculated from the consumption of diesel oil by operation of diesel traction and using the simple tier 1 methodology according to the IPCC 2006 GL. According to the key category analysis, this source is not key category in 2015 inventory. IPCC default emission factors were used. According to the UNFCCC recommendation E.28 (SVK ARR 2016), the country specific NCVs were used in calculations for all-time series and therefore the fuel consumptions (and subsequently also GHG emissions) were recalculated from 1990 onwards. The NCVs for diesel oil blended and esters are shown in ***Table 3.34*** in road transportation part.

According to the UNFCCC recommendation E.28 the emission factors were taken from the IPCC 2006 GL and used in this inventory submission (***Table 3.37***). GHG emissions were recalculated for the all-time series (***Table 3.51***).

Table 3.37: *The emission factors used in GHG inventory for railways transport*

IPCC DEFAULT EMISSION FACTORS		
CO_2	CH_4	N_2O
kg/TJ		
74 100.00	4.15	28.60

The consumption of diesel oil for the motor traction in the Slovak Republic was obtained from the Railways Company, Ltd. (ZSSK) for the all years in time series. 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 4 depots in the organizational structure of ZSSK since 2002 (Bratislava, Zvolen, Zilina and Kosice). ***Table 3.38*** shows activity data and statistical information used for inventory preparation. Fuel consumption of the new company operated on the Slovak rails (REGIOJET) is also included in the inventory.

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

Table 3.38: *Overview of activity data used in GHG inventory for railways transport in 2015*

DEPOTS	KOSICE	ZILINA	ZVOLEN	BRATI-SLAVA	TOTAL PUBLIC	TOTAL CARGO	REGIO JET
Number of loco	168	92	144	105	280	242	13
km per year (x1 000)	5 202.1	2 846.8	7 310.8	3 224.9	15 202.5	4 775.4	1 393.3
Operations (hrkm)x1 000	611 191	278 838	1 377 711	368 596	1 566 596	1 193 352	123 612
Consumption (m^3) (blended)	10 886.7	4 067.5	12 850.3	5 480.2	22 155.7	12 496.8	1 367.7
Consumption (t) (blended)	9 097	3 399	10 738	4 579	18 513	10 442	1 143

Domestic Navigation (1.A.3.d) - This subcategory includes emissions from national shipping between ports on Danube River on Slovak territory and domestic shipping on lakes and dams for touristic purposes.

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. It was assumed that total fuel sold to international companies is reported in the memo items subcategory (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, Devin and Komarno). 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. The NIS expert was informed that they register total number of ships and boats operated except the Danube River, but without information about their activity or fuel consumption. Based on expert research, three other relevant shipping routes, except the shipping routes on Danube river, occur in Slovakia, however in limited extent. The three shipping routes are:

- River – basin of the Vah (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:

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):

The duration can differ according to the type of trips (mostly short or long tours).

- The technical parameters of the most populated ships:

The 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 on diesel oil.

- The average consumption of diesel oil in litres per hour:

The average consumption based on technical description of the engines 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 (0.84 kg/dm^3).

The GHG emissions are calculated from the consumed fuel by diesel motor boats multiplied by emission factor. The country specific NCVs, obtained from the SU SR, were used to convert the quantity of fuel consumption in energy units. The NCV for diesel fuel is shown in the ***Table 3.34*** in road transportation part. The emission factors are taken from the IPCC 2006 GL and GHG emissions were recalculated for all-time series. The default emission factors used in category 1.A.3.d and 1.D.1.b are identical (***Table 3.39***). Activity data for domestic navigation are shown in ***Tables 3.40*** **-** ***3.42***.

Table 3.39: *The default emission factors for GHG in navigation*

PARAMETER	EMISSIONS FACTORS (kg/TJ of fuel)	
EMISSIONS	DOMESTIC NAVIGATION	INTERNATIONAL NAVIGATION
CO_2	74 100	74 100
CH_4	7	7
N_2O	2	2

Table 3.40: *Total consumption of fuel in domestic navigation in particular years*

YEAR	FUEL CONSUMPTION	
	(TJ)	(t)
1990	0.30	7.14
1995	0.27	6.51
2000	0.33	7.70
2005	0.47	11.08
2010	4.41	104.49
2011	11.20	265.31
2012	14.87	352.35
2013	45.93	1 092.89
2014	59.00	1 403.26
2015	83.87	1 990.22

Table 3.41: *The amount of diesel oil sold by shipping companies and allocation to the categories 1.A.3.d and 1.D.1.b in 2005 – 2015*

YEAR	SHIPPING COMPANIES	SALE OF DIESEL OIL (t)		
		NATIONAL	INTERNATIONAL	TOTAL
		1.A.3.d	1.D.1.b	1.A.3.d + 1.D.1.b
2005	Slovak Shipping and Ports (Danube)	1.30	128.70	130.00
	International shipping companies	0.00	84.00	84.00
	Total	**1.30**	**212.70**	**214.00**
2006	Slovak Shipping and Ports (Danube)	90.87	8 996.13	9 087.00
	International shipping companies	0.00	482.00	482.00
	Total	**90.87**	**9 478.13**	**9 569.00**
2007	Slovak Shipping and Ports (Danube)	94.84	9 389.16	9 484.00
	International shipping companies	0.00	747.00	747.00
	Total	**94.84**	**10 136.16**	**10 231.00**
2008	Slovak Shipping and Ports (Danube)	99.38	9 838.62	9 938.00
	International shipping companies	0.00	985.00	985.00
	Total	**99.38**	**10 823.62**	**10 923.00**
2009	Slovak Shipping and Ports (Danube)	90.73	8 982.27	9 073.00
	International shipping companies	0.00	935.00	935.00
	Total	**90.73**	**9 917.27**	**10 008.00**
2010	Slovak Shipping and Ports (Danube)	91.79	9 087.21	9 179.00
	International shipping companies	0.00	1 363.00	1 363.00
	Total	**91.79**	**10 450.21**	**10 542.00**
2011	Slovak Shipping and Ports (Danube)	79.75	7 895.25	7 975.00
	Slovak Water Management Enterprise	175.00	0.00	175.00
	Other Companies	1.03	101.97	103.00
	International shipping companies	0.00	1 104.00	1 104.00
	Total	**255.78**	**9 101.22**	**9 357.00**
2012	Slovak Shipping and Ports (Danube)	21.01	2 079.99	2 101.00
	Slovak Water Management Enterprise	321.00	0.00	321.00
	Other companies	0.70	69.30	70.00
	International shipping companies	0.00	764.00	764.00
	Total	**342.71**	**2 913.29**	**3 256.00**
2013	Slovak Shipping and Ports (Danube)	1 083.10	3 249.30	4 332.40
	Slovak Water Management Enterprise	0.00	0.00	0.00

YEAR	SHIPPING COMPANIES	SALE OF DIESEL OIL (t)		
		NATIONAL	INTERNATIONAL	TOTAL
		1.A.3.d	1.D.1.b	1.A.3.d + 1.D.1.b
	Other companies	0.00	0.00	0.00
	International shipping companies	0.00	801.00	801.00
	Total	**1 083.10**	**4 050.30**	**5 133.40**
2014	Slovak Shipping and Ports (Danube)	1 244.00	3 732.00	4 976.00
	Slovak Water Management Enterprise	149.00	0.00	149.00
	Other companies	0.00	0.00	0.00
	International shipping companies	0.00	844.00	844.00
	Total	**1 393.00**	**4 576.00**	**5 969.00**
2015	Slovak Shipping and Ports (Danube)	1 981.79	5 945.38	7 927.17
	Slovak Water Management Enterprise	0.00	0.00	0.00
	Other companies	0.48	47.52	48.00
	International shipping companies	0.00	1 016.00	1 016.00
	Total	**1 982.27**	**7 008.90**	**8 991.17**

Table 3.42: *The emission estimation in national shipping for touristic purposes (CRF 1.A.3.d) in 2015*

2015	LOCATION							TOTAL SR
ACTIVITY DATA	PIESTANY LONG TRIP	PIESTANY SHORT TRIP	TRENCIN	LIPTOV-SKA MARA	ORAVSKA PRIE-HRADA SHORT TRIP	ORAVSKA PRIE-HRADA LONG TRIP	ZEMPLIN-SKA SIRAVA	
Number of Trips (per year)	237	0	36	120	353	90	150	**985**
Duration of Trip (hours)	1	0	0.35	1	0.5	1.5	0.75	
Total Duration (hours/year)	237	0	13	120	176	135	113	**793**
Fuel Consumption (l/hour)	12	0	12	12	12	12	12	
Total Consumption (l/year)	2 840	0	151	1 440	2 115	1 620	1 350	**9 516**
Total Consumption (kg/year)	2 373	0	126	1 203	1 767	1 354	1 128	**7 952**
Total Consumption (TJ/year)	0.100	0.000	0.005	0.051	0.074	0.057	0.048	**0.335**

Pipeline Transport (1.A.3.e.i) - The activity data on consumption of natural gas used for energy to drive turbines were obtained from the NEIS database. Tier 2 methodology and the country specific emission factor was used for CO_2 emissions estimation in pipeline transport category. The emission factor for combustion of natural gas is 55.72 t (CO_2)/TJ in 2015.

3.2.8.2 Uncertainties and time-series consistency

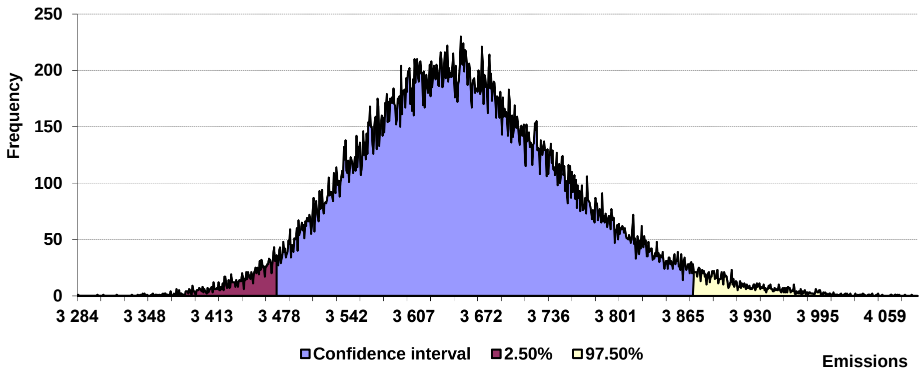
Domestic Aviation (1.A.3.a) - Trend in aviation transport for the years after 2008 is decreasing. The period 2004 – 2008 was influenced by the boom of low-cost airlines and advantage of Bratislava airport with the lower charges in comparison with the big international airports in the neighbouring countries. 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, Kosice and Poprad are the busiest airports. Other airports have only local character for domestic and sport flights.

The average mean value of GHG emissions for the 1.A.3.a obtained by the Monte Carlo simulation is 3.66 Gg per year 2015. The average mean value is comparable with the real result of the CO_2 emissions, which is 3.69 Gg. Confidence interval (95%) is within the range: <3.28; 4.09>, which represents the uncertainty by relative values to the mean value: -4.97%; +6.00%. The following table and figure described calculated results of uncertainty analyses.

Table 3.43: *Selected statistical characteristics for 1.A.3.a, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (Gg of CO_2)*

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
3.65	**3.66**	0.10	3.28	4.09	-4.97%	6.00%

Figure 3.20: *Probability density function for 1.A.3.a (t of CO_2)*



Road Transportation (1.A.3.b) - 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 and fuel consumption. Until 2008, trend of gasoline consumption has fluctuated and after 2008, the trend is decreasing due to the improvement in fuel consumption and implementation of renewable directive. The trend of diesel consumption was increasing since 1990, but it is more stable in the recent years. This was caused by the variation of fuel price for transit transport, 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.

The elimination of negative influences of road transportation continues with the increase of LPG and CNG vehicles (mostly buses and light duty vehicles). 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 COPERT V 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 yearly overrun kilometres;
- The average speed in the traffic mode;

- The average temperatures;
- The beta-factor.

COPERT V 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.

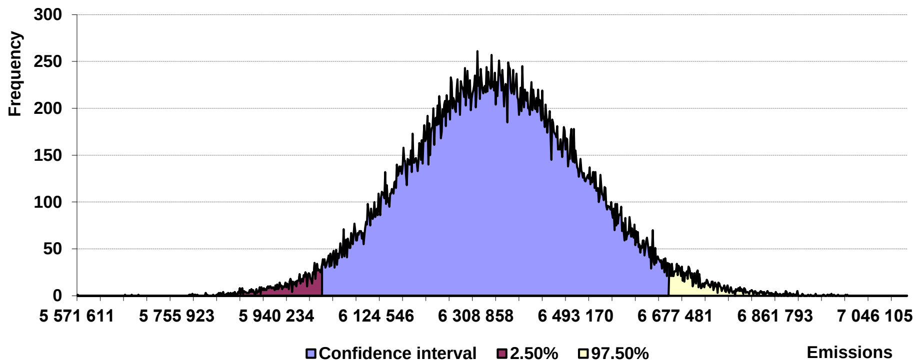
The consistency of time series was improved by the use of the most updated version of COPERT V model for the whole time series.

The average mean value of GHG emissions for the 1.A.3.b obtained by the Monte Carlo simulation is 6 344 Gg per year 2015. The average mean value is comparable with the real result of the CO_2 emissions, which is 6 342 Gg. Confidence interval (95%) is within the range: <5 571; 7 108>, which represents the uncertainty by relative values to the mean value: -4.89%; +5.06%. The following table and figure described calculated results of uncertainty analyses.

Table 3.44: *Selected statistical characteristics for 1.A.3.b, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (Gg of CO_2)*

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
6 342.314	**6 344.215**	161.323	5 571.610	7 107.542	-4.89%	5.06%

Figure 3.21: *Probability density function for 1.A.3.b (t of CO_2)*



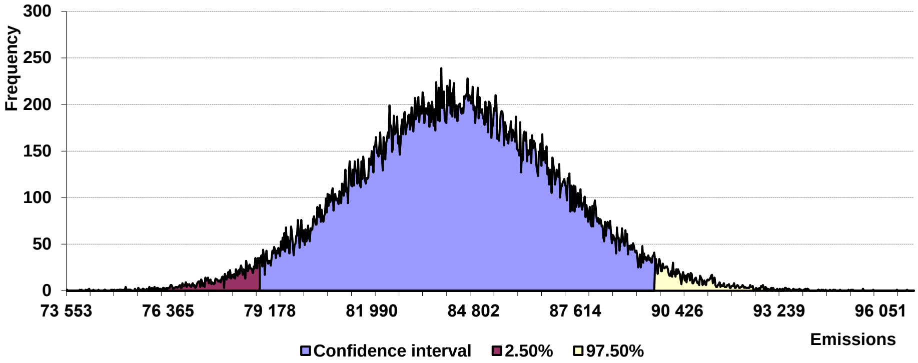
Railways (1.A.3.c) - Methodology, activity data and used emission factors for diesel oil are consistent for the whole time series. The blending of biomass in liquid fuels used in railways transport was considered since 2007.

The average mean value of GHG emissions for the 1.A.3.c obtained by the Monte Carlo simulation is 84.32 Gg per year 2015. The average mean value is comparable with the real result of the CO_2 emissions, which is 83.89 Gg. Confidence interval (95%) is within the range: <73.55; 96.99>, which represents the uncertainty by relative values to the mean value: -6.43%; +6.50%. The following table and figure described calculated results of uncertainty analyses.

__Table 3.45:__ Selected statistical characteristics for 1.A.3.c, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (Gg of CO_2)

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
84.30	**84.32**	2.79	73.55	96.99	-6.43%	6.50%

__Figure 3.22:__ Probability density function for 1.A.3.c (t of CO_2)



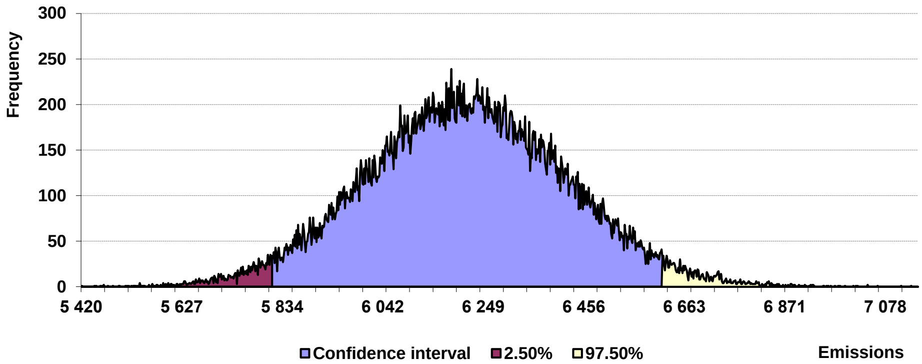
Domestic Navigation (1.A.3.d) - Emissions from domestic navigation represent emissions from shipping on lakes for the period 1990 – 2015 and emissions from shipping on lakes and movements between national ports on Danube River for the years 1990 – 2015. The time series consistency was improved in previous 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 average mean value of GHG emissions for the 1.A.3.d obtained by the Monte Carlo simulation is 6.21 Gg per year 2015. The average mean value is comparable with the real result of the CO_2 emissions, which is 6.21 Gg. Confidence interval (95%) is within the range: <5.42; 7.15>, which represents the uncertainty by relative values to the mean value: -6.43%; +6.50%. The following table and figure described calculated results of uncertainty analyses.

__Table 3.46:__ Selected statistical characteristics for 1.A.3.d, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (Gg of CO_2)

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
6.21	**6.21**	0.21	5.42	7.15	-6.43%	6.50%

__Figure 3.23:__ Probability density function for 1.A.3.d (t of CO_2)



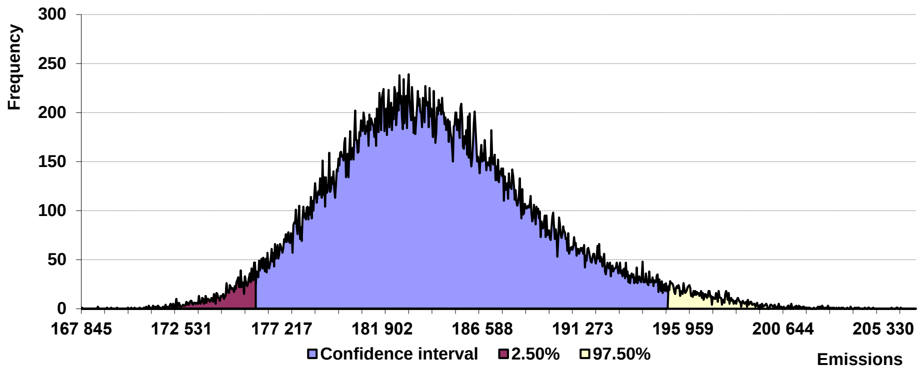
Pipeline Transport (1.A.3.e.i) - Methodology, activity data and used emission factors for natural gas are consistent in the time series and energy-related categories.

The average mean value of GHG emissions for the 1.A.3.e.i obtained by the Monte Carlo simulation is 184.39 Gg per year 2015. The average mean value is comparable with the real result of the CO_2 emissions, which is 184.40 Gg. Confidence interval (95%) is within the range: <167.84; 206.89>, which represents the uncertainty by relative values to the mean value: -4.55%; +5.90%. The following table and figure described calculated results of uncertainty analyses.

Table 3.47: *Selected statistical characteristics for 1.A.3.e.i, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (Gg of CO_2)*

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
183.96	**184.39**	4.83	167.84	206.89	-4.55%	5.90%

Figure 3.24: *Probability density function for 1.A.3.e.i (t of CO_2)*



3.2.8.3 Category-specific QA/QC and verification process

Category specific QA/QC plan is based on the general QA/QC plan described in chapter 1 of this report. The emissions inventory in transport categories were prepared by the sectoral experts with the cooperation of the Transport Research Institute in Zilina. Formal bilateral agreement was set up in 2013 and will continue in the future.

Domestic Aviation (1.A.3.a) - Several bilateral meetings were held between the Ministry of the Environment of the Slovak Republic, the Ministry of Transport and Regional Development of the Slovak Republic and the SHMU to establish more formal frame for sustainable cooperation between ministries and their institutions (SHMU and the Transport Research Institute in Zilina).

Since 2011, the agreement of the European Commission (the 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 reporting data in aviation is provided by the individual EU Member State. The information and data provided in this evaluation are intended to be used for QA/QC activities regarding emissions from 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.

The verification process is also based on cross-checking of input data from the Slovak airports by sectoral experts and the comparison with the sectoral statistical indicators from the Ministry of Transport, Construction and Regional Development of the Slovak Republic. The background documents are archived by the sectoral experts in the central archiving system at the SHMU. The quality manager of the NIS has responsibility for the verification, approval and archiving.

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 sectoral experts. The Transport Research Institute in Zilina is responsible for the data collection from different subjects in transport. Transport sectoral experts are responsible for the verification of these input parameters and for the emissions calculation by the COPERT V model.

The preliminary results of emissions inventory are sent to other subjects (Ministry of the Environment of the Slovak Republic, Transport Research Institute in Zilina, Ministry of Transport, Construction and Regional Development of the Slovak Republic) for valuation and QA activities. The QA verification process includes the exercise of statistical and calculated data on fuel consumption. The statistical data on fuel consumption is provided by the Statistical Office of the Slovak Republic. The calculated data on fuel consumption is direct outcome from the COPERT V model.

The process of verification is based on cross-checking of input data from the Statistical Office of the Slovak Republic and the comparison with the fuel balance from the COPERT. The background documents are archived by sectoral experts and in central archiving system of SNE at SHMU.

Railways (1.A.3.c) - Verification process is based on cross-checking of the input data on fuel consumption from the Railways Company, Ltd. and the Statistical Office of the Slovak Republic. The preliminary results of emissions inventory are sent to other subjects (Ministry of the Environment of the Slovak Republic, Transport Research Institute in Zilina, Ministry of Transport, Construction and Regional Development of the Slovak Republic) 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.

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

Other/Urea Based Catalysts (1.A.3.e.ii allocated in 2.D.3) - The COPERT V model was used for these emissions estimation and information of category specific QA/QC and verification are described in section road transportation.

3.2.8.4 Category-specific recalculations

Recalculations and reallocations made in Energy sector were provided in implemented in the line with the Improvement and Prioritisation Plan reflecting recommendations made during previous reviews.

Table 3.48: *Summary of the recalculations and changes in 1.AA.3*

NUMBER	CATEGORY	DESCRIPTION	REFERENCE
1.	1.A.3.a	Change in the share of fuel consumption between domestic and international aviation, change of methodology and accepting of EUROCONTROL methodology and results.	ARR SVK 2016, E.11 and E.21
2.	1.A.3.b	A new version of COPERT V model was used for 2010 – 2014, change in NCVs, biofuels share and recalculation of fuel consumption were made from 2007 – 2014; use of country specific H/C ratio for CS EF (CO_2) calculation since 2010 was implemented. Recalculation of N_2O in CNG vehicles was performed for the years 2000 – 2014, due to the fact that the IEF was out of range in whole time series.	ARR SVK 2016, E.27
3.	1A.3.c	Change of NCVs from the base year 1990 and the new EFs from the IPCC 2006 GL; recalculations of fuel consumption.	ARR SVK 2016, E.28
4.	1.A.3.d	Change of NCVs from the base year 1990 and the new EFs from the IPCC 2006 GL; recalculations of fuel consumption.	ARR SVK 2016, E.28
5.	1.D.1.a	Change in the share of fuel consumption between domestic and international aviation, change of methodology and accepting of EUROCONTROL methodology and results.	ARR SVK 2016, E.11 and E.21

NUMBER	CATEGORY	DESCRIPTION	REFERENCE
6.	1.D.1.b	Change of NCVs from the base year 1990 and the new EFs from the IPCC 2006 GL; recalculations of fuel consumption.	see chapter 3.6.2

Ad 1: Domestic Aviation (1.A.3.a) - Slovakia decided to use the data from the new EUROCONTROL file “2016” for the years 2005 – 2014 in this submission. Fuel consumption in domestic and international aviation was recalculated by using the NCVs of fuels from the EUROCONTROL for the years 1990 – 2004. GHG emissions were calculated by using updated fuel consumption, updated EFs and new share of aviation gasoline for domestic aviation and international bunkers and new share of jet kerosene for domestic aviation and international bunkers (also based on the EUROCONTROL data). The changes in fuel consumptions affected the emissions of all gases. The results of recalculations and differences between submissions are shown in ***Table 3.49***.

Table 3.49: *The difference between the new (2017) and the old (2016) submissions in 1.A.3.a*

YEAR	EMISSIONS (Gg)								
	CO_2		CH_4		N_2O		CO_2 eq.		%
	2016	2017	2016	2017	2016	2017	2016	2017	Change
1990	7.737	3.738	0.001	0.000	0.001	0.000	8.000	3.770	-53%
1991	7.193	3.476	0.001	0.000	0.001	0.000	7.438	3.505	-53%
1992	6.649	3.213	0.001	0.000	0.001	0.000	6.876	3.241	-53%
1993	6.474	3.135	0.001	0.000	0.001	0.000	6.695	3.162	-53%
1994	5.496	2.654	0.001	0.000	0.001	0.000	5.683	2.677	-53%
1995	5.485	2.656	0.001	0.000	0.001	0.000	5.672	2.679	-53%
1996	6.428	3.120	0.001	0.000	0.001	0.000	6.648	3.147	-53%
1997	5.695	2.764	0.001	0.000	0.001	0.000	5.890	2.788	-53%
1998	5.234	2.543	0.001	0.000	0.001	0.000	5.413	2.565	-53%
1999	5.306	2.574	0.001	0.000	0.001	0.000	5.487	2.596	-53%
2000	5.499	2.650	0.001	0.000	0.001	0.000	5.686	2.673	-53%
2001	5.229	2.511	0.001	0.000	0.001	0.000	5.406	2.532	-53%
2002	5.453	2.615	0.001	0.000	0.001	0.000	5.638	2.637	-53%
2003	6.988	3.385	0.001	0.000	0.001	0.000	7.226	3.415	-53%
2004	9.070	4.456	0.001	0.000	0.001	0.000	9.383	4.494	-52%
2005	8.571	7.793	0.001	0.000	0.001	0.000	8.870	7.860	-11%
2006	10.950	10.216	0.001	0.000	0.001	0.000	11.333	10.304	-9%
2007	13.245	12.326	0.001	0.000	0.001	0.000	13.708	12.432	-9%
2008	15.628	14.594	0.001	0.000	0.002	0.000	16.174	14.719	-9%
2009	11.458	10.864	0.001	0.000	0.001	0.000	11.859	10.957	-8%
2010	5.374	5.132	0.001	0.000	0.001	0.000	5.560	5.176	-7%
2011	4.529	4.247	0.000	0.000	0.000	0.000	4.686	4.283	-9%
2012	4.304	3.920	0.000	0.000	0.000	0.000	4.452	3.954	-11%
2013	3.673	3.395	0.000	0.000	0.000	0.000	3.801	3.424	-10%
2014	4.171	3.437	0.000	0.000	0.000	0.000	4.316	3.467	-20%

Ad 2: Road Transportation (1.A.3.b) - In this submission, the corrections of country specific NCVs of gasoline blended and diesel oil blended were provided for the years 2007 – 2014. This change was connected with the corrections in biomass share of fuels (expressed as energy share of biomass, not

mass share, as used previously). It caused the changes in fuel consumption of gasoline and diesel oil (in energy units). Secondly, the recalculations related to the update of COPERT model, version V led to the recalculations for the years 2010 – 2014. Third recalculation was made in CNG category for the years 2000 – 2014, due to change in IEF(CO_2). The results of recalculations and differences between submissions are shown in ***Table 3.50***.

Table 3.50: *The difference between the new (2017) and the old (2016) submissions in 1.A.3.b*

YEAR	EMISSIONS (Gg)								
	CO_2		CH_4		N_2O		CO_2 eq.		Change
	2016	2017	2016	2017	2016	2017	2016	2017	%
2000	3 989.01	3 989.01	0.96	0.96	0.19	0.19	4 068.18	4 068.32	0.0036%
2001	4 541.25	4 541.25	1.06	1.06	0.21	0.21	4 631.43	4 631.58	0.0032%
2002	4 686.24	4 686.24	1.00	1.00	0.20	0.20	4 770.50	4 770.65	0.0031%
2003	4 826.84	4 826.84	0.98	0.98	0.20	0.20	4 911.38	4 911.52	0.0030%
2004	5 090.84	5 090.84	0.95	0.95	0.19	0.19	5 172.38	5 172.52	0.0028%
2005	6 045.33	6 045.33	0.94	0.94	0.22	0.22	6 133.95	6 134.09	0.0024%
2006	5 636.49	5 636.49	0.86	0.86	0.20	0.20	5 717.88	5 718.03	0.0026%
2007	6 238.45	6 238.45	0.83	0.83	0.20	0.20	6 318.67	6 318.82	0.0023%
2008	6 440.89	6 440.89	0.83	0.83	0.22	0.22	6 526.07	6 526.07	0.0000%
2009	5 914.13	5 914.13	0.73	0.73	0.21	0.21	5 994.32	5 994.46	0.0024%
2010	6 409.25	6 382.01	0.72	0.72	0.18	0.18	6 480.91	6 453.68	-0.4201%
2011	6 153.56	5 923.48	0.63	0.63	0.19	0.18	6 225.50	5 991.44	-3.7597%
2012	6 343.82	6 316.04	0.61	0.62	0.19	0.19	6 415.48	6 387.67	-0.4334%
2013	6 119.38	6 091.87	0.62	0.62	0.18	0.18	6 189.77	6 162.20	-0.4454%
2014	6 186.95	6 153.47	0.63	0.63	0.18	0.17	6 255.13	6 221.41	-0.5390%

Ad 3: Railways (1.A.3.c) - The fuel consumption in energy unit was recalculated by using country specific NCVs. The consumptions of diesel oil were recalculated for the years 1990 – 2014 and consumptions of biomass were recalculated for the years 2007 – 2014. According to the UNFCCC recommendation E.28 (SVK ARR 2016), the CO_2, CH_4 and N_2O emissions were recalculated for 1990 – 2014 using tier 1 methodology according to the IPCC 2006 GL. The results of recalculations and differences between submissions are shown in ***Table 3.51***.

Table 3.51: *The difference between the new (2017) and the old (2016) submission in 1.A.3.c*

YEAR	EMISSIONS (Gg)								
	CO_2		CH_4		N_2O		CO_2 eq.		Change
	2016	2017	2016	2017	2016	2017	2016	2017	%
1990	376.77	372.29	0.03	0.02	0.16	0.14	425.76	415.63	-2%
1991	283.42	280.35	0.02	0.02	0.12	0.11	320.27	312.99	-2%
1992	233.83	231.31	0.02	0.01	0.10	0.09	264.23	258.23	-2%
1993	200.75	198.47	0.02	0.01	0.09	0.08	226.85	221.58	-2%
1994	189.50	187.04	0.01	0.01	0.08	0.07	214.04	208.81	-2%
1995	204.07	199.58	0.01	0.01	0.09	0.08	230.51	222.81	-3%
1996	200.26	197.71	0.01	0.01	0.09	0.08	226.21	220.73	-2%
1997	188.18	185.65	0.01	0.01	0.08	0.07	212.57	207.26	-2%
1998	172.62	169.74	0.01	0.01	0.07	0.07	194.99	189.50	-3%
1999	158.02	156.73	0.01	0.01	0.07	0.06	178.49	174.97	-2%
2000	155.75	154.18	0.01	0.01	0.07	0.06	175.92	172.13	-2%
2001	153.61	150.71	0.01	0.01	0.07	0.06	173.51	168.25	-3%
2002	142.69	140.96	0.01	0.01	0.06	0.05	161.17	157.37	-2%
2003	114.13	111.43	0.01	0.01	0.05	0.04	128.90	124.40	-3%
2004	109.45	106.86	0.01	0.01	0.05	0.04	123.63	119.30	-4%

YEAR	EMISSIONS (Gg)								
	CO_2		CH_4		N_2O		CO_2 eq.		Change
	2016	2017	2016	2017	2016	2017	2016	2017	%
2005	106.59	104.57	0.01	0.01	0.05	0.04	120.45	116.74	-3%
2006	113.24	111.09	0.01	0.01	0.05	0.04	127.91	124.03	-3%
2007	104.33	102.90	0.01	0.01	0.05	0.04	118.41	115.32	-3%
2008	95.13	93.91	0.01	0.01	0.04	0.04	108.05	105.31	-3%
2009	81.64	80.63	0.01	0.00	0.04	0.03	92.77	90.44	-3%
2010	83.34	82.32	0.01	0.00	0.04	0.03	94.71	92.35	-2%
2011	79.82	78.90	0.01	0.00	0.04	0.03	90.80	88.58	-2%
2012	67.77	66.97	0.00	0.00	0.03	0.03	77.07	75.16	-2%
2013	82.98	81.62	0.01	0.00	0.04	0.03	94.42	91.66	-3%
2014	77.94	76.66	0.00	0.00	0.04	0.03	88.81	86.21	-3%

Ad 4: Domestic Navigation (1.A.3.d) - The fuel consumption in energy unit was recalculated by using country specific NCVs. The consumptions of diesel oil were recalculated for the years 1990 – 2014 and consumptions of biomass were recalculated for the years 2007 – 2014. The CO_2, CH_4 and N_2O emissions were recalculated for the years 1990 – 2014 using tier 1 methodology according to the IPCC 2006 GL. The results of recalculations and differences are shown in ***Table 3.52***.

Table 3.52: *The difference between the new (2017) and the old (2016) submission in 1.A.3.d*

YEAR	EMISSIONS (Gg)								
	CO_2		CH_4		N_2O		CO_2 eq.		Change
	2016	2017	2016	2017	2016	2017	2016	2017	%
1990	0.02	0.02	0.00	0.00	0.00	0.00	0.03	0.02	-11%
1991	0.02	0.02	0.00	0.00	0.00	0.00	0.02	0.02	-11%
1992	0.02	0.02	0.00	0.00	0.00	0.00	0.02	0.02	-11%
1993	0.02	0.02	0.00	0.00	0.00	0.00	0.02	0.02	-11%
1994	0.02	0.02	0.00	0.00	0.00	0.00	0.02	0.02	-11%
1995	0.02	0.02	0.00	0.00	0.00	0.00	0.02	0.02	-12%
1996	0.02	0.02	0.00	0.00	0.00	0.00	0.02	0.02	-11%
1997	0.02	0.02	0.00	0.00	0.00	0.00	0.03	0.02	-11%
1998	0.02	0.02	0.00	0.00	0.00	0.00	0.03	0.02	-11%
1999	0.02	0.02	0.00	0.00	0.00	0.00	0.03	0.02	-11%
2000	0.02	0.02	0.00	0.00	0.00	0.00	0.03	0.02	-11%
2001	0.03	0.02	0.00	0.00	0.00	0.00	0.03	0.03	-12%
2002	0.03	0.03	0.00	0.00	0.00	0.00	0.03	0.03	-11%
2003	0.03	0.03	0.00	0.00	0.00	0.00	0.03	0.03	-12%
2004	0.03	0.03	0.00	0.00	0.00	0.00	0.03	0.03	-12%
2005	0.04	0.03	0.00	0.00	0.00	0.00	0.04	0.04	-12%
2006	0.32	0.32	0.00	0.00	0.00	0.00	0.36	0.32	-12%
2007	0.34	0.33	0.00	0.00	0.00	0.00	0.38	0.34	-12%
2008	0.36	0.35	0.00	0.00	0.00	0.00	0.40	0.35	-12%
2009	0.33	0.32	0.00	0.00	0.00	0.00	0.37	0.33	-12%
2010	0.33	0.33	0.00	0.00	0.00	0.00	0.37	0.33	-12%
2011	0.85	0.83	0.00	0.00	0.00	0.00	0.95	0.84	-12%
2012	1.12	1.10	0.00	0.00	0.00	0.00	1.26	1.11	-12%
2013	3.48	3.40	0.00	0.00	0.00	0.00	3.91	3.44	-12%
2014	4.47	4.37	0.00	0.00	0.00	0.00	5.02	4.42	-12%

Pipeline Transport (1.A.3.e.i) - No recalculation was provided in this category.

Other/Urea Based Catalysts (1.A.3.e.ii allocated in the 2.D.3) - In this submission, the CO_2 emissions from urea based catalysts were reallocated into IPPU sector, category 2.D.3.

3.2.8.5 Category-specific improvements and implementation of recommendations

Improvements are implemented in line with the Improvement and Prioritization Plan for the year 2017.

Domestic aviation (1.A.3.a) – No specific improvements are planned for the next submission.

Road transportation (1.A.3.b) – consecutive recalculation of the time-series for all emissions with COPERT V model is planned for the next submission.

Railways (1.A.3.c) – the information on fuel consumption in the international public transport corridors will be verified in the future submissions.

Domestic navigation (1.A.3.d) – Information about inland tourists shipping in the Slovak Republic can be collected in more details and update of activity data about transport on small lakes and Rivers is planned.

Pipeline transport (1.A.3.e.i) – No specific improvements are planned for the next submission.

Other/Urea Based Catalysts (1.A.3.e.ii) – No specific improvements are planned for the next submission.

3.2.9 OTHER SECTORS (CRF 1.A.4)

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 this subcategory expressed in energy units represented 27 315.26 TJ in 2015. Total CO_2 emissions were 1 486.92 Gg, total CH_4 emissions were 0.46 Gg and total N_2O emissions were 0.010 Gg in 2015.

Residential (1.A.4.b) - Total volume of fuels in this subcategory expressed in energy units represented 66 807.55 TJ in 2015. Total CO_2 emissions were 2 703.17 Gg, total CH_4 emissions were 6.99 Gg and total N_2O emissions were 0.09 Gg in 2015. The fuels are allocated among solid, gaseous and biomass fuels categories. No liquid fuels are reported in this subcategory.

Agriculture, forestry and fisheries (1.A.4.c) - Total volume of fuels in this subcategory expressed in energy units represented 5 199.90 TJ in 2015. Total CO_2 emissions were 253.35 Gg, total CH_4 emissions were 0.17 Gg and total N_2O emissions were 0.06 Gg in 2015. The fuels are allocated among solid, liquid, gaseous and biomass fuels categories.

Also all non-road mobile machinery is 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.

3.2.9.1 Methodological issues, emission factors and NCVs

A description of the general methodologies used for GHG emissions estimation from fuel combustion is given in the chapter 3.2.6.1.

Activity data (emission factors and NCVs) are collected from several sources (in agreement with the other energy subcategories) a provided in ***Table 3.53***:

- Annual energy balance (publication Energy,[9] published by the SU SR, annually);
- Disaggregated data provided by the SU SR (restricted from public, provided only for the SNE);
- The NEIS Central database;
- Transport Research Institute.

The activity data allocated in 1.A.4.b - Residential is summarized in the NEIS Central database as the category of small sources. Activity data on solid fuels sold to households from retailers are collected in the separate module of the NEIS database. The consumption of natural gas for individual households and dwellings is periodically announced by the Slovak Gas Industry, LtD. (SPP, a.s.). The activity data are compared and verified with the information collected in the statistical questionnaires. This comparison is available since the year 2001.

Table 3.53: *Overview of the country or plant specific CO_2 emission factors in 1.A.4 in 2015*

1.AA.4.a	WEIGHTED EF CO_2 (t/TJ)	FUEL TYPE	EF C (t/TJ)	EF CO_2 (t/TJ)
Liquid	66.06	Liquefied petroleum gases	17.22	63.15
		Gas/Diesel oil	20.21	74.10
		Residual fuel oil	21.12	77.46
		Other petroleum products	20.00	73.33
Solid	98.23	Lignite	27.87	102.21
		Brown coal briquettes	26.60	97.53
		Other bituminous coal	26.52	97.23
		Gas coke	29.67	108.81
Gaseous	55.72	Natural Gas	15.20	55.72
Biomass	76.59	Wood/Wood waste	30.50	111.83
		Sludge gas	14.90	54.63
1.AA.4.b	**WEIGHTED EF CO_2 (t/TJ)**	**FUEL TYPE**	**EF C (t/TJ)**	**EF CO_2 (t/TJ)**
Liquid	63.15	Liquefied petroleum gases	17.22	63.15
Solid	99.91	Other bituminous coal	26.52	97.23
		Lignite	27.87	102.21
		Brown coal briquettes	26.61	97.57
		Gas coke	29.67	108.81
Gaseous	55.72	Natural Gas	15.20	55.72
Biomass	111.83	Wood/Wood waste	30.50	111.83
1.AA.4.c	**WEIGHTED EF CO_2 (t/TJ)**	**FUEL TYPE**	**EF C (t/TJ)**	**EF CO_2 (t/TJ)**
Liquid	72.95	Liquefied petroleum gases	17.22	63.15
		Gas/Diesel oil	20.21	74.10
		Gasoline	18.10	66.37
		Diesel oil	20.44	74.95
Solid	101.28	Lignite	27.87	102.21
		Gas coke	29.67	108.81
		Other bituminous coal	26.52	97.23
		Brown coal briquettes	26.61	97.57
Gaseous	55.72	Natural gas	15.20	55.72
Biomass	67.79	Other biogas	14.90	54.63
		Wood/Wood waste	30.50	111.83
		Other primary Solid biomass	27.30	100.10

[9] Energy 2015, Statistical Office of Slovak Republic (2014) ISBN: 978-80-8121-389-2

3.2.9.2 Uncertainties and time-series consistency

The emissions inventory in the energy sector – sectoral approach is based on activity data directly provided by producers and compared with the energy balance provided by the Statistical Office of the Slovak Republic on the enterprise level. 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). Statistical data, available for the years 1990 – 1999, was based on different aggregation level and therefore the activity data were not possible to allocate into appropriate CRF subcategories automatically. This disaggregation was made manually and in some subcategories also regression was used to reconstruct consistent time series for the years 1990 – 1999 (mostly in the 1.A.2.f). The important is to highlight, that the aggregated sum of fuels consumption in the individual subcategories 1.A.1, 1.A.2, 1.A.4 and 1.A.5 is based on the data provided (from the producers and the national statistics. Emission factors of non-CO_2 gases were used according to the default values of the IPCC 2006 GL for the time series.

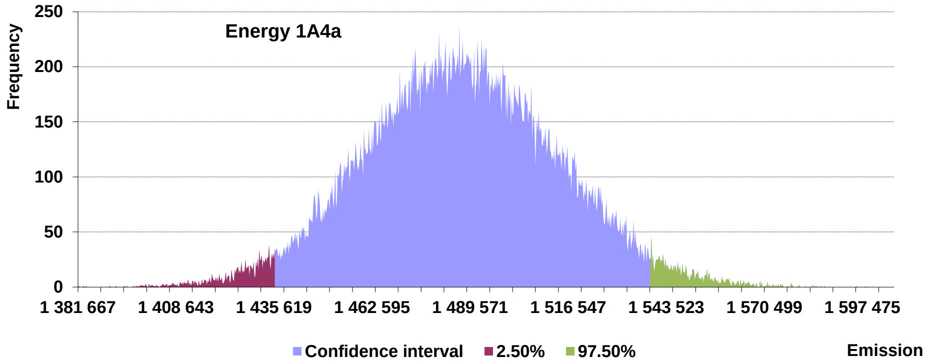
Since 2000, complete time series have been evaluated by checking in order to remove possible inconsistencies in earlier inventories caused by missing data of some plants, changing classifications and reallocation of fuels between energy and industrial processes sectors. Most of these corrections can be done on the basis of data from the EU ETS (from 2005 – 2007 and 2008 – 2015). Overall, methodologies, emission factors and data sources are consistent with the small interannual fluctuations caused by changes explained in this Report.

The average mean value of CO_2 emissions for the 1.A.4.a obtained by the Monte Carlo simulation is 1 487 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 1 487 Gg. Confidence interval (95%) is within the range: <1 436; 1 539>, which represents the uncertainty by relative values to the mean value: -3.44%; +3.50%. The following table and graph described calculated results of uncertainty analyses.

Table 3.54: *Selected statistical characteristics for 1.A.4.a, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in Gg of CO_2)*

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
1 486.78	**1 487.12**	26.39	1 381.67	1 606.47	-3.44%	3.50%

Figure 3.25: *Probability density function for 1.A.4.a in tons of CO_2*

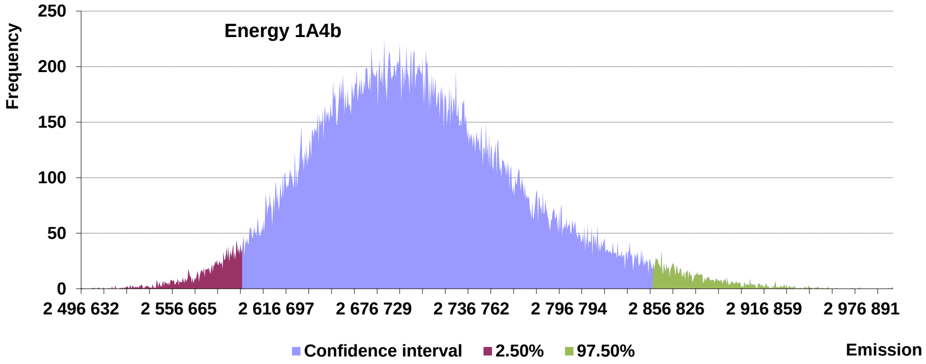


The average mean value of CO_2 emissions for the 1.A.4.b obtained by the Monte Carlo simulation is 2 704 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 2 703 Gg. Confidence interval (95%) is within the range: <2 592; 2 997>, which represents the uncertainty by relative values to the mean value: -4.13%; +5.37%. The following table and graph described calculated results of uncertainty analyses.

Table 3.55: Selected statistical characteristics for 1.A.4.b, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in Gg of CO_2)

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
2 697.82	**2 703.53**	64.54	2 496.63	2 996.90	-4.13%	5.37%

Figure 3.26: Probability density function for 1.A.4.b in tons of CO_2

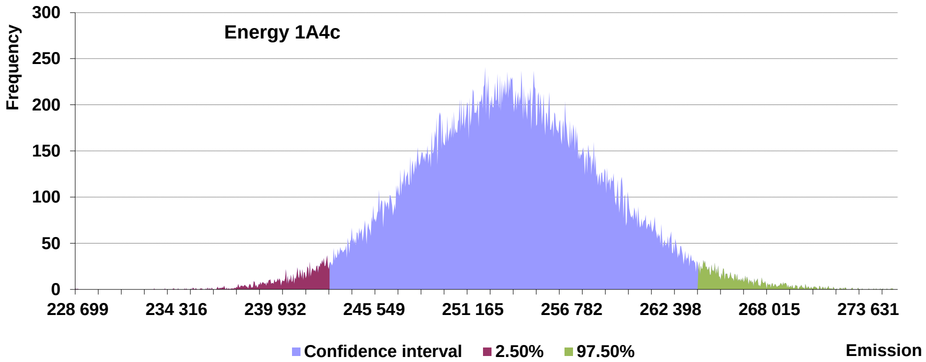


The average mean value of CO_2 emissions for the 1.A.4.c obtained by the Monte Carlo simulation is 253 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 253 Gg. Confidence interval (95%) is within the range: <243; 264>, which represents the uncertainty by relative values to the mean value: -4.02%; +4.23%. The following table and graph described calculated results of uncertainty analyses.

Table 3.56: Selected statistical characteristics for 1.A.4.c, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in Gg of CO_2)

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
253.27	**253.37**	5.34	228.7	275.5	-4.02%	4.23%

Figure 3.27: Probability density function for 1.A.4.c in tons of CO_2



3.2.10 NON-SPECIFIED (CRF 1.A.5)

Emissions reported in these subcategories arising from the military aviation and from fuel combustion in stationary sources that are not specified elsewhere. Total volume of fuels in this subcategory expressed in energy units represented 1 379.27 TJ in 2015. Total CO_2 emissions were 47.38 Gg, total CH_4 emissions were 0.03 Gg and total N_2O emissions were 0.0006 Gg in 2015.

3.2.10.1 Methodological issues, emission factors and NCVs

A description of the general methodology used for estimation of emissions from fuel combustion is given in the Section 3.2.6.1.

In 1.A.5.a, the main source of activity data is provided by the SU SR (disaggregated data – information on fuels consumption at the level of individual subjects). The jet kerosene from military aviation is reported in 1.A.5.b. These emissions were reallocated from the 1.A.3.e based on the **ERT´s recommendation from previous review**. GHG emissions from military aviation, i.e. jet kerosene consumption, are estimated since 1990. 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 3.57*** provides overview of the weighted average and fuels in the category 1.A.5 for the year 2015.

Table 3.57: *Overview of the country or plant specific CO_2 emission factors in 1.A.5 in 2015*

1.AA.5	WEIGHTED EF CO_2 (t/TJ)	FUEL TYPE	EF C (t/TJ)	EF CO_2 (t/TJ)
Liquid	70.65	Liquefied petroleum gases	17.22	63.15
		Residual fuel oil	21.12	77.46
		Jet kerosene	0.00	0.00
Solid	102.17	Gas coke	19.84	72.75
		Lignite	29.67	108.81
		Other bituminous coal	27.87	102.21
Gaseous	55.72	Natural gas	26.52	97.23
Biomass	60.49	Sludge gas	15.20	55.72
		Other biogas	14.90	54.63
		Other primary solid biomass	14.90	54.63
		Wood/Wood waste	27.30	100.10

3.2.10.2 Uncertainties and time-series consistency

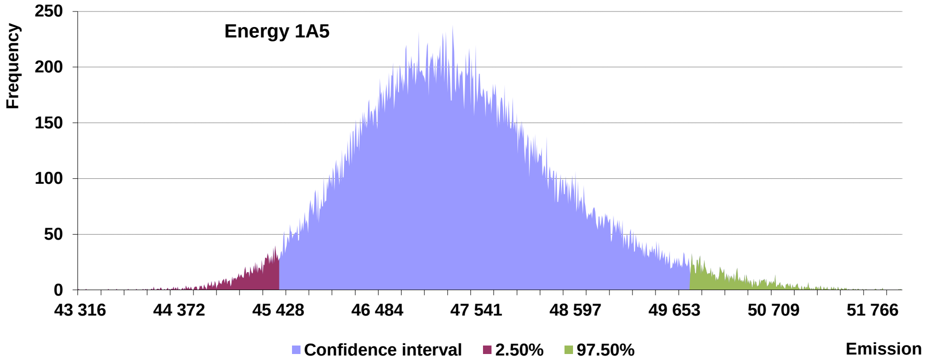
In accordance with the IPCC 2006 GL, natural gas consumption used for pipeline transport, which was previously reported under 1.A.5 is now reported under 1.AA.3.e.i. This reallocation dramatically decreased emissions reported under the 1.A.5. This recalculation had no significant effect on timeline consistency. The consistency of time series of 1.AA.5 is good. 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).

The average mean value of CO_2 emissions for the 1.A.5 obtained by the Monte Carlo simulation is 47.38 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 47.38 Gg. Confidence interval (95%) is within the range: <45.48; 49.84>, which represents the uncertainty by relative values to the mean value: -4.02%; +5.19%. The following table and graph described calculated results of uncertainty analyses.

Table 3.58: *Selected statistical characteristics for 1.A.5, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in Gg of CO_2)*

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
47.29	**47.38**	1.10	43.32	52.12	-4.02%	5.19%

Figure 3.28: *Probability density function for 1.A.5 in tons of CO_2*



3.3 COMPARISON OF THE SECTORAL APPROACH WITH THE REFERENCE APPROACH

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 (SHMU). Frame contract specifies major responsibilities in providing information about energy balance and any changes or recalculations directly to the SU SR. A close cooperation of the NIS and the SU 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, SU SR or 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 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 2017 submission, time series consistency was improved and transparency increased (***Figure 3.29***). A difference between CO_2 emissions allocated in reference and sectoral approach was -4.35% in 2015. A difference in the total energy consumption was -0.52% in 2015.

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 SU 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 energy sector), or coking coal used as reducing agent in steel production (allocated in the IPPU, but in the statistical questionnaire allocated in energy sector), etc.

These reallocations were considered in the apparent consumption and the results are provided in the ***Tables 3.59* - *3.63***. However due to the differences in the methodological approach used in the national inventory for sectoral approach and used in the statistical energy balance, in some years the differences are higher than required according to the QA/QC. After thorough analyses of these years, the results show the major inconsistencies in liquid fuels.

One of the reasons for the reference and sectoral approach discrepancies during time series was 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 the liquid fuels combustion reported in 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. The 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 summarize the effect of the uncertainty in the estimation of these parameters.

Table 3.59: *Effect of the uncertainty in the estimation of NCV and EF and its impact on RA SA difference*

NCV AND EF DIFFERENCE (%)	-5%	-2%	-1%	0%	1%	2%	-5%
NCV (TJ/kt)	44.097	42.837	42.417	41.997	41.577	41.157	39.897
EF (tC/TJ)	21.006	20.406	20.206	20.005	19.805	19.605	19.005
Emission difference (liquid fuels) (%)	18.86	4.80	0.20	-4.35	-8.86	-13.32	-26.43

In the first row the uncertainty of EF and NCV is depicted. Following rows shows the actual values of NCV and EF which were used to compare the difference between RA and SA. From the following table it is clear, that the increase of the actual values of NCV and EF by 5% causes increase of the RA-SA difference to 26 %. It is also important to underline that the uncertainty of few percent in the case of liquid fuels is nothing unusual. We performed several steps to increase the quality of the NCV and EF estimation, however the uncertainty of these estimates were always higher than 2 %. Therefore in current submission the EF was left unchanged (IPCC default) and the NCV was adopted from the Statistical office of Slovak republic. The consumption of crude oil is not included in sectoral approach therefore the problems mentioned here does not affect the inventory. Therefore we hope, that bottom up approach is more accurate. Based on the results of performed analysis we do not expect that it will be possible to decrease the RA SA difference in liquid fuels bellow 2% in all years. Significantly better is situation in solid and gaseous fuels.

Another significant difference is visible in the case of waste. Based on our research the main source of the difference is caused by manner in which the Statistical Office processes information about waste incineration. We identified incorrect categorization of waste between municipal and industrial in the Energy balance provided by the Statistical Office. Moreover, the estimation of composition (biogenic/fossil part) of waste in SA is based on information provided directly by the operators. We are currently in a discussion with the Statistical Office to provide improvements in their statistics of waste.The largest difference (in relative values) is in the case of peat consumption. The primary reason of this difference is absence of peat as a fuel type in the Energy balance provided by the Statistical Office of the Slovak Republic. Based on the EU ETS reports, there is just one company, which uses peat as fuel. SA is mainly based on information provided by operators in the EU ETS reports. On the other hand RA is prepared strictly based on information included in the Energy balance provided by the Statistical Office, where peat is not included (mentioned company reports the fuel type in Energy balance as briquettes). We are currently in a discussion with the Statistical Office to provide improvements in their statistics of peat.

In current submission a detail review of solid and gaseous fuels was performed. Based on ERT review several discrepancies in activity data were identified. These deviations were identified for years 1990-2000. Therefore complete time series of activity data were compared to information provided by statistical office of Slovak republic. Currently the information about import, export production and stock changes are fully correlated with information in international databases (Eurostat IEA).

The information on the emission factors used in sectoral approach is presented in the Chapter 3.2. The minor differences were caused by the use of average NCVs (net calorific values) in reference approach and fuel specific NCVs in sectoral approach.

Since 1990, total fuels combustion decreased significantly. After the medium increase in solid fuels in 2001, the decreasing trend in 2002 – 2015 appeared. The balance of solid fuels consumption is complicated due to the calculation of the stock change. The SU SR updates the fuel categories and methodology for stock fuel, annually.

Figure 3.29: *The difference between reference and sectoral approaches CO_2 emissions (in Gg) in 1990 – 2015*

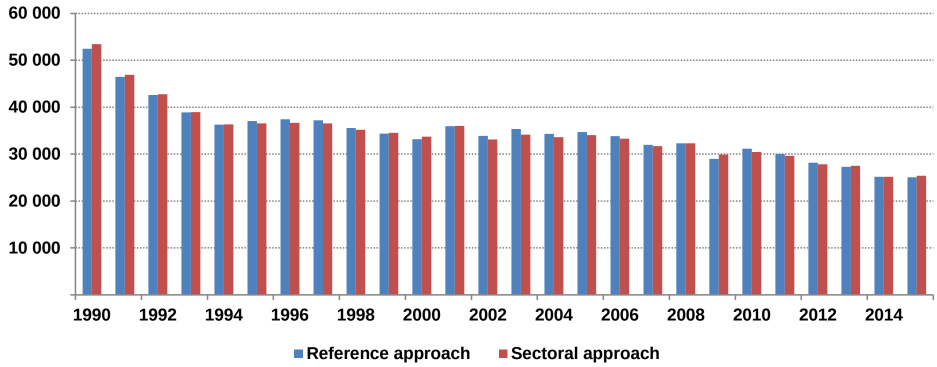


Table 3.60: *The comparison of RA and SA in total fuels consumption and CO_2 emissions in 1990 – 2015*

TOTAL FUELS							
YEAR	RA	SA	Apparent energy consumption	Energy consumption difference	RA	SA	Difference
	(PJ)	(PJ)	(PJ)	%	CO_2 (Gg)	CO_2 (Gg)	%
1990	752	664	650	-2.15	52 451	53 445	-1.86
1991	659	585	583	-0.25	46 474	46 931	-0.97
1992	624	538	533	-0.89	42 607	42 749	-0.33
1993	587	495	489	-1.24	38 888	38 967	-0.20

TOTAL FUELS							
YEAR	RA	SA	Apparent energy consumption	Energy consumption difference	RA	SA	Difference
	(PJ)	(PJ)	(PJ)	%	CO_2 (Gg)	CO_2 (Gg)	%
1994	561	464	457	-1.56	36 286	36 346	-0.16
1995	591	475	481	1.29	37 065	36 547	1.42
1996	599	481	489	1.53	37 431	36 663	2.09
1997	599	482	490	1.60	37 183	36 563	1.70
1998	582	471	468	-0.61	35 562	35 184	1.07
1999	566	466	455	-2.48	34 374	34 559	-0.53
2000	545	461	448	-2.86	33 200	33 726	-1.56
2001	575	494	491	-0.63	35 962	36 015	-0.15
2002	558	455	453	-0.41	33 880	33 117	2.30
2003	564	460	460	-0.02	35 364	34 143	3.58
2004	554	456	441	-3.32	34 300	33 618	2.03
2005	565	462	458	-0.78	34 682	34 066	1.81
2006	549	440	436	-0.93	33 811	33 290	1.56
2007	529	423	416	-1.59	31 996	31 721	0.87
2008	531	436	424	-2.72	32 324	32 316	0.02
2009	481	397	377	-4.95	28 967	29 911	-3.16
2010	513	405	408	0.71	31 184	30 440	2.44
2011	490	389	388	-0.44	30 039	29 646	1.33
2012	464	370	365	-1.48	28 178	27 845	1.20
2013	464	367	360	-1.73	27 279	27 534	-0.93
2014	424	327	324	-1.20	25 173	25 176	-0.01
2015	428	334	334	-0.07	25 041	25 396	-1.40

Table 3.61: *The comparison of RA and SA in liquid fuels consumption and CO_2 emissions in particular years*

LIQUID FUELS							
YEAR	RA	SA	Apparent energy consumption	Energy consumption difference	RA	SA	Difference
	(PJ)	(PJ)	(PJ)	%	CO_2 (Gg)	CO_2 (Gg)	%
1990	197	163	155	-5.22	11 624	12 189	-4.64
1995	145	102	107	4.62	7 930	7 604	4.29
2000	122	88	86	-1.94	6 504	6 525	-0.31
2005	139	113	109	-4.23	8 517	8 394	1.46
2010	144	114	115	0.79	8 896	8 381	6.14
2011	141	107	111	4.27	8 618	7 827	10.10
2012	134	111	113	1.87	8 709	8 102	7.49
2013	129	108	107	-0.41	8 045	7 895	1.90
2014	125	105	104	-0.59	7 891	7 672	2.86
2015	129	111	111	0.52	7 717	8 068	-4.35

Table 3.62: *The comparison of RA and SA in solid fuels consumption and CO_2 emissions in particular years*

SOLID FUELS							
YEAR	RA	SA	Apparent energy consumption	Energy consumption difference	RA	SA	Difference
	(PJ)	(PJ)	(PJ)	%	CO_2 (Gg)	CO_2 (Gg)	%
1990	342	288	287	-0.45	29 866	29 277	2.01
1995	226	167	170	1.98	17 796	17 402	2.27
2000	179	138	135	-2.37	14 125	14 235	-0.77
2005	178	125	123	-1.63	13 556	13 334	1.66
2010	159	102	99	-2.50	11 492	11 552	-0.51
2011	155	108	103	-4.44	11 785	12 125	-2.80
2012	147	88	89	0.81	10 389	10 203	1.82
2013	145	86	84	-2.87	9 715	9 927	-2.13
2014	141	81	77	-4.12	9 248	9 488	-2.52
2015	137	81	80	-0.81	9 257	9 312	-0.59

Table 3.63: *The comparison of RA and SA in gaseous fuels consumption and CO_2 emissions in particular years*

GASEOUS FUELS							
YEAR	RA	SA	Apparent energy consumption	Energy consumption difference	RA	SA	Difference
	(PJ)	(PJ)	(PJ)	%	CO_2 (Gg)	CO_2 (Gg)	%
1990	1990	214	210	208	10 945	11 780	-7.09
1995	1995	221	204	204	11 296	11 379	-0.73
2000	2000	244	233	226	12 513	12 817	-2.37
2005	2005	247	223	225	12 442	12 237	1.67
2010	2010	210	187	192	10 659	10 310	3.39
2011	2011	194	172	171	9 494	9 464	0.31
2012	2012	183	167	161	8 933	9 250	-3.43
2013	2013	191	169	166	9 207	9 382	-1.87
2014	2014	158	138	137	7 662	7 668	-0.08
2015	2015	162	139	138	7 678	7 765	-1.13

Table 3.64: *The comparison of RA and SA in other fossil fuels consumption and CO_2 emissions in particular years*

OTHER FOSSIL FUELS							
YEAR	RA	SA	Apparent energy consumption	Energy consumption difference	RA	SA	Difference
	(PJ)	(PJ)	(PJ)	%	CO_2 (kt)	CO_2 (kt)	%
1990	0.18	2.74	0.18	-93.46	16	198	-91.88
1995	0.48	2.24	0.48	-78.72	43	163	-73.75
2000	0.64	2.03	0.64	-68.55	57	149	-61.55
2005	1.89	1.27	1.89	47.96	168	100	67.46
2010	1.53	2.37	1.53	-35.52	136	198	-31.23
2011	1.59	2.63	1.59	-39.47	142	220	-35.52
2012	1.65	3.06	1.65	-46.06	147	259	-43.34
2013	3.51	3.19	3.51	9.91	313	269	16.32
2014	4.23	3.85	4.23	9.78	372	322	15.60
2015	4.39	2.82	4.39	55.58	389	235	65.50

3.4 FEEDSTOCKS AND NON-ENERGY USE OF FUELS

Using the IPCC 2006 Guidelines, the quantity of carbon excluded from reference approach (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 reference approach was 2 009.99 Gg in 2015, which represents 7 369.96 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 (50.7% and 52.6%, respectively) The other significant source of carbon excluded is using of natural gas (22.4% in fuel consumption and 18.4% in quantity of carbon). Details on the share in fuel units and carbon units are presented on ***Figures 3.30*** and ***3.31***. The CO_2 emissions excluded from the RA are presented in ***Figure 3.32*** for the whole time series 1990 – 2015.

Figure 3.30: *The share of different fuels consumption for feedstocks and non-energy use in 2015*

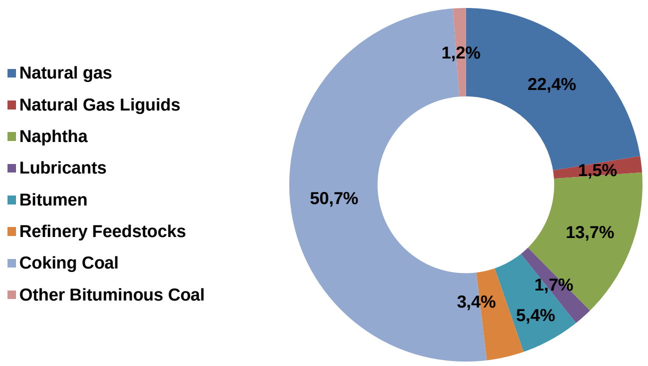


Figure 3.31: *The share of carbon for feedstocks and non-energy use in 2015*

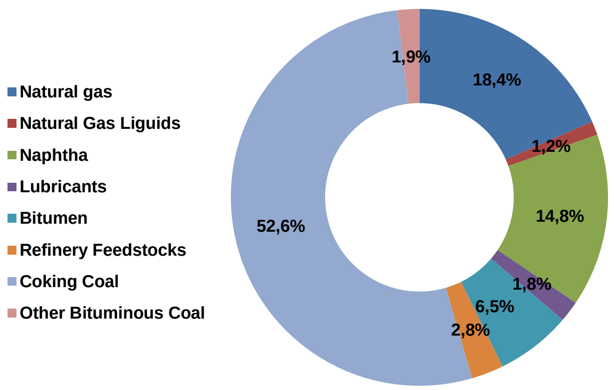
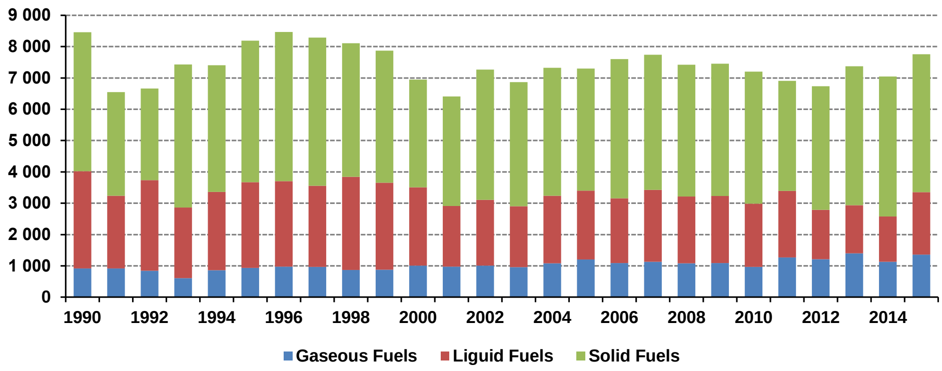


Figure 3.32: *The CO_2 emissions (in Gg) excluded from the reference approach in 1990 – 2015*



Liquid fuels (natural gas liquids, naphtha, and refinery feedstocks), solid fuels (coking coal, other bituminous coal) and gaseous fuels (natural gas) are used as feedstock in Slovakia. Lubricants and bitumen (liquid fuels) are used for non-energy purposes. The respective amounts of mentioned fuels are allocated in the IPPU sector and emissions are included there. The allocation of the fuels excluded from the reference approach and included in the IPPU sector is presented in the ***Tables 3.65*** and ***3.66***.

Table 3.65: *The allocation of fuels excluded from the reference approach 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
Natural gas liquid	2.B.8 Petrochemicals
Naphtha	2.B.8 Petrochemicals
Lubricants	2.D.1 Lubricants
Bitumen	2.D.3 Solvents Use
Refinery feedstocks	2.B.8 Petrochemicals
Coking coal	2.B.5 Carbide production 2.C.1 Iron and steel production 2.C.2 Ferroalloys production 2.C.3 Aluminium 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 reference approach balance.

The following fuels were balanced as feedstocks and non-energy use: natural gas, natural gas liquids, naphtha, lubricants, refinery feedstocks, coking coal, other bituminous coal. The quantities of the fuels and carbon used for non-energy purposes were provided directly by the plant operators or by the Statistical Office of the Slovak Republic. The results are presented in the ***Table 3.66***.

Table 3.66: *Total volume of carbon in different types of fuels excluded from the RA in particular years*

YEAR	CARBON EXCLUDED FROM RA (kt)							
	Natural Gas	Natural Gas Liquids	Naphtha	Lubricants	Bitumen	Refinery Feedstocks	Coking Coal	Other Bituminous Coal
1990	250.61	NO	297.35	65.54	418.77	65.58	1 209.70	IE
1995	254.92	19.61	385.42	65.54	199.63	76.18	1 231.99	IE
2000	274.56	35.38	432.51	65.54	83.40	65.80	937.52	IE
2005	329.10	15.49	348.80	39.49	126.88	67.55	1 025.05	37.72
2010	263.78	18.67	340.08	16.90	112.07	63.64	1 111.31	37.91

YEAR	CARBON EXCLUDED FROM RA (kt)							
	Natural Gas	Natural Gas Liquids	Naphtha	Lubricants	Bitumen	Refinery Feedstocks	Coking Coal	Other Bituminous Coal
2011	345.90	19.17	334.85	25.27	130.46	69.99	919.05	38.59
2012	331.44	10.46	218.00	36.99	114.05	50.60	972.18	103.11
2013	382.35	13.65	230.21	44.37	82.46	48.34	1 137.30	71.98
2014	308.83	8.77	225.39	36.27	86.39	37.60	1 102.47	116.29
2015	370.41	23.76	298.32	36.64	129.79	55.39	1 058.04	37.64

IE - included in coking coal

3.5 FUGITIVE EMISSIONS FROM FUELS

3.5.1 OVERVIEW OF FUGITIVE EMISSIONS FROM FUELS (CRF 1.B)

Fugitive emissions from the categories 1.B.1 Solid Fuel and 1.B.2 Oil and Natural Gas, as key categories, 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. Charcoal emissions were estimated since the base year and reported firstly in 2015 submission.

In 2015, total aggregated fugitive emissions in the category 1.B represented 1 602.89 Gg of CO_2 eq. Compared to other categories, the trend is almost stable and has not been influenced by changes in recent decades. Fugitive emissions from the transport and distribution of fossil fuels (oil and natural gas) are significant while Slovakia is an important transit country for pipelines 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 it has 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.

Overview of reported emissions and methodological tiers in category 1.B for the year 2015 is provided in the ***Table 3.2***. Methane emissions from abandoned underground mines (category 1.B.1.a.1.iii) are reported starting in 2015. More information is provided below.

Overview of total GHG emissions reported in the category 1.B is provided in the ***Table 3.1***. Following ***Tables 3.67*** and ***3.68*** summarizes emissions according to the most significant categories within 1.B in particular years.

Table 3.67: *GHG emissions by categories within 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	19.0080	25.1137	2.0840	NO	NO
1995	21.5416	27.4374	2.2667	NO	0.0900
2000	21.5125	26.6203	2.2005	NO	0.1500
2005	20.7805	14.6584	1.5142	NO	1.4400
2010	19.7399	13.8616	1.4337	NO	0.0906
2011	18.4591	14.7941	1.4327	NO	0.1269

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				
2012	17.6260	14.5817	1.3822	NO	0.1290
2013	18.2808	14.7722	1.4187	NO	0.1200
2014	26.4191	13.9029	1.3192	NO	0.1260
2015	19.5125	11.3245	1.1694	0.2638	0.1200

Table 3.68: *GHG emissions by categories within 1.B.2 Oil and Natural Gas 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	0.0257	0.5917	0.5832	44.1391	0.0069	0.0527	0.2282	23.5520
1995	0.0254	0.5469	0.5338	43.6110	0.0071	0.0535	0.2282	23.5520
2000	0.0199	0.4857	0.4939	41.3668	0.0056	0.0425	0.2127	21.9520
2005	0.0133	0.3987	0.5015	44.1017	0.0029	0.0223	0.2291	23.6480
2010	0.0083	0.3248	0.4103	38.4017	0.0012	0.0094	0.2024	20.8966
2011	0.0088	0.3532	0.3957	39.2904	0.0014	0.0108	0.2111	21.7898
2012	0.0070	0.3064	0.3701	28.1526	0.0010	0.0079	0.1410	14.5504
2013	0.0074	0.3296	0.3931	32.1526	0.0010	0.0072	0.1636	16.8896
2014	0.0075	0.3055	0.3124	27.6495	0.0011	0.0086	0.1442	14.8800
2015	0.0079	0.3409	0.3231	32.2001	0.0014	0.0086	0.1741	17.8646

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					
1990	2.9986	0.0018	47 E-06	1.3320	0.0009	20 E-06
1995	3.0441	0.0019	48 E-06	1.0320	0.0007	16 E-06
2000	2.4190	0.0015	38 E-06	0.5190	0.0003	8 E-06
2005	1.2710	0.0008	20 E-06	0.4410	0.0003	7 E-06
2010	0.5330	0.0003	8 E-06	0.3120	0.0002	5 E-06
2011	0.6150	0.0004	10 E-06	0.3630	0.0002	6 E-06
2012	0.4510	0.0003	7 E-06	0.4500	0.0003	7 E-06
2013	0.4100	0.0003	6 E-06	0.3720	0.0002	6 E-06
2014	0.4920	0.0003	8 E-06	0.3000	0.0002	5 E-06
2015	0.4920	0.0003	7.7 E-06	0.2790	0.0002	4.3E-06

3.5.2 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The Approach 1 uncertainty analysis was performed according to the IPCC 2006 Guidelines. 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 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 Statistical Office of the Slovak Republic. More information can be find in chapter 3.5.6.1 (***Figure 3.33***).

The verification process in 1.B.2 is based on cross-checking the input data from the supplier companies Transpetrol Company (oil) and the Slovak Gas Industry, LtD. (NG) and the statistics from the Ministry of Economy of the Slovak Republic and the Statistical Office of the Slovak Republic. According to the activity and input data resulted from analytical measurements done in accredited laboratories of Slovak Gas Industry, the calculation of so-called recalculation factor for the estimation of CO_2 emissions from NG treatment was evaluated to be 7.75 grams CO_2 per Gg of CH_4. More information can be find in chapter 3.5.7.1 (***Figure 3.35***).

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

3.5.4 CATEGORY-SPECIFIC RECALCULATIONS

No recalculations were made in this category.

3.5.5 CATEGORY-SPECIFIC IMPROVEMENTS AND IMPLEMENTED RECOMMENDATIONS

The future planned improvements can be done in applied EFs. The implementation of EFs measured directly from the mines is not satisfactory at the present due to insufficient accuracy of measurements, which are not continual. More effort could be invested into the determination of appropriate national EFs for mining and post-mining activities in the Slovak Republic.

3.5.6 SOLID FUELS (CRF 1.B.1)

Coal mining and handling (CRF 1.B.1.a) – 1 939.33 kt of brown coal was mined from underground mines in the Slovak Republic in 2015, mostly for domestic consumption (energy industry and households). Total methane emissions from the underground coal mining were estimated to be 12.76 Gg (11.324 Gg of CH_4 from mining activities, 1.169 Gg of CH_4 from post-mining activity and 0.26 Gg from abandoned mines) in 2015. Methane recovery and flaring in mine Handlova-east shaft was in practice since 2007 till 2014 (no activity in 2015). Total CO_2 emissions from the underground coal mining were estimated to be 19.51 Gg in 2015.

Table 3.69: *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
2011	2 376.03	14.794	0.062	1.433	NO	16.227	18.459
2012	2 292.21	14.582	0.027	1.382	NO	15.964	17.626
2013	2 352.72	14.772	0.045	1.419	NO	16.191	18.281
2014	2 187.72	13.903	0.026	1.319	NO	15.222	26.419
2015	1 939.33	11.324	NO	1.169	0.264	12.757	19.513

Solid fuel transformation (CRF 1.B.1.b) - fugitive methane emissions from charcoal production in the Slovak Republic is reported in this category in 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 are estimated for the years 1993 – 2015. Total volume of wood charcoal produced in Slovakia was 4 000 t in 2015. Total CH_4 emissions were 0.12 Gg in 2015.

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

Tier 2 method and the country specific EFs were used. The amount of mined brown coal (in the raw form) is the primary activity data. The fugitive methane emissions from underground coal mining and emissions from the post-mining activities in the Slovak Republic were estimated in accordance with the IPCC 2006 GL.

For the calculation of fugitive methane emissions from mining activities the emission factors from the following sources were used:

- 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;
- International Energy Agency - CIAB Global Methane and the Coal Industry;
- measurements of EF CH_4 as specified by the mines operator - HBP, a.s.

According to the IPCC 2006 GL, the emission factor is identical for all mines 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. Both values are on the lower level of the suggested scale. 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. 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. The emission factors for post-mining activities were used from the IPCC 2006 Guidelines (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 3.70***.

Based on the national circumstances and in accordance with the conservative principle, it was decided to calculate fugitive methane emissions in the period 1990 – 2015 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 3.70, point 2***).

Table 3.70: *Coal production, characteristics of mine and the emission factors for mining and post-mining in single mines in the Slovak Republic in 2015*

MINE	Coal Production (kt)	Depth of Mine (m)	EF CH_4 (m^3/t)					
			1. IPCC 2006 GL		2. IEA - CIAB		3. HPB, a.s.	
			Mining	Post-mining	Mining	Post-mining	Mining	Post-mining
Mine Novaky	1 093.000	200	10	0.9	6	0.9	0.92	0.39
Mine Novaky 6th logging place	0.000	200	10	0.9	6	0.9	4.17	0.46
Mine Cigel	0.000	500	10	0.9	13	0.9	0.00	0.00
Mine Cigel 7th logging place	606.000	500	10	0.9	13	0.9	4.17	0.46
Mine Handlova	0.000	500-1500	10	0.9	13	0.9	0.00	0.00
Mine Handlova east shaft	253.000	500-1500	10	0.9	13	0.9	4.17	0.46
Mine Dolina	69.520	600	10	0.9	13	0.9	0.02	0.01
Mine Cary	166.203	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 Handlova and did not occur in 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 6.37 kg/t in 2015.

Table 3.71: *Cogeneration of methane from Mine Handlova, the east shaft during 2007 – 2015 (CH_4 density in 20°C is 0.67 kg/m^3)*

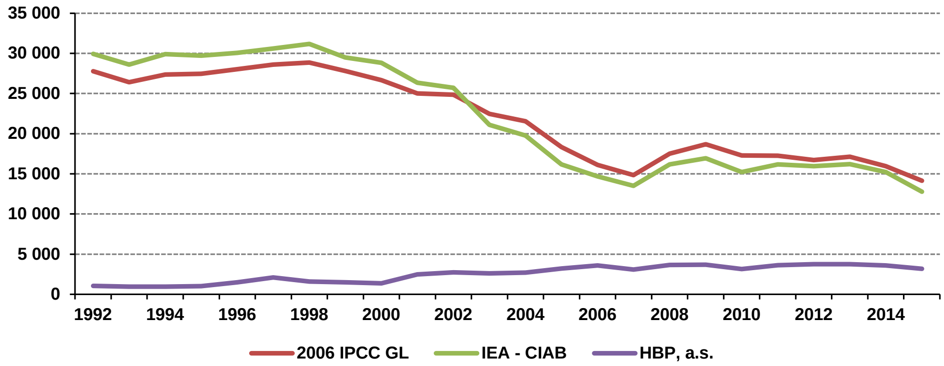
Methane cogenerated in Mine Handlova East Shaft	2008	2009	2010	2011	2012	2013	2014	2015
Mixture Methane + Air (m^3)	910 560	925 000	150 590	290 290	119 563	178 378	117 537	NO
Average Concentration of CH_4 (%)	30	17	32	32	34	38	34	34
Quantity of CH_4 (m^3)	273 168	158 175	48 189	92 893	41 130	67 605	39 492	NO
Quantity of Flared CH_4 (t)	182	106	32	62	27	45	26	NO

Five localities of underground mines operated by three companies are in the Slovak Republic. Data of coal production from the underground mines were obtained from official sources (official statistical sources: the Ministry of Economy of the Slovak Republic and the Statistical Office of the Slovak Republic) and directly from the companies: Hornonitrianske bane Prievidza (HBP), Bana Dolina Velky Krtis (BD) and Bana Cary (BC). According to the Regulation of the Slovak Office of Mines No 21/1988 Coll. the mines are differentiated based on gas release as follows:

- HBP, a.s. Prievidza:
  - Mine Cigel – non-gaseous (except 7th logging place),
  - Mine Handlova – gaseous,
  - Mine Novaky – gaseous,
- Bana Cary Holic – gaseous;
- Bana Dolina Velky Krtis – gaseous (closed).

Figure 3.33 shows the comparison of trends in estimated CH_4 emissions in the Slovak Republic in the years 1990 – 2015 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. The emissions can be underestimated.

Figure 3.33: *Comparison of trends in CH_4 emissions in the Slovak Republic in years 1990 – 2015*



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 realised 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 2015.

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 Cary have the same depth as the mines of the HBP, a.s. company, therefore the same EFs were used.

Table 3.72: *Overview of CO_2 emission factors for single mines in the Slovak Republic in 2015*

MINE	COAL PRODUCTION (t)	EF (t CO_2/t)	EMISSIONS CO_2 (t)
Mine Novaky	1 187 000	0,012356	14 666
Mine Cigel	400 500	0,003750	1 502
Mine Handlova	232 500	0,011708	2 722
Mine Dolina	21 996	0,011708	258
Mine Cary	97 329	0,003750	365
Total	**1 939 325**		**19 513**

Solid fuel transformation (CRF 1.B.1.b) - The CH_4 fugitive emission from solid fuel transformation have been calculated by the IPCC tier 1 default methodology with using Revised 1996 IPCC Guidelines 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 1996 IPCC Guidelines – Table 1-14 (no methodology available in the IPCC 2006 GL for this category). Fugitive methane emissions from charcoal production were estimated based on the IPCC default EF (CH_4) = 1 000 kg/TJ. The GHG emissions from charcoal combustion were included in energy sector, where the activity data represents the quantity of production excluding export.

Activity data were obtained from 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 FAO) but it was not possible to reconstruct the reasons of this trend.

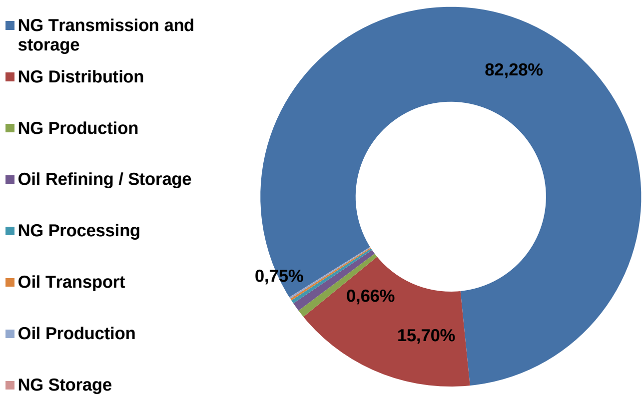
Table 3.73: *Charcoal production and fugitive emissions in particular years*

YEAR	CHARCOAL PRODUCTION (kt)	CH_4 EMISSIONS (kt)
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

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 are negligible in the Slovak Republic and the major share of these stocks comes from import. These subcategories are important key sources in level and trend assessment. Total aggregated emissions in this subcategory represented 1 261.43 Gg of CO_2 eq. (50.41 Gg CH_4) in 2015. Total CO_2 emissions were 1.28 Gg in 2015 and the estimation was based on the composition of natural gas and carbon content. Total N_2O emissions were 11.96 kg in 2015. The major share belongs to the NG transmission and storage (81.28%) and NG distribution (16%). Production of natural gas is decreasing and represented only 0.84% from the total fugitive emissions from oil and NG activities.

Figure 3.34: *The share of individual activities in fugitive emissions of oil and natural gas in 2015*



Total fugitive GHG emissions from oil activities (1.B.2.a) were 8.53 Gg of CO_2 eq. (7.99 t of CO_2 and 340.97 t of CH_4) in 2015. Total GHG emissions are decreasing continuously since the base year due to decrease in production and storage (***Table 3.73***).

Table 3.74: *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	CO_2 (t)	CH_4 (t)	(kt)	CO_2 (t)	CH_4 (t)	kt	CH_4 (t)
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	13.00	3.38	46.80	10 075.33	4.94	54.41	5 453.00	223.57
2011	15.00	3.90	54.00	9 919.73	4.86	53.57	5 991.00	245.63
2012	11.00	2.86	39.60	8 417.68	4.12	45.46	5 399.00	221.36
2013	10.00	2.60	36.00	9 788.06	4.80	52.86	5 871.00	240.71
2014	12.00	3.12	43.20	8 945.00	4.38	48.30	5 220.00	214.02
2015	12.00	3.12	43.20	9 932.04	4.87	56.63	5 954.53	244.14

Total fugitive GHG emissions from natural gas activities (1.B.2.b) were 805.32 Gg of CO_2 eq. (323.1 t of CO_2 and 32.20 Gg of CH_4) in 2015. 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 3.75: *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 m^3	CO_2 (t)	CH_4 (t)	mil m^3	CO_2 (t)	CH_4 (t)	mil m^3	CO_2 (t)	CH_4 (t)
1990	444	36.41	1 021.20	444	142.08	457.32	73 600	64.77	35 328.00
1995	344	28.21	791.20	344	110.08	354.32	73 600	64.77	35 328.00
2000	173	14.19	397.90	173	55.36	178.19	68 600	60.37	32 928.00
2005	147	12.05	338.10	147	47.04	151.41	73 900	65.03	35 472.00
2010	104	8.53	239.20	104	33.28	107.12	65 302	57.47	31 344.96
2011	121	9.92	278.30	121	38.72	124.63	68 093	59.92	32 684.64
2012	150	12.30	345.00	150	48.00	154.50	45 470	40.01	21 825.60
2013	124	10.17	285.20	124	39.68	127.72	52 780	46.45	25 334.40
2014	100.00	8.20	230.00	100	32.00	103.00	46 500	40.92	22 320.00
2015	93.00	7.63	213.90	93.00	29.76	95.79	55 800	49.1	26 784.00

YEAR	1.B.2.b NATURAL GAS					
	1.B.2.b.5 Distribution			1.B.2.b.6 Other		
	Distribution	Emissions		Storage	Emissions	
	mil m^3	CO_2 (t)	CH_4 (t)	mil m^3	CO_2 (t)	CH_4 (t)
1990	6 666.00	339.97	7 332.60	1.00	0.00	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	103.00	0.01	2.575
2011	5 630.00	287.13	6 193.00	395.00	0.04	9.875
2012	5 289.00	269.74	5 817.90	385.00	0.04	9.625
2013	5 820.00	296.82	6 402.00	132.00	0.01	3.300
2014	4 535.00	231.29	4 988.50	319.00	0.04	7.975
2015	4 639.00	236.59	5 102.90	139.00	0.02	3.475

Total fugitive GHG emissions from flaring and venting activities (1.B.2.c) were 447.58 Gg of CO_2 eq. (945.12 t of CO_2, 17.87 Gg of CH_4 and 11.96 kg of N_2O) in 2015 (***Table 3.76***). Total emissions are slightly decreasing due to the decrease of natural gas transit. 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 (99.78%) in 2015.

Table 3.76: *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		
	Emissions		Emissions		Emissions			Emissions		
	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	23 552	3 044	1.86	0.048	1 032	0.67	0.016
2000	5.61	42.48	212.66	21 952	2 419	1.48	0.038	519	0.34	0.008
2005	2.95	22.32	229.09	23 648	1 271	0.78	0.020	441	0.29	0.007
2010	1.24	9.36	202.44	20 897	533	0.33	0.008	312	0.20	0.008
2011	1.43	10.80	211.09	21 790	615	0.38	0.010	363	0.24	0.006
2012	1.05	7.92	140.96	14 550	451	0.28	0.007	450	0.29	0.007
2013	0.95	7.20	163.62	16 890	410	0.25	0.006	372	0.24	0.006
2014	1.14	8.64	144.15	14 880	492	0.30	0.008	300	0.20	0.005
2015	1.14	8.64	172.98	17 856	492	0.30	0.008	279	0.18	0.004

3.5.7.1 Methodological issues

The fugitive emissions from the transport and the distribution of oil and natural gas in the Slovak Republic were calculated according to the IPCC 2006 GL using tier 1 default methodology. 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 emission factors for fugitive emissions (including venting and flaring) from oil and gas operations in developed countries. The upper limit was used.

For the comparison and verification of used approach, the CH_4 emissions were estimated also with the use of following emission factors:

- IPCC 2006 GL, table 4.2.4 -tier 1 emission factors for fugitive emissions (including venting and flaring) from oil and gas operations in developed countries, lower and upper limits were given.
- IPCC 2006 GL, table 4.2.5 - tier 1 emission factors for fugitive emissions (including venting and flaring) from oil and gas operations in developed countries with economies in transition, lower and upper limits were given.
- The methodology provided by the Slovak Gas Industry, LtD.

Table 3.77: *Overview of activity data, EFs and fugitive emissions in the subcategory 1.B.2 in 2015*

ACTIVITY	OIL (kt), NG (mil m^3)	EF CO_2	EF CH_4	EF N_2O	CO_2	CH_4	N_2O
		Gg/mil m^3			t		
Oil Production	12	2.60E-04	3.60E-03		3.12	43.20	
Oil Transport	9932	4.90E-07	5.40E-06		4.87	53.63	
Oil Refining / Storage	5955		4.10E-05			244.13	
Oil Venting	12	9.50E-05	7.20E-04		1.14	8.64	
Oil Flaring	12	4.10E-02	2.50E-05	6.40E-07	492.00	0.30	0.0077
NG Production	93	8.20E-05	2.30E-03		7.63	213.9	
NG Processing	93	3.20E-04	1.03E-03		29.76	95.79	

ACTIVITY	OIL (kt), NG (mil m³)	EF CO_2	EF CH_4	EF N_2O	CO_2	CH_4	N_2O
		Gg/mil m³			t		
NG Transmission and storage	55 800	8.80E-07	4.80E-04		49.10	26 784.00	
NG Distribution	4 639	5.10E-05	1.10E-03		236.59	5 102.90	
NG Storage	139	1.10E-07	2.50E-05		0.02	3.48	
NG Venting	55 800	3.10E-06	3.20E-04		172.98	17 856	
NG Flaring (from production and processing)	93	1.20E-03	7.60E-07	2.10E-08	111.60	0.07	0.0019
		1.80E-03	1.20E-06	2.50E-08	167.4	0.11	0.0023

Activity data used in emissions estimation in oil production, transport and refining/storage are provided by the Transpetrol Company, the exclusive company for transit and inland oil transportation and storage for its customers and the State Resource Reserves. The activity data were compared with the information provided by the Statistical Office of the Slovak Republic. Activity data used in emissions estimation in natural gas activities were obtained from the Slovak Gas Industry, LtD., from the Ministry of the Economy of the Slovak Republic and the Statistical Office of the Slovak Republic.

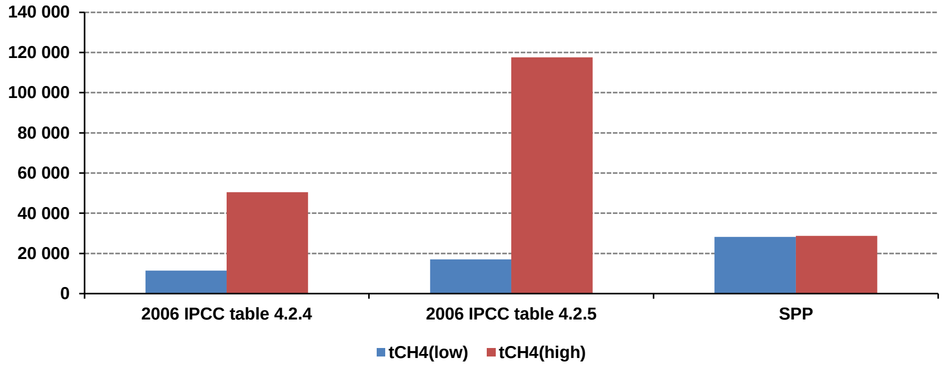
Table 3.78: *Activity data on production, export and import of NG in the Slovak Republic in 2015*

ACTIVITY	NATURAL GAS (m³)
Indigenous Production	93 000 000
Associated Gas	8 000 000
Non-associated Gas	85 000 000
Stock Changes	139 000 000
Gas Vented	1 000 000
Gas Flared	4 000 000
Export	0
Import	4 407 000 000
INLAND CONSUMPTION	**4 639 000 000**

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, the IPCC 2006 GL table 4.2.4 - tier 1 emission factors for fugitive emissions from oil and gas operations in developed countries was used and the results represented the most real values with the application conservative principle (higher values of EFs) (***Figure 3.35***).

Figure 3.35: The comparison of the methodologies used for the calculation (national approach according to the Slovak Gas Industry, LtD. and IPCC) of fugitive methane emissions from oil and natural gas activities



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 – 2015. Based on the national circumstances (size of country), the international aviation occurs more frequently than the national aviation. In this submission, for time series 2005 – 2015 there were used EUROCONTROL 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, Kosice, Poprad, Sliac, Piestany and Zilina) in the period 1990 – 2004. In 2015, the emissions in the international civil aviation represented 145.60 Gg of CO_2 equivalents. 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.

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 methodology based on fuel sold, both for aviation gasoline and jet kerosene for 1990 – 2004. In the previous submissions, there were used the expert judgment on the sharing of domestic and international flights. According to the UNFCCC recommendations E.11 and E.21 (SVK ARR 2016), in this submission, the share between domestic and international aviation for the years 1990 – 2004 was estimated by using the trend for the years 2005 – 2015 from the available EUROCONTROL data. The changes are shown in the ***Table 3.31*** (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 2016 were used for emissions´ estimation of aviation transport for time series 2005 – 2015. The decision follows an analysis of the national data and data obtained from EUROCONTROL and approved by the Ministry of Transport, Construction and Regional Development of the Slovak Republic. Aggregated national fuel and emissions balance was calculated using a tier 3 methodology 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 2016 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, N_2O emissions for all subcategories.

Total consumption of jet kerosene was 1 982.76 TJ and total consumption of aviation gasoline was 2.19 TJ in international flights in 2015.

The overview of the international aviation fuels consumption according to the type (aviation gasoline and jet kerosene) is presented in the ***Table 3.79***. 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.

Table 3.79: *Fuels consumption and GHG emissions in international flights in particular years*

YEAR	AVIATION GASOLINE				JET KEROSENE			
	CONSUMPTION	EMISSIONS (t)			CONSUMPTION	EMISSIONS (t)		
	(TJ)	CO_2	CH_4	N_2O	(TJ)	CO_2	CH_4	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
2011	1.90	134.609	0.001	0.004	1 854.99	134 947.57	1.298	3.667
2012	2.14	151.032	0.001	0.004	1 650.32	120 057.87	1.180	3.263
2013	1.98	140.064	0.001	0.004	1 539.95	112 028.64	1.129	3.044
2014	1.56	110.545	0.001	0.003	1 626.62	118 333.72	1.123	3.216
2015	2.19	154.854	0.001	0.004	1 982.76	144 242.52	1.334	3.920

3.6.1.1 Source specific recalculations

Recalculations in this category were provided for time series 2005 – 2014. Recalculations are based on recalculations provided by the EUROCONTROL in 2016. Explanation was provided by the EUROCONTROL in line with changes in methodology for fuel consumption in international flights and changes in emission factors.

Recalculations were provided also for time series 1990 – 2004, where the total fuel consumption in domestic and international flights was change by using NCVs taken from the EUROCONTROL. In addition, new share for fuels´ consumption in national and international flights was used.

The changes in fuel consumptions affected emissions of all GHGs. Following ***Table 3.80*** shows comparison of old and new recalculated data in time series.

__Table 3.80:__ Comparison and effect of recalculations in international aviation transport

THE DIFFERENCE BETWEEN THE NEW (2017) AND THE OLD (2016) SUBMISSION IN 1.D.1.a										
YEAR	EMISSIONS (Gg)									
	CO_2		CH_4		N_2O		CO_2 eq.		Difference
	2016	2017	2016	2017	2016	2017	2016	2017	
1990	63.10	67.08	0.00	0.00	0.00	0.00	63.75	67.64	6%
1991	58.68	62.37	0.00	0.00	0.00	0.00	59.28	62.89	6%
1992	54.25	57.66	0.00	0.00	0.00	0.00	54.80	58.14	6%
1993	53.14	56.45	0.00	0.00	0.00	0.00	53.68	56.92	6%
1994	44.78	47.60	0.00	0.00	0.00	0.00	45.23	47.99	6%
1995	45.04	47.85	0.00	0.00	0.00	0.00	45.50	48.25	6%
1996	53.16	56.45	0.00	0.00	0.00	0.00	53.70	56.92	6%
1997	47.08	49.99	0.00	0.00	0.00	0.00	47.56	50.41	6%
1998	43.41	46.09	0.00	0.00	0.00	0.00	43.86	46.47	6%
1999	43.80	46.52	0.00	0.00	0.00	0.00	44.25	46.91	6%
2000	44.51	47.34	0.00	0.00	0.00	0.00	44.97	47.73	6%
2001	41.86	44.56	0.00	0.00	0.00	0.00	42.29	44.93	6%
2002	43.46	46.28	0.00	0.00	0.00	0.00	43.91	46.67	6%
2003	57.46	61.04	0.00	0.00	0.00	0.00	58.05	61.55	6%
2004	77.68	82.28	0.00	0.00	0.00	0.00	78.48	82.97	6%
2005	141.46	139.44	0.00	0.00	0.00	0.00	142.91	140.60	-2%
2006	169.22	166.13	0.00	0.00	0.01	0.00	170.96	167.51	-2%
2007	176.95	173.65	0.00	0.00	0.01	0.00	178.77	175.09	-2%
2008	198.07	194.57	0.00	0.00	0.01	0.01	200.11	196.19	-2%
2009	146.21	143.19	0.00	0.00	0.00	0.00	147.71	144.38	-2%
2010	134.81	132.16	0.00	0.00	0.00	0.00	136.19	133.27	-2%
2011	138.12	135.08	0.00	0.00	0.00	0.00	139.53	136.21	-2%
2012	123.27	120.21	0.00	0.00	0.00	0.00	124.54	121.21	-3%
2013	115.25	112.17	0.00	0.00	0.00	0.00	116.43	113.11	-3%
2014	120.95	118.44	0.00	0.00	0.00	0.00	122.19	119.43	-2%

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 22.12 Gg of CO_2 eq. in 2015. The decrease is significant in comparison with the base year but the interannual fluctuations are visible also in recent years.

__Table 3.81:__ Overview of the GHG emissions inventory in international shipping in 2015

SHIPPING COMPANIES	SALE OF DIESEL OIL		EMISSIONS		
	(TJ)	(t)	CO_2	CH_4	N_2O
Slovak Shipping and Ports (Danube)	250.56	5 945.38	18 566.20	1.75	0.50
Slovak Water Management Enterprise	0.00	0.00	0.00	0.00	0.00
Other companies	2.00	47.52	148.40	0.01	0.00

SHIPPING COMPANIES	SALE OF DIESEL OIL		EMISSIONS		
	(TJ)	(t)	CO_2	CH_4	N_2O
International shipping companies	42.82	1 016.00	3 172.76	0.30	0.09
TOTAL	**295.38**	**7 008.90**	**21 887.36**	**2.07**	**0.59**

The Slovak Republic used tier 1 methodology based on the IPCC 2006 GL. The emissions of greenhouse gases are calculated from the consumed fuel by diesel motor boats multiplied by emission factor. The country specific NCVs were used to convert the quantity of fuel consumption in energy units. The NCVs for diesel fuel blended are shown in the ***Table 34*** in the chapter 3.2.8.1 of this report. According to the UNFCCC recommendations E.11 and E.21 (SVK ARR 2016), 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 the ***Table 3.82***.

Table 3.82: *The default emission factors used in navigation for time series*

PARAMETER	EMISSIONS FACTORS (kg/TJ)	
EMISSIONS	DOMESTIC NAVIGATION	INTERNATIONAL NAVIGATION
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, Devin and Komarno 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.

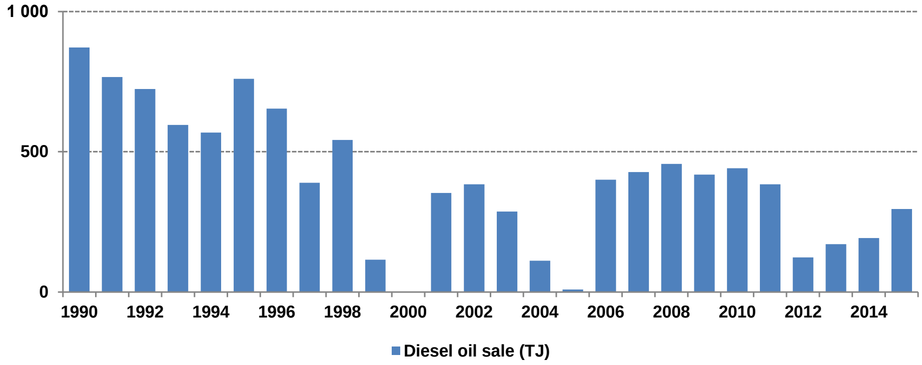
The GHG emissions from diesel oil sold to international transportation in the important Slovak ports Bratislava and Komárno were balanced is shows in the ***Table 3.83***.

Table 3.83: *GHG emissions balance of diesel oil sold for shipping companies in particular years*

YEAR	CONSUMPTION		EMISSIONS (t)			
	(t)	(TJ)	CO_2	CH_4	N_2O	Total 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	0.00	0.00	0.0	0.00	0.00	0.0
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
2011	9 101.22	384.13	28 463.7	2.69	0.77	28 759.9
2012	2 913.29	122.96	9 111.2	0.86	0.25	9 206.0
2013	4 050.30	170.23	12 614.3	1.19	0.34	12 745.6
2014	4 576.00	192.39	14 256.0	1.35	0.38	14 404.3
2015	7 008.90	295.38	21 887.4	2.07	0.59	22 115.1

The sources of activity data for the period 1994 – 2015 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 3.36: *Overview of diesel oil consumption (TJ) for shipping transport in 1990 – 2015*



3.6.2.1 Source specific recalculations

The fuel consumption in energy unit was recalculated by using country specific NCVs for the years 1990 – 2014 (based on the Statistical Office of the Slovak Republic). Emissions of CO_2, CH_4 and N_2O were recalculated for time series by using default emission factors (tier 1 methodology). The default emission factors used in 2017 submission meet the requirements of consistency better than the emission factors used in previous submissions. The differences are shown in the ***Table 3.84*** below.

Table 3.84: *The difference between the new (2017) and the previous (2016) submission in 1.D.1.b*

YEAR	EMISSIONS (Gg)								
	CO_2		CH_4		N_2O		CO_2 eq.		Difference
	2016	2017	2016	2017	2016	2017	2016	2017	
1990	65.35	64.58	0.01	0.01	0.00	0.00	66.09	65.25	-1%
1991	57.38	56.76	0.00	0.01	0.00	0.00	58.03	57.35	-1%
1992	54.20	53.61	0.00	0.01	0.00	0.00	54.81	54.17	-1%
1993	44.63	44.13	0.00	0.00	0.00	0.00	45.14	44.58	-1%
1994	42.68	42.12	0.00	0.00	0.02	0.00	48.21	42.56	-12%
1995	57.59	56.33	0.00	0.01	0.02	0.00	65.06	56.91	-13%
1996	49.06	48.44	0.00	0.00	0.02	0.00	55.42	48.94	-12%
1997	29.22	28.83	0.00	0.00	0.01	0.00	33.01	29.13	-12%
1998	40.85	40.17	0.00	0.00	0.02	0.00	46.14	40.58	-12%
1999	8.61	8.54	0.00	0.00	0.00	0.00	9.73	8.63	-11%
2000	NO	NO	NO	NO	NO	NO	NO	NO	NO
2001	26.67	26.17	0.00	0.00	0.01	0.00	30.13	26.44	-12%
2002	28.78	28.43	0.00	0.00	0.01	0.00	32.51	28.72	-12%
2003	21.79	21.28	0.00	0.00	0.01	0.00	24.62	21.50	-13%
2004	8.48	8.28	0.00	0.00	0.00	0.00	9.58	8.37	-13%
2005	0.68	0.67	0.00	0.00	0.00	0.00	0.77	0.67	-12%
2006	30.22	29.64	0.00	0.00	0.01	0.00	34.13	29.95	-12%
2007	32.31	31.71	0.00	0.00	0.01	0.00	36.50	32.04	-12%
2008	34.51	33.86	0.00	0.00	0.01	0.00	38.98	34.21	-12%
2009	31.62	31.02	0.00	0.00	0.01	0.00	35.71	31.35	-12%
2010	33.32	32.69	0.00	0.00	0.01	0.00	37.57	33.03	-12%
2011	29.01	28.46	0.00	0.00	0.01	0.00	32.77	28.76	-12%
2012	9.29	9.11	0.00	0.00	0.00	0.00	10.49	9.21	-12%
2013	12.91	12.61	0.00	0.00	0.01	0.00	14.59	12.75	-13%
2014	14.59	14.26	0.00	0.00	0.01	0.00	16.48	14.40	-13%

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:

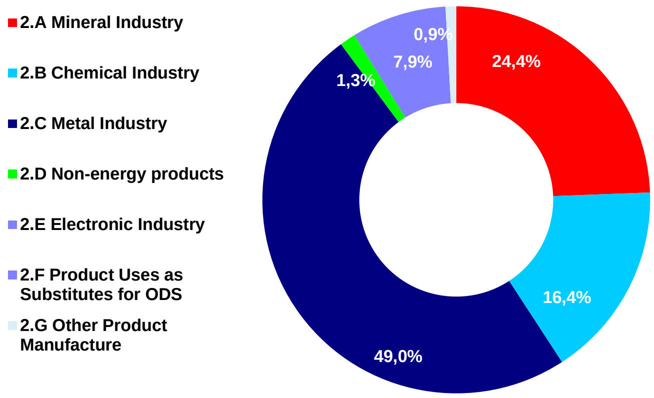
INSTITUTE	CHAPTER	SECTORAL EXPERT
Slovak Technical University	All chapters	Vladimir Danielik

4.1 OVERVIEW OF THE SECTOR

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 2015, total aggregated GHG net emissions from the sector of industrial processes and product use were 9 285.16 Gg of CO_2 eq. and they increased compared with the previous year by approximately 2.4%. Compared to the base year 1990 the emissions decreased by 5.4%. CO_2 is the most important gas with the share of 90%, followed by F-gases (8%) and N_2O emissions (2%) shares. The most important emission sources are categories of metal production (49%), mineral products (24%), chemical industry (16%) and substituents for ODS (8%). Other product manufacture and non-energy products categories shares 1% and 1%, respectively. The most important source of N_2O emissions are categories nitric acid production and N_2O from Product Uses, which share almost the total amount of N_2O emissions with the ratio near to 2:1 (***Figure 4.1***).

Figure 4.1: *The share in emissions of individual categories in sector industrial processes in 2015*



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 2015 is presented in ***Table 4.1***.

Table 4.1: *GHG gases reported in IPPU sector according to the CRF categories in 2015*

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
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	T1	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

CATEGORY (CODE AND NAME)	METHODOLOGY/TIER	GHG GASES REPORTED
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

4.1 OVERALL TRENDS IN INDUSTRIAL PROCESSES

Energy intensity of industrial processes in the Slovak Republic decreased significantly in comparison with the base year 1990. Between 2003 and 2015, substantial energy savings were made, while the sharp GDP growth was recorded in Slovakia. Also in 2015 a slow decrease in energy intensity of industry by 3.7% occurred (in the level of gross inland energy consumption). However, the energy intensity of industrial processes sector in Slovakia is still relatively higher in comparison with the EU average. This is caused by the historical structure of industrial production.

The decreasing trend in the final energy consumption in this sector is characterized by the decrease in total energy consumption. This represents the 32.5% share of total final energy consumption in Slovakia. The following branches of industrial sector contribute significantly to fuel and energy consumption: metallurgy 32%, energy industry 32%, chemical industry 11%, pharmaceutical industry 11%, wood processing 4%, machinery 3%, textile 2%, electro-production, glass production and leather and shoemaking approximately 1% for each of them.

The structure of Slovak industry has been stabilized after the implementation of significant changes prior to the EU membership. The share of mining, distribution of electricity, gas and water has been reduced (on VAT generation) and recently is comparable with other developed countries.

In 2015, the industrial production indicated a moderate increase in the dynamics of growth in comparison with the base year. This was caused by the increase of production in following activities: manufacture of coke and refined petroleum products; pulp and paper industry; production of plastics and rubber products and predominantly, in car production, with the dynamics increase above 7%. On the other hand, the decrease in domestic demand has continued in the production of chemicals, chemical products and chemical fibres; foodstuffs, beverages and tobacco products; pharmaceuticals and medicinal chemicals; manufacture of basic metals and electricity, gas, steam and air conditioning and nuclear fuel.

The industrial production and emissions were influenced by the world economic crisis in 2009 and at the beginning of the year 2009 also with a gas crisis. The decrease in almost all industrial categories was visible and represented in general by almost 20% reduction compared to the year 2008. The decrease in CO_2 emissions was more than 16% and in N_2O emissions more than 18%. However, the 4% increase in CH_4 emissions was caused by increasing emissions in ammonia production. The decrease in mineral product industry was 24%, in chemical industry 10% and in metal industry 16%. The re-start-up of economy has been visible since 2010, but according to the current results, the recovery of industrial production was not fully finished and the productivity decrease is still continuing in several industrial categories in 2015.

The overview of emission trends in gases and categories is provided in the ***Tables 4.2*** and ***4.3*** and ***Figures 4.2*** and ***4.3***.

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

YEAR	SECTOR IPPU (Gg of CO_2 *eq.*) ACCORDING TO GASES			
	CO_2 EMISSIONS	CH_4 EMISSIONS	N_2O EMISSIONS	HFC, PFC and SF_6
1990	8339.50	0.32	1158.31	314.92
1995	8 075.98	0.37	1 150.86	156.12
2000	7 423.40	0.66	1 037.12	133.00
2005	8 604.65	1.00	1 318.38	333.53
2010	8 020.01	1.20	946.86	641.88
2011	8 074.35	1.46	478.26	645.93
2012	8 067.89	1.40	378.69	675.10
2013	7 913.98	1.63	252.31	678.99
2014	8 158.29	1.71	225.26	679.16
2015	8 317.13	1.77	208.56	757.70

***Table 4.3:** GHG emissions in the IPPU individual categories in particular years*

YEAR	SECTOR IPPU (Gg of CO_2 *eq.*) ACCORDING TO CATEGORIES						
	2.A	2.B	2.C	2.D	2.E	2.F	2.G
1990	2 714.02	2 019.80	4 900.90	161.88	NO	NO	16.45
1995	2 070.94	2 383.51	4 749.59	126.01	NO	13.32	39.95
2000	2 230.10	2 392.92	3 717.46	114.82	NO	106.46	32.40
2005	2 631.81	2 719.87	4 413.45	99.61	NO	293.43	99.39
2010	2 041.27	2 172.89	4 597.96	103.30	NO	597.24	97.28
2011	2 448.16	1 969.15	3 973.15	110.81	NO	605.03	93.71
2012	2 220.57	1 654.97	4 412.13	98.22	NO	628.20	109.00
2013	2 132.25	1 600.55	4 204.48	118.21	NO	646.88	144.53
2014	2 277.12	1 364.75	4 552.77	121.75	NO	653.84	94.20
2015	2 265.07	1 525.17	4 553.91	123.70	NO	734.88	82.42

***Figure 4.2:** Emission trend in IPPU sector in individual gases (Gg of CO_2 eq.) in 1990 – 2015*

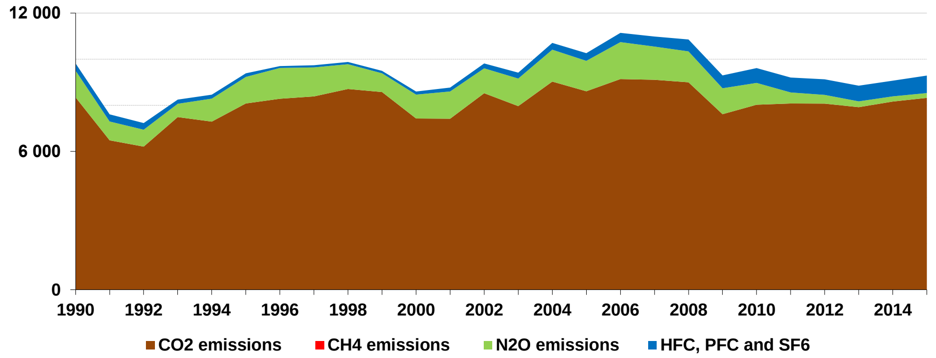
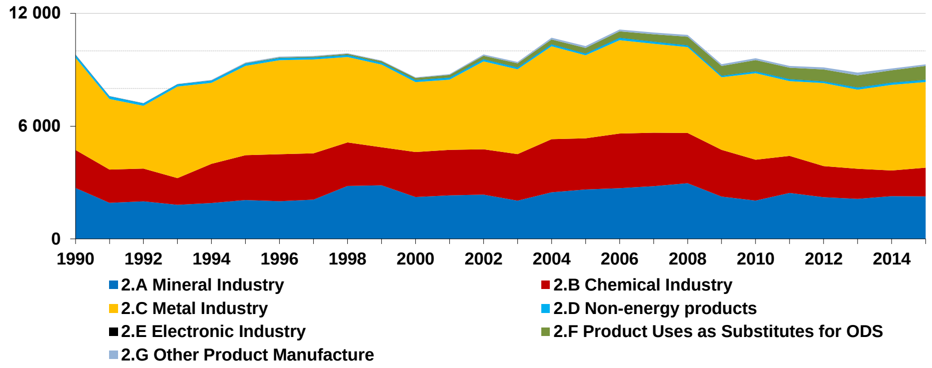


Figure 4.3: *Emission trend in IPPU sector in individual categories (Gg of CO_2 eq.) in 1990 – 2015*



4.2 UNCERTAINTY ANALYSES

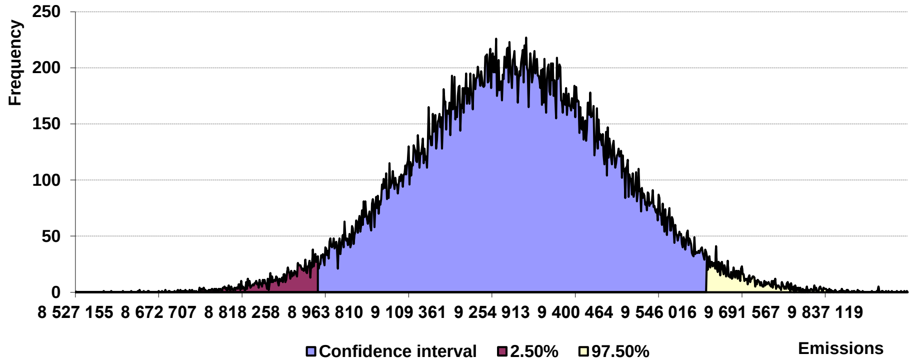
Aggregated uncertainty is computed from partial uncertainties. Every category is computed from disaggregated data. The data are split by emission factors or by technological processes. Computed uncertainties are aggregated consecutively to the total uncertainty of sector. The results of every category 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 were 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 EU ETS reports are taken from the criteria presented in EU ETS reports (uncertainty of scales, of laboratory analysis, *etc.*); (ii) uncertainty of data that are not covered by EU ETS reports was assumed as default values from 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 industry sector and its subsectors following the mentioned assumptions can be seen in the text below.

Table 4.4: *Selected statistical characteristics for IP sector, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2 eq.)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
9 293 190	**9 293 121**	173 699	8 527 155	9 982 670	-3.66%	3.63%

[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)

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



Several uncertainties for EFs are country specific and were used in the overall tier 2 uncertainty preparation. The average mean value of GHG emissions for the Industrial Processes and Product Use sector obtained by the Monte Carlo simulation is 9 293 Gg of CO_2 eq. in 2015. The average mean value is comparable with the tier 1 result of the GHG emissions expressed in CO_2 eq., which is 9 285 Gg. Confidence interval (95%) is represented by the relative values to the mean: (-3.66%; +3.63%). The utilizing of normal distributions almost for every category has influence to the shape of total uncertainty. Several updates and changes in methodology for emission estimation in industrial processes were considered also in uncertainty analyses. Several input data were reviewed and QA check was improved.

4.3 SECTOR SPECIFIC QA/QC AND VERIFICATION PROCESSES

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 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). 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 sectoral inventory preparation in October and November (year X+1). Following QC activities are provided during data collection step:

- comparison with the information provided by the Statistical Office of the Slovak Republic,
- comparison with the information provided by the different associations of producers (if existent),

- comparison with the available information in EU ETS reports (if existent).

Further QC activities during the sectoral inventory preparation:

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

Any discrepancies are directly discussed with subject or data providers. Draft of the sectoral GHG emissions inventory is prepared in the middle of November (year X+1). Quality assurance activities are performed on the draft of the sectoral inventory and 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). 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 SHMU 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 1 308.20 Gg. All sources reported in this category are included in the EU ETS. The emissions reported in the national inventory were nearly the same (difference +0.37 Gg). 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 are recorded according to the category of products. In 2015, there are 5 plants included in "others" (2 sugar plants, 2 pulp and paper 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 1.4 Gg of CO_2 (higher emissions are in GHG inventory, difference in percentage of 1.2%). The difference is caused by using of LKD factor in inventory (one plant did not reported LKD factor in EU ETS).

Glass Production - All sources reported in this category are included in the EU ETS and final emissions are almost the same as in the GHG inventory (the difference is 0.02 Gg).

Ceramics - The EU ETS covers all operators reported in this category. CO_2 emissions reported in the EU ETS reports are 14.24 Gg. The same value is reported also in the GHG inventory.

Magnesia Production - All sources reported in this category are included in the EU ETS. CO_2 emissions reported in the EU ETS reports were 246.91 Gg in 2015; the difference with the GHG inventory is caused only by rounding.

Other Carbonates - All sources reported in this category are included in the EU ETS. CO_2 emissions reported in the EU ETS reports were 34.56 Gg in 2015, which is the same value as was estimated in the GHG inventory.

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. Mathematical model of the ammonia synthesis unit (including production of synthesis gas) was developed and the results were compared with the measurements results (provided by producer).

Nitric Acid Production - Activity data are from the EU ETS reports and information provided by the operators in questionnaires (requested by the SNE) is compared with the measurements 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.

Ethylene 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.

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 is made for the integrated iron and steel company that represents the biggest source of CO_2 emissions in 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 this chapter and in the Annex 4.1 of this report. The difference between emissions calculated from these two sources is 0.04% in 2015.

Ferroalloys Production - Activity data are compared with the information from the Statistical Office of the Slovak Republic (ferroalloy production). Another source used for verification is the U.S. Geological Survey (www.usgs.gov). The data for the time period 1990 – 2011 were available and were compared with the results estimated in our national GHG inventory. The consistency of the whole time series was verified.

Aluminium Production - Activity data and emissions are 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 aluminium production in Slovakia is 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 Statistical Office of the Slovak Republic. Due to the lack of appropriate statistical information and methodological advises in the IPCC 2006 GL, inputs were taken directly from the questionnaires sent to operators and producers of solvents in the Slovak Republic. 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 Emission Reduction of Non-Methane Volatile Organic Compounds in the Slovak Republic and adopted from CLRTAP inventory.

QA/QC activities and verification process for F-gases is provided in the chapter 4.12.6 of this report.

4.4 CATEGORY-SPECIFIC RECALCULATIONS

Recalculations and reallocations made in IPPU sector were provided and implemented in the line with the Improvement and Prioritization Plan reflecting recommendations made during previous reviews. Recalculations for F-gases are provided in the chapter 4.12.7 of this report.

NUMBER	CATEGORY	DESCRIPTION	REFERENCE
1.	2.D.3	NMVOC recalculations resulted in recalculation of CO_2 emissions in this category.	Chapter 4.10 of this report

Ad. 1: Recalculations focused on the NMVOC emissions from road paving with asphalt, solvent use (coating applications; degreasing and dry cleaning; chemical products, manufactured and processing) have been done since the base year 1990 in the CLRTAP inventory. The NMVOC emissions were adopted from there which resulted in the recalculation of indirect CO_2 emissions. Influence of recalculation is presented in the following ***Table 4.5***. More information about recalculations in NMVOC emissions can be found in the CLRTAP official submission 2017 (15. February).

Table 4.5: *Summary of the recalculations and changes in 2.A-2.D categories - influence of the recalculation on the NMVOC in 2.D.3 category*

YEAR	SUBMISSION 2016 v3		SUBMISSION 2017 v2		CHANGES IN CO_2 (%)
	NMVOC (kt)	CO_2 (Gg)	NMVOC (kt)	CO_2 (Gg)	
1990	52.82	111.99	93.72	111.39	-0.54%
1991	44.40	91.45	86.32	94.23	3.04%
1992	37.90	74.77	79.77	79.41	6.20%
1993	34.75	66.40	75.54	71.30	7.37%
1994	36.12	67.90	74.86	71.12	4.74%
1995	36.80	72.23	73.81	75.52	4.55%
1996	33.59	63.94	70.69	68.83	7.66%
1997	28.99	52.33	65.67	58.44	11.68%
1998	29.89	54.88	64.49	60.34	9.95%
1999	28.14	50.22	61.27	55.47	10.44%
2000	26.72	46.48	62.71	64.33	38.40%
2001	51.24	51.43	59.22	62.23	21.01%
2002	55.18	56.32	61.64	70.43	25.06%
2003	54.54	59.75	58.73	66.46	11.23%
2004	56.39	64.84	60.33	77.38	19.34%
2005	54.14	66.82	50.83	69.44	3.92%
2006	60.18	69.77	59.89	87.96	26.08%
2007	60.07	67.88	54.02	70.35	3.63%
2008	58.68	69.21	55.13	70.43	1.76%
2009	51.26	68.49	51.17	70.31	2.66%
2010	56.69	66.36	67.94	88.37	33.18%
2011	58.04	77.56	60.30	90.39	16.54%
2012	51.35	64.68	49.96	68.60	6.06%
2013	41.80	67.32	46.14	83.16	23.52%
2014	43.80	68.02	45.73	92.00	35.26%

4.5 CATEGORY-SPECIFIC IMPROVEMENTS AND IMPLEMENTATION OF RECOMMENDATIONS

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

- During the ESD review 2017 (SK-2C1-2017-0001), the technical expert review team reflecting the EU Inventory under the UNFCCC in September 2016, pointed out that pig iron production in Slovakia 2014 was 24 kt and seemed not to correspond to the emissions level from 2.C.1 category – 4 025 kt CO_2. The ERT noted that the pig iron production in Slovakia according to the Steel Statistical Yearbook 2015 of Worldsteel Association was 3 838 kt of pig iron in 2014. The mass of pig iron reported in 2.C.1 in national inventory is lower than this information. The reason is, that reported value is the amount of pig iron that was NOT PROCESSED into steel. The Steel Statistical Yearbook 2015 of Worldsteel Association presents total pig iron production in Slovakia. The methodology used in Slovakia is based on the material balance and needs to take into account the pig iron that is not converted into steel. More information can be find in chapter 4.9 of this report.
- Improvements are planned in category 2.D.3 based on results of CLRTAP inventory review what will take place in 2017.

Planned improvements for F-gases are provided in the chapter 4.12.8 of this report.

Improvements are implemented in line with the Improvement and Prioritization Plan for the year 2017.

4.6 MINERAL PRODUCTS (CRF 2.A)

4.6.1 SOURCE CATEGORY DESCRIPTION

The major share of CO_2 emissions comes from the production and transformation of mineral products. Total emissions were 2 265.07 Gg of CO_2 in 2015 (only CO_2 emissions are reported in this category), almost the same as in previous year 2014. Compared to 1990, the decrease in mineral production is approximately 16%. Major trend behind the decrease in mineral production is decrease in demand of products.

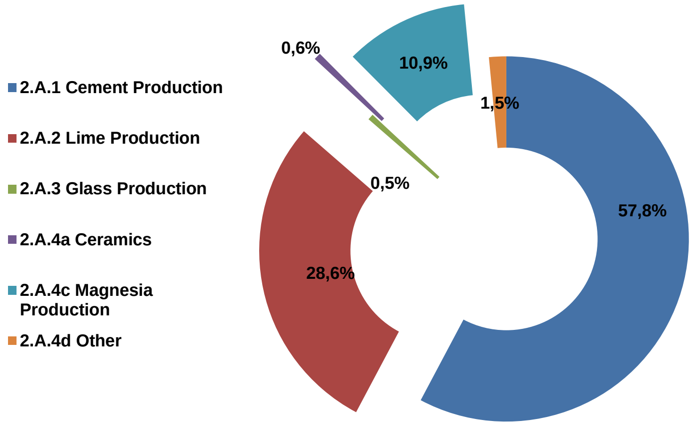
The major share of emissions in this category belongs to cement production (57.8%), lime production (28.6%) and dead burned magnesia production (10.9%). The ceramics production shared 0.6% and glass production is only 0.5%. The rest of emissions (1.5%) are reported in other category. Emissions in 2.A.4.b are not occurring.

Table 4.6: *CO_2 emissions in the category 2.A by categories (Gg) 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
1990	1 464.50	794.92	7.88	14.79	431.94	0.00
1995	1 154.63	593.23	18.01	11.04	294.03	0.00
2000	1 190.45	556.73	22.82	10.36	409.82	39.92
2005	1 256.40	810.82	33.04	13.06	476.01	42.49
2010	859.92	751.98	13.15	12.75	376.35	27.13
2011	1 261.79	761.23	11.83	11.65	363.83	37.83
2012	1 095.93	735.57	11.46	12.93	318.04	46.65
2013	1 135.27	662.16	13.22	14.94	279.56	27.10

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
2014	1 266.76	666.84	12.26	12.99	278.33	39.94
2015	1 308.57	648.00	11.93	14.24	247.76	34.56

Figure 4.5: *The share in CO_2 emissions of individual categories in 2.A in 2015*



4.6.2 CEMENT PRODUCTION (CRF 2.A.1)

Cement production plants in the Slovak Republic (4 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 verifiers´ reports. Presented parameters are weighted averages. Total CO_2 emissions from cement clinker production were 1 308.57 Gg in 2015 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 11%. The reasons for declining trend are described in the previous section of this report.

Table 4.7: *Activity data and CO_2 emissions in 2.A.1 (Gg) in particular years*

YEAR	CEMENT CLINK PRODUCTION (kt)	CaO CONTENT	MgO CONTENT	CORRECTION FACTOR	CO_2 EMISSIONS (Gg)	IEF (CO_2) (t/t)
1990	2 835.75	64.60%	*	1.0184	**1 464.50**	0.5164
1995	2 235.75	64.60%	*	1.0184	**1 154.63**	0.5164
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

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

4.6.2.1 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 methodology 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 on the basis of cement clinker production and CaO and MgO contents. The data required for calculation of CO_2 emissions are summarized in ***Table 4.8*** (C = confidential, but available for the sectoral experts).

Table 4.8: *Input data used for the CO_2 emissions estimation in 2.A.1 in 2015*

PLANT/OPERATOR	CEMENT CLINK	CaO CONTENT	MgO CONTENT	CORREC-TION FACTOR	CO_2
	kt	%	%		Gg
Cemmac	C	65.52%	1.60%	0.9845	200.88
VSH (CRH)	C	64.57%	4.09%	0.7144	170.09
CRH – Portland	C	65.32%	2.43%	1.0154	500.85
CRH – white	C	66.79%	2.39%	1.0310	62.32
Považská cementáreň	C	66.86%	2.40%	1.0198	374.43
TOTAL	**2 506.12**	**65.70%**	**2.58%**	**0.9600**	**1 308.57**

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 0.5221 t CO_2/t of cement clink in 2015 (correction factor is also included in this value). Correction factors provided in ***Table 4.8*** consist of CKD (Cement Kiln Dust) and the amounts of non-carbonate origin of CaO and MgO (using of ground granulated blast-furnace slag). All these data are plant-specific.

$$\text{Corr.factor} = \text{CKD} * \frac{(0.785 * \%\text{CaO}_c + 1.092 * \%\text{MgO}_c) * m_c - (0.785 * \%\text{CaO}_s + 1.092 * \%\text{MgO}_s) * m_s}{(0.785 * \%\text{CaO}_c + 1.092 * \%\text{MgO}_c) * m_c}$$

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.

Based on data supplied by plants in the EU ETS reports, total CO_2 emissions from cement production were 1 308.57 Gg and the IEF was 0.5221 t/t of clinker. Total production of cement clinker was 2 506.12 kt in 2015.

4.6.2.2 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 on the basis of stoichiometry.

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. Correction factor reflects it in calculation. CKD 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, correction factor does not include correction for slag.

There were totally 5 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 4 cement sites did not produce cement clinker. During the period 1990 – 2015 no changes in technologies were made in plants; only the changes in composition of the clinker and use of raw materials (slag) occurred.

Country specific value of cement clink mass uncertainty (1.5%) and country specific value of cement clink composition uncertainty (2%) were used in uncertainty analyses by Monte Carlo method for this category. The overall uncertainty of CO_2 emissions was calculated in interval (-2.87%; +2.88%).

Following formula was used for Monte Carlo simulation (uncertainties are represented by Δ symbol in formula):

$$Emissions = (clinker \pm \Delta clinker) * \sum_i [(content of CaO \pm \Delta CaO) * 0.785 +$$

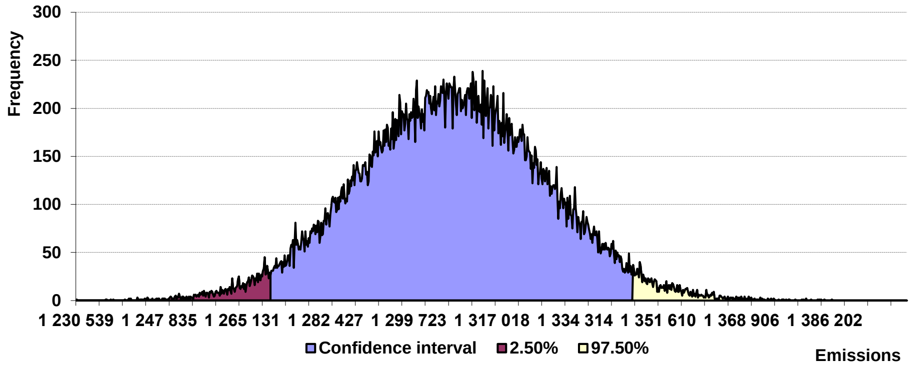
$$(content of MgO \pm \Delta MgO) * 1.092] * (cor\_f \pm \Delta\Delta cor)$$

During the uncertainty computation the relation between the content of CaO and the content of MgO is verified. It means that the sum of CaO and MgO contents cannot exceed the value 1 in cement clink. This correlation is integrated to the computational procedure. The average mean value of GHG emissions in 2.A.1 obtained by the Monte Carlo simulation is 1 309 Gg CO_2 per year 2015. The average mean value is comparable with the real CO_2 emissions in 1.A.1, which is 1 309 Gg CO_2.

Table 4.9: *Selected statistical characteristics for 2.A.1, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
1 308 600	**1 308 609**	19 276	1 230 539	1 403 498	-2.87%	2.88%

Figure 4.6: *Probability density function for 2.A.1 (t of CO_2)*



4.6.3 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 3% when compared with the previous year and were 648.00 Gg in 2015. The decrease in emissions by 19% is achieved when compared with the base year.

Table 4.10: *Activity data and CO_2 emissions in 2.A.2 (Gg) in particular years*

YEAR	LIME PRODUCTION (kt)	CO_2 EMISSIONS (Gg)	CaO CONTENT
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 (kt)	CO_2 EMISSIONS (Gg)	CaO CONTENT	MgO CONTENT	"HYPOTHETIC" CaO CONTENT
2001	815.96	602.80	90.56%	0.47%	91.20%
2005	1 041.71	810.82	89.91%	4.45%	96.10%
2010	952.60	751.98	87.71%	7.01%	97.46%
2011	971.62	761.23	86.72%	7.19%	96.73%
2012	932.11	735.57	80.37%	12.30%	97.43%
2013	849.29	662.16	88.19%	5.79%	96.24%
2014	852.60	666.84	87.64%	6.56%	
2015	828.16	648.00	88.26%	6.14%	

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

4.6.3.1 Methodological issues

Table 4.10 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" will be no more present in ***Table 4.10*** 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 4.11***.

Based on availability of information, the plant specific emission factors have been used since 2001. The annual estimation of overall EFs was calculated as weighted average and is based on purity of lime in each producer and varies over the years. The implied CO_2 emission factor is 0.782 t CO_2/t of lime in 2015 (correction factor is included in the IEF). Total CO_2 emissions decreased only slightly and were 648.00 Gg in 2015. Correction factor presented in ***Table 4.10*** 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 828.16 kt in 2015. Activity data used for inventory are summarized in ***Table 4.11***. Large and medium producers provided activity data in their EU ETS reports or reports from verifiers, small plants like sugar and paper producers provided activity data based on questionnaires to the SNE.

Table 4.11: *Activity data necessary for the CO_2 emissions estimation in 2.A.2 in 2015*

PLANT	LIME PRODUCTION (kt)	CaO CONTENT	MgO CONTENT	LKD	CO_2 EMISSIONS (Gg)
Calmit	C	92.23%	0.83%	1.0057	97.13
Dolvap Varín	C	82.64%	10.25%	1.0200	72.49
Carmeuse	C	86.19%	8.94%	1.0440	327.04
Others*	C	92.50%	2.00%	1.0200	151.34
TOTAL	**828.16**	**88.26%**	**6.14%**	**1.0297**	**648.00**

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

4.6.3.2 Uncertainties and time-series consistency

Time series consistency is assured by using the "hypothetic" CaO content during the period 1990 – 2000 as explained in details 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 and pulp and paper 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.

Country specific value of lime mass uncertainty (1.5%) and default value of uncertainty in CaO and MgO contents in lime (2%) were used in uncertainty analyses by Monte Carlo method for this category. Based on calculation, the overall uncertainty of CO_2 emissions was calculated in interval (-3.95%; +3.99%). Following formula was used for Monte Carlo simulation (uncertainties are represented by Δ symbol in formula):

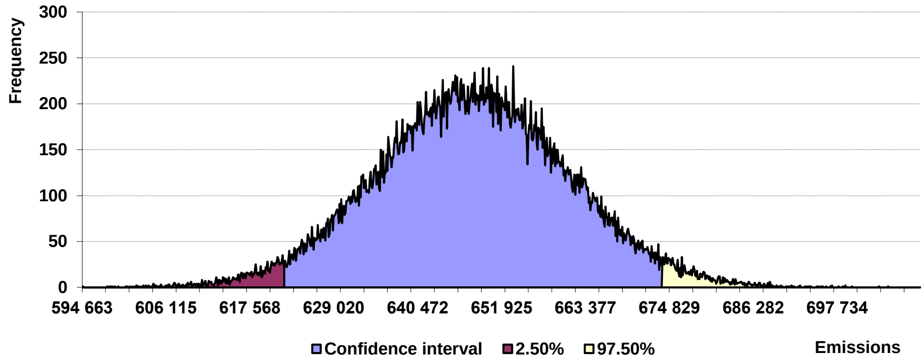
$$\text{Emissions} = (\text{lime} \pm \Delta\text{lime}) * \sum_i \left[(\text{content of CaO} \pm \Delta\text{CaO}) * 0.785 + (\text{content of MgO} \pm \Delta\text{MgO}) * 1.092 \right] * (\text{cor\_f} \pm \Delta\Delta\text{cor})$$

During the uncertainty computation, the relation between content of CaO and content of MgO is verified again. It means that the sum of CaO and MgO contents cannot exceed the value 1 in lime. This correlation is integrated to the computational procedure. The average mean value of GHG emissions in 2.A.2 obtained by the Monte Carlo simulation is 638 Gg CO_2 per year 2015. The average mean value is comparable with real CO_2 emissions, which is 648 Gg CO_2.

Table 4.12: *Selected statistical characteristics for 2.A.2, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
647 902	**647 936**	13 073	594 663	709 187	-3.95%	3.99%

Figure 4.7: *Probability density function for 2.A.2 (t of CO_2)*



4.6.4 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 11.93 kt in 2015. CH_4 and N_2O emissions are not estimated due to the lack of appropriate methodology and therefore notation key “NE” was used for the whole time series.

4.6.4.1 Methodological issues

CO_2 emissions from used carbonates were calculated by tier 3 methodology on the stoichiometry principle according to the IPCC 2006 GL. The calcination fraction was assumed to be 1.

Based on availability of information, the plant specific emission factors were used since 2004. The annual estimation of overall EF is expressed as weighted average and is based on stoichiometry of used carbonates and CO_2 emissions and varies over the years. Implied emission factor was 0.424 t/t of used carbonates mixture in 2015 or 0.035 t/t of glass produced. This value is much lower than the default factor 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 of recycled glass.

Glass production based on direct information from producers was as follows: 256 439.8 t of white glass and 85 356 t of green glass in 2015. No leaded glass was produced in 2015. Total amount of produced glass was 341 795.8 t. $SrCO_3$ and Li_2CO_3 were not used for glass production. Total amounts of used carbonates were 28.11 kt in 2015 and time series is presented in ***Table 4.13***.

Table 4.13: *Total amounts of used carbonates (kt) and CO_2 emissions (Gg) in particular years*

YEAR	USED CARBONATES (kt)								CO_2 (kt)
	$CaCO_3$	K_2CO_3	Na_2CO_3	$BaCO_3$	$MgCO_3$	$SrCO_3$	Li_2CO_3	Total	
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**

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

4.6.4.2 Uncertainties and time-series consistency

There were several operators producing glass (from 3 to 7) in Slovakia during the time series 1990 – 2015. 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 ton 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.

Country specific value of used carbonates uncertainty (1.5%) is used in uncertainty analyses by Monte Carlo method for this category. Based on calculation, the overall uncertainty of CO_2 emissions was calculated in interval (-0.78%; +0.78%). Following formula was used for Monte Carlo simulation (uncertainties are represented by Δ symbol in formula):

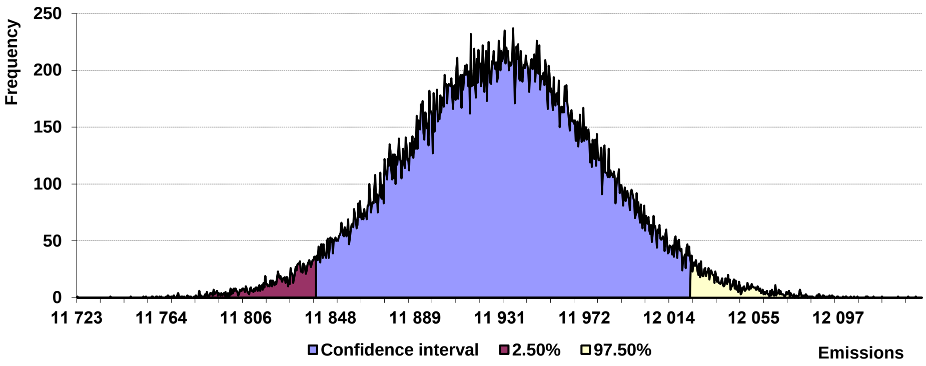
$$Emissions = \sum_{i} [(Na_2CO_3 \pm \Delta Na_2CO_3) * (0.415) + (K_2CO_3 \pm \Delta K_2CO_3) * 0.318 + (CaCO_3 \pm \Delta CaCO_3) * 0.44 + (BaCO_3 \pm \Delta BaCO_3) * 0.223 + (MgCO_3 \pm \Delta MgCO_3) * 0.522]$$

The accumulated uncertainty and statistical characteristics for glass production are presented in the following table and figure. The average mean value of GHG emissions in 2.A.3 obtained by the Monte Carlo simulation is 11.93 Gg per year 2015. The average mean value is comparable with the tier 1 CO_2 emissions in 1.A.3, which is 11.93 Gg CO_2.

Table 4.14: *Selected statistical characteristics for 2.A.3, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
11 931	**11 931**	48	11 723	12 139	-0.78%	0.78%

Figure 4.8: *Probability density function for 2.A.3 (t of CO_2)*



4.6.5 OTHER PROCESS USES OF CARBONATES – CERAMICS (CRF 2.A.4.a)

Ceramics includes the production of bricks and roof tiles, vitrified clay pipes, refractory products, expanded clay products, wall and floor tiles, table and ornamental ware (household ceramics), sanitary ware, technical ceramics, and inorganic bonded abrasives. Process-related CO_2 emissions reported from ceramics result from the calcination of carbonates in the clay, as well as from addition of additives. CO_2 emissions from ceramics production were 14.24 Gg CO_2 in 2015.

4.6.5.1 Methodological issues

CO_2 emissions from the used carbonates were calculated by tier 3 methodology according to the IPCC 2006 GL based on principle of the stoichiometry. The assumed calcination fraction was 1.

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 2015 was 0.464 t/t of used carbonates mixture. This approach was used for every year of time series.

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 30.71 kt in 2015 and time series is presented in ***Table 4.15***.

Table 4.15: *Total amounts of used carbonates (kt) and CO_2 emissions (Gg) in particular years*

YEAR	$CaCO_3$	$MgCO_3$	TOTAL CARBONATES	CO_2 EMISSIONS
	kt	kt	kt	Gg
1990	25.41	6.92	32.33	14.79
1995	17.19	6.66	23.85	11.04
2000	15.79	6.54	22.33	10.36
2005	21.80	6.64	28.44	13.06
2010	18.95	8.46	27.41	12.75
2011	16.61	8.32	24.93	11.65
2012	19.06	8.71	27.77	12.93
2013	22.76	9.43	32.19	14.94
2014	19.64	4.33	27.97	12.99
2015	21.83	8.88	30.71	14.24

4.6.5.2 Uncertainties and time-series consistency

The same tier approach is used for the time period 1990 – 2015. 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 (NIR 2014). Several (14) plants were reported in this category during time series, recently only 5 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 also decrease in production occurred in the other plants.

Default value of used carbonates uncertainty (2.5%) was used in uncertainty analyses by Monte Carlo method for this category. Based on calculation, the overall uncertainty of CO_2 emissions was calculated in interval (-1.22%; +1.23%). Following formula was used for Monte Carlo simulation (uncertainties are represented by Δ symbol in formula):

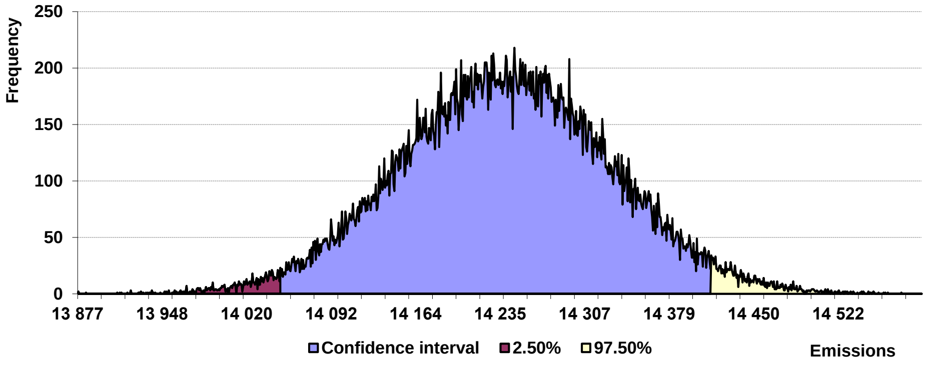
$$\text{Emissions} = \sum_i \left[(CaCO_3 \pm \Delta CaCO_3) * 0.44 + (MgCO_3 \pm \Delta MgCO_3) * 0.522 \right]$$

The accumulated uncertainty and statistical characteristics for ceramics production are presented in the following table and figure. The average mean value of GHG emissions in 2.A.4a obtained by the Monte Carlo simulation is 14.24 Gg CO_2 per year 2015. The average mean value is comparable with the real CO_2 emissions, which is 14.24 Gg CO_2.

Table 4.16: *Selected statistical characteristics for 2.A.4.a, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
14 240	**14 240**	89	13 877	14 594	-1.22%	1.23%

Figure 4.9: *Probability density function for 2.A.4.a (t of CO_2)*



4.6.6 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

4.6.7 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 247.76 Gg in 2015 and decreased by 11% when compared with the year 2014. When compared to 1990, the decrease is approximately 43%. 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).

4.6.7.1 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 – 2015 are summarized in ***Table 4.17***. CH_4 and N_2O emissions are not estimated due to lack of appropriate methodology and therefore notation key “NE” 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 550.04 kt in 2015. The composition of raw materials is summarized in ***Table 4.17***. 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 4.17: *Consumption and composition of magnesite raw materials (kt) and CO_2 emissions (Gg) in particular years*

YEAR	RAW MATERIALS USED (kt)	$MgCO_3$ CONTENT	$CaCO_3$ CONTENT	$FeCO_3$ CONTENT	CO_2 EMISSIONS (Gg)	EF (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

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

4.6.7.2 Uncertainties and time-series consistency

There were 6 plants producing magnesite clinker in Slovakia in 1990 – 2015. 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 is used for the whole time period 1990 – 2015. 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 are 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.

Default value of magnesite raw materials uncertainty (2%) and country specific value of $MgCO_3$, $CaCO_3$ and $FeCO_3$ contents uncertainty (2.5%) were used in uncertainty analyses by Monte Carlo method for this category. Based on calculation, the overall uncertainty of CO_2 emissions was calculated in interval (-2.69%; +2.71%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by Δ symbol in formula):

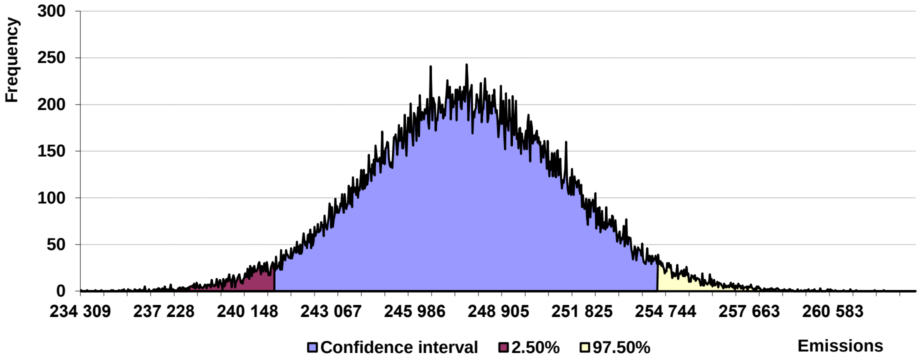
$$\text{Emissions} = (\text{raw mat.} \pm \Delta\text{raw mat.}) * \sum_{i} \left[(\text{content of } CaCO_3 \pm \Delta CaCO_3) * 0.440 + (\text{content of } MgCO_3 \pm \Delta MgCO_3) * 0.522 + (\text{content of } FeCO_3 \pm \Delta FeCO_3) * 0.380 \right]$$

The accumulated uncertainty and statistical characteristics for magnesite are presented in the following table and figure. The average mean value of GHG emissions in 2.A.4c obtained by the Monte Carlo simulation is 248 Gg CO_2 per year 2015. The average mean value is comparable with the real CO_2 emissions, which is 248 Gg CO_2.

Table 4.18: *Selected statistical characteristics for 2.A.4.c, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
247 751	**247 772**	3 409	234 309	263 502	-2.69%	2.71%

Figure 4.10: *Probability density function for 2.A.4.c (t of CO_2)*



4.6.8 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/t on consumed $CaCO_3$ and 522 kg CO_2/t on 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.

4.6.8.1 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 – 2015 are summarized in ***Table 4.19***.

Based on available information, 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 IEFs varies over the years. Implied emission factor in 2015 was 0.441 t/t of used carbonates mixture.

Total volume of carbonates used at desulphurization was 78.30 kt in 2015, the activity data are summarized in ***Table 4.19***. The consumption reached approximately the same level as in 2011 and decreased by 13% when compared with the previous year. The decrease is caused by partial closing of desulphurization unit in one coal plant. Total CO_2 emissions estimated in this category were 34.56 Gg.

Table 4.19: *Total carbonates used (kt) and CO_2 emissions (Gg) in 2.A.4.d in particular years*

YEAR	DESULPHURIZATION ($CaCO_3$)	DESULPHURIZATION ($MgCO_3$)	TOTAL CARBONATES	CO_2 EMISSIONS
	kt	kt	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	77.71	0.59	78.30	34.56

4.6.8.2 Uncertainties and time-series consistency

The same tier approach is used for the time period 1996 – 2015. Before 1996, no desulphurization technology was used in Slovakia. Data presented in ***Table 4.19*** 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 7 plants with desulphurization technology.

Country specific value of their composition uncertainty in $CaCO_3$ and $MgCO_3$ (2.5%) were used in uncertainty analyses by Monte Carlo method for this category. Based on calculation, the overall uncertainty of CO_2 emissions was calculated in interval (-1.73%; +1.73%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by Δ symbol in formula):

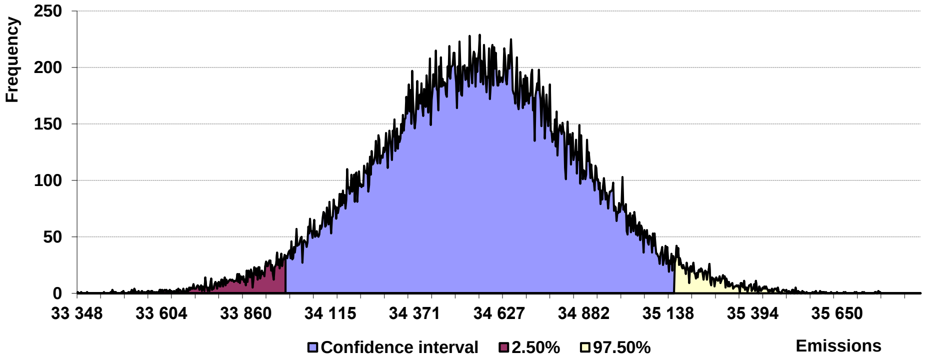
$$Emissions = \sum_{i} \left[(CaCO_3 \pm \Delta CaCO_3) * 0.440 + (MgCO_3 \pm \Delta MgCO_3) * 0.522 \right]$$

The emissions of desulphurization enter the calculation. Accumulated uncertainty and statistical characteristics for this category are presented in the following figure and table. The average mean value of GHG emissions in 2.A.4d obtained by the Monte Carlo simulation are 34.56 Gg CO_2 per year 2015. The average mean value is comparable with the real CO_2 emissions in 2.A.4d, which is 34.56 Gg CO_2.

Table 4.20: *Selected statistical characteristics for 2.A.4.d, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
34 561	**34 560**	305	33 348	35 905	-1.73%	1.73%

Figure 4.11: *Probability density function for 2.A.4.d (t of CO_2)*



4.7 CHEMICAL INDUSTRY (CRF 2.B)

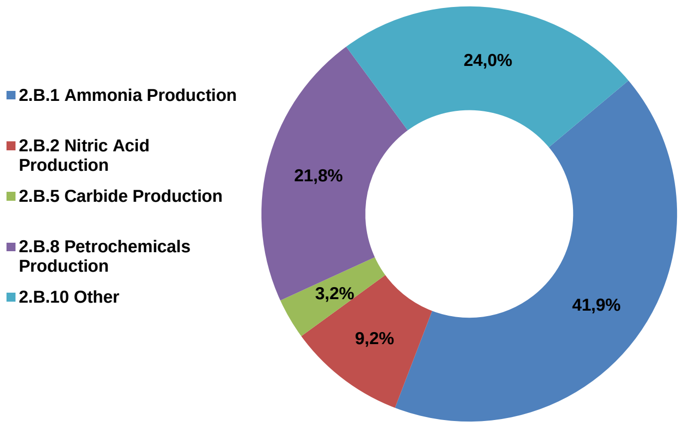
Production of ammonia is the major source of CO_2 emissions and nitric acid production is the major source of N_2O emissions in this category. Total GHG emissions reported in this category were 1 525.18 Gg of CO_2 eq. in 2015. The increase of emissions in the comparison with the previous year is approximately 12% and decrease of 25% in the comparison with the base year. The increase is caused by higher production of ammonia (by 21% in comparison with the previous year). 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 (41.9%) in emissions belongs to ammonia production, 24.0% belongs to hydrogen production (other), 21.8% belongs to petrochemicals production, 9.2% belongs to nitric acid production and 3.2% to carbide production.

Table 4.21: *Emissions in 2.B according to the categories (Gg of CO_2 eq.) 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
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

Figure 4.12: *The share in CO_2 emissions of individual subcategories in 2.B in 2015*



4.7.1 AMMONIA PRODUCTION (CRF 2.B.1)

Ammonia is basically 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 4.22***.

4.7.1.1 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 (34.955 in 2015); CCF is content of carbon in the fuel in t/TJ (15.197 in 2015) and OF is oxidation factor of the fuel (1). It should be noted, that parameters (NCV, EF) used for natural gas are the same as presented in the energy sector. $R(CO_2)$ 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. Emissions from the use of urea are reported in Agriculture sector, category 3.H Urea application and in 2.D.3 Other (using of urea in urea-based catalytic converters in cars). Another use of urea as in catalytic converters for NO_x emissions in industrial plants is not reported in Slovakia. This possible use of urea is annually monitored by questionnaires that are sent to the operators at which the decrease of NO_x emissions occurred.

The implied emission factor is 1.339 t CO_2 per 1 t of ammonia produced in 2015 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 energy sector. Results are provided in ***Tables 4.22*** and ***4.23***.

Production of ammonia decreased in 2015 to the level comparable with 2013 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 2015 that are necessary for the calculation of emissions. The presented data are based on direct measurements in plant.

Table 4.22: *Ammonia production (kt) and GHG emissions (Gg, t) 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

* CO_2 emissions without consideration of urea production

Table 4.23: *Urea production (kt), CO_2 used for the production and resulting CO_2 emissions (Gg, t) in particular years*

YEAR	UREA PRODUCTION (kt)	CO_2 CONSUMED (Gg)	Net CO_2 EMISSIONS* (Gg)	IEF (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

YEAR	UREA PRODUCTION (kt)	CO_2 CONSUMED (Gg)	Net CO_2 EMISSIONS* (Gg)	IEF (t/t)
2015	C	246.24	638.58	1.339

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

4.7.1.2 Uncertainties and time-series consistency

Consistent tier 3 method is used for the whole time period 1990 – 2015. 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 uncertainty estimation used several input parameters such as fuel consumption (*FR*), content of Carbon in fuel (*CCF*), the amount of carbon dioxide that is recovered and used for urea production (*R*), their emission factors and their default uncertainties according to the IPCC 2006 GL. The production process generates CO_2 emissions and CH_4 and N_2O emissions. Based on calculation, the overall uncertainty of CO_2 emissions (in eq.) was calculated in interval (-9.61%; +9.89%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by Δ symbol in formula):

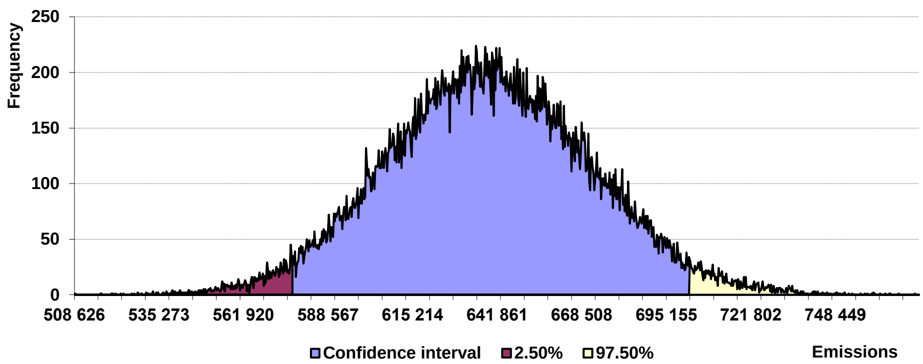
$$Emissions = (FR \pm \Delta FR) * (CCF \pm \Delta CCF) * \frac{44}{12} / 1000 - (R \pm \Delta R) * 1000 +$$
$$+ \sum_{I} (FR \pm \Delta FR) * (EF_i \pm \Delta EF_i) * CF_i / 1000000$$

In the formula subscript "I" represents CH_4 and N_2O emissions contribution to total emission uncertainty, *CF* is used as a conversion factor for computing CO_2 emission eq. The accumulated uncertainty and statistical characteristics for ammonia are presented in the following table and figure. The average mean value of GHG emissions in 2.B.1 obtained by the Monte Carlo simulation is 639 Gg CO_2 *eq.* per year 2015. The average mean value is comparable with the real GHG emissions, which is 639 Gg CO_2 *eq.*

Table 4.24: *Selected statistical characteristics for 2.B.1, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2 eq.)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
638 762	**639 232**	31 996	508 626	775 096	-9.61%	9.89%

Figure 4.13: *Probability density function for 2.B.1 (t of CO_2 eq.)*



4.7.2 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 increased inter-annually (2014/2015) by 9%. But the N_2O

emissions decreased by 7% in 2015 in comparison with 2014. It is a typical characteristic of the used technology (with secondary YARA catalyst) that emissions are low but fluctuate in a certain degree. Thus continuous monitoring of emissions is necessary.

4.7.2.1 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 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 4.25***.

Table 4.25: *Measured EFs in medium pressure nitric acid plant in 2005 – 2010*

YEAR	2005	2006	2007	2008	2009	2010
EF N_2O (kg/t)	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 2015 is presented in ***Table 4.26***. The overall EF = 0.74 kg N_2O/t of HNO_3 in 2015 was estimated as weighted average. N_2O emissions were 469.07 t in 2015. The detailed results are in ***Tables 4.26*** and ***4.27***.

Table 4.26: *Detailed information on measured N_2O concentrations in 2015*

PLANT	N_2O CONCETRATION (ppm)	WEIGHTED AVERAGE EF (kg/t)
MEDIUM PRESSURE PLANT 1	94.92	0.302
MEDIUM PRESSURE PLANT 2	86.71	0.345
HIGH PRESSURE PLANT	346.63	1.139

Table 4.27: *Estimated N_2O emissions (t) and IEFs (N_2O) in particular years*

YEAR	NITRIC ACID PROD. (kt)	EF N_2O (kg/t HNO_3)	N_2O atmospheric (t)	N_2O medium pressure (t)	N_2O high pressure (t)	TOTAL N_2O EMISSIONS (t)	TOTAL NO_x EMISSIONS (t)
1990	400.54	9.564	1 953.77	1 876.88	NO	3 830.65	227.27
1995	398.80	9.429	1 818.70	1 941.77	NO	3 760.47	226.28
2000	407.22	8.383	NO	1 256.58	2 157.06	3 413.64	231.06
2005	497.68	8.326	NO	1 584.29	2 559.28	4 143.57	282,39
2010	510.97	5.706	NO	1 393.18	1 522.15	2 915.33	331.26
2011	593.75	2.288	NO	739.54	618.68	1 358.22	371.14
2012	550.51	1.770	NO	587.81	386.52	974.33	329,86
2013	611.65	0.710	NO	136.50	297.76	434.26	360.85
2014	580.09	0.837	NO	156.40	329.13	485.53	344.56
2015	634.31	0.740	NO	95.27	373.80	469.07	325.05

Total production of nitric acid in 2015 was 634.31 kt. N_2O emissions were 469.07 t and the NO_x emissions were 325.05 t in 2015. Activity data and emissions are presented in ***Table 4.27***.

4.7.2.2 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.

Default value of nitric acid volume uncertainty (2.5%) and country specific value EFs uncertainty (7%) were used in uncertainty analyses by Monte Carlo method for this category. The production process generates N_2O emissions. Based on calculation, the overall uncertainty of CO_2 emissions (in eq.) was calculated in interval (-6.03%; +6.10%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by ∆ symbol, CF is a conversion factor to CO_2 eq.):

$$Emissions = \sum_{I} \left[(HNO_3\ amount \pm \Delta amount) * (EF \pm \Delta EF) * CF_I / 1000 \right]$$

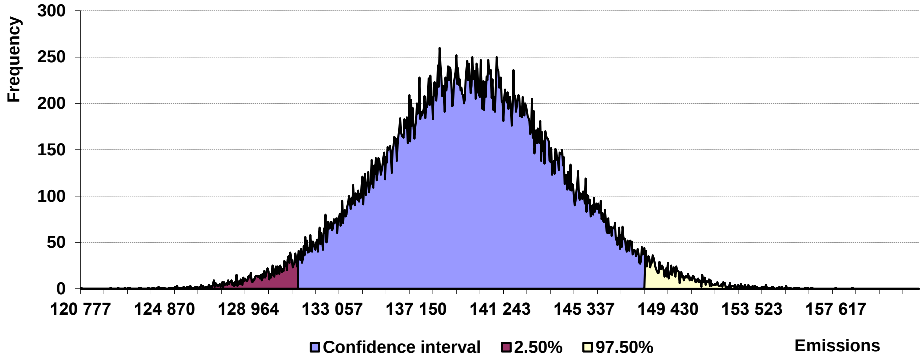
Three sources entered the calculation. The accumulated uncertainty and statistical characteristics for nitric acid are presented in the following figure. In the formula subscript "I" represents sources of emissions. The accumulated uncertainty and statistical characteristics for nitric acid production are presented in the following table and figure. The average mean value of GHG emissions in 2.B.2

obtained by the Monte Carlo simulation is 140 Gg CO_2 *eq.* per year 2015. The average mean value is comparable with the real GHG emissions (140 Gg CO_2 *eq.*).

Table 4.28: *Selected statistical characteristics for 2.B.2, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2 eq.)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
139 766	**139 788**	4 329	120 777	161 710	-6.03%	6.10%

Figure 4.14: *Probability density function for 2.B.2 (t of CO_2 eq.)*



4.7.3 ADIPIC ACID PRODUCTION (CRF 2.B.3)

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

4.7.4 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.

4.7.5 CARBIDE PRODUCTION (CRF 2.B.5)

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

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

4.7.5.2 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 48.47 Gg of CO_2 in 2015 and decreased by 43% in comparison with 2015. The decrease was caused partially by declining production of calcium carbide (by 25%). The main part of the reduction of CO_2 emissions was caused by continuing modernization of the technology: (i) the reduction of the carbon content in the waste lime mud; (ii) change of the used carbon raw materials. Since 2015 the calcinated anthracite is used instead of other bituminous coal.

4.7.5.3 Methodological issues

Carbon balance of all input – output flows was used. The method is similar to tier 3 methodology 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 × NCV × EF(C)) – (carbide production × C content in carbide)) × 44/12

Acetylene is produced in the plant not only for welding application. A part of produced acetylene is used for the production of 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 the ***Table 4.29*** (C = confidential data are available in the SNE archive).

Table 4.29: *Estimated CO_2 emissions (Gg), carbide production and export (kt) in particular years*

YEAR	CARBIDE PROD.	CARBIDE EXPORT	CARBIDE FOR VCM PROD.	$CaCO_3$ CONSUM.	COKING COAL CONSUM.	OTHER BITUMI-NOUS COAL CONSUM.	IEF CO_2	CO_2
	kt						t/t	Gg
1990	NO	NO	NO	NO	NO	NO	NO	NO
1995	84.30	C	C	131.63	66.61	7.14	1.65	139.01
2000	88.82	C	C	138.68	70.26	7.44	1.76	156.73
2005	97.03	C	C	151.50	76.73	8.15	1.82	176.72
2010	98.26	C	C	158.17	77.69	8.28	2.01	197.56
2011	107.40	C	C	172.89	84.89	9.07	2.07	222.28
2012	100.48	C	C	NO	79.44	8.46	1.41	141.26
2013	81.79	C	C	NO	60.93	6.16	1.17	95.35
2014	74.30	C	C	NO	57.99	4.34	1.15	85.76
2015	56.18	C	C	NO	41.05	3.55*	0.86	48.47

* 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 2015 was 0.81 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 0.86 t CO_2/t of produced CaC_2. The significant decrease of IEF in comparison with the previous years was caused by technological improvement, when the reduction of carbon in the waste lime mud was achieved and therefore less coal is needed for production step. Another decrease in IEF is caused by using of calcinated anthracite instead of other bituminous coal since 2015.

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. No calcium carbide was imported to Slovakia in 2015. The rest of produced calcium carbide was used for acetylene production for welding applications (conservative approach). No production of CaO occurred in 2015. 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 to be min. 95%, for ensuring conservatism the assumption of 100% content of carbon is used for the calculation of emission estimates.

4.7.5.4 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 – 2015) 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 4.29***). The CaO production finished in 2011. In the present, the CaO is produced by the lime producers and bought for carbide production.

Default value of calcium carbide production uncertainty (1.5%), country specific values for fuels used uncertainty (2%), the value for C content in carbide (5%), the value for carbide in use (4%) and calculated value EFs uncertainty (10%) based on methodology for emissions estimation were used in uncertainty analyses by Monte Carlo method for this category. Based on calculation, the overall uncertainty of CO_2 emissions was calculated in interval (-11.61%; +11.46%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by Δ symbol in formula):

$$Emissions = \sum_{i} \left[(consum\_coal \pm \Delta consum\_coal) \cdot (NCV \pm \Delta NCV) \cdot (EF(C) \pm \Delta EF(C)) \right.$$

$$- (prod\_carbide \pm \Delta prod\_carbide) \cdot (content\_C \pm \Delta content\_C) \big] \cdot 44/12 +$$

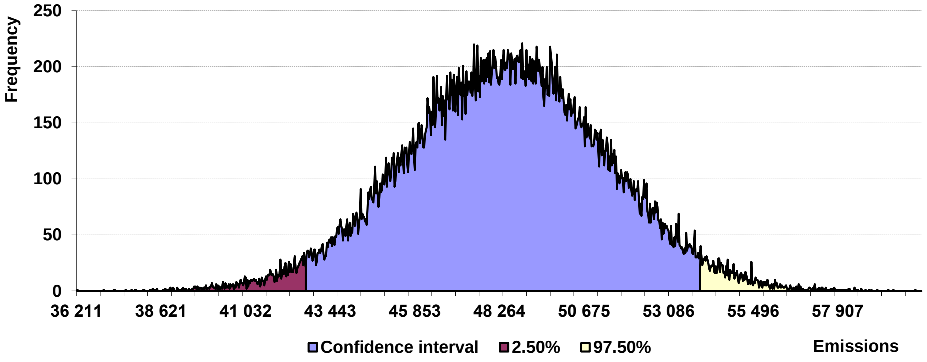
$$\left. - (consumed\_limestone \pm \Delta consumed\_limestone) \cdot 0.44 + (carbide\_used \pm \Delta carbide\_used) \cdot (EF \pm \Delta EF) \right]$$

The accumulated uncertainty and statistical characteristics for calcium carbide production are presented in the following table and figure. The average mean value of CO_2 emissions in 2.B.5.b obtained by the Monte Carlo simulation is 48.43 Gg CO_2 per year 2015. The average mean value is comparable with the real CO_2 emissions, which is 48.47 Gg CO_2.

Table 4.30: *Selected statistical characteristics for 2.B.5.b, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
48 451.22	**48 432.70**	2 850.16	36 210.56	60 317.72	-11.61%	11.46%

Figure 4.15: *Probability density function for 2.B.5.b (t of CO_2)*



4.7.6 TITANIUM DIOXIDE PRODUCTION (CRF 2.B.6)

Titanium dioxide is not produced in the Slovak Republic and “NO” notation key was used.

4.7.7 SODA ASH PRODUCTION (CRF 2.B.7)

Soda ash is not produced in the Slovak Republic and “NO” notation key was used.

4.7.8 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.

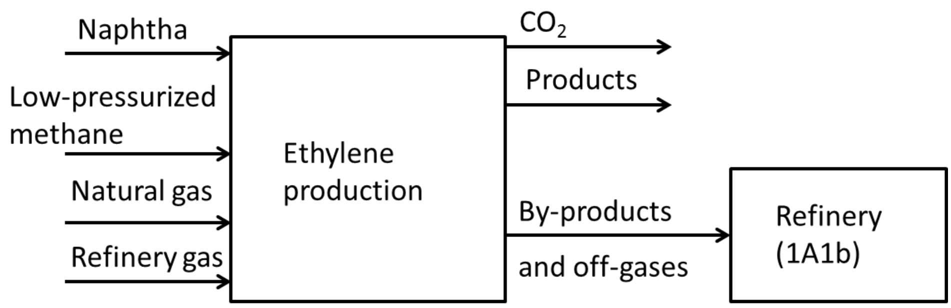
4.7.9 ETHYLENE (CRF 2.B.8.b)

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 323.91 Gg in 2015, which represents the increase by 33% in comparison with 2014 and reached the value as in 2013. The increase is caused by rising the production.

4.7.9.1 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 4.16***). Methane emissions do not occur when using approach described in the IPCC 2006 GL.

Figure 4.16: *Scheme of carbon material balance used in for 2.B.8.b*



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. Due to a large number of the other produced chemicals, total carbon content is balanced in once. These chemicals are transferred into refinery and they are reported in 1.A.1.b. Detailed data are presented in the ***Table 4.31***.

Table 4.31: *Activity data and related CO_2 emissions (Gg) from ethylene and propylene production in particular years*

YEAR	INPUTS IN TJ			
	NAPHTHA	NATURAL GAS	REFINERY GAS	LOW-PRESSURIZED CH_4
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

YEAR	INPUTS IN TJ			
	NAPHTHA	NATURAL GAS	REFINERY GAS	LOW-PRESSURIZED CH_4
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

YEAR	OUTPUTS IN kt			CO_2 EMISSIONS (Gg)	IEF (CO_2) (t/t)
	ETHYLENE PRODUCTION	PROPYLENE PRODUCTION	CARBON IN OTHER CHEMICALS		
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

4.7.9.2 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 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 the ***Table 4.31*** were subtracted from 1.A.2.c in energy sector.

Country specific values of different fuels´ uncertainty, country specific values for fuels NCV and EFs uncertainty and calculated value for ethylene and propylene production uncertainty (2.0%) based on methodology for emissions estimation described above were used in this uncertainty analyses by Monte Carlo method. Uncertainties are provided in the ***Table 4.32***. Based on calculation, the overall uncertainty of CO_2 emissions was calculated in interval (-21.24%; +21.59%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by ∆ symbol in formula):

Emission = [(NG± ∆NG)*(NG_NCV± ∆NG_NCV)*(NG_EF± ∆NG_EF)/1000 +
+ (RG± ∆RG)*(RG_NCV± ∆RG_NCV)*(RG_EF± ∆RG_EF)/1000 +
+ (NMT± ∆NMT)*(NMT_NCV± ∆NMT_NCV)*(NMT_EF± ∆NMT_EF)/1000 +
+ (naphta±∆naphta) *(naphtha_NCV±∆naphta_NCV) *(naphtha_EF±∆naphta_EF) -
- (ethylen±∆ethylen)*0.856 – (propylene±∆propylene)*0.8563 – (other± ∆other)]*44/12

Table 4.32: *Used uncertainties for inputs (fuels), NCV, carbon EFs and final production*

NG	refinery gas (RG)	methane	NG (NCV)	NG (EF C)	RG (NCV)	RG (EF C)	NMT (NCV)
2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%

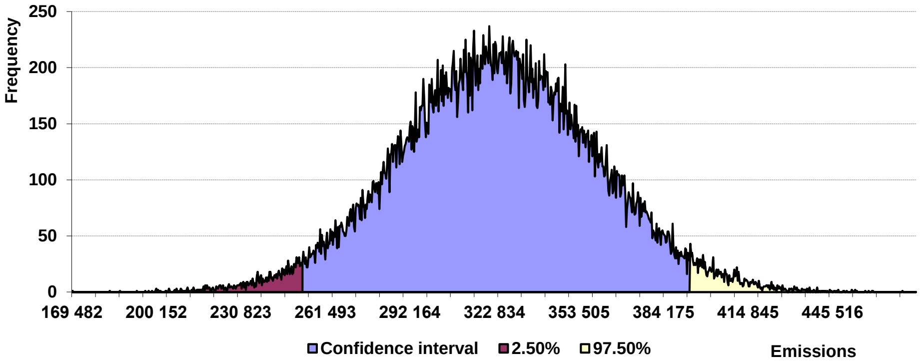
NMT (EF C)	ethylene production	propylene production	Other C	naphtha	naphtha (NCV)	naphtha (EF C)
2.00%	1.50%	1.50%	5.00%	2.00%	2.00%	10.00%

The accumulated uncertainty and statistical characteristics for ethylene and propylene production are presented in the following table and figure. The average mean value of CO_2 emissions in 2.B.8.b obtained by the Monte Carlo simulation is 324 Gg CO_2 per year. The average mean value is comparable with the real CO_2 emissions, which is 324 Gg CO_2.

Table 4.33: *Selected statistical characteristics for 2.B.8.b, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
323 783	**324 019**	35 393	169 482	476 186	-21.24%	21.59%

Figure 4.17: *Probability density function for category 2.B.8.b (t of CO_2)*



4.7.10 ETHYLENE DICHLORIDE AND VINYL CHLORIDE MONOMER (CRF 2.B.8.c)

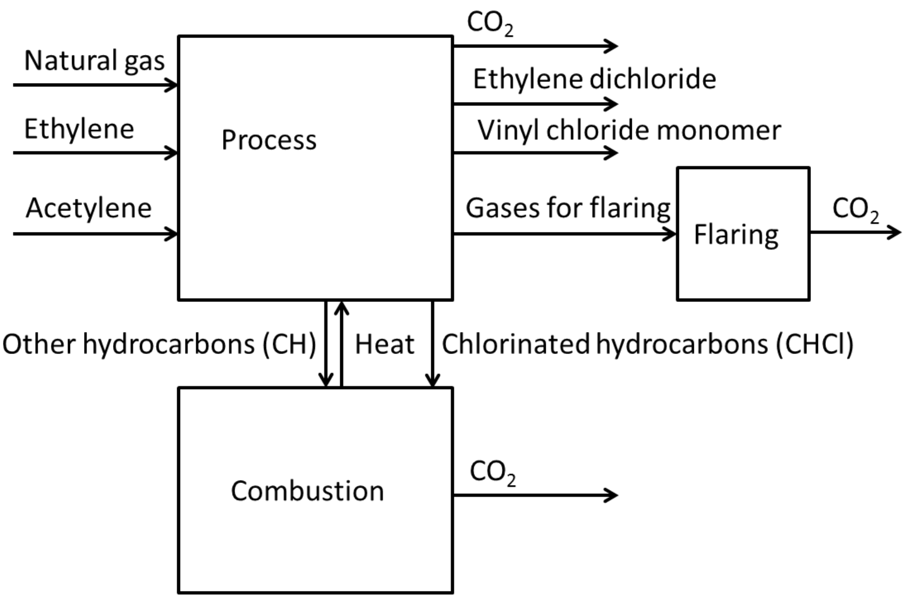
Ethylene dichloride (EDC) is produced by direct chlorination process in the Slovak Republic. Cracking of ethylene dichloride results in vinyl chloride monomer (VCM) and HCl. The HCl is consumed in the reaction with acetylene that results in another amount of vinyl chloride monomer. This amount of consumed acetylene is not reported in 2.B.5b (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 in 2015 were 7.91 Gg and increased by 12% in comparison with the previous year 2014. The increase was caused by the increase in production.

4.7.10.1 Methodological issues

Tier 2 methodology and carbon balance approach, as described in IPCC 2006 GL was used. The used approach is described on the following scheme (***Figure 4.18***).

Ethylene dichloride and vinyl chloride monomer is produced by one operator in Slovakia. All streams (inputs) shown in the ***Figure 4.18*** were taken into account with respective emission factors and contents of carbon (plant specific data). These parameters were updated annually.

Figure 4.18: Carbon material balance used in emissions estimation of 2.B.8.c



Total production of vinyl chloride monomer and the production of ethylene dichloride (a part of it which 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 the ***Table 4.34***.

Table 4.34: *Activity data and related CO_2 emissions (Gg) from the EDC and VCM production in particular years*chlorinated hydrocarbons, **other hydrocarbons*

YEAR	NATURAL GAS CONSUMPTION (1 000 m^3)	ETHYLENE CONSUMPTION (kt)	ACETYLENE CONSUMPTION (kt)	EDC PRODUCTION (kt)	VCM PRODUCTION (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	3174	10.816	3.486	-0.158	31.127

YEAR	NG FOR FLARING (1 000 m^3)	CHCl (kt)*	CH (kt)**	PROC. CO_2 (Gg)	COMBUS. CO_2 (Gg)	FLARING CO_2 (kt)	TOTAL CO_2 (Gg)	IEF (CO_2) (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
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

4.7.10.2 Uncertainties and time-series consistency

Consistent methodology and tier method is 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.

Country specific values of different inputs (fuels) uncertainty, country specific values for fuels NCV and EFs uncertainty and calculated value for VCM and EDC production uncertainty (2.0%) based on methodology for emissions estimation described above were used in this uncertainty analyses by Monte Carlo method. Uncertainties are provided in the ***Table 4.35***. Based on calculation, the overall uncertainty of CO_2 emissions was calculated in interval (-14.83%; +14.83%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by Δ in symbol formula):

Emission1 = [(NG± ΔNG)*(NG_NCV± ΔNG_NCV)*(NG_EF± ΔNG_EF)/1000 +

+ (ethylene± Δethylene)*0,856 + (acetylene± Δacetylene)*0.9228 –

- (EDC± Δ EDC)*0,245 – (VCM± ΔVCM)*0,384 – (flaring± Δ flaring)*(flar_EF± Δ flar_EF) –

- (ClU± Δ ClU)*(ClU_NCV± Δ ClU_NCV)*(ClU_EF± Δ ClU_EF) /1000 –

- (CHU± Δ CHU)*(CHU_C± Δ CHU_C)]*3.6642

Emission2 = (flaring± Δ flaring)*(flar_EF± Δ flar_EF) *3.6642

Emission3 = (ClU± Δ ClU)*(ClU_NCV± Δ ClU_NCV)*(ClU_EF± Δ ClU_EF) /1000

Emission = Emission1 + Emission2 + Emission3

Table 4.35: *Used uncertainties for inputs (fuels), NCV, carbon EFs and final production*

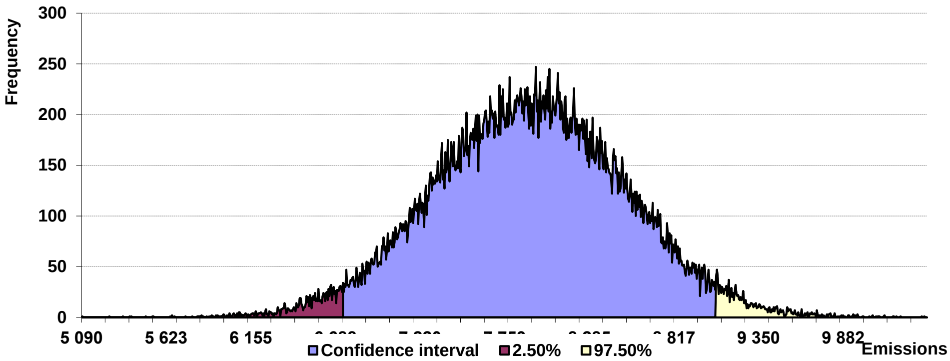
NG	ethylene	acetylene	EDC	VCM	flaring (th. m^3)	ClU (t)
2.00%	2.00%	2.00%	2.00%	2.00%	5.00%	2.00%
CHU (t)	**NG (NCV)**	**NG (EF C)**	**Flaring (EF C)**	**ClU (NCV)**	**ClU (EF C)**	**CHU (w C)**
2.00%	2.00%	2.00%	10.00%	5.00%	5.00%	5.00%

The accumulated uncertainty and statistical characteristics for EDC and VCM production are presented in the following table and figure. The average mean value of CO_2 emissions in 2.B.8.c obtained by the Monte Carlo simulation is 7.91 Gg CO_2 per year 2015. The average mean value is comparable with the real CO_2 emissions, which is 7.91 Gg CO_2.

Table 4.36: *Selected statistical characteristics for 2.B.8.c, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2)*

Median	Average	St. dev.	Min	Max	Per_2.5	Per_97.5
7 910	**7 909**	599	5 090	10 415	-14.83%	14.83%

Figure 4.19: *Probability density function for 2.B.8.c (t of CO_2)*



4.7.11 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 in 2015 were 365.29 Gg and they increased by 3% in comparison with the previous year 2014.

4.7.11.1 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 Nm^3) and CF is a conversion factor (in MJ/m^3) (34.955 in 2015); CCF is content of carbon in the fuel (in t/TJ) (15.197 in 2015) and OF is oxidation factor of the fuel (1). It should be noted that all parameters used for natural gas are consistent with the parameters used in energy sector (NCV, EF C).

Also hydrogen is produced only by one operator in Slovakia. Therefore, 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 in 2015 was 41.99 kt. Detailed activity data are presented in the ***Table 4.37***. The volume of used natural gas presented in this category was subtracted from the energy sector in order to avoid the double-counting.

Table 4.37: *Activity data and related CO_2 emissions (Gg) from 2.B.10 hydrogen production in particular years*

YEAR	HYDROGEN PRODUCTION (kt)	NATURAL GAS CONSUM. (TJ)	CO_2 EMISSIONS (Gg)	IEF (CO_2 t/t)	CH_4 EMISSIONS (t)	N_2O EMISSIONS (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

4.7.11.2 Uncertainties and time-series consistency

Consistent methodology and tier method is 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. Increase in IEF in 2010 was caused by technological modifications in the plant.

Country specific values for fuel uncertainty (2.0%) and calculated value for EF uncertainty (10.0%) based on methodology for emissions estimation described above were used in this uncertainty analyses by Monte Carlo method. Based on calculation, the overall uncertainty of CO_2 emissions was calculated in interval (-2.78%; +2.82%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by Δ in symbol formula):

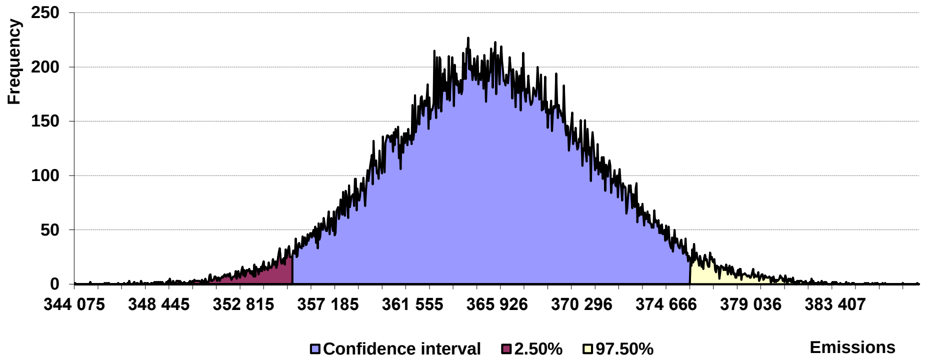
$$Emissions = (FR \pm \Delta FR) * (CCF \pm \Delta CCF) * \frac{44}{12} / 1000 +$$
$$+ \sum_i (FR \pm \Delta FR) * (EF_i \pm \Delta EF_i) * CF_i / 1000000$$

The accumulated uncertainty and statistical characteristics for hydrogen production are presented in the following table and figure. The average mean value of CO_2 emissions in 2.B.10 obtained by the Monte Carlo simulation is 366 Gg CO_2 eq. per year. The average mean value is comparable with the real CO_2 emissions, which is 365 Gg CO_2 eq.

Table 4.38: *Selected statistical characteristics for 2.B.10, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2 eq.)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
365 528	**365 571**	5 268	344 075	387 777	-2.78%	2.82%

Figure 4.20: *Probability density function for 2.B.10 (t of CO_2 eq.)*



4.8 METAL PRODUCTION (CRF 2.C)

This category produces emissions of CO_2, CH_4 and PFCs emissions (Aluminium Production). Total emissions were 4 553.91 Gg of CO_2 eq. in 2015 nearly the same as in 2014. Comparing with the base year, the decrease is more than 7%. This trend is mostly caused by the decrease in CO_2 emissions from iron and steel production with respect to the base year. 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.

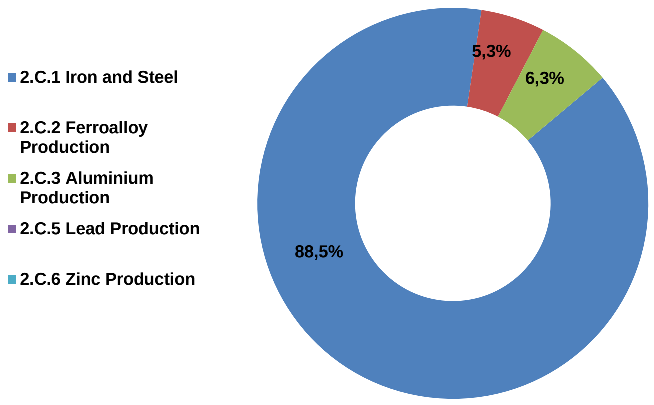
Table 4.39: *Emissions in the 2.C (Gg of CO_2 eq.) in particular years*

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
1990	4 167.97	296.74	436.18	0.00	0.00
1995	4 322.63	235.64	191.33	0.00	0.00
2000	3 344.72	182.69	190.05	0.00	0.00

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
2005	3 907.36	228.16	277.94	0.00	0.00
2010	4 089.57	219.91	288.48	0.00	0.00
2011	3 488.82	202.93	281.38	0.01	0.00
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

The major share of emissions (88.5%) belongs to the iron and steel production, 5.3% belongs to the ferroalloy production and 6.3% to the aluminium production. Other subcategories are not significant in emission share within the category 2.C.

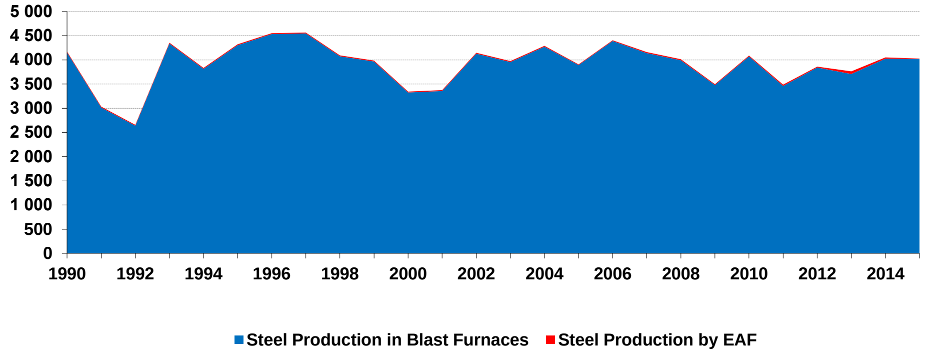
Figure 4.21: *The share in GHG emissions in the 2.C in 2015*



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

Total CO_2 emissions in this category were 4 028.13 Gg in 2015, almost the same as in the year 2014. Comparing the base year, the decrease is approximately 3%. 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 whole production process 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 4.22: *Emission trend in 2.C.1 (in Gg of CO_2 eq.) in 1990 – 2015*



4.8.1.1 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 ***Annex 4.1*** of this report).

All streams were calculated based on the plant-specific conversion units and carbon EFs or on the basis of carbon content oi iron ore and steel. Carbon balance of iron and steel production is described in full details in 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 methodology, methane emissions were not balanced in line with the IPCC 2006 GL.

EFs are estimated annually on plant level which 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 in 2015 was 3.036 kg/t, in pig iron it was 44.03 kg/t and 0.743 kg/t in steel (data supplied directly). Emission factors and other parameters are summarized in ***Tables 4.40*** - ***4.42***. The CO_2 emissions from the EAF process are estimated based on carbon balance, where all material flows are taken into account.

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 manufacturers of iron and steel in blast furnaces (integrated production of iron and steel) produced totally 34.33 kt of pig iron (which was sold) and 4 310.94 kt of steel in 2015. Total production of steel produced by the EAF technology was 315.05 kt in 2015. The plant UNEX Prakovce did not produced steel in 2013. New plant, Slovakia Steel Mills, started their production by the EAF technology in 2013. However, due to the sanctions to 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 4.40: *Activity data, emission factors and CO_2 emissions in integrated iron and steel production in 2005 – 2015*

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

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

Table 4.41: *Production (kt) and CO_2 emissions (Gg) in steel production in 1990 – 2004*

YEAR	STEEL PRODUCTION	LIMESTONE USED	CO_2 EMISSIONS	IEF (CO_2)
	kt	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
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 4.42: *Activity data (t), emission factors (t/t) (below) and CO_2 emissions (t) 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
1990	C	3 810.00	13 970.00	NO	NO	NO	C	1 096.60	4 021.00
1995	C	3 878.00	14 219.00	NO	NO	NO	C	1 044.30	3 829.00
2000	C	3 879.00	14 223.00	NO	NO	NO	C	1 117.10	4 096.00
2005	C	3 409.00	12 490.00	NO	NO	NO	C	242.20	888.00
2010	C	4 465.00	16 372.00	NO	NO	NO	C	335.20	1 229.00
2011	C	7 058.00	25 879.00	NO	NO	NO	C	297.30	1 090.00
2012	C	4 635.00	16 995.00	NO	NO	NO	C	169.40	621.00

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
2013	C	3 968.37	14 550.70	C	10 854.33	39 799.20	C	4.01	14.70
2014	C	3 002.76	11 010.10	C	4 208.59	15 431.50	C	14.45	53.00
2015	C	2 492.51	9 139.20	NO	NO	NO	NO	NO	NO

YEAR	UNEX, PRAKOVCE		TOTAL		
	steel by EAF (t)	CO_2 (t)	steel by EAF (t)	CO_2 (t)	IEF (t/t)
1990	C	162.00	310 729.00	18 153.00	0.0584
1995	C	164.00	314 641.00	18 212.00	0.0579
2000	C	167.00	316 358.00	18 486.00	0.0584
2005	C	83.00	356 900.00	13 461.00	0.0377
2010	NO	0.00	331 248.00	17 601.00	0.0531
2011	NO	0.00	374 215.00	26 969.00	0.0721
2012	NO	0.00	372 404.00	17 616.00	0.0473
2013	NO	0.00	711 343.56	54 364.60	0.0764
2014	NO	NO	527 850.70	26 494.60	0.0502
2015	NO	NO	315 047.29	9 139.20	*0.0290*

4.8.1.2 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 the time period 2005 – 2015. 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 taken into account to ensure the reliable results. This way of extrapolation provided more consistent data as can be seen from the 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.

- 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.
- 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 also production significantly decreased (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.

Compatible methodology to energy sector was used for uncertainty analyses in this category. Estimation is based on materials properties, carbon balance and default values for uncertainty of production (1.5%-2.5%), NCV (1.6%-2.5%) and EFs (0.72%-2.75%). Based on calculation, the overall uncertainty of CO_2 emissions was calculated in interval (-7.49%; +7.44%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by Δ in symbol formula):

$$Emissions = \sum_{j} ((production \pm \Delta production) * (caloric \pm \Delta caloric) * (EF\_C \pm \Delta EF\_C)) * \frac{44}{12}$$

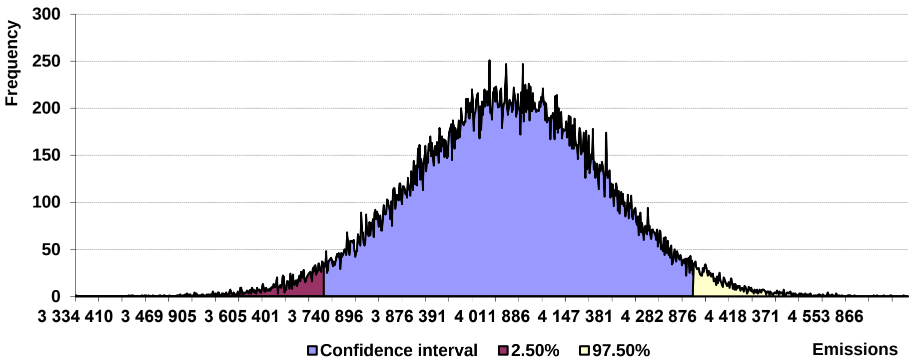
$$+ \sum_{l} (amount of\ C \pm \Delta C) * (EF \pm \Delta EF)$$

In the formula subscript "I" represents different sources of emissions. The accumulated uncertainty and statistical characteristics for iron and steel production are presented in the following table and figure. The average mean value of CO_2 emissions in 2.C.1 obtained by the Monte Carlo simulation is 4 038 Gg CO_2 per year 2015. The average mean value is comparable with the Tier 1 CO_2 emissions, which is 4 019 Gg CO_2. The difference between emissions estimation and tier 2 uncertainty calculation is caused by not including of EAF technology in the Monte Carlo simulation due to lack of data. The overall uncertainty is higher in the comparison with other categories in IPPU sector due to the more input parameters and their uncertainties entered in the calculation.

Table 4.43: *Selected statistical characteristics for 2.C.1, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
4 038 355	**4 037 917**	153 869	3 334 410	4 689 361	-7.49%	7.44%

Figure 4.23: *Probability density function for 2.C.1 (t of CO_2)*



4.8.2 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 in 2015 were 239.67 Gg of CO_2 and 48.43 t of CH_4. According to the IPCC 2006 GL, also limestone used for the production was included in this estimation.

4.8.2.1 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 on the basis of operation specific emission factors (tier 2). The production of FeSi started in 1998. Further information is provided in ***Tables 4.44*** - ***4.46***.

Plant specific emission factors are estimated annually (on the basis of 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 4.44***.

Table 4.44: *Activity data (t) used for carbon balance and CO_2 emissions (t) in ferroalloys production in 2015*

CARBON IN "RAW MATERIALS" (t)	CARBON IN COALS (t)	LIMESTONE CONSUMED (t)	CARBON IN PRODUCTS (t)	CO_2 EMISSIONS (Gg)
6 173.018	60 417.082	6 427.954	1 996.609	239.671

Table 4.45: *Activity data (t), CO_2 (t) and CH_4 emissions in ferroalloys production in 1990 – 2001*

YEAR	FERROALLOYS (t)				$CaCO_3$ USED (t)	TOTAL CO_2 (t)	EF (CO_2) (t/t)	TOTAL CH_4 (t)
	based on Cr	based on Mn	based on Si	total				
1990	53 000	116 000	NO	169 000	73 853	296 739.32	1.756	NO
1991	52 000	113 000	NO	165 000	72 105	289 618.20	1.755	NO
1992	50 000	110 000	NO	160 000	69 920	281 004.80	1.756	NO
1993	47 000	103 000	NO	150 000	65 550	263 394.00	1.756	NO
1994	34 000	111 300	NO	145 300	63 496	259 567.44	1.786	NO
1995	45 000	89 800	NO	134 800	58 908	235 642.72	1.748	NO
1996	46 000	84 000	NO	130 000	56 810	226 252.40	1.740	NO
1997	42 000	78 000	NO	120 000	52 440	209 025.60	1.742	NO
1998	44 000	81 000	8 666	133 666	58 412	246 984.48	1.848	11.27
1999	46 700	56 300	13 205	116 205	50 782	220 040.05	1.894	17.17
2000	17 658	69 458	7 611	94 727	41 396	182 446.45	1.926	9.89
2001	12 140	69 380	5 200	86 720	37 897	165 901.40	1.913	6.76

Table 4.46: *Activity data (t), CO_2 (t) and CH_4 emissions in ferroalloys production in 2002 – 2015*

YEAR	$FeSi_{75}$	$FeSi_{65}$	$FeSi_{45}$	FeSiMn	FeMnC	FeCr	FeSiCa	TOTAL
	t							
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

YEAR	$FeSi_{75}$	$FeSi_{65}$	$FeSi_{45}$	FeSiMn	FeMnC	FeCr	FeSiCa	TOTAL
	t							
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

YEAR	$CaCO_3$ USED (t)	TOTAL CO_2 (t)	EF (CO_2) (t/t)	TOTAL CH_4 (t)
2002	67 068	333 657.12	2.174	40.57
2003	61 423	328 038.22	2.334	54.00
2004	73 965	371 066.70	2.192	45.09
2005	47 510	227 646.50	2.094	20.35
2006	58 853	275 660.72	2.047	19.23
2007	67 377	301 324.58	1.954	11.09
2008	57 674	263 043.66	1.993	13.59
2009	25 221	115 512.24	2.001	5.67
2010	42 314	219 069.16	2.262	33.53
2011	33 894	201 979.86	2.604	38.03
2012	44 396	265 502.64	2.613	36.75
2013	28 713	165 003.20	2.512	42.53
2014	41 893	222 894.40	2.443	50.36
2015	6 428	239 671.10	2.509	48.43

4.8.2.2 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). The verification of emissions calculation in previous submissions for the period 1990 – 2001 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.

Following input parameters were applied for the uncertainty analyses in this category: carbon content in materials and products, their emission factors (for carbon dioxide) and their uncertainties for both AD and EF. Additionally, not only CO_2, but also CH_4 emissions from FeSi were included in calculation. The emission factors and uncertainty for both AD and EF (represented by symbol Δ in formula) were used for uncertainty estimation. The uncertainty of CO_2 emissions (in eq.) is in interval (-2.77%; +2.79%). Formula can be written in the following form:

$$Emissions = \left[(C\_coal\_mat \pm \Delta C\_coal\_mat) + (C\_raw\_mat \pm \Delta C\_raw\_mat) - (C\_products \pm \Delta C\_products)\right] *$$
$$* 44/12/1E3 + (limestone \pm \Delta limestone) * 0.44/1E3 + CF * (alloys \pm \Delta alloys) * EF/1E6$$

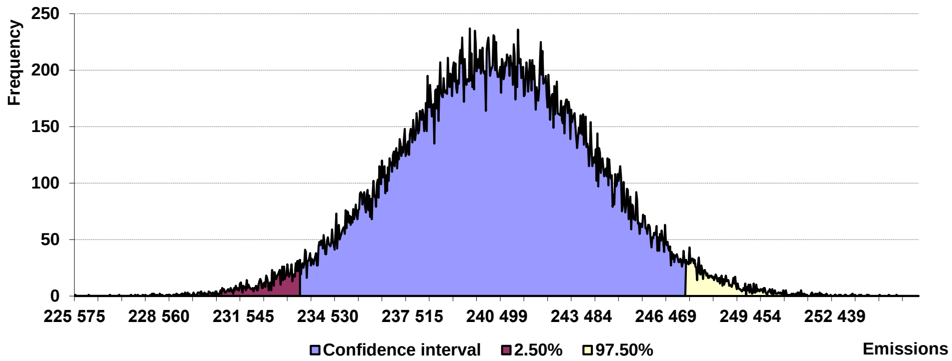
In the formula subscript "I" represents different sources of emissions. The accumulated uncertainty and statistical characteristics for ferroalloys production are presented in the following table and figure.

The average mean value of CO_2 emissions eq. in 2.C.2 obtained by the Monte Carlo simulation is 240 Gg CO_2 eq. per year 2015. The average mean value is comparable with the real CO_2 emissions, which is 240 Gg CO_2 eq.

Table 4.47: *Selected statistical characteristics for 2.C.2, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2 eq.)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
240 442	**240 456**	3 408	225 575	255 423	-2.77%	2.79%

Figure 4.24: *Probability density function for 2.C.2 (t of CO_2 eq.)*



4.8.3 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.

4.8.3.1 Methodological issues

Tier 3 in combination with tier 2 methodology 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, 70 107 t of graphite anodes were used in 2015 with the sulphur and ash contents 1.12% and 0.17%, respectively. 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 (253.74 Gg CO_2 in 2015). 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: 15.95 Gg and 6.64 Gg, respectively. The total PFC emissions were 1.08 t (8.05 Gg of CO_2 *eq.*) in 2015 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 0.045 and their average duration was 0.87 min in 2015. It follows that the emission of CF_4 was 0.959 t and C_2F_6 emission was 0.116 t. Production of aluminium in 2015 was 171 328 t. Consumption of graphite in electrolysis was 70 107 t and from 90 446 t of "green" anodes 85 404 t of anodes was produced. SF_6 is not used in aluminium castings in the Slovak Republic.

4.8.3.2 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 methodology 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 methodology 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 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 was achieved in 2013. 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 years 2014 and 2015 and recalculation of the time series 1996 – 2012 is not necessary.

Table 4.48: *CO_2 emissions (Gg) and EFs (t/t) in aluminium production in particular years*

YEAR	ALUMINIUM PRODUCTION (kt)	CO_2 (ELECTROLYSIS) (kt)	CO_2 (ANODE PRODUCTION) (kt)	TOTAL CO_2 (Gg)	EF per ALUMINIUM (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

Table 4.49: *PFC emissions (t) and EFs (kg/t) in aluminium production in particular years*

YEAR	CF_4 (t)	EF per ALUMINIUM (kg/t)	C_2F_6 (t)	EF per ALUMINIUM (kg/t)	TOTAL PFC (Gg of 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

YEAR	CF_4 (t)	EF per ALUMINIUM (kg/t)	C_2F_6 (t)	EF per ALUMINIUM (kg/t)	TOTAL PFC (Gg of CO_2 *eq.*)
2014	1.26	0.0075	0.15	0.0009	11.15
2015	0.96	0.0056	0.12	0.0007	8.50

The uncertainties in the mass of produced aluminium (1.5%), the amount of anodes, carbon content in anodes, the mole fraction of PFC (11%), current efficiency, the number of anode effects per pot day, duration the anode effect and their uncertainty for both AD and EF were used in uncertainty analyses by Monte Carlo method for this category. The uncertainties of CO_2 and PFC (CF_4 and C_2F_6) emissions were calculated. Based on calculation, the overall uncertainty of CO_2 emissions in eq. was calculated in interval (-3.63%; +3.63%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by Δ symbol in formula):

Emission = Emission1 + Emission2 + Emission3 + Emission4 + Emission5
Emission1 = (anode ± Δanode)*[1 – (sulfur_content ± Δsulfur_content) – (ash_content ± Δash_content)]*44/12

Emission2 = (GPA ± ΔGPA - PA ± ΔPA – hydrogen ± Δhydrogen – tar ± Δtar)*44/12

Emission3 = (CC ± ΔCC)*(PA ± ΔPA)*)*[1 – (sulfur_content ± Δsulfur_content) – (ash_content ± Δash_content)]*44/12

Emission4 = (ALP± ΔALP)*(AED ± ΔAED)*(min ± Δmin)*(slope ± Δslope)/1000

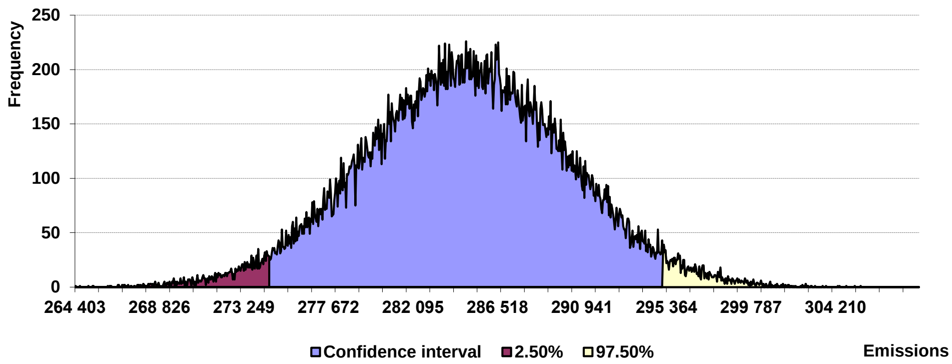
Emission5 = Emission4*(EF± ΔEF)

First row of formula is related to CO_2 emissions, other rows are related to PFC emissions. In the formula subscript "I" represents different PFC gases. The accumulated uncertainty and statistical characteristics for aluminium production are presented in the following table and figure. The average mean value of CO_2 emissions eq. in 2.C.3 obtained by the Monte Carlo simulation is 285 Gg CO_2 eq. per year 2015. The average mean value is comparable with the real CO_2 emissions, which is 285 Gg CO_2 eq.

Table 4.50: *Selected statistical characteristics for 2.C.3, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2 eq.)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
284 859	**284 846**	5 275	264 403	308 633	-3.63%	3.63%

Figure 4.25: *Probability density function for 2.C.3 (t of CO_2 eq.)*



4.8.4 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.

4.8.5 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 64.62 t in 2015.

4.8.5.1 Methodological issues

This category is not key category and therefore tier 1 methodology 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, 323.1 t of lead was produced from the secondary raw materials in 2015.

Table 4.51: *The overview of activity data and CO_2 emissions from lead production in 1990 – 2015*

YEAR	LEAD PRODUCTION FORM SECONDARY MATERIALS (t)	CO_2 EMISSIONS (t)	IEF (t/t)
1990-2010	NO	NO	NO
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

4.8.5.2 Uncertainties and time-series consistency

Tier 1 method according to the IPCC 2006 GL is used in whole time series.

The uncertainties in the mass of produced lead (1.5%) and EF (20%) were used in uncertainty analyses by Monte Carlo method. The uncertainties of CO_2 emissions in eq. were calculated. Based on calculation, the overall uncertainty of CO_2 emissions in eq. was calculated in interval (-20.16%; +20.12%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by Δ symbol in formula):

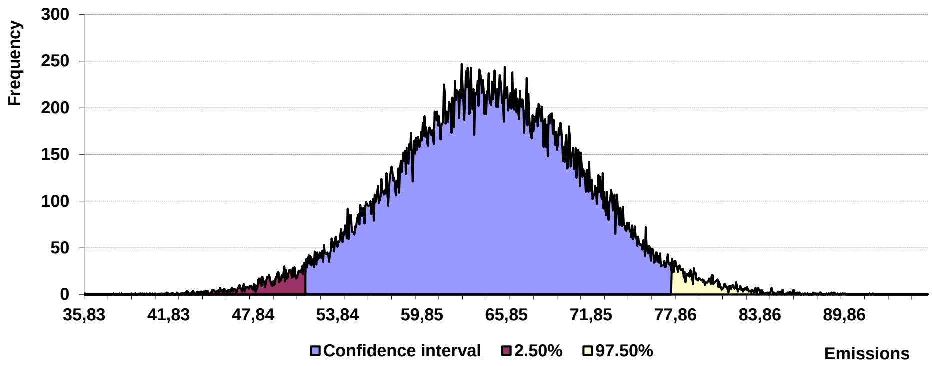
Emissions = (prod_lead ± Δ prod_lead)*(EF ± ΔEF)

The accumulated uncertainty and statistical characteristics for lead production are presented in the following table and figure. The average mean value of CO_2 emissions eq. in 2.C.5 obtained by the Monte Carlo simulation is 64.61 Gg CO_2 per year 2015. The average mean value is comparable with the real CO_2 emissions, which is 64.62 Gg CO_2.

Table 4.52: *Selected statistical characteristics for 2.C.5, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
64.60	**64.61**	6.63	35.84	95.86	-20.16%	20.12%

Figure 4.26: Probability density function for 2.C.5 (t of CO_2)



4.8.6 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 2015, the production was not occurring.

4.8.6.1 Methodological issues

This category is not key category and therefore tier 1 methodology 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 2015.

***Table 4.53:** The overview of activity data and CO_2 emissions from zinc production in 1990 – 2015*

YEAR	ZINC PRODUCTION (PYROMETALLURGICAL - ISF) (t)	CO_2 EMISSIONS (t)	IEF (t/t)
1990-2011	NO	NO	NO
2012	43.90	18.88	0.43
2013	31.45	13.52	0.43
2014	23.94	10.29	0.43
2015	NO	NO	NA

4.9 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 also indirect (potential) CO_2 emissions were calculated in this submission. Total CO_2 emissions in 2015 were 123.70 Gg and increased by ca 2% compared with the previous year. When comparing with the base year, the decrease is ca 24%. This decrease is mostly caused by changes in share of different types of solvents used. Except of solvents use previously presented in the Sector 3 according to the 1996 Revised IPCC GL, the lubricants and paraffin waxes use are reported in this category in this submission (in line with the IPCC 2006 GL).

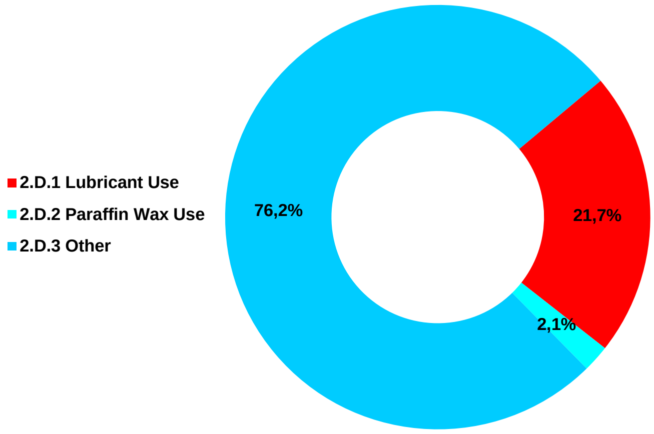
***Table 4.54:** Emissions in 2.D according to the categories (Gg of CO_2 eq.) in particular years*

YEAR	2.D.1 LUBRICANT USE	2.D.2 PARAFFIN WAX USE	2.D.3 OTHER
1990	48.02	2.46	111.39
1995	48.02	2.46	75.52
2000	48.02	2.46	64.33

YEAR	2.D.1 LUBRICANT USE	2.D.2 PARAFFIN WAX USE	2.D.3 OTHER
2005	28.94	1.23	69.44
2010	12.39	2.54	88.37
2011	18.52	1.90	90.39
2012	27.11	2.52	68.60
2013	32.51	2.54	83.16
2014	26.58	3.17	92.00
2015	26.85	2.54	94.31

The major share (76.2%) in emissions belongs to the solvent use, 21.7% belongs to the lubricant used and 2.1% to the paraffin wax use.

Figure 4.27: *The share in GHG emissions of individual categories of the 2.D in 2015*



4.9.1 LUBRICANT USE (CRF 2.D.1)

Lubricants are mostly used in industrial and transportation applications. The CO_2 emission estimated from this category in Slovakia were 26.85 Gg in 2015.

4.9.1.1 Methodological issues

This category is not key category and therefore tier 1 methodology 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 on non-energy use of lubricants in Slovakia are available from the Statistical Office of the Slovak Republic. Total volume of lubricants for non-energy use in Slovakia was 1 831.8 TJ in 2015. Due to technical reasons, the activity data in this category are presented in the 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 4.55: *The overview of activity data and CO_2 emissions in lubricant non-energy use in particular years*

YEAR	LUBRICANT USE (kt)	LUBRICANTS USE (TJ)	CO_2 EMISSIONS (Gg)
1990	78	3 276.8	48.024
1995	78	3 276.8	48.024
2000	78	3 276.8	48.024

YEAR	LUBRICANT USE (kt)	LUBRICANTS USE (TJ)	CO_2 EMISSIONS (Gg)
2005	47	1 974.5	28.938
2010	20	845.2	12.388
2011	30	1 263.5	18.517
2012	44	1 849.5	27.106
2013	53	2 218.4	32.513
2014	44	1 813.4	26.577
2015	45	1831.8	26.847

4.9.1.2 Uncertainties and time-series consistency

Tier 1 method according to the IPCC 2006 GL is used in whole time series.

The uncertainties in the mass of used lubricants (2.5%), NCV uncertainty (2.5%), carbon content in lubricants uncertainty (5%) and ODU uncertainty (50%) were used in uncertainty analyses by Monte Carlo method for this category. The uncertainties of CO_2 emissions were calculated. Based on calculation, the overall uncertainty of CO_2 emissions in eq. was calculated in interval (-49.90%; +50.68%). This high uncertainty was caused by the ODU default value of uncertainty used in simulation. Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by Δ symbol in formula):

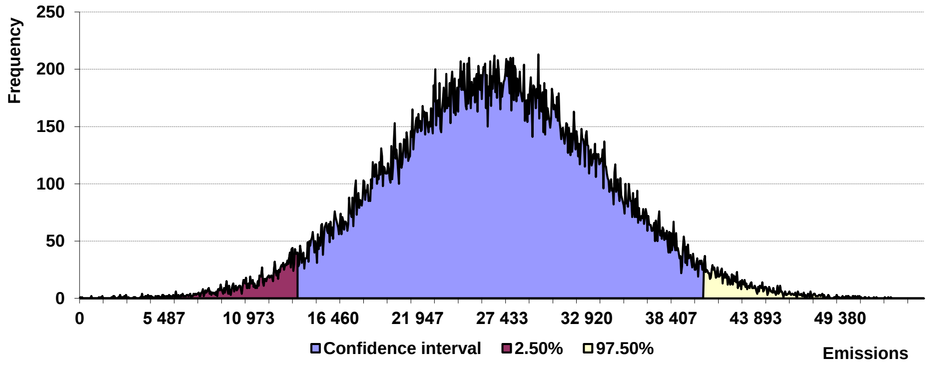
Emissions = (consum_lub± Δ consum_lub)*(EF ± ΔEF)* (NCV ± ΔNCV) *(ODU ± ΔODU)*3.664

The accumulated uncertainty and statistical characteristics for lubricants use are presented in the following table and figure. The average mean value of CO_2 emissions eq. in 2.D.1 obtained by the Monte Carlo simulation is 26.88 Gg CO_2 per year 2015. The average mean value is comparable with the real CO_2 emissions, which is 26.85 Gg CO_2.

Table 4.56: *Selected statistical characteristics for 2.D.1, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
26 860.32	**26 882.01**	6 926.10	0.00	54 866.84	-49.90%	50.68%

Figure 4.28: *Probability density function for 2.D.1 (t of CO_2)*



4.9.2 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 emission estimated from this category in Slovakia were 2.54 Gg in 2015.

4.9.2.1 Methodological issues

This category is not key category and therefore tier 1 methodology 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 in 2015 (4 kt). Due to lack of relevant statistics, data for the time series 1990 – 2002 were approximated by the Statistical Office of the Slovak Republic. No paraffin wax was reported in the years 2004 and 2006 (based on the statistical data).

Table 4.57: *The overview of activity data and CO_2 emissions in paraffin wax non-energy use in particular years*

YEAR	PARAFFIN WAX USE (kt)	PARAFFIN WAX USE (TJ)	CO_2 EMISSIONS (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

4.9.2.2 Uncertainties and time-series consistency

Tier 1 method according to the IPCC 2006 GL is used in whole time series.

The uncertainties in the mass of used paraffin wax (2.5%), NCV uncertainty (2.5%), carbon content in paraffin uncertainty (5%) and ODU uncertainty (100%) were used in uncertainty analyses by Monte Carlo method for this category. The uncertainties of CO_2 emissions were calculated. Based on calculation, the overall uncertainty of CO_2 emissions in eq. was calculated in interval (-63.05%; +120.71%). This high uncertainty was caused by the ODU default value of uncertainty used in simulation. Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by Δ symbol in formula):

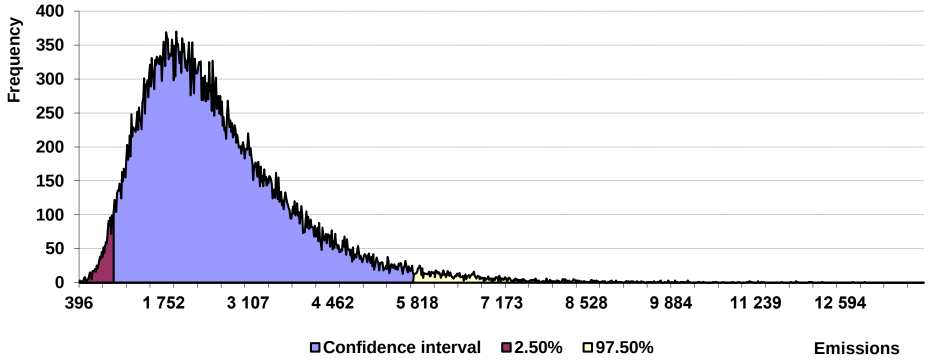
Emissions = (consum_paraf± Δ consum_paraf)*(EF ± ΔEF)* (NCV ± ΔNCV) *(ODU ± ΔODU)*3.664

The accumulated uncertainty and statistical characteristics for lubricants use are presented in the following table and figure. The average mean value of CO_2 emissions eq. in .2.D.2 obtained by the Monte Carlo simulation is 2.61 Gg CO_2 per year 2015. The average mean value is comparable with the real CO_2 emissions, which is 2.54 Gg CO_2.

Table 4.58: *Selected statistical characteristics for 2.D.2, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
2 344.31	**2 607.30**	1 251.97	396.30	13 949.44	-63.05%	120.71%

Figure 4.29: *Probability density function for 2.D.2 (t of CO_2)*



4.9.3 OTHER (CRF 2.D.3)

This category includes potential CO_2 and NMVOC emissions from solvent use, road paving with asphalt, asphalt roofing and asphalt blowing. 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 which originate from the oxidation of NMVOC emissions. 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. In 2016 and 2017, the CLRTAP inventory was recalculated in several categories. The results of the recalculation were adopted in this inventory which resulted in the recalculation of NMVOC and CO_2 emissions in 2.D.3 category since the base year. More information can be found in the CLRTAP submission 2017 (15th February submission).

Urea used in catalytic converters is reported in the category for the first time. The CO_2 emissions were reallocated from the Energy sector, other transportation – other (1.A.3.e.ii) in this category for time series. 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 1.A.3.b.

Until now, the use of urea in industrial plants is not reported in Slovakia. This possible use of urea is annually monitored by questionnaires that are sent to the operators at which the decrease of NO_x emissions occurred. The only NO_x reduction method used in Slovakia occurs in ammonia plant where ammonia is used for reduction purposes and no CO_2 emissions occur at this method.

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 Emission Reduction of Non-Methane Volatile Organic Compounds in the Slovak Republic.

Total GHG emissions in this category were 94.31 Gg of CO_2 eq. in 2015 Total NMVOC emissions were 47.23 kt, CO emissions from asphalt roofing are not occurring in 2015, the other sources of the CO emissions are reported in 1.A.2.c category of energy sector (IE). ***Table 4.59*** summarizes CO_2, CO and NMVOC emissions foe particular years of time series.

Table 4.59: *CO_2, NMVOC and CO emissions in 2.D.3 in particular years*

YEAR	TOTAL CO_2 (Gg)	TOTAL NMVOC (Gg)	TOTAL CO (t)
1990	111.389	93.722	IE
1995	75.522	73.806	IE
2000	64.332	62.706	IE
2005	69.438	50.827	0,726

YEAR	TOTAL CO_2 (Gg)	TOTAL NMVOC (Gg)	TOTAL CO (t)
2010	88.373	67.943	1,020
2011	90.389	60.300	1,610
2012	68.596	49.959	1,377
2013	83.159	46.138	59,970
2014	92.001	45.730	62,590
2015	94.315	47.232	2,972

4.9.3.1 Methodological issues

This category use was divided into 5 parts: (i) coating applications; (ii) degreasing and dry cleaning; (iii) chemical products, manufactured and processing; (iv) using of asphalt (road paving and asphalt roofing); and (v) urea used in catalytic converters. The CO_2 emissions estimation is based on the NMVOC emissions in this category for parts (i) and (ii). The CO_2 emissions from urea use were calculated by COPERT 5 model.

Thorough survey of used solvents for (i) coating applications was provided and results were published in previous submissions. In 2017, the NMVOC emissions from (i) coating applications were recalculated in the CLRTAP inventory since 2000 and were adopted in this submission. It resulted in the recalculation of the indirect CO_2 emissions since 2000. According to the survey results, solvents were divided into several classes based on the carbon content. Solvents were divided into 8 different classes in the time period 1990 – 1999. The carbon content in each class is summarized in the ***Table 4.60***. In the period 2000 – 2015, more detailed information was available and the appropriate carbon content is listed in ***Table 4.61***.

Table 4.60: *Carbon content in solvents used for (i) coating applications in 1990 – 1999*

SOLVENT	SOLVENT NAPHTHA	AROMATICS	ESTERS	ALCOHOLS	ACETONE	DICHLORO-METHANE	CYCLO-HEXANE	OTHERS
CARBON CONTENT	0.86	0.91	0.59	0.59	0.62	0.14	0.28	0.60

Table 4.61: *Carbon content in solvents used for (i) coating applications in 2000 – 2015*

SOLVENT	SOLVENT NAPHTHA	XYLENE	TOLUENE	STYRENE	ETHYL-ACETATE	BUTYL-ACETATE	METHYL-ACETATE	METHOXY-PROPYL-ACETATE
CARBON CONTENT	0.860	0.905	0.913	0.923	0.545	0.620	0.486	0.545
SOLVENT	**ETHYL-ALCOHOL**	**BUTYL-ALCOHOL**	**ISO-PROPANOL**	**ISO-BUTANOL**	**ACETONE**	**DICHLORO-METHANE**	**CYCLO-HEXANE**	**OTHERS**
CARBON CONTENT	0.521	0.648	0.600	0.648	0.620	0.141	0.273	0.600

The indirect (potential) CO_2 emissions from (ii) degreasing and dry cleaning have been estimated since the base year 1990. The calculation of the CO_2 emissions is based on the NMVOC emissions. In 2017 the NMVOC emissions from (ii) degreasing and dry cleaning were recalculated in the CLRTAP inventory since 1990 and were adopted in this submission. It resulted in the recalculation of the indirect CO_2 emissions since 1990. In this category, the solvents are divided into 4 classes. The carbon content is summarized in the ***Table 4.62***.

Table 4.62: *Carbon content in solvents used in (ii) degreasing and dry cleaning since 1990*

SOLVENT	TRICHLOROETHYLENE	TETRACHLOROETHYLENE	ACETONE	ISOPROPANOL
CARBON CONTENT	0.183	0.145	0.620	0.600

The indirect (potential) CO_2 emissions from (iii) chemical products, manufactured and processing have not been estimated since the base year 1990. Composition of NMVOC emissions is not known and there is not known methodology to estimate it. Therefore, the CO_2 emissions are not estimated due to the lack of available methodology and data in this category. The NMVOC emissions were taken directly from CLRTAP inventory in this category. The NMVOC emissions from road paving with asphalt were adopted in this category from the recalculated CLRTAP inventory. It is based on the national methodology from the frame of the National Program for Emission Reduction of Non-Methane Volatile Organic Compounds in the Slovak Republic. Asphalt roofing is produced by saturation without spray (by rolling). The NMVOC and CO emissions were estimated in this category based on the 2013 EMEP/CORINAIR Guidebook methodology. The NMVOC emissions from blowing of asphalt were also estimated according to the 2013 Guidebook. It is in agreement with the CLRTAP inventory. No asphalt roofing was occurring in 2015. The CO_2 emissions from these three categories were not estimated due to the non-availability of methodology and therefore notation key "NE" was used for the whole time series.

The CO_2 emissions from urea based catalysts 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 – 2015. As the number of vehicles with SCR technology is no known, the default value in COPERT model 5 was used. The urea based catalysts were not used before 2010 in Slovakia. More information is included in the chater energy of this report.

The NMVOC and CO emission factors taken from the CORINAIR methodology (2013 Guidebook) were 0.046 kg NMVOC/t for asphalt roofing and 0.0095 kg CO/t for asphalt roofing, 0.66 kg NMVOC/t for asphalt blowing. The NMVOC emission factor for solvent use was estimated to be 1. Emission factors for CO_2 were calculated on the basis of the carbon content in known NMVOC emissions for the respective solvent (***Tables 4.60 - 4.62***).

The NMVOC emissions reported in the CLRTAP inventory were used as the activity data for (i) coating applications; (ii) degreasing and dry cleaning; (iii) chemical products, manufactured and processing. The resulting emissions are presented in the ***Tables 4.63*** - ***4.66***. Total quantity of asphalt used for paving the roads was 147.3 kt in 2015. The data were obtained from the Slovak Association for Asphalt Roads http://www.vuis-cesty.sk/en/). Asphalt was not used for roofs in 2015. This activity data was obtained from producer. The same activity data were used in the category asphalt for blowing. NMVOC and CO emissions together with the activity data are summarized in the ***Table 4.67***. The CO_2 emissions from urea based catalysts estimated by COPERT 5 model are presented in the ***Table 4.68***.

Table 4.63: *NMVOC and CO_2 emissions (t) in solvents use for coating applications in 1990 – 1999*

YEAR	NMVOC EMISSIONS (t)								CO_2 (t)
	SOLVENT NAPHTHA	AROMATIC	ESTER	ALCOHOLS	ACETONE	DICHLORO METHANE	CYCLO HEXANE	OTHERS	
1990	11 910.40	10 171.40	6 234.10	2 788.90	1 214.00	65.60	262.50	164.10	94 439.80
1991	9 801.00	8 370.00	5 130.00	2 295.00	999.00	54.00	216.00	135.00	77 714.10
1992	7 986.00	6 820.00	4 180.00	1 870.00	814.00	44.00	176.00	110.00	63 322.50
1993	7 023.70	5 998.20	3 676.30	1 644.70	715.90	38.70	154.80	96.70	55 692.20
1994	7 332.60	6 262.00	3 838.00	1 717.00	747.40	40.40	161.60	101.00	58 141.50
1995	7 509.40	6 413.00	3 930.50	1 758.40	765.40	41.40	165.50	103.40	59 543.30
1996	6 941.30	5 927.80	3 633.20	1 625.40	707.50	38.20	153.00	95.60	55 038.80
1997	5 682.20	4 852.60	2 974.10	1 330.50	579.20	31.30	125.20	78.30	45 055.30
1998	5 820.70	4 970.90	3 046.70	1 363.00	593.30	32.10	128.30	80.20	46 153.80
1999	5 214.50	4 453.20	2 729.40	1 221.00	531.50	28.70	114.90	71.80	41 346.90

Table 4.64: *NMVOC and CO_2 emissions (t) in solvents use for coating applications in 2000 – 2015*

YEAR		2000	2001	2002	2003	2004	2005	2006	2007	2008
NMVOC EMISSIONS (t)	**TOTAL**	**17 272**	**17 029**	**19 204**	**17 901**	**21 872**	**18 890**	**25 024**	**19 845**	**19 929**
	Solvent Naphtha	6 358	6 268	7 069	6 579	7 979	6 931	9 211	7 298	7 324
	Xylene	2 954	2 912	3 284	3 085	3 903	3 281	4 280	3 410	3 435
	Toluene	1 816	1 791	2 019	1 879	2 279	1 980	2 631	2 085	2 092
	Styrene	755	744	839	781	947	823	1 094	867	870
	Ethyl acetate	321	317	357	333	403	350	466	369	370
	Butyl acetate	1 616	1 593	1 796	1 672	2 027	1 761	2 341	1 854	1 861
	Methyl acetate	200	197	223	207	251	218	290	230	231
	Methoxypropyl acetate	421	415	468	435	528	458	609	483	484
	Ethyl alcohol	161	158	179	166	202	175	233	184	185
	Butyl alcohol	1 494	1 473	1 662	1 546	1 875	1 629	2 165	1 715	1 722
	Isopropanol	126	125	140	131	159	138	183	145	146
	Isobutanol	301	297	335	312	378	329	437	346	347
	Acetone	686	676	763	710	861	748	994	788	790
	Dichlormethane	26	25	29	27	32	28	37	30	30
	Cyclohexane	37	36	41	38	46	40	53	42	42
CO_2 EMISSIONS (t)		**50 459**	**49 748**	**56 103**	**52 307**	**63 974**	**55 211**	**73 105**	**57 984**	**58 235**

YEAR		2009	2010	2011	2012	2013	2014	2015
NMVOC EMISSIONS (t)	**TOTAL**	**20 309**	**27 062**	**23 799**	**20 777**	**24 901**	**28 042**	**28 884**
	Solvent Naphtha	7 458	9 945	8 761	7 648	9 154	10 306	10 624
	Xylene	3 514	4 664	4 070	3 553	4 285	4 833	4 959
	Toluene	2 130	2 841	2 503	2 185	2 615	2 944	3 035
	Styrene	885	1 181	1 040	908	1 087	1 224	1 261
	Ethyl acetate	377	503	443	387	463	521	537
	Butyl acetate	1 895	2 527	2 226	1 943	2 326	2 619	2 699
	Methyl acetate	235	313	276	241	288	325	335
	Methoxypropyl acetate	493	658	579	506	606	682	703
	Ethyl alcohol	188	251	221	193	231	260	268
	Butyl alcohol	1 753	2 338	2 059	1 798	2 152	2 422	2 497
	Isopropanol	148	198	174	152	182	205	211
	Isobutanol	354	472	415	363	434	489	504
	Acetone	805	1 073	945	825	988	1 112	1 146
	Dichlormethane	30	40	35	31	37	42	43
	Cyclohexane	43	58	51	44	53	60	62
CO_2 EMISSIONS (t)		**59 350**	**79 076**	**69 528**	**60 697**	**72 760**	**81 940**	**84 391**

Table 4.65: *NMVOC and CO_2 emissions (t) in solvents use for degreasing and dry cleaning in particular years*

YEAR	NMVOC EMISSIONS (t)					CO_2 EMISSIONS (t)
	TRICHLORO-ETHYLENE	TETRACHLORO-ETHYLENE	ACETONE	ISO-PROPANOL	TOTAL	
1990	3 000.1	2 000.0	6 000.1	111.1	11 111.3	16 948.7
1995	2 128.4	1 505.7	5 804.0	257.8	9 695.8	15 978.6
2000	2 166.5	906.4	4 147.4	1 145.3	8 365.5	13 873.6
2005	531.3	454.7	4 807.8	1 231.4	7 025.2	14 226.7
2010	218.0	260.4	2 233.5	1 186.8	3 898.7	7 967.4
2011	184.8	236.0	7 110.3	1 438.9	8 970.1	19 564.9

YEAR	NMVOC EMISSIONS (t)					CO_2 EMISSIONS (t)
	TRICHLORO-ETHYLENE	TETRACHLORO-ETHYLENE	ACETONE	ISO-PROPANOL	TOTAL	
2012	156.6	210.0	1 125.0	1 648.8	3 140.4	6 396.9
2013	122.0	166.7	2 393.0	1 514.2	4 195.9	8 935.3
2014	3.0	151.9	2 793.2	903.4	3 851.5	8 414.0
2015	568.5	576.4	2 594.1	935.9	4 674.8	8 637.9

Table 4.66: *NMVOC emissions (kt) in solvents use in chemical products in particular years*

YEAR	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
NMVOC (kt)	49 665	43 355	37 023	24 870	36 950	27 493	26 008	17 022	13 810	13 654

Table 4.67: *NMVOC and CO emissions (t) in solvents use from asphalt using in particular years*

YEAR	ASPHALT USE (kt)		NMVOC EMISSIONS (t)		CO EMISSIONS (t)
	ROAD PAVING WITH ASPHALT	ASPHALT ROOFING	ROAD PAVING WITH ASPHALT	ASPHALT ROOFING AND ASPHALT BLOWING	ASPHALT ROOFING
1990	366,8	130.2	43.020	91,900	NA
1995	171,0	65.9	21.510	46,542	NA
2000	52,5	46.5	12.255	32,808	NA
2005	113.0	32.3	19.138	5,949	NA
2010	102,40	25.3	14.373	2,431	NA
2011	121,0	28.1	18.230	2,412	NA
2012	102.3	27.6	14.870	2,373	NA
2013	86.0	6.6	15.197	3,151	54.75
2014	79.2	18.5	13.746	2,865	62.1
2015	147.3	NO	20.067	NO	NA

Table 4.68: *CO_2 emissions (t) originating from the use of urea in catalytic converters in 2010 – 2015*

YEAR	2010	2011	2012	2013	2014	2015
CO_2 EMISSIONS (t)	1 329.6	1 295.8	1 502.0	1 464.2	1 647.5	1 285.6

4.9.3.2 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 Overlap method described in the IPCC 2006 GL (Volume 1, chapter 6) was used in the subcategories paint application in order to ensure time series consistency for different aggregated data (before and after year 2000). This approach ensured consistency in time series and transparency in resulted emissions.

In this submission, the information provided in the NECD and CLRTAP inventories were adopted in the GHG inventory resulting in consistency between inventories.

Content of carbon in NMVOC emissions was used for the uncertainty analyses in the category 2.D.3 according to the individual sources. The emission factors and uncertainty for both AD and EF (represented by Δ symbol in formula) were used for uncertainty estimation. The uncertainty of CO_2 emissions (in eq.) is in interval (-2.30%; +2.30%). Formula can be written in the following form:

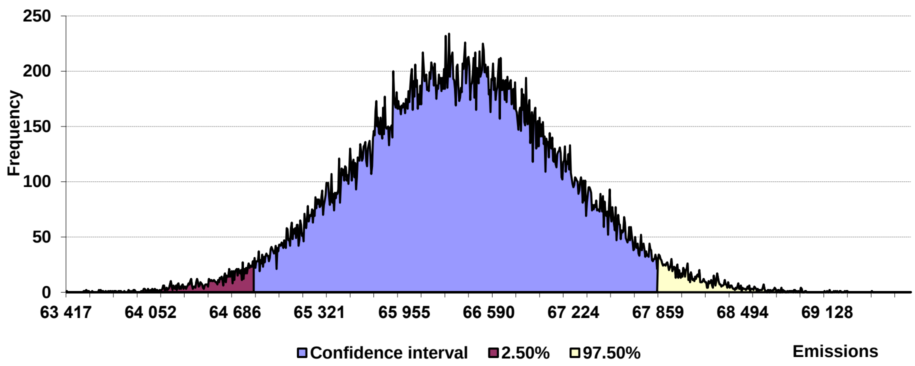
$$Emissions = \sum_{I} (NMVOC \pm \Delta NMVOC) * (content of\ C \pm \Delta\_content of\ C) * \frac{44}{12}$$

First row of formula is related to CO_2 emissions, second row is related to CO_2 eq. The accumulated uncertainty and statistical characteristics for solvent are presented on the following table and figure. The normal distribution of all categories influenced total uncertainty. The symmetry of aggregate uncertainty was not surprising in this case. The average mean value of CO_2 emissions eq. obtained by the Monte Carlo simulation is 93.03 Gg CO_2 eq. per year 2015. The average mean value is comparable with the real CO_2 emissions, which is 94.32 Gg CO_2 eq.

Table 4.69: *Selected statistical characteristics for 2.D.3, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
93 033	**93 033**	1 089	88 790	97 973	-2.30%	2.30%

Figure 4.30: *Probability density function for 2.D.3 (t of CO_2)*



4.10 ELECTRONIC INDUSTRY (CRF 2.E)

No halocarbons, SF_6 or NF_3 were used in the Slovak Republic in 1990 – 2015 in this category, therefore notation key “NO” was used in all 2.E categories.

4.11 PRODUCT USES AS SUBSTITUTES FOR ODS (CRF 2.F)

4.11.1 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 4.70: *The overview of actual HFCs and PFCs emissions in 1990 – 2015*

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
1991	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO
1994	NO	NO	0.196	NO	NO	NO	0.196
1995	11.223	NO	2.095	NO	NO	NO	13.318
1996	24.778	NO	3.609	NO	NO	NO	28.387
1997	35.685	NO	5.527	NO	0.680	NO	41.892
1998	49.365	NO	5.243	NO	2.253	NO	56.861
1999	64.931	5.892	6.463	NO	2.857	NO	80.142
2000	88.476	6.157	7.745	2.667	1.420	NO	106.464
2001	117.429	5.891	9.864	5.598	2.501	NO	141.284
2002	153.141	7.334	11.981	5.999	3.695	NO	182.150
2003	187.721	6.725	12.807	6.263	1.774	NO	215.290
2004	228.345	5.964	13.548	6.528	0.776	NO	255.161
2005	266.953	5.280	13.959	6.800	0.443	NO	293.435
2006	315.364	4.545	14.515	7.064	0.111	NO	341.598
2007	361.257	4.312	15.500	7.193	NO	NO	388.261
2008	427.117	2.446	17.687	7.222	NO	NO	454.472
2009	488.283	2.315	18.981	7.347	NO	NO	516.927
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	702.398	1.978	20.549	9.960	NO	NO	734.885

Figure 4.31: *The emission share in individual subcategories in the 2.F category in 2015*

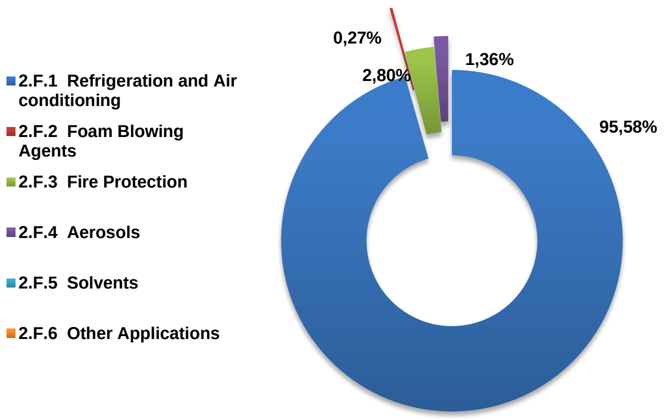
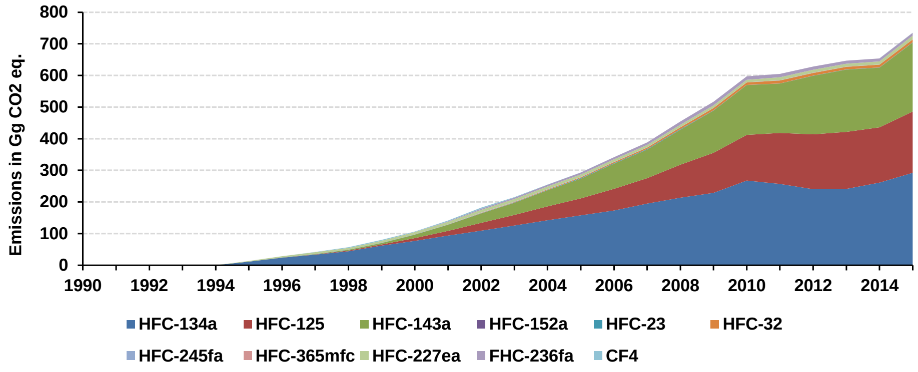


Figure 4.32: *Trend in individual gases categories in the 2.F category in 1990 – 2015*



Total actual HFCs emissions reported in the category 2.F Product uses as substitutes for ODS were 734.89 Gg of CO_2 eq. in 2015 and they increased by 12% compared to the previous year. The increase is due the higher decommissioning of retired products and respective increase in disposal emissions in refrigeration and air conditioning category (2.F.1). 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.

The actual emissions of PFCs in the category 2.F did not occur in 2015.

4.11.2 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 the tables according to the way of use. Since the year 2009, input data are reported through the new electronic system which 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 on www.szchkt.org 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. Added value 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 and is available on web page http://www.szchkt.org/?locale=en_GB. 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 2013 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.

4.11.3 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.

4.11.4 METHODS

The actual emission estimation of time series was performed mainly by tier 2 methodology that accounts for the time lag between the consumption and the emissions. Detailed description of methodology is provided in the subcategories.

4.11.5 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Well documented consistent time series of the HFCs import-export exists since 1995, 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 the last reporting years. A new, consistent method for the estimation of retiring equipment was used in

2015 submission. The main change in 2016 submission is the recalculation of reported recovery (in CRF reporter). In previous submission, the recovery represented the amount of HFCs and PFCs that was recovered and recycled from the disposed systems and could be used again. Since this 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.

4.11.6 SOURCE SPECIFIC QA/QC AND VERIFICATION

Slovakia has a unique reporting system of F-gases in bulks and in products. Data processing system and verification is done automatically via the webpage www.szchkt.org. 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,
- the Notified Body has access to historical development in all monitored categories and compares it with ex-post and ex-ante projections up to 2025.

This data processing systems 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 more precise data. 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 also 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 (http://www.zvhp.sk/) 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. Sector specific QA/QC activities were performed as described in Chapter 4.2 and in the Chapter 4.7.6 of this 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.

4.11.7 SOURCE SPECIFIC RECALCULATIONS

In this submission, several recalculations have been made, all of them in 2.F.1. The recalculation of operational emissions considered the possibility of no servicing of equipment few years before its decommissioning. The recalculation of disposal emissions and recovery has been made, as well. The detailed data about recovery in recycling factories have been obtained. Another recalculation of operational emissions in 2.F.1.b domestic refrigeration has been made where the assumption that domestic refrigeration units are not serviced is applied since this submission. The change in emissions in 2.F was nearly 17% increase.

Recalculation of the subcategories 2.F.1.a – 2.F.1.f was performed. The recalculation of operational emissions was based on the assumption that equipment that are planned to be decommissioning are not serviced for several years before the decommissioning. The operational emissions from that equipment are not covered by database Leaklog and also by top-down approach. Therefore we assumed that the operational emissions from that equipment decrease the bank of chemical and were added to the emissions reported by Leaklog.

Another source of recalculation was gathering of new, complete, data about recovery of the ODS gases. These data are also covered by database Leaklog since 2014. There is available amount of gas that is recovered, reused and destroyed in recycling factories. All of these terms are covered in CRF term "recovery". Comparison of amount of gas in disposed equipment and recovered in recycling factories together with the fraction of gas that are recovered from disposed equipment is presented in ***Table 4.71***. For years before 2013 the average value of the years 2014 and 2015 is assumed. 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.

Specific recalculation of 2.F.1.b has been done. In previous submission the operational emissions were calculated as in the other 2.F.1 categories. However, the domestic refrigeration units usually are not serviced, which means that the bank of chemical is not restocked. Therefore we used the default product life factor (0.5 %) and the assumption that the emissions decrease the bank of the chemical.

In the 2017 submission the error in the allocating of the new imported fillings was corrected. New fillings that were filled in Slovakia in 2014 and 2015 were reallocated from the 2.F.1.b category domestic refrigeration into 2.F.1.a category commercial refrigeration. The amount of reallocated gas HFC-134a was below 0.02t (0.03 Gg CO_2 eq.). Due the negligible amount of the reallocated gas, the comparison of submissions is not presented.

Effect of the recalculations on the total HFC emissions in the 2.F.1 and in each category is presented in the ***Table 4.71* - *4.77***.

Table 4.71: *The recalculations changes and comparison of the submissions 2016 and 2017 in 2.F.1.*

YEAR	HFCS AND PFCS EMISSIONS		2016/2017 CHANGES
	SUBMISSION 2016	SUBMISSION 2017	
	Gg CO_2 eq.		
1990	NO	NO	NO
1991	NO	NO	NO
1992	NO	NO	NO
1993	NO	NO	NO
1994	NO	NO	NO
1995	8.396	11.223	33.67%
1996	18.623	24.778	33.05%
1997	26.858	35.685	32.86%
1998	37.378	49.365	32.07%
1999	49.280	64.931	31.76%

YEAR	HFCS AND PFCS EMISSIONS		2016/2017 CHANGES
	SUBMISSION 2016	SUBMISSION 2017	
	Gg CO_2 eq.		
2000	68.157	88.476	29.81%
2001	91.479	117.429	28.37%
2002	120.916	153.141	26.65%
2003	149.223	187.721	25.80%
2004	182.903	228.345	24.84%
2005	214.635	266.953	24.38%
2006	256.550	315.364	22.92%
2007	298.436	361.257	21.05%
2008	358.874	427.117	19.02%
2009	412.983	488.283	18.23%
2010	500.988	568.550	13.49%
2011	491.166	574.336	16.93%
2012	499.705	597.847	19.64%
2013	505.200	616.885	22.11%
2014	515.598	623.422	20.91%

Table 4.72: *The recalculations changes and comparison of the submissions 2016 and 2017 in 2.F.1.a*

YEAR	SUBMISSION 2016			SUBMISSION 2017			2016/2017
	OPERATIONAL EMISSIONS	DISPOSAL EMISSIONS	TOTAL EMISSIONS	OPERATIONAL EMISSIONS	DISPOSAL EMISSIONS	TOTAL EMISSIONS	CHANGES %
	Gg CO_2 eq.			Gg CO_2 eq.			
1990	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO	NO	NO
1995	0.75	NO	0.78	0.84	NO	0.87	11.86%
1996	2.42	NO	2.46	2.67	NO	2.71	10.06%
1997	3.58	NO	3.63	4.00	NO	4.05	11.50%
1998	5.74	NO	5.84	6.48	NO	6.58	12.66%
1999	8.51	NO	8.64	9.67	NO	9.80	13.38%
2000	15.94	NO	16.28	18.17	NO	18.51	13.67%
2001	25.75	NO	26.22	29.41	NO	29.88	13.94%
2002	38.96	NO	39.61	44.33	NO	45.08	13.82%
2003	50.71	NO	51.33	57.33	NO	58.29	13.55%
2004	65.39	0.44	66.65	73.78	0.55	75.67	13.54%
2005	78.38	1.69	80.90	88.35	2.63	92.46	14.29%
2006	97.48	2.51	101.13	109.87	3.90	115.62	14.33%
2007	110.87	4.14	115.98	124.76	6.55	132.94	14.62%
2008	135.62	5.78	142.91	152.17	9.36	163.70	14.55%
2009	157.85	10.34	169.79	176.50	16.97	195.77	15.30%
2010	184.97	17.23	203.37	199.27	28.61	229.81	13.00%
2011	166.16	25.96	192.97	183.76	43.21	228.61	18.47%
2012	184.30	33.08	218.10	204.17	55.14	260.83	19.59%
2013	192.45	38.99	232.25	214.46	65.11	281.17	21.06%
2014	188.27	41.99	231.27	212.21	67.61	281.69	21.80%

Table 4.73: *The recalculations changes and comparison of the submissions 2016 and 2017 in 2.F.1.b*

YEAR	SUBMISSION 2016			SUBMISSION 2017			2016/2017
	OPERATIONAL EMISSIONS	DISPOSAL EMISSIONS	TOTAL EMISSIONS	OPERATIONAL EMISSIONS	DISPOSAL EMISSIONS	TOTAL EMISSIONS	CHANGES %
	Gg CO_2 eq.			Gg CO_2 eq.			
1990	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO	NO	NO
1995	NO	NO	NO	NO	NO	NO	NO
1996	NO	NO	NO	NO	NO	NO	NO
1997	NO	NO	NO	NO	NO	NO	NO
1998	0.05	NO	0.28	0.12	NO	0.35	25.10%
1999	0.10	NO	0.35	0.24	NO	0.49	42.09%
2000	0.12	NO	0.27	0.31	NO	0.46	69.48%
2001	0.15	NO	0.26	0.36	NO	0.47	85.32%
2002	0.15	NO	0.20	0.38	NO	0.43	114.88%
2003	0.16	NO	0.20	0.40	NO	0.44	117.41%
2004	0.17	NO	0.18	0.41	NO	0.43	131.14%
2005	0.17	NO	0.19	0.41	NO	0.43	131.07%
2006	0.17	NO	0.19	0.42	NO	0.44	129.83%
2007	0.17	NO	0.17	0.42	NO	0.42	142.37%
2008	0.17	NO	0.17	0.42	NO	0.42	141.19%
2009	0.17	NO	0.17	0.42	NO	0.42	140.02%
2010	0.17	1.24	1.41	0.38	2.83	3.22	128.74%
2011	0.15	2.55	2.70	0.35	5.82	6.17	128.98%
2012	0.13	3.30	3.43	0.33	7.53	7.86	129.12%
2013	0.12	3.86	3.98	0.30	8.82	9.12	129.22%
2014	0.12	2.84	2.97	0.24	4.91	5.16	73.91%

Table 4.74: *The recalculations changes and comparison of the submissions 2016 and 2017 in 2.F.1.c*

YEAR	SUBMISSION 2016			SUBMISSION 2017			2016/2017
	OPERATIONAL EMISSIONS	DISPOSAL EMISSIONS	TOTAL EMISSIONS	OPERATIONAL EMISSIONS	DISPOSAL EMISSIONS	TOTAL EMISSIONS	CHANGES %
	Gg CO_2 eq.			Gg CO_2 eq.			
1990	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO	NO	NO
1995	0.11	NO	0.14	0.11	NO	0.14	1.00%
1996	0.30	NO	0.36	0.31	NO	0.37	0.88%
1997	0.47	NO	0.54	0.47	NO	0.54	0.83%
1998	0.78	NO	0.90	0.79	NO	0.91	0.67%
1999	1.18	NO	1.34	1.19	NO	1.34	0.61%
2000	2.28	NO	2.68	2.30	NO	2.69	0.46%
2001	3.75	NO	4.30	3.77	NO	4.31	0.41%
2002	5.72	NO	6.46	5.74	NO	6.49	0.38%
2003	7.42	NO	8.15	7.46	NO	8.18	0.38%
2004	9.64	NO	10.59	9.68	NO	10.63	0.37%

YEAR	SUBMISSION 2016			SUBMISSION 2017			2016/2017
	OPERATIONAL EMISSIONS	DISPOSAL EMISSIONS	TOTAL EMISSIONS	OPERATIONAL EMISSIONS	DISPOSAL EMISSIONS	TOTAL EMISSIONS	CHANGES %
	Gg CO_2 eq.			Gg CO_2 eq.			
2005	11.68	NO	12.64	11.73	NO	12.69	0.36%
2006	14.65	NO	15.96	14.70	NO	16.02	0.35%
2007	16.74	NO	17.87	16.81	NO	17.93	0.36%
2008	20.57	NO	22.31	20.65	NO	22.38	0.35%
2009	24.18	NO	26.01	24.26	NO	26.09	0.32%
2010	25.87	0.06	27.27	25.96	0.07	27.37	0.37%
2011	33.21	0.17	34.84	33.34	0.23	35.04	0.57%
2012	53.78	0.27	55.00	54.01	0.38	55.35	0.63%
2013	56.16	0.45	57.48	56.52	0.68	58.06	1.01%
2014	46.97	0.69	48.19	47.64	0.97	49.14	1.97%

Table 4.75: *The recalculations changes and comparison of the submissions 2016 and 2017 in 2.F.1.d*

YEAR	SUBMISSION 2016			SUBMISSION 2017			2016/2017
	OPERATIONAL EMISSIONS	DISPOSAL EMISSIONS	TOTAL EMISSIONS	OPERATIONAL EMISSIONS	DISPOSAL EMISSIONS	TOTAL EMISSIONS	CHANGES %
	Gg CO_2 eq.			Gg CO_2 eq.			
1990	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO	NO	NO
1995	0.18	NO	0.18	0.27	NO	0.27	51.69%
1996	0.39	NO	0.39	0.59	NO	0.59	51.82%
1997	0.57	NO	0.58	0.87	NO	0.88	51.14%
1998	0.80	NO	0.81	1.22	NO	1.23	51.32%
1999	1.08	NO	1.09	1.64	NO	1.66	51.55%
2000	1.53	NO	1.56	2.33	NO	2.36	51.62%
2001	2.10	NO	2.14	3.19	NO	3.22	50.43%
2002	2.83	NO	2.88	4.19	NO	4.25	47.22%
2003	3.49	0.25	3.80	5.12	0.19	5.36	41.29%
2004	4.19	0.58	4.83	6.20	0.44	6.71	38.75%
2005	4.92	0.61	5.59	7.29	0.48	7.84	40.19%
2006	5.88	0.68	6.64	8.69	0.56	9.34	40.65%
2007	6.69	0.86	7.63	9.79	0.74	10.61	39.00%
2008	7.81	1.36	9.30	11.35	1.22	12.70	36.58%
2009	8.86	2.05	11.04	12.82	1.91	14.86	34.61%
2010	11.02	2.65	13.78	15.06	2.53	17.69	28.36%
2011	10.13	3.00	13.26	14.67	2.86	17.66	33.15%
2012	10.96	3.38	14.46	16.15	3.24	19.50	34.90%
2013	9.92	3.78	13.76	15.70	3.65	19.40	41.05%
2014	6.47	4.66	11.14	12.92	3.97	16.91	51.81%

Table 4.76: *The recalculations changes and comparison of the submissions 2016 and 2017 in 2.F.1.e*

YEAR	SUBMISSION 2016			SUBMISSION 2017			2016/2017
	OPERATIONAL EMISSIONS	DISPOSAL EMISSIONS	TOTAL EMISSIONS	OPERATIONAL EMISSIONS	DISPOSAL EMISSIONS	TOTAL EMISSIONS	CHANGES %
	Gg CO_2 eq.			Gg CO_2 eq.			
1990	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO	NO	NO
1995	4.76	NO	5.00	7.13	NO	7.36	47.31%
1996	10.27	NO	10.51	15.37	NO	15.61	48.54%
1997	14.59	NO	15.07	21.84	NO	22.31	48.10%
1998	19.33	NO	19.80	28.93	NO	29.41	48.47%
1999	24.91	NO	25.62	37.28	NO	37.99	48.28%
2000	31.09	NO	31.80	46.53	NO	47.23	48.55%
2001	38.33	NO	39.04	57.37	NO	58.08	48.76%
2002	46.00	NO	46.71	68.84	NO	69.55	48.90%
2003	54.48	NO	55.43	81.54	NO	82.48	48.81%
2004	63.60	NO	64.78	94.88	NO	96.06	48.29%
2005	72.94	NO	74.12	107.93	NO	109.11	47.20%
2006	82.54	NO	84.01	120.45	NO	121.91	45.12%
2007	91.19	6.51	100.41	131.53	4.88	139.12	38.55%
2008	99.09	14.05	116.15	141.90	10.54	155.45	33.83%
2009	106.38	19.96	129.20	151.78	14.97	169.60	31.27%
2010	145.46	26.45	174.55	182.35	19.83	204.83	17.35%
2011	124.22	27.56	154.81	164.83	20.67	188.53	21.78%
2012	104.96	28.48	137.82	150.56	21.36	176.30	27.92%
2013	93.61	32.47	130.62	144.20	24.36	173.10	32.52%
2014	110.39	36.48	150.44	165.51	20.70	189.79	26.16%

Table 4.77: *The recalculations changes and comparison of the submissions 2016 and 2017 in 2.F.1.f*

YEAR	SUBMISSION 2016			SUBMISSION 2017			2016/2017
	OPERATIONAL EMISSIONS	DISPOSAL EMISSIONS	TOTAL EMISSIONS	OPERATIONAL EMISSIONS	DISPOSAL EMISSIONS	TOTAL EMISSIONS	CHANGES %
	Gg CO_2 eq.			Gg CO_2 eq.			
1990	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO	NO	NO
1995	2.16	NO	2.30	2.44	NO	2.58	12.09%
1996	4.73	NO	4.90	5.33	NO	5.50	12.30%
1997	6.90	NO	7.04	7.76	NO	7.90	12.23%
1998	9.55	NO	9.73	10.71	NO	10.89	11.84%
1999	12.03	NO	12.25	13.44	NO	13.66	11.49%
2000	15.22	NO	15.57	16.87	NO	17.22	10.61%
2001	19.08	NO	19.52	21.02	NO	21.47	9.95%
2002	24.45	NO	25.05	26.74	NO	27.35	9.15%
2003	29.67	NO	30.31	32.32	NO	32.96	8.74%

YEAR	SUBMISSION 2016			SUBMISSION 2017			2016/2017
	OPERATIONAL EMISSIONS	DISPOSAL EMISSIONS	TOTAL EMISSIONS	OPERATIONAL EMISSIONS	DISPOSAL EMISSIONS	TOTAL EMISSIONS	CHANGES %
	Gg CO_2 eq.			Gg CO_2 eq.			
2004	35.12	NO	35.87	38.10	NO	38.85	8.31%
2005	40.40	NO	41.19	43.63	NO	44.42	7.85%
2006	47.61	NO	48.62	51.02	NO	52.03	7.01%
2007	54.01	1.37	56.37	57.57	1.68	60.24	6.86%
2008	63.59	3.01	68.03	67.33	3.70	72.47	6.52%
2009	70.87	4.42	76.77	74.59	5.46	81.54	6.21%
2010	73.26	6.18	80.61	76.73	7.74	85.63	6.24%
2011	84.94	6.47	92.58	88.93	8.24	98.33	6.21%
2012	62.44	7.12	70.89	67.34	9.34	78.01	10.04%
2013	57.63	8.50	67.11	63.65	11.39	76.03	13.29%
2014	60.38	10.71	71.59	67.42	12.81	80.73	12.77%

4.11.8 SOURCE SPECIFIC PLANNED IMPROVEMENTS

Trend in the ratio of recovered gases from disposed equipment will be monitored and the average value from broader time series will be calculated for extrapolation purposes. The availability of historical data from recycling factories will be checked. The recovery and disposal emissions will be recalculated for the years before 2013 in 2019 submission.

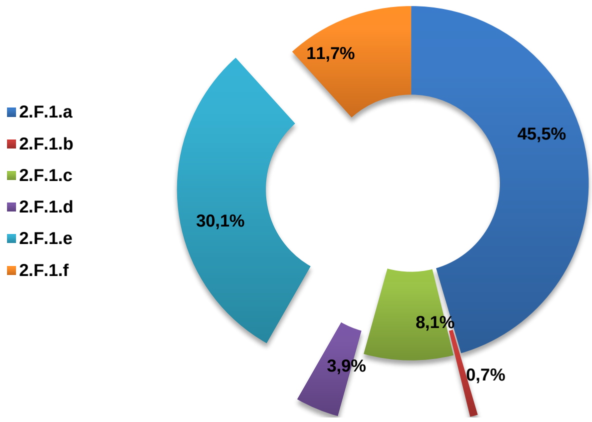
Improvements are implemented in line with the Improvement and Prioritization Plan for the year 2017.

4.11.9 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 702.40 Gg of CO_2 eq. in 2015 and they increased by 12% in comparison with the previous year. The increase is due the higher decommissioning of retired products and respective increase in disposal emissions. The emissions of PFCs and SF_6 are not occurring in this category. The following gases and subcategories are reported in 2.F.1:

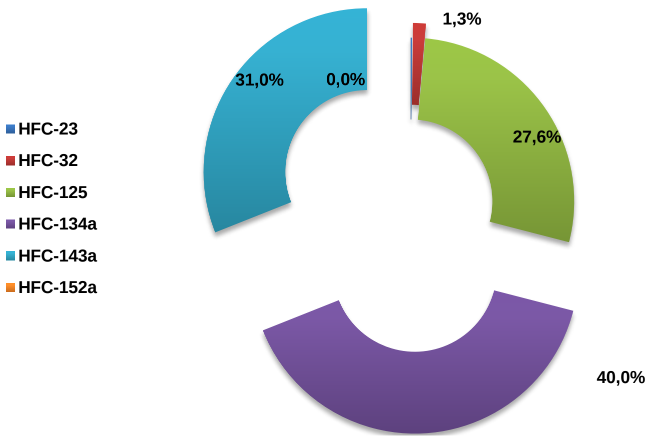
- HFC-23, HFC-32, HFC-125, HFC-134a, HFC-143a and HFC-152a in 2.F.1.a - Commercial refrigeration.
- HFC-134a in 2.F.1.b - Domestic refrigeration.
- HFC-32, HFC-125, HFC-134a, HFC-143a and HFC-152a in 2.F.1.c - Industrial refrigeration.
- HFC-32, HFC-125, HFC-134a and HFC-143a in 2.F.1.d - Transport refrigeration.
- 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 4.33: *The share of individual subcategories in 2.F.1 in 2015*



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. 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.

Figure 4.34: *The share of individual gases in 2.F.1 in 2015*



Approximately 45% of total F-gases emissions (in CO_2 eq.) are allocated in 2.F.1.a – Commercial refrigeration in 2015 followed by 2.F.1.e – Mobile AC (30%) (***Figure 4.33***). This is connected with the high share of automotive industry in last years in Slovakia. About 12% 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 4.78*** - ***4.83***. Gradual substitution of HCFCs and CFCs coolants by the HFCs (HC) coolants, especially by coolant R134a or coolants R125 and R143a as components in mixtures of coolants R 404A, R407C, R410A takes place in Slovakia.

Table 4.78: *Aggregated data on HFCs using (Gg CO_2 eq.) in 2.F.1.a in particular years*

YEAR	NEW FILLINGS	NEW ADDITIONS TO BANK	BANK	RETIRED EQUIPMENT	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

Table 4.79: *Aggregated data on HFCs using (Gg CO_2 eq.) in 2.F.1.b in particular years*

YEAR	NEW FILLINGS	NEW ADDITIONS TO BANK	BANK	RETIRED EQUIPMENT	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

Table 4.80: *Aggregated data on HFCs using (Gg CO_2 eq.) in 2.F.1.c in particular years*

YEAR	NEW FILLINGS	NEW ADDITIONS TO BANK	BANK	RETIRED EQUIPMENT	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

Table 4.81: *Aggregated data on HFCs using (Gg CO_2 eq.) in 2.F.1.d in particular years*

YEAR	NEW FILLINGS	NEW ADDITIONS TO BANK	BANK	RETIRED EQUIPMENT	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

Table 4.82: *Aggregated data on HFCs using (Gg CO_2 eq.) in 2.F.1.e in particular years*

YEAR	NEW FILLINGS	NEW ADDITIONS TO BANK	BANK	RETIRED EQUIPMENT	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

Table 4.83: *Aggregated data on HFCs using (Gg CO_2 eq.) in 2.F.1.f in particular years*

YEAR	NEW FILLINGS	NEW ADDITIONS TO BANK	BANK	RETIRED EQUIPMENT	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

4.11.9.1 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 takes the time lag 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 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. Calculation of emission estimates by the bottom-up approach using the corrected data.

In 2015, the corrections were made as follow: (i) the difference of 39.7593 t of R134.a was added to operational emissions in 2.F.1.e. No other correction were necessary, the differences between top-down and bottom-up approaches were negligible (up to 3 kg, e.g. for R410A the difference was 0.9 kg).

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 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 are few years before decommissioning are not serviced and bank is not restock at these 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 4.84***. 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 4.85*** are consistent. These emissions do not restore the bank of the chemical and are subtracted from the bank.

Table 4.84: *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 of these terms are covered in CRF term "recovery". Therefore in this submission the disposal emission factors were recalculated. 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 are presented in ***Table 4.85***. For years before 2013 the average value of the years 2014 and 2015 is assumed. 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.

Table 4.85: *Comparison of amount of gases in retired units and amount of recovered gases in 2014 and 2015*

F-GAS	YEAR 2014			YEAR 2015			BEFORE 2013 YEAR
	AMOUNT IN RETIRED EQUIPMENT (t)	RECOVER. AMOUNT (t)	RATIO	AMOUNT IN RETIRED EQUIPMENT (t)	RECOVER. AMOUNT (t)	RATIO	RATIO
HFC-23	0.035	NO	-	0.040	NO	-	-
HFC-32	2.128	1.451	68.2%	3.255	1.4215	43.7%	55.0%
HFC-125	12.528	3.426	27.3%	14.771	3.353	22.7%	25.0%
HFC-134a	49.361	26.973	54.6%	50.218	14.232	28.3%	40.0%
HFC-143a	12.200	1.907	15.6%	13.994	1.669	11.9%	13.0%
HFC-152a	0.711	NO	-	0.476	NO	-	-

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.

Emissions factor from the filling chemicals into new equipment (product manufacturing factor) is assumed to be 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 4.85***. For years before 2013 the average value of the years 2014 and 2015 is assumed.

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 are R-134a, R-402A, R-404A, R-507. Refrigerants of less importance: R-407C, R-410A R-23, R-401A, R-402A R-417A, R-422D. Lifetime of equipment was assumed to be 9-12 years. Nameplate capacity of retired equipment was calculated as follows:

Retired equipment$_{in\ year\ t}$ = New addition to stock$_{in\ year\ t-12}$ / 4 + New addition to stock$_{in\ year\ t-11}$ / 4 + New addition to stock$_{in\ year\ t-10}$ / 4 + New addition to stock$_{in\ year\ t-9}$ / 4

The fraction of the gas that remained in the retired equipment is presented in ***Table 4.84*** and the recovered fraction is presented in ***Table 4.85***.

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 with 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 to be 12-15 years. Nameplate capacity of retired equipment was calculated as follows:

Retired equipment$_{in\ year\ t}$ = New addition to stock$_{in\ year\ t-15}$ / 4 + New addition to stock$_{in\ year\ t-14}$ / 4 + New addition to stock$_{in\ year\ t-13}$ / 4 + New addition to stock$_{in\ year\ t-12}$ / 4

The fraction of the gas that remained in the retired equipment is presented in ***Table 4.84*** and the recovered fraction is presented in ***Table 4.85***.

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 industrial 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 of importance today are R-404A, R-407C, R-507, R410A and R407F. The HCFC R-22 is still in use, especially in older equipment. Lifetime of equipment was assumed to be 15-19 years. Nameplate capacity of retired equipment was calculated as follows:

Retired equipment$_{in\ year\ t}$ *= New addition to stock*$_{in\ year\ t-19}$ */ 5 + New addition to stock*$_{in\ year\ t-18}$ */ 5 + New addition to stock*$_{in\ year\ t-17}$ */ 5 + New addition to stock*$_{in\ year\ t-16}$ */ 5 + New addition to stock*$_{in\ year\ t-15}$ */ 5*

The fraction of the gas that remained in the retired equipment is presented in ***Table 4.84*** and the recovered fraction is presented in ***Table 4.85***.

2.F.1.d – Transport refrigeration: This group includes refrigerated road vehicles (vans 400pc/year total 3000 pcs, charge 1.6 kg 50% R134a, 50% R404A, trucks 50pc/year total 1500 pcs, (direct drive, diesel tract compressor), trailers 150 pc/year total 2000 pcs pre-charged 5-8 kg R404A, second hand + 20%). Recently, the most important refrigerants are R-404A and R-134a. Refrigerants of less importance are R-407C, HCFC/HFC-blends R-401A and R-402A and HCFC R-22. Manufacturing of refrigeration units does not take place in Slovakia. Emissions occur from stock and from disposal. Lifetime of equipment was assumed to be 8-9 years. Nameplate capacity of retired equipment was calculated as follows:

Retired equipment$_{in\ year\ t}$ *= New addition to stock*$_{in\ year\ t-9}$ */ 2 + New addition to stock*$_{in\ year\ t-8}$ */ 2*

The fraction of the gas that remained in the retired equipment is presented in ***Table 4.84*** and the recovered fraction is presented in ***Table 4.85***.

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 2015, 85 264 new vehicles were registered in Slovakia. In these vehicles, the average charge was assumed to be 0.6 kg of HFC per car. HFC-134a represents 90% of the HFC charge, the rest (10%) is HFO1234ye. The number of imported and registered second-hand vehicles was 5 887 pcs. HFC-134a charge in these vehicles was assumed to be 1 kg per car. Lifetime of equipment was assumed to be 12-15 years. Nameplate capacity of retired equipment was calculated as follows:

Retired equipment$_{in\ year\ t}$ *= New addition to stock*$_{in\ year\ t-15}$ */ 4 + New addition to stock*$_{in\ year\ t-14}$ */ 4 + New addition to stock*$_{in\ year\ t-13}$ */ 4 + New addition to stock*$_{in\ year\ t-12}$ */ 4*

The fraction of the gas that remained in the retired equipment is presented in ***Table 4.84*** and the recovered fraction is presented in ***Table 4.85***.

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. Used refrigerants are R-407C and R-410A.

The installation of heat pumps with the HFCs started in Slovakia mainly in the 2004. Heat pumps are manufactured in Slovakia and also imported. Used F-gases are R-134a, R-404A, R-407C and R-410A. Propane is also important. Lifetime of air conditioning equipment and heat pumps was assumed to be 12-15 years. Nameplate capacity of retired equipment was calculated as follows:

Retired equipment$_{in\ year\ t}$ = New addition to stock$_{in\ year\ t-15}$ / 4 + New addition to stock$_{in\ year\ t-14}$ / 4 + New addition to stock$_{in\ year\ t-13}$ / 4 + New addition to stock$_{in\ year\ t-12}$ / 4

The fraction of the gas that remained in the retired equipment is presented in ***Table 4.84*** and the recovered fraction is presented in ***Table 4.85***.

4.12.9.2 Uncertainties and time-series consistency

Well documented and consistent time series of HFCs import-export exists since 1995, due to the collected information in 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 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 to be average value of product life factors in the period 2010 – 2013 (outliers were excluded from the average). The used product life factors are presented in the ***Table 4.86*** 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 the 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. In Slovakia, there are exist three factories. 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 2009 – 2014. For the rest of the time series the new fillings were estimated on the basis of 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 (90% with HFC-134a; 10% with HFO1234ye).

The emissions in the category 2.F.1.f have stable trend since 2012 (interannual 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 4.86: *Product life factors of individual gases in the 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

CATEGORY	HFC-125	HFC-134a	HFC-143a	HFC-152a	HFC-23	HFC-32
	%					
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

The nonsymmetrical error distribution in reported data on operational emissions in the range from -8% to +17% was assumed. This error was lowered since the year 2009. The symmetrical error distribution of the other parameters was assumed.

The uncertainty of CO_2 emissions (in eq.) is in interval (-3.37%; +3.40%). It was computed by Monte Carlo simulation with next formula (uncertainties for AD and EF are represented by Δ):

$$\text{Emission} = \sum_c \sum_g [\,(\text{New fillings} \pm \Delta\text{New\_fillings})*(\text{EF\_new} \pm \Delta\ \text{EF\_new}) +$$

$$+ (\text{Oper\_emissions} \pm \Delta\ \text{Oper\_emissions})+(\text{Disposed\_equipment} \pm \Delta\ \text{Disposed\_equipment}) *$$

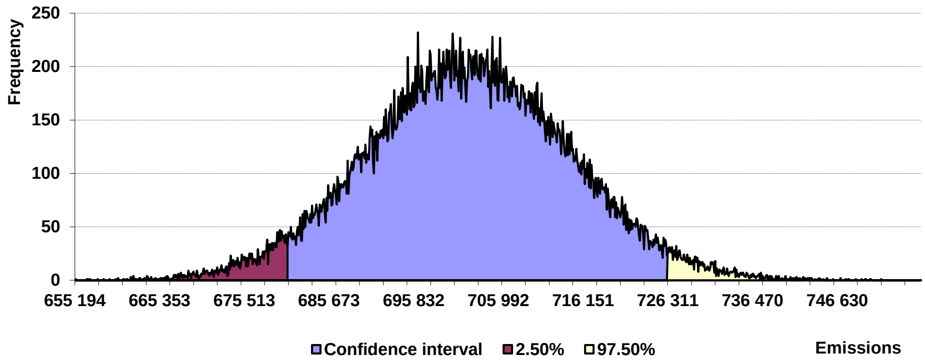
$$* (\text{fraction\_gas} \pm \Delta\ \text{fraction\_gas})* (\text{EF\_disposed} \pm \Delta\ \text{EF\_disposed})]$$

The sums in formula for emission are done by gases (HFC-134a, HFC-125, HFC143a, HFC-152a, HFC-23, HFC-32) and by the categories (2.F.1.a, 2.F.1.b, 2.F.1.c, 2.F.1.d, 2.F.1.e, 2.F.1.f). The accumulated uncertainty and statistical characteristics for 2.F.1 category are presented on the following table and figure. The average mean value of CO_2 emissions eq. in 2.F.1 obtained by the Monte Carlo simulation is 702 Gg CO_2 eq. per year 2015. The average mean value is comparable with the real CO_2 emissions, which is 702 Gg CO_2 eq.

Table 4.87: *Selected statistical characteristics for 2.F.1, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2 eq.)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
702 367	**702 387**	12 120	655 194	756 789	-3.37%	3.40%

Figure 4.35: *Probability density function for 2.F.1 (t of CO_2 eq.)*



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 1.98 Gg CO_2 eq. in 2015 (***Table 4.88***).

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 on the basis of 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 to 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 4.88: *Aggregated data on HFCs using (Gg CO_2 eq.) in 2.F.2 in particular years*

YEAR	NEW FILLINGS	BANK	RETIRED EQUIP.	EMISSIONS FROM:			RECOV.	TOTAL EMISSIONS
				NEW FILLINGS	BANK	DISPOSAL		
	Gg CO_2 eq.							
1990	NO	NO	NO	NO	NO	NO	NO	NO
1995	NO	NO	NO	NO	NO	NO	NO	NO
2000	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

4.12.10.2 Uncertainties and time-series consistency

Well documented and consistent time series of HFCs import-export exists since the first years of HFCs using in foams (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.

The uncertainty of CO_2 emissions (in eq.) is in interval (-11.05%; +11.65%). It was computed by Monte Carlo simulation with next formula (uncertainties for AD and EF are represented by Δ):

$$\text{Emission} = \sum_{g} [(\text{New fillings} \pm \Delta\text{New\_fillings})*(\text{EF\_new} \pm \Delta\ \text{EF\_new}) + (\text{Stock} \pm \Delta\ \text{Stock}) *$$

$$* (\text{EF\_stock} \pm \Delta\ \text{EF\_stock})+(\text{Disposed\_equipment} \pm \Delta\ \text{Disposed\_equipment}) *$$

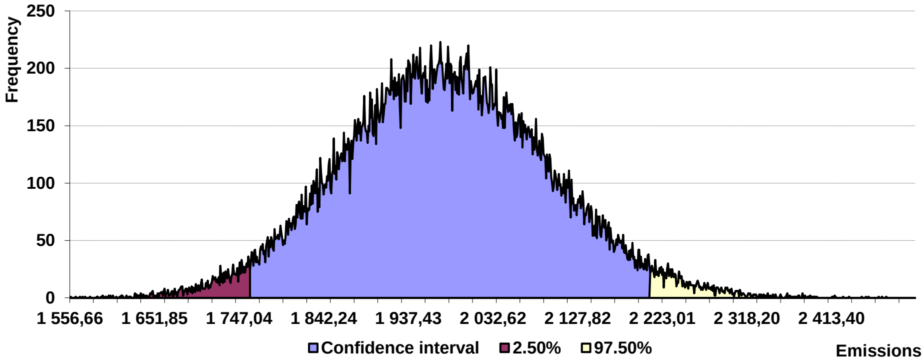
$$* (\text{fraction\_gas} \pm \Delta\ \text{fraction\_gas})]$$

The sum in formula for emission is done by gases (HFC-134a, HFC-227ea, HFC-246fa, HFC-365mfc). The accumulated uncertainty and statistical characteristics for HFCs are presented on the following table and figure. The normal distribution of all categories influenced total uncertainty. The symmetry of aggregate uncertainty was not surprising in this case. The average mean value of CO_2 emissions eq. in 2.F.2 obtained by the Monte Carlo simulation is 1.98 Gg CO_2 eq. per year 2015. The average mean value is comparable with the real CO_2 emissions, which is 1.98 Gg CO_2 eq.

Table 4.89: *Selected statistical characteristics for 2.F.2, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2 eq.)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
1 976.53	**1 978.67**	114.83	1 556.66	2 508.59	-11.05%	11.65%

Figure 4.36: *Probability density function for 2.F.2 (t of CO_2 eq.)*



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 the 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 20.55 Gg CO_2 eq. in 2015.

4.12.11.1 Methodological issues

Annual sales of single HFC gases are calculated on the basis of 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 life time from 10-12 years (given by the producer). After this time, extinguishing media are recovered, recycled and used again. No emissions from disposal are reported. 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 are in agreement with references and were consulted with the fire protection companies. 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).

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. These data served as tools for differentiating of annual sales data into new fillings and operational emissions (from bank).

Table 4.90: *Aggregated data on HFCs used (Gg CO_2 eq.) in 2.F.3 in particular years*

YEAR	NEW FILLINGS	NEW ADDITIONS TO BANK	BANK	RETIRED EQUIP.	EMISSIONS FROM:			RECOV.	TOTAL
					NEW FILLINGS	BANK	DISP.		
	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
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

4.12.11.2 Uncertainties and time-series consistency

Well documented and consistent time series of HFCs import-export data exists since 1995 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.

The uncertainty of CO_2 emissions (in eq.) is in interval (-21.87%; +22.77%). It was computed by Monte Carlo simulation with next formula (uncertainties for AD and EF are represented by Δ):

Emission = $\sum_g$[(New fillings ± ΔNew_fillings)*(EF_new ± Δ EF_new) + (Stock ± Δ Stock) *

* (EF_stock ± Δ EF_stock) + (Disposed_equipment ± Δ Disposed_equipment) *

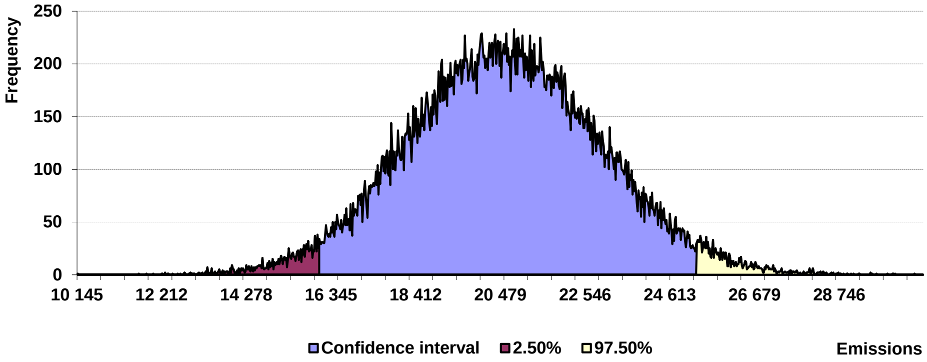
* (fraction_gas ± Δ fraction_gas)]

The sum in formula for emission is done by gases (HFC-134a, HFC-227ea, HFC-236fa). The accumulated uncertainty and statistical characteristics for HFCs are presented on the following table and figure. The normal distribution of all categories influenced total uncertainty. The symmetry of aggregate uncertainty was not surprising in this case. The average mean value of CO_2 emissions eq. in 2.F.3 obtained by the Monte Carlo simulation is 20.58 Gg CO_2 eq. per year 2015. The average mean value is comparable with the real CO_2 emissions, which is 20.55 Gg CO_2 eq.

Table 4.91: *Selected statistical characteristics for 2.F.3, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2 eq.)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
20 546.90	**20 575.35**	2 335.83	10 144.70	30 813.17	-21.87%	22.77%

Figure 4.37: *Probability density function for 2.F.3 (t of CO_2 eq.)*



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.

Total HFCs emissions in this category are not significant and were 9.96 Gg CO_2 eq. in 2015. 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:

$Emissions_{in\ year\ t} = Initial\ charge_{in\ year\ t-1} * (1-EF) + Initial\ charge_{in\ year\ t} * EF$

where EF = 0.5.

The State Institute for Drug Control of Slovakia (http://www.sukl.sk/en?page_id=256) 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 (SUKL) provided this data on behalf of the Act No 286/2010 Coll. Data are available since 2000. Based on the statement of the SUKL experts, no MDIs had been imported to Slovakia before the year 2000.

Table 4.92: *Aggregated data on HFCs using (Gg CO_2 eq.) in 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

4.12.12.2 Uncertainties and time-series consistency

Well documented and consistent time series of HFCs import-export data exists since the first years of MDIs using (2000). 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.

The uncertainty of CO_2 emissions (in eq.) is in interval (-20.20%; +21.39%). It was computed by Monte Carlo simulation with next formula (uncertainties for AD and EF are represented by Δ):

$$\text{Emission} = \sum_g [\,(\text{gas\_sales\_current} \pm \Delta\ \text{gas\_sales\_current}) * (\text{EF\_current} \pm \Delta\ \text{EF\_current}) +$$

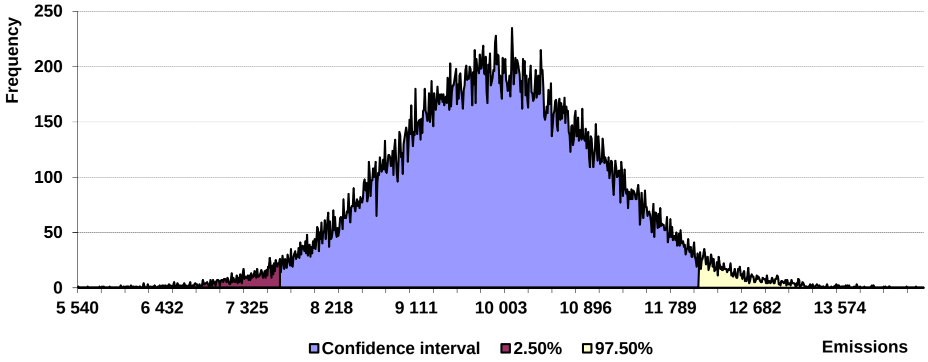
$$+ (\text{gas\_sales\_prev} \pm \Delta\ \text{gas\_sales\_prev}) * (1-(\text{EF\_prev} \pm \Delta\ \text{EF\_prev}))]$$

The sum in formula for emission is done by gases (HFC-134a, HFC-227ea). The accumulated uncertainty and statistical characteristics for HFCs are presented on the following table and figure. The normal distribution of all categories influenced total uncertainty. The average mean value of CO_2 emissions eq. in 2.F.4 obtained by the Monte Carlo simulation is 9.96 Gg CO_2 eq. per year 2015. The average mean value is comparable with the real CO_2 emissions, which is 9.96 Gg CO_2 eq.

Table 4.93: *Selected statistical characteristics for 2.F.4, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2 eq.)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
9 949.86	**9 958.06**	1 087.17	5 539.77	14 466.95	-21.20%	21.39%

Figure 4.38: *Probability density function for 2.F.4 (t of CO_2 eq.)*



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 2014. 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 4.94: *PFC14 emissions in 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
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

YEAR	FILLED INTO NEW PRODUCTS	BANK	EMISSIONS FROM:		TOTAL EMISSIONS
			NEW FILLINGS	BANK	
	Gg CO_2 eq.				
2005	NO	0.443	NO	0.443	0.443
2006	NO	0.111	NO	0.111	0.111

Emissions are considered to be 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%. This description 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 – 2015.

4.13 OTHER PRODUCT MANUFACTURE (CRF 2.G)

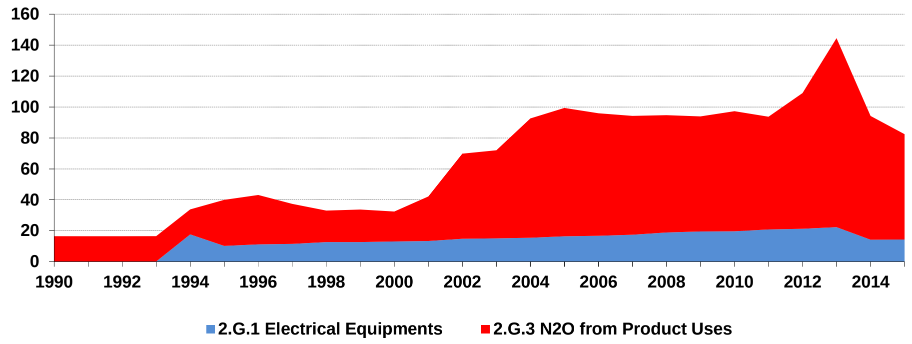
4.13.1 SOURCE CATEGORY DESCRIPTION

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. in 2015 were 82.42 Gg and decreased by ca 13% compared with the previous year. The decrease is caused by lowering of use of N_2O in aerosol cans. 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 4.95: *Emissions in 2.G according to the subcategories (Gg of CO_2 eq.) in particular years*

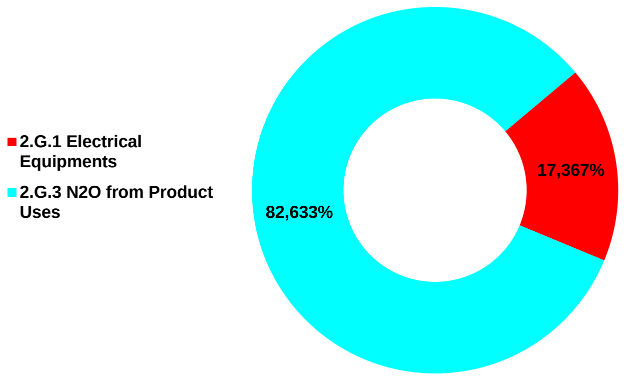
YEAR	2.G.1 ELECTRICAL EQUIPMENT	2.G.2 SF_6 AND PFCs FROM OTHER PRODUCT USE	2.G.3 N_2O FROM PRODUCT USE
1990	0.06	NO	16.39
1995	10.15	IE	29.79
2000	13.04	IE	19.36
2005	16.38	IE	83.01
2010	19.62	IE	77.66
2011	20.80	IE	72.91
2012	21.24	IE	87.76
2013	22.30	IE	122.23
2014	14.17	IE	80.03
2015	14.31	IE	68.11

__Figure 4.39:__ The trend of individual categories in emissions (Gg of CO_2 eq.) in 2.G in 1990 – 2015



The major share (82.6%) in emissions belongs to the N_2O emissions from the product use (72.6% from aerosol cans, the rest from the anaesthesia using), 17.4% belongs to SF_6 emissions from electrical equipment.

__Figure 4.40:__ The share in GHG emissions of individual categories of the 2.G in 2015



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 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 7 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 14.31 Gg CO_2 eq. (0.628 t SF_6) in 2015 and are summarized in the ***Table 4.96***. In 2013, old equipment started to be disposed.

Table 4.96: *SF_6 emissions in the category 2.G.1 in particular years*

YEAR	NEW FILLINGS	NEW ADD. TO BANK	BANK	RETIRED EQUIP.	EMISSIONS FROM: NEW FILLINGS	EMISSIONS FROM: BANK	EMISSIONS FROM: DISP.	RECOV.	TOTAL
	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

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 2015);
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 to be 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 2015 0.20 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

Well documented and consistent time series of SF_6 import-export data exists since 1993. 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 to be average value 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.

The uncertainty of CO_2 emissions (in eq.) is in interval (-4.63%; +4.61%). It was computed by Monte Carlo simulation with next formula (uncertainties for AD and EF are represented by Δ):

Emission = (New fillings ± ΔNew_fillings)*(EF_new ± Δ EF_new) +

+ (Oper_emissions ± Δ Oper_emissions) +

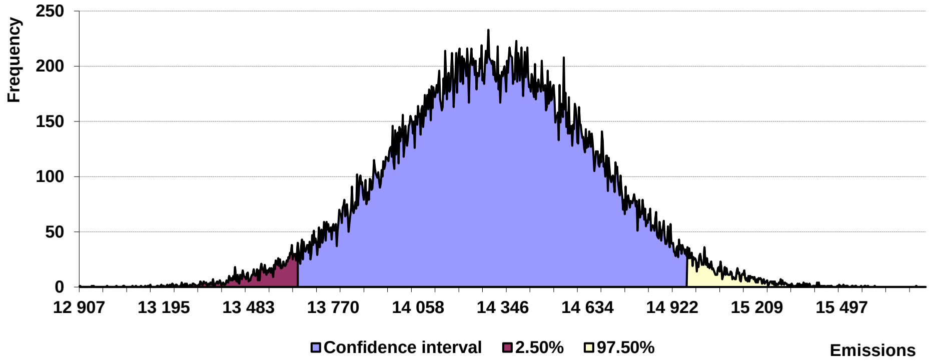
+ (Disposed_equipment ± Δ Disposed_equipment) * (EF_disposed ± Δ EF_disposed).

The accumulated uncertainty and statistical characteristics for SF_6 are presented on the following table and figure. The normal distribution of all categories influenced total uncertainty. The symmetry of aggregate uncertainty was not surprising in this case. The average mean value of CO_2 emissions eq. in 2.G.1 obtained by the Monte Carlo simulation is 14.31 Gg CO_2 eq. per year 2015. The average mean value is comparable with the real CO_2 emissions, which is 14.31 Gg CO_2 eq.

Table 4.97: *Selected statistical characteristics for 2.G.1, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2 eq.)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
14 311.17	**14 313.01**	337.12	12 907.09	15 785.09	-4.63%	4.61%

Figure 4.41: *Probability density function for 2.G.1 (t of CO_2 eq.)*



4.13.3 USE OF SF_6 AND PFCs IN OTHER PRODUCTS (CRF 2.G.2)

SF_6 can be used as an extinguishing medium in electronics, protection against explosion, isolation, sterilization, detection gas, alloying of Al and Mg and in tobacco production. SF_6 gas is rather expensive and therefore was never used as an extinguishing medium and in the Slovak industry. Shoes and tires with F-gas cushions are not manufactured or imported to Slovakia for the time series 1990 – 2015. 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 2015. 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 201.0 t and total N_2O emissions from anaesthesia were 27.5 t in 2015.

4.13.4.1 Methodological issues

The methodology is based on the default tier 1 method due to less significant of this category (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 the ***Table 4.98***.

Table 4.98: *N_2O emissions from product uses in particular years*

YEAR	TOTAL N_2O (Gg)	TOTAL N_2O	
		2.G.3.A MEDICAL APPLICATIONS (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

YEAR	TOTAL N_2O (Gg)	TOTAL N_2O	
		2.G.3.A MEDICAL APPLICATIONS (ANAESTHESIA)	2.G.3.B OTHER (AEROSOL CANS)
		Gg	
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

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 was used for the whole time series.

Activity data uncertainty (3%) and emission factor uncertainty (1%) were used for the uncertainty analyses in 2.G.3 according to the individual sources. The emission factors and uncertainty for both AD and EF (in formula represent by symbol Δ) were used for uncertainty estimation. The uncertainty of CO_2 emissions (in eq.) is in interval (-2.96%; +2.96%). Formula can be written in the following form:

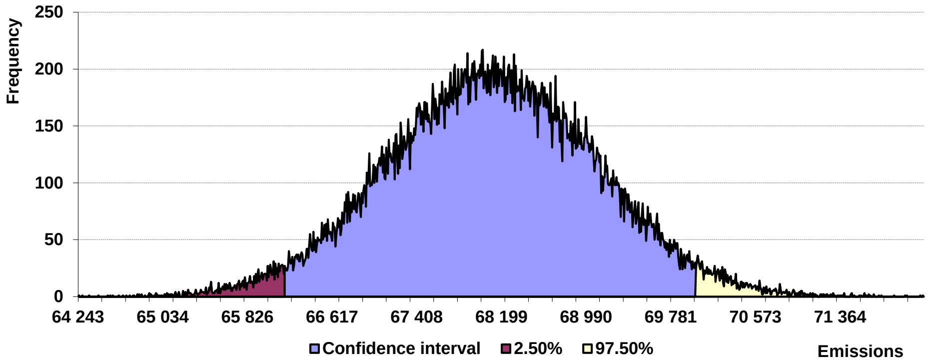
$$Emissions = \sum_i \left(CF_i * (AD \pm \Delta AD) * (EF \pm \Delta EF) \right)$$

The process is related to N_2O emissions. The CO_2 eq. is obtained after applying of a conversion factor (CF) to equation above. The accumulated uncertainty and statistical characteristics are presented on the following table and figure. The normal distribution of all categories influenced total uncertainty. The average mean value of CO_2 emissions eq. obtained by the Monte Carlo simulation is 68 Gg CO_2 eq. per year. The average mean value is comparable with the real CO_2 emissions, which is 68 Gg CO_2 eq.

Table 4.99: *Selected statistical characteristics for 2.G.3, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2 eq.)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
68 104.70	**68 106.84**	972.54	64 243.14	72 155.01	-2.80	2.80

Figure 4.42: *Probability density function for 2.G.3 (t of CO_2 eq.)*



4.14 OTHER PRODUCTION (CRF 2.H)

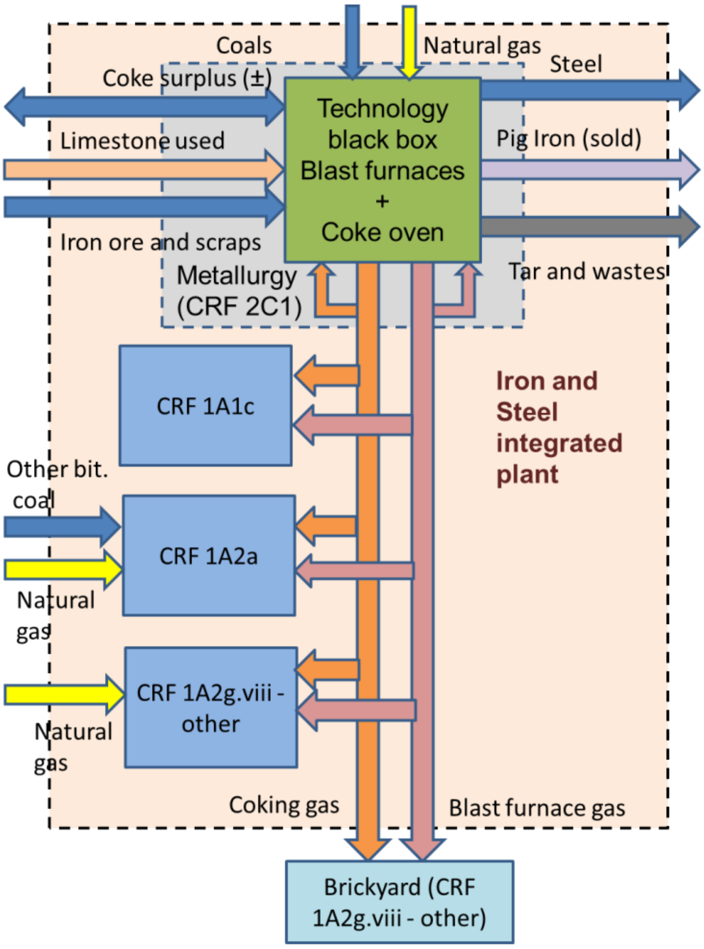
The NMVOC emissions from food industry were reported in this category in 2015. Total emissions of NMVOC were 310.7 t and are consistent with the CLRTAP inventory. No GHG emissions occurred in the time series 1990 – 2015.

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 revised country specific methodology was implemented in this submission (see Chapter 4.4.2 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 on the basis of 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 taken into account, 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 on the basis of 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 1A2g.viii - other.

Table A4.1.1: *Balance of the category 2.C.1 in 2015*

STREAM	AD (kt; mil. m^3)	NCV (TJ /m.j.)	EF(C) (t/TJ; mass fraction)	CARBON (kt)
Coking coal	2 596.50	29.712	25.720	1 984.25
Anthracite	45.38	26.166	28.715	34.09
Coke surplus	-29.98	28.107	29.857	-25.16
Natural gas	20.18	35.052	15.196	10.75
Tar and wastes	-2 470.90		0.038	-93.13
Coking gas	-657.42	16.347	11.530	-123.91
Blast furnace gas	-3 586.84	3.144	71.240	-803.38
Iron ore	7 232.78		3.036E-03	21.96
Steel	-4 310.94		7.430E-04	-3.20
Pig iron sold	-34.33		4.403E-02	-1.51
Limestone used	800.39		1.201E-01	96.12
TOTAL	**1 096.89**			

CO_2 emissions estimation in the 2.C.1 is based on the carbon balance (from that plant) and represents the value 4 018.99 Gg (total carbon × 3.664).

Table A4.1.2: *Balance of 1.A.1.c in 2015*

STREAM	AD (kt; mil. m^3)	NCV (TJ /m.j.)	EF(C) (t/TJ; mass fraction)	CARBON (kt)
Natural gas	8.55	35.052	15.20	4.56
Coking gas	126.14	16.35	11.53	23.78
Blast furnace gas	1 398.43	3.14	71.24	313.22
TOTAL	**341.55**			

CO_2 emissions estimation in 1.A.1.c is based on the carbon balance (from that plant, not total 1.A.1.c) and represents the value 1 251.44 Gg (total carbon × 3.664).

Table A4.1.3: *Balance of 1.A.2.a in 2015*

STREAM	AD (kt; mil. m^3)	NCV (TJ /m.j.)	EF(C) (t/TJ; mass fraction)	CARBON (kt)
Other bituminous coal	374.79	27.421	26.643	273.81
Natural gas	0.03	35.052	15.196	0.01
Coking gas	320.75	16.347	11.530	60.45
Blast furnace gas	1 865.67	3.144	71.240	417.87
TOTAL	**752.15**			

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 2 755.86 Gg (total carbon × 3.664).

Table A4.1.4: *Balance of 1A2g.viii - other in 2015*

STREAM	AD (kt; mil. m^3)	NCV (TJ /m.j.)	EF(C) (t/TJ; mass fraction)	CARBON (kt)
Natural gas	109.49	35.052	15.20	58.32
Coking gas	210.28	16.35	11.53	39.63
Blast furnace gas	322.73	3.14	71.24	72.29
TOTAL	**170.24**			

CO_2 emissions estimation in 1A2g.viii - other is based on the carbon balance (from that plant, not total 1A2g.viii - other) and represents the value 623.76 Gg (total carbon × 3.664).

The output from the plant was 0.249 mil. m^3 of coking gas and 0 mil. m^3 of blast furnace gas in 2015. 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 1A2g.viii - other.

Carbon balance presented in this Annex is only from the integrated iron and steel plant. The CO_2 emission estimation presented here is allocated in the categories 2.C.1, 1.A.1.c, 1.A.2.a and 1A2g.viii - other. The presented energy sector categories include 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. 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 0.04% (NIR: 8 650.05 Gg CO_2; EU ETS: 8 646.63 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. Added value of electronic logbook is indirect detection of refrigerant leak. The fault detection classifier estimates the probability of refrigerant leak.

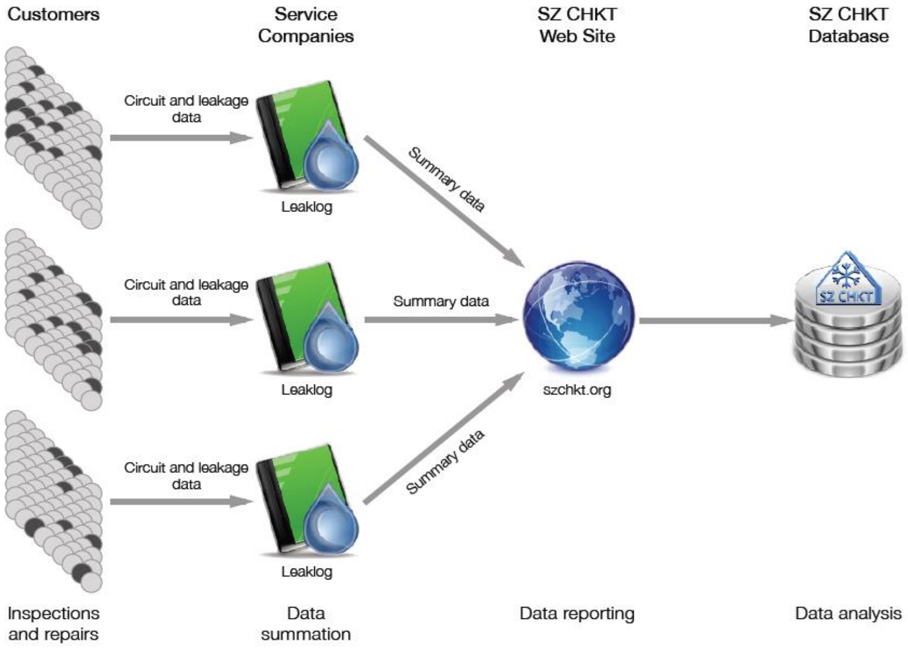
In the year 2003 Slovakia started software with access to the processing and data assessment. This software system is based on the activities of the Slovak Association for Cooling and Air-conditioning Technology (SZCHKT). The electronically led documentations have been developed from the previous paper questionnaires. Evaluated data were collected from the service organizations and customers. The backward running contact with inventoried companies enabled more effective cooperation. 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 on web page http://www.szchkt.org/?locale=en_GB. 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.

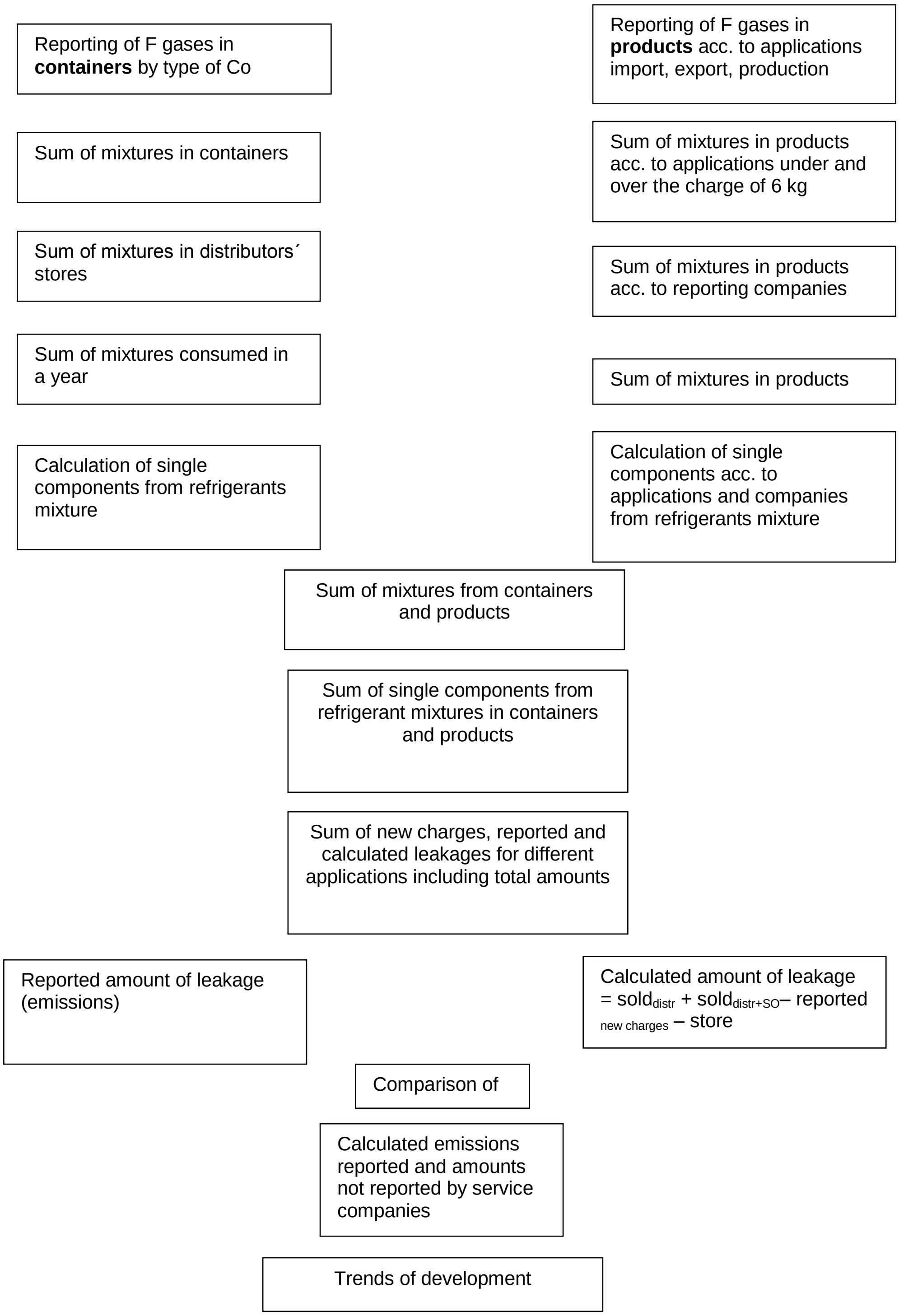
All companies dealing with the F-gases have access to the electronic system based on certificate provided by the Notified Body. Advantages of electronic data logging and reporting are in the possibilities of automatic analysis, fault detection and comparison of, fast access to the full history of leak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

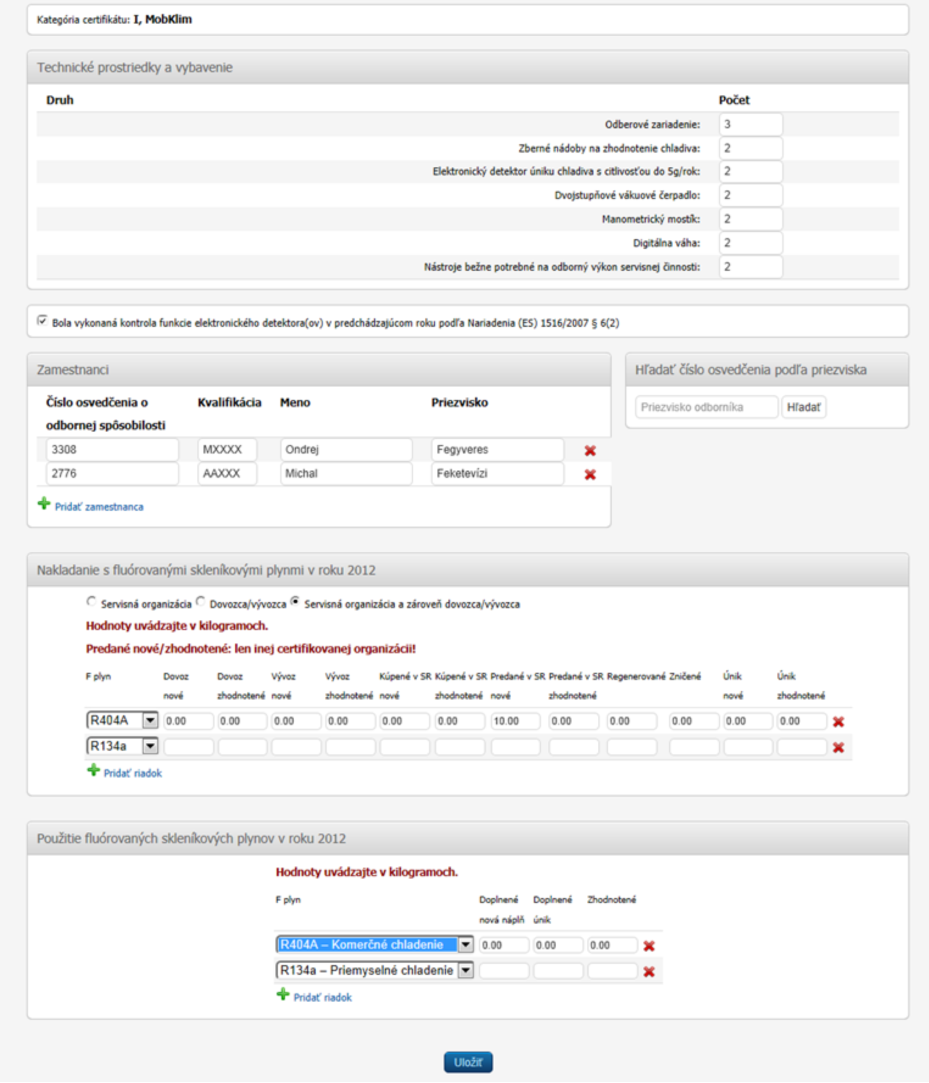
Figure A4.2.2: *Diagram of data flow in reporting (data flow direction: top to down)*



A4.2.1 REPORTING OF F-GASES IMPORTED IN BULKS

Refrigerant movements reporting are 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. The table in the ***Figure A4.2.3*** is showing the 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 till 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

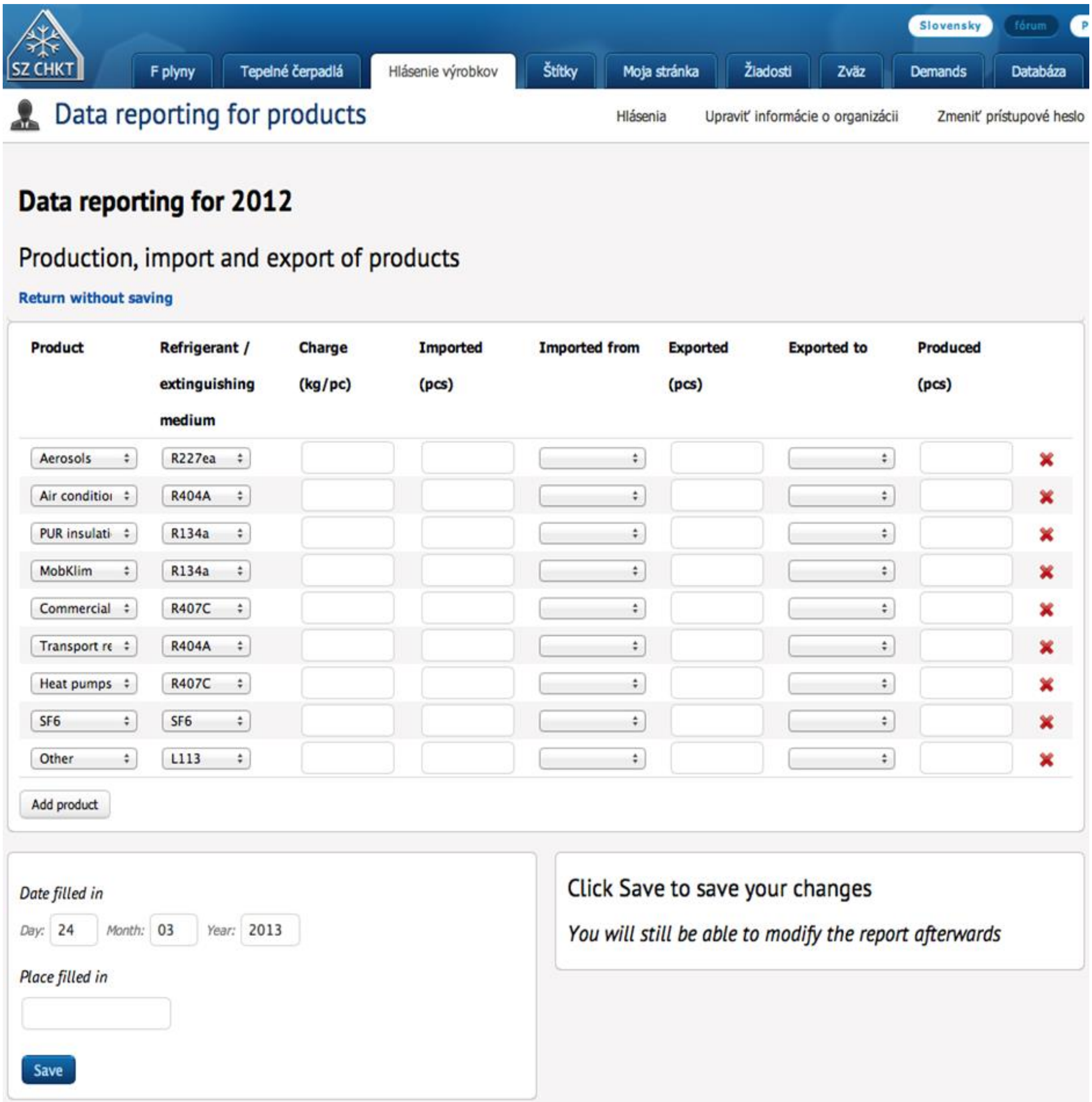
Uložiť

A4.2.2 REPORTING OF F-GASES IMPORTED IN PRODUCTS

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.

The ***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 till 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 sector 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 in operation until present. Therefore also trends are consistent.

Reporting is made by the Logbook software Leaklog available on the webpage www.szchkt.org. 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*

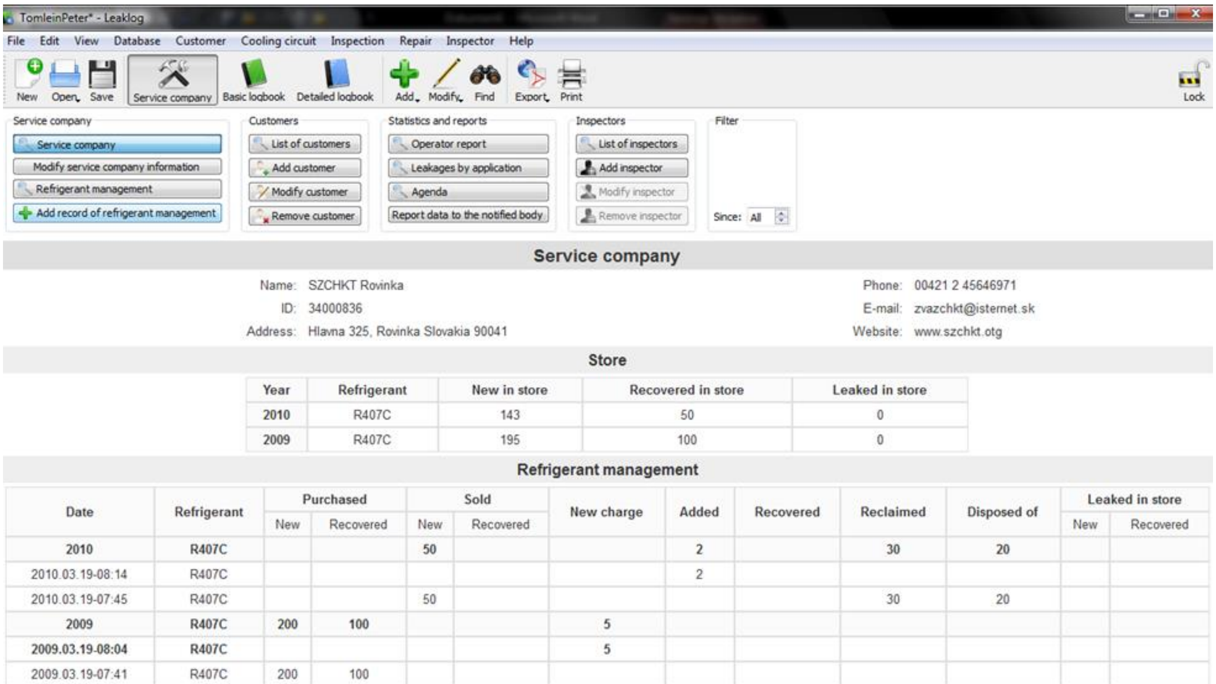


Figure A4.2.6: *Procedure of data reporting of F-gases*

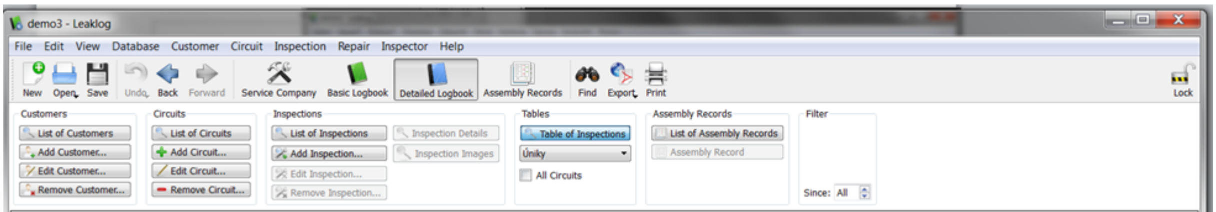


Table of Inspections: CHLJ-1

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***).

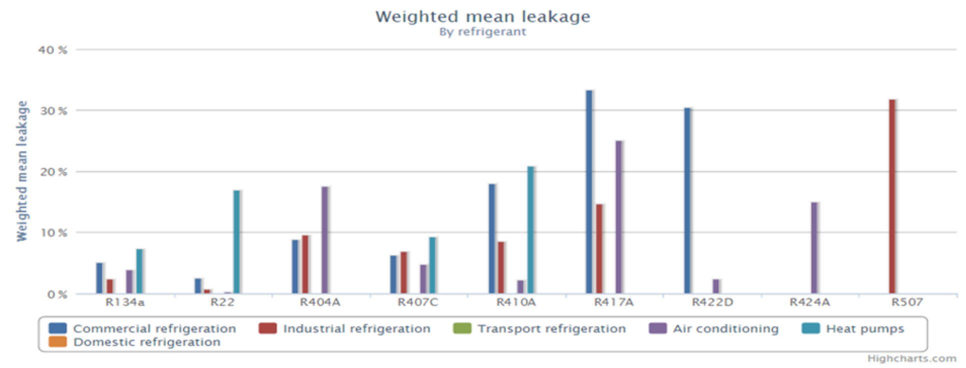
Figure A4.2.7: *Table of leakages by application*

Tables of Leakages by Application

Back | Tables | Charts by refrigerant | Charts by field of application

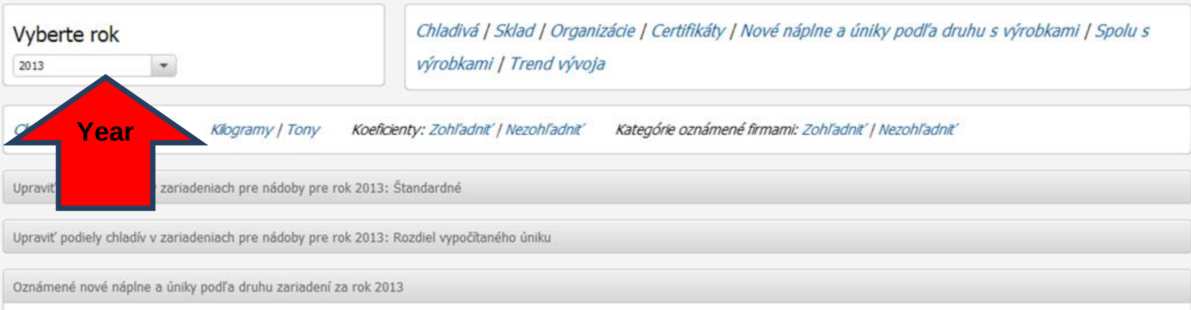
Weighted mean leakage

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



After the completing of input data, the blends are converted into single substances according to the appliances (***Figure A4.2.8***).

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



Oznámené nové náplne a úniky podľa druhu zariadení za rok 2013

Skratky: **NN** - Nová náplň, **Ú** - Únik, **ÚV** - Únik vypočítaný

Chlad.	MobKlim			Komerčné chladenie			Priemyselné chladenie			Prepravné chladenie			Klimatizácia a TČ		
	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 which 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. 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*$_{in\ year\ t\text{-}1}$ *+ 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.

This data processing is used for the 2.F.1 Refrigeration and air conditioning equipment, 2.F.3 Fire protection and 2.G.1 Electrical equipment categories. The data processing for the other categories is described in respective chapters of NIR.

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CHAPTER 5: AGRICULTURE (CRF 3)

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

INSTITUTE	CHAPTER	SECTORAL EXPERT
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5.1 OVERVIEW OF THE SECTOR (CRF 3)

The humankind activities in agriculture sector significantly contribute to the changes of concentration of some gases in atmosphere which consequently increases their greenhouse effect as well as the acidity of environment. Despite of the fact that water vapour and CO_2 are the gases with the highest share to greenhouse effect of the atmosphere, N_2O and CH_4 emitted from agriculture are considered as the most important gases from the point of view of planning adaptive measures to reduce their influence on environment. Sources of N_2O and CH_4 emissions are analysed according to the IPCC 2006 GL methodologies while principles of good practice in GHGs inventory in agriculture were taken into account. Some national data from research projects were utilized too. The emissions from agriculture can be reduced if effective adaptation measures were implemented in agricultural practice. Effective measures have been already proposed for the conditions of the Slovak Republic. The shortage of data in relation to storage and application of manures has resulted in the fact that the emissions are evaluated at the level of business as usual. The methodology also makes use of results of research institutions sharing nitrogen fluxes in the conditions of the Slovak Republic. Emissions from burning of field residuals have not been evaluated because these forms of soil cultivation are prohibited by law in the Slovak Republic. This source is not evaluated in the GHG inventory. Methane and nitrous oxide are the most important gases emitted from agriculture. Agriculture produces about 26% of total methane and more than 77% of total nitrous oxide emissions in the Slovak Republic.

The share of agriculture and food industry in the macro-economic indicators of the national economy has increased in most indicators in 2015 (income, cost, sales from own products). Result of this development was a consequence of the stagnation of the agriculture and food sector in the Slovak economy and a continuing dampening of agriculture and food industry production with negative impact on the total economic income and social benefits generated by these sectors. Subsidies from EU funds to improve economic results and without they would most businesses in losses. Gross value added in agriculture upsurges a result of the increase in gross agricultural output, more so in crops than in animals, with a concurrent in intermediate consumption and a significant upsurge in product subsidies. The biggest fall in prices of all agricultural products was in raw cow's milk (-10.7%) and slaughter pigs (-10.5%).The decline in yields of most commodity crop production (excluding wheat, legumes, fruit), with an impact on the reduction of their mass production and cereals (19.2%) and one in particular (48.8%) root crops, especially maize, fodder root crops (40%), sugar beet (22.2%) and potatoes (19.1%), oil (23.8%), fruit (3.6%), vegetables (14.1%) without leguminous, carrots, peaches and wine grapes. Lower-mass production of almost all groups of crucial slaughter animals, in particular pigs (9.7%), sheep (30.7%) and goats (1.3%), in addition to the slaughter of cattle and poultry (9.5% and 15.1%) (based on references published in the Green Report 2016).

Agriculture sector with its share of 7% on total GHG emissions (without LULUCF) represented 3014.46 Gg of CO_2 equivalents in 2015. Agriculture activities are the main sources of methane and N_2O

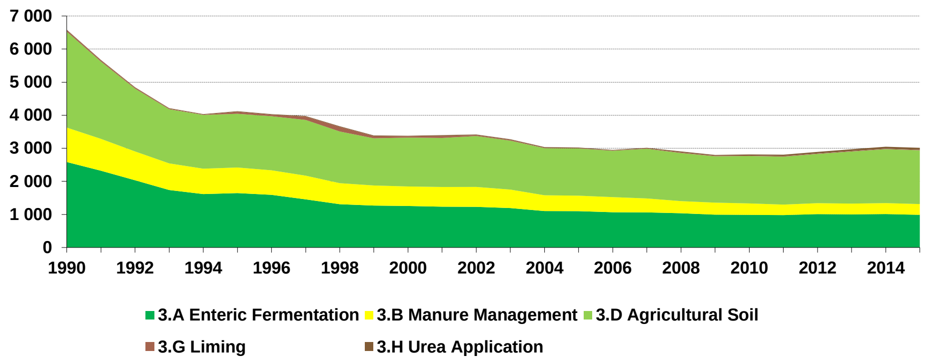
emissions in the GHG emissions balance. The emission balance is compiled annually on the basis of sectoral statistics and in recent years on the basis of a new regionalisation of agricultural areas of the Slovak Republic. The Ministry of Agriculture and Rural Development of the Slovak Republic issues annual statistics in the Green Report, part agriculture and food industry on a yearly basis. Activity data are also available in the Statistical Yearbooks. We cooperated with external institute – Research Institute for Animal Production in Nitra in 2017 submissions. This Institute provides activity data and improved methodology for recalculations and revisions included and described in this sector.

The trend in the GHG emissions has been mildly decreasing (except CO_2) since the base year. It is related mainly to the reduction of livestock number, in particular cattle. In last year, extensive recalculation has been prepared in enteric fermentation and manure management categories. These changes had influence also at 3.D Agriculture soils category. The reasons were to provide detailed data from the Statistical Office of the Slovak Republic and implemented of the recommendations from United Nations Framework Convention on Climate Change review (UNFCCC) and Effort Sharing Decision review (ESD).

The largest share of methane emissions was generated by enteric fermentation of cattle, which produced 34.59 Gg (75%) of methane within sector in 2015. Regarding N_2O emissions, direct emissions from synthetic fertilization of agricultural soils were the most important sources, and they produced 1.80 Gg of N_2O (33%) within N_2O emissions in sector in 2015. The major N_2O emissions source is category 3.D with the share of 56%, followed by the category 3.B representing 10% of the total sector emissions. Categories 3.C, 3.E and 3.F are not reported.

Following ***Figure 5.1*** and ***Table 5.1*** show overall emissions trends since base year 1990 according to gases and major categories. Emissions of CO_2 were reported in this submission in the categories 3.H – Liming (60.92 Gg) and 3.G – Urea Application (14.99 Gg). Entire time series were completed since 1990

Figure 5.1: *Trend in aggregated emissions (in Gg of CO_2 eq.) by categories within agriculture sector in 1990 – 2015*



Tables 5.1: *Trend of GHG emissions in individual categories in the agriculture sector in particular years*

YEAR	AGRICULTURE ACCORDING TO GASES (in Gg)				
	CO_2	CH_4	N_2O	NOx	NMVOC
1990	59.91	125.24	11.40	13.73	23.25
1995	78.44	83.08	6.60	6.15	14.84
2000	55.77	62.96	5.87	5.67	12.66
2005	29.01	53.71	5.54	5.58	11.10
2010	46.33	46.00	5.43	5.39	9.36
2011	60.32	45.04	5.44	5.51	9.09
2012	60.86	46.59	5.59	5.87	9.24
2013	68.22	46.28	5.86	6.30	9.04

2014	73.57	46.76	6.06	6.57	9.34
2015	75.91	45.68	6.03	6.38	9.15

Tables 5.2: *Trend of GHG emissions in individual categories in the agriculture sector in particular years*

YEAR	AGRICULTURE ACCORDING TO THE CATEGORIES (Gg of CO_2 eq.)				
	3.A ENTERIC FERMENTATION	3.B MANURE MANAGEMENT	3. D AGRICUL. SOIL	3.G LIMING	3.H UREA APPLICATION
1990	2 584.09	1 041.72	2 901.30	44.62	15.29
1995	1 644.57	774.44	1 624.42	63.15	15.29
2000	1 255.06	590.02	1 477.89	43.67	12.10
2005	1 098.17	468.51	1 425.97	8.70	20.31
2010	985.05	346.99	1 435.01	15.39	30.94
2011	979.15	317.58	1 449.19	20.61	39.71
2012	1 007.97	332.13	1 489.56	15.44	45.42
2013	1 000.01	326.49	1 576.10	16.23	51.99
2014	1 010.10	331.92	1 631.53	15.63	57.94
2015	986.04	326.47	1 626.04	14.99	60.92

Figure 5.2: *The share of aggregated emissions by main categories within agriculture sector in 2015*

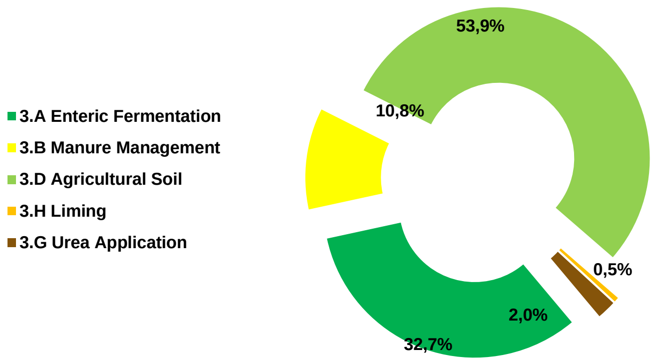


Table 5.3: *Overview of the GHG gases and tiers reported in agriculture sector according to the CRF categories in 2015*

CATEGORY (CODE AND NAME)	METHODOLOGY/TIER	GHG GASES REPORTED
3.A.1 Dairy Cattle	T2/CS	**CH_4**
3.A.1 Non-Dairy Cattle	T2/CS	**CH_4**
3.A.2 Mature Ewes	T2/CS	**CH_4**
3.A.2 Growing Lambs	T2/CS	**CH_4**
3.A.2 Other Mature Sheep	T2/CS	**CH_4**
3.A.3 Swine	T1/D	**CH_4**
3.A.4 Goats	T1/D	**CH_4**
3.A.4 Horses	T1/D	**CH_4**
3.B.1.1 Dairy Cattle	T2/CS	**CH_4**
3.B.1.1 Non-Dairy Cattle	T2/CS	**CH_4**
3.B.1.2 Mature Ewes	T2/CS	**CH_4**
3.B.1.2 Growing Lambs	T2/CS	**CH_4**
3.B.1.2 Other Mature Sheep	T2/CS	**CH_4**
3.B.1.3 Swine	T1/D	**CH_4**
3.B.1.4 Goats	T1/D	**CH_4**

CATEGORY (CODE AND NAME)	METHODOLOGY/TIER	GHG GASES REPORTED
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	T2/CS	**N_2O**
3.B.2.2 Growing Lambs	T2/CS	**N_2O**
3.B.2.2 Other Mature Sheep	T2/CS	**N_2O**
3.B.2.3 Swine	T2/CS	**N_2O**
3.B.2.4 Goats	T2/CS	**N_2O**
3.B.2.4 Horses	T2/CS	**N_2O**
3.B.2.4 Poultry	T2/CS	**N_2O**
3.B.2.5 Indirect N_2O Emissions	T1/D	**N_2O**
3.C Rice Cultivation	NA	NA
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	NA	**NO**
3.D.1.2.c Other Organic Fertilizers Applied to Soils	NA	NO
3.D.1.3 Urine and Dung Deposited by Grazing Animals	T1/CS	**N_2O**
3.D.1.4 Crop Residues	T2/CS	**N_2O**
3.D.1.5 Mineralization/Immobilization Associated with Loss/Gain of Soil Organic Matter	NA	NO
3.D.1.6 Cultivation of Organic Soils	NA	NO
3.D.2.1 Atmospheric Deposition	T1/D	**N_2O**
3.D.2.2 Nitrogen Leaching and Run-off	T1/D	**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 reviews in Agriculture sector by ESD and UNFCCC teams resulted in several recommendations. These recommendations were implemented in to the Improvement plan 2017. Not implemented references will be presented in the next NIRs. Recommendations are described below and referenced to relevant paragraphs of recalculations chapters. Recommendations led to the recalculations, which were prepared in almost every sub sectors (see chapters Recalculation). Therefore, these recalculations have impact on the emissions.

Table 5.4: *Implemented recommendations in agriculture in 2017 submission*

NUMBER	CATEGORY	DESCRIPTION	REFERENCE
1.	3.A.1	Changed Ym	5.6.4
2.	3.A.1	National circumstances	5.6
3.	3.B.2.2	Revise of N_2O emissions in sheep category	5.8.4
4.	3.D.1.3	Revise of N_2O emissions in pasture	5.11.2
5.	3.D.1.2	New source of emissions was estimated	5.11.2
6.	3.B.2	Revise of N_2O emissions from 3.B.2	5.8.1
7.	3.G	Observation and explanation were done	5.14

N_2O emissions from sheep were revised for time series. Changes are available in Chapter 5.8.1 provided by explanation on the UNFCCC recommendation A.7 (SVK 2016 ARR), which describes changes in 3.B.2.2 Manure Management.

Emissions from agriculture for 3.B.2.2 category were recalculated due to the UNFCCC recommendation A.9 (SVK 2016 ARR).

Discrepancy in emissions from pasture (double counting) in categories 3.B Manure Management and 3.D Agricultural Soils was corrected according to the ESD recommendation SK-3B-2016-0019. References are available in the Chapter 5.11.2.

Ym parameter have been changed from national specific value 6% to default value 6.5% according to the ESD recommendation SK-3B-2016-0022. Results are described in the Chapter 5.6.4.

A new estimate for sewage sludge was prepared in 2016 submission. This was based on the ESD recommendation SK-3D1-2016-0002. Input data are available in the Chapter 5.11.2.

In response to the recommendation ESD/ SK-3G-016-0001 it was definitely confirmed, that in the category 3.G Liming, no dolomite is used in Slovakia. This information is descripted in the Chapter 5.14.

The explanation about the regional differences according to recommendation UNFCCC No. A/2 was included in this submission. Results are described in the Chapter 5.6 National Circumstances.

5.3 SOURCE SPECIFIC QA/QC AND VERIFICATION

QA/QC procedures in the agricultural 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 Guidelines.

The QC checks (e.g. consistency check between CRF data and national statistics) were done during the CRF and NIR compilation, General QC formulary was filled in and is archived by QA/QC manager.

Part of QA/QC activities is comparison of FAO database and national inventory, descripted in the Chapter 5.3.1 below.

5.3.1 COMPARISON OF THE FAO DATA WITH THE NATIONAL ACTIVITY DATA

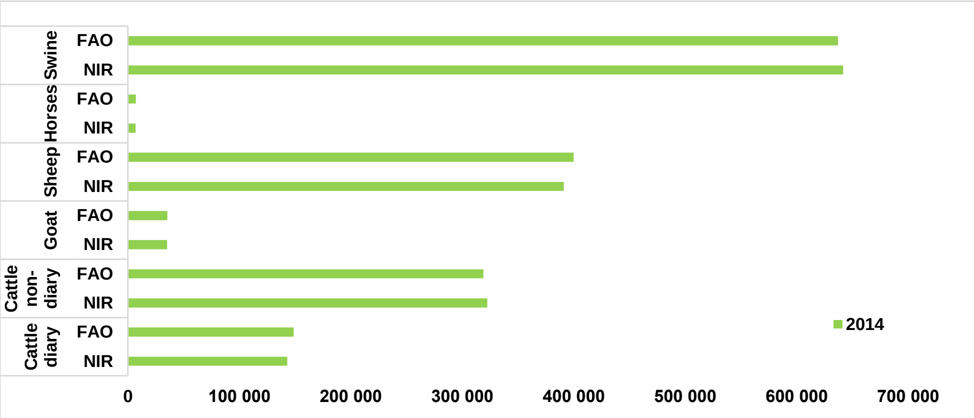
Comparison of activity data is described in this section when trying to find out if the differences in inputs found in both databases can explain the differences in emissions, analysing trend of livestock population, cultivated area and fertilizer use for the time series 1993 – 2014.

Livestock population - Number of animals is the most important input parameter into emission inventory. Inconsistencies in population are significant source of differences in calculated emissions. We recognized differences in methodological approach of data collection used in FAOSTAT and in national statistical authority. FAOSTAT grouped livestock numbers in 12-months period ending by September, 30 of each year. On the other hand, Statistical Office of the Slovak Republic provide national data on annual livestock numbers by December, 31 of a given year. Statistical survey is based on data from selected farms and by selected animal's categories and up to the regional level, and finally up to national level. Therefore, the data on animal population of the FAO 2016 and the data used in the SVK NIR 2016 are different.

In addition, with the detailed analyses of the data provided in the ***Table 5.5***, we can see shift of the time series and wrong allocation of animal population in FAO 2016 for goats (since 1994), for sheep (since 1994), for horses (since 2000) and for swine (since 1994).

The highest inconsistences occurred in cattle and this is caused by the different rules for allocation between dairy and non-dairy. In total cattle population differences are not that significant, for example in 2014, national number of cattle population is 465 543 heads and FAO's is 467 820 heads. ***Figure 5.3*** shows comparison between FAO and NIR databases.

Figure 5.3: *Comparison of population according to animal's species in 2016 submission*



Sowing area - Sowing areas were adopted from the FAO 2016 and those was compared with the national inventory data 2016. Sowing areas is important input parameter for calculation of PM, TSP and NMVOC emissions and emissions from crop residues.

The Statistical Office of the Slovak Republic provides sowing area by July, 31 each year. This sowing area shows ***Figure 5.4.*** The FAOSTAT has its own calculation methodology for sowing area estimation. This approach is based on simple equation:

$$\text{Share of Agricultural land over total land (\%)} = \frac{\text{Agricultural area}}{\text{Land area}} * 100$$

This approach estimates constant value (2 347.90 kha) of sowing area in Slovakia, which does not in correspond with the national data variables from year to year according to the actual statistics.

Figure 5.4: *Sowing area in national inventory of Slovakia (kha)*

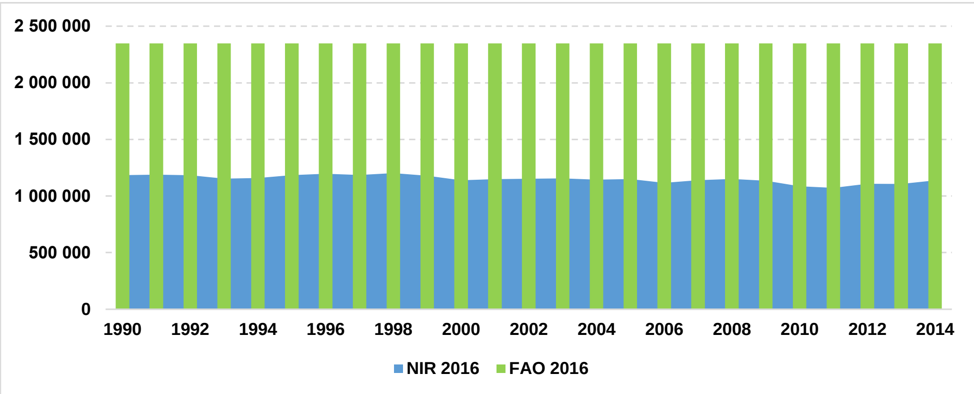
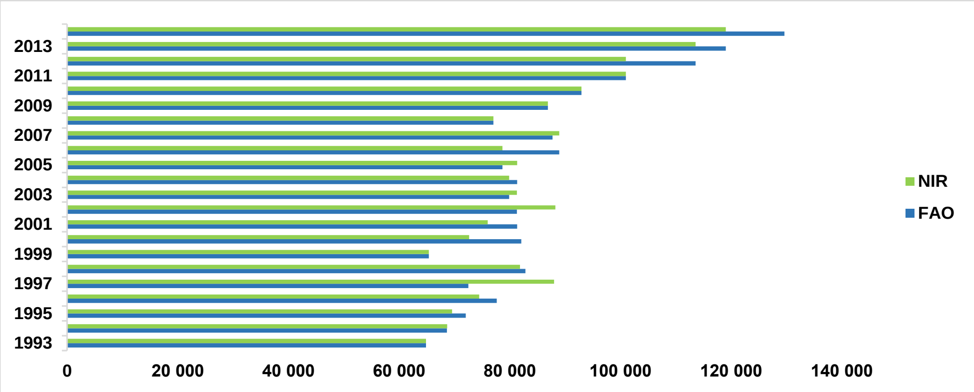


Table 5.5: *Comparison of livestock population for the time series 1993 – 2014 (wrong time series discovered in the FAO 2016)*

YEAR	CATTLE DIARY		CATTLE NON-DIARY		GOATS		SHEEP		HORSES		SWINE	
	SU SR	FAO 2016	SU SR	FAO 2016	SU SR	FAO 2016	SU SR	FAO 2016	SU SR	FAO 2016	SU SR	FAO 2016
1993	282 274	386 000	710 689	817 497	24 974	20 278	411 442	571 837	11 000	11 000	2 179 029	2 269 200
1994	272 450	364 000	643 703	628 963	25 010	24 974	397 043	411 442	11 000	11 000	2 037 371	2 179 029
1995	262 664	350 000	666 042	566 153	25 046	25 135	427 844	397 043	10 109	10 000	2 076 439	2 037 370
1996	245 833	339 000	646 158	589 706	26 147	25 046	418 823	427 844	9 722	10 000	1 985 223	2 076 439
1997	299 614	309 700	503 784	582 291	26 778	26 147	417 337	418 823	9 533	10 000	1 809 868	1 985 223
1998	267 282	287 600	437 510	515 798	50 905	26 778	326 200	417 337	9 550	10 000	1 592 599	1 809 868
1999	250 974	262 000	414 081	442 792	51 075	38 900	340 346	326 199	9 342	10 000	1 562 106	1 592 599
2000	242 496	250 974	403 652	414 081	51 419	51 075	347 983	340 346	9 516	9 342	1 488 441	1 562 106
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
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
2003	214 467	230 182	378 715	377 653	39 225	29 769	325 521	316 028	8 114	8 122	1 443 013	1 553 880
2004	201 725	210 317	338 421	382 865	39 012	39 225	321 227	325 521	8 209	8 114	1 149 282	1 443 013
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
2006	184 950	198 580	322 870	329 309	38 352	39 566	332 571	320 487	8 222	8 328	1 104 829	1 108 266
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
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
2009	162 504	165 918	309 461	322 463	35 686	37 088	376 978	361 634	7 199	8 421	740 862	748 516
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
2011	154 105	159 300	309 253	307 825	34 053	35 292	393 927	394 175	6 937	7 111	580 393	687 260
2012	150 272	156 126	320 819	307 232	34 823	34 053	409 569	393 927	7 249	6 937	631 464	580 393
2013	144 875	149 790	322 945	321 301	35 457	34 823	399 908	409 569	7 161	7 249	637 167	631 464
2014	143 083	148 750	322 460	319 070	35 178	35 457	391 151	399 908	6 828	7 161	641 827	637 167

Fertilizers - The last QA comparison exercise was provided for the data of fertilizers' consumption. Differences between FAO 2016 and SVK NIR 2016 were caused by using different methodological approach in FAOSTAT. This approach is based on annual balance of nitrogen production and net trade. On the other hand, activity data on fertilizers in national inventory is based on nitrogen consumption provided directly by farmers. ***Figure 5.5*** shows comparison between both databases.

Figure 5.5: *Fertilizers consumption and comparison of FAO 2016 and SVK NIR 2016 data (kg/year)*



5.4 CATEGORY-SPECIFIC RECALCULATIONS

Recalculations made in agriculture sector were provided and implemented in line with the Improvement and Prioritisation Plan reflecting recommendations made during previous reviews. ***Table 5.6*** shows overview of these recalculations and corrections, which were corrected and implemented in submission to 9.9.2016 and 15.1.2017.

Table 5.6: *Overview of recalculations in agricultural sector*

CRF	CATEGORY	YEAR	EMISSION	DESCRIPTION	REFERENCE
3.A.1	Enteric fermentation - Cattle	1990-2014	CH_4	Methodological change. Revision of Ym parameter, and change AD, Change of dividing: Suckling cows were allocated in non-dairy cattle. Revision of Ym parameter.	Chapter 5.6.4
3.A.1	Enteric fermentation - Dairy Cattle	2015	CH_4	Values emissions and milk yield were exchanged and MCF was corrected from 3% to 2%.	Chapter 5.6.4
3.A.2	Enteric fermentation - Sheep	1990-2014	CH_4	New category was added: 3.A.2 growing lambs and other mature sheep	Chapter 5.6.4
3.A.2	Enteric fermentation - Growing lambs	1992,1994,2015	CH_4	AD change – population. Changes had influence on the emissions and body weight.	Chapter 5.6.4
3.A.2	Enteric fermentation - Other mature sheep	1998,2005,2015	CH_4	AD change – population. Changes had impact on body weight, DE, GE because there were calculate as weighted average. Correction of emission was made.	Chapter 5.6.4
3.A.3	Enteric fermentation - Swine	1990-2014	CH_4	AD change. Extrapolating data were change for available statistical data	Chapter 5.6.4
3.A.3	Enteric fermentation - Swine	1990-2015	CH_4	CRF reporter worked incorrectly. Uploading of the new date into the CRF reporter was not successful. AD and emissions were changed.	Chapter 5.6.4
3.A.4	Enteric fermentation Other livestock	1990-2014	CH_4	AD change. Extrapolating data were change for available statistical data	Chapter 5.6.4

CRF	CATEGORY	YEAR	EMISSION	DESCRIPTION	REFERENCE
3.A.4	Enteric fermentation - Goats	1992,1998, 2002,2009.	CH_4	AD change – population. Correction had impact on emissions.	Chapter 5.6.4
3.B.1.1	Manure Management - cattle	1990-2014	CH_4,N_2O	Methodological change. More detailed livestock subcategory, new VS parameters for cattle category and Bo parameter for western Europe (non-dairy cattle categories)	Chapter 5.7.4
3.B.1.1	Manure management - Dairy cattle	2014	CH_4,N_2O	VS and emissions were change, because weighted average was not calculated correctly.	Chapters 5.7.4 and 5.8.4
3.B.1.1	Manure management - Non-dairy cattle	1991	CH_4,N_2O	AD change – population. Correction of number of livestock was done. Correction is connected with the correction in the category 3.A.1.	Chapters 5.7.4 and 5.8.4
3.B.1.2	Manure Management-sheep	1990-2014	CH_4	Methodological change. More detailed livestock subcategory, new VS parameters for cattle and sheep category	Chapter 5.7.4
3.B.1.2	Manure management - Growing lambs	1992,1994,	CH_4,N_2O	AD change - population, changes had influence on body weight, percentage of MMS because, they were a weighted average.	Chapters 5.7.4 and 5.8.4
3.B.1.2	Manure management - Growing lambs	2002,2015	CH_4	Emissions and VS daily excretion change were change. Changes had impact on emissions because weighted average was calculate wrong	Chapter 5.7.4
3.B.1.2	Manure management - Other mature sheep	1998,2005,2015	CH_4,N_2O	AD change – population. Correction of number of livestock was done. Correction is connected with the correction in the category 3.A.2.	Chapters 5.7.4 and 5.8.4
3.B.1.2	Manure management - Other mature sheep	2002,2003	CH_4	AD change – population. Correction of number of livestock was done. Correction is connected with the correction in the category 3.A.2.	Chapter 5.7.4
3.B.1.3	Manure management - Swine	1991	CH_4,N_2O	AD change – population. Correction of number of livestock was done. Correction is connected with the correction in the category 3.A.3.	Chapters 5.7.4 and 5.8.4
3.B.1.4	Manure management - Goats	1992,2002,2009	CH_4,N_2O	AD change – population. Changes had influence on the emissions and body weight.	Chapters 5.7.4 and 5.8.4
3.B.1.4	Manure management - Poultry	1994,1998	CH_4,N_2O	AD change – population. Change had impact on emissions and body weight, because there are wrong weighted average.	Chapters 5.7.4 and 5.8.4
3.B.2.2	Manure Management	1990-2014	N_2O	Revision of AWMS allocation of animal categories based on national data. Revision of emission factors and Nex for AWMS based on national data	5.8.4
3.B.2.5	Indirect N_2O Emissions	1991,1999,1994, 1999,2002,2005, 2009	N_2O	Due to recalculations in 3.B.2	Chapter 5.8.4
3.D.1.3	Urine and Dung Deposited by Grazing Animals	1991,1992,1994, 2002,2009	N_2O	Due to recalculations in 3.B.2	Chapter 5.11.2
3.D.1.2.a	Animal Manure Applied to Soil	1992,1994,1998, 2002,2005,2009	N_2O	Due to recalculations in 3.B.2	Chapter 5.11.2
3.D.2.2	Indirect emissions from AS	1991,1992,1994 1998,2002,2005 2009-2014	N_2O	Due to recalculations in 3.B.2	Chapter 5.11.2

5.5 NATIONAL CIRCUMSTANCES

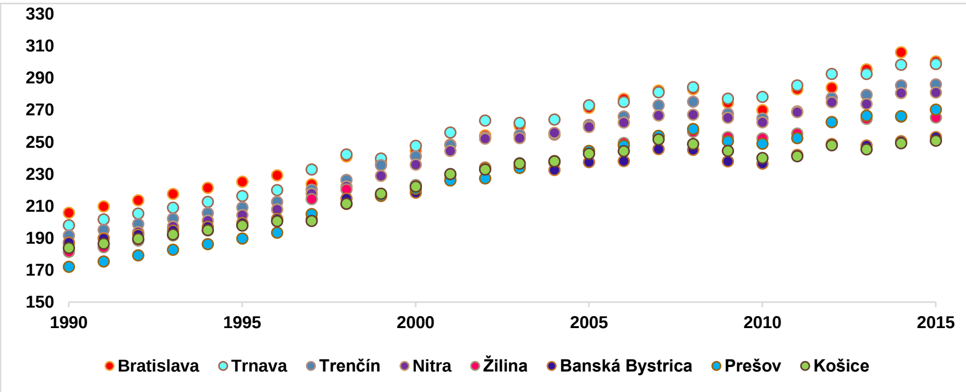
Slovak farmers adapted on changed situation in Agriculture after 1990. They invested in to the development of own farms to avoid the bankrupt and also they will be self-competitiveness in this sector. The used tools as base of transformation were supported by the EU policy. The EU policy and measures transformed into the Slovak legal system. Farmers had to observe new strictly criteria like higher milk yield, changing of housing systems, decrease of pasture time, new storage capacity for organic waste, which are supported by the Degree No 389/2005 Coll and Nitrates Directive[1]. These measures are advanced and copy the practices of Western European countries. Therefore, default parameters for Western Europe are used.

Example: Cattle breeding in Slovakia is comparable with the Western European countries, which is documented by high milk yield of dairy cattle and high daily weight gains in non-daily cattle. To maintain a high milk yield and high daily gain food rich on proteins´ and cereals´ components is important. Dairy cows in 3 Slovak regions (Bratislava, Trnava, and Nitra) produce 20-23 liters milk/day. In other regions milk productivity is 14-15 liters/day. Lower milk production relates with different feeding situation. In this case, pasture is included into the feeding ratio. It is typical for semi-intensive farming (Kosice,Presov, Banska Bystrica,Zilina). These circumstances documented ***Figures 5.6***. High producing dairy cows (milked 23 litres/day) need to be fed by 8 kg of cereal feed with very good digestibility and high nutrition. This practice is typical for Western European countries and comparable with it see ***Table 5.7***. Balanced and sustainable farming in Slovakia has an impact on the high value of AGEI (274.96 MJ/head/day). Taking into account the mentioned parameters it is evidently, that our production can be considered as "Western Europe" according to the ***UNFCCC recommendation no. A.2***.

Table 5.7: *The comparison of the Slovak milk yield with other milk production in 2015*

DAIRY CATTLE	SLOVAKIA	WESTERN EUROPE	EASTERN EUROPE	NORTH AMERICA
Milk yield kg/year/cow	6 537	6 000	2 550	8 400

Figure 5.6 *Trend of GE in the different Slovak regions*



5.6 ENTERIC FERMENTATION (CRF 3.A)

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 has decreased by more than 3% and non-dairy cattle decreased by 1.2% during the evaluated period. Except for population of domestic livestock, the amount of emitted methane is

[1] http://www.mpsr.sk/index.php?start&navID=78&id=1325%20 (in Slovak)

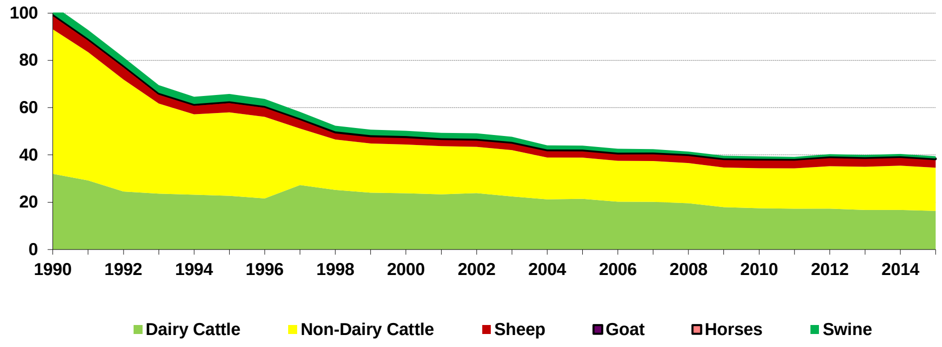
influenced by some parameters within the category such as the age or the weight of animals, the amount of food and its quality and the consumption of energy for basal metabolisms, milk production per day and fat content, average amount of work performed, percentage of females that give birth, wool growth, feed digestibility.

Methane emissions from enteric fermentation are dominant emissions from animal husbandry and from agriculture. The cattle produces nearly 90% of these emissions and dairy cattle gives more than half of emissions in the category 3.A. Less than 10% of emissions are produced by other categories of domestic livestock. An intensification of animal husbandry increased also methane emissions. On the other hand, a higher efficiency leads to the decrease in the number of dairy cattle and consequently to the decrease in total methane emissions from this category. 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 for 2015. Total methane emissions from enteric fermentation decreased from 103.36 Gg in 1990 to 39.44 Gg in 2015, which is the decrease by 60.8% and decrease by nearly 0.3% compared to the previous year. More information is available in ***Table 5.8*** *and* ***Figure 5.7***.

Table 5.8: *Methane emissions from enteric fermentation according to the livestock in particular years*

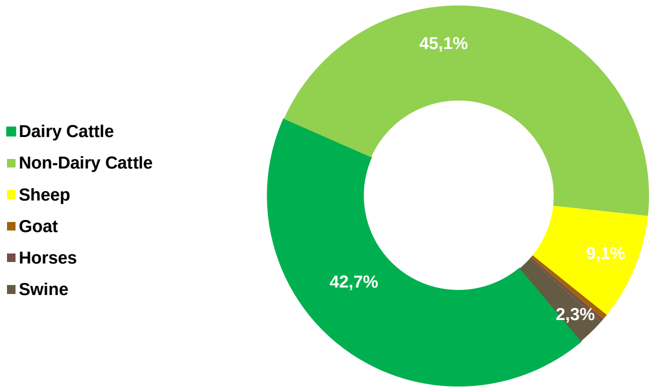
YEAR	CATEGORY 3.A ENTERIC FERMENTATION - CH_4 (Gg)					
	DAIRY CATTLE	NON-DAIRY CATTLE	SHEEP	GOAT	HORSES	SWINE
1990	31.992	61.126	6.168	0.052	0.245	3.781
1995	22.703	35.300	4.358	0.125	0.182	3.115
2000	23.778	20.622	3.142	0.257	0.171	2.233
2005	21.423	17.438	3.056	0.198	0.150	1.662
2010	17.448	16.917	3.702	0.176	0.128	1.031
2011	17.246	17.070	3.685	0.170	0.125	0.871
2012	17.271	17.957	3.839	0.174	0.130	0.947
2013	16.717	18.272	3.750	0.177	0.129	0.956
2014	16.729	18.728	3.685	0.176	0.123	0.963
2015	16.321	18.274	3.593	0.182	0.124	0.950

Figure 5.7: *Trend in methane emissions (Gg) by animals within enteric fermentation in 1990 – 2015*



Dairy and non-dairy cattle methane emissions represent the major share of enteric fermentation emissions (43% and 45%). More than 9.1% belongs to sheep methane emissions. These sources are significant and key sources in enteric fermentation and were estimated by the tier 2 methodology. Other, not so significant, animal categories were estimated by the tier 1 methodology. The share of emissions shows ***Figure 5.8***.

Figure 5.8: The share of aggregated emissions by categories within enteric fermentation in 2015



5.6.1 METHODOLOGICAL ISSUES – METHODS

Last year the Slovak Republic prepared and implemented new time series for years 1990 – 2013. SHMU cooperated with external research organisations. The intensive cooperation was with the Research Institute for Animal Production in Nitra (the CVZV) as a part of the National Agricultural and Food Centre. Implementation of new national data in the enteric fermentation was prepared in cooperation with CVZV. Changes and improvements are fully in accordance with the IPCC 2006 GL tier 2 approach for significant animal categories. For other insignificant animals (goats, horses, and swine), the IPCC 2006 GL tier 1 approach was used, but national parameters were taken into consideration. Overview of tier used in enteric fermentation is provided in ***Tables 5.9*** - ***5.13***.

Used methodology is based on detailed national data about animal number (based on more advanced livestock characteristics and more divided number of livestock). These data were provided by the Statistical Office of the Slovak Republic (the SU SR). In submission 2017, full time series (1990 – 2013) of more divided number of livestock was provided by the SU SR. These improvements increased quality of inventory in this year.

The regional input data about feeding situation, weight, milk production and wool production, which are available, were provided by the SU SR. Other parameters in the ***Tables 5.9*** - ***5.13*** were provided by CVZV for dairy cattle, non-dairy cattle and sheep categories (significant animal categories in Slovakia). In addition also inventory of other animals' categories was improved.

Cattle - In terms of increased transparency in methodology and activity data of dairy cattle, estimation was completed by the parameters for average animal weight (597.81 kg), share of pregnancy (41.43%) and share of digestibility of feed (71.58%). Typical feeding situation for cattle is straw, silage and pasture in the Slovak Republic.

Total methane emissions from enteric fermentation of cattle were estimated based on detailed classification of animals into the following categories: dairy cattle (high producing dairy cows, calves 6 months, heifers, pregnancy heifers, oxen, breeding bull, fattening) and meat cattle (suckling cows, calves 6 months, heifer, pregnancy heifer, breeding bull, oxen, fattening).The country specific EFs for dairy and non-dairy are estimated as weighted average based on AGEI and other parameters specific for each subcategory (***Tables 5.9*** - ***5.11***).

***Table 5.9:** The overview of used country specific parameters for dairy (milk) cattle in 2015*

DAIRY (MILK) CATTLE						
COUNTRY SPECIFIC DATA WEIGHTED AVERAGE	**Dairy cows**	**Calves 6 months**	**Heifer**	**Heifer pregnant**	**Fattening**	**Oxen**
Body weight (kg)	597.81	103.89	300.97	528.58	331.09	700
Milk yield (l/day)	17.31	-	-	-	-	-
Milk yield (kg/day)	17.85	-	-	-	-	-
Fat milk (%)	3.90	-	-	-	-	-
Daily gain (kg)	-	0.711	0.668	0.677	0.757	-
DE (%) weighted average	71.58	81.23	70.48	70.66	71.60	60.00
Methane conversion factor/100	0.065	0.065	0.065	0.065	0.065	0.065
Maintenance NE_m (MJ/day)	45.57	10.48	23.26	35.49	28.70	43.82
Activity NE_a (MJ/day)	0.92	-	1.493	0.95	-	-
Lactation N_{El} (MJ/day)	53.95	-	-	-	-	-
Draft power Ne_{work} (MJ/day)	-	-	-	-	-	21.91
Wool production Ne_{wool} (MJ/day)	-	-	-	-	-	-
Growth (NE_g) (MJ/day)	-	10.57	12.69	14.97	10.49	-
Pregnancy NEp (MJ/day)	4.56	-	-	3.55	-	-
Ratio of net energy (REM)	0.53	0.55	0.53	0.53	0.53	0.49
Ratio of net energy (REG)	0.34	0.37	0.33	0.34	0.34	0.28
Gross energy (MJ/head/day)	274.96	58.43	120.05	169.89	118.42	221.46
Emission factors (kg/head/year)	117.22	24.91	51.18	72.43	50.48	94.41

***Table 5.10:** The overview of used country specific parameters for dairy cattle in 2015*

ACTIVITY DATA DISTRICT	Pop. in heads	from dairy cows	Energy MJ/head/ average	EFs kg/head/yr average	CH_4 in tons
Bratislava	**5 139**	5 139	300.32	128.04	657.97
Trnava	**23 749**	23 749	298.83	127.40	3025.60
Trenčín	**14 127**	14 127	286.06	121.95	1722.84
Nitra	**22 978**	22 978	280.93	119.77	2752.00
Žilina	**22 617**	22 617	265.41	113.15	2559.16
Banská Bystrica	**20 069**	20 069	253.02	107.87	2164.86
Prešov	**20 716**	20 716	270.20	115.19	2386.34
Košice	**9 834**	9 834	250.89	106.96	1051.85
Slovak Republic	**139 229**	**139 229**	**274.96**	**117.22**	**16320.62**

***Table 5.11:** The overview of used country specific parameters for non-dairy (beef) cattle in 2015*

NON-DAIRY (BEEF) CATTLE							
COUNTRY SPECIFIC DATA WEIGHTED AVERAGE	**Suckling cow**	**Calves 6 months**	**Heifer**	**Heifer pregnant**	**Fattening**	**Oxen**	**Breeding bull**
Body weight (kg)	592.02	124.75	330.23	521.14	337.29	700	800
Milk yield l/day	6.27	-	-	-	-	-	-
Milk yield kg/day	6.46	-	-	-	-	-	-
Fat milk (%)	4.00	-	-	-	-	-	-
Daily gain (kg)		0.902	0.500	0.500	0.719	-	-
DE (%) weighted average	64.84	76.29	65.60	64.52	65.95	60.00	68.80
Methane conversion factor/100	0.065	0.065	0.065	0.065	0.065	0.065	0.065
Maintenance NE_m (MJ/day)	42.10	12.02	24.94	35.12	29.11	43.82	55.66
Activity NE_a (MJ/day)	8.30	1.35	4.92	6.93	-	-	4.94
Lactation N_{El} (MJ/day)	19.83	-	-	-	-	-	-

NON-DAIRY (BEEF) CATTLE							
COUNTRY SPECIFIC DATA WEIGHTED AVERAGE	**Suckling cow**	**Calves 6 months**	**Heifer**	**Heifer pregnant**	**Fattening**	**Oxen**	**Breeding bull**
Draft power Ne_{work} (MJ/day)	-	-	-	-	-	21.91	-
Wool production Ne_{wool} (MJ/day)	-	-	-	-	-	-	-
Growth (NE_g) (MJ/day)	-	13.32	9.62	11.06	10.56	-	-
Pregnancy NEp (MJ/day)	4.21	-	-	3.51	-	-	-
Ratio of net energy (REM)	0.51	0.54	0.52	0.51	0.52	0.49	0.53
Ratio of net energy (REG)	0.31	0.36	0.31	0.31	0.31	0.28	0.33
Gross energy (MJ/head/day)	223.70	81.25	135.33	193.95	136.46	221.46	167.58
Emission factors (kg/head/year)	95.37	17.92	57.69	82.69	58.18	94.41	71.44

Table 5.12: *The overview of used country specific parameters for non-dairy cattle in 2015*

ACTIVITY DATA DISTRICT	**Pop. in heads**	**from suckling cows**	**from calves**	**from heifer**	**from fattening**	**Energy MJ/head/ average**	**EFs kg/head/yr average**	**CH_4 in tons**
Bratislava	**9 091**	1 864	2 540	4 105	505	140.98	57.23	535.44
Trnava	**41 033**	1 966	11 755	17 088	9 814	118.88	49.52	2068.72
Trenčín	**27 586**	3 894	7 336	11 445	4 425	129.93	53.26	1508.77
Nitra	**40 025**	1 703	12 625	17 991	7 110	117.24	49.32	1995.51
Žilina	**43 768**	7 796	9 580	20 814	4 365	140.93	57.76	2582.55
Banská Bystrica	**56 830**	13 104	12 855	23 450	6 390	139.82	55.33	3295.45
Prešov	**64 033**	19 185	14 420	24 917	4 521	151.96	61.84	4025.88
Košice	**35 991**	10 768	6 959	13 886	3 120	151.78	61.36	2261.30
Slovak Republic	**318 357**	**60 280**	**78 070**	**133 696**	**40 250**	**137.41***	**57.40***	**18 273.63**

Note: Oxen (in total 913 heads) and breeding bull (in total 5148 heads) are not included in this table, but included in calculation of weighted average energy and EFs

* = weighted average

This data was used for calculation of emission factor, which is characteristic for Slovak conditions. Average weights of cattle were based on breed structure in Slovakia. Breed structure of non-dairy cattle is very populated, therefore the table is not available. Breed structure of dairy cattle is divided on heavy and light breed (***Table 5.13***) below. Milk production is taken from the Statistical Yearbook. DE is calculated as weighted average of calculated values from feed ratio. DE is parameter from Research Institute for Animal Production Nitra. Methane conversion factor is in line with the default values in the IPCC 2006 GL. Gross energy is sum of energies calculated by formulas referred to the IPCC 2006 GL with using typical national breed conditions. Following formula was used for calculation of EFs:

$$EF = \left[\frac{GE * \left(\frac{Y_m}{100}\right) * 365}{55.65} \right]$$

Where: EF = emission factor, kg $CH_4.head^{-1}.yr^{-1}$

GE = gross energy intake, $MJ.head^{-1}.day^{-1}$

Y_m = methane conversion factor, percent of gross energy in feed converted to methane

The factor 55.65 (MJ/kg CH_4) is the energy content of methane

National emission factors were calculated by this approach for cattle and sheep category.

Table 5.13: *Breed structure of dairy cattle in the Slovak Republic (in %)*

DISTRICT BREED	Banská Bystrica	Bratislava	Košice	Nitra	Prešov	Trenčín	Trnava	Žilina
Braunvieh	1.11	0	0	0.5	0	0	0	0
Holstein	45.29	100	42	84.25	31.85	63.13	87.03	55.52
Pinzgauer	0.67	0	2.74	0	7.2	0	0	5.09
Slovak Spotted	52.93	0	55.26	15.25	60.95	36.87	12.97	39.39

Sheep - Total methane emissions from enteric fermentation of sheep were estimated on the basis of detailed classification of animals to 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 weighted average from these four categories based on gross energy intake (milk productivity, wool productivity, average methane conversion rate) and other country specific information. The overview of used parameter shows ***Tables 5.14*** - ***5.17*** below.

Table 5.14: *The overview of used country specific parameters for sheep in 2015*

COUNTRY SPECIFIC DATA*	DAIRY SHEEP				BEEFSHEEP			
	Mature ewes	Growing lambs	Growing lambs pregnant	Other mature sheep	Mature ewes	Growing lambs	Growing lambs pregnant	Other mature sheep
Body weight (kg)	60.00	32.50	55.00	80	70	47.50	65	90
Milk yield l/day	0.21	-	-	-	0.266	-	-	-
Milk yield kg/day	0.22	-	-	-	0.274	-	-	-
DE of feed (%)	65.04	65.04	65.04	65.04	65.48	65.48	65.48	65.48
Methane conversion factor/100	0.065	0.052	0.065	0.065	0.065	0.049	0.065	0.065
Maintenance NE_m (MJ/day)	4.68	3.13	4.38	6.68	5.25	4.20	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)	1.00	-	-	-	1.26	-	-	-
Draft power Ne_{work} (MJ/day)	-	-	-	-	-	-	-	-
Wool production Ne_{wool} (MJ/day)	0.12	-	0.12	0.12	0.13	-	0.12	0.13
Growth (NE_g) (MJ/day)	-	1.201	1.79	-	-	1.64	2.09	-
Pregnancy NEp (MJ/day)	0.45	-	0.370	-	0.53	-	0.470	-
Ratio of net energy (REM)	0.51	0.51	0.51	0.51	0.52	0.52	0.52	0.52
Ratio of net energy (REG)	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
Gross energy (MJ/head/day)	21.83	16.29	26.45	22.71	25.06	21.90	30.29	24.62
Emission factors (kg/head/year)	9.31	5.52	11.27	9.68	10.68	7.0459	12.92	10.50

* country specific data calculated as weighted average from the eight district of the Slovak Republic

Table 5.15: *The overview of used country specific parameters for mature ewes in 2015*

ACTIVITY DATA/DISTRICT	Pop. in heads	Milk in litre/day	Milk in kg/day	Energy MJ/head/day	EFs kg/head/year	CH_4 in tons
Bratislava	691	0.273	0.281	24.398	10.402	7.188
Trnava	1 468	0.253	0.261	24.577	10.478	15.381
Trenčín	23 087	0.290	0.299	23.645	10.080	232.725
Nitra	8 287	0.199	0.205	23.366	9.961	82.550
Žilina	61 176	0.244	0.252	22.882	9.755	596.770
Banská Bystrica	86 309	0.234	0.241	23.442	9.994	862.556
Prešov	49 617	0.205	0.211	22.410	9.554	474.048

Košice	29 832	0.213	0.219	22.897	9.762	291.207
Weighted average SR	**260 467***	**0.232**	**0.240**	**23.076**	**9.838**	**2 562.425**

Table 5.16: *The overview of used country specific parameters for growing lambs in 2015*

ACTIVITY DATA/DISTRICT	Population in heads	Energy MJ/head/day	EFs kg/head/year	CH_4 in tons
Bratislava	112	22.692	7.735	0.866
Trnava	938	23.083	8.858	8.309
Trenčín	11 268	21.410	8.180	92.171
Nitra	3 257	22.745	8.617	28.064
Žilina	26 857	21.265	8.101	217.566
Banská Bystrica	36 377	22.804	8.812	320.537
Prešov	21 422	21.588	8.212	175.925
Košice	13 321	21.914	8.249	109.881
Weighted average (SR)	**113 552**	**21.969**	**8.395**	**953.320***

Table 5.17: *The overview of used country specific parameters for other mature sheep in 2015*

ACTIVITY DATA/DISTRICT	Population in heads	Energy MJ/head/day	EFs kg/head/year	CH_4 in tons
Bratislava	18	23.99	11.95	0.18
Trnava	47	24.33	12.80	0.49
Trenčín	693	23.16	11.76	6.84
Nitra	240	24.07	12.54	2.46
Žilina	1 795	23.09	11.62	17.67
Banská Bystrica	2 588	23.65	12.33	26.09
Prešov	1 454	23.18	11.84	14.37
Košice	870	23.77	12.33	8.81
Weighted average (SR)	**7 705***	**23.42**	**12.08**	**76.92**

* values are sums

Activity data for sheep are available in detailed categories such as mature ewes, growing lambs and other mature sheep also on district level. In year 2016, the Statistical Office of the Slovak Republic provided detailed data on the number of sheep at the district level. The data were provided for the years 1990 – 2013 including the input parameters (the wool production and the amount of milk for categories ewes).

Emission factors for cattle and sheep were estimated from milk production, wool production and average gross energy intake. These parameters are country specific. Methane emissions from enteric fermentation of dairy cattle reflect milk and wool production for the period 1997 – 2015. The extrapolation of a linear function was used back to the base year 1990 for the milk production at district level estimation for methane emissions from enteric fermentation of dairy and non-dairy cattle. The time series of EFs is based on average gross energy intake (AGEI) and detailed analysis of cattle categories show ***Tables 5.18*** *and* ***5.19***.

Table 5.18: *Activity data, EFs and methane emissions for dairy cattle in particular years*

YEAR	ACTIVITY DATA FOR DAIRY CATTLE IN ENTERIC FERMENTATION				
	Population in 1 000 heads	Milk kg/day	AGEI MJ/head/day*	EFs kg/head/year*	CH_4 emissions Gg
1990	401.123	6.96	187.08	79.76	31.99
1995	262.664	8.83	202.74	86.43	22.70
2000	242.496	12.24	230.00	98.05	23.78
2005	198.580	15.18	253.04	107.88	21.42
2010	159.260	15.62	256.98	109.56	17.45

YEAR	ACTIVITY DATA FOR DAIRY CATTLE IN ENTERIC FERMENTATION				
	Population in 1 000 heads	Milk kg/day	AGEI MJ/head/day*	EFs kg/head/year*	CH_4 emissions Gg
2011	154.105	16.35	262.50	111.91	17.25
2012	150.272	17.22	269.58	114.93	17.27
2013	144.875	17.34	270.65	115.39	16.72
2014	143.083	17.74	274.24	116.92	16.73
2015	139.229	17.85	274.96	117.22	16.32

Table 5.19: *Activity data, EFs and methane emissions for non-dairy cattle in particular years*

YEAR	ACTIVITY DATA FOR NON-DAIRY IN ENTERIC FERMENTATION			
	Population in 1 000 heads	AGEI MJ/head/day*	EFs kg/head/year*	CH_4 emissions Gg
1990	1 161.947	124.691	52.607	61.126
1995	666.042	125.834	53.000	35.300
2000	403.652	120.255	51.089	20.622
2005	329.309	124.818	52.954	17.438
2010	307.865	130.319	54.948	16.917
2011	309.253	130.791	55.197	17.070
2012	320.819	133.040	55.973	17.957
2013	322.945	134.587	56.580	18.272
2014	322.460	136.309	58.079	18.728
2015	318.357	137.406	57.400	18.274

* weighted average

Goats, horses and swine - Emission factors for goats, horses and swine in enteric fermentation are constant default parameters based on the IPCC 2006 GL. EF for goats is 5 kg/head/year (default value),EF for horses is 18 kg/head/year (default value) and EF for swine is 1.5 kg/head/year (***Table 5.20***).

Table 5.20: *Activity data, EFs and methane emissions for other animal in particular years*

YEAR	GOATS			HORSES			SWINE		
	Pop. in 1 000 heads	EFs kg/head / year	CH_4 Gg	Pop. in 1 000head s	EFs kg/head/ year	CH_4 Gg	Pop. in 1 000 heads	EFs kg/head/ year	CH_4 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
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

5.6.2 ACTIVITY DATA

The Research Institute for Animal Production in Nitra has taken responsibility for emissions inventory of enteric fermentation and manure management as a part of agriculture sector. Implemented methodology used also the research results of breading and nitrogen fluxes in the conditions of the Slovak Republic. Basic sources of data used for the evaluations of emissions were published in:

- Census of sowing areas of field crops in the Slovak Republic;

- Annual census of domestic livestock in the Slovak Republic;
- Statistical Yearbooks 1990 – 2015, the Statistical Office of the Slovak Republic;
- Research results from projects and studies provided by several organisations inside the National Agricultural and Food Centre.

Activity data for dairy, non-dairy cattle and sheep used for tier 2 methodology are based on bottom-up statistical information at district level. The aggregation of input parameters is performed as weighted average. The Statistical Office of the Slovak Republic provided national data of annual livestock numbers on a detailed region level in 2016 see ***Table 5.21***. These data are based on livestock counts held on 31st December of each year.

In 2016 a complete time series of the number of livestock at region level was provided. Between years 1990 – 1996, the Slovak Republic was divided into three regions, due to the historical context. During these years, were available data only for the three regions: Zapadoslovensky, Stredoslovensky and Vychodoslovensky). Due to this reason the data were reallocated into the 5 regions (Bratislavsky, Nitriansky, Trnavsky, Bansko Bystricky, Presovsky, Kosicky, using the extrapolation tools.

In 2016, the Statistical Office of the Slovak Republic provided detailed information on cattle and sheep (milk production, wool production, daily gain) at region level, which has been practiced since 1997. Activity data used for methane emissions estimation for dairy cattle is summarized in the ***Table 5.21*** for the year 2015**.** Detailed statistical information is available at the district level and emissions are estimated by bottom-up tier 2 methodology.

The Research Institute for Animal Production in Nitra implemented the results of a questionnaire survey. Better classification and disaggregation of cattle categories were used. Based on survey data, cattle were divided into dairy cattle and beef cattle. Dairy cattle is estimated separately from beef cattle. According to this method dairy cows are defined as cows that producing milk only for human consumption (high producing cows). Suckling cows is defined as cow, which are farmed for nutrition of calves (low producing cows). Suckling cows and other category of cattle as for example breeding bull, oxen, calves, heifer are in beef cattle category.

Decline in the number of all species of livestock except of poultry and goats were recorded in the Slovak Republic. Number of poultry and goats has increased trend compared to base year. The highest decrease was observed in pigs (-75%) and non-dairy cattle category (-73%). Number of dairy cows (-3 %), non-dairy cattle (-1%) and sheep (-2 %) slightly decreased in the 2014 – 2015.

This decrease was mainly affected by the poor economic situation in agriculture. Food manufacturers and retailers pushed down raw material prices (even below the production costs) because of competitiveness of final products between Slovak and European food market. Continuous reduction in number of dairy cows was caused by political decision about milk quotas ending. These quotas ensured stable milk prices for primary producer. Decrease of the number of livestock had significant influence to cancel the milk quota.

Table 5.21: *Animal population in enteric fermentation according to the districts for the year 2015*

CATEGORY		**NUMBER OF LIVESTOCK**							
DISTRICT		**Bratislava**	**Trnava**	**Trenčín**	**Nitra**	**Žilina**	**Banská Bystrica**	**Prešov**	**Košice**
DAIRY CATTLE	**Dairy cows**	5 139	23 749	14 127	22 978	22 617	20 069	20 716	9 834
	Calves in 6 month	1 956	11 093	6 098	12 369	6 585	7 192	7 223	3 090
	Heifer	1 809	9 741	5 203	9 958	10 978	9 103	9 340	4 494
	Heifer (pregnant)	1 630	6 731	4 472	7 868	5 695	4 985	5 408	2 584
	Fattening	243	9 244	3 765	6 754	3 384	3 252	2 983	1 939
	Oxen	14	13	169	67	563	27	0	21

CATEGORY		NUMBER OF LIVESTOCK							
DISTRICT		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
BEEF CATTLE	Suckling cows	1 864	1 966	3 894	1 703	7 796	13 104	19 185	10 768
	Calves in 6 month	584	662	1 238	256	2 995	5 663	7 197	3 869
	Heifer	396	407	1 031	106	2 627	6 116	6 739	4 620
	Heifer (pregnant)	270	209	739	59	1 514	3 246	3 430	2 188
	Fattening	262	570	660	356	981	3 138	1 538	1 181
	Oxen	0	0	0	0	0	10	17	12
	Breeding bull	63	397	317	529	650	994	973	1225
DAIRY SHEEP	Mature ewes	221	429	16 085	3 799	45 908	43 060	36 471	13 962
	Growing lambs	6	298	5 289	1 067	12 971	12 383	9 566	5 308
	Growing lambs (pregnant)	1	245	3 658	725	8 510	11 158	6 339	3 145
	Other mature sheep	6	17	494	113	1 360	1 355	1 070	428
BEEF SHEEP	Mature ewes	470	1 039	7 002	4 488	15 268	43 249	13 146	15 870
	Growing lambs	91	217	1 372	872	3 246	6 752	3 318	3 057
	Growing lambs (pregnant)	14	178	949	593	2 130	6 084	2 199	1 811
	Other mature sheep	12	30	199	127	435	1 233	384	442
SWINE	Market swine	4 652	26 894	8 893	18 081	583	15 576	5 609	3 415
	Breeding swine	19 524	187 549	45 108	146 846	13 373	53 603	42 401	41 009
HORSES	Horses (0-3year)	99	95	160	405	158	341	233	187
	Stallions	61	78	97	281	166	250	292	112
	Mares	173	132	228	404	209	555	403	208
	Castrated stallions	81	82	121	146	270	305	377	157
GOATS	Mature goats	491	1498	2324	3035	5130	7 194	3 613	3 660
	Growing goats (pregnant)	82	319	689	830	1071	1939	966	994
	Other mature goats	93	163	222	364	316	605	407	319
POULTRY	Laying hens and cocks	674 426	524 399	634 420	1 747665	612 010	983 472	438 980	596 346
	Broilers	166 757	273 173	1 201 507	1 813670	639 272	269 593	108 433	1 828 758
	Turkeys	1 892	13 650	3 484	85 433	8 074	7 014	3 505	2 827
	Ducks	6 429	33 191	10 265	67 832	7 341	27 185	14 638	4 123
	Geese	1 341	4 053	1 909	8 522	2 909	4 494	1 659	1 573

5.6.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Data on number of domestic livestock according to the categories and amount of applied fertilizers are required either for the calculation of GHG or ammonia emissions. Basic sources of the data used for the evaluations of emissions inventory are:

- Green Reports of the Slovak Republic published by the Ministry of Agriculture and Rural Development of the Slovak Republic;
- Statistical Yearbooks published by the Statistical Office of the Slovak Republic;
- Annual Census of Domestic Livestock in the Slovak Republic.

In the GHG emissions inventory, data published by the Statistical Office of the Slovak Republic in the Statistical Yearbooks is used for all years. Data published in the Green Reports of the Slovak Republic and in the Annual Census of Domestic Livestock in the Slovak Republic, as well as in the Statistical Yearbooks can differ slightly, especially if the number of animals in some category is very low. The comparison with the data included in the Green Report or in the Annual Census of Domestic Livestock in the Slovak Republic is performed. Differences are very small and can be caused by rounding if the numbers of domestic livestock are given in thousands of heads and due to different methodology used in census or timing of census. Observed differences are up to 3%. Subcategories of domestic livestock can be compared to the data from the Statistical Yearbooks which are issued in the middle of following year. The productivity of different categories of domestic livestock varies in conditions of the Slovak Republic depending upon the scale and production level of a farm.

Tier 1 and default uncertainties were used in total assessment evaluated by Approach 1 (see Annex to this report).

5.6.4 CATEGORY SPECIFIC RECALCULATIONS

Agriculture sector is very specific sector. If, recalculations are implement in enteric fermentation, these changes will be influence on emissions in Manure Management sector and changes in Manure Management sector had to also influence on emissions from Agriculture Soils.

A revision of number of livestock based on the new statistical data from the Statistical office of the Slovak Republic was implemented for the time series 1990 – 2013. Available statistical data are in regional level.

Emissions for categories dairy and non-dairy cattle were recalculated in all-time series, according to the new available data.

Cattle category was redistributed. Suckling cows were allocated in non-dairy cattle category. The new methodology, which was introduced in 2014, has been applied back to the base year. According to the ESD recommendation SK-3B-2016-0022, default Ym parameter (6.5%) for all cattle sub categories was implemented and also digestibility was revised. Due to these implementations emissions in 1990 increased by 9% in 1990 increased by 9% and in 2014 decrease by 4%. Despite these changes, total emissions decreased by 4% in 2014.

Methodology has been revised for sheep category. Ym parameter was changed for growing lamb's category. Also new parameters (milk production and wool production) were implemented in all years.

Other animal's categories also were change. Due to the change of statistical data which were provided from the Statistical Office of the Slovak Republic. For non-key category of livestock emission factors were not to be changed and it remains consistent across the time series. ***Figure 5.9*** and ***Tables 5.22 - 5.24*** summarized comparisons of CH_4 emissions and activity data.

Recalculations led to decrease in total CH_4 emissions from enteric fermentation by 3% in 2014. Total methane emissions increased by 9% in 1990.

Figure 5.9: *Comparison of CH_4 emissions (in Gg) between 2016 and 2017 submissions*

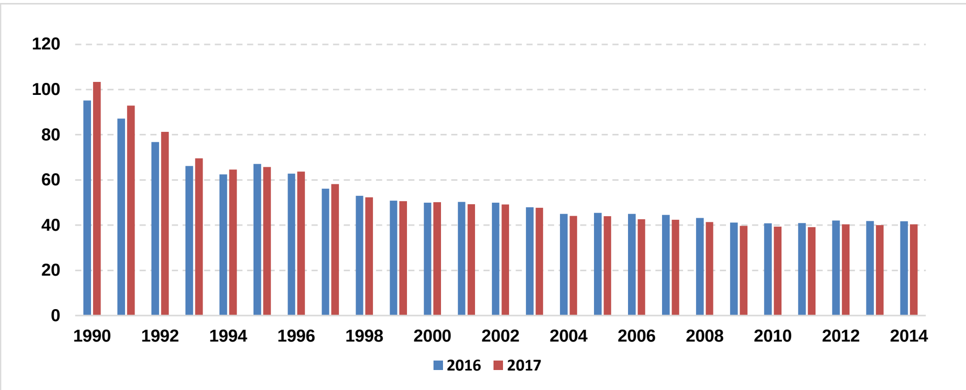


Table 5.22: *The impact of recalculations, new input data and methane emissions in 1990 – 2014 for dairy cattle and swine*

DAIRY CATTLE	NUMBER OF LIVESTOCK		EMISSIONS (Gg)		SWINE	NUMBER OF LIVESTOCK		EMISSIONS (Gg)	
YEAR	**2017**	**2016**	**2017**	**2016**	**YEAR**	**2017**	**2016**	**2017**	**2016**
1990	401.123	549.000	40.368	31.992	**1990**	2 520.524	2 035.000	3.781	3.053
1991	361.902	501.000	37.832	29.194	**1991**	2 427.997	1 942.000	3.642	2.913
1992	298.072	429.000	33.245	24.518	**1992**	2 269.232	1 799.200	3.404	2.699
1993	282.274	386.000	30.678	23.613	**1993**	2 179.029	1 730.800	3.269	2.596
1994	272.450	359.000	29.243	23.170	**1994**	2 037.371	1 613.100	3.056	2.420
1995	262.664	355.200	29.638	22.703	**1995**	2 076.439	1 644.400	3.115	2.467
1996	245.833	335.400	28.650	21.594	**1996**	1 985.223	1 574.800	2.978	2.362
1997	299.614	309.742	26.746	27.252	**1997**	1 809.868	1 434.700	2.715	2.152
1998	267.282	284.165	25.648	25.199	**1998**	1 592.599	1 220.000	2.389	1.830
1999	250.974	274.065	25.041	24.021	**1999**	1 562.106	1 191.660	2.343	1.787
2000	242.496	271.184	25.105	23.778	**2000**	1 488.441	1 099.400	2.233	1.649
2001	230.379	259.269	24.883	23.325	**2001**	1 517.291	1 115.700	2.276	1.674
2002	230.182	259.873	25.613	23.844	**2002**	1 553.880	1 236.900	2.331	1.855
2003	214.467	245.802	24.529	22.432	**2003**	1 443.013	1 184.325	2.165	1.776
2004	201.725	231.874	23.216	21.203	**2004**	1 149.282	1 149.282	1.724	1.724
2005	198.580	229.607	23.642	21.423	**2005**	1 108.265	1 044.984	1.662	1.567
2006	184.950	218.653	23.328	20.206	**2006**	1 104.829	1 104.829	1.657	1.657
2007	180.207	215.659	23.236	20.140	**2007**	951.934	951.934	1.428	1.428
2008	173.854	211.185	22.861	19.560	**2008**	748.515	748.515	1.123	1.123
2009	162.504	204.133	21.550	17.900	**2009**	740.862	740.862	1.111	1.111
2010	159.260	204.386	21.406	17.448	**2010**	687.260	687.260	1.031	1.031
2011	154.105	201.307	21.796	17.246	**2011**	580.393	580.393	0.871	0.871
2012	150.272	202.589	22.285	17.271	**2012**	631.464	631.464	0.947	0.947
2013	144.875	198.978	21.585	16.717	**2013**	637.167	637.167	0.956	0.956
2014	143.083	201.795	22.167	16.729	**2014**	641.827	641.827	0.963	0.963

Table 5.23: *The impact of recalculations, new input data and methane emissions in 1990 – 2014for non -dairy cattle and sheep*

NON-DAIRY CATTLE	NUMBER OF LIVESTOCK		EMISSIONS (Gg)		SHEEP	NUMBER OF LIVESTOCK		EMISSIONS (Gg)	
YEAR	**2017**	**2016**	**2017**	**2016**	**YEAR**	**2017**	**2016**	**2017**	**2016**
1990	1 161.947	1 014.000	61.126	45.443	**1990**	600.426	600.000	6.168	5.932
1991	1 034.668	896.000	54.271	40.811	**1991**	531.263	531.000	5.430	5.250
1992	883.588	753.000	47.377	34.849	**1992**	571.837	572.000	5.700	5.655
1993	710.689	607.000	38.116	28.537	**1993**	411.442	411.000	4.191	4.063
1994	643.703	557.000	34.007	26.594	**1994**	397.043	397.000	4.042	3.925
1995	666.042	627.500	35.300	30.420	**1995**	427.844	427.844	4.358	4.230
1996	646.158	556.600	34.507	27.390	**1996**	418.823	418.823	4.285	4.141
1997	503.784	493.656	23.901	22.773	**1997**	417.337	417.337	4.025	4.126
1998	437.510	420.627	21.323	21.842	**1998**	326.200	326.199	3.005	3.225
1999	414.081	390.990	20.819	20.248	**1999**	340.346	340.346	3.076	3.365
2000	403.652	374.964	20.622	19.375	**2000**	347.983	347.983	3.142	3.440
2001	394.811	365.921	20.386	20.265	**2001**	316.302	316.302	2.999	3.127
2002	377.653	347.944	19.577	18.963	**2002**	316.028	316.028	3.045	3.124
2003	378.715	347.380	19.597	18.005	**2003**	325.521	325.521	3.141	3.218

NON-DAIRY CATTLE	NUMBER OF LIVESTOCK		EMISSIONS (Gg)		SHEEP	NUMBER OF LIVESTOCK		EMISSIONS (Gg)	
YEAR	2017	2016	2017	2016	YEAR	2017	2016	2017	2016
2004	338.421	308.272	17.697	16.368	2004	321.227	321.227	3.070	3.374
2005	329.309	298.282	17.438	16.690	2005	320.487	320.487	3.056	3.188
2006	322.870	289.167	17.306	16.388	2006	332.571	332.571	3.099	3.247
2007	321.610	286.158	17.281	16.144	2007	347.179	347.179	3.251	3.373
2008	314.527	277.252	16.994	15.290	2008	361.634	361.634	3.397	3.537
2009	309.461	267.834	16.775	14.536	2009	376.978	376.978	3.564	3.697
2010	307.865	262.739	16.917	14.222	2010	394.175	394.175	3.702	3.848
2011	309.253	262.051	17.070	13.889	2011	393.927	393.927	3.685	4.080
2012	320.819	268.502	17.957	14.491	2012	409.569	409.569	3.839	3.999
2013	322.945	268.842	18.272	15.185	2013	399.908	399.908	3.750	3.839
2014	322.460	263.748	18.728	14.632	2014	391.151	391.151	3.685	3.680

Table 5.24: *The impact of recalculations, new input data and methane emissions in 1990 – 2014 for horses and goats*

HORSES	NUMBER OF LIVESTOCK		EMISSIONS (Gg)		GOATS	NUMBER OF LIVESTOCK		EMISSIONS (Gg)	
YEARS	2017	2016	2017	2016	YEAR	2017	2016	2017	2016
1990	13.595	14.000	0.245	0.252	1990	10.322	25.000	0.052	0.125
1991	12.858	13.000	0.231	0.234	1991	16.676	25.000	0.083	0.125
1992	11.652	12.000	0.210	0.216	1992	20.278	25.000	0.101	0.125
1993	11.188	11.000	0.201	0.198	1993	24.974	25.000	0.125	0.125
1994	10.652	11.000	0.192	0.198	1994	25.010	25.000	0.125	0.125
1995	10.109	10.109	0.182	0.182	1995	25.046	25.000	0.125	0.125
1996	9.722	9.722	0.175	0.175	1996	26.147	26.100	0.131	0.131
1997	9.533	9.533	0.172	0.172	1997	26.778	26.778	0.134	0.134
1998	9.550	9.550	0.172	0.172	1998	50.905	50.905	0.255	0.255
1999	9.342	9.342	0.168	0.168	1999	51.075	51.075	0.255	0.255
2000	9.516	9.516	0.171	0.171	2000	51.419	51.419	0.257	0.257
2001	7.883	7.883	0.142	0.142	2001	40.386	40.386	0.202	0.202
2002	8.122	8.122	0.146	0.146	2002	40.194	40.194	0.201	0.201
2003	8.114	8.114	0.146	0.146	2003	39.225	39.225	0.196	0.196
2004	8.209	8.209	0.148	0.148	2004	39.012	39.012	0.195	0.195
2005	8.328	8.328	0.150	0.150	2005	39.566	39.566	0.198	0.198
2006	8.222	8.222	0.148	0.148	2006	38.352	38.352	0.192	0.192
2007	8.017	8.017	0.144	0.144	2007	37.873	37.873	0.189	0.189
2008	8.421	8.421	0.152	0.152	2008	37.088	37.088	0.185	0.185
2009	7.199	7.199	0.130	0.130	2009	35.686	35.866	0.178	0.179
2010	7.111	7.111	0.128	0.128	2010	35.292	35.292	0.176	0.176
2011	6.937	6.937	0.125	0.125	2011	34.053	34.053	0.170	0.170
2012	7.249	7.249	0.130	0.130	2012	34.823	34.823	0.174	0.174
2013	7.161	7.161	0.129	0.129	2013	35.457	35.457	0.177	0.177
2014	6.828	6.828	0.123	0.123	2014	35.178	35.178	0.176	0.176

5.7 MANURE MANAGEMENT (CRF 3.B.1) – CH_4 EMISSIONS

Methane can be emitted also in anaerobic conditions due to the decomposition of manure. These conditions can be found especially 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. In future, a lower share of total methane emission will originate from animal excreta that are much easier to manage, e.g. by proper storage, than the emission from enteric fermentation.

Methane emissions from this source decreased from 21.88 Gg in 1990 to 6.24 Gg in 2015. CH_4 emissions in category manure management decreased due to decrease in livestock number of all categories except for poultry. Extreme decrease of animals was recorded in swine due to economic reasons and due to new activity data, which better reflect Slovak conditions. This situation consequently influenced methane emissions from manure management. Emissions decreased by 71% in this category in comparison with the base year, however, cattle is key source by the trend. Methane emissions in manure management decreased in comparison with the previous year by 3%, caused by decreasing of cattle population. The ***Figure 5.10*** and ***Table 5.25*** summarize the increases in non-dairy cattle and poultry methane emissions from manure management category. In this submission, new methodological approach based on national parameters was implemented for time series. Used methodology is based on detailed national data about animal number (based on more advanced livestock characteristics and more divided number of livestock). Activity data was provided by the Statistical Office of the Slovak Republic in 2016.

Figure 5.10: *Trend in CH_4 emissions (Gg) by categories within manure management in 1990 – 2015*

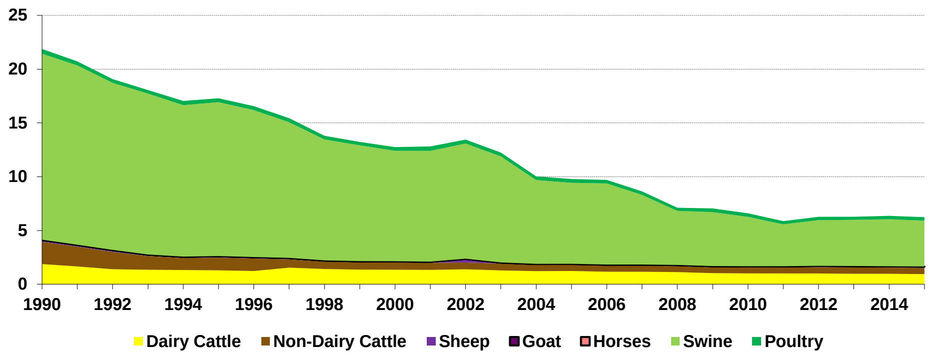


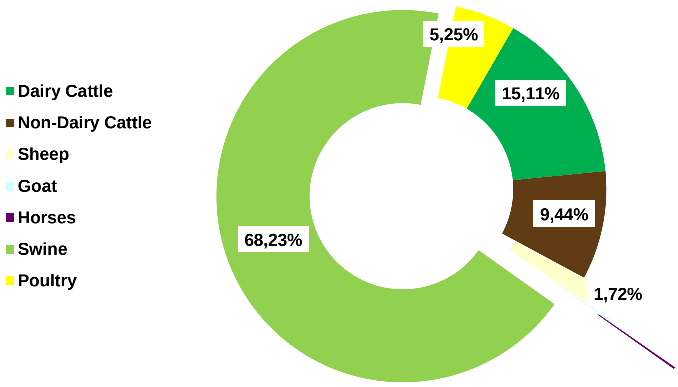
Table 5.25: *CH_4 emissions from manure management according to the animals in particular years*

YEAR	3.B.1 MANURE MANAGEMENT - CH_4 (Gg)						
	Dairy cattle	Non-dairy cattle	Swine	Sheep	Horses	Poultry	Goats
1990	1.875	2.066	17.296	0.177	0.021	0.439	0.001
1995	1.294	1.183	14.310	0.125	0.016	0.362	0.003
2000	1.348	0.676	10.270	0.094	0.015	0.346	0.007
2005	1.232	0.561	7.532	0.089	0.013	0.352	0.005
2010	1.008	0.543	4.592	0.108	0.011	0.332	0.005
2011	1.005	0.549	3.894	0.108	0.011	0.299	0.004
2012	1.001	0.583	4.248	0.112	0.011	0.310	0.005
2013	0.971	0.598	4.293	0.109	0.011	0.288	0.005
2014	0.970	0.578	4.374	0.108	0.011	0.316	0.005
2015	0.942	0.588	4.255	0.108	0.011	0.328	0.005

Methane emissions produced in manure management for cattle (dairy and non-dairy) and sheep were estimated using a tier 2 methodology and country specific emissions factors and parameters. This estimation was provided in line with the emissions estimation in enteric fermentation based on regional data available for Bratislava, Trnava, Trenčín, Nitra, Žilina, district has different parameters for calculation. Methane emissions of swine were calculated by tier 1 with the default emission factors for fattening and breeding swine according to average temperature in districts.

Figure 5.11 shows the share of individual categories in the production of manure methane emissions. Major share is represented by swine (68.23%). The important animal categories are also dairy cattle (15.11%) and non-dairy cattle (9.44%).

Figure 5.11: *The share of methane emissions by animals within manure management in 2015*



5.7.1 METHODOLOGICAL ISSUES – METHODS

Tier 2 methodology based on the national data was evaluated for the estimation of methane emissions in manure management for dairy, non-dairy cattle and sheep while also in swine, poultry and goats some country specific parameters were introduced. The national approach is based on the number of animals divided by subcategories per district, 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. These parameters were estimated for country specific conditions - ***Table 5.26***. The country specific regional data are available since 1997. The time series were extrapolated back to the base year. The methodology used for the methane emissions estimation in manure management for goats, horses, swine and poultry is based on tier 1 IPCC methodology using the default EFs and activity data. Emission factors for cattle and sheep are weighted average from the districts and animals' subcategories.

$$EF = (VS * 365) * \left[B_o * \frac{0{,}67kg}{m^3} * \sum \frac{MCF}{100} * MS\right]$$

VS= daily volatile solid excreted for livestock category, kg dry mater animal^{-1} day^{-1}

365 = basis for calculating annual VS production, days yr^{-1}

B_o = maximum methane producing capacity for manure produced by livestock category m^3 CH_4 kg^{-1} 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 for all Slovak territory.

Table 5.26: Overview of country specific parameters for cattle and sheep in 2015

PARAMETERS	DAIRY CATTLE	NON-DAIRY CATTLE	MATURE EWES	GROWING LAMBS	OTHER MATURE SHEEP
B_o Maximum methane-producing capacity of the manure (m^3/kg VS)	0.24	0.18*	0.19	0.19	0.19
Typical animal mass average (kg)	597.81	360.65	63.56	46.80	83.71
Ash content (%)	8	8	8	8	8
VS daily excretion (kg dm/head/day)	3.889	2.123	0.399	0.383	0.408
MCF values (weighted average) (%):					
Liquid system	11.126	11.216	-	-	-
Solid storage and dry lot	2	2	1	1	1
Pasture range and paddock	1	1	2	2	-

*Change over the previous submission. B_o was changed from Eastern Europe to Western Europe.

This year changes from latest submission (Submission 2016) were implemented. These changes had impact on the amount of emissions. New methodological approach introduces more accurate country specific data such as the gross energy intake (GE in MJ/head/day), digestibility of feed (DE in %) new ash content. Values of maximum methane producing capacity for cattle see above in ***Table 5.26***.

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 producing capacity for all sheep subcategories is 0.19 m^3/kg VS are provided in **Table 5.27**.

MCF for manure management systems in cool climate condition were used according to the Table 10.21 of the IPCC 2006 GL. Allocation of animals into AWMS is described in the Chapter 5.8.4.

Tables 5.27: The overview of used VS for livestock in 2015

VOLATILE SOLID EXCRETION PER DAY ON A DRY-ORGANIC MATTER BASE									
DISTRICT		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
DAIRY CATTLE	Dairy cows	3.971	4.057	3.939	3.609	4.063	3.604	4.154	3.649
	Calves in 6 month	0.530	0.497	0.498	0.571	0.566	0.564	0.594	0.574
	Heifer	1.712	1.694	1.694	1.668	1.947	1.669	1.882	1.799
	Heifer (pregnant)	2.415	2.407	2.613	2.411	2.755	2.154	2.697	2.400
	Fattening	1.680	1.745	1.676	1.749	1.586	1.446	1.836	1.436
	Oxen	4.419	4.419	4.419	4.419	4.419	4.419	4.419	4.419
BEEF CATTLE	Suckling cows	3.948	4.008	3.812	3.911	3.896	3.952	3.930	3.925
	Calves in 6 month	1.101	1.055	0.912	1.045	0.980	0.963	0.959	0.929
	Heifer	2.404	2.436	2.244	2.334	2.360	2.312	2.333	2.304
	Heifer (pregnant)	3.481	3.449	3.305	3.464	3.461	3.351	3.521	3.437
	Fattening	2.230	2.490	2.335	2.295	2.339	2.311	2.391	2.161
	Oxen	4.419	4.419	4.419	4.419	4.419	4.419	4.419	4.419
	Breeding bull	2.609	2.609	2.609	2.609	2.609	2.609	2.609	2.609
DAIRY SHEEP	Mature ewes	0.403	0.394	0.404	0.368	0.389	0.382	0.376	0.357
	Growing lambs	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286
	Growing lambs (pregnant)	0.463	0.470	0.461	0.469	0.462	0.464	0.463	0.465

VOLATILE SOLID EXCRETION PER DAY ON A DRY-ORGANIC MATTER BASE									
DISTRICT		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
	Other mature sheep	0.398	0.405	0.396	0.404	0.397	0.399	0.397	0.400
BEEF SHEEP	Mature ewes	0.433	0.440	0.431	0.439	0.432	0.433	0.432	0.435
	Growing lambs	0.379	0.379	0.379	0.379	0.379	0.379	0.379	0.379
	Growing lambs (pregnant)	0.523	0.530	0.521	0.529	0.522	0.524	0.522	0.525
	Other mature sheep	0.426	0.432	0.424	0.431	0.424	0.426	0.425	0.427

Tables 5.28: *The overview of used emissions factors for livestock in 2015*

EMISSIONS FACTORS in kg/head/year									
DISTRICT		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
DAIRY CATTLE	Dairy cows	13.644	9.016	5.863	7.988	5.429	5.730	5.283	4.492
	Calves in 6 month	0.467	0.438	0.438	0.503	0.498	0.497	0.523	0.505
	Heifer	1.489	1.473	1.473	1.451	1.693	1.452	1.637	1.564
	Heifer (pregnant)	2.100	2.093	2.273	2.096	2.396	1.873	2.346	2.087
	Fattening	2.144	2.381	2.140	2.387	1.955	1.782	2.263	1.833
	Oxen	3.891	3.891	3.891	3.891	3.891	3.891	3.891	3.891
BEEF CATTLE	Suckling cows	3.364	3.415	3.248	3.333	3.320	3.368	3.349	3.345
	Calves in 6 month	0.352	0.359	0.293	0.309	0.327	0.311	0.301	0.281
	Heifer	1.537	1.557	1.434	1.492	1.509	1.478	1.491	1.473
	Heifer (pregnant)	2.225	2.204	2.112	2.214	2.212	2.142	2.251	2.197
	Fattening	3.730	4.603	3.906	4.243	3.707	3.662	3.789	3.614
	Oxen	3.891	3.891	3.891	3.891	3.891	3.891	3.891	3.891
	Breeding bull	2.014	2.014	2.014	2.014	2.014	2.014	2.014	2.014
DAIRY SHEEP	Mature ewes	0.280	0.274	0.281	0.256	0.270	0.266	0.262	0.248
	Growing lambs	0.199	0.199	0.199	0.199	0.199	0.199	0.199	0.199
	Growing lambs (pregnant)	0.322	0.327	0.321	0.326	0.321	0.322	0.321	0.323
	Other mature sheep	0.370	0.377	0.368	0.376	0.369	0.370	0.369	0.371
BEEF SHEEP	Mature ewes	0.292	0.297	0.291	0.296	0.291	0.292	0.292	0.293
	Growing lambs	0.256	0.256	0.256	0.256	0.256	0.256	0.256	0.256
	Growing lambs (pregnant)	0.353	0.358	0.352	0.357	0.352	0.353	0.353	0.354
	Other mature sheep	0.396	0.402	0.394	0.401	0.394	0.396	0.395	0.397

5.7.2 ACTIVITY DATA

The number of animals in category dairy cows starts to be limited by milk quotation. The number of animals was consistent with the number of animals from enteric fermentation and the figures were provided by regional statistics at district level. Swine category has been divided into two subcategories (breeding and market swine), poultry category has been divided into laying hens and cocks, broilers, turkeys, ducks, geese categories. More information on animal population can be found in the ***Table 5.18***.

5.7.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Tier 1 uncertainty was included in total uncertainty assessment. Time series consistency is ensured during recalculation back to base year. More information is in the Chapter 5.6.3 of this report.

5.7.4 CATEGORY - SPECIFIC RECALCULATIONS

The new statistical data from the Statistical office of the Slovak Republic was implemented in this category a revision of number of livestock based on for the time series 1990 – 2013. In addition, the time series of methane emissions was recalculated. Categories of cattle were redistributed. Suckling cows were allocated in non-dairy cattle category. The new methodology, which was introduced in 2014, has been applied in to the base year.

The new methodology, which was introduced in 2016, has been applied to the base year for cattle and sheep categories see above ***Figure 5.12***. Changes in enteric fermentation (Chapter 5.7.3) have impact to the category Manure management.

Cattle category were change compared to 2016 submission. Parameter B_o (maximum methane producing capacity for manure produced by livestock category) was changed for non-dairy cattle category at 0.18 m^3/kg VS.

Also new AWMS was implemented for categories cattle and sheep. Anaerobic lagoon were reallocate into the liquid because of very cold conditions in Slovak republic. Burned of manure was reallocate into the solid, because of lack of information was about this source.

Other animal’s categories also were change. Due to the change of statistical data which were provided from the Statistical Office of the Slovak Republic. Emission factors were not changed and they are consistent across the time series.

Recalculations led to decrease in total CH_4 emissions from enteric fermentation by 3 %. In year 2014, Emission decreases by 9%in base year see in ***Tables 5.29* - *32***.

Figure 5.12: *Comparison of CH_4 emissions (Gg) between 2016 and 2017 submissions*

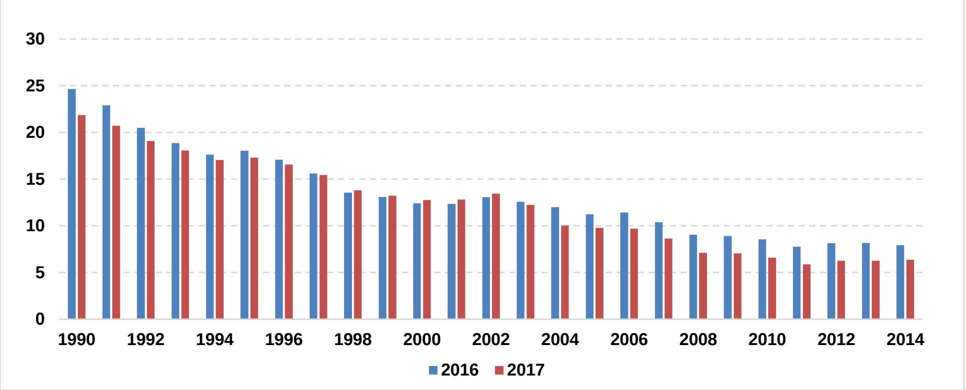


Table 5.29: *The impact of recalculations, new input data and methane emissions in 1990 – 2014 for dairy cattle and swine*

DAIRY CATTLE	NUMBER OF LIVESTOCK		EMISSIONS (Gg)		SWINE	NUMBER OF LIVESTOCK		EMISSIONS (Gg)	
YEAR	2017	2016	2017	2016	YEAR	2017	2016	2017	2016
1990	401.123	549.000	1.875	6.856	**1990**	2 520.524	2 035.000	17.296	13.166
1991	361.902	501.000	1.654	6.257	**1991**	2 427.997	1 942.000	16.675	12.565
1992	298.072	429.000	1.397	5.357	**1992**	2 269.232	1 799.200	15.537	11.641
1993	282.274	386.000	1.346	4.820	**1993**	2 179.029	1 730.800	14.966	11.198
1994	272.450	359.000	1.321	4.483	**1994**	2 037.371	1 613.100	14.083	10.437
1995	262.664	355.200	1.294	4.436	**1995**	2 076.439	1 644.400	14.310	10.639

DAIRY CATTLE	NUMBER OF LIVESTOCK		EMISSIONS (Gg)		SWINE	NUMBER OF LIVESTOCK		EMISSIONS (Gg)	
YEAR	**2017**	**2016**	**2017**	**2016**	**YEAR**	**2017**	**2016**	**2017**	**2016**
1996	245.833	335.400	1.231	4.189	**1996**	1 985.223	1 574.800	13.662	10.189
1997	299.614	309.742	1.541	3.868	**1997**	1 809.868	1 434.700	12.620	9.282
1998	267.282	284.165	1.416	3.549	**1998**	1 592.599	1 220.000	11.245	7.893
1999	250.974	274.065	1.360	3.423	**1999**	1 562.106	1 191.660	10.770	7.710
2000	242.496	271.184	1.348	3.387	**2000**	1 488.441	1 099.400	10.270	7.113
2001	230.379	259.269	1.334	3.238	**2001**	1 517.291	1 115.700	10.297	7.219
2002	230.182	259.873	1.388	3.245	**2002**	1 553.880	1 236.900	10.714	8.003
2003	214.467	245.802	1.285	3.070	**2003**	1 443.013	1 184.325	9.858	7.663
2004	201.725	231.874	1.218	2.896	**2004**	1 149.282	1 149.282	7.792	7.436
2005	198.580	229.607	1.232	2.822	**2005**	1 108.265	1 044.984	7.532	6.761
2006	184.950	218.653	1.162	2.687	**2006**	1 104.829	1 104.829	7.542	7.148
2007	180.207	215.659	1.159	2.648	**2007**	951.934	951.934	6.472	6.159
2008	173.854	211.185	1.129	2.729	**2008**	748.515	748.515	5.028	4.843
2009	162.504	204.133	1.032	2.632	**2009**	740.862	740.862	5.019	4.793
2010	159.260	204.386	1.008	2.635	**2010**	687.260	687.260	4.592	4.447
2011	154.105	201.307	1.005	2.598	**2011**	580.393	580.393	3.894	3.755
2012	150.272	202.589	1.001	2.611	**2012**	631.464	631.464	4.248	4.086
2013	144.875	198.978	0.971	2.577	**2013**	637.167	637.167	4.293	4.122
2014	143.083	201.795	0.970	2.571	**2014**	641.827	641.827	4.374	4.374

Table 5.30: *The impact of recalculations, new input data and methane emissions in 1990 – 2014 for non - dairy cattle and sheep*

NON-DAIRY CATTLE	NUMBER OF LIVESTOCK		EMISSIONS (Gg)		SHEEP	NUMBER OF LIVESTOCK		EMISSIONS (Gg)	
YEAR	**2017**	**2016**	**2017**	**2016**	**YEAR**	**2016**	**2017**	**2016**	**2017**
1990	1 161.947	1 014.000	2.066	4.083	**1990**	600.426	600.000	0.177	0.114
1991	1 034.668	896.000	1.842	3.608	**1991**	531.263	531.000	0.156	0.101
1992	883.588	753.000	1.609	3.032	**1992**	571.837	572.000	0.165	0.109
1993	710.689	607.000	1.277	2.444	**1993**	411.442	411.000	0.120	0.078
1994	643.703	557.000	1.114	2.243	**1994**	397.043	397.000	0.116	0.075
1995	666.042	627.500	1.183	2.526	**1995**	427.844	427.844	0.125	0.081
1996	646.158	556.600	1.158	2.241	**1996**	418.823	418.823	0.123	0.080
1997	503.784	493.656	0.773	1.988	**1997**	417.337	417.337	0.118	0.079
1998	437.510	420.627	0.693	1.694	**1998**	326.200	326.199	0.089	0.062
1999	414.081	390.990	0.678	1.574	**1999**	340.346	340.346	0.092	0.065
2000	403.652	374.964	0.676	1.510	**2000**	347.983	347.983	0.094	0.066
2001	394.811	365.921	0.664	1.473	**2001**	316.302	316.302	0.088	0.060
2002	377.653	347.944	0.632	1.401	**2002**	316.028	316.028	0.337	0.060
2003	378.715	347.380	0.633	1.399	**2003**	325.521	325.521	0.092	0.062
2004	338.421	308.272	0.570	1.241	**2004**	321.227	321.227	0.089	0.061
2005	329.309	298.282	0.561	1.213	**2005**	320.487	320.487	0.089	0.061
2006	322.870	289.167	0.560	1.179	**2006**	332.571	332.571	0.091	0.063
2007	321.610	286.158	0.562	1.172	**2007**	347.179	347.179	0.095	0.066
2008	314.527	277.252	0.547	1.111	**2008**	361.634	361.634	0.099	0.069
2009	309.461	267.834	0.538	1.065	**2009**	376.978	376.978	0.104	0.072
2010	307.865	262.739	0.543	1.047	**2010**	394.175	394.175	0.108	0.075
2011	309.253	262.051	0.549	1.036	**2011**	393.927	393.927	0.108	0.075

NON-DAIRY CATTLE	NUMBER OF LIVESTOCK		EMISSIONS (Gg)		SHEEP	NUMBER OF LIVESTOCK		EMISSIONS (Gg)	
2012	320.819	268.502	0.583	1.065	**2012**	409.569	409.569	0.112	0.078
2013	322.945	268.842	0.598	1.103	**2013**	399.908	399.908	0.109	0.076
2014	322.460	263.748	0.578	0.542	**2014**	391.151	391.151	0.108	0.113

Table 5.31: *The impact of recalculations, new input data and methane emissions in 1990 – 2014 for horses and goats*

HORSES	NUMBER OF LIVESTOCK		EMISSIONS (Gg)		GOATS	NUMBER OF LIVESTOCK		EMISSIONS (Gg)	
YEAR	2017	2016	2017	2016	YEAR	2017	2016	2017	2016
1990	13.595	14.000	0.021	0.022	**1990**	10.322	25.000	0.001	0.003
1991	12.858	13.000	0.020	0.020	**1991**	16.676	25.000	0.002	0.003
1992	11.652	12.000	0.018	0.019	**1992**	20.278	25.000	0.003	0.003
1993	11.188	11.000	0.017	0.017	**1993**	24.974	25.000	0.003	0.003
1994	10.652	11.000	0.017	0.017	**1994**	25.010	25.000	0.003	0.003
1995	10.109	10.109	0.016	0.016	**1995**	25.046	25.000	0.003	0.003
1996	9.722	9.722	0.015	0.015	**1996**	26.147	26.100	0.003	0.003
1997	9.533	9.533	0.015	0.015	**1997**	26.778	26.778	0.003	0.003
1998	9.550	9.550	0.015	0.015	**1998**	50.905	50.905	0.007	0.007
1999	9.342	9.342	0.015	0.015	**1999**	51.075	51.075	0.007	0.007
2000	9.516	9.516	0.015	0.015	**2000**	51.419	51.419	0.007	0.007
2001	7.883	7.883	0.012	0.012	**2001**	40.386	40.386	0.005	0.005
2002	8.122	8.122	0.013	0.013	**2002**	40.194	40.194	0.005	0.005
2003	8.114	8.114	0.013	0.013	**2003**	39.225	39.225	0.005	0.005
2004	8.209	8.209	0.013	0.013	**2004**	39.012	39.012	0.005	0.005
2005	8.328	8.328	0.013	0.013	**2005**	39.566	39.566	0.005	0.005
2006	8.222	8.222	0.013	0.013	**2006**	38.352	38.352	0.005	0.005
2007	8.017	8.017	0.013	0.013	**2007**	37.873	37.873	0.005	0.005
2008	8.421	8.421	0.013	0.013	**2008**	37.088	37.088	0.005	0.005
2009	7.199	7.199	0.011	0.011	**2009**	35.686	35.866	0.005	0.005
2010	7.111	7.111	0.011	0.011	**2010**	35.292	35.292	0.005	0.005
2011	6.937	6.937	0.011	0.011	**2011**	34.053	34.053	0.004	0.004
2012	7.249	7.249	0.011	0.011	**2012**	34.823	34.823	0.005	0.005
2013	7.161	7.161	0.011	0.011	**2013**	35.457	35.457	0.005	0.005
2014	6.828	6.828	0.011	0.011	**2014**	35.178	35.178	0.005	0.005

Table 5.32: *The impact of recalculations, new input data and methane emissions in 1990 – 2014 for poultry*

YEAR	NUMBER OF LIVESTOCK		EMISSIONS (Gg)	
	2017	2016	2017	2016
1990	16 477.763	16 477.763	0.439	0.417
1991	13 866.297	13 866.297	0.377	0.351
1992	13 266.789	13 266.789	0.347	0.336
1993	12 234.120	12 234.120	0.330	0.310
1994	14 245.954	14 245.954	0.393	0.361
1995	13 382.391	13 382.391	0.362	0.339
1996	14 147.177	14 147.177	0.371	0.358
1997	14 221.713	14 221.713	0.374	0.360
1998	13 353.654	13 353.654	0.342	0.332

YEAR	NUMBER OF LIVESTOCK		EMISSIONS (Gg)	
	2017	2016	2017	2016
1999	12 247.440	12 247.440	0.316	0.310
2000	13 580.042	13 580.042	0.346	0.315
2001	15 590.404	15 590.404	0.415	0.344
2002	13 959.404	13 959.404	0.363	0.353
2003	14 216.798	14 216.798	0.359	0.360
2004	13 713.239	13 713.239	0.344	0.347
2005	14 084.079	14 084.079	0.352	0.356
2006	13 038.303	13 038.303	0.331	0.330
2007	12 880.124	12 880.124	0.328	0.326
2008	11 228.140	11 228.140	0.290	0.284
2009	13 583.284	13 583.284	0.344	0.344
2010	12 991.916	12 991.916	0.332	0.329
2011	11 375.603	11 375.603	0.299	0.288
2012	11 849.818	11 849.818	0.310	0.300
2013	10 968.918	10 968.918	0.288	0.278
2014	12 494.074	12 494.074	0.316	0.316

5.8 MANURE MANAGEMENT (CRF 3.B.2) – N_2O EMISSIONS

Domestic livestock produces different kinds of nitrogen inputs (liquid, solid) into the ecosystem also the structure of domestic livestock is important (the ratio of different categories of domestic livestock) from the point of view of direct emissions as well as the emissions from the AWMS. Except for it, the production of nitrogen per head per year also plays certain role.

Solid and liquid systems are the most common form of excreta storage in manure management (especially for cattle and swine) in the Slovak Republic. The pasture range in some periods of year (200 days per year on average) is a characteristic management system for sheep, horses and goats (partly for non-dairy cattle). Input of nitrogen oxide from manure management was 0.57 Gg of N_2O in 2015 and total decrease was about 66% compared to the base year. Decrease of emissions compared to the base year shows ***Figure 5.13***.

Figure 5.14 shows the share of individual categories in the production of nitrogen from manure. Major share represents dairy cattle (27.04%), non-dairy cattle (21.7%), poultry (23.6%) and swine (12.5%).

Figure 5.13: *Trend in nitrogen excretion (Gg) by categories within manure management in 1990 – 2015*

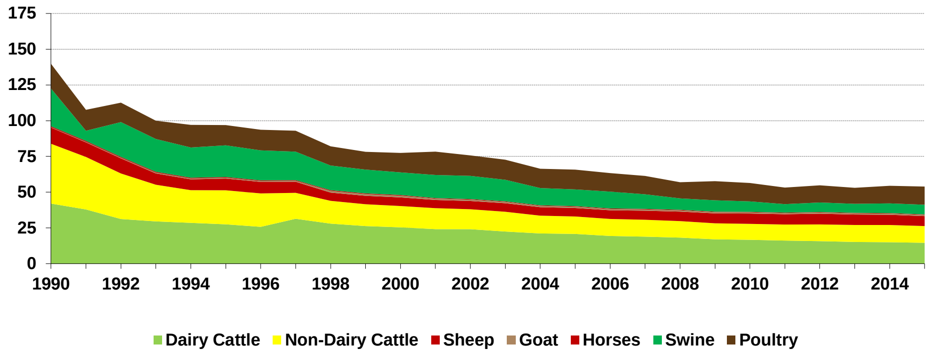
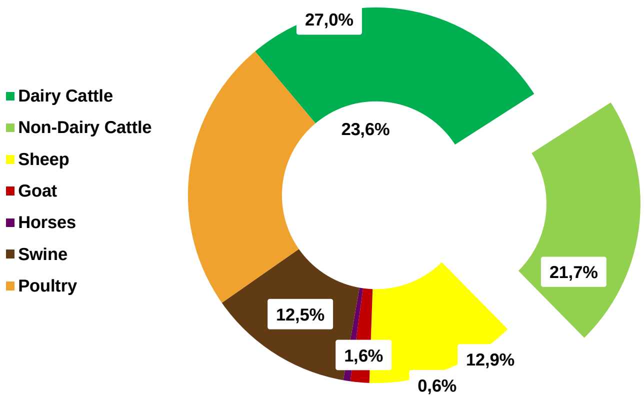


Table 5.33: *N-excretions in manure management according to the animal categories in particular years*

YEAR	3.B.2 MANURE MANAGEMENT N-EXCRETIONS (kt)						
	Dairy Cattle	Non-Dairy Cattle	Sheep	Goat	Horses	Swine	Poultry
1990	42.02	41.85	11.33	0.25	0.69	26.37	17.28
1995	27.51	23.82	8.20	0.60	0.50	22.15	14.16
2000	25.40	14.91	6.03	1.23	0.48	15.80	13.61
2005	20.80	12.19	5.93	0.95	0.39	11.68	13.84
2010	16.68	11.15	7.22	0.84	0.33	7.33	12.88
2011	16.14	11.22	7.20	0.82	0.32	5.94	11.57
2012	15.74	11.70	7.49	0.83	0.34	6.68	12.02
2013	15.17	11.87	7.31	0.85	0.34	6.32	11.19
2014	14.99	12.05	7.15	0.84	0.32	6.82	12.30
2015	14.58	11.71	6.97	0.87	0.33	6.75	12.73

Figure 5.14: *The share of aggregated N-excretion by animals within manure management in 2015*



5.8.1 METHODOLOGICAL ISSUES – METHODS

For the calculation of nitrogen emissions the nitrogen cycle must be taken into account, which is the basis for the correct calculation of the nitrogen emissions. This nitrogen cycle and available national parameters are taken account for more accurate emissions estimations.

Nitrogen is an essential element for livestock and for the growth of crops. Livestock transforms plant-proteins to animal proteins. Livestock integrated the nitrogen into the musculoskeletal (5-45%), it is necessary for the milk production. The unused nitrogen is excreted as manure and slurry back into the soil.

Approximately 2-40% of the nitrogen evaporates during the storage of manure, by it depends on kind of storage. After wards manure and slurry are spread into the soil. During these procedures approximately 2-50% of the remaining nitrogen is emitted into the atmosphere, depending on the used technique.

The production of organic manure is continuously decreasing, therefore it is necessary to compensate this lack by inorganic nitrogen fertilizers. The application of mineral fertilizers and next the denitrification processes emit approximately 8% of nitrogen, and the leaching of fertilizer another approximately 30%[2]

N_2O emissions from manure storage in the AWMS were based on the analysis of housing practices in farms of the Slovak Republic. Questionnaire survey was performed with the cooperation of the Research

[2] Brestenský; Straty hmotnosti dusíka pri manipulácií s maštalným hnojom (in Slovak)

Institute for Animal Production in Nitra and other research institutions. Results of this survey were implemented also in the inventory submission 2017. This survey also defined more accurate days for cattle, sheep, goats and horses which stay on pasture. For grazing categories of cattle, sheep, horses and goats it is approximately 180-200 days and for dairy cattle it is 150 days. The pasture is used in mountainous regions. Share of nitrogen allocated in AWMS according to animals is provided in the ***Table 5.33*** below. Allocation according to the climate conditions is 100% for cool climate for all animals based on the IPCC 2006 methodology and climate data. Default nitrogen excretion is taken for Western Europe, the reasons of this choice is described in Chapter 5.5 above.

Solid storage of manure was found as the most frequent AMWS in the conditions of the Slovak Republic mostly for cattle. Liquid storage of slurry is also frequently used especially in category swine. Housing on grasslands from April to October is frequent for sheep, goats and horses (partly for non-dairy cattle). The methodology used for the estimation of manure management is based on IPCC methodology using country specific parameters and activity data for cattle, sheep, horses, goats, poultry and swine. Detailed parameters are in ***Table 5.34***.

Table 5.34: *N_{EX} and share (%) for different domestic livestock and share in AWMS in 2015*

CATEGORY SUBCATEGORY		WEIGHTED AVERAGE FOR BODY WEIGHT	N_{EX}	LIQUID SYSTEM	SOLID SYSTEM	PASTURE	LITTER
		kg	N kg/head/year	%			
DAIRY CATTLE	Dairy cows	597.81	104.744	11.50	81.20	7.30	-
	Weighted average in 2015	597.81	104.744	11.50	81.20	7.30	-
BEEF CATTLE	Suckling cows	592.00	71.31	-	45.21	54.79	-
	Calves (6 month)	103.71	14.41	-	-	100.00	-
	Heifer	297.77	35.87	-	97.56	2.44	-
	Heifer pregnant	522.04	62.88	-	97.56	2.44	-
	Fattening	353.85	42.62	10	90	-	-
	Oxen	700.00	84.32	-	100	-	-
	Calves (6 month)	119.73	7.70	-	40	60	-
	Heifer	317.79	38.28	-	45.21	54.79	-
	Heifer pregnant	506.87	61.05	-	45.21	54.79	-
	Fattening	365.87	44.07	20	80	-	-
	Oxen	700.00	84.32	-	100	-	-
	Breeding bull	800.00	96.36	-	75.34	24.66	-
	Weighted average in 2015	360.65	45.36	1.54	76.89	21.57	-
SHEEP	Mature ewes	60.00	18.62	-	49.59	50.41	-
	Mature ewes	70.00	21.72	-	45.20	54.80	-
	Weighted average in 2015	63.56	19.81	-	47.90	52.10	-
	Growing lambs	32.50	10.8	-	49.59	50.41	-
	Growing lambs pregnant	55.00	17.6	-	49.59	50.41	-
	Growing lambs	47.50	14.74	-	45.21	54.79	-
	Growing lambs pregnant	65.00	20.17	-	45.21	54.79	-
	Weighted average in 2015	46.80	14.17	-	47.90	52.10	-
	Rams	55.00	26.1	-	100.00	-	-

CATEGORY SUBCATEGORY		WEIGHTED AVERAGE FOR BODY WEIGHT	N_{EX}	LIQUID SYSTEM	SOLID SYSTEM	PASTURE	LITTER
		kg	N kg/head/year	%			
	Rams	90.00	27.92	-	100.00	-	-
	Weighted average in 2015	83.71	25.97	-	100.00	-	-
BREEDING SWINE	Piglets 1,2-20 kg	10.60	1.63	80.00	20.00	-	-
	Piglets 21-51 kg	35.50	5.44	80.00	20.00	-	-
	Yong sows 50-140 kg	95.00	14.56	80.00	20.00	-	-
	Sows 180 kg	180.00	27.59	80.00	20.00	-	-
	Hogs	145.00	22.23	80.00	20.00	-	-
	Weighted average in 2015	108.94	16.7	80.00	20.00	-	-
MARKET SWINE	Fattening 1,2-20 kg	10.60	1.97	70.00	20.00	-	10.00
	Fattening 21-51 kg	35.50	6.61	70.00	20.00	-	10.00
	Fattening 50-80 kg	65.00	12.1	70.00	20.00	-	10.00
	Fattening 80-110 kg	95.00	17.68	70.00	20.00	-	10.00
	Fattening 110 < kg	110.00	20.48	70.00	20.00	-	10.00
	Weighted average in 2015	52.32	9.74	70.00	20.00	-	10.00
SWINE	Weighted average in 2015	59.81	10.66	71.32	28.68-	-	
GOATS	Mature female goats	55	25.70	-	49.60	50.40	-
	Pregnant goats	47.5	22.19	-	49.60	50.40	-
	Other mature goats	21.5	10.05	-	49.60	50.40	-
	Weighted average in 2015	51.28	23.96	-	49.60	50.40	-
HORSES	Young horses	287.50	27.28	70.00	-	30.00	-
	Castrated horses	700.00	66.43	70.00	-	30.00	-
	Stallions	550.00	52.20	70.00	-	30.00	-
	Mares	500.00	47.45	70.00	-	30.00	-
	Weighted average in 2015	502.63	47.70	70.00	-	30.00	-
POULTRY	Laying hens + cocks	3.14	1.10	85.00	-	15.00	-
	Broilers	1.10	0.80	-	-	100.00	-
	Turkeys	17.00	4.59	-	-	100.00	-
	Ducks	4.00	1.21	-	-	100.00	-
	Geese	6.00	1.82	-	-	100.00	-
	Weighted average in 2015	2.29	0.99	-	-	100.00	-

Better estimate of N_2O emission was provided according to UNFCCC recommendation A.7 (SVK 2016 ARR). As base of calculation different animal weights of different animal subcategories were used. Each animal's categories respectively subcategories have their own body weight. This parameter was measured and it is country specific. Also AWMS share were derived from measured amount of nitrogen. If we have these parameters, nitrogen excretion rate can be calculated. Annual nitrogen excretion rates were determined for each livestock species respectively category of farm animals. N excretions rate were transposed default values from IPCC 2006 GL. This data has been provided by Research Institute for Animal Production in Nitra.

Nitrogen excretion rates for animals' categories were calculated based on the IPCC 2006 GL, equation 10.30:

$$NEX_T = N_{rate(T)} * \frac{TAM}{1000} * 365$$

Where: NEX_T = annual N excretion for each livestock spices respectively category, kg N animal/year; $N_{RATE(T)}$ = default N excretion rate, kg N (100 kg per animal mass)/day (IPCC 2006 GL) and TAM = country specific animal mass for each livestock spices/category (kg per animal).

Direct emissions from manure management systems were estimated according to following equation:

$$N_2O_{EM} = \left[\sum \left[\sum (N.N_{EX}.AWMS)\right].EF\right].\frac{44}{28}$$

Where: N_2O_{EM} = direct N_2O emissions from manure management (kg N_2O per year); N = number of livestock species respectively category; N_{EX} = annual average N excretion per head of species respectively category (kg N per animal per year); AMWS = percentage of total annual nitrogen excretion for each livestock respectively category, that is managed in manure management systems in the country, EF = default emission factor for direct N_2O emissions from manure management system (kg N_2O-Nkg N in manure management system) and 44/28 = conversion of N_2O-N emissions to N_2O emissions.

The IPCC default emission factors for N_2O emissions estimation per AWMS are based on the Table 10.21 of the IPCC 2006 GL. Liquid and solid AWMS 0.005 kg/head/year, for pasture, range and paddocks it is EF = 0.02 kg/head/year for cattle and EF = 0.01 kg/head/year for other animals on pasture. Poultry were revised. Solid and liquid manure were changed in with litter (solid) and without litter (liquid), which has EF = 0.001 kg/head/year. Other animal systems have EF = 0 kg/head/year.

5.8.2 ACTIVITY DATA

The Research Institute for Animal Production in Nitra is the most important sources of data on animal housing, pasture and production of manures and slurries. More information on animal numbers can be found in previous chapters.

5.8.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Trends of total N_2O emissions from agriculture sector reflect the trends of direct emissions from cultivated soils, emissions from AWMS and indirect emissions from leaching and deposition of ammonia and NO_x. Tier 1 uncertainty was included in total assessment. Time series consistency is ensured for used methodology. The productivity of different categories of domestic livestock varies significantly in the conditions of the Slovak Republic depending on the scale and the production level of farms of different regions. In the Slovak Republic, both the extensive and intensive farming system in animal husbandry can be found. Nitrogen inputs can differ from the calculations in range ±10%. Towards the future, this mistake should be lower because the level of animal husbandry can be concentrated to a relatively smaller number of producers and so it can be much easier to define production level of farms.

5.8.4 CATEGORY - SPECIFIC RECALCULATIONS

Better categorisation and reallocation of all animal category respectively subcategories and changes in AWMS share for the time series 1990 – 2013 were done. Changes documented ***Figure 5.15***. In latest submission, N-inputs for anaerobic lagoon and manure burned for fuel or as waste from cattle categories was reported. Anaerobic lagoons were reallocated into the liquid because of very cold conditions in Slovak republic. Burned of manure was reallocate into the solid, because of lack of information was about this source.

The most important parameter for nitrogen estimation – N_{EX} was revised in this submission. More information can be found in the Chapter 5.8.1 of this report. Due to changes in methodology, changes in the share of AWMS among animal categories and EFs, following recalculation in total N_2O emissions per animal categories took place. In total, emissions decreased by 22.75% in 2014. Decrease is mainly caused by more detailed disaggregation of the categories for example: In 2014 N_2O emissions have been calculated for the whole goats' category. (N_{EX} = 23.81 N.kg/head/year). In submission 2015 have been prepared emission of N_2O for mature goats (25.696 N.kg/head/year), growing goats pregnant (22.192 N.kg/head/year) and other mature goats (10.0448 N.kg/head/year) in according to. Very big decline was in Poultry category. The reason of this decrease was change of EFs. EFs were used for solid and liquid manure (EF = 0.005 kg N_2O-N kg N; EF = 0.005 kg N_2O-N kg N) in 2016 submission. EFs were revised on EF = 0.001 kg N_2O-N kg N (poultry manure with and without litter).

Figure 5.15: *Comparison of N_2O emissions (Gg) between 2016 and 2017 submissions*

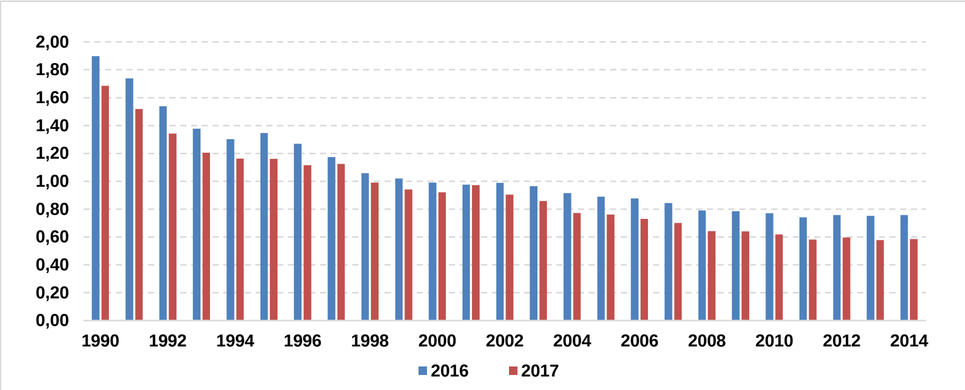


Table 5.35: *The impact of recalculations of N_2O emissions in manure management in 1990 – 2014 for dairy cattle and swine*

DAIRY CATTLE	NUMBER OF LIVESTOCK		EMISSIONS (Gg)		SWINE	NUMBER OF LIVESTOCK		EMISSIONS (Gg)	
YEAR	2017	2016	2017	2016	YEAR	2017	2016	2017	2016
1990	401.123	549.000	0.292	0.360	1990	2 520.524	2 035.000	0.222	0.184
1991	361.902	501.000	0.264	0.329	1991	2 427.997	1 942.000	0.216	0.175
1992	298.072	429.000	0.217	0.282	1992	2 269.232	1 799.200	0.205	0.163
1993	282.274	386.000	0.206	0.253	1993	2 179.029	1 730.800	0.193	0.156
1994	272.450	359.000	0.198	0.236	1994	2 037.371	1 613.100	0.178	0.146
1995	262.664	355.200	0.191	0.233	1995	2 076.439	1 644.400	0.186	0.149
1996	245.833	335.400	0.179	0.220	1996	1 985.223	1 574.800	0.176	0.142
1997	299.614	309.742	0.218	0.203	1997	1 809.868	1 434.700	0.167	0.130
1998	267.282	284.165	0.195	0.186	1998	1 592.599	1 220.000	0.144	0.110
1999	250.974	274.065	0.183	0.180	1999	1 562.106	1 191.660	0.140	0.108
2000	242.496	271.184	0.177	0.178	2000	1 488.441	1 099.400	0.133	0.099
2001	230.379	259.269	0.168	0.170	2001	1 517.291	1 115.700	0.136	0.101
2002	230.182	259.873	0.168	0.171	2002	1 553.880	1 236.900	0.137	0.112
2003	214.467	245.802	0.156	0.161	2003	1 443.013	1 184.325	0.127	0.107
2004	201.725	231.874	0.147	0.152	2004	1 149.282	1 149.282	0.102	0.104
2005	198.580	229.607	0.145	0.151	2005	1 108.265	1 044.984	0.099	0.094
2006	184.950	218.653	0.135	0.144	2006	1 104.829	1 104.829	0.099	0.100
2007	180.207	215.659	0.131	0.142	2007	951.934	951.934	0.086	0.086
2008	173.854	211.185	0.127	0.139	2008	748.515	748.515	0.068	0.068
2009	162.504	204.133	0.118	0.134	2009	740.862	740.862	0.068	0.067
2010	159.260	204.386	0.116	0.134	2010	687.260	687.260	0.062	0.062

DAIRY CATTLE	NUMBER OF LIVESTOCK		EMISSIONS (Gg)		SWINE	NUMBER OF LIVESTOCK		EMISSIONS (Gg)	
2011	154.105	201.307	0.112	0.132	**2011**	580.393	580.393	0.050	0.052
2012	150.272	202.589	0.109	0.133	**2012**	631.464	631.464	0.057	0.057
2013	144.875	198.978	0.106	0.131	**2013**	637.167	637.167	0.053	0.058
2014	143.083	201.795	0.104	0.138	**2014**	641.827	641.827	0.058	0.058

Table 5.36: *The impact of recalculations of N_2O emissions in manure management in 1990 – 2014 for non-dairy cattle and sheep*

NON-DAIRY CATTLE	NUMBER OF LIVESTOCK		EMISSIONS (Gg)		SHEEP	NUMBER OF LIVESTOCK		EMISSIONS (Gg)	
YEAR	**2017**	**2016**	**2017**	**2016**	**YEAR**	**2017**	**2016**	**2017**	**2016**
1990	1 161.947	1 014.000	0.304	0.430	**1990**	600.426	600.000	0.056	0.038
1991	1 034.668	896.000	0.264	0.380	**1991**	531.263	531.000	0.050	0.033
1992	883.588	753.000	0.227	0.319	**1992**	571.837	572.000	0.053	0.036
1993	710.689	607.000	0.184	0.258	**1993**	411.442	411.000	0.039	0.026
1994	643.703	557.000	0.164	0.236	**1994**	397.043	397.000	0.038	0.025
1995	666.042	627.500	0.171	0.266	**1995**	427.844	427.844	0.041	0.027
1996	646.158	556.600	0.168	0.236	**1996**	418.823	418.823	0.040	0.026
1997	503.784	493.656	0.137	0.209	**1997**	417.337	417.337	0.037	0.026
1998	437.510	420.627	0.120	0.178	**1998**	326.200	326.199	0.030	0.021
1999	414.081	390.990	0.115	0.166	**1999**	340.346	340.346	0.031	0.021
2000	403.652	374.964	0.112	0.159	**2000**	347.983	347.983	0.031	0.022
2001	394.811	365.921	0.111	0.155	**2001**	316.302	316.302	0.030	0.020
2002	377.653	347.944	0.104	0.148	**2002**	316.028	316.028	0.030	0.020
2003	378.715	347.380	0.102	0.147	**2003**	325.521	325.521	0.031	0.020
2004	338.421	308.272	0.092	0.131	**2004**	321.227	321.227	0.031	0.020
2005	329.309	298.282	0.090	0.127	**2005**	320.487	320.487	0.031	0.020
2006	322.870	289.167	0.086	0.123	**2006**	332.571	332.571	0.031	0.021
2007	321.610	286.158	0.086	0.121	**2007**	347.179	347.179	0.032	0.022
2008	314.527	277.252	0.084	0.118	**2008**	361.634	361.634	0.034	0.023
2009	309.461	267.834	0.081	0.114	**2009**	376.978	376.978	0.035	0.024
2010	307.865	262.739	0.079	0.111	**2010**	394.175	394.175	0.036	0.025
2011	309.253	262.051	0.080	0.111	**2011**	393.927	393.927	0.036	0.025
2012	320.819	268.502	0.082	0.114	**2012**	409.569	409.569	0.037	0.026
2013	322.945	268.842	0.083	0.114	**2013**	399.908	399.908	0.037	0.025
2014	322.460	263.748	0.083	0.073	**2014**	391.151	391.151	0.036	0.029

Table 5.37: *The impact of recalculations of N_2O emissions in manure management in 1990 – 2014 for horses and goats*

HORSES	NUMBER OF LIVESTOCK		EMISSIONS (Gg)		GOATS	NUMBER OF LIVESTOCK		EMISSIONS (Gg)	
YEAR	**2017**	**2016**	**2017**	**2016**	**YEAR**	**2017**	**2016**	**2017**	**2016**
1990	13.595	14.000	0.004	0.004	**1990**	10.322	25.000	0.001	0.002
1991	12.858	13.000	0.004	0.004	**1991**	16.676	25.000	0.002	0.002
1992	11.652	12.000	0.003	0.004	**1992**	20.278	25.000	0.002	0.002
1993	11.188	11.000	0.003	0.003	**1993**	24.974	25.000	0.002	0.002
1994	10.652	11.000	0.003	0.003	**1994**	25.010	25.000	0.002	0.002
1995	10.109	10.109	0.003	0.003	**1995**	25.046	25.000	0.002	0.002
1996	9.722	9.722	0.003	0.003	**1996**	26.147	26.100	0.002	0.002
1997	9.533	9.533	0.003	0.003	**1997**	26.778	26.778	0.003	0.003

HORSES	NUMBER OF LIVESTOCK		EMISSIONS (Gg)		GOATS	NUMBER OF LIVESTOCK		EMISSIONS (Gg)	
YEAR	2017	2016	2017	2016	YEAR	2017	2016	2017	2016
1998	9.550	9.550	0.003	0.003	**1998**	50.905	50.905	0.005	0.005
1999	9.342	9.342	0.003	0.003	**1999**	51.075	51.075	0.005	0.005
2000	9.516	9.516	0.003	0.003	**2000**	51.419	51.419	0.005	0.005
2001	7.883	7.883	0.002	0.002	**2001**	40.386	40.386	0.004	0.004
2002	8.122	8.122	0.002	0.002	**2002**	40.194	40.194	0.004	0.004
2003	8.114	8.114	0.002	0.002	**2003**	39.225	39.225	0.004	0.004
2004	8.209	8.209	0.002	0.002	**2004**	39.012	39.012	0.004	0.004
2005	8.328	8.328	0.002	0.003	**2005**	39.566	39.566	0.004	0.004
2006	8.222	8.222	0.002	0.002	**2006**	38.352	38.352	0.004	0.004
2007	8.017	8.017	0.002	0.002	**2007**	37.873	37.873	0.004	0.004
2008	8.421	8.421	0.002	0.003	**2008**	37.088	37.088	0.004	0.003
2009	7.199	7.199	0.002	0.002	**2009**	35.686	35.866	0.003	0.003
2010	7.111	7.111	0.002	0.002	**2010**	35.292	35.292	0.003	0.003
2011	6.937	6.937	0.002	0.002	**2011**	34.053	34.053	0.003	0.003
2012	7.249	7.249	0.002	0.002	**2012**	34.823	34.823	0.003	0.003
2013	7.161	7.161	0.002	0.002	**2013**	35.457	35.457	0.003	0.003
2014	6.828	6.828	0.002	0.002	**2014**	35.178	35.178	0.003	0.003

Table 5.38: *The impact of recalculations of N_2O emissions in manure management in 1990 – 2014 for poultry*

POULTRY	NUMBER OF LIVESTOCK		EMISSIONS (Gg)	
YEAR	2017	2016	2017	2016
1990	16 477.763	16 477.763	0.038	0.065
1991	13 866.297	13 866.297	0.030	0.054
1992	13 266.789	13 266.789	0.027	0.052
1993	12 234.120	12 234.120	0.024	0.048
1994	14 245.954	14 245.954	0.036	0.056
1995	13 382.391	13 382.391	0.029	0.052
1996	14 147.177	14 147.177	0.028	0.056
1997	14 221.713	14 221.713	0.030	0.056
1998	13 353.654	13 353.654	0.028	0.052
1999	12 247.440	12 247.440	0.025	0.049
2000	13 580.042	13 580.042	0.027	0.050
2001	15 590.404	15 590.404	0.036	0.054
2002	13 959.404	13 959.404	0.031	0.056
2003	14 216.798	14 216.798	0.027	0.057
2004	13 713.239	13 713.239	0.026	0.055
2005	14 084.079	14 084.079	0.027	0.057
2006	13 038.303	13 038.303	0.025	0.052
2007	12 880.124	12 880.124	0.025	0.051
2008	11 228.140	11 228.140	0.021	0.044
2009	13 583.284	13 583.284	0.025	0.054
2010	12 991.916	12 991.916	0.024	0.052
2011	11 375.603	11 375.603	0.022	0.045
2012	11 849.818	11 849.818	0.023	0.047
2013	10 968.918	10 968.918	0.022	0.043
2014	12 494.074	12 494.074	0.023	0.050

5.9 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 NOx. The fraction of excreted organic nitrogen that is mineralized to ammonia nitrogen during manure storage depends primarily on time, and to a degree of 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 stall and continue on site management in storage and treatment systems. Pasture losses are considered separately in emissions from managed soils.

5.9.1 METHODOLOGICAL ISSUES – METHODS

Tier 1 of the IPCC 2006 GL approach for nitrogen estimation of N volatilisation in forms of NH_3 and NOx 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 volatilised nitrogen. N losses were then summed from all manure management systems. Emission factor 0.01 kg NH_3-N for N_2O emissions from atmospheric deposition of nitrogen have been used. The losses were calculated for almost farm animals without non-dairy cattle, because $Frac_{GasMS}$ was not available for liquid animal waste management system for non-dairy cattle category. Calculations were performed using the follows equations:

$$N_{volatilization-MMS} = \sum_{S}\left[\sum_{T}\left[(N_T.Nex_T.MS_{T,S}).\left(\frac{Frac_{GasMS}}{100}\right)_{(T,S)}\right]\right]$$

$$N_2O_{MM} = (N_{volatilization-MMS}.EF).\frac{44}{28}$$

Where: N_T = number of head of farm animals' species/category; N_{EXT}= annual average N excretion per head of species respectively category (kg N per animal^{-1}. year^{-1}); $MS_{T.S}$= fraction of total annual nitrogen excretion for each farm animals' species respectively category that is managed in manure management systems and $Frac_{GasMS}$= percent of managed manure nitrogen for livestock category T that volatilizes as NH_3 and NO_x in the manure management systems (%).

5.9.2 ACTIVITY DATA

Volatilized nitrogen (NH_3 and NO_x) from animal wastes was 269 848.10kg N which represents 0.27 Gg of N_2O in 2015. Activity data in this category are not in consistency with the activity data in animal manure applied to soil 3.D.1.2, because non-dairy cattle category have not $Frac_{GasMS}$ for animal waste manure system liquid. ***Table 5.38*** shows the time series of input data and emissions.

Table 5.39: *Input parameters and EFs in category 3.B.2.5 atmospheric deposition in particular years*

YEAR	Volatilized N from animal manure (kg)	Total volatilized N (kg)	EFs (kg N_2O-N/kg N)	N_2O emissions (Gg)
1990	47 284 981	743 049.70	0.010	0.743
1995	33 329 983	523 756.87	0.010	0.524
2000	26 886 866	422 507.89	0.010	0.423
2005	22 526 790	353 992.42	0.010	0.354
2010	18 336 092	288 138.59	0.010	0.288
2011	17 017 047	267 410.74	0.010	0.267
2012	17 497 081	274 954.14	0.010	0.275
2013	16 753 244	263 265.26	0.010	0.263
2014	17 292 845	271 744.70	0.010	0.272
2015	17 172 152	269 848.10	0.010	0.270

5.10 RICE CULTIVATION (CRF 3.C)

No emissions from rise cultivation were estimated in this category, because no rice was cultivated in the Slovak Republic in 1990 – 2015.

5.11 AGRICULTURAL SOILS (CRF 3.D)

The applied amounts of synthetic fertilizers into cultivated soils have been very low for the last 15 years. The potential for the volatilization of ammonia and N_2O 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 applied nitrogen fertilizers. Emissions also depend on the type of fertilizers, soil parameters (pH), meteorological conditions and time of application in relation to crop development. Applied nitrogen fertilizers have been provided on the basis of SO SR materials for the Slovak Republic. The selection of emission coefficients reflects IPCC 2006 GL. N-inputs from symbiotic fixation of leguminous crops in the conditions of the Slovak Republic vary in the range of 20-30 kg/ha[3] 26 kg $N.ha^{-1}$ can be accepted as an average value[4]. This value varies in the range ±20% from the mean value. The data on the production of nitrogen from the excreta of domestic livestock are influenced by N production of domestic livestock and the number of domestic livestock according to the categories.

The content of nitrogen in crop residuals as well as their decomposition in soil significantly influences the formation of yield in the following years. National methodology for the calculation of nitrogen inputs from crop residuals was used when the nitrogen amount was calculated according to the acreage of field crops and the nitrogen content in different crops[4]. The yield of field crops can vary in range ±20% from year to year.

Total N_2O emissions from agricultural soils were 5.46 Gg of N_2O in 2015. The emissions decreased by almost 0.4% in comparison with 2014 and decreased by 45% in comparison with the base year 1990 see ***Table 5.40***. The major reason for the 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 with the decrease in the number of animals (***Table 5.6***). ***Figure 5.16*** shows, that since 1999, trend is stable with the small fluctuations caused by the changes in animal population and year to year changes in subcategory 3.D.1.4 Crop residues, 3.D.1 Inorganic nitrogen fertilizers and 3D.2 Indirect N_2O emissions,

No emissions are reported in the categories 3.D.1.2.c Other organic fertilizers applied to soils, 3.D.1.5 Mineralization/immobilization associated with loss/gain of soil organic matter and 3.D.1.6 Cultivation of organic soils (not occurring in Slovakia).

Table 5.40: *N_2O emissions (Gg) in agricultural soils according to the subcategories in particular years*

YEAR	3.D.1 DIRECT N_2O EMISSIONS FROM MANAGED SOILS (Gg)				3.D.2 INDIRECT N_2O EMISSIONS FROM MANAGED SOILS (Gg)	
	3.D.1.1 Synthetic fertilizes	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.2.1 Atmospheric deposition	3.D.2.2 Nitrogen leaching and run-off
1990	3.493	1.901	0.495	1.452	0.789	1.607
1995	1.094	1.323	0.329	1.390	0.414	0.902
2000	1.142	1.086	0.202	1.340	0.358	0.832
2005	1.278	0.913	0.185	1.269	0.335	0.806
2010	1.365	0.752	0.204	1.366	0.314	0.814

[3] Bielek, P. *Nitrogen in Agricultural Soils of the SR* Bratislava 1998 in Slovak.
[4] Jurcova, O.; Toma, S. *Methodology for Quantification of Nutriment Potential of Residual Crops* Bratislava, 1998 in Slovak.

YEAR	3.D.1 DIRECT N_2O EMISSIONS FROM MANAGED SOILS (Gg)				3.D.2 INDIRECT N_2O EMISSIONS FROM MANAGED SOILS (Gg)	
	3.D.1.1 Synthetic fertilizes	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.2.1 Atmospheric deposition	3.D.2.2 Nitrogen leaching and run-off
2011	1.461	0.702	0.203	1.360	0.313	0.823
2012	1.587	0.720	0.216	1.301	0.331	0.844
2013	1.785	0.692	0.218	1.355	0.345	0.894
2014	1.871	0.710	0.227	1.384	0.358	0.925
2015	1.804	0.702	0.228	1.451	0.350	0.923

Figure 5.16: *Trend in N_2O emissions (Gg) by categories within agricultural soils in 1990 – 2015*

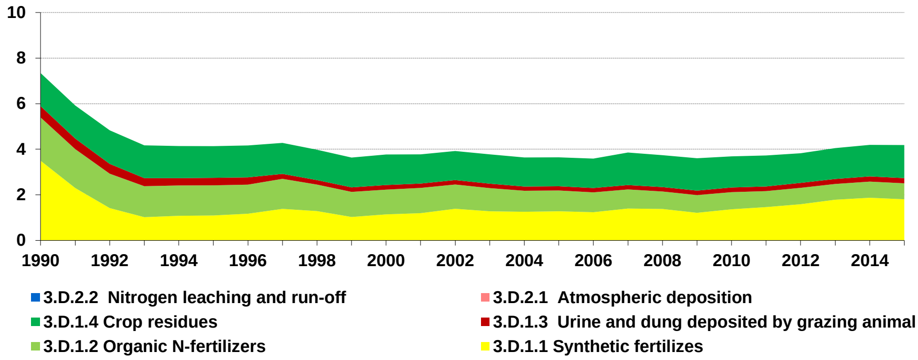
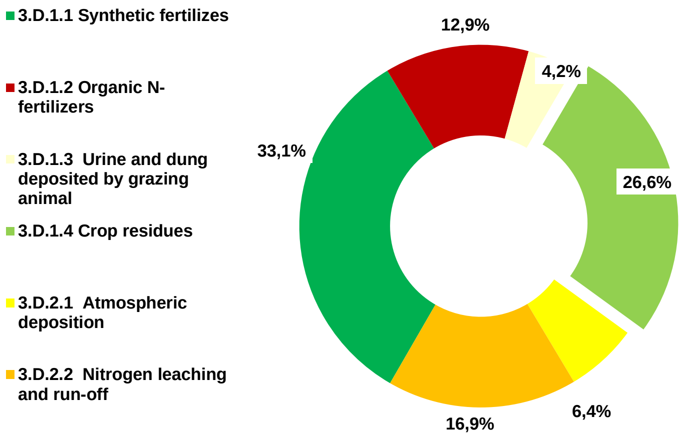


Figure 5.17 shows the major share belongs to synthetic fertilizers use (33.1%) and crop residues (26.6%). Organic fertilizers use (12.9%) and nitrogen leaching and run-off (16.9%) are influenced by manure management and the number of animals.

Figure 5.17: *The share of aggregated emissions by categories within agricultural soils in 2015*



5.11.1 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Tier 1 uncertainty was included in total uncertainty assessment. Uncertainties are defined by emission coefficients. The values can differ from reality within the range from 20 to 200% for direct soil N_2O emissions, from 25 to 150% for N_2O from animal waste management system, from 20 to 200% for indirect N_2O emissions from NH_3 volatilization and from 10 to 500% for indirect N_2O emissions from leaching. High uncertainties are defined for N_2O and NH_3 emissions (especially from agricultural soils. foliar emissions and decomposition) and therefore presented results should be considered as estimation. Direct measurements show that ammonia can volatilize in a large range. The values were found within the range of 2 – 20 $kg.ha^{-1}$ in winter wheat crop[5]. Volatilization is influenced by soil parameters, where e.g. haplic fluvisols emit less ammonia in the same climatic conditions than other soils. The highest uncertainties are observed in case of cultivated soils (soils with fertilizers). More exact data on NH_3 and N_2O emissions from cultivated soils can be reached by modelling e.g. by DNDC model. This kind of model is used at the Department of Biometeorology and Hydrology at the Slovak Agricultural University in Nitra.

Time series consistency is ensured by the using of consistent source of activity data since the base year, which is the Statistical Office of the Slovak Republic and the Green Reports of the Ministry of Agriculture and Rural Development. Methodological approaches used across category 3.D – Agricultural Soils are based on the IPCC 2006 GL and default emission factors.

5.11.2 CATEGORY -SPECIFIC RECALCULATIONS

Recalculations of categories 3.D.1.3 Urine and Dung Deposited by Grazing Animals and 3.D.1.2 Manure Management Applied to Soils were connected with the methodological changes and improvements implemented in 3.B.2 Manure Management. Detailed information of recalculation from 3.B.2 Manure management is available in the Chapter 5.7.4. Double counting in to the category Urine and dung deposited in soils was deleted according to ESD recommendation no. SK-3B-2016-0019.

Category 3.D.1.2 Sewage Sludge has been extended to the category 3.D.1.2 Organic N-fertilizers. Methodology is fully in line with the IPCC 2006 GL. Total N_2O emissions in 2014 decreased by 10%.Fully recalculated data are available in ***Figure 5.18*** and ***Table 5.41.***

Figure 5.18: *Comparison of N_2O emissions (Gg) between 2016 and 2017 submissions*

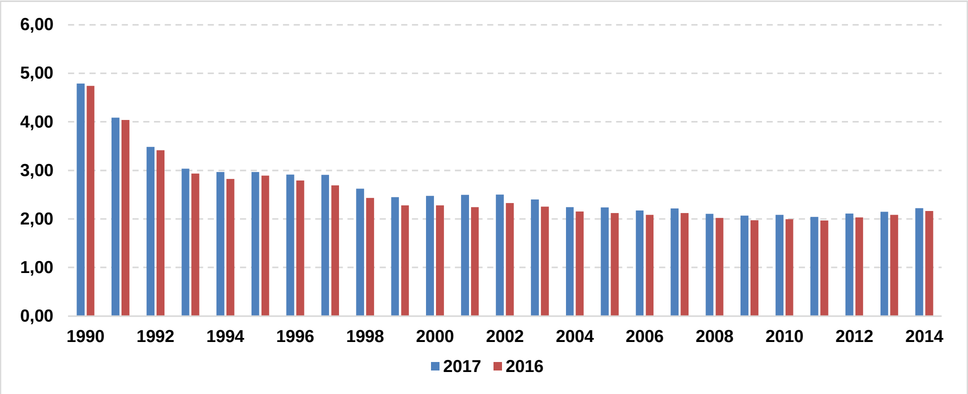


Table 5.41: *The impact of recalculations of N_2O emissions in agricultural soils in 1990 – 2014*

YEAR	3.D.1.2.ORGANIC N-FERTILIZERS (Gg)		3.D.1.3 URINE AND DUNG DEPOSITED BY GRAZING ANIMALS (Gg)	
	2017	2016	2017	2016
1990	1.901	1.937	0.495	0.424
1991	1.707	1.755	0.464	0.380
1992	1.509	1.547	0.430	0.338
1993	1.360	1.362	0.353	0.279
1994	1.332	1.289	0.320	0.260
1995	1.323	1.324	0.329	0.276
1996	1.277	1.250	0.319	0.256
1997	1.318	1.153	0.216	0.237
1998	1.163	1.023	0.196	0.210

[5] Bielek, P. *Nitrogen in Agricultural Soils of the SR* Bratislava 1998 in Slovak.

YEAR	3.D.1.2.ORGANIC N-FERTILIZERS (Gg)		3.D.1.3 URINE AND DUNG DEPOSITED BY GRAZING ANIMALS (Gg)	
	2017	2016	2017	2016
1999	1.102	0.981	0.197	0.203
2000	1.086	0.955	0.202	0.200
2001	1.109	0.936	0.191	0.189
2002	1.066	0.953	0.193	0.186
2003	1.017	0.926	0.195	0.183
2004	0.923	0.874	0.185	0.171
2005	0.913	0.850	0.185	0.169
2006	0.872	0.832	0.190	0.165
2007	0.839	0.798	0.191	0.165
2008	0.768	0.739	0.193	0.164
2009	0.777	0.742	0.196	0.162
2010	0.752	0.728	0.204	0.163
2011	0.702	0.689	0.203	0.162
2012	0.720	0.710	0.216	0.166
2013	0.692	0.697	0.218	0.164
2014	0.710	0.734	0.227	0.153

Table 5.42: *The impact of recalculations of N_2O emissions in agricultural soils in 1990 – 2014*

YEAR	3.D.2.1 ATMOSPHERIC DEPOSITION (Gg)		3.D.2.2 NITROGEN LEACHING AND RUN-OFF (Gg)		TOTAL	
	2017	2016	2017	2016	2017	2016
1990	0.789	0.781	1.607	1.598	4.792	4.740
1991	0.627	0.621	1.290	1.283	4.087	4.039
1992	0.496	0.488	1.049	1.040	3.484	3.414
1993	0.416	0.404	0.907	0.893	3.036	2.938
1994	0.413	0.394	0.903	0.881	2.968	2.824
1995	0.414	0.404	0.902	0.890	2.967	2.894
1996	0.411	0.395	0.910	0.891	2.917	2.792
1997	0.431	0.395	0.946	0.907	2.911	2.693
1998	0.387	0.357	0.879	0.846	2.625	2.434
1999	0.349	0.322	0.802	0.772	2.450	2.279
2000	0.358	0.328	0.832	0.799	2.478	2.283
2001	0.366	0.328	0.834	0.792	2.499	2.245
2002	0.377	0.351	0.867	0.837	2.502	2.327
2003	0.356	0.334	0.834	0.809	2.402	2.252
2004	0.334	0.320	0.804	0.789	2.246	2.154
2005	0.335	0.318	0.806	0.787	2.238	2.123
2006	0.323	0.310	0.793	0.778	2.177	2.085
2007	0.333	0.319	0.853	0.838	2.216	2.121
2008	0.317	0.306	0.827	0.814	2.104	2.022
2009	0.302	0.290	0.796	0.782	2.072	1.976
2010	0.314	0.302	0.814	0.801	2.084	1.994
2011	0.313	0.304	0.823	0.813	2.042	1.968
2012	0.331	0.322	0.844	0.833	2.110	2.031
2013	0.345	0.338	0.894	0.886	2.149	2.086
2014	0.358	0.355	0.925	0.922	2.220	2.164

5.11.3 INORGANIC N FERTILIZERS (CRF 3.D.1.1)

The consumption of synthetic fertilizers decreased during the last decade of 20th century, from 222 kt in 1990 to 115 kt in 2015. Consumption of the synthetic fertilizers increased by about 41% in 2015 compared with 2005 and the increase is almost 23.5% in the comparison with the year 2011. Because of decreasing numbers of domestic livestock in some categories (on-going production of less nitrogen in waste), this trend in higher consumption of synthetic fertilizers should continue if the present level of yields of field crops is accepted (Green Report, 2016).

Applied synthetic fertilizers lose the definite amount of nitrogen by volatilization and N–NO_x conversion. This is 10% for synthetic fertilizers that means that only 90% of total applied synthetic fertilizers remain for the conversion of N to N_2O. Default emission factor was used from the IPCC 2006 GL 0.01 kg N_2O–N/kg N. Total emissions of N_2O from using the synthetic fertilizers were 1.80 Gg in 2015. Tier 1 methodology was applied in combination with IPCC default EF. The loss by volatilization is 10% and default emission factor 0.01 kg N_2O-N/kg N was used for the calculation.

Nitrogen inputs from applied fertilizers are published annually by the Central Controlling and Testing Institute in Agriculture. This institute is also providing data to the Statistical Office of the Slovak Republic. Activity data on N input from application of inorganic fertilizers to agricultural soils is summarized in the ***Table 5.43***.

Table 5.43: *Input parameters and EFs in 3.D.1.1 Inorganic N fertilizers in particular years*

YEAR	N-INPUT IN FERTILIZERS(kg/year)	Efs (kg N_2O-N/kg N)	N_2O EMISSIONS (Gg)
1990	222 255 000	0.01	3.493
1995	69 587 000	0.01	1.094
2000	72 653 000	0.01	1.142
2005	81 317 000	0.01	1.278
2010	86 873 000	0.01	1.365
2011	92 969 000	0.01	1.461
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

5.11.4 ANIMAL MANURE APPLIED TO SOIL (CRF 3.D.1.2)

As domestic livestock produces 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) from the point of view of direct emissions as well as the emissions from AWMS. Except for it the production of nitrogen per head per year plays also certain role.

The direct inputs of nitrogen slightly vary according to the applied methodology. Based on the IPCC 2006 GL total nitrogen excretion per liquid (11 949.1 t/N/year) and solid system (32 711.1 t/N/year) in manure management in 2015 were used for the estimation of total nitrogen input of manure applied to soils.

Calculated amount of nitrogen input from animal waste applied to soils was 44 660.2 t/N/year and default EF was 0.01 kg N_2O-N/kg N. Total amount of N_2O emissions from animal excreta applied to soils was 0.702 Gg in 2015.

Activity data on manure consumption in agriculture is based on the data provided by the Ministry of Agriculture and Rural Development of the Slovak Republic and its research organisation Research Institute for Animal Production Nitra. Trend of emissions and N- input from Manure Management is summarized ***Table 5.44***.

Table 5.44: *Input parameters and EFs in 3.D.1.2 Animal Manure in particular years*

YEAR	N-INPUT FROM LIQUID SYSTEM (kg/year)	N-INPUT FROM SOLID SYSTEM (kg/year)	N-INPUT FROM MANURE (kg/year)	EFs (kg N_2O-N/kg N)	N_2O EMISSIONS (Gg)
1990	31 438 480	89 532 818	120 971 299	0.01	1.901
1995	26 198 219	57 967 363	84 165 582	0.01	1.323
2000	19 367 823	49 770 245	69 138 068	0.01	1.086
2005	15 618 424	42 478 583	58 096 979	0.01	0.913
2010	12 701 437	35 134 393	47 835 830	0.01	0.752
2011	11 579 262	33 092 404	44 671 665	0.01	0.702
2012	12 217 318	33 539 171	45 756 489	0.01	0.719
2013	11 430 558	32 581 575	44 012 134	0.01	0.692
2014	11 685 062	33 491 507	45 176 569	0.01	0.710
2015	11 949 099	32 711 132	44 660 230	0.01	0.702

5.11.5 SEWAGE SLUDGE APPLIED TO SOILS (CRF 3.D.1.2)

Reduction of organic matter in soil is dependent on the continuous decline in livestock production. Decrease of the amount of organic fertilizers causes pressure to find alternative sources of organic fertilizers. Sewage sludge is one of ways how to resolve this issue. The sludge is a potential source of nutrients and organic matter. Sewage sludge must be stabilized, then will be applied in to the soils. Sludge must be biological, chemical or heat treatment, long-term storage or any other appropriate process. These processes cause significant reduction of health risks and save the environment. Act No 188/2003 Coll regulates application of sludge to agricultural soils. Sludge only from treatment plants cleaning wastewater from domestic or urban waste water applied to agricultural soils.

Default methodology tier 1 and default emission factors were used (0.01 kg N_2O-N/kg N) for the estimation of direct N_2O emissions from sewage sludge applied to soils. Methodology was accordance to IPCC Guidelines 2006. Percentage of pure nitrogen in sewage sludge was provided from the Soil Science and Conservation Research Institute.[6] Emissions were estimated, by using these equations:

$$N_2O - N_{\text{sewage sludge}} = N_{\text{sewage sludge}} * P_N$$

$$N_2O_{\text{sewage sludge}} = N_2O - N_{\text{sewage sludge}} * EF * \frac{44}{28}$$

Where: N_2O-$N_{\text{sewage sludge}}$: Input of pure nitrogen from sewage sludge applied in to the soil in kg, $N_{\text{sewage sludge}}$: amount of sludge from waste water treatment in kg, P_N: Weight percentage of nitrogen from sewage sludge (3.31%), EF: default emission factor kg N_2O-N/kg N.

Activity data on sewage sludge consumption in agriculture is based on the data provided by the Water Research Institute. Sewage sludge was applied into the soil even before year 2010, but there are no data available. The Water Research Institute informed that sewage sludge was not applied into agricultural soils in year 2015. The notation key NO was used in this year.

[6]Guideline for sewage sludge application (In Slovak):http://www.vupop.sk/dokumenty/prv/prirucka_pre_aplikaciu_kalu.pdf

Table 5.45: *Input parameters and EFs in 3.D.1.2 Sewage Sludge in particular years*

YEAR	INPUT IN TO THE SOIL (kg/year)	N-INPUT FROM SEWAGE SLUDGE (kg/year)	N_2O EMISSIONS (Gg)
2010	923 000	30 551	0.0004801
2011	358 000	11 850	0.0001862
2012	1 254 000	41 507	0.0006523
2013	518 000	17 146	0.0002694
2014	8 000	265	0.0000042
2015	NO	NO	NO

5.11.6 OTHER ORGANIC FERTILIZERS APPLIED TO SOILS (CRF 3.D.1.2)

Compost deposing on cropland has very limited use mostly in small private gardens, not industrial in the Slovak Republic. Available data on the real amount of compost applied on soil is missing in the database of the special institute (The Central Control and Testing Institute in Agriculture) dealing with organic and inorganic fertilizers has no data about it. Notation key for this category is NE in time series.

5.11.7 URINE AND DUNG DEPOSITED BY GRAZING ANIMALS (CRF 3.D.1.3)

Pasture is typical for some livestock categories. Animals graze mainly during spring, summer and autumn in the small farms. Sheep, goats, horses and some subcategories of cattle were grazed in the Slovak condition. During the winter they are in own winter grounds.

It is supposed that sheep, goats and horses can stay at pasture for 200 days, 41% of dairy cattle stays only for 150 days. Results of the analysis on animal waste management system were used for the calculation of nitrogen input from animal husbandry into N-cycle. This analysis was based on the questionnaires from 222 agricultural subjects (21.3% of total amount of subjects in the Slovak Republic). These subjects cultivated 14.7% of total agricultural land and 15.2% of arable land. The storage of dry manure is probably more frequent than the questionnaires showed and the emissions from AWMS could be higher. Housing at grasslands from April to October is frequent for sheep, goats and horses. The duration of grazing period can vary significantly depending on weather conditions in different parts of the Slovak Republic. 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 Research Institute for Animal Production in Nitra. Proportion of the pasture for category of animals is demonstrated in ***Table 5.46***.

The estimation of N_2O from pasture of animals is based on default emission factor 0.02 kg N_2O-N/kg N for cattle, other animals have 0.01 kg N_2O-N/kg N. Nitrogen excretions per AWMS estimated by manure management category. Total nitrogen from pasture was 9 278.61 kg/N/year in 2015. Total emissions of N_2O from pasture of animals were 0.23 Gg of N_2O in 2015. This category is estimated in the connection with the category Manure Management.

Activity data are summarized in ***Table 5.46***. Activity data on manure deposited on pasture is based on the data provided by the Ministry of Agriculture and Rural Development of the Slovak Republic and its research organisation Research Institute for Animal Production Nitra. Activity data in this category are in consistency with the activity data in category 3.B.2.2 Manure management.

Table 5.46: Input parameters and EF in 3.D.1.3 Urine and Dung Deposited by Grazing Animals in particular years.

YEAR	N-EXCRETION ON PASTURE (kg)	EFs (kg N_2O-N/kg N)	N_2O EMISSIONS (Gg)
1990	18 817 027	0.02	0.50
1995	12 780 781	0.02	0.33
2000	8 323 981	0.02	0.20
2005	7 679 898	0.02	0.19
2010	8 593 850	0.02	0.20
2011	8 544 186	0.02	0.20
2012	9 044 154	0.02	0.22
2013	9 040 889	0.02	0.22
2014	9 294 475	0.02	0.23
2015	9 278 603	0.02	0.23

5.11.8 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 presented 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 in the present requirements of biologicalisation in plant production. According to the IPCC 2006 GL this category includes also N_2O emissions from nitrogen fixing crops. Total N_2O emissions from crop residues and N-fixing crops represented 1.451 Gg of N_2O from the 92 309 469 kg of nitrogen in crop residues returned to soils in 2015.

Table 5.47: Input parameters and EFs in 3.D.1.4 Crop Residue in particular years

YEAR	CROPLAND ACREAGE (ha)	NITROGEN IN CROP RESIDUES RETURNED TO SOILS (kg/year)	EFs (kg N_2O-N/kg N)	N_2O EMISSIONS (Gg)
1990	1 184 532	92 381 856	0.01	1.452
1995	1 184 530	88 475 897	0.01	1.390
2000	1 139 329	85 242 436	0.01	1.340
2005	1 149 857	80 763 018	0.01	1.269
2010	1 086 340	86 924 080	0.01	1.366
2011	1 072 082	86 574 066	0.01	1.360
2012	1 108 229	82 778 949	0.01	1.301
2013	1 106 810	86 237 934	0.01	1.355
2014	1 138 151	88 090 295	0.01	1.384
2015	1 127 918	92 309 469	0.01	1.451

During the period of 1986 – 1997, the crop and root residues from 29 crop species were observed at three to seven different soil-climate sites in the Slovak Republic (partly at small production parcels and partly at large scale production). The sampling was provided according to the plant specification (a number of plants per hectare). The crop residues were abstracted from the same field as root residues directly after root take off. According to the applied methodology, crop residues as well as symbiotic fixation depend on the acreage of field crops and leguminous. Nitrogen input from crop residues varies round about the value of 65 kt per year. Nitrogen in crop residues of different categories was determined from the results of field trial of the Research Institute of Plant Production[7]. The estimation of nitrogen from residual crops was calculated according to the growing areas of crops and vegetable.

[7] Jurcova, O.; Toma, S. *Methodology for Quantification of Nutriment Potential of Residual Crops* Bratislava, 1998 in Slovak.

The content of mineral component in crop residues fluctuates mostly depending on genetic plant attributes and the level of agro technique in primary fertilization. The content of nitrogen can differ in the residues of the same crop and is higher in roots. The content of nitrogen fluctuates and is the highest in the N-fixing crops. Besides the nutrient content in a plant, the second factor is the weight of crop residues and root residues and its influence on the nitrogen content in soils. This depends on the crop specification and harvesting practice. Potential content of nitrogen in kg per hectare in residues can be specified. Within the national research activities, the observation of 29 crops potential in relation to the content of nitrogen in kg per hectare and the most common harvesting practices were studied. ***Tables 5.48*** - ***5.51*** describe the results of statistical average of potential values of nitrogen inputs for the observed crops. The average nitrogen potential ranges between 10 – 100 kg N per hectare. The decision regarding the calculation of nitrogen inputs from crop residues according to the acreage of field crops and the average N potential of crop has been taken for the reasons as follows:

- Preferable use of national data from direct measurements instead of default values.
    - According to the IPCC 2006 GL, the basic information on nitrogen input into soil from crop residues comes from the yields of field crops. Some crops suffer from winter frosts (oil seed rape, winter wheat, winter barley) and summer drought (sunflower and others) and they are not harvested. So they are not included into official statistics on crop yields. However, they are the source of nitrogen in soils. If there was only crop yield taken into account they would not be included into the calculation of N_2O emissions. Therefore, the acreage of field crops and the national data on nitrogen content in crop residues look as more representative. The importance of crops is changing. More and more agricultural lands cease from utilizing. The acreage of oil seed rape and sunflower increases, while the acreage of sugar beet, potato and fodder crops (alfalfa, clover, leguminous plants) decreases.
- Regional differences.

Total growing area of crops (wheat, ray, barley, oat, maize, potato, sugar beet, oil plants, tobacco, vegetable, fodder crops, grassland and other) decreased in comparison with the previous year. In 2015 total area was 1 127 918 ha and the direct inputs of nitrogen from crop residues were 92 310 t. The used default emission factor was 0.01 kg N_2O-N/kg N and total N_2O emissions from crops residues were 1.45 Gg in 2015.

Stems and leaves are usually utilized as a fodder for domestic livestock. Data on export of straw abroad are missing. Except for it, the data on grasslands, alfalfa, horse bean, maize for silage and clover includes also a green part of crops (leaves and stems) utilized for animal feeding. Therefore, the crop residuals are defined only as a part of plants – short stems and roots staying on the field. According to the Statistical Yearbook and the Green Report of the Slovak Republic it is not possible to split fodder crops and grasslands into subcategories.

The activity data on crop residues start collected in 1989 because of mineralization rate. It is supposed that crop residues from one year are mostly the source of N_2O emissions in the following year. Scientists from the Department of Plant Nutrition and Agro Chemistry at the Agricultural University in Nitra recommended this approach. The acreage instead of the yield was used for several reasons, such as:

- Missing statistics on yield of some fodder crops at the beginning of evaluated period.
- Some crops suffer from winter frosts (oil seed rape, winter wheat, winter barley) and summer drought (sunflower and other) and they are not harvested. So they are not included into the official statistics on crop yields. However, they are the source of nitrogen in soils. If there was only crop yield taken into account they would not be included into the calculation of N_2O emissions. Therefore, the acreage of field crops and national data about nitrogen content in crop residues look as more representative data for calculation.

- The differences between these approaches were caused by excluding the permanent grasslands as well as the soil from statistics. These soils are not cultivated and fertilized and sufficient data on nitrogen inputs and acreage are not available.

Table 5.48: *Growing areas and total nitrogen amount (kg) of crops in 2015*

CROP		AVERAGE NITRIENT POTENTIAL OF CROP RESIDUES (kg N/ha)	AREA OF CROPS (ha)	NITROGEN FIXED TOTAL (kg)
Cereals	Wheat	52.5	380163	19 958 558
	Ray	45.0	15 175	682 875
	Barley	45.0	138 920	6 112 480
	Oat	55.0	16 422	903 210
	Maize	39.0	219607	8 564 673
Potato		59.0	8 900	525 100
Sugar beet		20.0	22 070	441 400
Oil plants		107.0	243 435	26 047 545
Tobacco		45.0	12	555
Fodder crops		20.0	350	20 650
Maize for silage		55.0	82 864	4 557 520
2015 TOTAL		-	**1 127 918**	**67 814 566**

Table 5.49: *Nutrition potential in crop residues in kg of nitrogen per hectare according to the study of the Research Institute of Plant Production*[8]

CROP	PARAM.	CROP	PARAM.	CROP	PARAM.	CROP	PARAM.
kg N/ha							
Horse Been	298	Beans as fodder	46	Tobacco	45	Oat	89
Chicken Pea	201	Oil Seed rape - spring form	166	Sugar Beet	20	Spring Wheat	84
Beans	192	Sunflower	108	Clover in mix in 2nd year	153	Triticale	80
Lens	163	Oil See drape - winter form	107	Alfalfa + Grass in 3rd year	127	Winter Wheat	79
Soybean	132	Mustard	91	Clover in 3rd year	127	Winter Ray	77
Corn	127	Potato	59	Grasslands in 3rd year	123	Winter Barley	66
Popper	115	Maize for Silage	55	Grassland in 2nd year	113	Spring Barley	60
Peas	112						

Parameter = Average nitrient potential of crop residues

5.11.9 N-FIXING CROPS

Nitrogen inputs from symbiotic fixation are of local importance and depend on the acreage of leguminous plants. Total input of nitrogen into cultivated soils drastically decreased in the first half of the nineties (from 620 t in 1990 to 500 t in 1995). During recent years the inputs of nitrogen into soils were stabilized on the level of approximately 350 t per year.

Nitrogen inputs from symbiotic fixation are within the range of 20 – 30 kg/ha[9], but there are enough reasons mentioned in the publication to accept an experimental value 26 kg N/ha. Details for the estimation of total input of nitrogen from N-fixing residues were recalculated according to the data obtained from direct measurement[10] at national conditions and recalculated for the growing areas of N-fixing crops and average harvest.

Total growing areas of N-fixing crops (peas, lens, beans, mix of fodder beans and cereals, soybeans, alfalfa and clover) slightly decreased and were 93 184 ha in 2015 due to decrease of area of fodder beans been and alfalfa production. On the other hand, the area of soy, peas, lens and cloves decreased. The direct inputs of nitrogen from N-fixing crops (higher than in previous year) were 24 494 t of N in 2015. The crop residues from the previous year were the basis for the calculation of N_2O emissions from N-fixing crops (according to the used methodology) in recent inventory year. The used default emission factor was 0.01 kg N_2O-N/kg N and total N_2O emissions from N-fixing crops were 0.385 Gg including biologic fixation in 2015.

Total N_2O emissions from N–fixing crops (residues + biologic fixation) were 1.451 Gg in 2015. Except for total nitrogen inputs into soils certain changes of the importance of nitrogen sources were identified. While the consumption of synthetic fertilizers as well as the input of nitrogen from animal husbandry decreased, N-fixing crops created a relatively stable input of nitrogen. This fact documents an abnormal intake of nutrients from soils which can influence their fertility during next years. 1.25% of nitrogen from inputs defined above in sense of applied methodology creates direct N_2O emissions and so the trends reflect their sources.

Table 5.50: *Crops characteristics in 3.D.1.4 for N-fixing crops in 2015*

CROP	AREA OF N-FIXING CROPS	HARVESTED RESIDUES	CONTENT OF N IN DRY MATTER	NITROGEN IN SOIL	NITROGEN FIXED
	(ha)	(t/ha)	(%)	(kg/ha)	(kg)
Peas	2 483	6.51	1.66	0.11	268.33
Lens	275	7.00	2.42	0.17	46.59
Beans	61	7.00	2.96	0.21	12.64
Mix of fodder beans and cereals	3 330	10.94	2.96	0.32	1 078.33
Soybeans	33 432	3.44	4.19	0.14	4 818.75
Alfalfa	48 346	7.00	2.42	0.17	8 189.81
Clover	5 257	6.00	1.97	0.12	6 335.87
Other Fodder Crops*	-	6.00	1.97	0.12	3 744.58
2015 TOTAL	**93 184**				**24 495**

*permanent (not including in total harvested area)

Table 5.51: *Input parameters and EFs in 3.D.1.4 for N-fixing crops in particular years*

YEAR	AREA OF N-FIXING CROPS (ha)	NITROGEN FIXED BY N-FIXING CROPS (kg/year)	EFs (kg N_2O-N/kg N)	N_2O EMISSIONS (Gg)
1990	193 412	31 551 835	0.01	1.452
1995	156 809	25 815 160	0.01	1.390
2000	100 886	17 543 586	0.01	1.340
2005	90 577	14 163 138	0.01	1.269
2010	89 716	19 508 495	0.01	1.366
2011	83 934	21 293 990	0.01	1.360

[9] *Bielek, P. Nitrogen in Agricultural Soils of the SR Bratislava 1998 in Slovak.*

[10] Jurcova, O.; Toma, S. *Methodology for Quantification of Nutriment Potential of Residual Crops* Bratislava, 1998 in Slovak.

YEAR	AREA OF N-FIXING CROPS (ha)	NITROGEN FIXED BY N-FIXING CROPS (kg/year)	EFs (kg N_2O-N/kg N)	N_2O EMISSIONS (Gg)
2012	82 191	17 977 255	0.01	1.301
2013	87 359	18 139 475	0.01	1.355
2014	95 489	19 893 364	0.01	1.384
2015	92 309	24 494 903	0.01	1.451

5.11.10 CULTIVATION OF ORGANIC SOILS (CRF 3.D.1.6)

The area of histosols is limited in the Slovak Republic. Information about area of histosols is from available databases BPEJ (National soils database) and LPIS (National soils register). The results of observation is, that area of histosols is 2 303 ha and is constant in time series. Emissions from this source are below the threshold of significance for all years. Notation key for this category is NE.

5.11.11 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. The indirect emissions decreased during the evaluated period due to their dependence on direct inputs of nitrogen that decreased too. Total indirect emissions from atmospheric deposition were 0.350 Gg in 2015 which is more than 56% below 1990 baseline.

IPCC default methodology tier 1 and default emission factors were used for estimation of indirect N_2O emissions from atmospheric deposition. This category is estimated in the connection with the category manure management.

$$N_2O_{(ATD)} = [(F_{SN} * Frac_{GASF}) + ((F_{ON} + F_{PRP}) * Frac_{GASM})] * EF_4 * \frac{44}{28}$$

Where:$N_2O_{(ATD)}$ are annual amounts of N_2O emissions produced from atmospheric deposition of N volatilised from managed soils in kg, F_{SN} are annual amount of synthetic fertilisers N applied to soils in regions in kg N/yr, F_{ON} annual amount of managed animal manure sewage sludge and applied to soils in kg N/yr, F_{PRP} is annual amount of urine and dung N deposited by grazing animals in kg N/yr, $Frac_{GASF}$ 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 fertiliser materials and urine and dung N deposited by grazing animals, that kg N volatilised as NH_3 and NO_x, EF_4 is emission factor for N_2O emissions from atmospheric deposition, kg of N on soils and water surfaces kg N-N_2O (kg NH_3-N + NO_x-N volatilised).

Mean value for leaching of nitrogen varies in the range of 7-10 kg per 1 ha per year (7% of N-inputs) in national conditions. The IPCC default emission factor (0.010kg N_2O-N/kg N) was used during the time series. It was assumed that 10% of nitrogen input from applied synthetic fertilizers to volatilize (NH_3 and NO_x) on soil and 20% of nitrogen from manure is volatilized on soils.

Activity data in this category are in consistent with the activity data in categories synthetic fertilizers and animal manure applied to soil 3.D.1.1 and 3.D.1.2. ***Table 5.52*** shows time series of parameters and emissions.

Table 5.52: *Input parameters and EFs in 3.D.2.1 Atmospheric Deposition in particular years*

YEAR	VOLATILIZED N FROM SYNTHETIC FERTILIZERS (kg)	VOLATILIZED N FROM ANIMAL MANURE, PASTURE AND SEWAGE SLUDGE (kg)	TOTAL VOLATILIZED N (kg)	EFs (kg N_2O-N/kg N)	N_2O EMISSIONS (Gg)
1990	22 225 500	27 957 665	50 183 165	0.010	0.789
1995	6 958 700	19 389 273	26 347 973	0.010	0.414
2000	7 265 300	15 492 410	22 757 710	0.010	0.358
2005	8 131 700	13 155 381	21 287 081	0.010	0.335
2010	8 687 300	11 292 046	19 979 346	0.010	0.314
2011	9 296 900	10 645 540	19 942 440	0.010	0.313
2012	10 100 400	10 968 430	21 068 830	0.010	0.331
2013	11 358 139	10 614 034	21 972 173	0.010	0.345
2014	11 903 605	10 894 262	22 797 867	0.010	0.358
2015	11 477 300	10 787 767	22 265 067	0.010	0.350

5.11.12 NITROGEN LEACHING AND RUN-OFF (CRF 3.D.2.2)

Total losses in soils were 30% of nitrogen input due to leaching, runoff and erosion in the Slovak Republic, which is default value from the IPCC 2006 GL. Total indirect emissions from nitrogen leaching and run-off were 0.925 which is more than 43% below 1990 value.

IPCC default methodology tier 1 and default emission factors were used for the estimation of indirect N_2O emissions from nitrogen leaching and run-off. This category is estimated in the connection with the category 3.B.2 Manure Management and 3.D Agricultural Soils. Emissions were estimated following of this equation:

$$N_2O_{(L)} = (F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}) * Frac_{LEACH-(H)} * EF_5 * \frac{44}{28}$$

Where: $N_2O_{(L)}$ are annual amount of N_2O emission produced from leaching and runoff of N additions to managed soils in kg, F_{SN} are annual amount of synthetic fertiliser N applied to soils kg N yr^{-1}, F_{ON} annual amount of managed animal manure, compost, sewage sludge and other organic N additions applied to soils, where leaching and runoff occurs, kg N/yr. F_{SOM} =0, F_{PRP} is annual amount of urine and dung N deposited by grazing animals where leaching and runoff occurs in kg N/yr, F_{CR} amount of N in crop residues including N fixing crops here leaching an runoff occurs in kg N/yr, $Frac_{LEACH-(H)}$ fraction of all N added in managed soils, where leaching runoff occurs, that is through leaching and runoff in kg of N additions, EF_5 is emission factor for N_2O emissions from N leaching and runoff, kg N_2O-N (kg N leached and runoff).

The IPCC default emission factor (0.0075 kg N_2O-N/kg N) was used during the time series. It was assumed, that 30% of nitrogen input from synthetic fertilizers, crop residues, pasture, manure and sewage sludge applied to soil is lost through leaching and run off.

Activity data in this category are in consistent with the activity data in categories synthetic fertilizers and animal manure applied to soil 3.D.1.1 and 3.D.1.2. ***Table 5.53*** shows time series of parameters and emissions.

Table 5.53: *Input parameters and EF in 3.D.2.2 Nitrogen Leaching and Run-off in particular years*

YEAR	LOST N FROM SYNTHETIC FERTILIZERS (kg)	LOST N FROM ANIMAL MANURE AND PASTURE (kg)	TOTAL LOSS OF N (kg)	EFs (kg N_2O-N/kg N)	N_2O EMISSIONS (Gg)
1990	66 676 500	41 936 498	136 327 554	0.0075	1.607
1995	20 876 100	29 083 909	76 502 778	0.0075	0.902
2000	21 795 900	23 238 615	70 607 245	0.0075	0.832
2005	24 395 100	19 733 072	68 357 077	0.0075	0.806
2010	26 061 900	16 928 904	69 077 194	0.0075	0.814
2011	27 890 700	15 964 756	69 831 230	0.0075	0.823
2012	30 301 200	16 440 193	71 587 530	0.0075	0.844
2013	34 074 417	15 915 907	75 866 848	0.0075	0.894
2014	35 710 815	16 341 313	78 479 296	0.0075	0.925
2015	34 431 900	16 181 650	78 306 391	0.0075	0.923

5.12 PRESCRIBED BURNING OF SAVANNAS (CRF 3.E)

The category 3.E Prescribed Burning of Savannas does not occur in the Slovak Republic.

5.13 FIELD BURNING OF AGRICULTURAL RESIDUES (CRF 3.F)

This form of cultivation is strictly prohibited by law in the Slovak Republic. No emissions from this category were estimated.

5.14 LIME APPLICATION (CRF 3.G)

The limestone fertilizers are applied on the most acidic agricultural soils in the Slovak Republic. In response to ESD recommendation SK-3G-016-0001, The Slovak Republic does not have any evidence about application of dolomite into the soils

The CO_2 emissions from liming were calculated according to the equation:

$$CO_2 \text{ emissions} = M * EF * \frac{44}{12}$$

Where: CO_2 emissions from application of besides limestone burnt lime and other materials, M is annual amount of limestone in tonnes, EF is default and carbon conversion factor (44/12) is coefficient for conversion CO_2-C to CO_2.

Data on liming of agricultural soils (cropland) come from summary of the Central Controlling and Testing Institute in Agriculture (UKSUP). For the years 1998 – 2015 the data are based on summarization of recordings that have to be submitted by land owners/users to the UKSUP in accordance with the national legislation. For the years 1992 and 1994 – 1997 the data are based on statistics of the UKSUP according to the former legislation. For the years 1990, 1991 and 1993 only estimated values are available.

The amount of applied limestone has been registered since 1998. For the previous years, only information on total application of CaO as component of various is available. Therefore, the quotient derived from years with detailed information on applied materials (limestone, burnt lime, lime sludge and other calcareous materials) is used for calculation of limestone application in this case. The default conversion factor (EF) used for limestone ($CaCO_3$) is 0.12.

Table 5.54: *The results for limestone fertilizers in category 3.G in 1990 – 2015*

YEAR	TOTAL AMOUNT OF $CACO_3$ (t)	CARBON CONVERSION FACTOR	CO_2 EMISSIONS (Gg)
1990	101 400.00	0.12	44.62
1995	143 520.00	0.12	63.15
2000	99 248.70	0.12	43.67
2005	19 772.00	0.12	8.70
2010	34 988.01	0.12	15.39
2012	35 089.00	0.12	15.44
2013	36 886.36	0.12	16.23
2014	35 529.55	0.12	15.63
2015	34 078.22	0.12	14.99

5.15 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 N without its uptake by plants. The urea is neither applied on very acid soils. Urea is not the main source of N, thus the data have been calculated for Tier 1 exclusively using the equation 11.13 from the IPCC 2006 GL. According to this, the CO_2 emissions from urea application have been calculated as follows:

$$CO_2 \text{ emissions} = M_{CO(NH_2)_2} * EF * \frac{44}{12}$$

Where: CO_2 emissions from application of urea in tonnes of CO_2 per year, M is annual amount of urea fertilizers in tonnes, EF is default and urea conversion factor (44/12) is coefficient for conversion CO_2-C to CO_2.

Data on urea application of agricultural soils (cropland) come from summary of the Central Controlling and Testing Institute in Agriculture. For the years 1998 – 2015 the data are based on summarization of recordings that have to be submitted by land owners/users to the UKSUP in accordance with 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 very fluctuating with low, medium and higher doses. The default conversion factor (EF) used for urea is 0.20. Estimated emissions shown ***Table 5.55***.

Table 5.55: *The results for urea application in category 3.H in particular years*

YEAR	TOTAL AMOUNT OF UREA (t)	UREA CONVERSION FACTOR	CO_2 EMISSIONS (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
2013	70 899.73	0.20	51.99
2014	79 009.80	0.20	57.94
2015	83 072.63	0.20	60.92

CHAPTER 6: LULUCF (CRF 4)

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	Chapter 6.5 Chapter 6.8 – 6.16 Annex	Ivan Barka, Pavel Pavlenda
National Food and Agriculture Centre Soil Science and Conservation Research Institute (NPPC-VUPOP)	Chapter 6.6	Zuzana Tarasovičová
Grassland and Mountain Agriculture Research Institute	Chapter 6.7	Štefan Pollák

6.1 OVERVIEW OF THE 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 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 – forest land, cropland, grassland, wetlands, settlements and other land and their temporal changes. The first three types of land use have the highest importance due to their relative coverage of the 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 -6 428.80 Gg of CO_2 eq. in 2015 is very important sector and comprises several key categories. ***Table 6.1*** shows summary of total emissions according to categories, emissions and removals are shown in ***Figure 6.1*** and ***Table 6.2***.

Figure 6.1: *Emissions and removals (in Gg of CO_2 eq.) according to the LULUCF land use categories in 1990 – 2015*

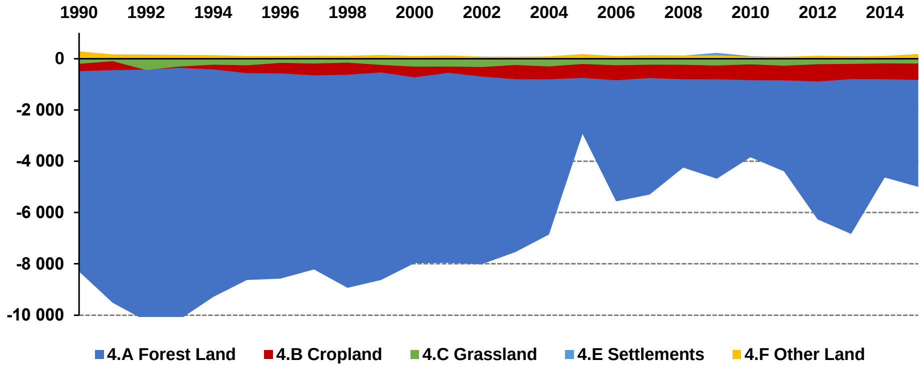


Table 6.1: *Summary of total emissions and removals according to the LULUCF categories in 2015*

CATEGORY	Net CO_2		CH_4	N_2O	NO_x	CO
	EMISSIONS/REMOVALS (Gg)		EMISSIONS (Gg)			
4. LULUCF	**NO**	**-6 474.21**	**0.67**	**0.096**	**0.43**	**15.30**
A. Forest Land	NO	-4 998.12	0.67	0.04	0.43	15.30
B. Cropland	NO	-830.21	NO	0.03	NO	NO
C. Grassland	NO	-191.10	NO	0.002	NO	NO
D. Wetlands	NO	NO	NO	NO	NO	NO
E. Settlements	84.15	NO	NO	0.01	NO	NO
F. Other Land	182.51	NO	NO	0.02	NO	NO

Table 6.2: *Summary of GHG emissions and removals (Gg) according to the LULUCF categories in particular years*

YEAR	FOREST LAND	CROPLAND	GRASS-LAND	SETTLE-MENTS	OTHER LAND	LULUCF (CO_2, CH_4, N_2O)		
	Net CO_2 in Gg					Gg		
1990	-8 297.98	-489.12	-202.29	96.06	285.40	**-9 078.35**	0.30	0.27
1995	-8 629.47	-565.19	-259.06	60.66	103.13	**-9 348.69**	0.24	0.20
2000	-7 968.66	-727.83	-310.72	53.79	103.26	**-9 770.23**	0.44	0.14
2005	-2 931.75	-750.84	-208.70	61.04	177.03	**-5 649.68**	0.62	0.10
2010	-3 844.18	-838.85	-221.44	99.57	87.26	**-6 052.15**	0.60	0.08
2011	-4 394.32	-844.43	-275.18	69.41	79.36	**-6 448.52**	0.60	0.08
2012	-6 265.36	-889.92	-216.90	81.01	114.22	**-7 657.15**	0.49	0.08
2013	-6 834.11	-799.14	-204.21	95.81	95.25	**-8 101.89**	0.36	0.07
2014	-4 633.25	-802.82	-184.65	80.60	104.36	**-6 166.40**	0.69	0.09
2015	-4 998.12	-830.21	-191.10	84.15	182.51	**-6 474.21**	0.67	0.10

Slovak inventory submission in 2017 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 Forest Land carbon stock change in living biomass, dead organic matter and mineral soils is reported. In category 4.B Cropland carbon stock change in living biomass is reported. The carbon stock changes in living biomass, dead organic matter and mineral soils are reported for Cropland, Grassland, Settlements and Other Land converted from 4.A category. 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 land-use conversion to cropland are reported (CRF 4(III). Emissions of CO_2, CH_4 and N_2O from biomass burning are reported in table 4(V). The summary of all categories and subcategories in the Slovak national inventory submission for LULUCF sector is described in the ***Table 6.3***.

Table 6.3: *Reported emissions, methodological tiers and emission factors (EF) in LULUCF in 2015*

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.G	**Harvested Wood Products**						
4.G	Harvested Wood Products	T2	CS,D				

The area of Forest Land in the Slovak Republic covers 41.1% 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 wind storm from the end of 2004, which consequently resulted in the decrease of total sinks to the half of previous volumes.

The identification of land-use 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 land use categories. The GCCA annually issues the Statistical Yearbook of the Soil Resources in the Slovak Republic. It provides updated cadastral information of land use 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 land, 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 Guidelines for National Greenhouse Gas Inventories, Volume 4, Agriculture, Forestry and Other Land Use (IPCC 2006 GL). The Slovak Republic used the following land use definitions for reporting of GHG emissions and removals in the LULUCF sector:

Forest Land - This category includes the land covered by all tree species serving for the fulfilment of forest functions and the lands 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 temporary 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 - This category represents the last of land use categories in the Slovak Republic. 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 lands remaining in the given category during the inventory year, and land converted into the category from another one. The areas of six land use categories remaining in the specific category are in ***Table 6.4***.

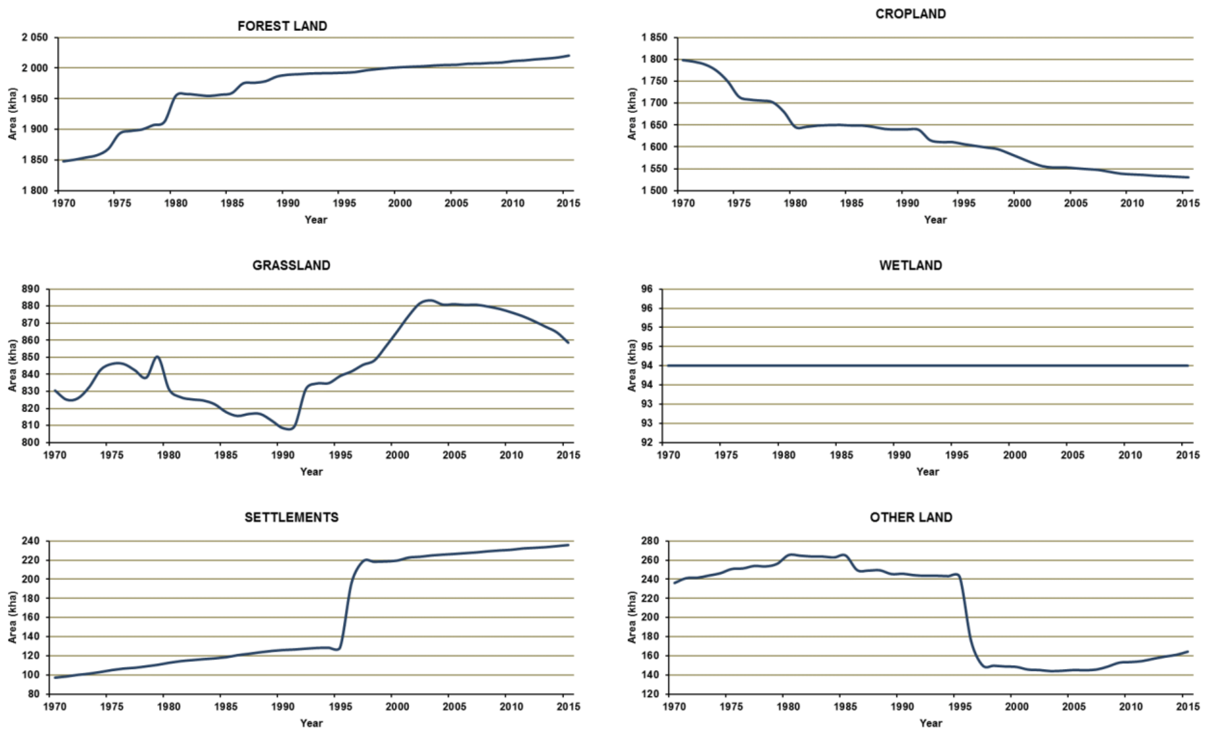
The increasing trend of forest land-use category is evident in the Slovak Republic since 1970. The opposite, decreasing trend of cropland land-use category was recorded at the same time. Grassland areas decreased from 1980 to the 1990 and since this year increasing trend was recorded up to 2005. Since 2005 moderately downward trend has been taking place. Settlements land-use category has continuous increasing trend during 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 categories area. Wetland represents 1.9% (94 kha) of the Slovak territory and it is considered to be constant, not involving any land use conversions.

Table 6.4: *The areas (kha) of land-use categories remaining in category in particular years*

YEAR	AREA (kha/year)				
	4.A.1	4.B.1	4.C.1	4.E.1	4.F.1
	FL remaining FL	CL remaining CL	GL remaining GL	S remaining S	OL remaining OL
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

The land-use matrixes shown in ***Table 6.4*** and ***Figure 6.2*** represent the areas of land-use change among the major land use categories from 1990 to 2015 for individual years. The annual totals for individual years in the matrices do not correspond to the areas referred to in the CRF Tables. These areas account for the progressing for 20 years' transition period beginning in 1970. This approach represents tier 1 assumption of 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.

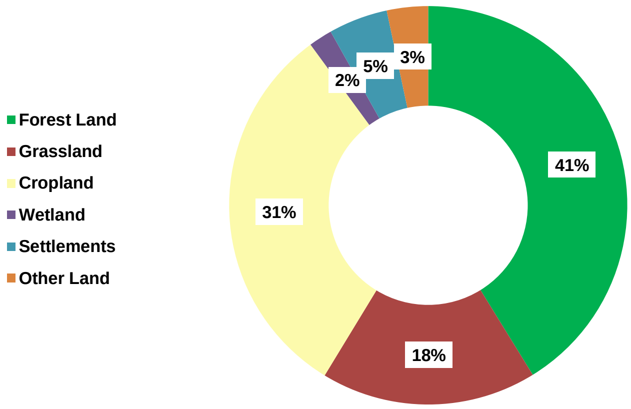
Figure 6.2: *Overall trends in the areas of the land-use categories from 1970 – 2015 (based on information from the GCCA of the Slovak Republic)*



Land-use matrixes identifying annual land-use conversions among the categories for the period 1990 – 2015 and describing initial and final areas of particular land-use categories are listed in annex of this chapter (***Table A6.1***).

The distribution of the IPCC land-use categories in Slovakia in 2015 is shown in ***Figure 6.3***. Forest Land represents the dominant land-use category, accounting for 41.2% of the total area, followed by the Cropland with 31.2%, Grassland with 17.5%, Settlements with 4.8%, Other Land with 3.4% and Wetlands category with 1.9% of the total country area.

Figure 6.3: *Distribution of IPCC land-use categories in Slovakia in 2015*



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 follow basic rules and activities of QA/QC as defined in IPCC 2006 GL.

The calculation is based on annually submitted or published input data of several institutions: the Office of Geodesy of the Slovak Republic,

- the Cartography and Cadastre Authority of the Slovak Republic (GCCA);
- the Statistical Office of the Slovak Republic (SU SR);
- the Institute for Forest Resources and Information (NFC-IFRI Zvolen);
- the Forest Management Planning Institute (NFC-FMPI Zvolen);
- the Central Controlling and Testing Institute in Agriculture (UKSUP);
- or information published by the research organizations, National Food and Agriculture Centre Soil Science and Conservation Research Institute (NPPC-VUPOP).

Each of them 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 participated 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 calculation and estimation all procedures are checked (correctness of equations, interim results, units, trend evaluation). Results of calculation and estimation (output data) are checked as well. 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 biogeoregion, site conditions, ways and intensity of land management, etc.).

Emission inventory methods and emissions 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, General QC formulary was filled and is archived by QA/QC manager. The QA is conducted by another LULUCF expert from the National Forest Centre and by independent expert from the Ministry of Agriculture and Rural Development of the Slovak Republic.

6.3 CATEGORY-SPECIFIC RECALCULATIONS

No recalculation was applied to this category since the last submission. There were no changes in input data and methods used.

6.4 CATEGORY-SPECIFIC IMPROVEMENTS AND IMPLEMENTATION OF RECOMMENDATIONS

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

- Further description of methodology with references to the original data – recommendation No L.6 is implemented in Chapters 6.5.3.1, 6.6.2.1, 6.7.2.1, 6.9.2.1 and 6.10.2.1;
- Improvement of uncertainty analyses – recommendation No L.7 implemented in each subcategory in chapters Uncertainties and time-series consistency;
- Provide more information on the average carbon stock of dead wood – recommendation No L.4 is implemented in Chapter 6.5.1.1;
- Apply consistent methods for the biomass increment and loss – recommendation No L.9 is implemented in Chapter 6.5.1.1;
- Explanation in histosols – recommendation No L.12 is implemented in Chapter 6.6.1.1;
- Explanation how instantaneous oxidation for carbon stock changes in litter for Forest land converted to other land-use categories was implemented – recommendation No L.15 is implemented in Chapters 6.6.2.1, 6.7.2.1, 6.9.2.1 and 6.10.2.1;
- Explanation on vegetation existing in land converted to forest land – recommendation No L.18 is implemented in Chapter 6.5.3.1.

Improvements are implemented in line with the Improvement and Prioritization Plan for the year 2017. Not implemented references will be presented in the SVK NIR 2018.

6.5 FOREST LAND (CRF 4.A)

Forests currently cover 41.2% of the Slovak Republic area. All forests can be considered to be temperate-zone managed forests. Slovak forests are known for their richly diverse species composition with European beech being the dominant forest tree species covering (33.2%) followed by Norway spruce (23.4%) and oaks (10.6%) (Green Report, 2016). At present, forest management is focused more on close-to-nature silvicultural procedures and establishment of forest stands with better structural and 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 478.12 mil. m^3 (merchantable volume, defined as tree stem and branch volume under bark with minimum diameter threshold of 7 cm) in 2015. Average hectare growing stock was 247 m^3.

The total volume of harvested timber reached 9 142.7 thousand m^3 in 2015, which represented 274.75 thousand m^3 (-2.9%) decrease compared to 2014. The volume of incidental felling was 56.4% of the total felling volume.

All actually available information on Slovak forests is based on two sources. The first one is the Forest Management Plans (FMP), which are 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).

Forest management plans (FMPs) are elaborated by professionally and technically competent non-state experts and companies. 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, recorded and reported yearly to the state authority.

The second source of information is data from the first cycle of the statistical (sample based, tree level) forest inventory performed during 2005 – 2006 by the NFC. The National Forest Inventory and Monitoring (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 source of data is not usable for detection of carbon stock changes in Slovak forests, because only one inventory cycle was performed. However, it is usable for estimation of carbon pools for example of dead organic matter – dead wood. The second inventory is performed recently, the field data collection started in 2015. In 2016, field data collection was finalised and data control and quality assessment started. The results of the second inventory are expected to be available in 2017.

The 4.A category includes emissions and removals of CO_2 (Gg) associated with forests. Category consists of two parts 4.A.1 Forest Land remaining Forest Land (FL remaining FL) and 4.A.2 Land converted to Forest Land (L converted to FL). ***Figure 6.4*** shows area changing during years and ***Figure 6.5*** shows map of Forest Land in Slovakia.

Figure 6.4: Development of activity data in kha for category 4.A Forest Land in the period 1990 – 2015

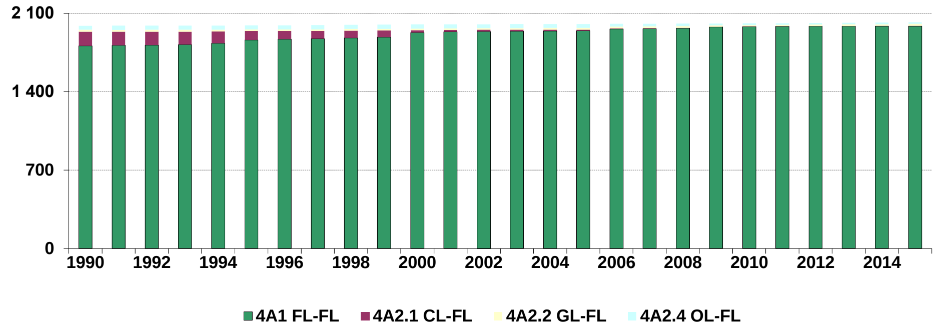
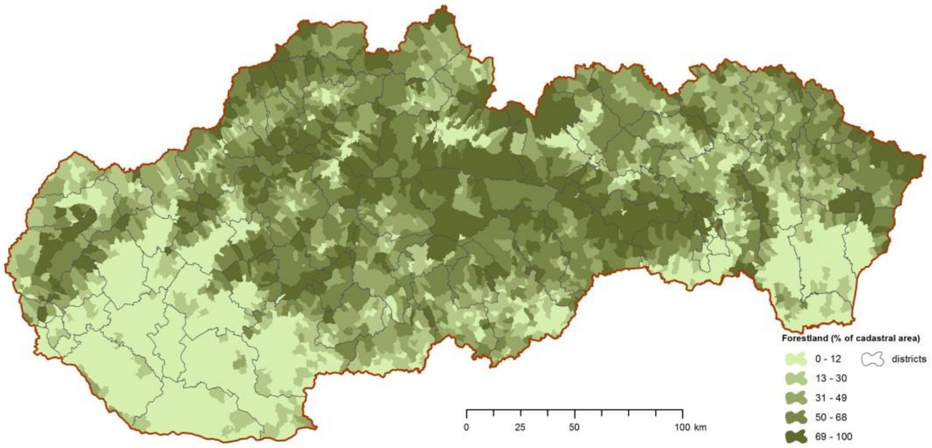


Figure 6.5: Forest Land in Slovakia – distribution calculated as a spatial share of the category within individual cadastral units



6.5.1 FOREST LAND REMAINING FOREST LAND (CRF 4.A.1)

Calculations are based on the IPCC 2006 GL and data from the Permanent Forest Inventory processed in the Slovak Republic continuously each year. Results of calculations 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 2015. This category includes carbon stock changes in following carbon pools: living biomass (above and below ground), dead organic matter (dead wood and litterfall) and organic soil carbon. Carbon stock changes are given by the sum of changes in living biomass, dead organic matter and soil. Total area of Forest Land remaining Forest Land category represents 1 986.73 kha, the changes in the FL were following: CL converted to FL 1.81 kha, GL converted to FL 17.17 kha, and OL converted to FL 14.41 kha in 2015. Total forest area in 2015 was 2 020.116 kha.

6.5.1.1 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 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 of the IPCC 2006 GL.

Current annual increment (CAI) data 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 have been traditionally calculated by the National Forest Centre – Institute for Forest Resources and Information (NFC-IFRI Zvolen) as the FMP database administrator in 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 followed:

- $G_{TOTAL} = G_W * (1 + R)$
- $G_W = I_V * BCEF_I$

The input data and factors used in the calculation of the biomass carbon stock increment for different tree species are presented in the following table (***Table 6.5***).

Table 6.5: *Annual biomass increment for individual forest tree species in the Slovak Republic*

TREE SPECIES	CURRENT ANNUAL INCREMENT	BIOMASS CONVERSION/ EXPANSION FACTOR	AVERAGE ANNUAL ABOVE-GROUND BIOMASS GROWTH	RATIO OF BELOW-GROUND BIOMASS TO ABOVE-GROUND BIOMASS	AVERAGE ANNUAL BIOMASS GROWTH ABOVE- AND BELOW-GROUND
	CAI m^3/ha/yr	BCEFI	GW t dm/ha/yr	R	G TOTAL t dm/ha/yr
Spruce	8.18	0.45	3.68	0.2	4.41
Fir	7.05	0.45	3.19	0.2	3.82
Pine	6.18	0.68	4.19	0.2	5.03
Larch	6.44	0.81	5.24	0.2	6.29
Other conifer	2.58	0.54	1.40	0.2	1.68
Oak	4.49	0.88	3.97	0.2	4.76
Beech	6.12	0.79	4.83	0.2	5.80
Hornbeam	6.08	0.93	5.65	0.2	6.78
Maple	5.77	0.73	4.22	0.2	5.06
Ash	7.35	0.73	5.38	0.2	6.45
Elm	6.05	0.75	4.57	0.2	5.48
Turkey oak	4.48	0.95	4.27	0.2	5.12
Robinia	3.47	0.93	3.22	0.2	3.87
Birch	2.86	0.70	1.99	0.2	2.39
Alder	2.48	0.70	1.73	0.2	2.07
Linden	7.35	0.52	3.84	0.2	4.61
Breeding poplars	12.32	0.51	6.32	0.2	7.58
Poplar	2.68	0.45	1.20	0.2	1.44
Willow	2.69	0.77	2.07	0.2	2.48
Other broad	1.79	0.70	1.25	0.2	1.50
AVERAGE	**5.32**	**0.70**	**3.61**	**0.2**	**4.33**

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 Slovak 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 6.5*** 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 of individual tree species were based on national growth and yield tables (Halaj and Petráš, 1998) using values of age and "bonita" degree (yield class) calculated by the NFC-IFRI Zvolen annually.

Estimation of annual increase in carbon stocks due to biomass increment in FL remaining FL requires inputs of actual stand area (A), annual increment of total biomass (G_{TOTAL}) and carbon fraction of dry matter and was calculated by the equation 2.9 of the IPCC 2006 GL as followed:

- $\Delta C_{FFG} = \sum (A * G_{TOTAL}) * CF$.

The carbon content 50% for coniferous and 49% for broadleaved wood was used for calculation of carbon gains in living biomass.

The annual increase in carbon stocks due to biomass increment in the category 4.A.1 FL remaining FL represents 4 977.40 kt C in 2015 as shows ***Table 6.6.***

Table 6.6: *Total carbon uptake increment for individual forest tree species in the Slovak Republic*

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 d.m./ha	(kt/d.m./yr)	(tC/t d.m.)	(kt C yr)
Spruce	464.498	4.41	2049.85	0.5	1024.92
Fir	80.661	3.82	308.44	0.5	154.22
Pine	134.899	5.03	678.46	0.5	339.23
Larch	49.668	6.29	312.37	0.5	156.19
Other conifer	22.053	1.68	37.04	0.5	18.52
Oak	210.395	4.76	1002.53	0.49	491.24
Beech	660.390	5.80	3828.89	0.49	1876.16
Hornbeam	116.423	6.78	788.94	0.49	386.58
Maple	47.682	5.06	241.48	0.49	118.32
Ash	31.589	6.45	203.79	0.49	99.86
Elm	0.596	5.48	3.27	0.49	1.60
Turkey oak	50.662	5.12	259.39	0.49	127.10
Robinia	34.569	3.87	133.70	0.49	65.51
Birch	30.596	2.39	73.15	0.49	35.84
Alder	14.901	2.07	30.89	0.49	15.14
Linden	8.146	4.61	37.53	0.49	18.39
Breeding poplars	8.940	7.58	67.76	0.49	33.20
Poplar	7.748	1.44	11.18	0.49	5.48
Willow	1.788	2.48	4.44	0.49	2.17
Other broad	10.530	1.50	15.76	0.49	7.72
TOTAL	**1 986.733**		**10 088.851**		**4 977.398**

The annual decrease in carbon stocks due to biomass loss in FL remaining FL follows equations 2.12 of the IPCC 2006 GL. The annual harvest volume (H) is collected in the mandatory reporting of forest managers and elaborated by the NFC-IFRI Zvolen. It covers all 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 forests companies, forest owners or users are obligated annually by the Regulation No 297/2011 Coll. of the Ministry of Agriculture and Rural Development of the Slovak Republic to provide data on forest management activities (harvest, silviculture) to the forestry register database. Annual reported harvest data covers the whole biomass harvested in Slovak forests during the reported year. Even the stolen timber is notified by owners and is included in the annual harvest each year. All subjects (users, companies) managing forests which realized or did not realized harvest have the statutory duty (Act No 326/2005 Coll. on Forests) to inform the NFC IFRI Zvolen -throughout district state authorities about the amount and type of harvest.

The annual amount of total harvest and fuel wood removals is published in the Green Reports. The forest harvest statistics of coniferous and broadleaved trees, CAI and total harvest during the reporting period 1990 – 2015 in Slovakia are presented on the following figures (***Figures 6.6*** and ***6.7***)

Figure 6.6: *The statistics of forest harvest (coniferous and broadleaved) (mil. m^3 volume >7 cm under bark) in 1990 – 2015*

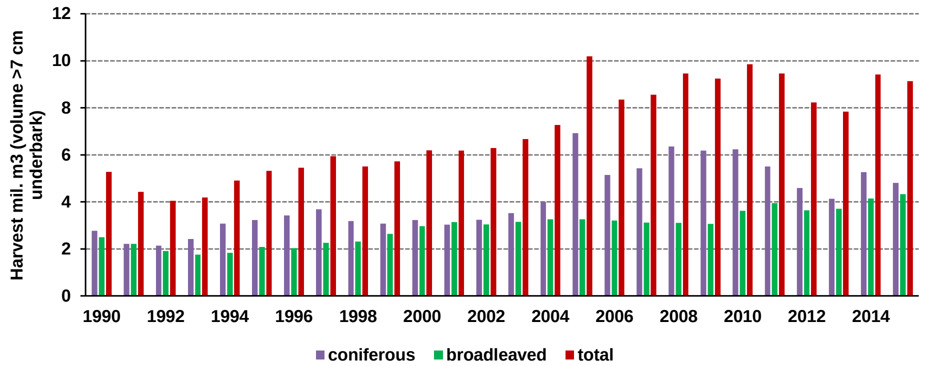
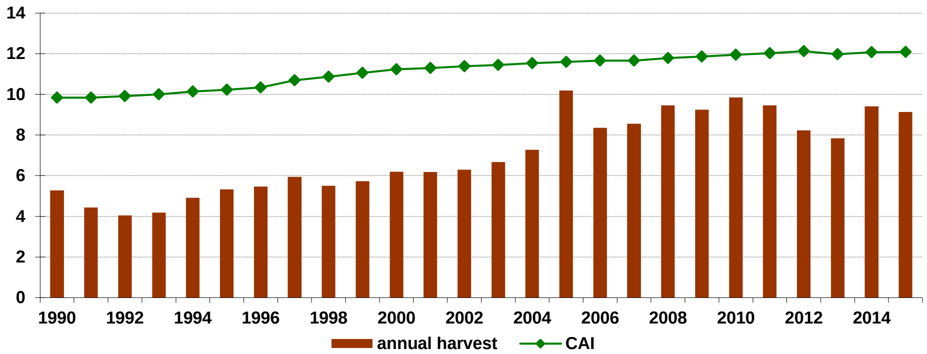


Figure 6.7: *Current annual increment (CAI) and total annual harvest (mil. m^3) in 1990 – 2015*



The annual carbon loss due to commercial felling was calculated using the equation 2.12 in the IPCC 2006 GL:

- $L_{fellings} = H * BCEF_R * (1+R) * CF$

Biomass conversion and expansion factors ($BCEF_R$) were developed based on new NFI data. $BCEF_R$ were developed for Norway spruce (Picea abies), Pine (Pinus sylvestris), Oak (Quercus robur) and Beech (Fagus sylvatica). The methodology follows a common procedure described in literature (Lehtonen et al., 2004) and cited in the IPCC 2006 GL. The BCEF is generally defined as:

- $BCEF_i = W_i / V$;

where i indicates a tree biomass component, W_i (Mg) is the dry biomass of component and V (m^3) is the tree merchantable volume.

Tree-level data of the new NFI in Slovakia 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, available at:
http://publications.jrc.ec.europa.eu/repository/handle/111111111/14708.

The values of $BCEF_R$ were calculated for each year separately considering actual age structure of forests in Slovakia. The CF factors used in calculation are described in the ***Table 6.7***. 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 in the Slovak republic was 3 718.04 kt C in 2015.

Table 6.7: *Activity data and $BCEF_R$ used in calculation of carbon losses in 2015*

TREE SPECIES	ANNUAL WOOD REMOVAL - HARVEST VOLUME	BIOMASS CONVERSION/EXPANSION FACTOR	ANNUAL WOOD REMOVAL - BIOMASS	RATIO OF BELOW-GROUND BIOMASS TO ABOVE-GROUND BIOMASS	ANNUAL WOOD REMOVAL - BIOMASS	CARBON FRACTION OF DRY MATTER	L WOOD-REMOVALS INCLUDING FUELWOOD
	H (m^3/y)	$BCEF_R$	t d.m./y	R	t d.m./y	CF t C/t d.m.	kt C /y
Spruce	3 955 660	0.625	2 474 014	0.2	2 968 817	0.5	1 484.41
Fir	358 969	0.625	224 512	0.2	269 415	0.5	134.71
Pine	383 967	0.526	201 929	0.2	242 315	0.5	121.16
Larch	105 991	0.526	55 741	0.2	66 889	0.5	33.44
Other conifer	5 999	0.526	3 155	0.2	3 786	0.5	1.89
Oak	679 005	0.833	565 509	0.2	678 610	0.49	332.52
Beech	3 053 023	0.750	2 288 244	0.2	2 745 892	0.49	1 345.49
Hornbeam	178 001	0.750	133 412	0.2	160 095	0.49	78.45
Robinia	73 001	0.750	54 714	0.2	65 657	0.49	32.17
Poplar	119 001	0.750	89 191	0.2	107 030	0.49	52.44
Other broad	230 002	0.750	172 387	0.2	206 864	0.49	101.36
TOTAL	**9 142 619**		**6 262 808**		**7 515 370**		**3 718.04**

The assessment of the net carbon stock change in DOM includes the dead wood and the 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. In the reflection of the ERT request No L.4 of the SVK 2016 ARR, the average C stock of dead wood is 4.878 t C/ha in the Forest Land in Slovak conditions. The information on dead wood stocks was obtained from the first National Forest Inventory (NFI) realized in 2005 – 2006. Before realization of NFI no reliable data on dead wood (except for standing dead trees) were available in Slovakia. Quantification of dead wood was performed by 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).

Estimation followed IPCC tier 1 assuming zero change in this carbon pool. This is a safe assumption, if the country did not experience significant changes in forest types, disturbance or management regimes within the reporting year.

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.

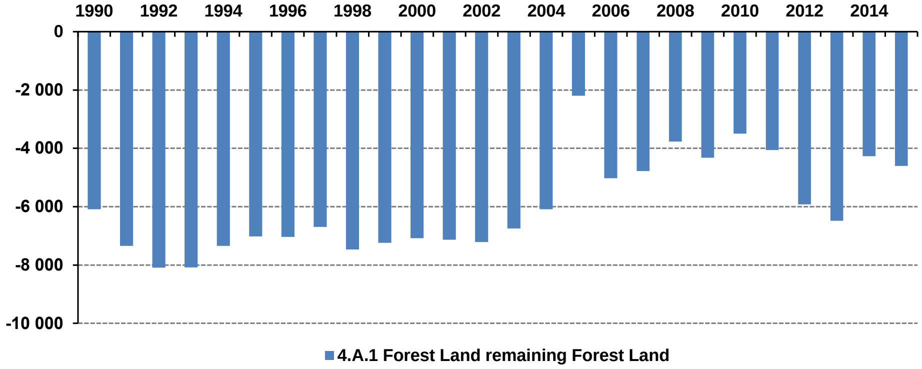
The mean carbon stock in forest litter is 8.3 t C/ha/yr. The value is derived from datasets of the Forest Monitoring System (FMS) and the National Forest Inventory (NFI). The changes of forests management that would dramatically change litter properties and litter carbon changes do not occur, i.e. no significant changes of carbon stocks in litter in forests remaining forests 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 most representative information source is the set of plots of the National Forest Inventory (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 soils 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.

Evaluation of changes from re-sampling after 13 years (in 16x16 km grid) and the validation of data management from the NFI plots has not been finished yet. Due to this reason, the results were not used for calculation of carbon stocks and changes. Though increase of soil carbon stocks seems to be possible, the preliminary results do not show significant changes. For estimation of carbon stock change for mineral soils carbon pool IPCC tier 1 approach was used and assumed that soil carbon stocks change in category 4.A.1 (FL remaining FL) is considered to equal zero, that means it did not change.

In central European conditions, within Forest Land managed according to the principles of sustainable forestry, the mineral soils, litter and deadwood 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, Germany and Austria).

Figure 6.8 shows that the net CO_2 removal in the FL remaining FL represents -4 606.87 Gg of CO_2 in 2015. 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 2014 the loss of carbon was higher than in 2013 due to harvested volume higher by 20% compared to the year 2013. In 2015, it was comparable with previous year.

Figure 6.8: *Summary results of CO_2 removals (Gg) from 4.A.1 in 1990 – 2015*



6.5.2 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, has summarized activity data from controlled burning and forest fires since 1999.

Slovak harvesting system in forestry 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 tree 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 category. The emissions from burning of biomass residues were calculated according to the equation 2.27 and default emission factors in table 2.5 in IPCC 2006 GL. Default combustion factor value 0.62 according to the table 2.6 in IPCC 2006 GL was used for post logging slash burn in other temperate forests.

The main information sources on wildfires or forest fires are the internal fires statistics of the Ministry of Interior as well as the "Reports of the occurrence of harmful agents in Slovakia". In the Slovak Republic there were reported forest fires at the area of 346.6 ha in 2015 as ***Table 6.8*** shows. This number increased compared to the previous year 2014, when the total burnt area was 188.7 ha. The average burnt forest area per one fire was 1.46 ha. The largest forest area damaged by fire was 105.4 ha. The forest fires occurred mostly in spring. The emissions of greenhouse gases from wildfires were calculated on the basis of known areas burnt annually and the 19.8 tonne of dry matter per hectare as default value from table 2.4 in IPCC 2006 GL. ***Table 6.9*** shows biomass burned in forest with emissions.

Table 6.8: *Activity data used for estimation of emissions from wildfires and controlled burning of the forest in 2015*

4.A.1 FL REMAINING FL	Area burnt	Mass of fuel available for combustion	Combustion factor	Emission factor for each GHG		CH_4 emissions from fires	CO_2 emissions from fires	N_2O emissions from fires	NO_x emissions from fires
	ha	t d.m./ha		t/kg d.m.		t			
Forest Fires	346.6	19.8	1	CH_4	4.7	32.26			
				CO_2	107		10 769.0		
				N_2O	0.26			1.79	

4.A.1 FL REMAINING FL	Area burnt	Mass of fuel available for combustion	Combustion factor	Emission factor for each GHG		CH_4 emissions from fires	CO_2 emissions from fires	N_2O emissions from fires	NO_x emissions from fires
	ha	t d.m./ha		t/kg d.m.		t			
				NO_x	3				20.59
Controlled Burning	-	219 296.6	0.62	CH_4	4.7	639.03			
				CO_2	107		14 548.1*		
				N_2O	0.26			35.35	
				NO_x	3				407.9
TOTAL						**671.29**	**25 317.1**	**37.14**	**428.49**

4.A.2 LAND CONV. TO FL	Area burnt	Mass of fuel available for combustion	Combustion factor	Emission factor for each GHG		CH_4 emissions from fire	CO_2 emissions from fire	N_2O emissions from fire	NO_x emissions from fire
	ha	t d.m./ha		t/kg d.m.		t			
Forest Fires			1	CH_4	4.7	0.55			
				CO_2	107		184.0		
				N_2O	0.26			0.03	
				NO_x	3				
Controlled Burning			0.62	CH_4	4.7	NO			
				CO_2	107		NO		
				N_2O	0.26			NO	
				NO_x	3				
TOTAL						**0.55**	**184.0**	**0.03**	

Table 6.9: *Biomass burned in forests, CO_2, CH_4 and N_2O emissions from wildfires and controlled burning of the Slovak forests in particular years*

YEAR	BIOMASS BURNED (t d.m.)		CO_2 EMISSIONS (Gg)*		CH_4 EMISSIONS (t)		N_2O EMISSIONS (t)	
	Controlled Burning	Wildfires	Controlled Burning	Wildfires	Controlled Burning	Wildfires	Controlled Burning	Wildfires
1990	94 700.4	4 137	IE	6.49	275.96	19.44	15.27	1.08
1995	81 573.4	1 297	IE	2.03	237.70	6.09	13.15	0.34
2000	119 889.4	17 679	IE	27.74	349.36	83.09	19.33	4.60
2005	195 422.8	10 131	IE	15.89	569.46	47.61	31.5	2.63
2010	198 795.9	3 745	IE	5.88	579.29	17.60	32.05	0.97
2011	191 545.8	7 856	IE	12.33	558.16	36.92	30.88	2.04
2012	114 327.0	32 846	IE	51.54	333.15	154.38	18.43	8.54
2013	115 246.5	5 271	IE	8.27	335.83	24.78	18.58	1.37
2014	229 254.8	3 737	IE	5.86	668.05	17.56	36.96	0.97
2015	219 296.6	6 863	IE	10.77	639.03	32.26	35.35	1.79

** = Under the tier 1 approach, CO_2 emissions from controlled burning are included in the total biomass loss associated with harvesting in the CRF table 4.A.*

6.5.2.1 Controlled burning

Total methane emissions from controlled burning were 639.03 t and total emissions of N_2O were 35.35 t in 2015. CO_2 emissions were 14.55 Gg in 2015.

6.5.2.2 Wildfires

Total methane emissions from wildfires were 32.26 t and total emissions of N_2O were 1.79 t in 2015. CO_2 emissions were 10.77 Gg in 2015.

6.5.3 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.

6.5.3.1 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 method (IPCC 2006 GL) was used for calculation of carbon stocks change in living biomass and DOM. Carbon stocks changes in living biomass in the category Land converted to Forest Land through the forest regeneration were estimated using 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 species included in the inventory are following: spruce 2.74 t C/ha/yr, pine 3.17 t C/ha/yr, beech 2.32 t C/ha/yr, oak 1.23 t C/ha/yr. 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 was constructed. The tree biomass was measured at the sites and calculated by different compartment (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.

The annual increment 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/yr, pine 0.40 t C/ha/yr, beech 0.57 t C/ha/yr and oak 0.90 t C/ha/yr. The ratio of main tree species from reforestation areas for different years was selected from the Statistical Office of the Slovak Republic (www.statistics.sk) and represented 45% for spruce, 21% for pine, 30% for beech and 4% for oak in 2015.

The carbon loss connected with living biomass due to silvicultural cuttings in the category 4.A.2 Land converted to Forest land was assumed to be insignificant (zero). The reason is that the first significant thinning occurs in older age forest stands.

The net carbon stock change in dead wood was assumed to be negligible (zero), in accordance with default tier 1 method. Methods to quantify emissions and removals of carbon in dead wood pools following conversion of land to forest land 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 (CL, GL, OL) does not produce dead wood so that corresponding carbon pools prior to conversion can be taken as zero.

In the reflection of the ERT request No L.18 of the SVK 2016 ARR, the changes in living biomass and deadwood are assumed to be zero at conversion because, according to common afforestation practices, if any vegetation exists in cropland or grassland it is not removed before conversion to forest land and remains in afforested areas. Due to economic reasons, land converted to forest land is located exclusively in mountainous regions of the Carpathians on the steeper slopes with less productive soils, while rich soils in the lowlands remain under managed cropland or grassland categories. 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 method. It was based on existing data sets from soil inventories and published information (Šály, 1998, Kobza et al., 1999, 2002, 2013, 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/yr for carbon stocks in litter (representing surface organic layer) were used for calculation of net carbon stock change in litter. The mean net annual accumulation of litter over length of transition period represents 0.415 t C/ha/yr. The equation 2.23 was used for calculation annual changes in carbon stocks in litter for Land converted to FL.

The change in litter carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category of land use associated with land converted to forest.

The net carbon stock change in mineral soils 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., 1997, 2002, Pavlenda, 2008) with the default assumption of 20 years period for carbon stock equilibrium in „new land-use" conditions.

The approach for calculation of soil organic carbon stocks in the soils is the same as applied in the last submission. In the reflection of the ERT request No L.6 of the SVK 2016 ARR, the description of the procedure used is as follows: Mean values of soil organic carbon stocks in each land-use category were calculated from datasets of Forest Monitoring System (112 representative monitoring plots in forests) and Soil Monitoring System (318 monitoring plots in other land use). Data was recalculated to 30 cm soil layer (topsoil) and compared for three altitudinal zones in each land use category. The significant changes in soil carbon caused by land use change during decades 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 Grassland, Forest Land and Grassland converted to forest) proved very similar results (Pavlenda et al. 2015).

For respective land use 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 category 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/yr) * 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/yr
- GL converted to FL 0.704 t C/ha/yr
- S converted to FL 1.758 t C/ha/yr
- OL converted to FL 1.758 t C/ha/yr

The change in soil carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category of land use associated with land converted to forest.

As mentioned in the category 4.A.1, the same values as in previous reports were used. For forest land the carbon stock in surface organic layer is separated from carbon stock in mineral soils. The land-use matrix from 1995 to 2015 is provided in the ***Table 6.10***.

Table 6.10: *The land-use matrix from 1995 – 2015*

LAND USE CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	**Total unmanaged land**	**Initial area (1995)**
	kha										
Forest Land (managed)	1 986.73	0.00	0.35	2.15	0.00	0.00	0.00	0.98	2.05	**0.00**	**1 992.26**
Forest Land (unmanaged)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**
Cropland	1.81	0.00	1 503.58	71.27	0.00	0.00	0.00	14.47	14.50	**0.00**	**1 606.62**
Grassland (managed)	17.17	0.00	25.08	784.51	0.00	0.00	0.00	5.67	6.59	**0.00**	**839.03**
Grassland (unmanaged)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**
Wetland (managed)	0.00	0.00	0.00	0.00	0.00	94.00	0.00	0.00	0.00	**0.00**	**94.00**
Wetland (unmanaged)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**
Settlements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	117.90	11.09	**0.00**	**128.99**
Other Land	14.41	0.00	1.997	0.682	0.00	0.00	0.00	95.50	130.04	**0.00**	**242.63**
Total unmanaged land	**0.00**	**0.00**	**0.000**	**0.000**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Final area (2015)	**2 020.12**	**0.00**	**1 531.02**	**858.60**	**0.00**	**94.00**	**0.00**	**235.51**	**164.28**	**0.00**	**4 903.52**
Net change	**27.86**	**0.00**	**-75.60**	**19.58**	**0.00**	**0.00**	**0.00**	**106.52**	**-78.354**	**0.00**	

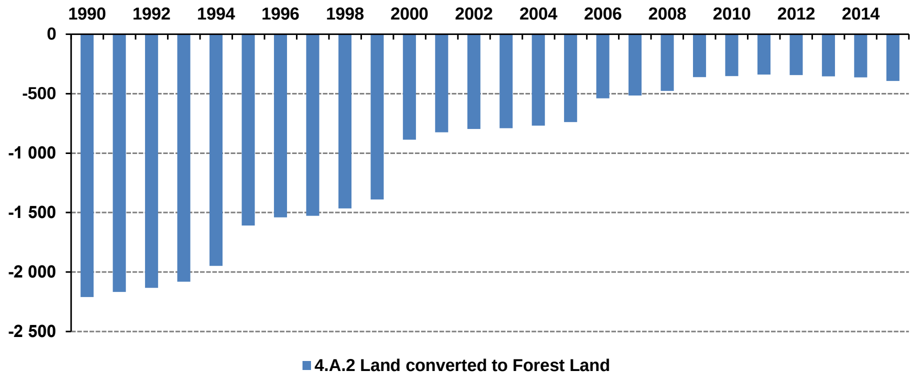
The results from the category 4.A.2 Land converted to Forest Land are summarized in the following ***Table 6.11*** and ***Figure 6.9***.

Table 6.11: *Results for the category 4.A.2 Land converted to Forest Land*

LAND USE CATEGORY	**CARBON STOCK CHANGE IN LIVING BIOMASS (Gg C)**			**Net carbon stock change in DOM (Gg C)**	**Net carbon stock change in soil (Gg C)**	**Net CO_2 emissions/ removals (Gg CO_2)**
	gains	**losses**	**net change**			
Land - FL	**52.88**	**NO**	**52.88**	**13.85**	**40.03**	**-391.44**
GL - FL	27.20	NO	27.20	7.13	12.09	-170.18
CL - FL	2.86	NO	2.86	0.75	2.61	-22.81
WL - FL	NO	NO	NO	NO	NO	NO
S - FL	NO	NO	NO	NO	NO	NO
OL - FL	22.82	NO	22.82	5.98	25.33	-198.45

The estimated removals for Land converted to Forest Land were 391.44 Gg CO_2 in 2015. In the 2015 the net carbon stock change in living biomass, DOM and soil from Land converted to Forest Land represented gains of 52.88, 13.85 and 40.03 Gg C respectively.

***Figure 6.9:** Summary results of CO_2 removals (Gg) in 4.A.2 in 1990 – 2015*



6.5.4 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 forest fires and biomass burning on forest areas. The National Forest Centre – Forest Protection Service Activity summarized data from forest fires (wildfires) since 1999. ***Table 6.12*** shows biomass burned with emissions in forest.

***Table 6.12:** Biomass burned in forests, CO_2, CH_4 and N_2O emissions from wildfires of the Slovak forests in particular years*

YEAR	BIOMASS BURNED (kg dm)	CO_2 EMISSIONS (t)	CH_4 EMISSIONS (t)	N_2O EMISSIONS (t)
1990	456.636	716.462	2.146	0.119
1995	97.725	153.331	0.459	0.025
2000	680.187	1 067.214	3.197	0.177
2005	322.997	506.782	1.518	0.084
2010	56.302	88.338	0.265	0.015
2011	114.786	180.099	0.539	0.030
2012	486.056	762.622	2.284	0.126
2013	79.852	125.288	0.375	0.021
2014	59.174	92.844	0.278	0.015
2015	117.230	184.043	0.551	0.030

6.5.4.1 Wildfires

Total methane emissions from wildfires in category 4.A.2 were 0.55 t and total emissions of N_2O were 0.03 t in 2015. Total CO_2 emissions in this category were 184.043 t in 2015. Due to persistent technical problems with CRF reporter it was not possible to insert the relevant information of activity data units (ha) and appropriate NK in the table 4(V).

6.5.5 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty analysis for land use category 4.A was guided by Tier 1 methods using the equations 3.1 and 3.2 (Volume 1, Chapter 3, IPCC 2006 GL) following the recommendations of the ERT (request No L.7 from the SVK 2016 ARR).

EQUATION 3.1
COMBINING UNCERTAINTIES – APPROACH 1 – MULTIPLICATION

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \ldots + U_n^2}$$

U_{total} is the percentage uncertainty in the product of the quantities and U_i denotes the percentage uncertainties with each of the quantities (IPCC 2006 GL).

EQUATION 3.2
COMBINING UNCERTAINTIES – APPROACH 1 – ADDITION AND SUBTRACTION

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

U_{total} is the percentage uncertainty in the sum of the quantities (half the 95 per cent confidence interval divided by the total (i.e., mean) and expressed as a percentage). This term 'uncertainty' is based upon the 95 per cent confidence interval; x_i and U_i are the uncertain quantities and the percentage uncertainties associated with them, respectively.

Table 6.13: *Uncertainties in Forest Land remaining Forest Land and Land converted to Forest Land*

IPCC CATEGORY		ACTIVITY DATA (%)	EMISSION FACTOR (%)	EF REFERENCES
4.A.1	Forest Land remaining Forest Land - living biomass	3	82.84	IPCC 2003 & 2006 GL
4.A.2.1	Land converted to Forest Land - living biomass	3	40.61	IPCC 2003 & 2006 GL
4.A.2.1	Land converted to Forest Land – DOM (litter)	3	75.00	expert judgement
4.A.2.1	Land converted to Forest Land - mineral soil	3	75.00	expert judgement

The following values of activity data and emission factors were used for estimation of uncertainty in individual C pools and LU categories: default uncertainty values (IPCC 2003, 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). This error range represents a nominal estimate of error, equivalent to two times standard deviation, as a percentage of the mean.

The accuracy of tree biomass (dry mass) annual increment on new afforested areas represented by standard deviation was following: spruce ±1.56 t/ha/yr, pine ±1.61 t/ha/yr, beech ±2.04 t/ha/yr and oak ±1.05 t/ha/yr. Accuracy of dead wood volume for different parts of DW and tree species: standing dead trees – coniferous ±0.03 m^3/ha, broadleaves ±0.02 m^3/ha, stumps – coniferous ±0.01 m^3/ha, broadleaves ±0.01 m^3/ha, coarse laying dead wood – coniferous ±0.07 m^3/ha, broadleaves ±0.04 m^3/ha and small-sized laying dead wood – coniferous ±0.02 m^3/ha, broadleaves ±0.03 m^3/ha (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 years period, the total uncertainty of C emission/removal for land use change of mineral soils can be estimated ±75%.

The uncertainty estimated for Forest Land category reached the 77%, uncertainty in Forest Land remaining Forest Land and land converted to Forest Land reached 83% and 114% in 2015.

The time series are consistent, estimated by the consistent methodology, activity data collection way and using consistent emission factors and other parameters.

6.6 CROPLAND (CRF 4.B)

The GHGs emissions and removals in this category were estimated by using the IPCC 2006 GL for AFOLU and national data on area of Cropland and Land converted to Cropland in 2015. The total area of cropland represented 1 531.02 kha in 2015, this is 31.2% of the total country area. This land use category has been constantly decreasing during whole reporting period, even since 1970. The total area of Cropland remaining Cropland (CL – CL) represents 1 503.58 kha, the changes in the Cropland were following: FL converted to CL 0.35 kha, GL converted to CL 25.09 kha and OL converted to the CL 2.00 kha in 2015 as shows ***Figures 6.10*** and ***6.11***.

Figure 6.10: *Development of activity data in kha for category 4.B Cropland in the period 1990 – 2015*

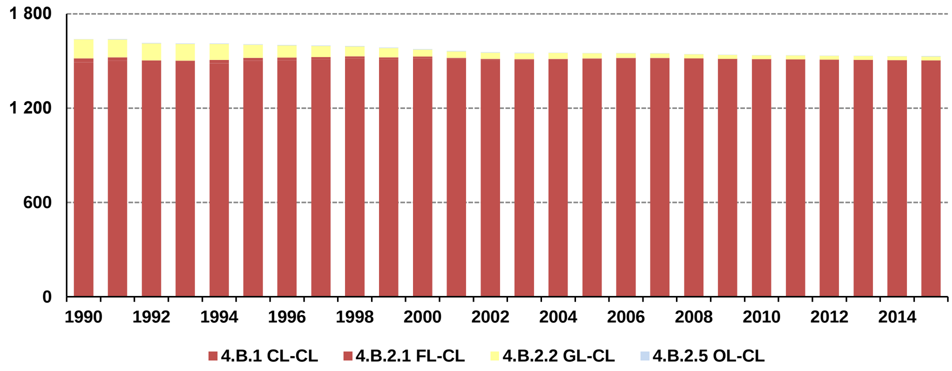
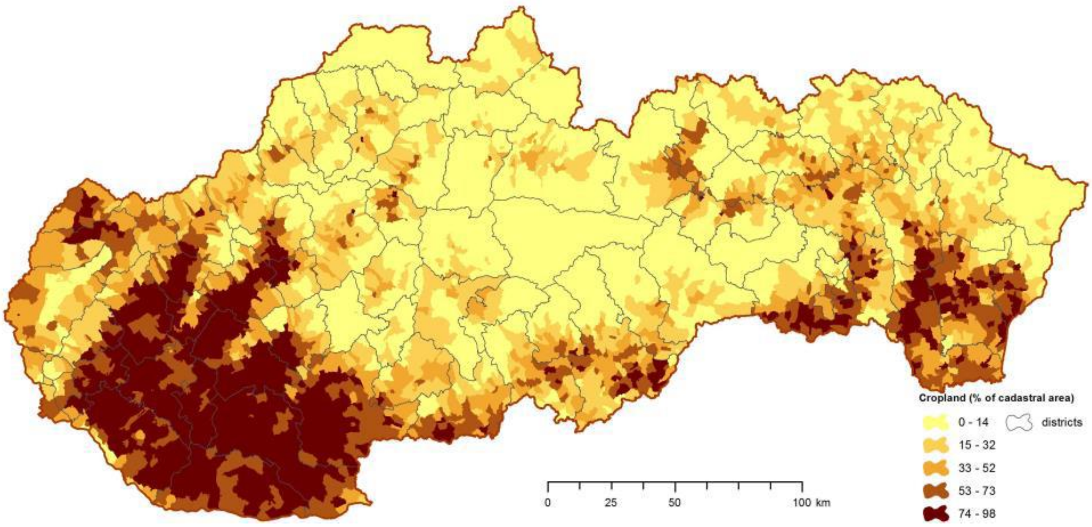


Figure 6.11: *Distribution of Cropland in Slovakia – calculated as a spatial share of the category within individual cadastral units*



6.6.1 CROPLAND REMAINING CROPLAND (CRF 4.B.1)

The emissions inventory in this category included net carbon stock change in living biomass, especially in perennial woody crops and net carbon stock change in soil. The perennial woody crops including vineyards, orchards and gardens represented 119.21 kha in 2015.

6.6.1.1 Methodological issues – methods, activity data, emission factors and parameters

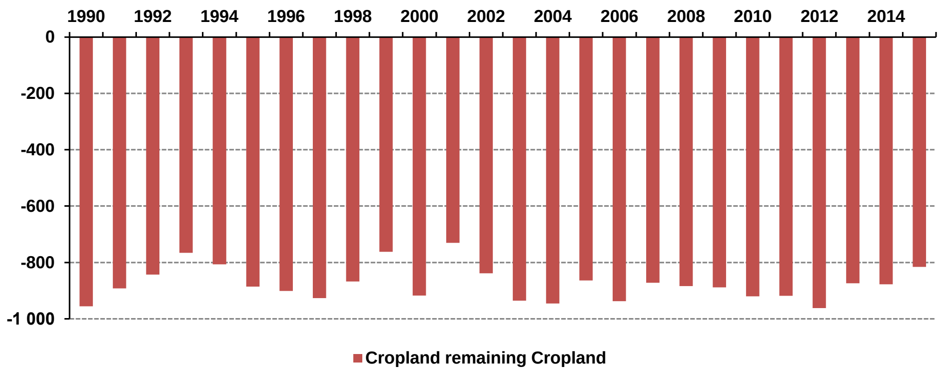
Change in biomass carbon stocks of Cropland remaining Cropland were estimated by tier 1 method. The annual change of carbon stocks in biomass was calculated using equation 2.7 from the IPCC 2006 GL for AFOLU. The immature perennial woody cropland area accumulates carbon at a rate of approximately 2.1 t of above ground carbon per hectare per year. Default value for above ground biomass carbon stock at harvest (temperate perennial woody cropland) is 63 t C/ha (table 5.1, IPCC 2006 GL).

In general, croplands have 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 method assumes that dead wood and litter stocks are not present in Cropland or are at equilibrium like in agroforestry systems and orchards. Thus, there is no need to estimate the carbon stock changes for these pools. The carbon stock change in soil in the category Cropland remaining Cropland was estimated for mineral soils.

Regarding to respond recommendation L.12 from the SVK ARR 2016, the total area of organic soil (histosols) represents about 5.5 kha in Slovakia. The total area of organic soils on the cropland represents 2.3 kha which is represented 0.16 per cent from cropland, so the notation key NO is used. These data are result from geographical analysis (intersect 2 geographical layer - LPIS 2015 and the value soil-ecological units). The method used for carbon stock changes in mineral soils calculation follows equation 2.25 and relative stock change factors for different activities on cropland according to the table 5.5 (IPCC 2006 GL). The default relative stock change factors for land use FLU = 0.80, stock change factors for management regime FMG = 1.0 and 1.1 respectively (full vs. no till.) and stock change factor for input of organic matter FI = 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.

Figure 6.12 below shows net CO_2 removals in the category 4.B.1 Cropland remaining Cropland (-909.66 Gg) in 2015.

Figure 6.12: *Summary results of CO_2 removals (Gg) in 4.B.1 in 1990 – 2015*



6.6.2 LAND CONVERTED TO CROPLAND (CRF 4.B.2)

This category includes all processes connected with the conversion of Land converted into 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.

6.6.2.1 Methodological issues – methods, activity data, emission factors and parameters

Carbon stock changes in biomass were calculated using tier 1 method (IPCC 2006 GL). Tier 1 follows the approach used in 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 (0.5) 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 and removals of carbon in dead organic matter pools following conversion of Land to FL require estimates of the carbon stocks just prior to and just following conversion. The data obtained from the first National Forest Inventory (NFI) realized in 2005 – 2006 was used in estimation of dead wood prior the conversion in FL. The NFI provides 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 into four categories according to decomposition degree as a fresh, hard, soft and decomposed dead wood. The dead wood carbon stock was estimated by mean dead wood biomass stocks (m^3/ha), dry wood density weighted by mean growing stock volume of coniferous (0.425 t/m^3) and broadleaves (0.675 t/m^3), reduction coefficient 0.8, 0.5, 0.5 and 0.2 and applicable to above described decomposition degrees and default carbon content (0.5 t C/t biomass). Because the cropland does not produce dead wood these carbon pools after conversion can be taken as zero (default assumption). The calculation of carbon stock change in litter was separated from calculations of changes in soil. The information about 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 (for the case of land use change forests to cropland) with the default assumption of 20 years period for carbon stock equilibrium in „new land use“ conditions.

The net carbon stock change in litter was estimated by 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., 1999, 2002, 2013, Pavlenda, 2008). The mean value of 8.3 t C/ha/yr 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 annual changes in carbon stocks in litter for Land converted to CL. To apply instant oxidation of carbon in litter with respect to recommendation L.15, litter stock under the new land-use category was set to 0 ad transition time period to 1. The change in litter carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category of land use associated with Land converted to CL.

The calculation of carbon stock changes 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 land-use „conditions. Calculations of carbon stock changes in mineral soils 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 method described in detail in section 6.7.4.1 of this chapter. For estimation of net carbon stock change in mineral soil the average carbon stocks per hectare noted above were used (category 4.A.2 Land converted to Forest Land). Current results of monitoring of agricultural soil and updated databases were used for calculation. The soil carbon stocks were calculated for the depth 30 cm for each of land use categories. For more information, see chapter 6.5.3.1 of this report.

The average annual C stock change in mineral soil for different conversion of Land to CL category 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/yr) 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/yr;

- GL converted to CL -0.742 t C/ha/yr;
- S converted to CL +0.313 t C/ha/yr;
- OL converted to CL +0.313 t C/ha/yr.

The change in soil carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category of land use associated with Land converted to Cropland. The land-use matrix from 1995 to 2015 is provided in the ***Table 6.10***.

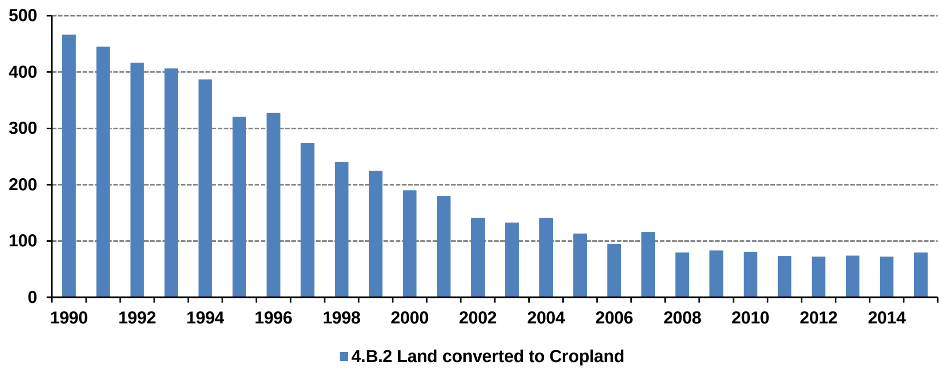
The results from the category 4.B.2 Land converted to Cropland are summarized in the following ***Table 6.14***, summary of CO_2 emissions are shown in ***Figure 6.13***.

Table 6.14: *Result for the category 4.B.2 Land converted to Cropland*

LAND USE CATEGORY	CARBON STOCK CHANGE IN LIVING BIOMASS (Gg C)			NET CARBON STOCK CHANGE IN DOM (Gg C)	NET CARBON STOCK CHANGE IN SOIL (Gg C)	NET CO_2 EMISSIONS/ REMOVALS (Gg CO_2)
	gains	losses	net change			
Land - CL	**NO**	**-3.07**	**-3.07**	**-0.11**	**-18.50**	**79.45**
FL – CL	NO	-0.87	-0.87	-0.11	-0.51	5.43
GL – CL	NO	-2.20	-2.20	NO	-18.61	76.31
WL – CL	NO	NO	NO	NO	NO	NO
S – CL	NO	NO	NO	NO	NO	NO
OL – CL	NO	NO	NO	NO	0.63	-2.29

The category 4.B.2 Land converted to Cropland represents net emissions 79.45 Gg of CO_2 in 2015. The net carbon stock change in living biomass, DOM and soil from Land converted to Cropland represented losses of -3.07, -0.11 and -18.50 Gg C in 2015.

Figure 6.13: *Summary of CO_2 emissions (in Gg) in 4.B.2 in 1990-2015*



6.6.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty analysis for land use category 4.B was guided by Tier 1 methods using the Equations 3.1 and 3.2 (Volume 1, Chapter 3, IPCC 2006 GL) following the recommendations of the ERT (request No L.7 of the SVK 2016 ARR).

EQUATION 3.1

COMBINING UNCERTAINTIES – APPROACH 1 – MULTIPLICATION

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \ldots + U_n^2}$$

U_{total} is the percentage uncertainty in the product of the quantities and U_i denotes the percentage uncertainties with each of the quantities (IPCC 2006 GL).

EQUATION 3.2
COMBINING UNCERTAINTIES – APPROACH 1 – ADDITION AND SUBTRACTION

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

U_{total} is the percentage uncertainty in the sum of the quantities (half the 95 per cent confidence interval divided by the total (i.e., mean) and expressed as a percentage). This term 'uncertainty' is based upon the 95 percent confidence interval; x_i and U_i are the uncertain quantities and the percentage uncertainties associated with them, respectively.

Table 6.15: *Uncertainties in Cropland remaining Cropland and Land converted to Cropland categories*

IPCC CATEGORY		ACTIVITY DATA (%)	EMISSION FACTOR (%)	EF REFERENCES
4.B.1	Cropland remaining cropland - living biomass	3	75.00	IPCC 2006 GL
4.B.1	Cropland remaining cropland – mineral soil	3	76.09	expert judgement
4.B.2.1	Land converted to cropland - living biomass	3	107.98	IPCC 2006 GL (tab. 5.1, 6.4), Šmelko et al. 2003
4.B.2.2	Land converted to cropland – DOM (DW/litter)	3	75.24	SVK NFI, expert judgement
4.B.2.3	Land converted to cropland - mineral soil	3	75.00	expert judgement

The default uncertainty for biomass accumulation rate and biomass carbon loss in CL ±75% and land use areas 3% were used, according to tier 1 (IPCC 2006 GL). The following values of activity data and emission factors were used for estimation uncertainty in individual C pools and land-use categories: default uncertainty values (IPCC 2003, 2006 GL) - areas of land use 3%, biomass stock prior conversion in FL 20%, biomass stock prior conversion in GL 75%, biomass stock after conversion 75%, dead wood 6%, litter stock 75%. The uncertainty for soil category was calculated using default relative stock change factor FLU for different management activities ±17% (IPCC 2006 GL) and reference C stocks ±75% values (expert judgment). According to the expert estimation and based on statistical approach for the estimation of forest wood stocks published by Šmelko et al. (2003), the uncertainty represented the range of 15-20%. Accuracy of dead wood volume for different parts of DW and tree species was published by Šmelko et al. (2008). More information is in the section Forest Land uncertainty of this chapter.

The uncertainty estimated for Cropland reached 100%, uncertainty in Cropland remaining Cropland and Land converted to Cropland reached 107% and 151% in 2015.

The time series are consistent, estimated by the consistent methodology, activity data collection way and using consistent emission factors and other parameters.

6.7 GRASSLAND (CRF 4.C)

The emissions and removals of GHGs 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 2015. The total area of Grassland represented 858.601 kha in 2015; this is approximately 17.51% 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 6.14*** and ***6.15*** show activity data and map of Grassland area in Slovakia.

Figure 6.14: *Development of activity data in kha for category 4.C Grassland in the period 1990 – 2015*

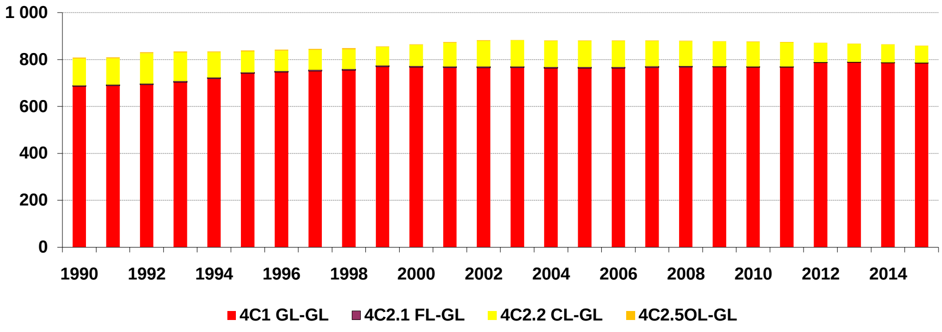
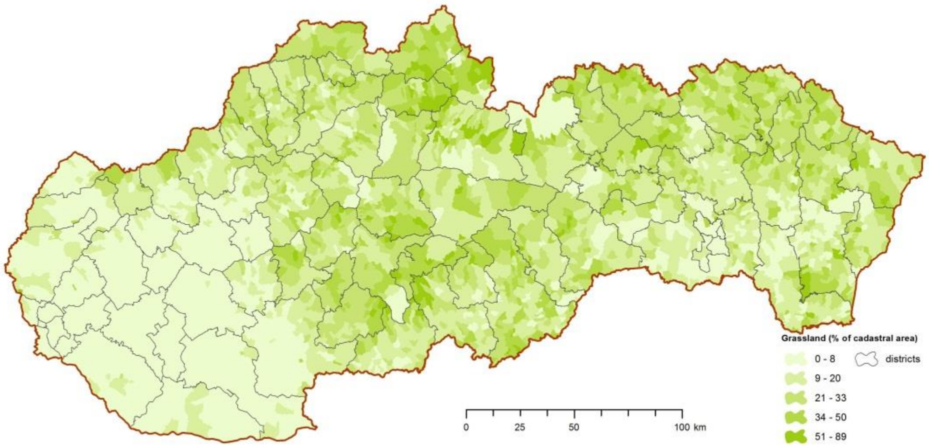


Figure 6.15: *Distribution of Grassland in Slovakia – calculated as a spatial share of the category within individual cadastral units*



The total area of Grassland remaining Grassland was 784.508 kha in 2015, the changes in Grassland were following: Forest Land converted to Grassland 2.145 kha, Cropland converted to Grassland 71.266 kha, Other Land converted to Grassland 0.682 kha in 2015.

6.7.1 GRASSLAND REMAINING GRASSLAND (CRF 4.C.1)

Tier 1 assumes no change in living biomass in Grassland remaining Grassland. This approach was used in the emissions/removals estimation in this category. This is a conservative approach for the conditions in country where any application of higher tier approaches would not 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 land use types, disturbance or management regimes within the reporting year. In CRF table 4.C.1 notation key "NO" 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.

6.7.2 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 methodology was used. Tier 1 method requires estimates of the biomass of the land use before conversion and after conversion. It is assumed that all biomass is cleared when preparing a site for grassland use, therefore the default value for biomass immediately after conversion is 0 t/ha. Tier 1 method follows the approach described in chapter Forest Land 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.

6.7.2.1 Methodological issues – methods, activity data, emission factors and parameters

For calculation of biomass carbon stocks in 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 (0.5) were used. For biomass carbon stock on grassland prior conversion the default values of 4.7 t C/ha for herbaceous above ground and below ground biomass were used. 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 Land converted to Cropland category.

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 (for the case of land use change of FL to GL) with the default 20 years' period for carbon stock equilibrium in „new land-use „conditions. The net carbon stock change in litter was estimated by 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., 1999, 2002, 2013, Pavlenda, 2008). The mean value of 8.3 t C/ha for carbon stocks in litter (representing surface organic layer) were used for calculation of net carbon stock change in litter. The equation 2.23 was used for calculation of annual changes in carbon stocks in litter for FL converted to GL. To apply instant oxidation of carbon in litter with respect to the UNFCCC recommendation L.15 from the SVK ARR 2016, litter stock under the new land-use category was set to 0 ad transition time period to 1. 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 the category FL converted to GL.

The calculation of carbon stock changes in mineral soils was based on the data from the soil inventory with the default 20 years' period for carbon stock equilibrium in „new land-use „conditions. The net carbon stock change in mineral soils was estimated by using country specific tier 2 method described in detail in the Chapter 6.5.3.1 of this report. Net carbon stock change in mineral soil was used for estimation of the average carbon stock per hectare noted above (4.A.2 Land converted to FL). Current results of monitoring of agricultural soil and updated databases were used for calculation. The soil carbon stocks were calculated for the depth 30 cm for each of land use categories.

The average annual C stock change in mineral soil for different conversion of the category Land 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/yr) * 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;

- CL converted to GL	+0.742 t C/ha;
- OL converted to GL	+1.055 t C/ha.

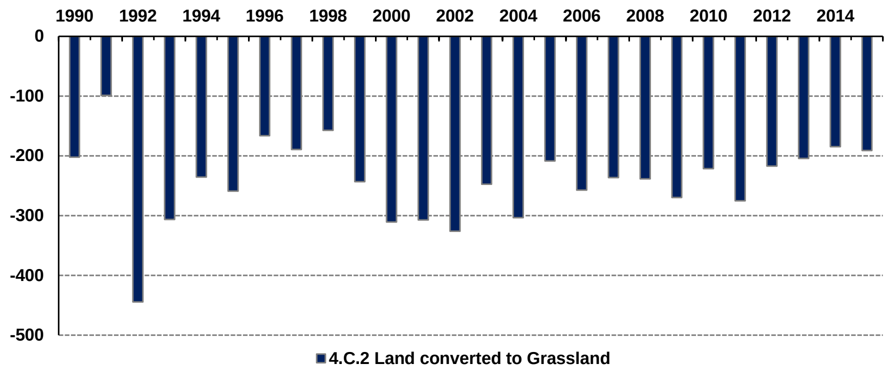
The change in soil carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category of land use associated with Land converted to Grassland. The land-use matrix from 1995 to 2015 is provided in the ***Table 6.10***. The results of balance of the category 4.C.2 Land converted to Grassland are summarized in the following ***Table 6.16***.

Table 6.16: *Results for the category 4.C.2 Land converted to Grassland*

LAND USE CATEGORY	CARBON STOCK CHANGE IN LIVING BIOMASS (Gg C)			NET CARBON STOCK CHANGE IN DOM (Gg C)	NET CARBON STOCK CHANGE IN SOIL (Gg C)	NET CO_2 EMISSIONS/ REMOVALS (Gg CO_2)
	gains	losses	net change			
Land - GL	**0.76**	**-0.65**	**0.11**	**-0.08**	**52.09**	**-191.1**
FL - GL	NO	-0.65	-0.65	-0.08	-1.51	8.22
CL - GL	0.76	NO	0.76	NO	52.88	-196.68
WL - GL	NO	NO	NO	NO	NO	NO
S - GL	NO	NO	NO	NO	NO	NO
OL - GL	NO	NO	NO	NO	0.72	-2.64

Total removals estimated in this category were -191.1 Gg CO_2 in 2015. The net carbon stock change in living biomass and net carbon stock change in soil for this category represented gains of 0.108 and 52.09 Gg C, but the DOM from Land converted to Grassland represented the losses of -0.079 Gg C in the reporting year 2015. Summary of CO_2 removals are shown in ***Figure 6.16***.

Figure 6.16: *Summary of CO_2 removals (in Gg) in the category 4.C.2 in 1990 – 2015*



6.7.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty analysis for land use category 4.C was guided by tier 1 methods using the equations 3.1 and 3.2 (Volume 1, Chapter 3, IPCC 2006 GL) following the recommendations of the ERT (UNFCCC recommendation No L.7 of the SVK 2016 ARR).

EQUATION 3.1

COMBINING UNCERTAINTIES – APPROACH 1 – MULTIPLICATION

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \ldots + U_n^2}$$

U_{total} is the percentage uncertainty in the product of the quantities and U_i denotes the percentage uncertainties with each of the quantities (IPCC 2006 GL).

EQUATION 3.2
COMBINING UNCERTAINTIES – APPROACH 1 – ADDITION AND SUBTRACTION

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

U_{total} is the percentage uncertainty in the sum of the quantities (half the 95 per cent confidence interval divided by the total (i.e., mean) and expressed as a percentage). This term 'uncertainty' is based upon the 95 per cent confidence interval; x_i and U_i are the uncertain quantities and the percentage uncertainties associated with them, respectively.

***Table 6.17:** Uncertainties in Grassland category*

IPCC CATEGORY		ACTIVITY DATA (%)	EMISSION FACTOR (%)	EF REFERENCES
4.B.1	Cropland remaining cropland - living biomass	3	75.00	IPCC 2006 GL
4.B.1	Cropland remaining cropland – mineral soil	3	76.09	expert judgement
4.B.2.1	Land converted to cropland - living biomass	3	107.98	IPCC 2006 GL (tab. 5.1, 6.4), Šmelko et al. 2003
4.B.2.2	Land converted to cropland – DOM (DW/litter)	3	75.24	SVK NFI, expert judgement
4.B.2.3	Land converted to cropland - mineral soil	3	75.00	expert judgement

Because the change in living biomass, DOM and soil was set to zero, assessment of uncertainty is not required for Grassland remaining Grassland (IPCC 2006 GL). The following values of activity data and emission factors were used for estimation uncertainty in individual C pools and LU categories: default uncertainty values (IPCC 2003, 2006 GL) - areas of land use 3%, biomass stock prior conversion in FL 20%, biomass stock prior conversion in CL 75%, biomass stock after conversion 75%, dead wood 6%, litter stock 75%, mineral soil C stock 75%. According to the expert estimation and based on statistical approach for the estimation of forest wood stocks published by Šmelko et al. (2003), the uncertainty represented the range of 15-20%. Accuracy of dead wood volume for different parts of DW and tree species was published by Šmelko et al. (2008). More information is in the section Forest Land uncertainty of this chapter.

The uncertainty estimated for Grassland category reached the 151%, uncertainty in Land converted to Grassland reached 151% in 2015.

The time series are consistent, estimated by the consistent methodology, activity data collection way and using consistent emission factors and other parameters.

6.8 WETLANDS (CRF 4.D)

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 land use category is unchanged since 1990.

Permanent surface waters have no carbon stock by definition.

6.9 SETTLEMENTS (CRF 4.E)

The settlements land use was reported as a separate category for the first time in the reporting year 2009. This category represented 4.8% of the total country area. Total area of settlements was

235.511 kha in 2015. The increasing trend of settlements area is visible in 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 area decrease of Cropland and other land use categories.

The total area of Settlements remaining Settlements category is 117.90 kha, the changes in the Settlements were as follows: FL converted to S 0.98 kha, CL converted to S 15.47 kha, GL converted to S 5.67 kha and OL converted to S 95.50 kha in 2015 as described in ***Figures 6.17*** and ***6.18***.

Figure 6.17: *Development of activity data in kha in 4.E Settlements in the period 1990 –2015*

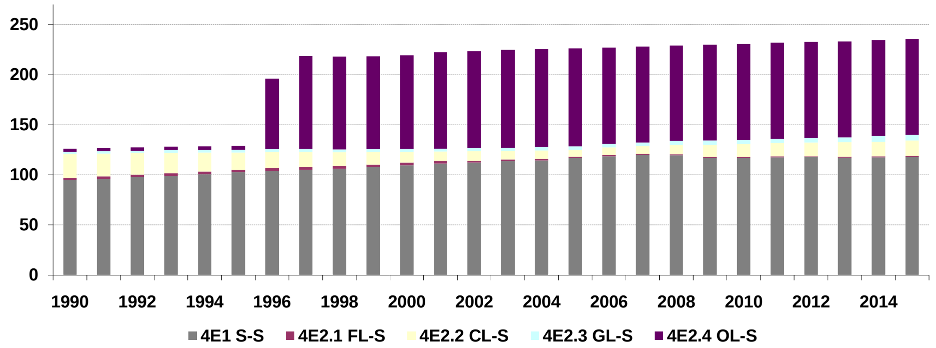
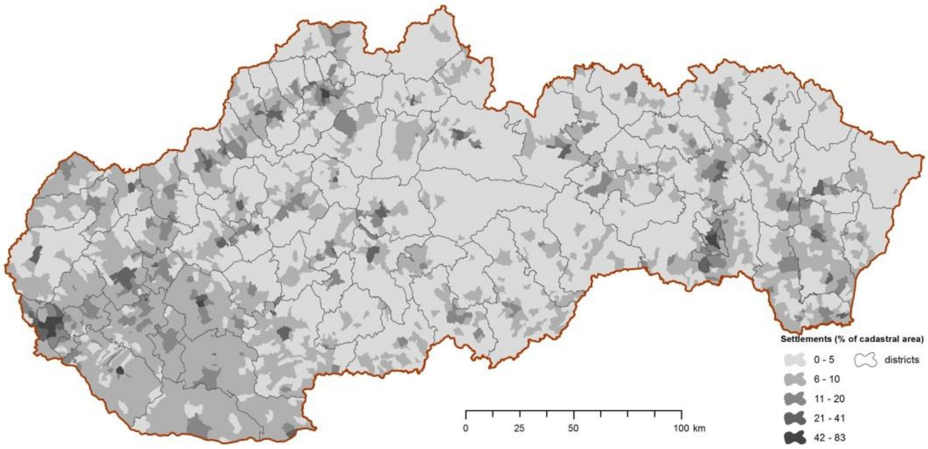


Figure 6.18: *Distribution of Settlements in Slovakia – calculated as a spatial share of the category within individual cadastral units*



6.9.1 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.

6.9.2 LAND CONVERTED TO SETTLEMENTS (CRF 4.E.2)

This category includes all processes connected with conversion of Lands into Settlements.

6.9.2.1 Methodological issues – methods, activity data, emission factors and parameters

Tier 1 method from the IPCC 2006 GL Vol. 4 was used for carbon stock changes in biomass calculation. Tier 1 method requires estimation of the biomass of the land use before conversion 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 method 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 sections 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 section Land converted to Cropland.

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., 1999, 2002, 2013, Pavlenda, 2008) and loss of carbon in the year of conversion. The mean value is 8.3 t C/ha/yr for C stocks in litter (representing surface organic layer) was used in calculation of annual change in litter C stocks for Forest Land converted to Settlements. To apply instant oxidation of carbon in litter with respect to the UNFCCC recommendation L.15 (SVK ARR 2016), litter stock under the new land-use category was set to 0 ad transition time period to 1 in equation 2.23 (IPCC 2006 GL).

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 land-use" conditions was applied. The net carbon stock change in mineral soils was estimated by using country specific tier 2 method 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 4.A.2 Land converted to FL. The soil carbon stocks were calculated for the depth to 30 cm for each of land use categories. More information is in the Chapter 6.5.3.1 of this report.

The average annual C stock change in mineral soil for different conversion of Land to Settlement category 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/yr) 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/yr;
- CL converted to S -0.313 t C/ha/yr;
- GL converted to S -1.055 t C/ha/yr.

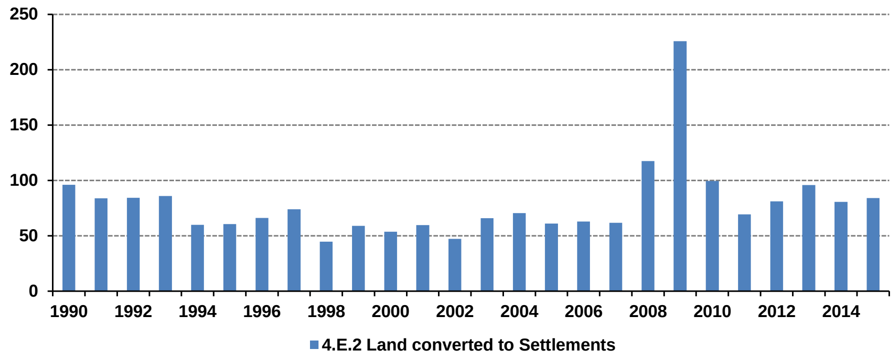
The change in soil carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category of land use associated with Land converted to Settlements. The land-use matrix from 1995 to 2015 is provided in the ***Table 6.10***. The results from the category 4.E.2 Land converted to Settlements in 2015 are summarized in the ***Table 6.18***. Summary of CO_2 removals are shown in ***Figure 6.19***.

Table 6.18: *Results for the category 4.E.2 Land converted to Settlements in 2015*

LAND USE CATEGORY	CARBON STOCK CHANGE IN LIVING BIOMASS (Gg C)			NET CARBON STOCK CHANGE IN DOM (Gg C)	NET CARBON STOCK CHANGE IN SOIL (Gg C)	NET CO_2 EMISSIONS/ REMOVALS (Gg CO_2)
	gains	losses	net change			
Land – S	**NO**	**-9.90**	**-9.90**	**-0.51**	**-12.54**	**84.15**
FL – S	NO	-4.24	-4.24	-0.51	-1.72	23.71
CL – S	NO	-3.06	-3.06	NO	-4.84	28.97
GL – S	NO	-2.60	-2.60	NO	-5.98	31.47
WL – S	NO	NO	NO	NO	NO	NO
OL – S	NO	NO	NO	NO	NO	NO

In the reporting year 2015 total emissions estimated in this category were 84.15 Gg CO_2, the net carbon stock change in living biomass, DOM and in soil for this category represented losses of -9.90, -0.51 and -12.54 Gg C respectively.

Figure 6.19: *Summary of CO_2 emissions (in Gg) in the category 4.E.2 in 1990 – 2015*



6.9.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty analysis for land use category 4.E was guided by tier 1 methods using the equations 3.1 and 3.2 (Volume 1, Chapter 3, IPCC 2006 GL) following the recommendations of the ERT (recommendation No L.7 of the SVK 2016 ARR).

EQUATION 3.1
COMBINING UNCERTAINTIES – APPROACH 1 – MULTIPLICATION

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \ldots + U_n^2}$$

U_{total} is the percentage uncertainty in the product of the quantities and U_i denotes the percentage uncertainties with each of the quantities (IPCC 2006 GL).

EQUATION 3.2
COMBINING UNCERTAINTIES – APPROACH 1 – ADDITION AND SUBTRACTION

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

U_{total} is the percentage uncertainty in the sum of the quantities (half the 95 per cent confidence interval divided by the total (i.e., mean) and expressed as a percentage). This term ‘uncertainty’ is based upon the 95 per cent confidence interval; x_i and U_i are the uncertain quantities and the percentage uncertainties associated with them, respectively.

Table 6.19: Uncertainties in Settlements category

IPCC CATEGORY		ACTIVITY DATA (%)	EMISSION FACTOR (%)	EF REFERENCES
4.E.2.1	Land converted to settlements - living biomass	3	107.98	IPCC 2006 GL (tab. 5.9, 6.4), Šmelko *et al.* 2003
4.E.2.2	Land converted to settlements – DOM (DW/litter)	3	75.24	SVK NFI, expert judgement
4.E.2.3	Land converted to settlements - mineral soil	3	75.00	expert judgement

The change in living biomass, DOM and soil was set to be zero, thus assessment of uncertainty is not required for Settlements remaining Settlements (IPCC 2006 GL). The following values of activity data and emission factors were used for estimation uncertainty in individual C pools and land-use subcategories: default uncertainty values (IPCC 2003, 2006 GL) - areas of land use 3%, biomass stock prior conversion in FL 20%, biomass stock prior conversion in CL 75%, biomass stock prior conversion in GL 75%, dead wood 6%, litter stock 75%, mineral soil C stock 75%. According to the expert estimation and based on statistical approach for the estimation of forest wood stocks published by Šmelko et al. (2003), the uncertainty represented the range of 15-20%. Accuracy of dead wood volume for different parts of DW and tree species was published by Šmelko et al. (2008). More information is in the section Forest land uncertainty of this chapter.

The uncertainty estimated for Settlements category reached the 151%, uncertainty in Land converted to Settlements reached 151% in 2015.

The time series are consistent, estimated by the consistent methodology, activity data collection way and using consistent emission factors and other parameters.

6.10 OTHER LAND (CRF 4.F)

The emissions and removals of GHGs in this category were estimated by using the IPCC 2006 GL and national data on area of Other Land and Land converted to Other Land during the inventory year 2015. The total area of Other Land represented 164.28 kha in 2015 which is 3.4% of the total country area. Other Land area decreased between 1995 and 1997, since that year the trend has been balanced.

The total area of Other Land remaining Other Land was 130.04 kha, the changes in Other Land were following: FL converted to OL 2.05 kha, CL converted to OL 14.50 kha, GL converted to OL 6.59 kha, S converted to OL 11.09 kha in 2015 as is as is described in ***Figures 6.20*** and ***6.21***.

Figure 6.20: *Development of activity data in kha for 4.F Other Land in the period 1990 – 2015*

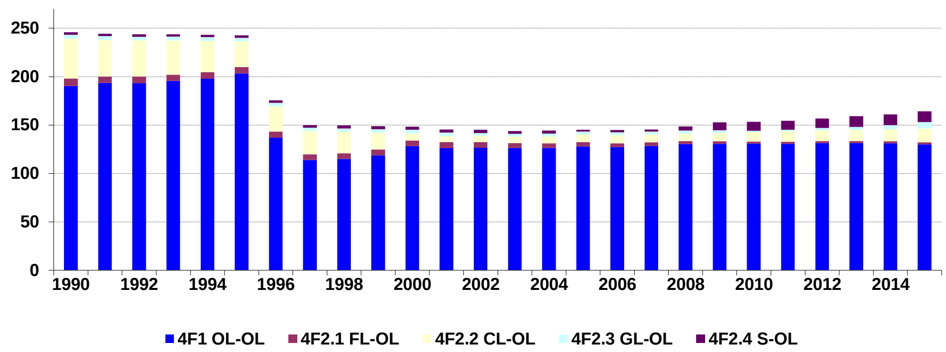
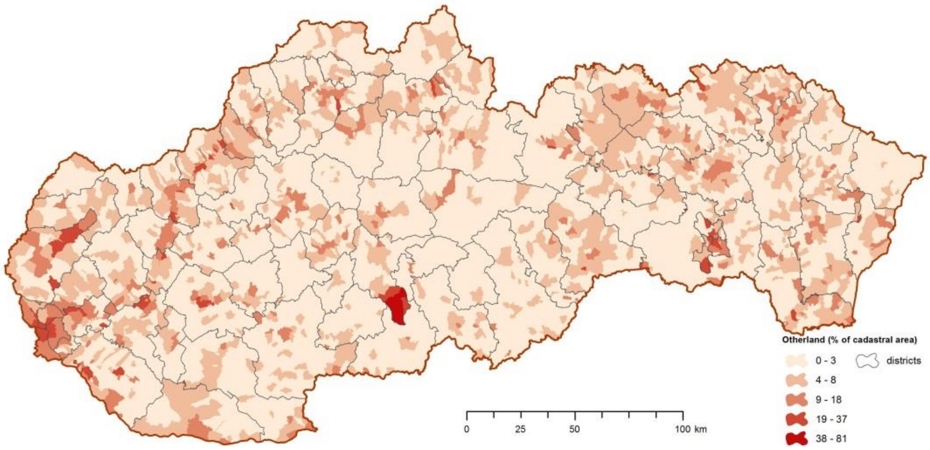


Figure 6.21: Distribution of Other Land in Slovakia – calculated as a spatial share of the category within individual cadastral units



6.10.1 OTHER LAND REMAINING OTHER LAND (CRF 4.F.1)

The emissions of CO_2 can be considered insignificant as no change in living biomass, DOM (dead wood and litter) and soil carbon pools is assumed (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.

6.10.2 LAND CONVERTED TO OTHER LAND (CRF 4.F.2)

This category includes all processes connected with conversion of Land into Other Land. Tier 1 method (IPCC 2006 GL) was used for carbon stock changes in biomass calculation. Tier 1 method requires estimates of the biomass of the land use before conversion 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.

6.10.2.1 Methodological issues – methods, activity data, emission factors and parameters

Tier 1 method follows the approach described in section Forest Land of this chapter, 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 sections above.

Estimation of DOM includes the emissions changes in dead wood in Forest Land. The calculation procedure is identical as described in detail in section Land converted to Settlements.

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., 1999, 2002, 2013, Pavlenda, 2008) and total loss of litter in the year of conversion. The mean value 8.3 Mg C/ha/yr 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/yr) * 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 of land-use associated with FL converted to OL. To apply instant oxidation of carbon in litter with respect to recommendations of the ERT (request No L.15 of the SVK 2016 ARR), litter stock under the new land-use category was set to 0 and transition time period to 1.

The calculation of carbon stock changes in mineral soils was based on the data from the soil inventory with the default 20 years period for carbon stock equilibrium in „new land-use“ conditions. The net carbon stock change in mineral soils was estimated by using country specific tier 2 method described in detail in Chapter 6.5.3.1 of this report. Net carbon stock change in mineral soil was used for estimation of the average carbon stock per hectare noted above (4.A.2 Land converted to FL). The soil carbon stocks were calculated for the depth 30 cm for each of land use categories.

The average annual C stock change in mineral soil for different conversion of Land to OL category 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/yr) * 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/yr
- CL converted to OL -0.313 t C ha/yr
- GL converted to OL -0.704 t C ha/yr

The change in soil carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category of land-use associated with Land converted to Other Land. The land-use matrix from 1995 to 2015 is provided in the ***Table 6.10***.

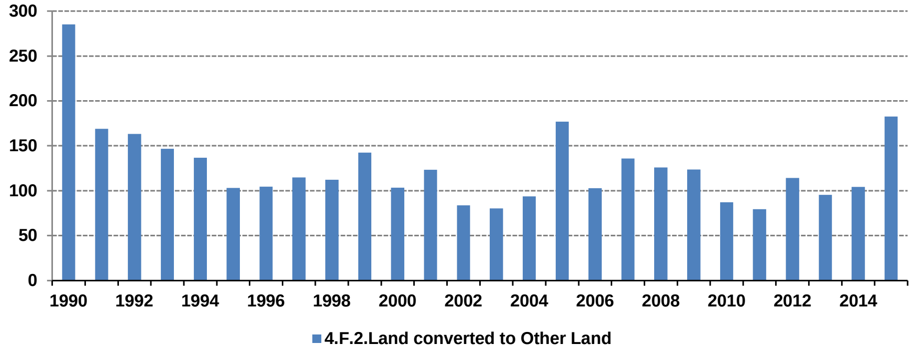
The results from the category 4.F.2 Land converted to Other Land are summarized in the following ***Table 6.20*** and summary of CO_2 emissions during the years in ***Figure 6.22***.

Table 6.20: *Results for the category 4.F.2 Land converted to Other Land in 2015*

LAND USE CATEGORY	CARBON STOCK CHANGE IN LIVING BIOMASS (Gg C)			NET CARBON STOCK CHANGE IN DOM (Gg C)	NET CARBON STOCK CHANGE IN SOIL (Gg C)	NET CO_2 EMISSIONS/ REMOVALS (Gg CO_2)
	gains	losses	net change			
Land - OL	**NO**	**-33.61**	**-33.61**	**-1.07**	**-15.10**	**182.51**
FL – OL	NO	-8.80	-8.80	-1.07	-3.61	49.40
CL – OL	NO	-8.67	-8.67	NO	-4.54	48.42
GL – OL	NO	-16.15	-16.15	NO	-6.95	84.70
WL – OL	NO	NO	NO	NO	NO	NO
S - OL	NO	NO	NO	NO	NO	NO

Total emissions estimated in this category were 182.51 Gg CO_2 in 2015. The net carbon stock change in living biomass, DOM and soil for this category represented losses of -33.61, -1.07 and -15.10 Gg C respectively.

Figure 6.22: *Summary of CO_2 emissions (in Gg) in 4.F.2 in 1990 – 2015*



6.10.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty analysis for land-use category 4.F was guided by Tier 1 methods using the equations 3.1 and 3.2 (Volume 1, Chapter 3, IPCC 2006 GL) following the recommendations of the ERT (recommendation No L.7 of the SVK 2016 ARR).

EQUATION 3.1
COMBINING UNCERTAINTIES – APPROACH 1 – MULTIPLICATION

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \ldots + U_n^2}$$

U_{total} is the percentage uncertainty in the product of the quantities and U_i denotes the percentage uncertainties with each of the quantities (IPCC 2006 GL).

EQUATION 3.2
COMBINING UNCERTAINTIES – APPROACH 1 – ADDITION AND SUBTRACTION

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

U_{total} is the percentage uncertainty in the sum of the quantities (half the 95 per cent confidence interval divided by the total (i.e. mean) and expressed as a percentage). This term 'uncertainty' is based upon the 95 per cent confidence interval; x_i and U_i are the uncertain quantities and the percentage uncertainties associated with them, respectively.

Table 6.21: *Uncertainties in Other Land category*

IPCC CATEGORY		ACTIVITY DATA (%)	EMISSION FACTOR (%)	EF REFERENCES
4.E.2.1	Land converted to Other land - living biomass	3	107.98	IPCC 2006 GL (tab. 5.9, 6.4), Šmelko *et al.* 2003
4.E.2.2	Land converted to Other land – DOM (DW/litter)	3	75.24	SVK NFI, expert judgement
4.E.2.1	Land converted to Other land - living biomass	3	107.98	IPCC 2006 GL (tab. 5.9, 6.4), Šmelko *et al.* 2003

Because the change in living biomass, DOM and soil was set to zero, assessment of uncertainty is not required for Other Land remaining Other Land (IPCC 2006 GL). The following values of activity data and emission factors were used for estimation uncertainty in individual C pools and land-use categories: default uncertainty values (IPCC 2003, 2006 GL) - areas of land use 3%, biomass stock prior conversion in FL 20%, biomass stock prior conversion in CL 75%, biomass stock prior conversion in GL 75%, dead wood 6%, litter stock 75%, mineral soil C stock 75%. According to the expert estimation and based on statistical approach for the estimation of forest wood stocks published by

Šmelko et al. (2003), the uncertainty represented the range of 15-20%. Accuracy of dead wood volume for different parts of DW and tree species was published by Šmelko et al. (2008). More information is in the section Forest Land uncertainty of this chapter.

The uncertainty estimated for Other Land category reached the 151%, uncertainty in Land converted to Other Land reached 151% in 2015.

The time series are consistent, estimated by the consistent methodology, activity data collection way and using consistent emission factors and other parameters.

6.11 DIRECT N_2O EMISSIONS FROM N FERTILIZATION OF FOREST LAND AND OTHER (CRF 5(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, as there is no practice of nitrogen fertilization of forest stands in Slovakia.

6.12 NON CO_2 EMISSIONS FROM DRAINAGE OF SOILS AND WETLANDS (CRF 4 (II))

Emissions and removals from drainage and rewetting and other management of organic and mineral soils (CRF 4 II)

There are not any CO_2 and non-CO_2 emissions related to drainage of wet forest soils reported. Spots of wet forest soils are classified as peat land in Slovakia and therefore this land belongs to protected areas without active management. The current area of peat lands is only 2 773 ha (Stanová et al., 2000).

6.13 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 4(III)

The emissions of N_2O (the annual release of N_2O from soils due to mineralisation of soil organic matter after disturbance) were calculated by default tier 1 methodology 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 and GL converted to CL, 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 6.22***.

Table 6.22: *Results for 4(III) – Direct N_2O emissions from N mineralization/Immobilization in 2015*

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA	IMPLIED EMISSION FACTORS	EMISSIONS
LAND-USE 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	**166.84**	**0.22**	**0.06**
B. Cropland	**25.44**	**0.71**	**0.03**
2. Lands converted to Cropland	25.44	1.11	0.03
Organic Soils	NO	NO	NO
Mineral Soils	25.44	1.11	0.03
2.1 Forest Land converted to Cropland	0.35	2.55	0.001
Organic Soils	NO	NO	NO
Mineral Soils	0.35	2.55	0.001
2.2 Grassland converted to Cropland	25.09	1.08	0.03
Organic Soils	NO	NO	NO
Mineral Soils	25.09	1.08	0.03
2.3 Wetlands converted to Cropland	NO	NO	NO
Organic Soils	NO	NO	NO
Mineral Soils	NO	NO	NO
2.4 Settlements converted to Cropland	NO	NO	NO
Organic Soils	NO	NO	NO
Mineral Soils	NO	NO	NO
2.5 Other Land converted to Cropland	2.00	NO	NO
Organic Soils	NO	NO	NO
Mineral Soils	2.00	NO	NO

Other non-CO_2 emissions may be related to those from biomass burning. Biomass burning is not common practice in Cropland and Grassland categories in Slovakia, these activities are strictly prohibited by the Act No 314/2001 Coll. on Fire Protection.

6.14 INDIRECT NITROUS OXIDE (N_2O) EMISSIONS FROM MANAGED SOILS (CRF 4 IV)

The indirect nitrous oxide (N_2O) emissions from managed soils are included in the Agricultural sector. The reason is that the sources of nitrogen (N) could not be separated other than between cropland and grasslands in Slovak conditions.

6.15 BIOMASS BURNING (CRF 4 V)

Calculation of GHG emissions from biomass burning is included in the category Forest Land remaining Forest Land as well as Land converted to Forest Land. Biomass burning is not common practice in Cropland and Grassland categories in Slovakia, these activities are strictly prohibited by the Act No 314/2001 Coll. on Fire Protection.

6.16 HARVESTED WOOD PRODUCTS (HWP)

Since 2015 Slovakia started to report on the carbon stock changes and associated emissions and removals of CO_2 from the harvested wood products pool. The considered carbon pool is defined as the wood products in service life within the country. The carbon pool includes products generated from the wood production in the country in forests remaining forests and land converted to forests. The losses from the pool are to landfill and the atmosphere. Emissions from landfill are reported under the waste sector of the inventory.

For the carbon balance purposes the roundwood category is split to the industrial roundwood and fuelwood subcategories. Contrary to the energetic use of wood (fuelwood) for which an instantaneous oxidation is applied, the long-term used HWP as sawnwood, 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 IPCC 2013 GL for KP: 35 years for sawnwood, 25 years for wood-based panels and 2 years for paper products.

The estimation approach applied for HWP accounting calculates delayed emissions on the basis of the annual stock change of semi-finished wood products using the first order decay function following equation 12.1 in the IPCC 2006 GL, Vol. 4, Ch. 12. The carbon stock changes in forests are estimated in the category 4.A (Forest Land).

6.16.1 ACTIVITY DATA

The activity data (production and trade of sawnwood, wood based panels and paper and paperboard) are derived from the FAO database on wood production and trade (http://faostat3.fao.org/download/F/FO/E). The data are available since 1961, however, data for Slovakia (SR) and Czech Republic (CR) are aggregated before the split of Czechoslovakia (CS) in 1993. To calculate share of SR and CR on individual HWP in the period 1961 – 1992, the CS figures were multiplied by 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 CR and SR production, import and export quantities of main HWP categories, calculated as an average of country specific shares according to FAO data in the period 1993 – 1997, is provided in the ***Table 6.23***.

Table 6.23: *The share of CR and SR on the HWP in the period 1993 – 1997 and default half-lives*

WOOD PRODUCT	FAO CODE	PRODUCTION		IMPORT		EXPORT		DEFAULT HALF-LIFE (YR)
		CR	SR	CR	SR	CR	SR	
Sawn wood	1872	0.834	0.166	0.868	0.132	0.723	0.277	35
Wood based boards	1873	0.716	0.284	0.719	0.281	0.851	0.149	25
Paper and paperboards	1876	0.655	0.345	0.772	0.228	0.598	0.402	2

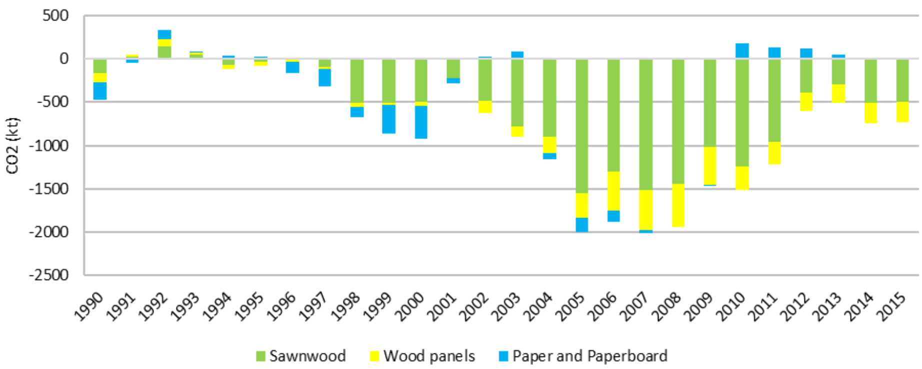
The change in carbon stocks was estimated separately for each product category by applying equation 2.8.4 in IPCC 2013 GL for KP. Instantaneous oxidation was applied to HWPs originating from deforestations, which results in a conservative estimate of carbon stock changes in the HWP-pool.

The results of gains and losses of CO_2 from domestically produced and used HWP are provided in the next ***Table 6.24*** and ***Figure 6.23***.

Table 6.24: *Greenhouse gas emissions (positive values) and removals (negative values) from HWP from Forest Land under Forest Management in particular years*

CO_2 EMISSIONS AND REMOVALS FROM HWP	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
	NET EMISSIONS/REMOVALS (Gg CO_2 eq.)									
4G (UNFCCC) / Art. 3.4 (KP)	**-470.41**	**-58.77**	**-920.07**	**-1 996.5**	**-1 334.5**	**-1 083.4**	**-480.21**	**-455.50**	**-730.64**	**-721.44**
gains sawnwood	644.3	528.7	1027.0	2144.2	1972.9	1704.9	1147.8	1066.0	1289.1	1285.3
gains wood panels	381.9	327.9	330.0	582.4	619.5	620.6	583.4	581.0	611.8	624.3
gains paper	606.8	382.8	1107.8	993.8	710.3	702.7	670.7	714.8	740.5	734.8
losses sawnwood	-482.8	-498.8	-526.2	-593.8	-726.0	-747.8	-761.1	-767.9	-775.9	-786.0
losses wood panels	-268.6	-277.6	-282.0	-299.0	-357.5	-364.7	-371.2	-377.0	-383.0	-389.4
losses paper	-411.2	-404.2	-736.5	-831.1	-884.6	-832.4	-789.4	-761.5	-751.8	-747.6

Figure 6.23: *CO_2 emissions (positive values) and removals (negative values) from HWP in Slovakia in 1990 and 2015 originating from Forest Land under Forest Management in Gg CO_2 eq.*



6.16.2 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty analysis for land use category 4.F was guided by tier 1 methods using the equation 3.1 (Volume 1, Chapter 3, IPCC 2006 GL).

EQUATION 3.1
COMBINING UNCERTAINTIES – APPROACH 1 – MULTIPLICATION

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \ldots + U_n^2}$$

U_{total} is the percentage uncertainty in the product of the quantities and U_i denotes the percentage uncertainties with each of the quantities (IPCC 2006 GL).

For the input data following information on relative uncertainty was used: roundwood harvest: ±5% (national activity data from reporting of forest managers), sawnwood, 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% (default from IPCC 2006 GL).

The total relative uncertainty of carbon losses and gains in HWP was 58% in 2015.

ANNEX

***Table A6.1**: Land-use matrixes identifying annual land-use conversions among the categories for the period 1990 – 2014 and describing initial and final areas of particular land-use categories (kha)*

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	**Initial area (1989)**
Forest Land (managed)	1 985.219	0.000	0.010	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**
Cropland	0.088	0.000	1 638.926	0.754	0.000	0.000	0.000	0.352	0.000	0.000	**1 640.120**
Grassland (managed)	1.421	0.000	1.407	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**
Wetland (managed)	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**
Settlements	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	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**
Final area (1990)	**1 988.989**	**0.000**	**1 640.343**	**808.291**	**0.000**	**94.000**	**0.000**	**126.034**	**245.863**	**0.000**	4 903.520
Net change	**2.961**	**0.000**	**0.223**	**-4.405**	**0.000**	**0.000**	**0.000**	**0.926**	**0.295**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	**Initial area (1990)**
Forest Land (managed)	1 988.001	0.000	0.045	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**
Cropland	0.012	0.000	1 638.008	2.323	0.000	0.000	0.000	0.000	0.000	0.000	**1 640.343**
Grassland (managed)	0.325	0.000	0.941	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**
Wetland (managed)	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**
Settlements	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	0.126	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**
Final area (1991)	**1 989.964**	**0.000**	**1 639.138**	**809.476**	**0.000**	**94.000**	**0.000**	**126.591**	**244.351**	**0.000**	4 903.520
Net change	**0.975**	**0.000**	**-1.205**	**1.185**	**0.000**	**0.000**	**0.000**	**0.557**	**-1.512**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	**Initial area (1991)**
Forest Land (managed)	1 989.640	0.000	0.002	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**
Cropland	0.202	0.000	1 614.944	22.173	0.000	0.000	0.000	0.492	1.327	0.000	**1 639.138**
Grassland (managed)	0.196	0.000	0.793	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**
Wetland (managed)	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**
Settlements	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	0.770	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**
Final area (1992)	**1 991.107**	**0.000**	**1 615.739**	**831.411**	**0.000**	**94.000**	**0.000**	**127.485**	**243.778**	**0.000**	**4 903.520**
Net change	**1.143**	**0.000**	**-23.399**	**21.935**	**0.000**	**0.000**	**0.000**	**0.894**	**-0.573**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	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	0.175	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**
Cropland	0.008	0.000	1 610.382	4.595	0.000	0.000	0.000	0.285	0.469	0.000	**1 615.739**
Grassland (managed)	0.227	0.000	0.975	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**
Wetland (managed)	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**
Settlements	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	0.158	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**
Final area (1993)	**1 991.463**	**0.000**	**1 611.359**	**834.632**	**0.000**	**94.000**	**0.000**	**128.267**	**243.799**	**0.000**	**4 903.520**
Net change	**0.356**	**0.000**	**-4.38**	**3.221**	**0.000**	**0.000**	**0.000**	**0.782**	**0.021**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	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	0.186	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**
Cropland	0.019	0.000	1 610.344	0.869	0.000	0.000	0.000	0.127	0.000	0.000	**1 611.359**
Grassland (managed)	0.308	0.000	0.553	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**
Wetland (managed)	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**
Settlements	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	0.044	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**
Final area (1994)	**1 991.671**	**0.000**	**1 611.203**	**834.826**	**0.000**	**94.000**	**0.000**	**128.463**	**243.357**	**0.000**	**4 903.520**
Net change	**0.208**	**0.000**	**-0.156**	**0.194**	**0.000**	**0.000**	**0.000**	**0.196**	**-0.442**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	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	0.063	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**
Cropland	0.028	0.000	1 605.789	5.386	0.000	0.000	0.000	0.000	0.000	0.000	**1 611.203**
Grassland (managed)	0.556	0.000	0.725	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**
Wetland (managed)	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**
Settlements	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	0.243	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**
Final area (1995)	**1 992.257**	**0.000**	**1 606.619**	**839.025**	**0.000**	**94.000**	**0.000**	**128.989**	**242.630**	**0.000**	**4 903.520**
Net change	**0.586**	**0.000**	**-4.584**	**4.199**	**0.000**	**0.000**	**0.000**	**0.526**	**-0.727**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	**Initial area (1995)**
Forest Land (managed)	1 991.789	0.000	0.098	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**
Cropland	0.107	0.000	1 602.023	4.015	0.000	0.000	0.000	0.474	0.000	0.000	**1 606.619**
Grassland (managed)	1.113	0.000	0.610	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**
Wetland (managed)	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**
Settlements	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	0.117	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**
Final area (1996)	**1 993.366**	**0.000**	**1 602.731**	**841.714**	**0.000**	**94.000**	**0.000**	**196.143**	**175.566**	**0.000**	**4 903.520**
Net change	**1.109**	**0.000**	**-3.888**	**2.689**	**0.000**	**0.000**	**0.000**	**67.154**	**-67.064**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	**Initial area (1996)**
Forest Land (managed)	1 992.978	0.000	0.026	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**
Cropland	0.130	0.000	1 597.803	4.634	0.000	0.000	0.000	0.164	0.000	0.000	**1 602.731**
Grassland (managed)	0.311	0.000	1.214	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**
Wetland (managed)	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**
Settlements	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	0.565	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**
Final area (1997)	**1 996.373**	**0.000**	**1 599.043**	**845.591**	**0.000**	**94.000**	**0.000**	**218.584**	**149.929**	**0.000**	**4 903.520**
Net change	**3.007**	**0.000**	**-3.688**	**3.877**	**0.000**	**0.000**	**0.000**	**22.441**	**-25.637**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	**Initial area (1997)**
Forest Land (managed)	1 995.995	0.000	0.004	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**
Cropland	0.067	0.000	1 593.835	4.724	0.000	0.000	0.000	0.000	0.417	0.000	**1 599.043**
Grassland (managed)	0.845	0.000	1.575	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**
Wetland (managed)	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**
Settlements	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	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**
Final area (1998)	**1 998.283**	**0.000**	**1 595.414**	**848.189**	**0.000**	**94.000**	**0.000**	**218.084**	**149.550**	**0.000**	**4 903.520**
Net change	**1.910**	**0.000**	**-3.629**	**2.598**	**0.000**	**0.000**	**0.000**	**-0.500**	**-0.379**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	**Initial area (1998)**
Forest Land (managed)	1 997.986	0.000	0.009	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**
Cropland	0.067	0.000	1 584.928	10.057	0.000	0.000	0.000	0.287	0.075	0.000	**1 595.414**
Grassland (managed)	0.831	0.000	0.868	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**
Wetland (managed)	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**
Settlements	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	0.027	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**
Final area (1999)	**2 000.088**	**0.000**	**1 585.805**	**856.427**	**0.000**	**94.000**	**0.000**	**218.427**	**148.773**	**0.000**	**4 903.520**
Net change	**1.805**	**0.000**	**-9.609**	**8.238**	**0.000**	**0.000**	**0.000**	**0.343**	**-0.777**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	**Initial area (1999)**
Forest Land (managed)	1 999.961	0.000	0.005	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**
Cropland	0.096	0.000	1 572.970	12.214	0.000	0.000	0.000	0.244	0.281	0.000	**1 585.805**
Grassland (managed)	0.693	0.000	2.471	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**
Wetland (managed)	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**
Settlements	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	0.643	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**
Final area (2000)	**2 001.253**	**0.000**	**1 575.446**	**865.220**	**0.000**	**94.000**	**0.000**	**219.337**	**148.264**	**0.000**	4 903.520
Net change	**1.165**	**0.000**	**-10.359**	**8.793**	**0.000**	**0.000**	**0.000**	**0.910**	**-0.509**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	**Initial area (2000)**
Forest Land (managed)	2 000.951	0.000	0.039	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**
Cropland	0.013	0.000	1 562.354	12.113	0.000	0.000	0.000	0.212	0.754	0.000	**1 575.446**
Grassland (managed)	0.422	0.000	2.596	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**
Wetland (managed)	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**
Settlements	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	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**
Final area (2001)	**2 002.129**	**0.000**	**1 564.989**	**874.416**	**0.000**	**94.000**	**0.000**	**222.475**	**145.511**	**0.000**	4 903.520
Net change	**0.876**	**0.000**	**-10.457**	**9.196**	**0.000**	**0.000**	**0.000**	**3.138**	**-2.753**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	**Initial area (2001)**
Forest Land (managed)	2 001.980	0.000	0.006	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**
Cropland	0.008	0.000	1 555.393	8.980	0.000	0.000	0.000	0.263	0.345	0.000	**1 564.989**
Grassland (managed)	0.509	0.000	1.094	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**
Wetland (managed)	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**
Settlements	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	0.596	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**
Final area (2002)	**2 002.773**	**0.000**	**1 556.493**	**881.857**	**0.000**	**94.000**	**0.000**	**223.355**	**145.042**	**0.000**	**4 903.520**
Net change	**0.644**	**0.000**	**-8.496**	**7.441**	**0.000**	**0.000**	**0.000**	**0.880**	**-0.469**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	**Initial area (2002)**
Forest Land (managed)	2 002.452	0.000	0.009	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**
Cropland	0.050	0.000	1 551.373	4.562	0.000	0.000	0.000	0.379	0.129	0.000	**1 556.493**
Grassland (managed)	1.110	0.000	1.988	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**
Wetland (managed)	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**
Settlements	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	0.872	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**
Final area (2003)	**2 004.100**	**0.000**	**1 553.370**	**883.506**	**0.000**	**94.000**	**0.000**	**224.671**	**143.873**	**0.000**	**4 903.520**
Net change	**1.327**	**0.000**	**-3.123**	**1.649**	**0.000**	**0.000**	**0.000**	**1.316**	**-1.169**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	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	0.020	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**
Cropland	0.086	0.000	1 550.248	2.156	0.000	0.000	0.000	0.517	0.363	0.000	**1 553.370**
Grassland (managed)	0.815	0.000	3.443	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**
Wetland (managed)	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**
Settlements	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	0.192	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**
Final area (2004)	**2 004.926**	**0.000**	**1 553.696**	**881.054**	**0.000**	**94.000**	**0.000**	**225.556**	**144.288**	**0.000**	4 903.520
Net change	**0.826**	**0.000**	**0.326**	**-2.452**	**0.000**	**0.000**	**0.000**	**0.885**	**0.415**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	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	0.219	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**
Cropland	0.023	0.000	1 551.175	1.146	0.000	0.000	0.000	0.601	0.751	0.000	**1 553.696**
Grassland (managed)	0.455	0.000	0.506	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**
Wetland (managed)	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**
Settlements	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	0.038	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**
Final area (2005)	**2 005.234**	**0.000**	**1 551.696**	**881.283**	**0.000**	**94.000**	**0.000**	**226.257**	**145.050**	**0.000**	4 903.520
Net change	**0.308**	**0.000**	**-2.000**	**0.229**	**0.000**	**0.000**	**0.000**	**0.701**	**0.762**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	**Initial area (2005)**
Forest Land (managed)	2 004.995	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**
Cropland	0.044	0.000	1 549.355	0.984	0.000	0.000	0.000	0.801	0.512	0.000	**1 551.696**
Grassland (managed)	0.504	0.000	0.452	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**
Wetland (managed)	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**
Settlements	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	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**
Final area (2006)	**2 006.940**	**0.000**	**1 549.807**	**880.872**	**0.000**	**94.000**	**0.000**	**227.092**	**144.809**	**0.000**	**4 903.520**
Net change	**1.706**	**0.000**	**-1.889**	**-0.411**	**0.000**	**0.000**	**0.000**	**0.835**	**-0.241**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	**Initial area (2006)**
Forest Land (managed)	2 006.486	0.000	0.068	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**
Cropland	0.065	0.000	1 547.098	1.085	0.000	0.000	0.000	0.742	0.817	0.000	**1 549.807**
Grassland (managed)	0.365	0.000	0.811	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**
Wetland (managed)	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**
Settlements	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	0.045	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**
Final area (2007)	**2 007.142**	**0.000**	**1 547.977**	**880.921**	**0.000**	**94.000**	**0.000**	**227.930**	**145.550**	**0.000**	**4 903.520**
Net change	**0.202**	**0.000**	**-1.830**	**0.049**	**0.000**	**0.000**	**0.000**	**0.838**	**0.741**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	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	0.119	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	
Cropland	0.084	0.000	1 542.661	1.248	0.000	0.000	0.000	2.479	1.505	0.000	**1 547.977**
Grassland (managed)	0.847	0.000	0.772	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	
Wetland (managed)	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	
Settlements	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	144.861	0.000	**145.550**
Total unmanaged land		0.000			0.000		0.000			0.000	
Final area (2008)	**2 008.257**	**0.000**	**1 543.625**	**879.852**	**0.000**	**94.000**	**0.000**	**229.059**	**148.727**	**0.000**	**4 903.520**
Net change	**1.115**	**0.000**	**-4.352**	**-1.069**	**0.000**	**0.000**	**0.000**	**1.129**	**3.177**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	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	0.050	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**
Cropland	0.044	0.000	1 538.045	1.264	0.000	0.000	0.000	3.371	0.901	0.000	**1 543.625**
Grassland (managed)	0.472	0.000	1.244	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**
Wetland (managed)	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**
Settlements	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	0.550	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**
Final area (2009)	**2 008.843**	**0.000**	**1 539.465**	**878.470**	**0.000**	**94.000**	**0.000**	**229.939**	**152.803**	**0.000**	**4 903.520**
Net change	**0.586**	**0.000**	**-4.160**	**-1.382**	**0.000**	**0.000**	**0.000**	**0.882**	**4.022**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	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	0.156	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**
Cropland	0.035	0.000	1 536.589	0.562	0.000	0.000	0.000	1.324	0.955	0.000	**1 539.465**
Grassland (managed)	1.218	0.000	0.778	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**
Wetland (managed)	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**
Settlements	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	0.524	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**
Final area (2010)	**2 011.249**	**0.000**	**1 537.805**	**876.484**	**0.000**	**94.000**	**0.000**	**230.588**	**153.394**	**0.000**	**4 903.520**
Net change	**2.406**	**0.000**	**-1.66**	**-1.986**	**0.000**	**0.000**	**0.000**	**0.649**	**0.591**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	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	0.013	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**
Cropland	0.115	0.000	1 535.335	0.157	0.000	0.000	0.000	0.713	1.485	0.000	**1 537.805**
Grassland (managed)	0.933	0.000	1.073	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**
Wetland (managed)	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**
Settlements	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	0.219	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**
Final area (2011)	**2 012.336**	**0.000**	**1 536.588**	**874.224**	**0.000**	**94.000**	**0.000**	**231.967**	**154.405**	**0.000**	**4 903.520**
Net change	**1.087**	**0.000**	**-1.217**	**-2.26**	**0.000**	**0.000**	**0.000**	**1.379**	**1.011**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	**Initial area (2011)**
Forest Land (managed)	2 012.214	0.000	0.002	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**
Cropland	0.274	0.000	1 533.791	0.546	0.000	0.000	0.000	0.725	1.252	0.000	**1 536.588**
Grassland (managed)	1.044	0.000	0.746	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**
Wetland (managed)	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**
Settlements	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	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**
Final area (2012)	**2 014.059**	**0.000**	**1 534.647**	**871.324**	**0.000**	**94.000**	**0.000**	**232.599**	**156.891**	**0.000**	**4 903.520**
Net change	**1.723**	**0.000**	**-1.941**	**-2.900**	**0.000**	**0.000**	**0.000**	**0.632**	**2.486**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unma-naged land	**Initial area (2012)**
Forest Land (managed)	2 013.955	0.000	0.006	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**
Cropland	0.057	0.000	1 532.540	0.258	0.000	0.000	0.000	0.915	0.877	0.000	**1 534.647**
Grassland (managed)	0.800	0.000	0.872	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**
Wetland (managed)	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**
Settlements	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	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**
Final area (2013)	**2 015.368**	**0.000**	**1 533.632**	**868.061**	**0.000**	**94.000**	**0.000**	**233.305**	**159.154**	**0.000**	**4 903.520**
Net change	**1.309**	**0.000**	**-1.015**	**-3.263**	**0.000**	**0.000**	**0.000**	**0.706**	**2.263**	**0.000**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	**Initial area (2013)**
Forest Land (managed)	2 015.219	0	0.004	0.052	0	0	0	0.037	0.056	0	**2 015.368**
Forest Land (unmanaged)	0	0	0	0	0	0	0	0	0	0	**0**
Cropland	0.168	0	1 531.511	0.113	0	0	0	0.604	1.236	0	**1 533.632**
Grassland (managed)	1.582	0	0.675	864.516	0	0	0	0.420	0.868	0	**868.061**
Grassland (unmanaged)	0	0	0	0	0	0	0	0	0	0	**0**
Wetland (managed)	0	0	0	0	0	94	0	0	0	0	**94**
Wetland (unmanaged)	0	0	0	0	0	0	0	0	0	0	**0**
Settlements	0	0	0	0	0	0	0	233.305	0	0	**233.305**
Other Land	0.136	0	0.169	0	0	0	0	0.05	158.799	0	**159.154**
Total unmanaged land	0	0	0	0	0	0	0	0	0	0	**0**
Final area (2014)	**2 017.105**	**0**	**1 532.359**	**864.681**	**0**	**94**	**0**	**234.416**	**160.959**	0	**4 903.52**
Net change	**1.737**	**0**	**-1.273**	**-3.380**	**0**	**0**	**0**	**1.111**	**1.805**	**0**	

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	**Initial area (2014)**
Forest Land (managed)	2 016.971	0	0.008	0.006	0	0	0	0.039	0.081	0	**2 017.105**
Forest Land (unmanaged)	0	0	0	0	0	0	0	0	0	0	**0**
Cropland	0.273	0	1 529.143	0.448	0	0	0	0.651	1.844	0	**1 532.359**
Grassland (managed)	2.302	0	1.299	858.147	0	0	0	0.407	2.526	0	**864.681**
Grassland (unmanaged)	0	0	0	0	0	0	0	0	0	0	**0**
Wetland (managed)	0	0	0	0	0	94	0	0	0	0	**94**
Wetland (unmanaged)	0	0	0	0	0	0	0	0	0	0	**0**
Settlements	0	0	0	0	0	0	0	233.414	0.002	0	**234.416**
Other Land	0.57	0	0.566	0	0	0	0	0	159.823	0	**160.959**
Total unmanaged land	0	0	0	0	0	0	0	0	0	0	**0**
Final area (2015)	**2 020.116**	**0**	**1 531.016**	**858.601**	**0**	**94**	**0**	**235.511**	**164.276**	0	**4 903.52**
Net change	**3.011**	**0**	**-1.343**	**-6.080**	**0**	**0**	**0**	**1.095**	**3.317**	**0**	

CHAPTER 7: WASTE (CRF 5) 341

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:

INSTITUTE	CHAPTER	SECTORAL EXPERT
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7.1 OVERVIEW OF THE SECTOR (CRF 5)

Inventory of emissions from waste sector includes direct (CH_4, CO_2, N_2O) and indirect emissions (NMVOCs) greenhouse gas emissions. Methane is generated from solid waste disposal sites, biological treatment of waste, waste incineration and waste water treatment. Main source of CO_2 is waste incineration. N_2O is generated from biological treatment of waste and from waste water treatment. Estimation of the following emission categories in 2017 submission is presented in this chapter:

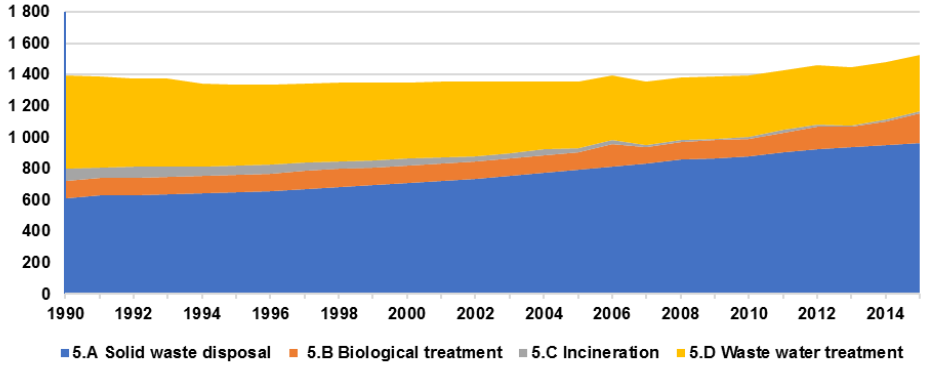
- 5.A Solid waste disposal;
- 5.B Biological treatment of solid waste;
- 5.C Incineration and open burning of waste;
- 5.D Wastewater treatment and discharge;
- 5.F Memo Items (HWP).

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 under energy sector, subcategory 1.A.1.a.iv (other fuels). Emissions from waste incineration without energy utilisation are reported under waste sector (5.C). Emissions from waste composting are reported under biological treatment. No anaerobic digestion of solid waste at biogas facilities without energy use was identified in Slovakia. The model for estimating emissions from domestic wastewater treatment was accommodated to reflect legal requirements on nitrogen removal, which shall achieve 75-85% removal efficiency[1] in advanced waste water treatment plants.

Emissions from waste sector are relatively stable over the entire period 1990 – 2015 as ***Figure 7.1*** shows. Emissions from waste disposal (5.A) are increasing in long term, due to improvement of disposal practice. Emissions from waste water treatment (5.D) are decreasing also due to modernisation of waste water treatment plants. Emissions from biological treatment (5.B) do not vary significantly, but there is an increase in the last years (2011 – 2015) due to increasing amounts of waste sent for composting. Emissions from incineration of waste without energy recovery (5.C) have decreased compared to base year, but they have stabilised in the period 2010 – 2015. However, trends on biological treatment and incineration should be taken with caution, because half of time series (1990 – 1997) had to be extrapolated due to missing data.

[1] Governmental Regulation No. 268/2010, as amended No. 491/2002 Z.z. and No. 242/1993 Z.z

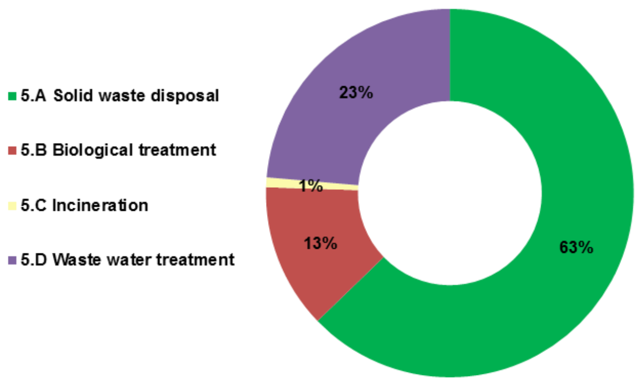
***Figure 7.1**: Trend in aggregated emissions by categories within waste sector in 1190 – 2015 (Gg of CO_2 eq.)*



Total aggregated emissions from waste were 1 524.67 Gg of CO_2 eq. in 2015 and they increased by 3% compared to previous year, due to increase of biologically treated waste. Compared to reference year 1990, emissions increased by 9.5%. Increase of emissions in waste disposal was compensated by decrease of emissions from waste water treatment, while biological treatment and incineration of waste had small impact on the sector balance Emissions from waste incineration with energy use were allocated to the energy sector (category 1.A.1.a - other fuels).

In ***Figure 7.2*** bellow is shown that the most important source of GHG emissions is solid waste disposal (62.9%), followed by waste water treatment (23.4%), biological treatment (12.8%) and incineration of waste without energy recovery (0.9%). Waste sector contributed 3.7% to total GHG emissions in year 2015.

***Figure 7.2**: The share of categories in waste sector in 2015*

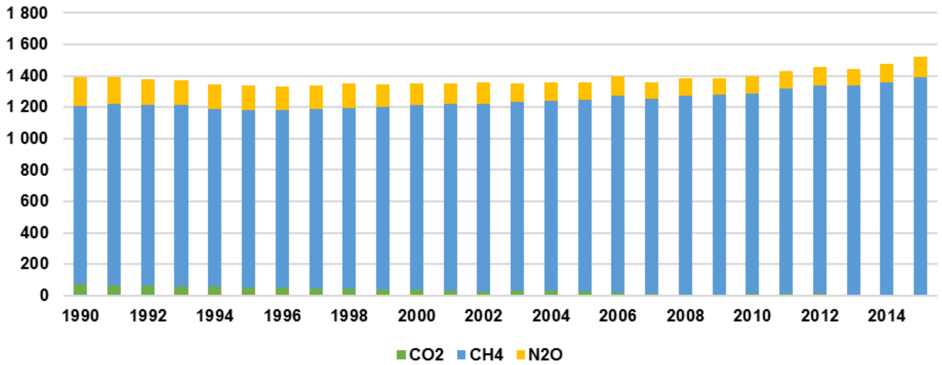


Majority of GHG emissions from waste sector are in form of CH_4 with 90.6% share, followed by 8.9% of N_2O and 0.5% of CO_2 as shows ***Table 7.1*** and ***Figure 7.3***.

***Table 7.1**: GHG emissions in Waste sector according to the gases and categories in particular years*

YEAR	CO_2	CH_4	N_2O	5.A	5.B	5.C	5.D	GHG
	Gg			Gg of CO_2 eq.				
1990	66.95	45.75	0.61	611.15	111.33	74.53	595.61	1 392.62
1995	51.40	45.21	0.53	648.05	113.98	58.44	518.11	1 338.58
2000	35.84	47.08	0.46	707.93	114.12	42.34	486.26	1 350.64
2005	24.28	48.86	0.37	795.73	107.07	31.04	423.32	1 357.15
2010	8.12	51.18	0.36	876.88	114.81	13.47	390.11	1 395.27
2011	10.64	52.20	0.37	902.78	129.04	13.35	381.85	1 427.02
2012	8.80	53.28	0.39	924.35	145.69	12.79	375.66	1 458.49
2013	7.38	53.19	0.37	937.10	128.75	10.80	369.61	1 446.26
2014	6.85	54.03	0.40	952.05	149.73	13.20	361.98	1 476.96
2015	6.97	55.27	0.46	960.55	194.76	13.10	356.26	1 524.67

***Figure 7.3**: Trend in aggregated emissions by gases within waste sector in 1990-2015 (Gg of CO_2 eq.)*



The general approach to estimate emissions in waste sector is to use default parameters and country specific data. Overview of used tiers by category is summarised in the following table (***Table 7.2***).

***Table 7.2**: Overview of tiers used by category in waste sector*

EMISSION CATEGORY	GAS/TIER USED		NOTE (RESPONSES TO DECISION TREE)
5.A Solid waste disposal	CH_4	T2	Good quality CS AD are available; CS models and parameters not available.
5.B Biological treatment	CH_4, N_2O	T1	CS data on waste available; CS emission factors not available.
5.C Incineration and open burning	CO_2	T2a	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	Plant specific data not available; CS data on waste available.
5.D Waste water	CH_4, N_2O	T2	Wastewater treatment pathways characterised; Measurements are available (BOD, COD), but CS method not available; CS emission factors not available, but CS model developed; Waste water is a key category.

European Waste Classification - The division of waste to Waste Groups defined in the European System of Waste Classification (Commission Decision 2000/532/EC) is used for estimating emissions. This classification divides waste to 20 waste groups and covers all waste types for which emission estimations are required by the IPCC 2006 GL.

- Municipal solid waste – Waste Group 20;
- Industrial solid waste – Waste Group 1 – 16;
- Agricultural waste – Waste Group 2;
- Hazardous waste – Waste Groups 1 – 19;
- Clinical waste – Waste Group 18;
- Waste water treatment sludge – Waste Group 19;
- Fossil liquid waste – Waste Group 13.

In this chapter, term “municipal solid waste” (MSW) means all waste reported in the Waste Group 20. All other waste types from Waste Groups 1 – 19 are called “non-municipal solid waste” (non-MSW) in this chapter. Statistical data on waste generation, disposal, incineration and recovery by waste groups are published by the Statistical Office of the Slovak Republic annually in publication “Odpady” (Waste). This is primary source of activity data for estimation of emissions in waste sector.

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 formulary was filled and is archived by QA/QC manager.

Verification of activity data used for estimation of emissions from municipal solid waste disposed to SWDS is performed by comparing reported year data to previous year's data. Verification on MSW data was strengthened by recently identified correlation with index of real wage. Data on MSW composition were verified by comparing with the National Waste Management Plan and the National Strategy on Biodegradable Waste Management.

Verification of activity data used for estimation of emissions from agricultural and industrial solid waste disposed to SWDS is performed by comparing reported year data to previous year's data.

Verification of data on biological treatment was done by comparing data from the Statistical Office of the Slovak Republic with the National Strategy of Biodegradable Waste Management provided by the Ministry of Environment of the Slovak Republic.

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 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 information provided in the Reports on Operation and Monitoring of Waste incinerators and in the Annual Reports from companies incinerating and co-incinerating waste.

Activity data are available from the Statistical Yearbook "Odpady". Default emission factors were used and these were verified to fully comply with the IPCC 2006 Guidelines.

Because dry matter content is not monitored in Slovak incinerators, parameters for wet weight were used consistently for all calculations.

Data on population were obtained from the demographic information updated by the Statistical Office of the Slovak Republic (SU 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 Statistical Office of the SR and sewage sludge data were obtained from the Report on Water Management prepared by the Water Research Institute (VUVH).

Data on use of retention tanks are based on population censuses done in years 1991, 2001 and 2011, these censuses are also used to verify population distribution to individual wastewater pathways. Additional information was collected from the Slovak Hydrometeorological Institute (SHMÚ) and from the Association of Wastewater Treatment Experts. The data available in statistical reports are verified by a comparison of the same category and previous years.

Data on COD were obtained based on information provided by the Statistical Office of the SR and from the Slovak Hydrometeorological Institute. Data available in statistical reports are verified by a comparison of the same category in previous years. Additional information was collected from the Slovak Hydrometeorological Institute and from the Association of Wastewater Treatment Experts.

Information about industrial wastewater is registered in the database of wastewaters at the SHMÚ, the Department of Water Quality and is published by the Statistical Office of the SR. Actual decrease in N_2O emissions is due to the decreasing industrial production and decreasing volume of generated wastewater.

7.3 CATEGORY-SPECIFIC RECALCULATIONS

Recalculations and reallocations made in Waste sector were provided and implemented in the line with the Improvement and Prioritisation Plan reflecting recommendations made during previous reviews.

***Table 7.3:** Summary of recalculations and changes in sector Waste*

NUMBER	CATEGORY	DESCRIPTION	REFERENCE
1.	5.A Solid Waste Disposal	Emissions from waste disposal (5.A) were recalculated due to requirement to improve estimation of emissions from non-MSW waste. We used this opportunity and fully reviewed the model for non-MSW, including new approach to modelling of AD on disposed sewage sludge.	Chapter 7.5.2.3
2.	5.B Biological Treatment of SW	Emissions from biological treatment (5.B) were recalculated due to requirement to apply new emission factor for N2O according to the corrigendum of IPCC guidelines from July 2015.	Chapter 7.6.3
3.	5.C Incineration and Open Burning of Waste	Emissions from incineration of waste without energy recovery (5.C) were recalculated due to requirement to apply oxidation factor 1. The previously used OF 0.9 based on was not accepted by the ERT because we could not provide documentation for this change of default value 1.	Chapters 7.7.1.1.3 and 7.7.1.2.3
4.	5.D Wastewater	Emissions from waste water treatment (5.D) were recalculated due to new information on the share of modern waste water treatment plants in Slovakia.	Chapters 7.8.1.3 and 7.8.2.3

Ad 1: The requirement of ERT recommended in the past that Slovakia should use tier 2 model for estimating emissions from non-MSW sources (industrial, agricultural, C&D, health care waste and WWT sludge). This required development of a country specific model which generates inputs for the IPPC Waste model. This model is based on selection of waste groups from the European Waste Classification (EWC) which are rich on biodegradable waste. This approach excludes from emission estimation majority of non-biodegradable waste (e.g. soils, rocks, ashes, chemicals), thus emissions are estimated only from waste which has the potential to generate them and use default parameters from the IPPC waste model.

For development of AD back to 1950, two types of surrogates for each waste group were tested to identify correlation with generated and disposed waste: index of production and final energy consumption. The CORREL function in Excel was used for assessing correlation. The surrogate with higher correlation coefficient was used for extrapolation of data.

Ad 2: The corrigendum from July 2015 to the chapter Biological Treatment of Solid Waste, IPCC 2006 Guidelines introduced change of the emission factor for N_2O emissions from waste composting (new 0.24 vs. previous 0.3 g N_2O / kg of waste). This change results in decrease of N_2O emission estimates for composted MSW and non-MSW.

Ad 3: Parallel to estimating emissions from MSW disposal, emissions from MSW incineration were estimated using MSW composition cited from Waste Management Plan of Slovakia, which was constant over the entire period. This can be characterised as using two different characteristics for the same activity data. With the aim to remove this discrepancy, the MSW incineration model was changed to variable MSW composition, as used in IPCC Waste model.

The MSW composition model, which is estimating share of MSW fractions, depending on share of population using natural gas as heating media and amount of MSW fractions removed from mixed

MSW by separate collection, was added to the model for estimating emissions from MSW incineration. This change results in time variable EF for CO_2.

Ad 4: Databases maintained by SHMÚ provide information on operational parameters of individual waste water treatment plants in Slovakia, including type of treatment. This data allowed more accurate estimation of share of modern waste water treatment plants in Slovakia. The new data indicate, that the share of waste water treated in modern WWTP is currently at 55%.

7.4 CATEGORY-SPECIFIC IMPROVEMENTS AND IMPLEMENTATION OF RECOMMENDATIONS

The reviews of Waste Chapter by ESD and UNFCC teams resulted in several recommendations. These are described below and referenced to relevant paragraphs of this chapter. Improvements are implemented in line with the Improvement and Prioritization Plan for the year 2017. Resolving the recommendations required recalculation of all sub-sectors. However, these recalculations do not have significant impact on the overall emissions from this sector.

Emissions from waste disposal (5.A) were recalculated due to requirement No. W.9 of the SVK 2016 ARR to improve estimation of emissions from non-MSW waste disposal by including Waste groups 17 - 19. We used this opportunity and fully reviewed the model for non-MSW, including new approach to modelling of AD on disposed sewage sludge.

The recommendation No. W.10 of the SVK 2016 ARR asked to include the article by Bodik and Kubaska (2013) in the reference list of the related NIR chapter. The list of literature was reviewed, updated and is attached to the end of this report.

In response to the recommendation No. W.11 of the SVK 2016 ARR a new table showing methods of WWT sludge management was added to the Waste water chapter 7.10.

Emissions from biological treatment (5.B) were recalculated due to requirement ESD/W12 SK-5B-2016-0001 to apply new emission factor for N_2O as in the corrigendum of IPCC guidelines from July 2015.

The recommendation ESD/W13 SK-5B-2016-0001 asked for review of the use of default FCF and CF used in estimation of emissions from MSW incineration.

Emissions from incineration of waste without energy recovery (5.C) were recalculated due to requirement ESD/W14 SK-5B-2016-0001 to apply oxidation factor 1. The previously used OF 0.9 based on was not accepted by the ERT because we could not provide documentation for this change of default value 1.

Non-MSW has higher data fluctuation than municipal solid waste. Therefore, the extrapolation should be based on quite a long time-series of reported data. For the current extrapolations, the data on non-MSW from the period 2005 – 2014 were used. A longer time series are needed, therefore these extrapolations will be regularly reviewed and updated.

The estimation of N_2O emissions from discharged industrial waste water requires further research, validation of activity data and evaluation of SHMU databases on waste water, to assess possibility for including also direct emissions from industrial waste water.

7.5 SOLID WASTE DISPOSAL (CRF 5.A)

Emissions from the Solid waste disposal sites (SWDS) are the major emissions source in waste sector. Methane emissions are estimated separately for municipal solid waste and non-municipal solid waste disposal. Emissions of CO_2 influencing national total are not occurring in this category as burning waste on landfills is prohibited by law and landfill fires are considered emergency situation and are extinguished immediately.

Total methane emissions in category CRF 5.A were 38.42 Gg (960.55 Gg of CO_2 eq.) in 2015 as ***Table 7.4*** shows and they increased by 0.9% compared to previous year. Emissions from solid waste disposal increased in comparison with the base year by 1.6 times due to improvement of disposal practices and increase of the amount of disposed waste. The emissions of NMVOC were estimated to be 6.14 Gg in 2015.

Table 7.4: *GHG emissions in individual categories of Solid waste disposal in particular years*

YEAR	TOTAL 5.A	MANAGED WASTE DISPOSAL SITES - ANAEROBIC (CRF 5.A.1.a)		UNMANAGED WASTE DISPOSAL SITES (CRF 5.A.2)	
	CH_4	MSW	non-MSW	MSW	non-MSW
	CH_4 in Gg				
1990	24.45	0.00	0.00	20.07	4.38
1995	25.92	0.13	0.02	21.23	4.54
2000	28.32	2.69	0.41	20.99	4.23
2005	31.83	7.93	1.35	18.78	3.77
2010	35.08	15.84	3.04	13.06	3.14
2011	36.11	17.46	3.12	12.52	3.00
2012	36.97	18.84	3.19	12.08	2.87
2013	37.48	20.09	3.38	11.27	2.75
2014	38.08	21.09	3.68	10.68	2.64
2015	38.42	22.02	3.74	10.13	2.53

Disposal of solid waste on land covers two categories: Managed Waste Disposal Sites (5.A.1) and Unmanaged Waste Disposal Sites (5.A.2). Emissions from both subcategories are estimated separately for municipal waste and for non-municipal waste, using the same methodology and parameters.

First legislation governing disposal of waste in Slovakia was adopted in 1991, followed by implementing regulations in 1992. The Act No. 239/1991 stipulated basic requirements for 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. Importance to increase share of recycled waste resulted in adoption of the Act No. 79/2015 on waste which introduces extended responsibility of producers and transfers organisation and financing waste recycling schemes from the state to organisations of waste producers. Impact of this change on separate collection of recyclables is not clear,

In 2015, there were 93 operating landfill sites receiving biodegradable waste in Slovakia. All of them are operated as anaerobic sites (CRF 5.A.1.a). CH_4 recovery takes place at 13 sites, mostly for energy generation at SWDS receiving municipal solid waste.

Before adopting legislation regulating waste management in 1991, municipal solid waste had been disposed mostly in uncontrolled manner in dumps.

The State Geological Institute (Štátny geologický ústav Dionýza Štúra (SGU DS)) published inventory of more than 5 000 disposal sites and landfills, which was analysed in order to obtain characteristics of past practice in disposal, with 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 the chapter on emission factors and parameters.

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 till 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.

Burning waste on SWDSs in not allowed by law, neither it is part of operation practice. Fires, which rarely occur on landfills, are considered as emergency situation and are extinguished as soon as possible. Therefore, no CO_2 emissions in the category 5.A. are reported.

Following the IPCC 2006 GL methodology, emissions from the SWD_S should be estimated separately for MSW and for non-MSW. The new CRF tables provide for reporting emissions from these two sources together, but in this chapter data are presented as disaggregated to MSW and non-MSW.

7.5.1 MUMINICPAL WASTE DISPOSAL SITES (MANAGED AND UNMANAGED)

7.5.1.1 Methodological issues

Methane emissions from MSW disposed to SWDSs were calculated using the IPCC 2006 Waste model. Tier 2 methods are 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 composition of municipal solid waste was modelled including the impact of waste separation.

Parameters used in the IPCC 2006 Waste model are of two types. Parameters characterising disposal situation in a country were derived from country specific information and for those defining process of waste decomposition the IPCC defaults were used.

Methane Generation Rate (k) - Methane generation rate defines how fast waste decomposes. IPCC default k-rates are estimated as function of climate zone, which is characterised by mean annual temperature (MAT) and ratio of mean annual precipitation and potential evapotranspiration (MAP/PET).

Slovakia belongs to temperate climate zone, because even warmest parts of Slovakia have MAT around 10°C. The MAP/PET ratio depends on altitude and the “breaking point” between dry and wet zone is at the altitude of 300 m in Slovakia. Therefore, the distribution of disposal sites by altitude was analysed. The result indicates that 77% of waste was disposed in altitudes under 300 m. Therefore, k-rates for dry zone were used for estimating emissions from SWDSs.

Degradable Organic Carbon (DOC) - This parameter identifies organic carbon in waste that is accessible to biochemical decomposition. DOC of municipal solid waste was estimated from MSW composition (Filip, Oral, 2003) in a model which takes in 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 and these are presented in the ***Table 7.5***. The DOC is first growing due to increasing of biodegradable fraction in MSW, then decreases due to diversion of recyclable and compostable waste from landfilled waste.

***Table 7.5:** Development of DOC in MSW disposal*

YEAR	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
DOC	0.134	0.138	0.138	0.136	0.125	0.125	0.126	0.126	0.121	0.119

Methane Correction Factor (MCF) - This parameter reflects the disposal management practices. Analysis of disposal sites database of the SGUDS by depth, year of creation and volume deposited resulted in the following development of the MCF in ***Table 7.6***.

***Table 7.6:** MCF distribution in solid waste disposal*

YEAR	SWDS CLASSIFICATION		
	UNMANAGED - SHALLOW (< 5 m waste)	**UNMANAGED - DEEP (> 5 m waste)**	**MANAGED - ANAEROBIC**
1959 - 1979	65%	35%	0%
1980 - 1993	60%	40%	0%
1995	53%	35%	12%
1997	47%	29%	24%
1999	40%	24%	36%
2001	33%	19%	48%
2003	27%	13%	60%
2005	20%	8%	72%
2007	13%	3%	84%
After 2007	10%	0%	90%

The development of MCF reflects the impact of waste legislation, causing continuous replacement of dumps by controlled landfills in the period 1993 – 2008. The remaining 10% of unmanaged shallow SWDS reflects illegal dumping of MSW.

Oxidation Factor (OX) - The 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. After completion are modern landfills covered by impermeable layer. Therefore, the default IPCC value (0) is used.

Methane Recovery (R) - Methane recovery means combusting landfill gas generated at SWDS in a flare or energy device. The development of landfill gas recovery in Slovakia is slow. From 13 landfills, 6 are flaring landfill gas and 7 are with energy generation.

Although landfill gas flaring is required by the EC Landfill Directive (Annex I, item 4.2.) at all landfills receiving biodegradable waste and Slovak legislation (Regulation No 283/2001 Coll.) was harmonised with this directive, a later amendment (Ordinance No 509/2002 Coll.) requires flaring only if landfill gas is generated in sufficient amounts. This condition has reflected the situation in the landfill sector, where new landfills did not generate sufficient amounts of landfill gas and old sites do not have gas collection systems.

Data on recovered methane (volume of landfill gas, % of methane) were obtained from the companies recovering landfill gas and from landfill operators:

- MAEN s.r.o.: 8 landfills, energy generation;
- gge s.r.o.: 1 landfill, energy generation;
- Terrasystems: 4 landfills, flaring;
- Individual operators: 2 landfills, flaring.

Only about 5% of generated methane is recovered, data on flared and utilised methane are provided and reported in CRF table 5.A.1.a.

Total MSW disposed on landfills annually is used as activity data for estimation of methane emissions from SWDS. Additionally, the overall MSW balance is used for verification of these activity data.

The Statistical Office of the Slovak Republic has been publishing data on MSW generation and disposal since 1993. Although this creates a timeline of 15 years, additional historical data have to be generated for the use of FOD method.

Analysis of MSW generation data shows a huge 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 explained in the following sections. 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 national system.

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 Statistical Office of the Slovak Republic and before 1993 the Statistical Office of the CSSR have 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 two MSW incinerators (Bratislava and Košice). These two incinerators burned in average 150 Gg MSW per year in the period 1993 – 2011 (Bratislava 100 Gg/yr, Košice 50Gg/yr). It is assumed that this amount of MSW was burned since they were put in operation. Thus, the input values for fraction of MSW landfills can be divided into three periods:

- 1960 – 1976: 1 – all waste disposed to SWDS.
- 1977 – 1994: 0.9 – MSW Incinerators in operation.
- 1995 – 2015: Real data on MSW disposed were used

Overview of activity data for the particular years is shown in the ***Table 7.7***.

Table 7.7: *Estimation of landfilled MSW based on index of real wage*

YEAR	POPULATION	IRW	MSW/CAP	% TO SWDS	MSW TO SWDS
1950	3 463 446	75.3	111	100%	385 745
1960	3 994 270	124.7	184	100%	736 901
1970	4 528 459	158.5	234	100%	1 061 904
1980	4 984 331	194.2	287	90%	1 288 855
1990	5 297 774	194.0	287	90%	1 368 495
1995	5 363 676	159.8	236	88%	1 116 152
2000	5 400 679	171.1	248	79%	1 055 925
2005	5 387 285	194.5	289	79%	1 226 570
2010	5 431 024	226.4	333	78%	1 411 543
2013	5 413 393	224.9	322	69%	1 201 906
2014	5 418 649	232.1	339	66%	1 210 043
2015	5 423 800	238,9	348	69%	1 303 845

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.

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 organised in Slovakia every 10 years.

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 +/-26%.

Table 7.8: *Uncertainties used in MSW disposal*

ACTIVITY DATA AND EMISSION FACTORS	UNCERTAINTY RANGE
Fraction of MSWT sent to SWDS (MSWF)	±30% for waste data in period 1950 – 1994 ±10% for waste data in period 1995 – 2013
Total uncertainty of waste composition	±30% for the entire modelled period
Degradable Organic Carbon (DOC): Paper/cardboard Textiles Food waste Garden and Park Waste	Default value (range): 40 (36 – 45) 24 (20 – 40) 15 (8 – 20) 20 (18 – 22)
Fraction of Degradable Organic Carbon Decomposed (DOCf)	± 20% (IPCC default values used)
Methane Correction Factor (MCF): = 1.0 = 0.8 = 0.4	IPCC default values used: -10%, +0% ±20% ±30%
Fraction of CH_4 in generated Landfill Gas (F) = 0.5	±5% (IPCC default values used)
Methane Recovery (R)	± 10% (CS, metering is in place)
k-rate: Paper/textile Garden and park waste Food waste	Default value (range): 0.04 (0.03 – 0.05) 0.05 (0.04 – 0.06) 0.06 (0.05 – 0.08)

7.5.2 NON-MUNICIPAL DISPOSAL SITES (MANAGED AND UNMANAGED)

Agricultural, industrial and other activities produce waste, which contains also biodegradable materials. These are sources of methane when landfilled. In the past, this waste was often disposed together with municipal solid waste. After adoption of waste legislation in 1991, agriculture, industries and other sources of waste started to be disposed to dedicated landfills. The legislation governing non-MSW management and disposal is the same as for municipal solid waste. Information on modernisation of non-MSW management is limited, compared to municipal solid waste.

7.5.2.1 Methodological issues

The estimation of methane emissions by FOD method from non-MSW disposed to SWDSs were calculated using the IPCC 2006 model. Tier 2 methods are used for emission estimations, using default parameters and country-specific activity data.

The IPCC 2006 waste model was accommodated to estimate emissions from waste disposal sites receiving non-MSW. European Waste Classification is dividing agricultural and industrial waste to 19 groups and seven of them were identified as containing mainly biodegradable waste (***Table 7.9***). According to the recommendation in the IPCC 2006 GL, these seven groups were selected as the input for the waste model, similarly to fractions of municipal solid waste.

The same model parameters were used as for municipal solid waste, but IPCC default DOC and k-rates for industrial waste were used. These are listed in the following table.

Table 7.9: *DOC and k-rate parameters used in IPCC Waste model for non-MSW*

ECW WASTE GROUPS CONTAINING BIODEGRADABLE WASTE	DOC	k-RATE	MAIN WASTE TYPE
02 Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing	0.2	0.06	Food waste
03 Wastes from wood processing and the production of panels and furniture, pulp, paper and cardboard	0.4	0.04	Paper, wood
04 Wastes from the leather, fur and textile industries	0.24	0.04	Textile
15 Waste packaging; absorbents, wiping cloths, filter materials and protective clothing not otherwise specified	0.24	0.02	Wood, paper
17 Construction and demolition wastes (including excavated soil from contaminated sites)	0.43	0.02	Wood
18 Wastes from human or animal health care and/or related research (except kitchen and restaurant wastes not arising from immediate health care)	0.15	0.05	Health care waste
19 Wastes from waste management facilities, off-site waste water treatment plants and the preparation of water intended for human consumption and water for industrial use	0.05	0.06	sludge

First data on non-MSW are from 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 Slovak economy. The first period, centrally planned economy from 1950 – 1989, is characterised by low environmental standards, little innovation 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 non-MSW amounts. Each of non-MSW groups (02, 03, 04, 15,) was tested if it correlated better with final energy consumption or with the sectoral production index in the period.

Time series for industrial waste groups (03, 04) were correlated to the final energy consumption in industry for the period 1990 – 2005 and to index of gross production of relevant industrial sector for the period 1950 – 1989. Time series for industrial waste groups (02, 15) were correlated to index of gross production of relevant industrial sector for the entire period 1950 – 2005.

Construction and demolition waste group (17) contains only one biodegradable waste type (wood). The driver for estimating amount of waste wood from C&D waste is the index of construction works (1950 – 2005). The driver for waste from health care (18) is number of beds in health care facilities. The amount of waste from group 19 was correlated to amount of generated sewage sludge and share of landfilling was estimated from available reported data.

Statistical yearbooks of the former Czechoslovakia and the Slovak Republic (after 1992) contain data on indexes of gross production of industrial sectors, index of construction works, number of hospital beds per 1 000 people back to the 1950 and amount of generated sewage sludge.

Biodegradable non-MSW was selected from the database based on European Waste Classification (EWC) which is maintained by the Ministry of Environment of the Slovak Republic and published by the Statistical Office of the Slovak Republic. 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. Hazardous waste, agricultural waste, construction waste, sewage sludge and waste from health care were included in emission estimation.

Consistency of time series is ensured by using continuous time series of sectoral growth indicators since 1950. Activity data were completely recalculated. Time series consistency was maintained by replacing data obtained under waste classification used in 1997 – 2001 by extrapolations, to avoid discrepancies caused due to differences in waste classification.

7.5.2.2 Uncertainties

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 non-MSW waste was estimated to +/- 27% (***Table 7.10***).

Table 7.10: *Uncertainties for non-MSW disposal*

ACTIVITY DATA AND EMISSION FACTORS	UNCERTAINTY RANGE
Amount of disposed non-MSW	±30% for waste data in period 1950 – 2004 ±10% for waste data in period 2005 – 2013
Degradable Organic Carbon (DOC) Paper/cardboard Textiles Food waste Garden and Park Waste Wood Clinical waste	Default value (range) 40 (36 – 45) 24 (20 – 40) 15 (8 – 20) 20 (18-22) 43 15
Fraction of Degradable Organic Carbon Decomposed (DOCf)	± 20% (IPCC default values used)
Methane Correction Factor (MCF) = 1.0 = 0.8 = 0.4	IPCC default values used –10%, +0% ±20% ±30%
Fraction of CH_4 in generated Landfill Gas (F) = 0.5	±5% IPCC default values used
k-rate Paper/textile Garden and park waste Food waste Wood	Default value (range) 0.04 (0.03 – 0.05) 0.05 (0.04 – 0.06) 0.06 (0.05 – 0.08) 0.02 (0.01 – 0.03)

7.5.2.3 Category - specific recalculations

The emissions from non-MSW disposal were fully recalculated. First recalculation was recommended by review team in recommendation no. W.9 to include waste groups 17, 18 and 19. The second recalculation was need because during QA/QC process wrong assignment of DOC and k parameters was identified. The recalculation decreased emission estimates by 30% – 40% for non-MSW. The overall impact on emissions from disposal (5.A) is about -8%. Comparison of previous and refined emission estimates in shown in the ***Table 7.11***.

Table 7.11: *Previous and refined non-MSW emission estimates*

YEAR	MANAGED WASTE DISPOSAL SITES			UNMANAGED WASTE DISPOSAL SITES			
	PREVIOUS	REFINED	CHANGE	PREVIOUS	REFINED	CHANGE	IMPACT ON 5.A
1990	0	0.00		6.71	4.70	-30%	-7.5%
1991	0	0.00		6.96	4.85	-30%	-7.7%
1992	0	0.00		7.13	4.96	-30%	-7.8%
1993	0	0.00		7.27	5.02	-31%	-8.0%
1994	0	0.00		7.34	5.04	-31%	-8.1%
1995	0.04	0.03	-32%	7.4	5.02	-32%	-8.3%

YEAR	MANAGED WASTE DISPOSAL SITES			UNMANAGED WASTE DISPOSAL SITES			
	PREVIOUS	REFINED	CHANGE	PREVIOUS	REFINED	CHANGE	IMPACT ON 5.A
1996	0.11	0.08	-26%	7.41	5.00	-33%	-8.3%
1997	0.22	0.16	-27%	7.41	4.96	-33%	-8.4%
1998	0.36	0.26	-28%	7.38	4.90	-34%	-8.4%
1999	0.51	0.37	-28%	7.31	4.81	-34%	-8.5%
2000	0.69	0.52	-25%	7.22	4.74	-34%	-8.4%
2001	0.9	0.68	-24%	7.13	4.65	-35%	-8.4%
2002	1.14	0.87	-24%	7.02	4.55	-35%	-8.4%
2003	1.42	1.07	-24%	6.9	4.44	-36%	-8.4%
2004	1.74	1.32	-24%	6.77	4.32	-36%	-8.3%
2005	2.01	1.52	-24%	6.61	4.18	-37%	-8.2%
2006	2.38	1.74	-27%	6.46	4.04	-38%	-8.4%
2007	2.88	2.22	-23%	6.3	3.92	-38%	-8.2%
2008	3.34	2.59	-22%	6.12	3.77	-38%	-8.4%
2009	3.88	3.07	-21%	5.92	3.61	-39%	-8.1%
2010	4.21	3.27	-22%	5.73	3.45	-40%	-8.3%
2011	4.38	3.33	-24%	5.53	3.29	-40%	-8.2%
2012	4.52	3.38	-25%	5.35	3.14	-41%	-8.2%
2013	4.77	3.56	-25%	5.17	3.01	-42%	-8.2%
2014	5.13	3.84	-25%	5.01	2.88	-42%	-8.2%

7.6 BIOLOGICAL TREATMENT OF SOLID WASTE (CRF 5.B)

EC Waste Directive requires Member States to reduce disposal of biodegradable waste in landfills. This was reflected in the Waste 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 Slovakia from January 2006. There is a range of private and municipal companies, which provide composting of municipal and agricultural waste. In ***Table 7.12*** is shown 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 88% in 2015. 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 7.12: *The overview of municipal and industrial composting in particular years*

YEAR	MSW (CRF 5.B.1.a)			Non-MSW (CRF 5.B.1.b)		
	WATE TREATED	CH_4	N_2O	WASTE TREATED	CH_4	N_2O
	kt (wet)	Gg	Gg	kt (wet)	Gg	Gg
1990	20.00	0.080	0.005	629.00	2.516	0.151
1995	35.46	0.142	0.009	629.00	2.516	0.151
2000	36.35	0.145	0.009	629.00	2.516	0.151
2005	45.00	0.180	0.011	579.15	2.317	0.139
2010	90.72	0.363	0.022	578.54	2.314	0.139
2011	99.84	0.399	0.024	652.55	2.610	0.157
2012	122.76	0.491	0.030	726.56	2.906	0.174
2013	130.67	0.523	0.031	619.85	2.479	0.149
2014	145.11	0.580	0.035	728.11	2.912	0.175
2015	200.49	0.802	0.048	934.99	3.740	0.224

7.6.1 METHODOLOGICAL ISSUES

The default IPCC 2006 GL methodology 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, as this technology is not used in Slovakia. Tier 1 is used for emission estimation.

Default IPCC emission factors for wet weight were used for emission estimations from composting:

- Emission factor 4 g CH_4/kg of waste treated;
- Emission factor 0.24 g N_2O/kg of waste treated.

Amounts of composted municipal solid waste are published since 1992. The missing data for 1990 and 1991 were extrapolated. Data on industrial waste composting are collected and published since 1997. No clear trend could be identified, as data vary ±50%, thus average of 2002 – 2013 data 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 IPCC 2006 default method and values. Emissions from biological treatment of waste were estimated to have +/- 60% total uncertainties as ***Table 7.13*** shows. The highest uncertainty come from CH_4 and N_2O emission factors.

Table 7.13: *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 N_2O from composted waste were fully recalculated, due to correction of emissions factor to 0.24 from 0.3 g N_2O/kg of waste treated by corrigendum of IPCC guidelines of July 2015. Applying the new factor resulted in decrease of N_2O emissions by 20% and total emissions from composting by 10%, ***Table 7.14*** shows difference between submissions.

No changes were made to estimation of methane emissions from composting.

Table 7.14: *The difference between the new (2017) and the old (2016) submissions in 5.B*

YEAR	PREVIOUS	REFINED	CHANGE
	Gg of CO_2 eq.		
1990	122.92	111.33	-9.43%
1991	122.92	111.33	-9.43%
1992	122.92	111.33	-9.43%
1993	123.19	111.57	-9.43%
1994	122.73	111.17	-9.42%
1995	125.84	113.98	-9.42%
1996	125.08	113.28	-9.43%
1997	126.46	114.54	-9.43%
1998	126.33	114.41	-9.44%
1999	126.57	114.62	-9.44%
2000	126.01	114.12	-9.44%

YEAR	PREVIOUS	REFINED	CHANGE
	Gg of CO_2 eq.		
2001	125.65	113.82	-9.42%
2002	126.57	114.62	-9.44%
2003	126.84	114.89	-9.42%
2004	122.17	110.63	-9.44%
2005	118.22	107.07	-9.44%
2006	161.43	146.20	-9.44%
2007	114.39	103.61	-9.43%
2008	125.64	113.74	-9.47%
2009	129.07	116.87	-9.45%
2010	126.75	114.81	-9.42%
2011	142.50	129.04	-9.45%
2012	160.85	145.69	-9.42%
2013	142.14	128.75	-9.42%
2014	165.36	149.73	-9.45%

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 emergency situation in Slovakia. Thus, no emissions were estimated for the category Open burning of waste (CRF 5.C.2).

7.7.1 WASTE INCINERATION (CRF 5.C.1)

Incineration of waste is an accepted practice in the Slovak Republic. It is regulated in accordance with the EU waste legislation. After period of modernisation of waste incineration sector, smaller and non-compliant facilities were replaced by more modern ones. Following facilities for waste incineration were in operation in 2015:

- Two large and several small MSW incinerators;
- Five ISW incinerators (one of them is co-incinerating waste water sludge);
- Six clinical waste incinerators;
- One incinerator of rendering plant residues;
- Four facilities co-incinerating ISW (cement and lime kilns).

Location of individual waste incineration and co-incineration facilities in 2013 is shown on the following ***Figure 7.4***. No changes to these data was observed in 2015

Figure 7.4: *Location of individual waste incineration and co-incineration facilities in 2015*

Legend:

- Red square – hospital waste incinerator;
- Yellow circle – municipal waste incinerator;
- Red circle – hazardous waste incinerator;
- Blue circle – co-incineration facility.

Estimation of emission from waste incineration was reviewed with the aim to increase coordination between the Waste Sector and Energy Sector. There are two key outputs from this review:

- Emissions from incineration with energy recovery are estimated and reported in the Energy Sector only. This is due to increasing import of waste-derived fuel for cement industry;
- Emission factor for methane used in the Energy Sector is now used also in Waste sector (see recalculation chapter for additional details).

These changes do not have impact on emissions from incineration reported in the Waste Sector.

Emissions from waste incineration were estimated in full disaggregation and the preview of estimated emissions is in the next ***Table 7.15***.

Table 7.15: *GHG emissions from waste incineration category 5.C.1 in particular years*

YEAR	EMISSIONS FROM INCINERATION WITHOUT ENERGY RECOVERY		
	CO_2 (Gg)	N_2O (Gg)	CH_4 (Gg)
1990	66.95	0.0196	0.0696
1995	51.40	0.0184	0.0624
2000	35.84	0.0172	0.0551
2005	24.28	0.0175	0.0618
2010	8.12	0.0131	0.0579
2011	10.64	0.0072	0.0226
2012	8.80	0.0100	0.0405
2013	7.38	0.0085	0.0354
2014	6.85	0.0185	0.0336
2015	6.97	0.0182	0.0284

Total CO_2 emissions reported in the category 5.C.1 from waste incineration without energy recovery were 6.97 Gg in 2015. This is an increase compared to the previous year caused by an increasing amount of incinerated waste without energy recovery. Total N_2O emissions reported in the category 5.C.1 from waste incineration were 0.018 Gg. Total CH_4 emissions reported in the category 5.C.1 were 0.0284 Gg. The trend in CH_4 and N_2O emissions is almost stable with the slight fluctuation in the recent years.

Disaggregation of MSW and other waste (non-MSW) to biogenic and non-biogenic waste is presented in ***Table 7.16***.

Table 7.16: *Activity data and emissions from waste incineration in particular years*

YEAR	BIOGENIC WASTE							
	MSW (CRF 1.AA.1.a)				Other (non-MSW) (CRF 5.C.1.1.b)			
	Amount (kt)	CO_2 (Gg)	N_2O (Gg)	CH_4 (Gg)	Amount (kt)	CO_2 (Gg)	N_2O (Gg)	CH_4 (Gg)
1990	130.12	83.20	0.0051	0.0385	75.34	124.00	0.0127	0.0452
1995	115.67	76.50	0.0046	0.0342	72.76	120.00	0.0129	0.0437
2005	141.48	91.86	0.0056	0.0418	88.22	145.56	0.0150	0.0529
2010	144.44	87.93	0.0057	0.0427	91.53	151.02	0.0124	0.0549
2011	146.83	88.21	0.0058	0.0434	31.27	51.59	0.0060	0.0188
2012	133.86	79.21	0.0053	0.0396	62.14	102.52	0.0092	0.0373
2013	138.18	80.86	0.0054	0.0408	54.58	90.05	0.0077	0.0328
2014	151.12	87.14	0.0060	0.0447	51.76	85.41	0.0171	0.0311
2015	152.66	86.41	0.0060	0.0451	43.09	71.10	0.0166	0.0259

YEAR	NON-BIOGENIC WASTE							
	MSW (CRF 1.AA.1.a)				Other (non-MSW) (CRF 5.C.1.2.b)			
	Amount (kt)	CO_2 (Gg)	N_2O (Gg)	CH_4 (Gg)	Amount (kt)	CO_2 (Gg)	N_2O (Gg)	CH_4 (Gg)
1990	39.88	25.50	0.0016	0.0118	40.58	66.95	0.0069	0.0244
1995	35.16	23.25	0.0014	0.0104	31.15	51.40	0.0055	0.0187
2000	49.68	33.40	0.0020	0.0147	21.72	35.84	0.0041	0.0130
2005	41.37	26.86	0.0016	0.0122	14.72	24.28	0.0025	0.0088
2010	38.84	23.64	0.0015	0.0115	4.92	8.12	0.0007	0.0030
2011	38.67	23.23	0.0015	0.0114	6.45	10.64	0.0012	0.0039
2012	34.07	20.16	0.0013	0.0101	5.33	8.80	0.0008	0.0032
2013	35.48	20.76	0.0014	0.0105	4.47	7.38	0.0008	0.0027
2014	38.81	22.38	0.0015	0.0115	4.15	6.85	0.0014	0.0025
2015	38.77	21.94	0.0015	0.0115	4.23	6.97	0.0016	0.0025

7.7.1.1 MSW (CRF 5.C.1.1.a)

The amount of incinerated MSW is published by the Statistical Office of the Slovak Republic since 1993. There are two large municipal waste incinerators in the country, in Bratislava and in Košice. The MSW incinerator in Bratislava was put in operation in 1978 and significantly modernised in 2002. Currently installed capacity is 135 Gg/y, the incinerator can be characterised as continuously operated stoker. The MSW incinerator in Košice with 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 energy sector, category 1.A.1.a Public electricity and heat production – other fuels.

7.7.1.1.1 Methodological issues

Consistently with the general IPCC 2006 GL, only CO_2 emissions resulting from the incineration of carbon in waste of fossil origin (e.g. plastics, certain textiles, rubber, liquid solvents, and waste oil) should be included in emissions estimates. The carbon fraction that is derived from biomass materials (e.g. paper, food waste, and wooden material) is not included. Tier 2a methodology for CO_2 emissions estimation for waste incineration and open burning is using the same equation as Tier 1 approach but is based on country-specific data regarding waste generation, composition and management practices.

Nitrous oxide is emitted in combustion processes at relatively low combustion temperatures between 500 and 950°C. Other important factors affecting the emissions are the type of air pollution control equipment, type and nitrogen content of the waste and the fraction of excess air. Although N_2O emissions are not directly monitored, the results of NO_X (as NO_2) monitoring are generally available and they were used as verification tool (emissions of N_2O must not be higher than those of NO_2). The formula for the estimation of emissions is based on multiplying the incinerated waste stream by emission factor specific for that waste stream. The equation shown in the IPCC 2006 GL was used for estimation of N_2O emissions from incineration. It should be noted, that the reconstruction of both incinerators has led to significant decrease of EF for NOx by ca 40%.

Methane emissions from MSW were estimated using IPCC default EF for continuous incineration on stoker 0.2 kg CH_4/Gg of waste.

For CO_2 emissions estimation from MSW incineration, IPPC default parameters and country specific parameters on waste composition were used. The oxidation factor is considered to be 100%.

The increasing importance of waste separation is influencing MSW composition. Therefore, the constant MSW composition was replaced by variable MSW composition, which is used in the IPCC model for disposal of MSW. This change also ensured, that the same MSW composition is used for modelling emissions from disposal and from incineration of MSW. The result of this approach are time variable emission factors for CO_2, these are shown in the following ***Table 7.17***.

Table 7.17: *CO_2 emission factors*

YEAR	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
EF CO_2 total	0.639	0.661	0.672	0.649	0.609	0.601	0.592	0.585	0.577	0.566
EF CO_2 C-fossil	0.150	0.154	0.160	0.147	0.129	0.125	0.120	0.120	0.118	0.115

Emissions of N_2O were estimated using country specific parameters, taking into account emission levels before modernisation (EF=20 g N_2O/t), after modernisation (EF=12 g N_2O/t) and emissions from small incinerators used in the past (EF=50 g N_2O/t). The default N_2O emission factors (wet weight) were selected from the IPCC 2006 GL, Table 5.6. The selection is based on incinerated waste types and technologies used. Waste amounts are normally given as wet weight in the Slovak Republic. Although the IPCC 2006 GL recommends using emission factor 50 for MSW, references from other European countries indicate different values.

Further review of available NO_X emission factors resulted in formulation of two hypotheses:

- Emission factors observed in Germany and Austria may be more suitable for the Slovak Republic, because many Slovak incinerators are of German origin.
- Emission factors for reconstructed plants should be lower, it is expected that the decrease of EF for NO_X (before and after reconstruction) is the same as for N_2O.

Thus, the calculation was performed also with the EF=20 g N_2O/t MSW and the results are 3 times higher than the estimate obtained by deposition calculation, which is within the range (0.002 – 0.05). For MSW incinerated in smaller scale, the EF=1.49 kg N_2O/TJ was used in 2015.

Methane emissions are estimated according to tier 2 method, using default parameter for continuous operation of stoker type incineration (0.2 kg/Gg).

Activity data on incinerated MSW are based on input into individual incinerators. Collection companies delivering waste monthly inform municipalities on method of treatment of their waste, and total amount of incinerated waste report municipalities to the Statistical Office of the Slovak Republic annually.

Although there is identification of “incineration with energy recovery” and “incineration without energy recovery” since 2002, these categories wasn´t correctly reported. The information from the MSW incinerator operators were used for the indication of proper option.

Activity data on MSW incineration were taken from the national statistics as national totals. Afterwards, data were disaggregated into waste incinerated in Bratislava district (representing input to Bratislava incinerator) and Košice district (representing input to Košice incinerator). The rest is considered as MSW incinerated in other incinerators. Emission factors were assigned to these three time-series. Because incinerators in Bratislava and Košice were significantly modernised, emission factors were adjusted from the year of modernisation to reflect improvement in air pollution control.

Consistency of time series is ensured by using the same source of activity data and the same methodology during time series. The data available in the statistical reports are verified by comparison with the previous years. Unexplainable deviations were replaced by interpolations.

7.7.1.1.2 Uncertainties

The default IPPC uncertainties for activity data were used. These are summarised in the ***Table 7.18***. The total uncertainty of emissions from incineration of waste was estimated to +/-45%.

Table 7.18: *Uncertainties for waste incinerations*

ACTIVITY DATA AND EMISSION FACTORS	UNCERTAINTY RANGE	
Incinerated waste	±5%	
Dry matter content (dm)	±11%	
Carbon fraction (CF)	±20%	
Oxidation factor	±10%	
EMISSION FACTORS:		
CO_2	±32%	Calculated as average
CH_4	±50%	
N_2O	±100%	

7.7.1.1.3 Category - specific recalculations

Emissions from MSW incineration were fully recalculated. The introduction variable MSW composition has impact on emission factors for CO_2 and on share of biogenic and non-biogenic waste. The following table shows previous and refined composition of MSW

Table 7.19 *Previous and refined composition of MSW*

PREVIOUS		REFINED		
			Min	Max
Food & Garden waste	38%	Food	33.6%	30.1%
		Garden	10.4%	3.1%
Paper	13%	Paper	14.2%	12.0%
Textiles	5%	Textiles	5.6%	4.7%
Plastics	7%	Plastics	4.4%	2.5%
Leather, rubber	3%	Glass	7.3%	4.2%
Metal, glass, inert waste	34%	Metal	6.9%	6.6%
		Other&Inert	31.9%	22.0%

Compared to previously used MSW composition, the new one shows lower share of plastics fraction and due to increased separation, the share of incombustible fractions is increasing. This has an impact on estimation of emissions, which are presented in the table below.

Table 7.20: *Comparison of previous and refined emissions in MSW*

YEAR	BIOGENIC EMISSIONS (Gg)					
	PREVIOUS			REFINED		
	CO_2	N_2O	CH_4	CO_2	N_2O	CH_4
1990	87.61	0.00258	0.000023	83.20	0.00297	0.000026
1991	87.61	0.00258	0.000023	83.97	0.00297	0.000026
1992	88.90	0.00267	0.000023	86.29	0.00307	0.000026
1993	95.47	0.00309	0.000025	93.85	0.00357	0.000028
1994	83.33	0.00233	0.000022	82.36	0.00269	0.000025
1995	77.73	0.00206	0.000020	76.50	0.00238	0.000023
1996	76.24	0.00203	0.000020	74.39	0.00233	0.000023
1997	83.08	0.00223	0.000021	81.72	0.00256	0.000025
1998	92.68	0.00245	0.000024	91.18	0.00281	0.000027
1999	89.92	0.00239	0.000023	89.04	0.00274	0.000027
2000	107.42	0.00284	0.000028	106.74	0.00325	0.000032
2001	67.55	0.00181	0.000017	67.42	0.00207	0.000020
2002	80.65	0.00213	0.000021	80.72	0.00245	0.000024
2003	83.75	0.00169	0.000022	83.75	0.00194	0.000025
2004	94.88	0.00186	0.000025	93.63	0.00214	0.000028
2005	94.23	0.00151	0.000024	91.86	0.00175	0.000028
2006	97.91	0.00162	0.000025	94.53	0.00188	0.000029
2007	92.87	0.00151	0.000024	88.69	0.00177	0.000028
2008	81.06	0.00127	0.000021	76.16	0.00149	0.000025
2009	91.60	0.00150	0.000024	85.84	0.00177	0.000028
2010	94.45	0.00152	0.000024	87.93	0.00180	0.000029
2011	95.60	0.00160	0.000025	88.21	0.00191	0.000029
2012	86.54	0.00146	0.000022	79.21	0.00174	0.000027
2013	89.50	0.00144	0.000023	80.86	0.00172	0.000028
2014	97.88	0.00171	0.000025	87.14	0.00204	0.000030

YEAR	NON-BIOGENIC EMISSIONS (Gg)					
	PREVIOUS			REFINED		
	CO_2	N_2O	CH_4	CO_2	N_2O	CH_4
1990	44.02	0.00130	0.000011	25.50	0.00091	0.000008
1991	44.02	0.00130	0.000011	25.59	0.00091	0.000008
1992	44.66	0.00134	0.000012	26.10	0.00093	0.000008
1993	47.97	0.00155	0.000012	28.19	0.00107	0.000009
1994	41.87	0.00117	0.000011	24.77	0.00081	0.000007
1995	39.05	0.00104	0.000010	23.25	0.00072	0.000007
1996	38.31	0.00102	0.000010	23.08	0.00072	0.000007
1997	41.74	0.00112	0.000011	25.21	0.00079	0.000008
1998	46.56	0.00123	0.000012	28.42	0.00088	0.000009
1999	45.18	0.00120	0.000012	27.73	0.00085	0.000008
2000	53.97	0.00143	0.000014	33.40	0.00102	0.000010
2001	33.94	0.00091	0.000009	21.05	0.00065	0.000006
2002	40.52	0.00107	0.000010	24.69	0.00075	0.000007
2003	42.08	0.00085	0.000011	25.50	0.00059	0.000008

YEAR	NON-BIOGENIC EMISSIONS (Gg)					
	PREVIOUS			REFINED		
	CO_2	N_2O	CH_4	CO_2	N_2O	CH_4
2004	47.67	0.00093	0.000012	28.31	0.00065	0.000009
2005	47.34	0.00076	0.000012	26.86	0.00051	0.000008
2006	49.19	0.00081	0.000013	27.46	0.00055	0.000009
2007	46.66	0.00076	0.000012	24.99	0.00050	0.000008
2008	40.73	0.00064	0.000011	21.34	0.00042	0.000007
2009	46.02	0.00075	0.000012	23.66	0.00049	0.000008
2010	47.45	0.00076	0.000012	23.64	0.00048	0.000008
2011	48.03	0.00081	0.000012	23.23	0.00050	0.000008
2012	43.48	0.00073	0.000011	20.16	0.00044	0.000007
2013	44.96	0.00072	0.000012	20.76	0.00044	0.000007
2014	49.18	0.00086	0.000013	22.38	0.00052	0.000008

Assignment of default fraction of fossil carbon and total carbon to waste fractions was reviewed and corrected. Disaggregation of previously used fraction ”Food and Garden waste” allowed correctly assign CF=0.38 Food waste and CF=0.49 to Garden waste. Disaggregation of previously used fraction “Metal, glass, inerts” allowed correctly assign CF=0 for metal and glass and CF=0.03 to Other and inert waste.

The refined total emissions are lower by 17% in average, this is caused by decrease of CO_2 emissions. Emissions of N_2O and CH_4 remain without change in total, but they are share in biogenic and non-biogenic fraction has changed. Non-biogenic emissions decreased by 40%. The decrease of emissions is more significant in recent years. This supports the need for variable MSW composition if a country is increasing separation of MSW.

7.7.1.2 Non-MSW incineration (CRF 5.C.1.1.b)

The non-MSW sector has undergone significant changes since 1990, but detailed research of their impact has not yet been done. The key drivers of these changes were stricter legislation, the new standards (EU approximation) and commercialisation of waste services. This led to replacing small incineration units in factories and hospitals by regional incinerators. Also, existing large incinerators were modernised to comply with the new standards or were decommissioned.

There is growing interest of cement industries to incinerate waste with high calorific value. The company Ecorec processes about 50 kt of waste annually – this is about 15% of all non-MSW incinerated with energy recovery. Review of the Reports on Operation and Monitoring of Waste Incinerators indicates that waste derived fuels are imported into Slovakia for co-incineration in cement plants.

From the total of 17 non-MSW incinerators and co-incineration plants only a few have installed capacity exceeding 2 t/hour. The following companies are using largest waste incineration facilities:

- Slovnaft a.s., Bratislava – rotary kiln and chamber furnace (3.5 t/hour);
- Duslo a.s., Šaľa - rotary kiln (1.26 t/hour);
- VAS s.r.o., Mojšová Lúčka (0.44 t/hour) – incineration of rendering plant residues;
- Light Stabilizers, s.r.o., Strážske (0.18 t/hour);
- Fecupral s.r.o., Prešov (0.15 t/hour);
- Archiv SB s.r.o., Liptovský Mikuláš (0.15 t/hour).

Co-incineration on waste derived fuels occurs in the following plants:

- Holcim a.s., Rohožník;
- Holcim a.s., Turňa nad Bodvou;
- Carmeuse s.r.o., Košice-Šaca;
- Cemmac a.s., Horné Sŕnie;
- Považská cementáreň a.s., Ladce.

The remaining 6 facilities are incinerating hospital waste.

MSW incinerators in Bratislava and Košice are receiving also non-MSW waste for incineration from companies and these amounts are included in national balances of incinerated non-MSW.

7.7.1.2.1 Methodological issues

Emissions from non-MSW are estimated by the IPCC 2006 GL, tier 2 method. Calculations were made for the total amount of incinerated waste to estimate 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.

Emissions from incineration of sewage sludge were estimated separately and added to non-MSW emissions. Separate reporting of sewage sludge was not used, as emissions from this waste stream are less than 5% of total incinerated non-MSW.

Similarly, the available data indicate that about 2.5 – 3 kt of waste from the health sector are incinerated annually. Currently the clinical waste incineration is included in the non-MSW incineration, but monitoring of this waste stream will continue and can be assessed individually in the future. These emissions are included in non-MSW incineration.

For CO_2 emissions estimation, default IPCC parameters were used for total carbon content, fossil carbon fraction and oxidation factor. CH_4 emissions were estimated using emission factor for semi-continuous incineration in stoker (6 kg/Gg). Emissions of N_2O are estimated using default emission factor for industrial waste – all types of incineration (100 g/t) and default emission factor for sludge in wet weight (900 g/t).

Methane emissions from other waste (non-MSW) were estimated using EF 600 kg CH4/Gg of waste. This EF was recommended by energy experts and is used for methane emissions estimation in the Energy sector. It can be assumed that the difference in EF for MSW and non-MSW is the result of differences in operation of incinerators (MSW – continuous operation while non-MSW often batch operation) and wider range of technologies used for non-MSW incineration, while there are only two incinerators for MSW.

Data on non-MSW incineration are generally available from 1997, but change of waste classification allows to use consistent time series from 2002. Data for the period 1990 – 2001 were extrapolated using surrogates, final energy consumption and sectoral production index. Published activity data allow disaggregation into incineration with and without energy use.

All waste generated in Slovakia according to the reports of the Statistical Office of the Slovak Republic were included in emissions estimation. Non-municipal waste includes all waste types defined in the IPCC 2006 GL.

Consistency of time series was ensured by using the official data published by the Statistical Office of the SR and the same methodology for processing activity data. The data available in the statistical reports are verified by comparison with the previous years. Unexplainable deviations were replaced by interpolations.

7.7.1.2.2 Uncertainties

Uncertainties for emissions from MSW incineration were calculated using the IPCC 2006 default methodology of error propagation. Uncertainty of emissions from incineration without energy recovery was estimated to be ±45%. Main source of uncertainty is N_2O emission factor, ranging ±100%.

7.7.1.2.3 Category - specific recalculations

The emissions of CO_2 were recalculated because ESD review team requested (recommendation No. ESD/W.14) the use of OX=1, replacing the previously used OX=0.9, which was used to account for old incinerators used in factories. This change increased emissions of CO_2 by 10% as ***Table 7.21*** shows, but does not have impact on N_2O or CH_4 emissions.

Table 7.21: *The difference between the new (2017) and the old (2016) submissions in 5.C.1.2b*

YEAR	PREVIOUS	REFINED	CHANGE
	CO_2 (Gg)		
1990	60.25	66.95	-10%
1991	57.45	63.84	-10%
1992	54.66	60.73	-10%
1993	51.86	57.62	-10%
1994	49.06	54.51	-10%
1995	46.26	51.40	-10%
1996	43.46	48.29	-10%
1997	40.66	45.18	-10%
1998	37.86	42.07	-10%
1999	35.06	38.95	-10%
2000	32.26	35.84	-10%
2001	29.46	32.73	-10%
2002	24.71	27.45	-10%
2003	26.42	29.35	-10%
2004	28.00	31.11	-10%
2005	21.86	24.28	-10%
2006	14.69	16.32	-10%
2007	7.52	8.36	-10%
2008	5.71	6.35	-10%
2009	5.04	5.60	-10%
2010	7.31	8.12	-10%
2011	9.58	10.64	-10%
2012	7.92	8.80	-10%
2013	6.64	7.38	-10%
2014	6.16	6.85	-10%

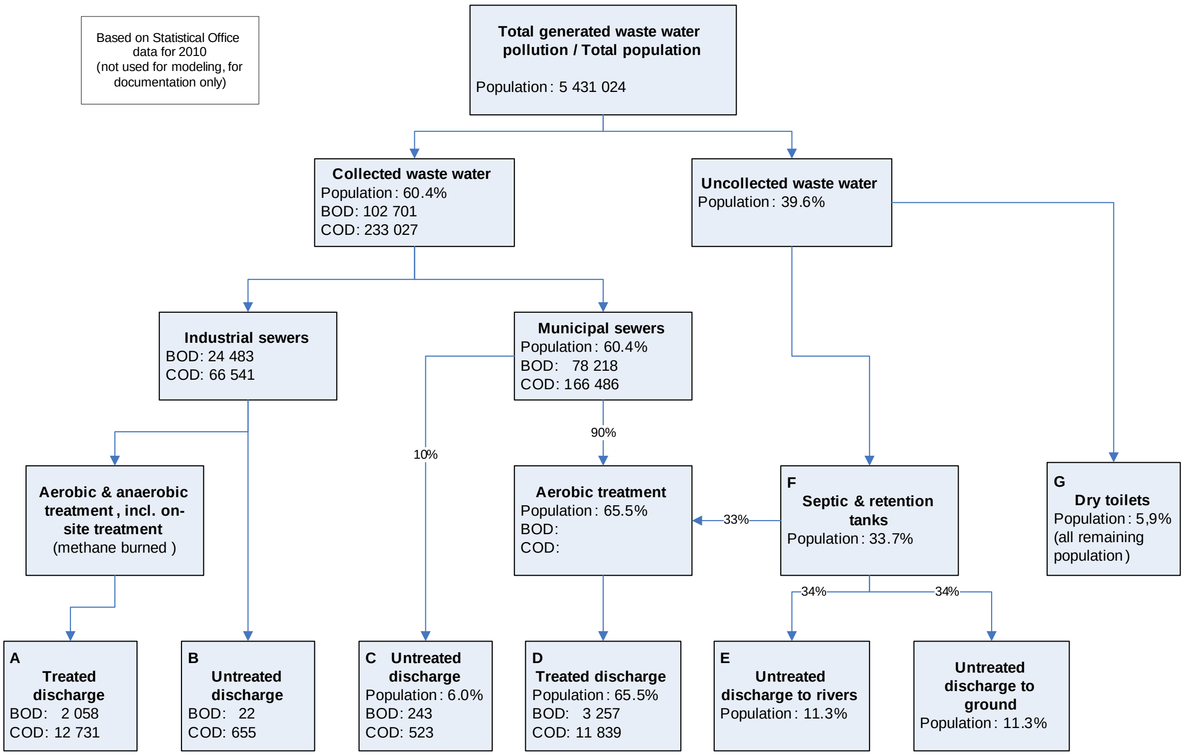
7.8 WASTEWATER TREATMENT AND DISCHARGE (CRF 5.D)

This sector 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 (WWT plants) and direct emissions from retention tanks are included. CO_2 emissions were not estimated, as they are of biogenic origin.

Total methane emissions from wastewater treatment were 12.28 Gg in 2015. Compared to the previous years, methane emissions continue to decrease, which is caused by modernisation of the

WWT plants. Total N_2O emissions from wastewater treatment were 0.17 Gg in 2015. The decreasing trend is caused by increasing volume of water treated in advanced WWT plants and decreasing consumption of proteins. ***Table 7.23*** shows emissions from domestic and industrial waste water.

Figure 7.5: *The typical balance of wastewater pathways for domestic and industrial waste water in Slovakia*



The legislation and practice in waste water treatment in Slovakia require that sewage sludge must be stabilised directly by the waste water treatment plant (e.g. Act No 188/2003 Coll. requires that only stabilised sewage sludge can be applied on agricultural land). Thus, according to the Slovak Technical Norm 75 6401 "Sewage Treatment Plants for more than 500 population equivalents" waste water treatment (WWT) plants with capacity to 10 000 person equivalents shall have sludge fields (aerobic stabilisation) and larger WWT plants shall have anaerobic sludge stabilisation. According to recommendation No. W.11, the following ***Table 7.22*** provides information on the data sources regarding the share of sludge.

Table 7.22: *WWT distribution of sludge*

YEAR	TOTAL GENERATED	TOTAL USE ON LAND	DIRECT LAND APPLIC.	COMPOSTED	INCINER.	LANDFILLED	TEMPORARY STORED ON-SITE
1990	55 000	45 207					
1995	55 000						
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
2014	56 883	52 570	8	36 524	16 038	1 073	3 240
2015	56 242	51 602	9 819	24 870	16 913	1 709	2 932

All WWT plants with anaerobic sludge stabilisation utilise biogas for generation of heat (all these WWT plants need heating for optimal operation of anaerobic reactor) and/or electricity. 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 sludge management in Slovakia. Information on the 12.7 GWh of electricity in 2007 from wastewater biogas is for documenting that the legal requirements are enforced and applied in the practice.

Table 7.23: *GHG emissions in individual categories in wastewater handling in particular years*

YEAR	DOMESTIC WASTE WATER				INDUSTRIAL WASTE WATER			
	BOD IN EFFLUENT AND RET, TANKS	CH_4	N IN EFFLUENT AND RET, TANKS	N_20	COD IN EFFLUENT	CH_4	N IN EFFLUENT	N_20
	Gg							
1990	108.76	17.471	50.92	0.4001	46.75	1.169	4.44	0.0348
1995	79.65	15.719	40.76	0.3202	33.81	0.845	3.67	0.0288
2000	73.13	15.322	33.42	0.2626	29.04	0.726	2.91	0.0228
2005	59.20	14.050	24.37	0.1915	16.88	0.422	1.90	0.0149
2010	51.41	13.040	22.13	0.1739	13.39	0.335	1.49	0.0131
2011	47.99	12.792	22.17	0.1742	10.75	0.269	1.20	0.0114
2012	46.58	12.617	21.75	0.1709	10.08	0.252	1.13	0.0101
2013	46.37	12.424	21.51	0.1690	9.92	0.248	1.11	0.0082
2014	44.63	12.198	21.10	0.1658	9.07	0.227	1.02	0.0065
2015	44.17	12.062	20.27	0.1592	8.81	0.220	0.98	0.0059

7.8.1 DOMESTIC WASTE WATER (CRF 5.D.1)

Generally, about two thirds of population are discharging wastewater through sewers and one third is using retention tanks. Wastewater collection and treatment in Slovakia is developing toward modern, advanced WWT plants with removal of nitrogen and phosphorus. Sludge from wastewater treatment is anaerobically stabilised on-site in majority of the WWT plants. Small number of WWT plants is using shallow sludge fields where aerobic stabilisation of sludge is expected. Methane from sludge stabilisation was not estimated, as all methane is used for generation of energy used in WWT plant operation (and reported in energy sector) and resulting CO_2 emissions are of biogenic origin. Total methane emissions from domestic wastewater treatment were 12.06 Gg in 2015. Main share on these emissions have retention tanks with 10.87 Gg in 2015. Total N_2O emissions from domestic wastewater treatment were 0.16 Gg. Majority of N_2O emissions is generated from retention tanks (0.079 Gg) (***Tables 7.24*** and ***7.25***)

Table 7.24: *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/ UNCATEGORISED	DOMESTIC WW TREATMENT PLANTS
	C	D	E	F	G	
MCF	**0.1**	**0.1**	**0.1**	**0.5**	**0.1**	
YEAR	Gg					
1990	1.042	2.055	0.834	12.639	0.900	0.000
1995	0.477	0.957	0.834	12.632	0.819	0.000
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

PATHWAY	DOMESTIC AND COMMERCIAL WW UNTREATED	DOMESTIC AND COMMERCIAL WW TREATED	UNTREATED DISCHARGE FROM SEPTIC TANKS	SEPTIC AND RETENTION TANKS	REST/ UNCATEGORISED	DOMESTIC WW TREATMENT PLANTS
	C	D	E	F	G	
MCF	0.1	0.1	0.1	0.5	0.1	
YEAR	Gg					
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	0.085	0.173	0.717	10.868	0.195	0.023

Table 7.25: *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
	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
2015	0.0789	0.0082	0.0721	0.1592

7.8.1.1 Methodological issues

The IPCC 2006 GL method was accommodated to reflect available data and observed trends in wastewater management. Known effluent BOD was used in emission estimation from WWT plants instead of calculating difference between total organics on input (TOW) and organic component removed with sludge (S).

The following wastewater pathways were identified and included in the model:

- Treated discharge from WWT plants,
- Untreated discharge from public sewers,
- Use of retention tanks,
- Use of domestic WWT plants,
- Dry toilets (and other non-specified methods).

N_2O emissions estimation is based on the IPCC 2006 Guidelines, but due to increased number of advanced WWT plants, the nitrogen removal by nitrification/denitrification had to be included in the model. The effectiveness of N removal in advanced WWT plants was estimated to be 75%, based on data published by Statistical Office of SR.

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.

Analysis of BOD data for TOW estimation confirmed, that the share of industrial wastewater in public sewers has significantly changed and a constant value is not suitable for emission estimation. Therefore, a time variable I-value was implemented in the model and applied in estimation for this submission.

Identification of waste water 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 water courses from public sewers. Emissions of CH_4 from retention tanks, dry toilets, domestic WWT plants and from untreated discharge from public sewers were estimated based on population and BOD per person per day (60 g - country specific value).

7.8.1.2 Uncertainties

Uncertainties were calculated using the IPCC 2006 GL default method and values. Country specific uncertainties are provided in the following ***Table 7.26***. The total uncertainty of emissions from municipal waste water was estimated to -32% +320%. The main source of uncertainty is N_2O emission factor.

Table 7.26: *Uncertainties for the category of domestic wastewater treatment*

PARAMETER	DEFAULT	MIN	MAX
EMISSION FACTOR PLANTS	3.2	2	8
EMISSION FACTOR EFFLUENT	0.005	0.0005	0.25
ANNUAL PER CAPITA PROTEIN CONSUMPTION	±10%		
FACTOR FOR NON-CONSUMED PROTEIN ADDED TO THE WASTEWATER	1.1	1	1.2
FRACTION OF NITROGEN IN PROTEIN	0.16	0.15	0.17
SLUDGE	±5%		
N IN SLUDGE	4	3	5
N DENIT	75%	50%	80%
SHARE OF ADVANCED PLANTS	±20%		

Total uncertainty of emissions from wastewater treatment was estimated in a range of -45% to +651%. Main source of uncertainty is N_2O emission factor, ranking from -90% to +4 900%.

7.8.1.3 Category - specific recalculations

Emissions of N_2O from domestic waste water were recalculated. Expert estimate on the share of modern waste water treatment plants was replaced by new information derived from SHMU databases. The revised estimate is 60%, compared to previously used 75%. This change cased reduction of direct emissions from WWTPs and increase of emissions from discharged waste water. Emissions of N_2O from untreated discharges remained without change. The comparison of previously estimated and recalculated N_2O emissions from WWTPs is shown in the following ***Table 7.27***.

Table 7.27: *The difference between the new (2017) and the old (2016) submissions*

YEAR	SHARE OF MODERN WWT PLANTS		DOMESTIC N_2O EMISSIONS	
	PREVIOUS	REFINED	PREVIOUS	REFINED
1990			0.4001	0.4001
1995			0.3202	0.3202
2000	17%	19.2%	0.2657	0.2626
2005	57%	46.8%	0.1792	0.1915

YEAR	SHARE OF MODERN WWT PLANTS		DOMESTIC N_2O EMISSIONS	
	PREVIOUS	REFINED	PREVIOUS	REFINED
2010	71%	52.7%	0.1514	0.1739
2011	74%	53.4%	0.1478	0.1742
2012	75%	53.6%	0.1436	0.1709
2013	75%	54.1%	0.1419	0.1690
2014	75%	55.0%	0.1412	0.1658

Previous year estimates of BOD and protein consumption were replaced by reported figures. This recalculation has minimal impact on sectoral emissions.

7.8.2 INDUSTRIAL WASTE WATER (CRF 5.D.2)

Water consumption for industrial purposes and resulting discharge of waste water have significantly decreased in the period 1990 – 2015. This decrease can be explained by general modernisation of Slovak industries and stricter standards for discharge of industrial wastewater to public sewers or to water courses.

Total methane emissions were estimated to be 0.22 Gg and total N_2O emissions were 0.006 Gg from industrial wastewater treatment in 2015. The pathways A and B are included in the estimation of methane emissions. The ***Table 7.23*** shows the activity data and resulting emissions estimation.

The model for industrial waste water does not estimate carbon and nitrogen removed with sludge, methane which is generated is used for energy generation and these emissions are included in the Energy Sector.

7.8.2.1 Methodological issues

The methodology recommended by the IPCC 2006 GL was used for estimating emissions from industrial wastewater. COD values reported by the Statistical Office of the SR were used in methane emissions estimation. It is assumed that use of the reported COD data will provide better results than estimation according to the methodology provided in the Chapter 6.2.3.3 of the IPCC 2006 GL. Only methane emissions 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, that all methane from this treatment was burned (with or without energy utilization).

The IPCC 2006 GL do not provide specific methodology for estimation of N_2O emissions from industrial waste water. Slovakia currently collects information on discharged pollution from all sources. The Statistical Office of the 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 treated and untreated discharge of industrial waste water.

For emissions estimation from industrial waste water, default IPCC 2006 emission factors 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. Full balance of COD was prepared covering generated pollution, pollution discharged as treated effluent and pollution discharged as treated effluent.

Data on discharged nitrogen are available for the period 2009 – 2015. A good correlation (0.92) was identified between 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

Default uncertainties based on the IPPC 2006 GL were used to assess emissions estimation. Uncertainty of CH_4 emissions from industrial waste water were estimated to -60% +880%. Main source of uncertainty is N2O Emission factor.

7.8.2.3 Category - specific recalculations

The N_2O emissions from industrial waste water were fully recalculated (***Table 7.28***). The previously used ISI methodology focused only on direct emissions from modern WWTPs and it does not seem compactible with the general IPCC approach to emission estimation from waste water. The refined approach is focusing on estimation of emissions from discharged industrial waste water.

Table 7.28: *The difference in N_2O emissions between the new (2017) and the old (2016) submissions in 5.D.2*

YEAR	PREVIOUS	REFINED
1990	0.0646	0.0348
1991	0.0652	0.0335
1992	0.0503	0.0321
1993	0.0402	0.0310
1994	0.0411	0.0299
1995	0.0386	0.0288
1996	0.0425	0.0237
1997	0.0396	0.0226
1998	0.0412	0.0207
1999	0.0355	0.0194
2000	0.0301	0.0228
2001	0.0301	0.0213
2002	0.0716	0.0198
2003	0.0306	0.0203
2004	0.0386	0.0172
2005	0.0431	0.0149
2006	0.0400	0.0115
2007	0.0404	0.0113
2008	0.0334	0.0117
2009	0.0289	0.0124
2010	0.0291	0.0131
2011	0.0281	0.0114
2012	0.0250	0.0101
2013	0.0229	0.0082
2014	0.0249	0.0065

Previous year (2014) estimates of COD were replaced by reported values.

7.9 MEMO ITEMS (CRF 5.F)

The IPCC 2006 model expects, that part of carbon is stored in the SWDS for a long time. This may be the reason for lower emissions from solid waste disposal estimated by the IPCC 2006 model compared to the previously used model.

The IPCC Waste Model provides estimates on stored carbon and overview of this parameter is shown in the ***Table 7.29***, disaggregated to municipal solid waste and non-municipal solid waste. (Note: These data were not inserted in the CRF table 5.E, 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 7.29: *Accumulated Long-term Stored C in SWDS*

YEAR	ACCUMULATED STORED C (Gg)			ANNUAL CHANGE STORED C(Gg)		
	MSW	non-MSW	Total	MSW	non-MSW	Total
1990	1 203	250	1 453	47	10	57
1995	1 399	287	1 686	43	7	51
2000	1 648	326	1 974	49	8	58
2005	1 953	382	2 336	66	11	77
2010	2 328	456	2 784	78	8	87
2011	2 400	465	2 865	72	8	81
2012	2 471	477	2 948	71	12	83
2013	2 536	492	3 027	64	15	79
2014	2 599	500	3 100	64	9	73
2015	2 667	511	3 178	68	11	78

The long-term stored carbon data were recalculated. This change was caused by changes in the non-MSW disposal. Refined estimates of long-term stored carbon in SWDS are 12% lower than previous estimates, because of lower amounts of disposed non-MSW.

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. 2006 IPCC 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 process were estimated and are included in the category 2.D – Non-energy products from fuels and solvent use as a part of CO_2 emissions estimate. More information can be found in the Chapter 4 – IPPU (in particular the source category 2.D.3 Other in IPPU Table 2(I)s2 and 2(I).A-Hs2), where the CRF reporter software contains pre-defined subcategories for solvent use, road paving with asphalt and asphalt roofing.

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 energy, LULUCF and waste sectors.

Slovakia does not report any indirect CO_2 and N_2O emissions separately in the CRF Table 6.

CHAPTER 10: RECALCULATIONS AND IMPROVEMENTS

10.1 EXPLANATIONS AND JUSTIFICATIONS FOR RECALCULATIONS, INCLUDING FOR KP-LULUCF INVENTORY

The main driver for recalculations in the 2017 greenhouse gas inventory submission of the Slovak Republic has been further the implementation of the methodologies and categories given in the 2006 IPCC Guidelines and improvements. The recommendations from the previous UNFCCC and EU ESD inventory reviews have been taken into account to the extent they are applicable taking into account the implementation of the revised UNFCCC reporting guidelines and the 2006 IPCC 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 (2016) are described also in the sector Chapters 3-7.

The list of the major recalculations with the short descriptions made in the 2016 submission is summarized in the ***Tables 10.3*** and ***10.4***. More information on recalculations can be found in the sector specific chapters.

10.2 IMPLICATIONS FOR EMISSION LEVELS

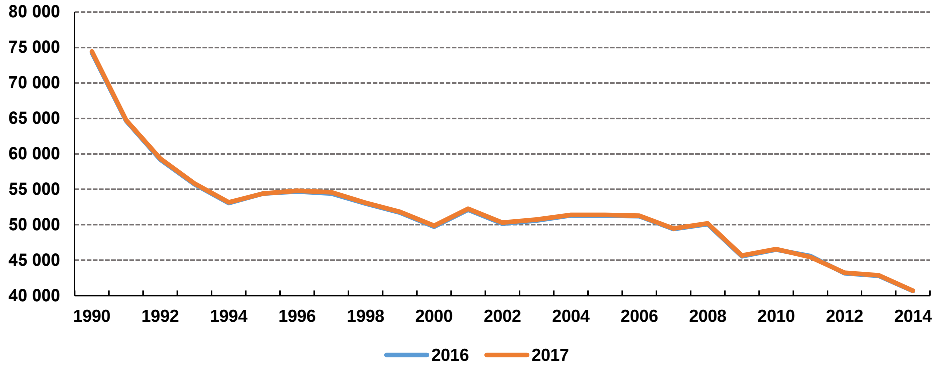
Reflecting the QA/QC activities for improving the emission inventory of GHG and recommendations provided by the experts during the review process for inventory submissions under UNFCCC and under the EU ESD, the experts involved in the National Inventory System of the Slovak Republic proposed the recalculations of several subsectors and categories. The recalculations are based on updated or revised methodologies (for LULUCF, transport and agriculture sectors) or updated statistical information (e.g. input data in IPPU, waste and energy sectors). The recalculations listed in the ***Tables 10.1*** and ***10.2*** were provided in the CRF Tables version 2017, version 3 against previous inventory submission from September 9, 2016, version 4 with and without LULUCF sector. The ***Table 10.3*** presents list of performed recalculations with the short summarizing description (detailed information is provided in the sectoral chapters in this report). Total GHG emissions without LULUCF increased in 2017 submission for the year 1990 by 0.25%, and increase in 2014 by 0.05% (***Table 10.1***). Regarding total GHG emissions with LULUCF, decreasing of recalculated removals caused increasing of GHG emissions in 2017 submission in all years of time series (except 2011) (***Table 10.2***).

Table 10.1: *Comparison of GHG emission trend without LULUCF of the 2016 and 2017 submissions*

National GHG Inventory without LULUCF in Gg of CO_2 eq.			
Year	**Submission 2016 v4**	**Submission 2017 v3**	**2017 v3/2016 v4 (%)**
1990	74 271.51	74 460.34	100.25%
1991	64 644.53	64 782.75	100.21%
1992	59 204.28	59 339.06	100.23%
1993	55 689.28	55 823.78	100.24%
1994	53 053.30	53 182.16	100.24%
1995	54 405.58	54 411.60	100.01%
1996	54 706.07	54 793.75	100.16%
1997	54 396.94	54 573.82	100.33%
1998	52 993.84	53 101.20	100.20%
1999	51 700.43	51 811.57	100.21%
2000	49 712.48	49 863.07	100.30%
2001	52 127.67	52 278.00	100.29%
2002	50 144.76	50 294.85	100.30%
2003	50 586.58	50 731.42	100.29%
2004	51 315.16	51 392.40	100.15%
2005	51 287.37	51 395.62	100.21%
2006	51 206.91	51 271.33	100.13%
2007	49 405.07	49 473.09	100.14%
2008	50 088.74	50 179.67	100.18%
2009	45 557.63	45 651.68	100.21%
2010	46 482.87	46 559.69	100.17%

National GHG Inventory without LULUCF in Gg of CO_2 eq.			
Year	**Submission 2016 v4**	**Submission 2017 v3**	**2017 v3/2016 v4 (%)**
2011	45 604.02	45 455.58	99.67%
2012	43 175.59	43 251.41	100.18%
2013	42 792.48	42 885.65	100.22%
2014	40 657.60	40 677.79	100.05%

Figure 10.1: *Comparison of GHG emission trend without LULUCF of the 2016 and 2017 submissions in Gg of CO_2 eq.*

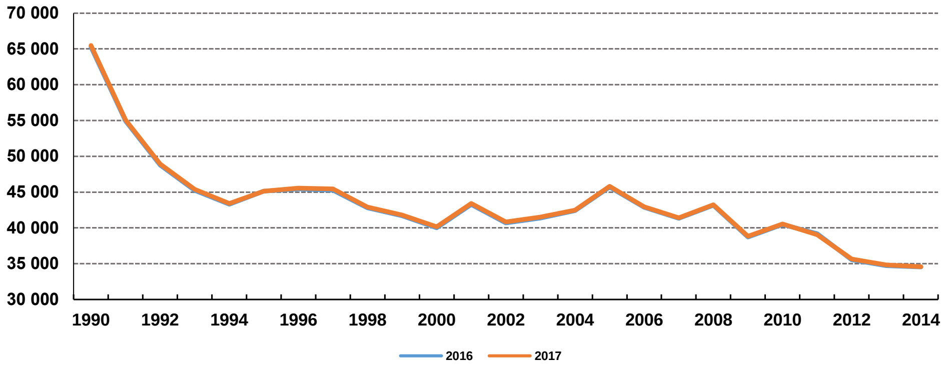


submission 2016, version 4, submission 2017 version 3, in Gg of CO_2 eq., 15.03.2017

Table 10.2: *Comparison of GHG emission trend with LULUCF of the 2016 and 2017 submissions*

National GHG Inventory with LULUCF in Gg of CO_2 eq.			
Year	**Submission 2016 v4**	**Submission 2017 v3**	**2017 v3/2016 v4 (%)**
1990	65 280.26	65 469.09	100.29%
1991	54 918.24	55 056.46	100.25%
1992	48 772.95	48 907.73	100.28%
1993	45 245.22	45 379.72	100.30%
1994	43 296.46	43 425.32	100.30%
1995	45 121.45	45 127.47	100.01%
1996	45 462.64	45 550.33	100.19%
1997	45 269.11	45 445.99	100.39%
1998	42 815.79	42 923.14	100.25%
1999	41 698.28	41 809.43	100.27%
2000	39 993.57	40 144.17	100.38%
2001	43 260.48	43 410.81	100.35%
2002	40 680.59	40 830.68	100.37%
2003	41 369.45	41 514.29	100.35%
2004	42 396.23	42 473.47	100.18%
2005	45 682.42	45 790.67	100.24%
2006	42 870.33	42 934.74	100.15%
2007	41 341.45	41 409.46	100.16%
2008	43 142.62	43 233.55	100.21%
2009	38 730.87	38 824.93	100.24%
2010	40 470.26	40 547.07	100.19%
2011	39 194.94	39 046.50	99.62%
2012	35 553.92	35 629.74	100.21%
2013	34 721.19	34 814.36	100.27%
2014	34 535.85	34 556.04	100.06%

Figure 10.2: *Comparison of GHG emission trend with LULUCF of the 2016 and 2017 submissions in Gg of CO_2 eq.*



submission 2016, version 4, submission 2017 version 3, in Gg of CO_2 eq., 15.03.2017

10.3 RECALCULATIONS, INCLUDING IN RESPONSE TO THE REVIEW PROCESS, AND PLANNED IMPROVEMENTS TO THE INVENTORY

The latest published Annual Review Report FCCC/ARR/2016/SVK of the individual review of the annual submission of the Slovak Republic was published in March 2017 at http://unfccc.int/resource/docs/2017/arr/svk02.pdf. This report covers the centralised review of the 2016 annual submission of the Slovak Republic, coordinated by the UNFCCC secretariat, in accordance with decision 22/CMP.1. This SVK NIR 2017 was prepared based on recalculated and resubmitted GHG inventory 1990 – 2014 in September 2016. More information on recalculations provided based on the ERT recommendations from the latest UNFCCC and KP review cycle can be found in this report.

In term to further improve GHG emissions inventory, the NIS SR planned in the frame "Improvement and Prioritisation Plan 2016" recalculations also for the 2017 submission. These can be listed in the ***Tables 10.3*** and ***10.4*** below. These recalculations focusing on the main issues highlighted in the regular EU ESD review performed in the years 2015 and 2016. In addition, recalculations are also planned in the short and long term perspective by the experts of the NIS SR, especially in the categories with the key impact on GHG emissions (for example national parameters applied in the agriculture or national methodology and data implemented in industrial waste incineration with energy use).

The status of recommendations including planned improvements can be found in the Annex 4, ***Table A4.3*** of this report, but also directly in sectoral chapters.

Table 10.3: *List of recalculations in January 15, 2017 submission (version 1) against September 09, 2016 submission (version 4) with short explanation*

RECALCULATED CATEGORY (SUBMISSION 2016 V4 VERSUS SUBMISSION 2017 V1)		YEARS	GHG AFFECTED	EXPLANATION
1. ENERGY SECTOR				
1.A.1.a.iv	Public Electricity and Heat Production – Other fuels, Municipal Solid Waste Incineration with energy use (other fossil fuels and biomass)	1990-2014	CO_2	SVK NIR 2017 (Chapter 3 - Energy), MSW incineration with energy use, category 1.A.1a.iv - Other fuels, C-fossil and biogenic MSW incinerated with energy use - Methodological refinement, the previously used method is insufficient to reflect mitigation activities in a transparent manner. The modelled MSW composition used for estimating emissions from MSW disposal was introduced to model for estimating emissions from MSW incineration.
1.A.1.4.c.ii	Agriculture/Forestry/Fishing	1990-2014	CO_2, CH_4, N_2O	Recalculations in off-road transportation included in the subcategory 1.A.4.c.ii was implemented in the connection with the recalculations made in road transport category. Revision of NCV of diesel oil and gasoline in connection with the recalculation of road transportation.
1.A.4.a	Commercial/Institutional	2014	CO_2, CH_4, N_2O	Natural gas in category 1.A.4.a was recalculated for year 2014. The reason for this recalculation was modification of the energy balance (fuel consumptions) provided by the Statistical Office of the Slovak Republic.
1.A.3.a	Domestic Aviation (aviation gasoline and jet kerosene)	1990-2014	CO_2, CH_4, N_2O	New share between domestic and international fuel consumption based on EUROCONTROL data and recommended by the ERT during previous review (chapter 3.2.7.5) Revision of NCV values for jet kerosene and aviation gasoline (chapter 3.2.7.5)
1.A.3.b	Road Transportation (gasoline and diesel oil)	2007-2014	CO_2, CH_4, N_2O	Revision of biomass share in fuels, revision of NCV of biomass blended in fuel (chapter 3.2.7.5)
1.A.3.b	Road Transportation (gasoline and diesel oil)	2007-2014	CO_2, CH_4, N_2O	Revision of biomass share in fuels, revision of NCV of biomass blended in fuel (chapter 3.2.7.5)
1.A.3.b	Road Transportation (urea catalysts)	2010-2014	CO_2, CH_4, N_2O	Revisions and completing of urea catalysts emissions, reallocation into IPPU sector (2.D.3) based on the ERT recommendations (chapter 3.2.7.5)
1.A.3.b	Road Transportation (urea catalysts)	2010-2014	CO_2, CH_4, N_2O	Recalculation relates to the changes in newly implemented version of COPERT 5 model (chapter 3.2.7.5)
1.A.3.c	Railways (diesel oil)	1990-2014	CO_2, CH_4, N_2O	Revision of the values of NCV of fuel (chapter 3.2.7.5)
1.A.3.c	Railways (diesel oil)	2007-2014	CO_2, CH_4, N_2O	Revision connected with including biomass share into calculation (chapter 3.2.7.5)
1.A.3.d	Navigation (Shipping) (diesel oil)	1990-2014	CO_2, CH_4, N_2O	Revision connected with correction of default EFs (chapter 3.2.7.5)
1.D.1.a	International Aviation (all fuels)	1990-2014	CO_2, CH_4, N_2O	Please see 1.A.3.a (chapter 3.2.3.1)
1.D.1.b	International Navigation (diesel oil)	1990-2014	CO_2, CH_4, N_2O	Revision of NCV of diesel oil and correction of EFs based on the ERT recommendations from 2014 review (chapter 3.2.3.2)

RECALCULATED CATEGORY (SUBMISSION 2016 V4 VERSUS SUBMISSION 2017 V1)		YEARS	GHG AFFECTED	EXPLANATION
1.B.2	Oil	2013	CO_2, CH_4	Revision of the energy balance in the National Energy Statistics
1.B.2	Natural Gas	2014	CO_2, CH_4	Revision of the energy balance in the National Energy Statistics
2. INDUSTRIAL PROCESSES SECTOR				
2.D.3	Non-energy Products from Fuels and Solvent Use – Other (Urea Based Catalysts)	2010-2014	CO_2, CH_4, N_2O	Reallocation of emissions from Road Transportation in reaction to the ERT recommendations.
2.F.1	Refrigeration and Air Conditioning	1990-2014	HFCs	Methodological change. Revision of F-gases emission in 2.F.1 – from decommission equipment
2.F.1	Refrigeration and Air Conditioning	1990-2014	HFCs	Methodological change. Revision of F-gases emission in 2.F.1 – from decommission equipment – recovery of gases
2.F.1.b	Domestic Refrigeration	1990-2014	HFCs	Methodological change. Revision of F-gases in 2.F.1.b – domestic refrigeration
3. AGRICULTURE				
3.A.1	Enteric fermentation - Cattle	1990-2014	CH_4	Methodological change. Revision of Ym parameter, and change AD, Change of dividing: Dairy cattle is only milk cows. Suckling cows were allocate in non-dairy cattle. Revision of Ym parameter.
3.A.2	Enteric fermentation - Sheep	1990-2014	CH_4	New category was added: 3.A.2 growing lambs and other mature sheep
3.A.3	Enteric fermentation - Swine	1990-2014	CH_4	AD change. Extrapolating data were change for available statistical data
3.A.4	Other livestock	1990-2014	CH_4	AD change. Extrapolating data were change for available statistical data
3.B.1.1	Manure Management-cattle	1990-2014	CH_4	Methodological change. More detailed livestock subcategory, new VS parameters for cattle category and Bo parameter for western Europe (non-dairy cattle categories)
3.B.1.2	Manure Management-sheep	1990-2014	CH_4	Methodological change. More detailed livestock subcategory, new VS parameters for cattle and sheep category
3.B.2.2	Manure Management	1990-2014	N_2O	Revision of AWMS allocation of animal categories based on national data. Revision of emission factors and Nex for AWMS based on national data
3.B.2.5	Indirect N_2O Emissions	1990-2014	N_2O	Due to recalculations in the all categories
4.D.1.2.a	Agricultural Soils – Animal Manure Applied to Soil	1990-2014	N_2O	Revision of emission factors for manure applied to soil based on the IPCC 2006 GL. Revision is connected also with the revision in the category 3.B.2.
4.D.1.3	Agricultural Soils – Urine and Dung Deposited by Grazing Animals	1990-2014	N_2O	Revision of EFs for grazing based on the IPCC 2006 GL. Revision was connected also with the revision in the category 3.B.2.
4.D.2	Agricultural Soils – Indirect N_2O Emissions from Managed Soils.	1990-2014	N_2O	Revision of EFs for atmospheric deposition and N-leaching and run off based on the IPCC 2006 GL. Revision is connected also with the revision in the category 3.B.2.

RECALCULATED CATEGORY (SUBMISSION 2016 V4 VERSUS SUBMISSION 2017 V1)		YEARS	GHG AFFECTED	EXPLANATION
5. WASTE				
5.A	Solid Waste Disposal	1990-2014	CH_4	Emissions from waste disposal (5.A) were recalculated due to requirement to improve estimation of emissions from non-MSW waste. We used this opportunity and fully reviewed the model for non-MSW, including new approach to modelling of AD on disposed sewage sludge.
5.B	Biological Treatment of SW	1990-2014	N_2O	Emissions from biological treatment (5.B) were recalculated due to requirement to apply new emission factor for N2O according to the corrigendum of IPCC guidelines from July 2015.
5.C	Incineration and Open Burning of Waste	1990-2014	CO_2, N_2O	Emissions from incineration of waste without energy recovery (5.C) were recalculated due to requirement to apply oxidation factor 1. The previously used OF 0.9 based on was not accepted by the ERT because we could not provide documentation for this change of default value 1.
5.D	Wastewater	1990-2014	N_2O	Emissions from wastewater treatment (5.D) were recalculated due to new information on the share of modern waste water treatment plants in Slovakia.
7. KP LULUCF				
KP.B.1	Forest Management	2013-2014	CO_2, CH_4, N_2O	Revision of FM area, fixed wrong calculation in 2013 and 2014. No changes in methodology (SVK NIR 2017 Chapter 11.5)

Table 10.4: *List of recalculations in March 15, 2017 submission (version 3) against January 15, 2017 submission (version 1) with short explanation*

RECALCULATED CATEGORY (SUBMISSION 2017 V1 VERSUS SUBMISSION 2017 V3)		YEARS	GHG AFFECTED	EXPLANATION
1. ENERGY SECTOR				
1.A.1a.iv	Public Electricity and Heat Production – Other Fossil Fuels, Industrial Waste Incineration with Energy Use (biogenic and fossil fuels)	1990-2014	CO_2	According to the recommendation from the ESD comprehensive (W.14), change in the oxidation factor from 0.9 to 1.0
2. INDUSTRIAL PROCESSES SECTOR				
2.F.1.b	Domestic Refrigeration	2014, 2015	HFCs	Revision of F-gases in 2.F.1.b – domestic refrigeration (reallocation of new fillings into 2.F.1.a category).
2.F.1a	Commercial Refrigeration	2014, 2015	HFCs	Revision of F-gases in 2.F.1.a – commercial refrigeration (reallocation of new fillings from 2.F.1.b category).
2.D.3	Other	1990-2015	CO_2, NMVOC	Recalculations in CLRTAP inventory were adopted.
3. AGRICULTURE				
3.A.1	Enteric fermentation – Dairy Cattle	2015	CH_4	Correction was made in update of values for emissions and milk yield.

RECALCULATED CATEGORY (SUBMISSION 2017 V1 VERSUS SUBMISSION 2017 V3)		YEARS	GHG AFFECTED	EXPLANATION
3.A.1 3.A.2	Enteric fermentation – Cattle, Sheep	1990-2015	CH_4	Revision of milk yield. Values are reported in kilograms.
3.A.1	Enteric fermentation – Cattle	1990-2015	CH_4	Revision of Ym parameter. Values were fixed from total values on the percentage.
3.A.1	Enteric fermentation – Non-dairy cattle	1991	CH_4	AD change - population. Change was not impact on emissions, because mistake in number of livestock was only in CRF reporter.
3.A.2	Enteric fermentation – Sheep	1990-2015	CH_4	Revision of Ym parameter and pregnancy factor. Values are reported in percentage.
3.A.2	Enteric fermentation – Growing lambs, Other mature sheep	1992, 1998, 2005, 1994, 2015	CH_4	AD change – population. Corrections had influence on the emissions and body weight.
3.A.3	Enteric fermentation – Swine	1990-2015	CH_4	CRF reporter worked incorrectly. Uploading of the new date into the CRF reporter was not successful. AD and emissions were changed.
3.A.4	Enteric fermentation - Goats	1990-2015	CH_4	CRF reporter worked incorrectly. Uploading of the new date into the CRF reporter was not successful. Average body weight was added in goats' category.
3.A.4	Enteric fermentation - Goats	1992, 1998, 2002, 2009.	CH_4	AD change – population. Corrections had impact on emissions.
3.B.1.1	Manure management – Dairy cattle	2014	CH_4, N_2O	VS and emissions were change due to not correct calculation of weighted average.
3.B.1.1	Manure management – Non-dairy cattle	1991	CH_4, N_2O	AD change – population. Correction of number of livestock. Correction is connected with the correction in the category 3.A.1.
3.B.1.2	Manure management – Growing lambs	1992, 1994,	CH_4, N_2O	AD change – population. Corrections had impact on body weight and percentage of MMS.
3.B.1.2	Manure management – Growing lambs	2002, 2015	CH_4	Emissions and VS daily excretion were change. Corrections had impact on emissions because weighted average was calculate wrong.
3.B.1.2	Manure management – Other mature sheep	1998, 2005, 2015	CH_4,N_2O	AD change – population. Correction of number of livestock was done. Correction is connected with the correction in the category 3.A.2.
3.B.1.2	Manure management – Other mature sheep	2002, 2003	CH_4	AD change – population. Correction of number of livestock was done. Correction is connected with the correction in the category 3.A.2.
3.B.1.3	Manure management – Swine	1991	CH_4,N_2O	AD change – population. Correction of number of livestock was done. Correction is connected with the correction in the category 3.A.3.
3.B.1.4	Manure management – Goats	1992, 2002, 2009	CH_4,N_2O	AD change – population. Changes had influence on the emissions and body weight.
3.B.1.4	Manure management – Poultry	1994, 1998	CH_4,N_2O	AD change – population. Change had impact on emissions and body weight, because there are wrong weighted average.
3.B.2.5	Indirect N_2O Emissions	1991, 1992, 1994, 1998,	N_2O	Due to recalculations in 3.B.2

RECALCULATED CATEGORY (SUBMISSION 2017 V1 VERSUS SUBMISSION 2017 V3)		YEARS	GHG AFFECTED	EXPLANATION
		2002, 2005, 2009		
3.D.1.2.a	Agricultural Soils – Animal Manure Applied to Soil	1992, 1994, 1998, 2002, 2005, 2009	N_2O	Revision is connected with the revision in the category 3.B.2.
3.D.1.3	Agricultural Soils – Urine and Dung Deposited by Grazing Animals	1991, 1992, 1994, 2002, 2009	N_2O	Revision was connected with the revision in the category 3.B.2.
3.D.2.1	Atmospheric deposition	1991, 1992, 1994 1998, 2002, 2005, 2009-2014	N_2O	Revision is connected with the revision in the category 3.B.2, 3.D.1.2
3:D.2.2	Nitrogen leaching and run-off	1991, 1992, 1994, 1998, 2002, 2005, 2009-2014	N_2O	Revision was connected with the revision in the category 3.B.2.
5. WASTE				
5.D.2	Industrial Waste Water	1990-2014	N_2O	

In major cases, recommendations raised during the UNFCCC centralized review and ESD review of the years 2015 and 2016 were already fully or partly implemented in 2017 submission and caused recalculations of emissions (transport, agriculture, waste).

<u>EU ESD review 2016:</u>

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 first annual review 2015 concerning Member States' inventories for the first compliance year 2013 was postponed to 2016 due to delays and technical problems with the UNFCCC CRF reporting software which made it impossible to carry out the annual review as planned in 2015.

The 2016 comprehensive review was carried out for the compliance years 2013 and 2014, and for the years 2005, 2008, 2009 and 2010 pursuant to MMR Article 27. This report presented the findings from the second step of the 2016 comprehensive review of the GHG emission inventory of Slovakia.

In Table 4 of the *Technical Review Report of Slovakia*, TERT provided several recommendations to the emissions inventory of Slovakia. One technical correction occurred in methane emissions from enteric fermentation of cattle was accepted and revised estimation was provided and approved by TERT.

These recommendations were added to Improvement Plan for the year 2016 and for the year 2017 and were planned to implement in this or next submission.

These recommendations with the comments are listed in the tabular format of Annex IV specified in Article 9.1 to the Implementing Regulation (EU) No 749/2014 (Article 7) of the Commission accompanied this submission.

<u>UNFCCC centralized review 2016:</u>

To the deadline of this submission, Slovakia received *final review reports of the 2015 and 2016 annual submissions of Slovakia submitted to the UNFCCC in 2015 (FCCC/ARR/2015/SVK) and 2016 (FCCC/ARR/2016/SVK)*.

Slovakia was reviewed in the UNFCCC centralized review during the week from 5th – 10th September 2016. Because of the 2015 and 2016 submissions´ review of Slovakia, Provisional main and additional findings were received in the end of review week. No Saturday paper or adjustments were applied. List of main findings includes two general and four sectoral recommendations. List of additional findings includes 21 recommendations. These recommendations were also included in the National Inventory Report 2017. These recommendations were added to Improvement Plan for the year 2016 and for the year 2017 and were planned to implement in this or next submission. These recommendations with the comments are listed in the tabular format of Annex IV specified in Article 9.2 to the Implementing Regulation (EU) No 749/2014 (Article 7) of the Commission accompanied this submission.

CHAPTER 11: KP-LULUCF

Summary information on emissions and removals accounted under Article 3.3 and 3.4 are provided in the 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 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 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 forests 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 Cadaster Authority of the Slovak Republic (GCCA). The GCCA issues yearly 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 changes from and to forests are considered to be human induced in the Slovak Republic. AR activities are reported together. All forests in the Slovak Republic are managed, thus forest land remaining forest land is considered as subject to the Forest Management activity under Article 3.4. Other Article 3.4 Activities 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 Article 3.4 (cropland management, grazing land management, revegetation or wetland drainage and rewetting). Because only FM as mandatory activity is reported by the Slovak Republic, no precedence conditions and/or hierarchy among 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

To meet the reporting requirements of the Marrakesh Accords, general information on activities under Articles 3.3 must include the geographical boundaries of areas encompassing units of land subject to the mandatory and elected activities.

To achieve this, reporting method 1 was chosen, see Chapter 2.2.2 - ***Figure 2.2.1*** of the 2013 KP Supplement (IPCC, 2014). The method entails delineating areas that include multiple land units subject to Article 3.3 activities by using legal and administrative boundaries. The data published by the Statistical Yearbook of the Soil Resources in the Slovak Republic permit spatial assessment and identification of AR, D and FM activities at the level of Slovak districts. The Slovak system has the attributes of both approach 2 and approach 3. The GCCA database provides information on eight land districts since 1996 and three districts in the period from 1990 to 1995 (see the following figures).

Figure 11.1: *Eight Slovak regional districts established in 1996*

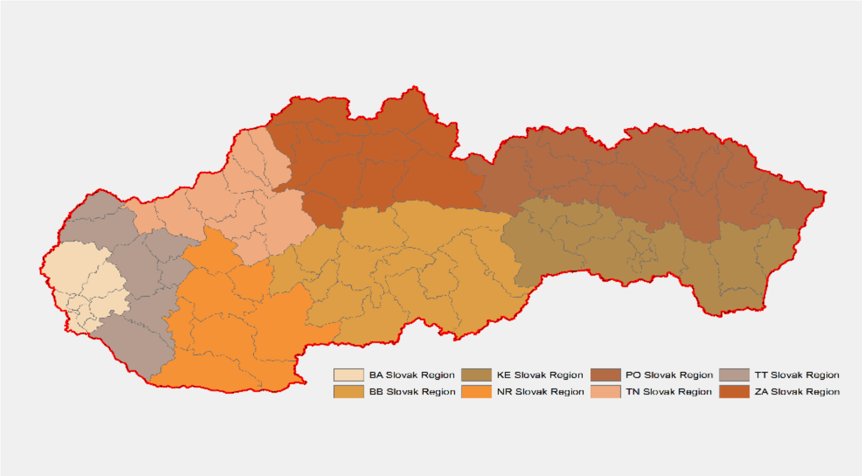
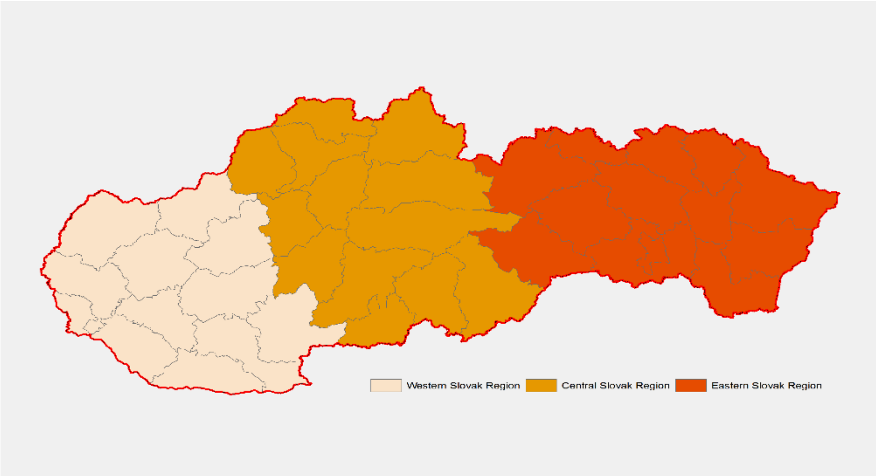


Figure 11.2: *Three Slovak regional districts used for the assessment of ARD activities since 1990*



Geographical boundaries of these districts 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.

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. The following ***Tables 11.2 – 11.4*** provide an overview of the spatial extent of ARD activities in each regional district/region in Slovakia.

Table 11.2: *The areas of ARD activities during 1990 – 1995 for whole country and Slovak regional districts*

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: *The areas of A/R activities during 1996 – 2015 for whole country and different Slovak districts*

A/R	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

Figure 11.3: *The district units with afforestation activity in Slovakia (2015)*

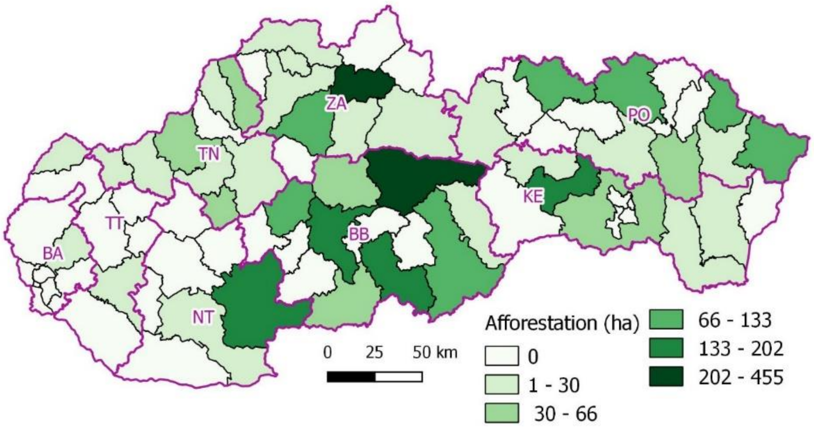


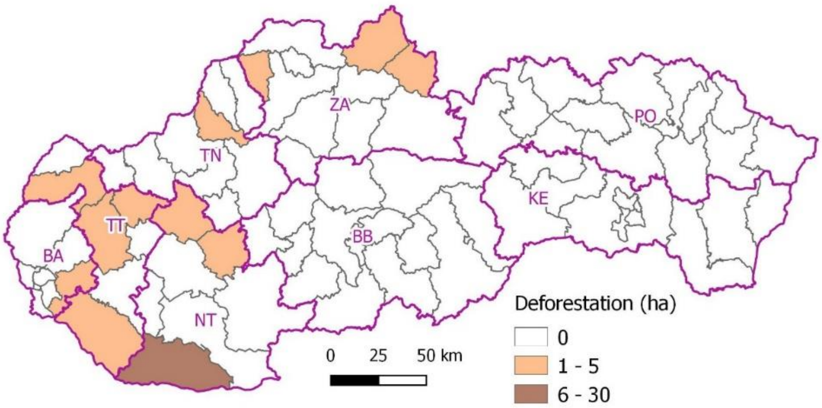
Table 11.4: *The areas of D activities during 1996 – 2015 for whole country and different Slovak districts*

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

DEF	SK	BA	TT	TN	NR	ZA	BB	PO	KE
	kha								
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

SK = the Slovak Republic, BA = Bratislava District, TT = Trnava District, TN = Trencin District, NR = Nitra District, ZA = Zilina District, BB = Banska Bystrica District, PO = Presov District, KE = Kosice District

Figure 11.4: *The district units with deforestation activity in Slovakia (2015)*



In the following ***Table 11.5***, there is 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 areas of AR activities during 1996 – 2015 from whole country and different Slovak districts*

A/R	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

A/R	SK	BA	TT	TN	NR	ZA	BB	PO	KE
	%								
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

SK = the Slovak Republic, BA = Bratislava District, TT = Trnava District, TN = Trencin District, NR = Nitra District, ZA = Zilina District, BB = Banska Bystrica District, PO = Presov District, KE = Kosice 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 42.585 kha in total and 1.638 kha yearly in average in Slovak conditions from 1990 to 2015. In the same time period the total deforestation area reached 8.497 kha in total resp. 0.327 kha in average. The differences between AR and D correspond to the net increment of cadastral forest land between 0.202 and 3.007 kha (***Table 11.6***).

Table 11.6: *The differences between AR and DEF activities during 1990 – 2015*

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				kha					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**
Total 90-15	**2.375**	**20.957**	**19.253**	**42.585**	**0.425**	**3.746**	**1.262**	**3.064**	**8.497**	**34.088**

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				kha					kha
Aver. 90-15	**0.091**	**0.806**	**0.741**	**1.638**	**0.016**	**0.144**	**0.049**	**0.118**	**0.327**	**1.311**

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 2012.

The identified land-use change from Cropland, Grassland or Other Land converted to Forest Land, were categorized as A/R (kha/year) and land use change from Forest Land to Cropland, Grassland, Settlements or Other Land represent D (kha/year) in Slovak conditions for the period 1990 – 2015. 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 forests reported under UNFCCC (kha) is included into ***Table 11.7***. The equal areas under both reporting schemes have appeared for year 2009 (20 years of transition).

Table 11.7: *Comparison of FL remaining FL and LUC to/from forests reported under UNFCCC and ARD and FM areas reported under KP (kha)*

YEAR	KP REPORTING (kha)					REPORTING UNDER THE CONVENTION (kha)		
	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
1990	3.770	3.770	0.809	0.809	1985.219	1809.147	179.842	38.684
1991	1.963	5.733	0.988	1.797	1984.231	1813.805	176.159	36.752
1992	1.467	7.200	0.324	2.121	1983.907	1817.647	173.460	36.504
1993	0.722	7.922	0.366	2.487	1983.541	1822.293	169.170	35.574
1994	0.559	8.481	0.351	2.838	1983.190	1833.676	157.995	34.575
1995	0.721	9.202	0.135	2.973	1983.055	1861.769	130.488	31.334
1996	1.577	10.779	0.468	3.441	1982.587	1868.438	124.928	28.971
1997	3.395	14.174	0.388	3.829	1982.199	1873.390	122.983	26.429
1998	2.288	16.462	0.378	4.207	1981.821	1881.172	117.111	25.726
1999	2.102	18.564	0.297	4.504	1981.524	1887.294	112.794	25.108
2000	1.292	19.856	0.127	4.631	1981.397	1929.759	71.494	24.789
2001	1.178	21.034	0.302	4.933	1981.095	1935.707	66.422	21.794
2002	0.793	21.827	0.149	5.082	1980.946	1938.383	64.39	17.533
2003	1.648	23.475	0.321	5.403	1980.625	1939.252	64.848	15.191
2004	0.992	24.467	0.166	5.569	1980.459	1941.977	62.949	14.497
2005	0.842	25.309	0.534	6.103	1979.925	1945.133	60.101	13.965
2006	1.945	27.254	0.239	6.342	1979.686	1961.945	44.995	12.921
2007	0.656	27.910	0.454	6.796	1979.232	1963.896	43.246	11.961
2008	1.438	29.348	0.323	7.119	1978.909	1968.266	39.991	10.211
2009	1.048	30.396	0.462	7.581	1978.447	1978.447	30.396	7.581
2010	2.732	33.128	0.326	7.907	1978.121	1981.891	29.358	7.098
2011	1.174	34.302	0.087	7.994	1978.034	1983.767	28.569	6.197
2012	1.845	36.147	0.122	8.116	1977.912	1985.112	28.947	5.995
2013	1.407	37.554	0.098	8.214	1977.814	1985.736	29.632	5.727
2014	1.886	39.440	0.149	8.363	1977.665	1986.146	30.959	5.525
2015	3.145	42.585	0.134	8.497	1977.531	1986.733	33.383	5.524

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 at the web page www.geoportal.sk. Beside this since 1st February 2004 a Cadastral Portal (KAPOR) has been established at the web site www.katasterportal.sk. The KAPOR establishment was supported by Decree of the Slovak Government No. 540/2002, 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 the ***Table 11.8***.

Table 11.8: *Reported emissions, methodological tiers and emission factors (EF) in KP LULUCF sector in 2015*

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.

- Change in Carbon Stocks in Living Biomass for Afforestation/Reforestation

Annual changes in carbon stocks in living biomass were estimated following the default approach tier 1, using equation 2.7 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories (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 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:
ΔC_{LFLB} - annual change in carbon stocks in living biomass in afforested land, t C/yr $\Delta C_{LFGROWTH}$ - annual increase in carbon stocks in living biomass due to growth in land converted to forest land, t C/yr, ΔC_{LFLOSS} - annual decrease in carbon stocks in living biomass due to losses from harvesting, fuel wood gathering and disturbances in land converted to forest, t C/yr

- Annual Increase in Carbon Stocks in Living Biomass

The method follows Equation 2.9 in 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:
ΔC_G - annual increase in carbon stocks in living biomass due to growth in land converted to forest land, t C/yr, A - area of land converted to forest (including plantations), ha, G_{Total} - annual growth rate of biomass in forest (including plantations), t d.m./ha/yr, CF = carbon fraction of dry matter (default = 0.5), t C /(t d.m.)

The carbon increment is proportional to the extent of afforested/reforested areas and the yearly growing biomass. 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 d.m./ha/y, pine 3.17 t d.m./ha/y, beech 2.32 t d.m./ha/y, oak 1.23 t d.m./ha/y. The activity data come from representative experimental plots, 7 plots per each tree species were established. Then, whole-tree samples including foliages, 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 dendromass.

Table 11.9: *Proportion of main tree species of 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

The annual increment of the below-ground biomass for the four main tree species included in the inventory are following: spruce 0.56 t d.m./ha/y, pine 0.40 t d.m./ha/y, beech 0.90 t d.m./ha/y and oak 0.57 t d.m./ha/y. The proportion of main tree species of total artificial reforestation areas for accounting years was selected from database of the Slovak Statistical Office (www.statistics.sk) and shown in the ***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, annual losses in biomass should be estimated with the 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/yr, $L_{fellings}$ - biomass loss due to harvest of industrial wood and saw logs in land converted to forest land, tonnes C yr^{-1}, $L_{fuelwood}$ - biomass loss due to fuelwood gathering in land converted to forest land, t C/yr, $L_{other\ losses}$ - biomass loss due to fires and other disturbances in land converted to forest land, t C/yr.

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 forests. 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. As a result 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 another land, t C/yr, $A_{Conv.}$ - area of annually deforested land from some initial land uses, ha/yr, 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/(tonnes d.m.)

Tier 1 and tier 2 methods were used for calculation. It follows the approach in the 2006 IPCC Guidelines for National GHG Inventories, Section 2.3.1.2 (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 calculation 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 (0.602 for conifers and 0.770 for broadleaves) and default carbon content (0.5) were used. The average growing stock (m^3/ha) were estimated on the basis of forest taxation data in the Forest Management Plans (FMP), differently for the individual Slovak districts.

For calculation of below-ground biomass stocks were used the default coefficient 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, tab. 4.4 GPG (IPCC 2006).

- 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 of the 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 of the IPCC 2006 GL. The methodologies as well as data used to estimate emissions/removals from FM activities were similar those used for FL remaning FL category (Chapters 6.5.1.1 and 6.5.2). However, the different areas of the activities compared to the UNFCCC category are considered in the estimates (see 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 lands) 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 data obtained from the first National Forest Inventory realized from 2005 to 2006 were used for the estimation of carbon stock in deadwood prior to deforestation. It provides data on the mean deadwood biomass stocks (m^3/ha) separately for coniferous and broadleaves in the following categories: standing dead trees, stumps, coarse lying deadwood and small-sized lying deadwood. Each of mentioned categories was classified in four categories according to decomposition degree as a fresh, hard, soft and decomposed deadwood. The deadwood carbon stock was estimated from mean deadwood biomass stocks (m^3/ha), dry wood density weighted by mean growing stock volume of coniferous (0.425 t/m^3) and broadleaves (0.675 t/m^3) tree species, reduction coefficient 0.8, 0.5, 0.5 and 0.2 and applicable to above described decomposition degrees and default carbon content (0.5 t C/t biomass).

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 average C stock of dead wood is 4.878 t C per hectare in the forest land in Slovak conditions.

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 condition. This definition is similar as definition of surface soil organic layer in forests comprises all humus sublayers or subhorizons (L, F, H – if present) included 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 (mean value per area unit is 8.3 t/ha). These values are derived from similar datasets of Forest Monitoring System (FMS) and 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. 1999, 2002, 2013, 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/yr for C stocks in litter (representing surface organic layer) as well as 0.415 t C/ha/yr 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/yr) x converted area (kha)

In the reflection of the ERT requests No KL.5 and KL.8 of the SVK 2016 ARR, litter stock under the new land use category was set to 0 and transition period to 1 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, see chapter Land converted to Forest Land (5.A.2) for AR activity and chapters (5.B.2, 5.C.2, 5.E.2, 5.F.2) concerning 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 carried out as follows 2006 IPCC Gudelines (IPCC 2006). The net carbon stock change in mineral soils was estimated using the country specific tier 2 method described in detail in Chapter LULUCF (6). The average soil carbon stock per hectare, noted above (category 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, Slovakia has changed the approach to calculation of soil organic carbon stocks in soil as for the soil depth. In order to have more precise results and to improve the methodological comparability for different land use, we calculate the soil carbon stocks to the depth 30 cm (not 100 cm as in previous years). As 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). Also 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/yr) x converted area (kha)

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:

Aff/Ref of Cropland +1.446 t C/ha/yr, Aff/Ref of Grassland +0.704 t C/ha/yr, Aff/Ref of Other Land +1.758 t C/ha/yr.

Def to Cropland -1.446 t C/ha/yr, Def to Grassland -0.704 t C/ha/yr, Def to Settlements and Other Land -1.758 t C/ha/yr.

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 Slovak districts.

- N_2O emissions from disturbance associated with deforestation (FL converted to Cropland)

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 IPCC Tier 1 methodology using equations 11.8 (IPCC 2006). N_2O emissions were estimated on the basis of the detected changes in mineral soils on respective areas of FL converted to CL. Total emissions from disturbance associated with deforestation were 0.000828 Gg N_2O in 2015.

- 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). The burnt area connected to AR activities was estimated as percentage of total burnt area. This percentage was calculated from areas of FM and areas of AR activities in corresponding year. Total CH_4, N_2O emissions on AR and FM areas from wildfires are shown in ***Table 11.10***. Due to persistent technical problems with CRF reporter, it was not possible to insert the relevant information on activity data units (ha) and appropriate NK in the table 4(KP-II) 4.

Table 11.10: *Total CH_4, N_2O emissions on AR and FM areas from wildfires*

YEAR	AR		FM	
	CH_4 (t)	N_2O (t)	CH_4 (t)	N_2O (t)
2013	0.467	0.026	24.684	1.365
2014	0.347	0.019	17.495	0.968
2015	0.692	0.038	32.119	1.777

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. 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 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.

The justification for omitting the DW carbon pool as well as soil and inherently the litter from the reporting under FM activity shoul be provided by Slovakia. The reasoning which demostrates that DW carbon pool is not a source of CO_2 emissions is based on the evidence of increasing growing stock in Slovak forests pubhished in the last Slovak Green report in 2016 http://www.mpsr.sk/en/index.php?navID=17&id=66 The growing stock in Slovak forests is gradually increasing as indicated by trends and actual age structure of forests. On large temporal and spatial scales, the amount of deadwood is roughly proportional to the growing stock. The statistically representative empirical data from the second Slovak NFI, which would to confirm this assumption, are under the evaluation process.

Slovakia has 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, see ***Table 11.11***. The results of statistical analysis have not confirmed the changes of soil C stocks on FM areas. A similar conclusion were obtained from comparison of carbon stocks in litter. The litter C stock in 2006 were even found slightly higher compared the first evaluation (1993).

In central european conditions, within forest management according to the principles of sustainable forestry, the mineral soils, litter and deadwood 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, Austria, Germany).

Table 11.11: *Average litter and mineral soil C stocks on FM areas*

YEAR	LITTER (t C/ha)		MINERAL SOIL (t C/ha)	
	average	st. deviation	average	st. deviation
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

Since the 2016 submission, no new GPG methods were applied.

11.3.1.5 Uncertainty estimate

The uncertainty analysis for KP A.1, KP A.2 and KP B.1 categories (***Table 11.12***) was guided by Tier 1 methods using the Equations 3.1 and 3.2 (Volume 1, Chapter 3, IPCC 2006).

EQUATION 3.1
COMBINING UNCERTAINTIES – APPROACH 1 – MULTIPLICATION

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \ldots + U_n^2}$$

U_{total} is the percentage uncertainty in the product of the quantities and U_i denotes the percentage uncertainties with each of the quantities (IPCC 2006).

EQUATION 3.2
COMBINING UNCERTAINTIES – APPROACH 1 – ADDITION AND SUBTRACTION

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

U_{total} is the percentage uncertainty in the sum of the quantities (half the 95 percent confidence interval divided by the total (i.e., mean) and expressed as a percentage). This term ‘uncertainty’ is based upon the 95 percent confidence interval; x_i and U_i are the uncertain quantities and the percentage uncertainties associated with them, respectively.

Table 11.12: *Uncertainties in KP A.1, KP A.2 and KP B.1 categories*

IPCC CATEGORY		ACTIVITY DATA (%)	EMISSION FACTOR (%)	EF REFERENCES
KP A.1	Afforestation and Reforestation - living biomass	3	40.61	IPCC 2003 & 2006
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 (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 2003 & 2006

The following values of activity data and emission factors were used for estimation uncertainty in individual C pools and LU sucategories: default uncertainty values (IPCC 2003, 2006) - 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/yr, pine ±1.61 t/ha/yr, beech ±2.04 t/ha/yr and oak ±1.05 t/ha/yr. 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 years period, the total uncertainty of C emission/removal for land use change of mineral soils can be estimated ±75%.

The uncertainty estimated for KP A.1 Afforestation and Reforestation category reached 114%, uncertainty in KP A.2 Deforestation reached 151 % and uncertainty in KP B.1 Forest Management reached 83% in 2015.

11.3.1.6 Information on other methodological issues

No other information is available.

11.3.1.7 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

Slovakia used for 3.3 activities reporting the anually updated cadastrial information provided by the Geodesy, Cartography and Cadastre Authority of the Slovak republic (GCCA). This is an official state institution and it is managed in accordance with the Slovak laws. The change of land use classification is always initiated by land owners in the Slovak Republic, if the owners have interest to make the ARD activity. They need a special plan for afforestation undertake. Deforestation is allowed only according to the Forest Act and requires an official administrative decision. For the reason, all activities under Article 3.3 can be 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 offical 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.

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 CO_2 eq. for the first commitment period.

The estimated removals from afforestation/reforestation activities represented -443.09 Gg CO_2 eq. in 2013, -441.82 Gg CO_2 eq. in 2014 and -465.13 Gg CO_2 eq. in 2015.

Emissions from deforestration were 43.04 Gg CO_2 in the year 2013, 62.80 Gg CO_2 in 2014 and 64.45 Gg in 2015. The activities under Article 3.3 of Kyoto Protocol represent the net removal of -400.03 Gg CO_2 eq. in 2013, -379.01 Gg CO_2 eq. in 2014 and -400.66 Gg CO_2 eq. in 2015. The details are noted in the corresponding CRF tables of KP LULUCF.

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 D activities is not subject of HWP balance; it is subject of instantaneous oxidation.

A default method described in the KP Supplement (IPCC 2014) has been applied to allocate the carbon stock changes to the particular forest activities under Art. 3.3 and Art. 3.4 as follows:

$f_{j(i)} = harvest_{j(i)} / harvestTotal_{(i)}$, 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 D in particular years was as follows: 0.0030 in 2013, 0.0036 in 2014 and 0.0036 in 2015.

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. Law must 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. These include Act 360/2007, which has direct or indirect impacts on emissions in the LULUCF sector. It provides a basic framework for the conservation of forests 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 living biomass. The net removals in this activity were 5 186.48 Gg CO_2 eq. in 2015. The emissions from biomass burning are associated with FM as well. The emissions of CH_4 and N_2O in 2015 were 0.67 Gg CH_4 and 0.04 Gg N_2O in 2015. The net CO_2 eq. removals were 5 158.64 Gg in 2015.

In 2017 submission, FM area has been recalculated and corrected for 2013 – 2014. New FM areas differ from the values reported previously by 7.630 kha in 2013 and 8.599 kha in 2014 (by 0.4%). The area reported under FM in Article 3.4 is lower than the area reported in LULUCF as “forest land remaining forest land” (FLremFL). The reason is that under LULUCF, areas afforested prior to 1990 have been included in FLremFL since 2010, whereas lands under afforestation remained under afforestation and did not move to FM (explanation according to the ERT request No KL.6 of the SVK 2015 ARR). Recalculation of FM area influenced reported CO_2 removals and emissions of CH_4 and N_2O as well. Net CO_2 removals are lower by 0.01% in 2013 and by 0.02% in 2014. The effect of recalculation on CH_4 and N_2O emissions is negligible due to their low absolute values. Recalculated values are shown in ***Table 11.13***.

Table 11.13: *FM area and net GHG emissions from Forest Management*

YEAR	AREA (kha)	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)	NET CO_2 eq. (Gg)
2013	1 977.814	-6 804.39	0.36	0.02	-6 789.44
2014	1 977.665	-4 873.70	0.69	0.04	-4 845.26
2015	1 977.531	-5 186.48	0.67	0.04	-5 158.64

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 State 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 CO2. 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 FCCC/KP/AWG/2010/CRP.4/Rev.4. The activity data (production and trade of sawnwood, wood based panels and paper and paperboard) were derived from the TIMBER database (UNECE 2011) (time series 1993 – 2009).

Slovakia's forest management reference level (FMRL) inscribed in the appendix to the annex to Decision 2/CMP.7 amounts to +358 kt CO_2 equivalent per year assuming instant oxidation of HWP and -1 084 kt CO_2 eq. applying a first-order decay function for HWP.

11.5.2.3 Technical corrections of FMRL

Slovakia will follow the recommendations from ERT published in Report of the technical assessment of the Forest Management Reference Level submission of Slovakia submitted in 2011 to ensure methodological consistency between the FMRL and reporting for Forest Management during the second commitment period and will to apply a technical correction to the FMRL using the assistance from JRC.

Technical corrections were not applied in this submission. Quantitative and qualitative information on TC will be reported in the next national inventories, consistently with the requirements of decision 2/CMP.7.

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 2014: 35 years for sawnwood, 25 years for wood-based panels and 2 years for paper products.

In the first accounting period, Slovakia reported only ARD activities. Emissions from HWP originating from management of forests have been included in the accounting since FM activity became mandatory.

Emissions from the HWP pool were not accounted for in the first commitment period. 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 2015. Harvest from deforestation was separated and excluded from calculations to apply instant oxidation. Following ***Table 11.14*** shows domestic production of sawn wood, wood based panels and paper (including paper board) as used for HWP stocks changes.

The uncertainty analysis for 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: roundwood 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), carbon contents in wood products: ±10% (assessment of carbon content in wood). Emission factors (half-life estimates): ±50% (default from IPCC 2006). The total relative uncertainty of carbon losses and gains in HWP was 58% in 2015.

Table 11.14: *Domestic production of sawn wood, wood based panels and paper (including paper board) as used for HWP stocks changes in 1990 – 2015*

YEAR	SAWN WOOD (m^3)	WOOD BASED PANELS (m^3)	PAPER AND PAPERBOARD (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
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	1 700 000	703 010	756 000

11.5.3 INFORMATION RELATING TO CROPLAND MANAGEMENT, GRAZING LAND MANAGEMENT AND REVEGETATION, WETLAND DRAINAGE AND REWETTING IF ELECTED, FOR THE BASE YEAR

Not elected activities for the second commitment period and therefore will be not reported in Slovakia.

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 2014 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 (see Chapter 1.2.12 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 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) 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: *Emission levels of the Slovak Republic set out in the terms of the joint fulfilment for the second commitment period under the Kyoto Protocol*

SLOVAKIA	EMISSION LEVEL (TONNES OF CO_2 eq.)
	202 268 939

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. ***Table 12.2*** 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 land-use change and forestry 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)
	tonnes CO_2 eq.		
	74 271 511	0	74 271 511

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.

[1] Declaration made in footnote to Annex B of the Doha Amendment.

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 . 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 2016 in format respecting both first and second commitment period (RREG1_SK_2016_1_2.xlsx and RREG1_SK_2016_2_1.xlsx) are included in the submission. The tables include all required information on Kyoto units concerning first and second commitment period in 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 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_2016_2_1.xlsx, RREG3_SK_2016_2_1.xlsx, RREG4_SK_2016_2_1.xlsx and RREG5_SK_2016_2_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 (http://emisie.icz.sk/) and it includes non-confidential information as stated in UN and EU legislation, especially account information, Joint Implementation project information, overall unit holdings and overall transaction information, authorized legal entities information and compliance information.

12.5 CALCULATION OF THE COMMITMENT PERIOD RESERVE (CPR)

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, multiplied by 8. ***Table*** 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 the Slovak Republic based on the lower value resulting from the two methods.

Table 12.4: *Commitment period reserve of Slovak Republic*

SLOVAKIA	ASSIGNED AMOUNT FOR SECOND COMMITMENT PERIOD	90% OF ASSIGNED AMOUNT	100% OF MOST RECENTLY REVIEWED INVENTORY MULTIPLIED BY 8	COMMITMENT PERIOD RESERVE
	tonnes CO_2 eq.			
	202 268 939	182 042 045	325 260 816	182 042 046

CHAPTER 13: INFORMATION ON CHANGES IN NATIONAL SYSTEM

There were no significant changes in the arrangement of the National Inventory System during inventory year 2016. National Inventory System description is provided in the Chapter 1.2 of the latest SVK National Inventory Report 2016 published in June 2016.

However, several institutional updates and steps led to increase of robustness and sustainability of the National Inventory System taken place in the year 2016. These changes were initiated by the new Government after spring (2016) elections and pushed by the Slovak Presidency of the European Council.

- Structural changes in the MŽP SR, establishment of the Directorate for Climate Change and Air Protection - in force since June 1, 2016;
- Structural changes are planned in the SHMÚ, establishment of the Department of Emissions and Biofuels –in force since January 1, 2017;
- Enhancement of the Single National Entity by new experts focusing on agricultural sector and transport. This new positions are permanent – in force since spring 2016.

Figure and Tables in Chapter 1 indicate these changes. On the ***Figure 1.4***, a new structure of the NIS is depicted, where the Committee on CCP is intergovernmental body responsible for climate change policy implementation on cross-ministerial level. On the ***Table 1.2*** is updated list of internal experts within SHMÚ and on the ***Table 1.2*** is a list of external experts and institutions within NIS SR.

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	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	New tables were added to the CSEUR database for the implementation of the CP2 SEF functionality. Versions of the CSEUR released after 6.7.3 (the production version at the time of the last submission) introduced other minor changes in the structure of the database. The database model, including the new tables, is provided in Annex A. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Changes introduced since version 6.7.3 of the national registry are listed in Annex B. Each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production (see Annex B). Annex H testing was completed in January 2017 and the test report is provided. No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	The mandatory use of hard tokens for authentication and signature of processes was introduced for privileged users such as registry administrators and service desk.
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.

REPORTING ITEM	DESCRIPTION
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	Both regression testing and tests on the new functionality were successfully carried out prior to release of each version to Production. The site acceptance test was carried out by quality assurance consultants on behalf of and assisted by the European Commission, the report is attached as Annex B. Annex H testing was carried out in January 2017 and the test report is provided.

CHAPTER 15: INFORMATION ON MINIMIZATION OF ADVERSE IMPACTS IN ACCORDANCE WITH ARTICLE 3, PARAGRAPH 14

Due to no updated information, this chapter can be find in the SVK NIR 2016 published on June 15, 2016.

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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 2015 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 ***Table A1.1*** and ***A1.2.***

Analysis for the base year 1990 was performed in this submission and 37 key categories with LULUCF and 29 without LULUCF were identified by level assessment using Approach 1 methodology. Key categories are similar to identified in 2015 level assessment. The results are presented in ***Table A1.3.***

More information on key categories and uncertainty assessment can be found in the 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 and without LULUCF in 2015*

IPCC SOURCE CATEGORIES	GAS	APPROACH 1 2015 WITH LULUCF	APPROACH 1 2015 WITHOUT LULUCF	APPROACH 2 2015 WITH LULUCF	APPROACH 2 2015 WITHOUT LULUCF
Refrigeration and Air conditioning	Aggregate F-gases	YES	YES	NO	NO
Fuel combustion - Energy Industries - Liquid Fuels	CO_2	YES	YES	NO	YES
Fuel combustion - Energy Industries - Solid Fuels	CO_2	YES	YES	YES	YES
Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	YES	YES	NO	NO
Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	YES	YES	NO	NO
Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	YES	YES	YES	YES
Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	YES	YES	NO	YES
Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	YES	NO	NO	NO
Fuel combustion - Road Transportation	CO_2	YES	YES	YES	YES
Fuel combustion - Other Sectors - Liquid Fuels	CO_2	YES	YES	NO	NO
Fuel combustion - Other Sectors - Solid Fuels	CO_2	YES	YES	NO	NO
Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	YES	YES	YES	YES
Mineral Industry - Cement Production	CO_2	YES	YES	NO	NO
Mineral Industry - Lime Production	CO_2	YES	YES	NO	NO
Mineral Industry - Other Process Uses of Carbonates	CO_2	YES	YES	NO	NO

IPCC SOURCE CATEGORIES	GAS	APPROACH 1 2015 WITH LULUCF	APPROACH 1 2015 WITHOUT LULUCF	APPROACH 2 2015 WITH LULUCF	APPROACH 2 2015 WITHOUT LULUCF
Chemical Industry - Ammonia Production	CO_2	YES	YES	NO	NO
Chemical Industry - Petrochemical and Carbon Black Production	CO_2	YES	YES	NO	YES
Chemical Industry - Other	CO_2	YES	YES	NO	NO
Metal Industry - Iron and Steel Production	CO_2	YES	YES	YES	YES
Metal Industry - Ferroalloys Production	CO_2	YES	YES	NO	NO
Metal Industry - Aluminium Production	CO_2	YES	YES	NO	NO
Non-energy Products from Fuels and Solvent Use	CO_2	NO	NO	YES	YES
Forest Land - Forest Land Remaining Forest Land	CO_2	YES	X	YES	X
Forest Land - Land Converted to Forest Land	CO_2	YES	X	YES	X
Cropland - Cropland Remaining Cropland	CO_2	YES	X	YES	X
Cropland - Land Converted to Cropland	CO_2	NO	X	YES	X
Grassland - Land Converted to Grassland	CO_2	NO	X	YES	X
Settlements - Land Converted to Settlements	CO_2	NO	X	YES	X
Other land - Land Converted to Other Land	CO_2	NO	X	YES	X
Harvested Wood Products	CO_2	YES	X	YES	X
Fuel combustion - Other Sectors - Biomass	CH_4	NO	NO	NO	YES
Fugitive emissions from fuels - Solid Fuels	CH_4	YES	YES	NO	NO
Fugitive emissions from fuels - oil, NG and Other - Natural gas	CH_4	YES	YES	NO	NO
Fugitive emissions from fuels - oil, NG and Other - Venting and flaring	CH_4	YES	YES	NO	NO
Enteric Fermentation	CH_4	YES	YES	YES	YES
Solid Waste Disposal	CH_4	YES	YES	YES	YES
Biological Treatment of Solid Waste	CH_4	NO	NO	NO	YES
Wastewater Treatment and Discharge	CH_4	YES	YES	YES	YES
Manure Management	N_2O	NO	NO	YES	YES
Direct N2O Emissions From Managed Soils	N_2O	YES	YES	YES	YES
Indirect N2O Emissions From Managed Soils	N_2O	YES	YES	YES	YES
Biological Treatment of Solid Waste	N_2O	NO	NO	NO	YES
Wastewater Treatment and Discharge	N_2O	NO	NO	YES	YES

Table A1.2: *Key categories identified using Approach 1 and Approach 2 by trend assessment with and without LULUCF in 2015*

IPCC SOURCE CATEGORIES	GAS	APPROACH 1 2015 WITH LULUCF	APPROACH 1 2015 WITHOUT LULUCF	APPROACH 2 2015 WITH LULUCF	APPROACH 2 2015 WITHOUT LULUCF
Refrigeration and Air conditioning	Aggregate F-gases	YES	YES	NO	YES
Fuel combustion - Energy Industries - Liquid Fuels	CO_2	YES	YES	NO	YES
Fuel combustion - Energy Industries - Solid Fuels	CO_2	YES	YES	YES	YES
Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	YES	YES	NO	YES
Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	YES	YES	YES	YES
Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	YES	YES	NO	YES
Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	YES	YES	NO	NO
Fuel combustion - Road Transportation	CO_2	YES	YES	YES	YES
Fuel combustion - Railways	CO_2	YES	YES	NO	NO
Fuel combustion - Other Transportation	CO_2	YES	YES	NO	YES
Fuel combustion - Other Sectors - Liquid Fuels	CO_2	NO	YES	NO	NO
Fuel combustion - Other Sectors - Solid Fuels	CO_2	YES	YES	YES	YES
Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	YES	YES	YES	YES
Fuel combustion - Other (Not specified elsewhere) - Stationary - Solid Fuels	CO_2	YES	YES	NO	NO
Mineral Industry - Cement Production	CO_2	YES	YES	NO	NO
Mineral Industry - Lime Production	CO_2	YES	YES	NO	NO
Chemical Industry - Ammonia Production	CO_2	YES	YES	NO	YES
Chemical Industry - Petrochemical and Carbon Black Production	CO_2	NO	NO	NO	YES
Chemical Industry - Other	CO_2	YES	YES	NO	NO
Metal Industry - Iron and Steel Production	CO_2	YES	YES	YES	YES
Metal Industry - Aluminium Production	CO_2	YES	YES	NO	NO
Non-energy Products from Fuels and Solvent Use	CO_2	NO	NO	NO	YES
Forest Land - Forest Land Remaining Forest Land	CO_2	YES	X	YES	X
Forest Land - Land Converted to Forest Land	CO_2	YES	X	YES	X
Cropland - Cropland Remaining Cropland	CO_2	YES	X	YES	X
Cropland - Land Converted to Cropland	CO_2	YES	X	YES	X
Grassland - Land Converted to Grassland	CO_2	YES	X	YES	X
Fuel combustion - Other Sectors - Solid Fuels	CH_4	YES	YES	YES	YES
Fuel combustion - Other Sectors - Biomass	CH_4	YES	YES	YES	YES

IPCC SOURCE CATEGORIES	GAS	APPROACH 1 2015 WITH LULUCF	APPROACH 1 2015 WITHOUT LULUCF	APPROACH 2 2015 WITH LULUCF	APPROACH 2 2015 WITHOUT LULUCF
Fugitive emissions from fuels - oil, NG and Other - Natural gas	CH_4	YES	YES	NO	NO
Fugitive emissions from fuels - oil, NG and Other - Venting and flaring	CH_4	YES	YES	NO	NO
Enteric Fermentation	CH_4	YES	YES	YES	YES
Manure Management	CH_4	YES	YES	YES	YES
Solid Waste Disposal	CH_4	YES	YES	YES	YES
Biological Treatment of Solid Waste	CH_4	NO	NO	NO	YES
Chemical Industry - Nitric Acid Production	N_2O	YES	YES	NO	YES
Manure Management	N_2O	NO	YES	YES	YES
Direct N2O Emissions From Managed Soils	N_2O	NO	NO	YES	YES
Biological Treatment of Solid Waste	N_2O	NO	NO	NO	YES
Wastewater Treatment and Discharge	N_2O	NO	NO	YES	YES
Metal Industry - Aluminium Production	PFCs	YES	YES	NO	YES

Table A1.3: *Key categories identified using Approach 1 and Approach 2 by level assessment with and without LULUCF in 1990*

IPCC SOURCE CATEGORIES	GAS	APPROACH 1 2015 WITH LULUCF	APPROACH 1 2015 WITHOUT LULUCF	APPROACH 2 2015 WITH LULUCF	APPROACH 2 2015 WITHOUT LULUCF
Fuel combustion - Energy Industries - Liquid Fuels	CO_2	YES	YES	YES	YES
Fuel combustion - Energy Industries - Solid Fuels	CO_2	YES	YES	YES	YES
Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	YES	YES	NO	NO
Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	YES	YES	NO	YES
Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	YES	YES	YES	YES
Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	YES	YES	NO	YES
Fuel combustion - Road Transportation	CO_2	YES	YES	YES	YES
Fuel combustion - Other Transportation	CO_2	YES	YES	NO	NO
Fuel combustion - Other Sectors - Liquid Fuels	CO_2	YES	YES	NO	NO
Fuel combustion - Other Sectors - Solid Fuels	CO_2	YES	YES	YES	YES
Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	YES	YES	NO	NO
Mineral Industry - Cement Production	CO_2	YES	YES	NO	NO
Mineral Industry - Lime Production	CO_2	YES	YES	NO	NO
Mineral Industry - Other Process Uses of Carbonates	CO_2	YES	YES	NO	NO

IPCC SOURCE CATEGORIES	GAS	APPROACH 1 2015 WITH LULUCF	APPROACH 1 2015 WITHOUT LULUCF	APPROACH 2 2015 WITH LULUCF	APPROACH 2 2015 WITHOUT LULUCF
Chemical Industry - Petrochemical and Carbon Black Production	CO_2	YES	NO	NO	NO
Metal Industry - Iron and Steel Production	CO_2	YES	YES	YES	YES
Non-energy Products from Fuels and Solvent Use	CO_2	NO	NO	YES	YES
Forest Land - Forest Land Remaining Forest Land	CO_2	YES	X	YES	X
Forest Land - Land Converted to Forest Land	CO_2	YES	X	YES	X
Cropland - Cropland Remaining Cropland	CO_2	YES	X	YES	X
Cropland - Land Converted to Cropland	CO_2	YES	X	YES	X
Grassland - Land Converted to Grassland	CO_2	NO	X	YES	X
Other land - Land Converted to Other Land	CO_2	NO	X	YES	X
Harvested Wood Products	CO_2	YES	X	YES	X
Fuel combustion - Other Sectors - Solid Fuels	CH_4	NO	NO	YES	YES
Fugitive emissions from fuels - Solid Fuels	CH_4	YES	YES	NO	NO
Fugitive emissions from fuels - oil, NG and Other - Natural gas	CH_4	YES	YES	NO	NO
Fugitive emissions from fuels - oil, NG and Other - Venting and flaring	CH_4	YES	YES	NO	NO
Enteric Fermentation	CH_4	YES	YES	YES	YES
Manure Management	CH_4	YES	YES	YES	YES
Solid Waste Disposal	CH_4	YES	YES	NO	YES
Wastewater Treatment and Discharge	CH_4	YES	YES	NO	YES
Chemical Industry - Nitric Acid Production	N_2O	YES	YES	NO	NO
Manure Management	N_2O	YES	YES	YES	YES
Direct N2O Emissions From Managed Soils	N_2O	YES	YES	YES	YES
Indirect N2O Emissions From Managed Soils	N_2O	YES	YES	YES	YES
Wastewater Treatment and Discharge	N_2O	NO	NO	YES	YES

ANNEX 2: ASSESSMENT OF COMPLETENESS

Assessment of completeness is one of the elements of quality control procedure in the inventory preparation on 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 (2017). The improvements were performed in the previous inventory submissions such as estimation of GHG emissions for the agricultural and industrial sectors and feedstock and non-energy used data. 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 2017 submission for 1990 – 2015 in the 2.D category of the IPPU sector. Explanation is given in the CRF Tables and in this report Chapter 4. Two reasons for not estimated categories are no methodology is available or insufficient activity data (mostly for indirect GHG emissions like CO, SO_2 or NMVOC). The list of these categories is provided in the CRF Table 9. The included elsewhere categories (IE) are listed in the CRF Table 9 with the explanations and also described in this report in appropriate sectoral chapters.

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.

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 the 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 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 assessment in 2015 (emissions in Gg of CO_2 eq., uncertainty in %)*

IPCC CATEGORY/GROUP	GAS	BASE YEAR EMISSIONS OR REMOVALS	YEAR 2015 EMISSIONS OR REMOVALS	ACTIVITY DATA UNCERTAINTY	EMISSION FACTOR UNCERTAINTY	UNCERTAINTY INTRODUCED INTO THE TREND IN TOTAL NATIONAL EMISSIONS
Refrigeration and Air conditioning	F-gases	0.00	702.40	10.00	40.00	0.0115
Foam Blowing Agents	F-gases	0.00	1.98	10.00	40.00	0.0000
Fire Protection	F-gases	0.00	20.55	10.00	40.00	0.0000
Aerosols	F-gases	0.00	9.96	10.00	40.00	0.0000
Fuel combustion - Energy Industries - Liquid Fuels	CO_2	3819.21	1225.23	5.00	3.60	0.0208
Fuel combustion - Energy Industries - Solid Fuels	CO_2	12861.05	4657.96	2.50	3.60	0.0928
Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	2176.70	1662.88	2.50	2.75	0.0142
Fuel combustion - Energy Industries - Other Fossil Fuels	CO_2	181.01	35.11	5.00	5.00	0.0000
Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	2867.64	208.49	5.00	3.60	0.0000
Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	9028.53	4144.52	5.00	2.80	0.0070
Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	3930.58	2131.75	2.50	2.75	0.2155
Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	0.00	197.73	5.00	5.00	0.0142
Fuel combustion - Manufacturing Industries and Construction - Peat	CO_2	0.00	15.35	5.00	5.00	0.0009
Fuel combustion - Domestic Aviation	CO_2	3.74	3.66	1.00	5.00	0.0001
Fuel combustion - Road Transportation	CO_2	4503.02	6342.97	1.00	5.00	0.0000
Fuel combustion - Railways	CO_2	372.29	84.33	1.00	5.00	0.0854
Fuel combustion - Domestic Navigation - Liquid Fuels	CO_2	0.02	6.22	1.00	5.00	0.0001
Fuel combustion - Other Transportation	CO_2	1813.95	184.40	1.00	5.00	0.0000
Fuel combustion - Other Sectors - Liquid Fuels	CO_2	580.74	221.25	5.00	3.60	0.0022

IPCC CATEGORY/GROUP	GAS	BASE YEAR EMISSIONS OR REMOVALS	YEAR 2015 EMISSIONS OR REMOVALS	ACTIVITY DATA UNCERTAINTY	EMISSION FACTOR UNCERTAINTY	UNCERTAINTY INTRODUCED INTO THE TREND IN TOTAL NATIONAL EMISSIONS
Fuel combustion - Other Sectors - Solid Fuels	CO_2	7171.66	506.01	5.00	4.00	0.0001
Fuel combustion - Other Sectors - Gaseous Fuels	CO_2	3704.26	3716.18	2.50	2.75	0.0534
Fuel combustion - Other (Not specified elsewhere) - Stationary - Liquid Fuels	CO_2	34.99	0.68	5.00	3.60	0.0817
Fuel combustion - Other (Not specified elsewhere) - Stationary - Solid Fuels	CO_2	216.08	3.18	5.00	4.00	0.0000
Fuel combustion - Other (Not specified elsewhere) - Stationary - Gaseous Fuels	CO_2	154.75	41.84	2.50	2.75	0.0001
Fuel combustion - Other (Not specified elsewhere) - Mobile- Liquid Fuels	CO_2	7.00	1.69	5.00	3.60	0.0000
Fugitive emissions from fuels - Solid Fuels	CO_2	19.01	19.51	2.00	5.00	0.0000
Fugitive emissions from fuels - oil, NG and Other - Oil	CO_2	0.03	0.01	5.00	7.00	0.0014
Fugitive emissions from fuels - oil, NG and Other - Natural gas	CO_2	0.58	0.32	2.00	5.00	0.0005
Fugitive emissions from fuels - oil, NG and Other - Venting and flaring	CO_2	4.57	0.95	5.00	7.00	0.0000
Mineral Industry - Cement Production	CO_2	1464.50	1308.57	1.50	2.80	0.0003
Mineral Industry - Lime Production	CO_2	794.92	648.00	1.50	2.80	0.0064
Mineral Industry - Glass Production	CO_2	7.88	11.93	1.50	3.00	0.0001
Mineral Industry - Other Process Uses of Carbonates	CO_2	446.73	296.56	2.50	4.30	0.0056
Chemical Industry - Ammonia Production	CO_2	331.77	638.58	5.00	5.00	0.0003
Chemical Industry - Carbide Production	CO_2	0.00	48.47	2.00	5.00	0.0345
Chemical Industry - Petrochemical and Carbon Black Production	CO_2	428.80	331.82	10.50	11.50	0.0001
Chemical Industry - Other	CO_2	116.99	365.29	2.00	2.00	0.0003
Metal Industry - Iron and Steel Production	CO_2	4167.97	4028.13	2.00	5.00	0.0000
Metal Industry - Ferroalloys Production	CO_2	296.74	239.67	3.00	5.00	0.0000
Metal Industry - Aluminium Production	CO_2	121.32	276.33	2.00	5.00	0.0001
Metal Industry - Lead Production	CO_2	0.00	0.06	1.50	20.00	0.0000
Metal Industry - Zinc Production	CO_2	0.00	0.00	1.50	20.00	0.0000
Non-energy Products from Fuels and Solvent Use	CO_2	162.48	98.81	5.00	50.00	14.1323
Liming	CO_2	44.62	14.99	2.00	5.00	0.7961
Urea Application	CO_2	15.29	60.92	2.00	5.00	2.1418
Forest Land - Forest Land Remaining Forest Land	CO_2	-6087.58	-4606.87	20.00	60.00	0.1096
Forest Land - Land Converted to Forest Land	CO_2	-2210.41	-391.25	20.00	60.00	0.1214

IPCC CATEGORY/GROUP	GAS	BASE YEAR EMISSIONS OR REMOVALS	YEAR 2015 EMISSIONS OR REMOVALS	ACTIVITY DATA UNCERTAINTY	EMISSION FACTOR UNCERTAINTY	UNCERTAINTY INTRODUCED INTO THE TREND IN TOTAL NATIONAL EMISSIONS
Cropland - Cropland Remaining Cropland	CO_2	-955.44	-909.66	75.00	100.00	0.2067
Cropland - Land Converted to Cropland	CO_2	466.32	79.45	75.00	100.00	0.0000
Grassland - Land Converted to Grassland	CO_2	-202.29	-191.10	75.00	100.00	0.0002
Settlements - Land Converted to Settlements	CO_2	96.06	84.15	75.00	100.00	0.0000
Other land - Land Converted to Other Land	CO_2	285.40	182.51	75.00	100.00	0.0194
Harvested Wood Products	CO_2	-470.41	-721.44	50.00	50.00	0.0774
Biomass Burning - Forest land	CO_2	7.21	10.95	5.00	100.00	0.0085
Incineration and Open Burning of Waste	CO_2	66.95	6.97	5.00	31.10	0.0000
Fuel combustion - Energy Industries - Liquid Fuels	CH_4	3.42	1.05	3.00	50.00	0.0057
Fuel combustion - Energy Industries - Solid Fuels	CH_4	3.18	1.01	3.00	50.00	0.2007
Fuel combustion - Energy Industries - Gaseous Fuels	CH_4	0.98	0.75	3.00	5.00	0.0132
Fuel combustion - Energy Industries - Other Fossil Fuels	CH_4	1.87	0.42	5.00	50.00	0.0007
Fuel combustion - Energy Industries - Biomass	CH_4	9.66	15.89	3.00	50.00	0.0000
Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CH_4	2.79	0.16	3.00	50.00	0.0000
Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CH_4	16.27	5.25	3.00	50.00	0.1093
Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CH_4	1.75	0.96	3.00	5.00	0.0001
Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CH_4	0.00	1.67	5.00	50.00	0.0000
Fuel combustion - Manufacturing Industries and Construction - Peat	CH_4	0.00	0.01	3.00	50.00	0.0036
Fuel combustion - Manufacturing Industries and Construction - Biomass	CH_4	1.99	10.76	3.00	50.00	0.0006
Fuel combustion - Domestic Aviation	CH_4	0.00	0.00	3.00	5.00	0.0436
Fuel combustion - Road Transportation	CH_4	29.14	14.81	3.00	5.00	0.0455
Fuel combustion - Railways	CH_4	0.52	0.13	1.00	40.00	0.0000
Fuel combustion - Domestic Navigation - Liquid Fuels	CH_4	0.00	0.01	1.00	40.00	0.0000
Fuel combustion - Other Transportation	CH_4	0.80	0.08	1.00	40.00	0.0000
Fuel combustion - Other Sectors - Liquid Fuels	CH_4	1.25	1.32	3.00	50.00	0.0000
Fuel combustion - Other Sectors - Solid Fuels	CH_4	416.75	18.17	3.00	50.00	0.0000
Fuel combustion - Other Sectors - Gaseous Fuels	CH_4	8.20	8.34	3.00	5.00	0.0000
Fuel combustion - Other Sectors - Biomass	CH_4	36.13	162.76	3.00	50.00	0.0000

IPCC CATEGORY/GROUP	GAS	BASE YEAR EMISSIONS OR REMOVALS	YEAR 2015 EMISSIONS OR REMOVALS	ACTIVITY DATA UNCERTAINTY	EMISSION FACTOR UNCERTAINTY	UNCERTAINTY INTRODUCED INTO THE TREND IN TOTAL NATIONAL EMISSIONS
Fuel combustion - Other (Not specified elsewhere) - Stationary - Liquid Fuels	CH_4	0.03	0.00	3.00	50.00	0.0000
Fuel combustion - Other (Not specified elsewhere) - Stationary - Solid Fuels	CH_4	0.05	0.01	3.00	50.00	0.0023
Fuel combustion - Other (Not specified elsewhere) - Stationary - Gaseous Fuels	CH_4	0.34	0.09	3.00	5.00	0.0005
Fuel combustion - Other (Not specified elsewhere) - Stationary - Biomass	CH_4	0.00	0.60	3.00	50.00	0.0000
Fuel combustion - Other (Not specified elsewhere) - Mobile- Liquid Fuels	CH_4	0.02	0.00	3.00	50.00	0.0003
Fugitive emissions from fuels - Solid Fuels	CH_4	679.94	321.94	5.00	7.00	0.0060
Fugitive emissions from fuels - oil, NG and Other - Oil	CH_4	14.79	8.52	5.00	7.00	0.0000
Fugitive emissions from fuels - oil, NG and Other - Natural gas	CH_4	1103.48	805.00	2.00	5.00	0.0060
Fugitive emissions from fuels - oil, NG and Other - Venting and flaring	CH_4	590.18	446.63	2.00	5.00	0.0003
Chemical Industry - Ammonia Production	CH_4	0.27	0.40	2.00	10.00	0.0493
Chemical Industry - Other	CH_4	0.05	0.16	2.00	10.00	0.0003
Metal Industry - Ferroalloys Production	CH_4	0.00	1.21	2.00	10.00	0.0004
Enteric Fermentation	CH_4	2565.88	989.33	3.00	20.00	0.0000
Manure Management	CH_4	546.91	155.86	3.00	45.00	0.0000
Forest Land - Forest Land Remaining Forest Land	CH_4	7.39	16.78	5.00	5.00	0.0002
Forest Land - Land Converted to Forest Land	CH_4	0.05	0.01	5.00	5.00	0.0000
Biomass Burning	CH_4	7.44	16.80	5.00	5.00	0.0000
Solid Waste Disposal	CH_4	619.25	960.56	17.35	20.31	5.5270
Biological Treatment of Solid Waste	CH_4	64.90	113.55	8.42	62.23	0.5441
Incineration and Open Burning of Waste	CH_4	1.74	0.71	5.00	50.00	2.5423
Wastewater Treatment and Discharge	CH_4	466.00	307.06	4.44	31.44	0.0826
Fuel combustion - Energy Industries - Liquid Fuels	N_2O	7.92	2.16	3.00	50.00	0.1119
Fuel combustion - Energy Industries - Solid Fuels	N_2O	54.11	15.28	3.00	50.00	0.0211
Fuel combustion - Energy Industries - Gaseous Fuels	N_2O	1.17	0.89	3.00	5.00	0.0894
Fuel combustion - Energy Industries - Other Fossil Fuels	N_2O	3.59	0.72	3.00	50.00	0.7350
Fuel combustion - Energy Industries - Biomass	N_2O	18.80	26.73	3.00	50.00	0.0001
Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	N_2O	6.81	0.39	3.00	50.00	0.0002
Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	N_2O	28.72	9.14	3.00	50.00	0.0000

IPCC CATEGORY/GROUP	GAS	BASE YEAR EMISSIONS OR REMOVALS	YEAR 2015 EMISSIONS OR REMOVALS	ACTIVITY DATA UNCERTAINTY	EMISSION FACTOR UNCERTAINTY	UNCERTAINTY INTRODUCED INTO THE TREND IN TOTAL NATIONAL EMISSIONS
Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	N_2O	2.09	1.14	3.00	5.00	0.0000
Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	N_2O	0.00	2.66	3.00	50.00	0.0000
Fuel combustion - Manufacturing Industries and Construction - Peat	N_2O	0.00	0.06	3.00	50.00	0.0000
Fuel combustion - Manufacturing Industries and Construction - Biomass	N_2O	3.17	25.23	3.00	50.00	0.0001
Fuel combustion - Domestic Aviation	N_2O	0.03	0.03	1.00	50.00	0.0000
Fuel combustion - Road Transportation	N_2O	56.48	57.41	1.00	50.00	0.0000
Fuel combustion - Railways	N_2O	42.82	10.40	1.00	50.00	0.0000
Fuel combustion - Domestic Navigation - Liquid Fuels	N_2O	0.00	0.05	1.00	50.00	0.0000
Fuel combustion - Other Transportation	N_2O	0.95	0.10	1.00	50.00	0.0000
Fuel combustion - Other Sectors - Liquid Fuels	N_2O	9.99	16.58	3.00	50.00	0.0001
Fuel combustion - Other Sectors - Solid Fuels	N_2O	29.27	2.20	3.00	50.00	0.0000
Fuel combustion - Other Sectors - Gaseous Fuels	N_2O	1.96	1.99	3.00	5.00	0.0000
Fuel combustion - Other Sectors - Biomass	N_2O	6.26	27.07	3.00	50.00	0.0000
Fuel combustion - Other (Not specified elsewhere) - Stationary - Liquid Fuels	N_2O	0.08	0.00	3.00	50.00	0.0000
Fuel combustion - Other (Not specified elsewhere) - Stationary - Solid Fuels	N_2O	0.90	0.01	3.00	5.00	0.0000
Fuel combustion - Other (Not specified elsewhere) - Stationary - Gaseous Fuels	N_2O	0.08	0.02	3.00	50.00	0.0000
Fuel combustion - Other (Not specified elsewhere) - Stationary - Biomass	N_2O	0.00	0.10	1.00	50.00	0.0241
Fuel combustion - Other (Not specified elsewhere) - Mobile- Liquid Fuels	N_2O	0.23	0.06	3.00	50.00	0.0000
Fugitive emissions from fuels - oil, NG and Other - Venting and flaring	N_2O	0.02	0.00	5.00	7.00	0.0121
Chemical Industry - Ammonia Production	N_2O	0.32	0.47	2.00	10.00	0.0000
Chemical Industry - Nitric Acid Production	N_2O	1141.53	139.78	2.50	7.00	0.0000
Chemical Industry - Other	N_2O	0.06	0.20	2.00	10.00	0.0000
Other Product Manufacture and Use	N_2O	16.39	68.11	3.00	1.00	0.0000
Manure Management	N_2O	494.81	170.56	10.00	100.00	0.0000
Direct N2O Emissions From Managed Soils	N_2O	2187.49	1246.75	25.00	100.00	0.0012
Indirect N2O Emissions From Managed Soils	N_2O	713.80	379.29	25.00	100.00	0.0000
Forest Land - Forest Land Remaining Forest Land	N_2O	4.87	11.07	5.00	5.00	0.0015
Forest Land - Land Converted to Forest Land	N_2O	0.04	0.01	5.00	5.00	0.0005

IPCC CATEGORY/GROUP	GAS	BASE YEAR EMISSIONS OR REMOVALS	YEAR 2015 EMISSIONS OR REMOVALS	ACTIVITY DATA UNCERTAINTY	EMISSION FACTOR UNCERTAINTY	UNCERTAINTY INTRODUCED INTO THE TREND IN TOTAL NATIONAL EMISSIONS
Cropland - Land Converted to Cropland	N_2O	59.89	8.44	75.00	100.00	0.0000
Grassland - Land Converted to Grassland	N_2O	0.96	0.47	75.00	100.00	0.0000
Settlements - Land Converted to Settlements	N_2O	4.29	3.91	75.00	100.00	0.0000
Other land - Land Converted to Other Land	N_2O	9.61	4.71	75.00	100.00	0.0172
Direct N2O emissions from N mineralization/immobilization	N_2O	74.75	17.54	5.00	5.00	0.0087
Biomass Burning	N_2O	4.91	11.08	5.00	5.00	0.0000
Biological Treatment of Solid Waste	N_2O	46.43	81.21	8.42	93.34	0.0000
Incineration and Open Burning of Waste	N_2O	5.84	5.44	5.00	100.00	0.0000
Wastewater Treatment and Discharge	N_2O	138.48	49.22	6.74	2250.85	0.1675
Metal Industry - Aluminium Production	PFCs	314.86	8.50	7.50	11.00	0.0061
Electrical equipment	SF_6	0.00	0.00	15.00	32.00	0.0000
TOTAL UNCERTAINTIES	**UNCERTAINTY IN LEVEL: 10.67%**			**UNCERTAINTY IN TREND: 3.46%**		

ANNEX 4: QUALITY ASSURANCE/QUALITY CONTROL PLAN

Table A4.1: *Quality Assurance/Quality Control Plan - Internal*

ACTIVITY		WHO	CHECK-IN	TIME SCHEDULE	RECORD
1.	Evaluation of Improvement plans for the year 2017	Sectoral experts NIS coordinator Deputy of NIS coordinator	Quality manager MŽP SR – NFP	15.01.2017	Improvement plan for the year 2017 for every sector
2.	Tasks and financial plan of NIS – preparation for year 2017.	NIS coordinator Deputy of NIS coordinator	MŽP SR – NFP Quality manager Head of the SHMÚ	12.02.2017	Information on budget, capacity (personal, external, internal), training plan, meetings and business trips plan, plan of QA/QC activities for year 2017.
3.	Update of capacity incorporating updates for each sector	Sectoral experts (SE) Deputy of SE	MŽP SR – NFP Quality manager Head of the SHMÚ	28.02.2017	Responsibilities matrix for 2017 Description of work activities
4.	Work assignment and contracts signing for each sector for the year 2017	NIS coordinator Deputy of NIS coordinator	MŽP SR - NFP Head of the SHMÚ	31.03.2017	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	10.03.2017	Description QA/QC activities in each sectoral chapters for the year 2017
6.	Key sources and uncertainty management for each sector for the inventory year 2015	Sectoral expert for uncertainty Sectoral experts NIS coordinator	Deputy of NIS coordinator Quality manager	15.03.2017	Report on key sources and uncertainty evaluation for year 2015 Template for the key sources and uncertainty evaluation for year 2015
7.	Final evaluation of emission data 2015 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	31.05.2017	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 2018	Sectoral experts NIS coordinator Deputy of NIS coordinator	MŽP SR – NFP Quality manager	April 2017 September 2017 December 2017	Report from the meeting

ACTIVITY		WHO	CHECK-IN	TIME SCHEDULE	RECORD
9.	Completeness check of emission inventory for the year 2017	Sectoral experts	NIS coordinator Deputy of NIS coordinator Quality manager MŽP SR – NFP	30.09.2017	Report from completeness check
10.	Methodical updates, recalculation list on sectoral level, according to IPCC 2006 GL	Sectoral experts	NIS coordinator Deputy of NIS coordinator Quality manager	31.10. 2017	Report of emission for each sector, for inventory year 2016
11.	Sectoral final reports delivery	Sectoral experts	NIS coordinator Deputy of NIS coordinator Quality manager	30.11. 2017	Delivery protocols Drafts of sectoral reports for the inventory year 2016
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
13.	Preparing documents for updating emission projections by sector – methodological inputs	Sectoral experts Projections coordinator	NIS coordinator MŽP SR - NFP	31.12.2017 15.3.2017	Preparing third biennial reports under UNFCCC. Actualization of emission projection under decision (EU) 525/2013

Table A4.2: *Quality Assurance/Quality Control Plan - External*

ACTIVITY		WHO	CHECK-IN	TIME SCHEDULE	RECORD
1.	Annual Report submission according to the Regulation EU 525/2013, Article 7: a. Preliminary Emission GHG inventory for years 1990-2015 b. Preliminary National Inventory Report information for year 2017 c. Annual Report of indicators for year 2015.	NIS coordinator Deputy of NIS coordinator Sectoral experts	Ministry of Environment (NFP)	15.01.2017	CDR (Central Data Repository) upload: http://cdr.eionet.europa.eu/sk/eu
2.	Draft of the second Initial Report according to the Article 19 of the Regulation (EU) 729/2014 in according with the Annex I of the decision 2/CMP.8	NIS coordinator Ministry of Environment Ministry of Agriculture and Rural Development	European Commission	15.01.2017	Report to facilitate determination of the assigned amount for the second commitment period of the Kyoto Protocol
3.	Annual Report submission according to the Dec. 525/2013/EU, Article 7: a) Emission GHG inventory for year 2015 b) National Inventory Report for year 2017 c) Key source and uncertainty analyses	NIS coordinator Deputy of NIS coordinator Sectoral experts of NIS	Quality manager Ministry of Environment (NFP)	15.03.2017	Uploaded to the CRF dbase 1990 – 2015 Uploaded to the KP CRF dbase 2008 – 2015 Annual report NIR SVK 2017 SEF 2016 Sheet of the key source and uncertainty analyses
4.	Nomination letters for the sectoral experts – update for the year 2017.	NIS coordinator Ministry of Environment - NFP	Quality manager	15.04.2017	Nomination Letters List of nominated sectoral experts for the year 2017.
5.	Report on the Status of Fulfilment of the International Commitments of the Slovak Republic on Climate Change (in line with the Governmental Resolution 821/2011 part B.3). Parts of the Report are the results of the GHG inventory and the NIR 2017.	NIS coordinator Deputy of NIS coordinator	Ministry of Environment (NFP)	15.02.2017	The final report on the implementation of the current status of the SVK adopted international commitments in the field of climate change policy Updated NIR SVK 2017 The report submitted to an agenda of Government by the end of March 2017.
6.	Report of the Slovak Republic according to the Article 4, 13 a 14	Expert for projections Ministry of	Quality manager Ministry of	15.03.2017	KP LULUCF tables for the years 1990 and 2015 for forest management and cropland and grassland management, Tables according to the Annex XI a XII

ACTIVITY		WHO	CHECK-IN	TIME SCHEDULE	RECORD
	of the Regulation (EU) 525/2013: - GHGs emission projections, - PAM, - Indicators and parameters for projections, - Description of models, - Sensitivity analysis.	Environment – NFP Sectoral experts NIS coordinator	Environment (NFP)		under decision (EU) 749/2014.
7.	Draft of the Improvement Plan for the GHG emissions inventory based on the SVK ARR 2016.	NIS coordinator Deputy of NIS coordinator Ministry of Environment – NFP Sectoral experts	Independent review	15.04.2017	NIR SVK 2017 ARR 2016
8.	Submission to the secretariat UNFCCC: a) Emission GHG inventory for years 1990-2015 b) National Inventory Report for year 2017 c) KP – LULUCF for years 2008-2015 e) Information from the National Registry for year 2017	NIS coordinator Deputy of NIS coordinator Sectoral experts National Registry	Quality manager Ministry of Environment (NFP)	30.04.2017	via CRF Reporter portal
9.	Publicity of the SVK NIR 2017 and emissions data on the official web of the SVK NIS	NIS coordinator Deputy of NIS coordinator	Quality manager Ministry of Environment (NFP)	30.05.2017	Update of data on www.ghg-inventory.shmu.sk
10.	Review of the Second Biennial Report of the Slovak Republic	NIS coordinator Deputy of NIS coordinator Ministry of Environment – NFP Sectoral experts	Parties of the UNFCCC and KP	7-11.03.2017	Review report 2017
11.	Initial Assessment to the UNFCCC submission 2017	NIS coordinator Deputy of NIS coordinator Sectoral experts	Quality manager Ministry of Environment (NFP)	6 weeks after 15.04.2017	Resubmission of the GHG inventory and SVK NIR 2017 in conjunction with the upgrade of the CRF Reporter software
13.	Audit of the status of the preparation of the sectoral reports 2016.	NIS coordinator Deputy of NIS coordinator	Ministry of Environment (NFP)	30.06.2017 31.12.2017	Report from the internal audit of the delivering of the 2016 inventory data.

ACTIVITY		WHO	CHECK-IN	TIME SCHEDULE	RECORD
		Quality manager Sectoral experts			
14.	Statistical data delivering Distribution of the SVK NIR 2017 to public institutions.	NIS coordinator Deputy of NIS coordinator Sectoral experts	Quality manager Ministry of Environment (NFP)	31.10.2017	Statistical questionnaires SVK NIR 2017
15.	Review under UNFCCC	NIS coordinator Deputy of NIS coordinator Sectoral experts Ministry of Environment – NFP Quality manager	Expert Review Team	2017	Annual Review Report for the submissions 2017
16.	Establishment of the National system for projections of GHG emissions – a description of the institutional, capacitive framework, methodology of various scenarios and sectors (based on the results of UNFCCC review)	Projection coordinator Sectoral experts	NIS coordinator Deputy of NIS coordinator Ministry of Environment (NFP) EC	until 07.07.2017	Projection Report, Meeting documents
17.	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 2017.	Sectoral experts Quality manager	NIS coordinator Deputy of NIS coordinator Quality manager	30.11.2017	Report and Improvement plan for the year 2018.

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
General/Inventory planning	ERT **recommends** that Slovakia include in the NIR the relevant information, provided during the review, for the planning and prioritization of the improvements for the next submission.	G.3 - FCCC/ARR/2016, p. 8	Information relevant for planning and prioritization of the improvements was added to the 2017 Improvements Plans and implemented in inventory preparation process/Implemented	Chapter 1.2.3 of the SVK NIR 2017 (15 March 2017)
General/NIR	The ERT **recommends** that Slovakia improve the transparency of its NIR and report on the actions taken in the NIR.	G.5 - FCCC/ARR/2016, p. 27	Further improvements in transparency of implemented steps and recalculations will be reported in the 2017 submission/Implemented	SVK NIR 2017 (15 March 2017)
General/Key category	The ERT **recommends** that Slovakia include in the NIR information on the methodological approach applied for the key category analysis, to justify that the analysis is carried out both with and without LULUCF in accordance with UNFCCC Annex I inventory reporting guidelines.	G.6 - FCCC/ARR/2016, p. 27	Key category analysis was improved and enhanced/Implemented	Chapter 1.2.12 and Annex 1 of the SVK NIR 2017 (15 March 2017)
General/Article 3, paragraph 14, of the Kyoto Protocol	The ERT **recommends** that Slovakia include, in the NIR, information on any changes in its information provided in accordance with Article 3, paragraph 14, of the Kyoto Protocol.	G.7 - FCCC/ARR/2016, p. 28	Information on changes in reporting under Article 3.14 will be included in 15 March 2017 submission/Implemented	Chapter 11.5 of the SVK NIR 2017 (15 March 2017)
General/Energy	ERT **recommends** that Slovakia provide a brief summary of the national energy balance in the NIR.	E.2 - FCCC/ARR/2016, p. 9	Information on brief summary of the national energy balance will be included in 15 March 2017 submission/ Implemented	Annex 4 of the SVK NIR 2017 (15 March 2017)
Consistency/Energy	ERT **recommends** that Slovakia improve the consistency of reporting and resolve the discrepancies among the three sources of AD for the reference approach.	E.4 - FCCC/ARR/2016, p. 9	Issue completely implemented, more information included also in issue E.6/Implemented	Chapter 3 Energy of the SVK NIR 2017 (15 March 2017)
Transparency/Energy	ERT **recommends** that Slovakia conduct more detailed analysis of the causes behind the discrepancies between the reference and the sectoral approaches for each individual liquid fuel type and provide the numerical data obtained because of such an analysis in the next NIR.	E.5 - FCCC/ARR/2016, p. 10	Data on liquid fuels was included into comparison of the Sectoral and Reference Approaches/Implemented	Chapter 3 Energy of the SVK NIR 2017 (15 March 2017)

Consistency – International aviation – liquid fuels, see E21	ERT **recommendations** for 1.A.3.a and memo items: Investigate the representativeness of the assumed time-trends of fuel consumption share between aviation and international bunker fuels throughout the entire time series	E.11 - FCCC/ARR/ 2016, p. 11	Implemented/Recalculations were made in 2017 submission. New fuel´ consumption share between domestic aviation and international bunker fuels was implemented for the years 1990-2004	SVK NIR 2017, chapter 3.2.3.1 and 3.2.7.2
Reporting of QA/QC/Feedstocks, reductants and other NEU of fuels – Adherence to UNFCCC Annex I inventory reporting guidelines	ERT **recommends** that Slovakia establish new QA/QC routines to govern fuel AD across the inventory, and implement specific AD quality checks to compare the NES data against the sum of AD in the energy and industrial processes sectors for all commodities used as fuels, feedstocks, reductants and other non-energy uses.	E.13 - FCCC/ARR/2016, p. 12	New QA/QC was implemented by the sectoral expert and quality manager/Implemented	Chapter 3.2.4 Energy of the SVK NIR 2017 (15 March 2017)
Transparency/1.A.1.b Petroleum Refining	ERT **recommends** that Slovakia improve transparency regarding the description of the methodology used for estimating emissions from petroleum refining and the estimation and allocation of the associated emissions in the NIR.	E.15 - FCCC/ARR/2016, p. 12	Further improvements in transparency of description of the methodology and allocation will be reported in the 2017 submission/Implemented	Chapter 3.2 Energy of the SVK NIR 2017 (15 March 2017)
Transparency/1.A.1.b Petroleum Refining	ERT **recommends** that Slovakia include in the NIR the detailed explanations of the methodological choices and recalculations provided during the review in order to increase the transparency of recalculations.	E.16 - FCCC/ARR/2016, p. 13	Further improvements in transparency of implemented methodology and recalculations will be reported in the 2017 submission/Implemented	Chapter 3.2 Energy of the SVK NIR 2017 (15 March 2017)
General/Energy	The ERT **recommends** that Slovakia include the full national energy balance for the most recent inventory year in its NIR.	E.19 - FCCC/ARR/2016, p. 28	Information on brief summary of the national energy balance will be included in 15 March 2017 submission/ Implemented	Annex 4 of the SVK NIR 2017 (15 March 2017)
Other fossil fuels – peat, Sectoral Approach	The ERT **recommends** that the Slovakia examine the data and reduce discrepancies between the reference and sectoral approaches to the extent possible and report the outcome of such research in the NIR.	E.20 - FCCC/ARR/2016, p. 28	Partly implemented for peat, issue for waste postponed to the next IP 2018 due to administrative burdens in the Statistical Office of the Slovak Republic (SU SR). The SU SR will introduce new fuel type "peat" into energy questionnaires for the year 2016 (evaluated for the inventory submission 2018) in line with the harmonisation with the EU ETS reports and NEIS database.	Chapter 3.2 Energy of the SVK NIR 2017 (15 March 2017)

Consistency – Memo Items	International aviation – jet kerosene and aviation gasoline: The ERT **recommends** that the Party, when investigating the issue E11 on distribution of the fuel use between domestic and international aviation, consider whether the newly available EUROCONTROL data for 2005–2014 could be used to inform the expert judgement used for 1990–2004, or alternatively, include an explanation on the fluctuation of fuel allocation between domestic and international aviation in the NIR.	E.21 - FCCC/ARR/2016, p. 29	Implemented/Recalculations were made in 2017 submission. New fuel´ consumption share between domestic aviation and international bunker fuels was implemented for the years 1990-2004	SVK NIR 2017, chapter 3.2.3.1 and 3.2.7.2
Adherence to UNFCCC Annex I inventory reporting guidelines - Feedstocks, reductants and other NEU of fuels	The ERT **recommends** that the Slovakia include the information on its QA/QC system for feedstocks and non-energy use in the NIR.	E.22 - FCCC/ARR/2016, p. 29	New QA/QC was implemented by the sectoral expert and quality manager/Implemented	Chapter 3.2.4 Energy of the SVK NIR 2017 (15 March 2017)
Transparency - 1.A.1.a Public electricity and heat production - other fossil fuels	The ERT **recommends** that the Slovakia provide, in the NIR, a more transparent and structured description on what is reported as 'other fossil fuels' under the subcategories public electricity and heat production – other (1.A.1.a.iv) and non-metallic minerals (1.A.2.f) and their linkages with reporting in the waste sector (5.C).	E.23 - FCCC/ARR/2016, p. 30	Partly implemented in 2017, but part of 2018 improvement plan/partly implemented	Chapter 3.2 Energy of the SVK NIR 2017 (15 March 2017)
Transparency/1.A.1.b Petroleum Refining	The ERT **recommends** that the Slovakia provide detailed methodological information on petroleum refining in the NIR. The ERT notes that such methodological information could be based on the annex 3.2 of the original 2015 NIR of 13 November 2015.	E.24 - FCCC/ARR/2016, p. 30	Further improvements in transparency of description of the methodology and allocation will be reported in the 2017 submission/Implemented	Chapter 3.2 Energy and Annex 3.1 of the SVK NIR 2017 (15 March 2017)
Comparability/1.A.1.c Manufacture of solid fuels and other energy industries	The ERT **recommends** that, in accordance with the 2006 IPCC Guidelines (volume 2, p. 2.8), the Party report the emissions from coke production under manufacture of solid fuels (1.A.1.c.i), and report own-energy use emissions from coal mines, oil and gas companies and possible emissions from charcoal production under other energy industries (1.A.1.c.ii), if they can be disaggregated from agriculture/ forestry/ fishing – stationary.	E.25 - FCCC/ARR/2016, p. 30	Reallocation of the emissions from coke production own energy use under 1.A.1.c.ii/Implemented	Chapter 3.2 Energy of the SVK NIR 2017 (15 March 2017)

Transparency/1.A.2.a Iron and steel	The ERT **recommends** that the Slovakia revise the carbon balance diagram for iron and steel production in its NIR by replacing the reference to 1.A.2.m by 1.A.2.g.viii	E.26 - FCCC/ARR/2016, p. 31	Correction of the carbon balance diagram/Implemented	Chapter 3.2 Energy of the SVK NIR 2017 (15 March 2017)
1.A.3.b Road transportation – Liquid fuels	The ERT **recommends** that the Party explain in the NIR that the CO2 EFs for gasoline and diesel oil used in the road transportation are based on country-specific carbon content, which was measured in the laboratories of the Slovak refinery in 2011, and provide country-specific NCVs, carbon contents and EFs of gasoline and diesel used in road transportation in the NIR, preferably in tabular format.	E.27 - FCCC/ARR/2016, p. 32	Implemented/Information on country-specific carbon content and NCV is included in road transportation.	SVK NIR 2017 chapter 3.2.7.2 (table).
Transparency/1.A.4 Other sectors	The ERT **recommends** that the Slovakia explain, in the NIR, the process of the energy balance revision and its impact on emission estimates, in cases where recalculations are carried out because of the revision of the energy balance	E.30 - FCCC/ARR/2016, p. 32	Explanation will be part of the SVK NIR 2017/Implemented	Chapter 3.2 Energy of the SVK NIR 2017 (15 March 2017)
Accuracy/1.B.2.b Natural gas	The ERT **recommends** that the Slovakia move to a higher tier approach, in accordance with the decision tree in figure 4.2.1 of the 2006 IPCC Guidelines, volume 2.	E.31 - FCCC/ARR/2016, p. 33	Will be considered in the next submission/not implemented	Submission 2018
Consistency – Memo Items, International aviation – liquid fuels	The ERT **recommends** that the Slovakia investigate the representativeness of the assumed time-trends of fuel consumption share between aviation and international bunker fuels throughout the entire time series.	E.11 - FCCC/ARR/2016, p. 11	Recalculations made in aviation (1.A.3.a and international aviation) based on the new EUROCONTROL data since 2005/implemented also back for time series new methodological approach for national/international share	Chapters 3.2.3 and 3.2.7 of Energy of the SVK NIR 2017 (15 March 2017)
Consistency – Memo Items, International aviation – liquid fuels	The ERT **recommends** that the Slovakia, when investigating the issue E11 on distribution of the fuel use between domestic and international aviation, consider whether the newly available EUROCONTROL data for 2005–2014 could be used to inform the expert judgement used for 1990–2004, or alternatively, include an explanation on the fluctuation of fuel allocation between domestic and international aviation in the NIR.	E.21 - FCCC/ARR/2016, p. 29	Recalculations made in aviation (1.A.3.a and international aviation) based on the new EUROCONTROL data since 2005/implemented also back for time series new methodological approach for national/international share	Chapters 3.2.3 and 3.2.7 of Energy of the SVK NIR 2017 (15 March 2017)

Transparency – 1.A.3.b Road transportation – Liquid fuels	The ERT **recommends** that the Slovakia explain in the NIR that the CO2 EFs for gasoline and diesel oil used in the road transportation are based on country-specific carbon content, which was measured in the laboratories of the Slovak refinery in 2011, and provide country-specific NCVs, carbon contents and EFs of gasoline and diesel used in road transportation in the NIR, preferably in tabular format.	E.27 - FCCC/ARR/2016, p. 17	The values of H/C ratio and carbon content were discussed and consequently updated, according to the real contents and ratio of H/C in fuels produced by Slovnaft Refinery Company in Slovakia. Detailed information sent by email by the Slovnaft refinery on 21.11.2016 / year 2015 implemented in 2017 submission, other years will be considered in the next submission (2018).	Incorporated into SVK NIR 2017, Chapter Energy – Transport, required recalculation back to base year, planned for the future submission and will be included in the IP Transport 2018.
Accuracy - 1.A.3.c Railways – diesel	The ERT **recommends** that the Slovakia convert the AD (amount of fuel used) from mass units to energy units by using the country-specific NCV, and then adopt the default EF from the 2006 IPCC Guidelines, volume 2, table 3.4.1 (74.10 t CO2/TJ) to calculate CO2 emissions from railways. The ERT also encourages the Party to develop a country-specific CO2 EF for diesel for this category.	E.28 - FCCC/ARR/2016, p. 31	Recalculations made in time series back to base year/implemented	Chapter 3.2.7 of the SVK NIR 2017 (15 March 2017)
Consistency - 1.A.3.e.ii Other (other transportation)	The ERT **recommends** that the Slovakia estimate CO2 emission from urea-based catalysts for the entire time series to improve time-series consistency. Furthermore, the ERT recommends that the Party report these emissions under the category non-energy products from fuels and solvent use – other (2.D.3).	E.29 - FCCC/ARR/2016, p. 32	No recalculations in road transportation needed, emissions from urea based catalysts is included in addition to the inventory in appropriate category of vehicles for the years 2010 – 2015. Fully implemented/description in chapter road transportation NIR 2017/emissions allocated in IPPU sector, category 2.D.3 - Other	Chapter 4.5 IPPU of the SVK NIR 2017 (15 March 2017)
Comparability – 2.G.1	The ERT further **recommends** that the Party explain in the NIR that SF6 emissions from window insulation are negligible compared with those from electrical equipment (only represented 0.09% of total SF6 emissions in 2014) and that since the production of windows stopped in 2002, the Party considered it unfeasible to report disaggregated emissions	I.14 - FCCC/ARR/2016, p. 33	No recalculations needed, implemented and explanation described in the SVK NIR 2017,	Chapter 4.8 IPPU of the SVK NIR 2017 (15 March 2017)

Transparency – 3.A Enteric fermentation CH4	The ERT **recommends** that the Slovakia include in the NIR documentation on the use of country-specific data and the methodology used to estimate CH4 emissions from enteric fermentation, especially an explanation about the regional differences and their implications on GE trends.	A.2 - FCCC/ARR/2016, p. 16	Implemented/resolved, emissions recalculated	Chapter 5 - Agriculture SVK NIR 2017
Accuracy - general 3.B.2 Nex	The ERT **recommends** that Slovakia estimate country-specific Nex values for the complete time series, taking into consideration the development of the animal weights, if appropriate, and recalculate the time series of N2O emissions from manure management and agricultural soils accordingly.	A.7 - FCCC/ARR/2016, p. 34	Implemented/resolved, emissions recalculated	Chapter 5 - Agriculture SVK NIR 2017
Accuracy - general 3.B.2 Nex cattle and sheep	The ERT **recommends** that Slovakia elaborate country-specific Nex rates for the entire time series for dairy cattle and sheep in accordance with decision tree in figure 10.4 of the 2006 IPCC Guidelines, volume 4. The ERT further **recommends** that Slovakia include in the NIR a description of calculations carried out to derive the country-specific Nex values for dairy cattle and sheep.	A.8 - FCCC/ARR/2016, p. 34	Implemented/resolved, emissions recalculated	Chapter 5 - Agriculture SVK NIR 2017
Accuracy - general	The ERT **recommends** that Slovakia continue the ongoing technical research in order to provide reliable data for estimating carbon stock changes in living biomass, dead organic matter and soil organic matter.	L.1 - FCCC/ARR/2016, p. 18	not implemented	next submission
Accuracy - general	The ERT **recommends** that Slovakia use default carbon stock values before conversion not only for the annual crops but also for the perennial woody crops, in accordance with the table 3.3.2 of the IPCC good practice guidance for LULUCF, for carbon stocks in a range of climate regions for generic perennial woody cropland and considering the area converted from annual crops and perennial woody crops, respectively	L.3 - FCCC/ARR/2016, p. 20	not implemented	next submission

Transparency – Forest Land 4.A	The ERT **recommends** that Slovakia include information on the average carbon stock of dead wood per hectare in forest land in the NIR	L.4 - FCCC/ARR/2016, p. 20	not implemented	next submission
Transparency - general	The ERT **recommends** that Slovakia improve the transparency of the reporting by providing a clear description of the process used to estimate the mean value of soil organic carbon stocks in each land-use category and refer to the original data source	L.6 - FCCC/ARR/2016, p. 20	not implemented	next submission
Reporting - general	The ERT **recommends** that Slovakia conduct the tier 1 uncertainty analyses at the land-use subcategory level	L.7 - FCCC/ARR/2016, p. 21	resolved	included in the key category analyses 15/1/2017
Accuracy – FL remaining FL 4.A.1	The ERT **recommends** that Slovakia apply consistent methods for the biomass increment and loss	L.9 - FCCC/ARR/2016, p. 21	not implemented	next submission
Accuracy – CL remaining CL 4.B.1	The ERT **recommends** that Slovakia estimate and report the carbon stock changes by disaggregating this category into annual cropland converted to perennial woody cropland and perennial woody cropland converted to annual cropland	L.10 - FCCC/ARR/2016, p. 21	not implemented	next submission
Transparency – CL remaining CL 4.B.1	The ERT **recommends** that Slovakia include in the NIR the explanation regarding the use of the notation key "NO" for histosols	L.13 - FCCC/ARR/2016, p. 22	not implemented	next submission
Transparency - general	ERT **recommends** that Slovakia include in the NIR a description on how instantaneous oxidation for carbon stock changes in litter for forest land converted to other land-use categories was implemented	L.15 - FCCC/ARR/2016, p. 35	not implemented	next submission
Accuracy – 4.A.2 - Land converted to FL	The ERT **recommends** that Slovakia provide, in the NIR, a justification to support the assumption that, according common afforestation practices, if any vegetation exists in cropland or grassland, it is not removed before conversion to forest land. If such justification cannot be provided, the ERT recommends that the Party revise its methodology.	L.18 - FCCC/ARR/2016, p. 35	not implemented	next submission

Completeness– 5.A Solid waste disposal on land – CH4	The ERT **recommends** that the Slovakia improve the completeness of its submission by including in its inventory the emissions from the landfilling of the waste categories 17–19, as provided during the review week, for the entire time series.	W.9 - FCCC/ARR/ 2016, p. 36	resolved, will be implemented in the March submission	March 2017 submission
Transparency– 5D WW treatment and discharge – CH4	The ERT **recommends** that the Slovakia include the article by Bodik and Kubaska (2013) in the reference list of the related NIR chapter.	W.10 - FCCC/ARR/ 2016, p. 36	resolved, will be implemented in the March submission	March 2017 submission
Transparency– 5D WW treatment and discharge – CH4	The ERT **recommends** that the Slovakia include the information on the data sources regarding the share of sludge applied to agricultural soils, sludge incinerated and sludge deposited to SWDS in the NIR, or in the documentation box of CRF table 5.D.	W.11 - FCCC/ARR/ 2016, p. 36	resolved, will be implemented in the March submission	March 2017 submission
Accuracy - Forest Management	The ERT **recommends** that the Slovakia make the improvements required to ensure methodological consistency between FMRL and the reporting of emissions and removals from forest management, particularly in the methodological approach to estimate the contribution of HWP, including the application of a technical correction to the FMRL	KL.6 - FCCC/ARR/ 2016, p. 37	not implemented	next submission
Transparency - Forest management	The ERT **recommends** that the Slovakia explain in the NIR that area reported under LULUCF ‘forest land remaining forest land’ is higher than the area under forest management because under LULUCF, areas afforested prior to 1990 have been included in forest land remaining forest land since 2010, whereas lands under afforestation remained under afforestation and did not move to forest management.	KL.7 - FCCC/ARR/ 2016, p. 37	not implemented	next submission
Transparency - Deforestation	The ERT **recommends** that the Slovakia include in the NIR a description of how it implemented instantaneous oxidation for carbon stock changes in litter in areas subject to deforestation.	KL.8 - FCCC/ARR/ 2016, p. 38	not implemented	next submission

Table A4.4: Energy Balance of the Statistical Office of the Slovak Republic for the year 2015
Electricity and Heat Balance in 2015 - in TJ

	Antracit *Anthra-cite*	Čierne uhlie kokso-vateľné *Coking Coal*	Čierne uhlie ostatné *Other Bituminous Coal*	Hnedé uhlie a lignit *Brown Coal and Lignite*	Koks čierno-uhoľný *Hard Coal Coke*	Hnedo-uhoľné brikety *Brown Coal Briquettes*	Čierno-uhoľné brikety *Patent Fuel*	Decht *Coal Tar*	Koksá-renský plyn *Coke Oven Gas*	Vysoko-pecný plyn *Blast Furnace Gas*	Konver-torový plyn *Oxygen Steel Furnace Gas*	
Primárna produkcia	-	-	-	21 810	-	-	-	-	-	-	-	Primary Production
Dovoz	3 198	81 652	21 025	4 904	5 385	342	224	-	-	-	-	Import
Vývoz	-	-	-	-	28	-	-	2 076	-	-	-	Export
Zmena stavu zásob	26	-30	2 674	2 508	-4 652	-36	-	-	-	-	-	Stock Changes
Hrubá domáca spotreba	**3 224**	**81 622**	**23 699**	**29 222**	**705**	**306**	**224**	**-2 076**	**-**	**-**	**-**	**Gross Inland Consumption**
Transformácia - vstup	**1 057**	**81 622**	**11 902**	**27 558**	**42 460**	**234**	**-**	**-**	**1 159**	**1 312**	**334**	**Transformation Input**
Výroba elektriny - tepelné zariadenia	1 057	-	11 902	27 558	-	234	-	-	1 159	1 306	309	Electricity Production - Thermal Equipment
v tom: Verejné	1 057	-	9 726	27 502	-	234	-	-	-	-	-	of which: Public
Autoproducenti	-	-	2 176	56	-	-	-	-	1 159	1 306	309	Autoproducers
Jadrové elektrárne	-	-	-	-	-	-	-	-	-	-	-	Nuclear Plants
Koksárne	-	63 504	-	-	-	-	-	-	-	-	-	Coke Ovens
Vysoké pece	-	18 118	-	-	42 460	-	-	-	-	-	-	Blast Furnaces
Rafinérie	-	-	-	-	-	-	-	-	-	-	-	Refineries
Výroba tepla	-	-	-	-	-	-	-	-	-	6	25	Heat Production
Transformácia - výstup	**-**	**-**	**-**	**-**	**46 125**	**-**	**-**	**2 076**	**12 459**	**18 284**	**3 679**	**Transformation Output**
Výroba elektriny - tepelné zariadenia	-	-	-	-	-	-	-	-	-	-	-	Electricity Production - Thermal Equipment
v tom: Verejné	-	-	-	-	-	-	-	-	-	-	-	of which: Public
Autoproducenti	-	-	-	-	-	-	-	-	-	-	-	Autoproducers
Jadrové elektrárne	-	-	-	-	-	-	-	-	-	-	-	Nuclear Plants
Koksárne	-	-	-	-	46 125	-	-	2 076	12 459	-	-	Coke Ovens
Vysoké pece	-	-	-	-	-	-	-	-	-	18 284	3 679	Blast Furnaces
Rafinérie	-	-	-	-	-	-	-	-	-	-	-	Refineries
Výroba tepla	-	-	-	-	-	-	-	-	-	-	-	Heat Production
Reklasifikácia a spätné toky	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**Exchanges and Transfers, Backflows**
Reklasifikácia produktov	-	-	-	-	-	-	-	-	-	-	-	Product Transferred
Spätné toky z petrochémie	-	-	-	-	-	-	-	-	-	-	-	Backflows from Petrochemical Sector
Spotreba energetického odvetvia	**-**	**-**	**-**	**11**	**-**	**-**	**-**	**-**	**3 707**	**10 890**	**-**	**Consumption of the Energy Sector**
Straty pri prenose a v rozvodoch	**-**	**-**	**26**	**22**	**-**	**-**	**-**	**-**	**49**	**69**	**876**	**Distribution Losses**

Fuels, Electricity and Heat Balance in 2015 - in TJ

1st continuation

	Antracit *Anthra-cite*	Čierne uhlie kokso-vateľné *Coking Coal*	Čierne uhlie ostatné *Other Bituminous Coal*	Hnedé uhlie a lignit *Brown Coal and Lignite*	Koks čierno-uhoľný *Hard Coal Coke*	Hnedo-uhoľné brikety *Brown Coal Briquettes*	Čierno-uhoľné brikety *Patent Fuel*	Decht *Coal Tar*	Koksá-renský plyn *Coke Oven Gas*	Vysoko-pecný plyn *Blast Furnace Gas*	Konver-torový plyn *Oxygen Steel Furnace Gas*	
Konečná spotreba	**2 167**	**-**	**11 771**	**1 631**	**4 370**	**72**	**224**	**-**	**7 544**	**6 013**	**2 469**	**Final Consumption**
Konečná neenergetická spotreba	**661**	**-**	**-**	**-**	**1 128**	**-**	**-**	**-**	**-**	**-**	**-**	**Final Non - Energy Consumption**
z toho: Chemický priemysel	-	-	-	-	-	-	-	-	-	-	-	of which: Chemical Industry
Konečná energetická spotreba	**1 506**	**-**	**11 771**	**1 631**	**3 242**	**72**	**224**	**-**	**7 544**	**6 013**	**2 469**	**Final Energy Consumption**
Priemysel	**1 506**	**-**	**9 071**	**630**	**1 917**	**-**	**-**	**-**	**7 544**	**6 013**	**2 469**	**Industry**
v tom: Železiarstvo a oceliarstvo	1 400	-	7 760	-	987	-	-	-	7 544	6 013	2 469	of which: Iron and steel
Metalurgia neželezných kovov	-	-	-	-	141	-	-	-	-	-	-	Non - ferrous metals
Chemický priemysel	-	-	-	-	-	-	-	-	-	-	-	Chemical
Nekovové minerálne výrobky	106	-	1 311	124	761	-	-	-	-	-	-	Non - metallic minerals
Ťažba nerastných surovín	-	-	-	11	-	-	-	-	-	-	-	Mining and quarrying
Potravinárstvo, nápoje a tabak	-	-	-	416	28	-	-	-	-	-	-	Food, beverages and tobacco
Textil a koža	-	-	-	-	-	-	-	-	-	-	-	Textile and leather
Celulóza, papierenstvo a polygrafia	-	-	-	-	-	-	-	-	-	-	-	Pulp, paper and print
Strojárstvo a dopravné zariadenia	-	-	-	79	-	-	-	-	-	-	-	Mach. and transport equipment
Inde nešpecifikované	-	-	-	-	-	-	-	-	-	-	-	Not elsewhere specified
Doprava	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**Transport**
Ostatné	**-**	**-**	**2 700**	**1 001**	**1 325**	**72**	**224**	**-**	**-**	**-**	**-**	**Other Sectors**
v tom: Domácnosti	-	-	288	360	28	72	-	-	-	-	-	of which: Households
Pôdohospodárstvo	-	-	-	11	-	-	-	-	-	-	-	Agriculture
Obchod a služby	-	-	2 412	630	1 297	-	224	-	-	-	-	Commercial and public services

Fuels, Electricity and Heat Balance in 2015 - in TJ

2nd continuation

	Zemný plyn *Natural Gas*	Ropa a gazolín *Crude Oil and NGL*	Rafinérske medziprodukty[1/] *Refinery Feedstock*[1/]	Rafinérsky plyn *Refinery Gas*	Etán *Ethane*	Propán - Bután *LPG*	Ťažký benzín *Naphta*	Benzín *Gasoline*	Petrolej *Kerosene*	
Primárna produkcia	3 258	494	9 450	-	-	-	-	-	-	Primary Production
Dovoz	154 390	247 866	210	-	-	1978	704	10 406	-	Import
Vývoz	-	420	-	-	-	2898	3 828	51 549	1 992	Export
Zmena stavu zásob	4 779	1 176	-	-	-	-92	-220	-	-173	Stock Changes
Hrubá domáca spotreba	**162 427**	**249 116**	**9 660**	**-**	**-**	**-1012**	**-3 344**	**-41 143**	**-2 165**	**Gross Inland Consumption**
Transformácia - vstup	**28 232**	**249 116**	**31 384**	**335**	**-**	**-**	**-**	**-**	**-**	**Transformation Input**
Výroba elektriny - tepelné zariadenia	17 429	-	-	335	-	-	-	-	-	Electricity Production - Thermal Equipment
v tom: Verejné	15 917	-	-	335	-	-	-	-	-	of which: Public
Autoproducenti	1 512	-	-	-	-	-	-	-	-	Autoproducers
Jadrové elektrárne	-	-	-	-	-	-	-	-	-	Nuclear Plants
Koksárne	-	-	-	-	-	-	-	-	-	Coke Ovens
Vysoké pece	-	-	-	-	-	-	-	-	-	Blast Furnaces
Rafinérie	-	249 116	31 384	-	-	-	-	-	-	Refineries
Výroba tepla	10 803	-	-	-	-	-	-	-	-	Heat Production
Transformácia - výstup	**-**	**-**	**-**	**15 094**	**1 659**	**8326**	**18 260**	**67 444**	**4 027**	**Transformation Output**
Výroba elektriny - tepelné zariadenia	-	-	-	-	-	-	-	-	-	Electricity Production - Thermal Equipment
v tom: Verejné	-	-	-	-	-	-	-	-	-	of which: Public
Autoproducenti	-	-	-	-	-	-	-	-	-	Autoproducers
Jadrové elektrárne	-	-	-	-	-	-	-	-	-	Nuclear Plants
Koksárne	-	-	-	-	-	-	-	-	-	Coke Ovens
Vysoké pece	-	-	-	-	-	-	-	-	-	Blast Furnaces
Rafinérie	-	-	-	15 094	1 659	8326	18 260	67 444	4 027	Refineries
Výroba tepla	-	-	-	-	-	-	-	-	-	Heat Production
Reklasifikácia a spätné toky	**-7 435**	**-**	**21 724**	**-**	**-**	**-1886**	**-5 940**	**-**	**-**	**Exchanges and Transfers, Backflows**
Reklasifikácia produktov	-7 435	-	13 898	-	-	-	-	-	-	Product Transferred
Spätné toky z petrochémie	-	-	7 826	-	-	-1886	-5 940	-	-	Backflows from Petrochemical Sector
Spotreba energetického odvetvia	**7 013**	**-**	**-**	**12 527**	**1 659**	**-**	**-**	**-**	**-**	**Consumption of the Energy Sector**
Straty pri prenose a v rozvodoch	**3 274**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**Distribution Losses**

Fuels, Electricity and Heat Balance in 2015 - in TJ

3. pokračovanie — 3rd continuation

	Zemný plyn *Natural Gas*	Ropa a gazolín *Crude Oil and NGL*	Rafinérske medziprodukty[1/] *Refinery Feedstock*[1/]	Rafinérsky plyn *Refinery Gas*	Etán *Ethane*	Propán - Bután *LPG*	Ťažký benzín *Naphta*	Benzín *Gasoline*	Petrolej *Kerosene*	
Konečná spotreba	**116 473**	**-**	**-**	**2 232**	**-**	**5428**	**8 976**	**26 301**	**1 862**	**Final Consumption**
Konečná neenergetická spotreba	**16 176**	**-**	**-**	**-**	**-**	**3174**	**8 976**	**-**	**-**	**Final Non - Energy Consumption**
z toho: Chemický priemysel	16 176	-	-	-	-	3174	8 976	-	-	of which: Chemical Industry
Konečná energetická spotreba	**100 297**	**-**	**-**	**2 232**	**-**	**2254**	**-**	**26 301**	**1 862**	**Final Energy Consumption**
Priemysel	**33 013**	**-**	**-**	**2 232**	**-**	**138**	**-**	**44**	**43**	**Industry**
v tom: Železiarstvo a oceliarstvo	6 272	-	-	-	-	-	-	-	-	of which: Iron and steel
Metalurgia neželezných kovov	1 354	-	-	-	-	-	-	-	-	Non - ferrous metals
Chemický priemysel	4 342	-	-	2 232	-	-	-	-	-	Chemical
Nekovové minerálne výrobky	5 866	-	-	-	-	46	-	-	-	Non - metallic minerals
Ťažba nerastných surovín	75	-	-	-	-	-	-	-	-	Mining and quarrying
Potravinárstvo, nápoje a tabak	2 998	-	-	-	-	-	-	-	-	Food, beverages and tobacco
Textil a koža	650	-	-	-	-	-	-	-	-	Textile and leather
Celulóza, papierenstvo a polygrafia	2 178	-	-	-	-	-	-	-	-	Pulp, paper and print
Strojárstvo a dopravné zariadenia	6 561	-	-	-	-	46	-	44	-	Mach. and transport equipment
Inde nešpecifikované	2 717	-	-	-	-	46	-	-	43	Not elsewhere specified
Doprava	**315**	**-**	**-**	**-**	**-**	**1564**	**-**	**26 257**	**1819**	**Transport**
Ostatné	**66 969**	**-**	**-**	**-**	**-**	**552**	**-**	**-**	**-**	**Other Sectors**
v tom: Domácnosti	43 984	-	-	-	-	184	-	-	-	of which: Households
Pôdohospodárstvo	951	-	-	-	-	46	-	-	-	Agriculture
Obchod a služby	22 034	-	-	-	-	322	-	-	-	Commercial and public services

[1/] vrátane aditív, oxygenátov a ostatných uhľovodíkov

1/ include Additives, Oxygenates and Other Hydrocarbons

Fuels, Electricity and Heat Balance in 2015 - in TJ

4. pokračovanie | 4th continuation

	Nafta *Diesel Oil*	Ľahký vykurovací olej *Light Fuel Oil*	Ťažký vykurovací olej nízkosírny *Heavy Fuel Oil - Low Sulphur (<1%)*	Ťažký vykurovací olej vysokosírny *Heavy Fuel Oil - High Sulphur (>=1%)*	Ostatné benzíny *White Spirit SBP*	Mazadlá *Lubricants*	Asfalty *Bitumens*	Parafíny *Paraffin Waxes*	Ropný koks *Petroleum Coke*	Ostatné rafinérske výrobky *Other Products*	
Primárna produkcia	-	-	-	-	-	-	-	-	-	-	Primary Production
Dovoz	33 588	41	404	2 262	336	2 524	6 881	173	4 014	5 695	Import
Vývoz	88 753	10 354	7 071	7 676	336	692	1 800	-	105	9 010	Export
Zmena stavu zásob	-3 119	447	2 667	-1 333	-	-	0	-	35	-680	Stock Changes
Hrubá domáca spotreba	**-58 284**	**-9 866**	**-4 000**	**-6 747**	**-**	**1 832**	**5 081**	**173**	**3 944**	**-3 995**	**Gross Inland Consumption**
Transformácia - vstup	**-**	**-**	**404**	**7 797**	**-**	**-**	**-**	**-**	**-**	**-**	**Transformation Input**
Výroba elektriny - tepelné zariadenia	-	-	404	7 797	-	-	-	-	-	-	Electricity Production - Thermal Equipment
v tom: Verejné	-	-	404	7 797	-	-	-	-	-	-	of which: Public
Autoproducenti	-	-	-	-	-	-	-	-	-	-	Autoproducers
Jadrové elektrárne	-	-	-	-	-	-	-	-	-	-	Nuclear Plants
Koksárne	-	-	-	-	-	-	-	-	-	-	Coke Ovens
Vysoké pece	-	-	-	-	-	-	-	-	-	-	Blast Furnaces
Rafinérie	-	-	-	-	-	-	-	-	-	-	Refineries
Výroba tepla	-	-	-	-	-	-	-	-	-	-	Heat Production
Transformácia - výstup	**120 318**	**10 760**	**4 484**	**14 544**	**-**	**-**	**-**	**-**	**2 024**	**7 735**	**Transformation Output**
Výroba elektriny - tepelné zariadenia	-	-	-	-	-	-	-	-	-	-	Electricity Production - Thermal Equipment
v tom: Verejné	-	-	-	-	-	-	-	-	-	-	of which: Public
Autoproducenti	-	-	-	-	-	-	-	-	-	-	Autoproducers
Jadrové elektrárne	-	-	-	-	-	-	-	-	-	-	Nuclear Plants
Koksárne	-	-	-	-	-	-	-	-	-	-	Coke Ovens
Vysoké pece	-	-	-	-	-	-	-	-	-	-	Blast Furnaces
Rafinérie	120 318	10 760	4 484	14 544	-	-	-	-	2 024	7 735	Refineries
Výroba tepla	-	-	-	-	-	-	-	-	-	-	Heat Production
Reklasifikácia a spätné toky	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**Exchanges and Transfers, Backflows**
Reklasifikácia produktov	-	-	-	-	-	-	-	-	-	-	Product Transferred
Spätné toky z petrochémie	-	-	-	-	-	-	-	-	-	-	Backflows from Petrochemical Sector
Spotreba energetického odvetvia	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2 024**	**-**	**Consumption of the Energy Sector**
Straty pri prenose a v rozvodoch	**42**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**Distribution Losses**

Fuels, Electricity and Heat Balance in 2015 - in TJ

5. pokračovanie | 5th continuation

	Nafta *Diesel Oil*	Ľahký vykurovací olej *Light Fuel Oil*	Ťažký vykurovací olej nízkosírny *Heavy Fuel Oil - Low Sulphur (<1%)*	Ťažký vykurovací olej vysokosírny *Heavy Fuel Oil - High Sulphur (>=1%)*	Ostatné benzíny *White Spirit SBP*	Mazadlá *Lubricants*	Asfalty *Bitumens*	Parafíny *Paraffin Waxes*	Ropný koks *Petroleum Coke*	Ostatné rafinérske výrobky *Other Products*	
Konečná spotreba	**61 992**	**894**	**80**	**-**	**-**	**1 832**	**5 081**	**173**	**3 944**	**3 740**	**Final Consumption**
Konečná neenergetická spotreba	**-**	**650**	**-**	**-**	**-**	**1 832**	**5 081**	**173**	**2 234**	**3 740**	**Final Non - Energy Consumption**
z toho: Chemický priemysel	-	650	-	-	-	-	-	-	-	3 740	of which: Chemical Industry
Konečná energetická spotreba	**61 992**	**244**	**80**	**-**	**-**	**-**	**-**	**-**	**1 710**	**-**	**Final Energy Consumption**
Priemysel	**505**	**-**	**80**	**-**	**-**	**-**	**-**	**-**	**1 710**	**-**	**Industry**
v tom: Železiarstvo a oceliarstvo	-	-	-	-	-	-	-	-	-	-	of which: Iron and steel
Metalurgia neželezných kovov	-	-	-	-	-	-	-	-	-	-	Non - ferrous metals
Chemický priemysel	-	-	-	-	-	-	-	-	-	-	Chemical
Nekovové minerálne výrobky	84	-	40	-	-	-	-	-	1 710	-	Non - metallic minerals
Ťažba nerastných surovín	126	-	-	-	-	-	-	-	-	-	Mining and quarrying
Potravinárstvo, nápoje a tabak	-	-	-	-	-	-	-	-	-	-	Food, beverages and tobacco
Textil a koža	-	-	-	-	-	-	-	-	-	-	Textile and leather
Celulóza, papierenstvo a polygrafia	-	-	40	-	-	-	-	-	-	-	Pulp, paper and print
Strojárstvo a dopravné zariadenia	84	-	-	-	-	-	-	-	-	-	Mach. and transport equipment
Inde nešpecifikované	211	-	-	-	-	-	-	-	-	-	Not elsewhere specified
Doprava	**58 706**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**Transport**
Ostatné	**2 781**	**244**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**Other Sectors**
v tom: Domácnosti	-	-	-	-	-	-	-	-	-	-	of which: Households
Pôdohospodárstvo	2 781	-	-	-	-	-	-	-	-	-	Agriculture
Obchod a služby	-	244	-	-	-	-	-	-	-	-	Commercial and public services

Fuels, Electricity and Heat Balance in 2015 - in TJ

6. pokračovanie — 6th continuation

	Jadrové teplo *Nuclear Heat*	Slnečná energia - teplo *Solar Heat*	Geo-termálne teplo *Geo-thermal Heat*	Teplo *Heat*	Drevo *Wood*	Tuhý mestský odpad *Municipal Solid Wastes*	Bioplyn *Biogas*	Priemy-selný odpad *Industrial Wastes*	Veterná energia *Wind energy*	Vodná energia *Hydro Energy*	Slnečná energia-elektrina *Solar Electricity*	Elektrina *Electricity*	Kvapalné biopalivá *Liquid Biofuels*	Spolu *Total*	
Primárna produkcia	161 733	230	297	-	37 254	1 668	6 223	6 905	22	13 918	1 822	-	6247	271 331	Primary Production
Dovoz	-	-	-	80	10	-	-	30	-	-	-	53 996	4196	646 514	Import
Vývoz	-	-	-	-	476	-	-	-	-	-	-	45 400	3942	238 406	Export
Zmena stavu zásob	-	-	-	-	26	-	-	4	-	-	-	-	-38	3 969	Stock Changes
Hrubá domáca spotreba	**161 733**	**230**	**297**	**80**	**36 814**	**1 668**	**6 223**	**6 939**	**22**	**13 918**	**1 822**	**8 596**	**6463**	**683 408**	**Gross Inland Consumption**
Transformácia - vstup	**159 765**	**-**	**242**	**-**	**18 134**	**1 118**	**4 574**	**184**	**-**	**-**	**-**	**-**	**-**	**668 923**	**Transformation Input**
Výroba elektriny - tepelné zariadenia	-	-	-	-	15 705	1 090	4 574	182	-	-	-	-	-	91 041	Electricity Production - Thermal Equipment
v tom: Verejné	-	-	-	-	8 135	-	883	-	-	-	-	-	-	71 990	of which: Public
Autoproducenti	-	-	-	-	7 570	1 090	3 691	182	-	-	-	-	-	19 051	Autoproducers
Jadrové elektrárne	159 765	-	-	-	-	-	-	-	-	-	-	-	-	159 765	Nuclear Plants
Koksárne	-	-	-	-	-	-	-	-	-	-	-	-	-	63 504	Coke Ovens
Vysoké pece	-	-	-	-	-	-	-	-	-	-	-	-	-	60 578	Blast Furnaces
Rafinérie	-	-	-	-	-	-	-	-	-	-	-	-	-	280 500	Refineries
Výroba tepla	-	-	242	-	2 429	28	-	2	-	-	-	-	-	13 535	Heat Production
Transformácia - výstup	**-**	**-**	**-**	**34 692**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**80 114**	**-**	**472 104**	**Transformation Output**
Výroba elektriny - tepelné zariadenia	-	-	-	22 679	-	-	-	-	-	-	-	25 588	-	48 267	Electricity Production - Thermal Equipment
v tom: Verejné	-	-	-	21 280	-	-	-	-	-	-	-	16 160	-	37 440	of which: Public
Autoproducenti	-	-	-	1 399	-	-	-	-	-	-	-	9 428	-	10 827	Autoproducers
Jadrové elektrárne	-	-	-	-	-	-	-	-	-	-	-	54 526	-	54 526	Nuclear Plants
Koksárne	-	-	-	-	-	-	-	-	-	-	-	-	-	60 660	Coke Ovens
Vysoké pece	-	-	-	-	-	-	-	-	-	-	-	-	-	21 963	Blast Furnaces
Rafinérie	-	-	-	-	-	-	-	-	-	-	-	-	-	274 675	Refineries
Výroba tepla	-	-	-	12 013	-	-	-	-	-	-	-	-	-	12 013	Heat Production
Reklasifikácia a spätné toky	**-1 968**	**-1**	**-**	**1 969**	**-**	**-**	**-**	**-**	**-22**	**-13 918**	**-1 822**	**15 762**	**-6 463**	**0**	**Exchanges and Transfers, Backflows**
Reklasifikácia produktov	-1 968	-1	-	1 969	-	-	-	-	-22	-13 918	-1 822	15 762	-6 463	0	Product Transferred
Spätné toky z petrochémie	-	-	-	-	-	-	-	-	-	-	-	-	-	0	Backflows from Petrochemical Sector
Spotreba energetického odvetvia	**-**	**-**	**-**	**2 792**	**10**	**-**	**-**	**-**	**-**	**-**	**-**	**8 665**	**-**	**49 298**	**Consumption of the Energy Sector**
Straty pri prenose a v rozvodoch	**-**	**-**	**-**	**5 827**	**28**	**-**	**-**	**-**	**-**	**-**	**-**	**349**	**-**	**10 562**	**Distribution Losses**

Fuels, Electricity and Heat Balance in 2015 - in TJ

dokončenie | End of table

	Jadrové teplo *Nuclear Heat*	Slnečná energia *Solar Heat*	Geo-termálne teplo *Geo-thermal Heat*	Teplo *Heat*	Drevo *Wood*	Tuhý mestský odpad *Municipal Solid Wastes*	Bioplyn *Biogas*	Priemyselný odpad *Industrial Wastes*	Veterná energia *Wind energy*	Vodná energia *Hydro Energy*	Slnečná energia-elektrina *Solar Electricity*	Elektrina *Electricity*	Kvapalné biopalivá *Liquid Biofuels*	Spolu *Total*	
Konečná spotreba	**-**	**229**	**55**	**28 122**	**18 642**	**550**	**1 649**	**6 755**	**-**	**-**	**-**	**95 458**	**-**	**426 729**	**Final Consumption**
Konečná neenergetická spotreba	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**43 825**	**Final Non - Energy Consumption**
z toho: Chemický priemysel	-	-	-	-	-	-	-	-	-	-	-	-	-	32 716	of which: Chemical Industry
Konečná energetická spotreba	**-**	**229**	**55**	**28 122**	**18 642**	**550**	**1 649**	**6 755**	**-**	**-**	**-**	**95 458**	**-**	**382 904**	**Final Energy Consumption**
Priemysel	**-**	**-**	**-**	**6 275**	**17 055**	**-**	**3**	**6 755**	**-**	**-**	**-**	**41 778**	**-**	**138 781**	**Industry**
v tom: Železiarstvo a oceliarstvo	-	-	-	-	174	-	-	-	-	-	-	8 413	-	41 032	of which: Iron and steel
Metalurgia neželezných kovov	-	-	-	-	-	-	-	-	-	-	-	9 228	-	10 723	Non - ferrous metals
Chemický priemysel	-	-	-	2 708	-	-	-	741	-	-	-	4 723	-	14 746	Chemical
Nekovové minerálne výrobky	-	-	-	298	13	-	-	5 997	-	-	-	1 987	-	18 343	Non - metallic minerals
Ťažba nerastných surovín	-	-	-	-	4	-	-	-	-	-	-	122	-	338	Mining and quarrying
Potravinárstvo, nápoje a tabak	-	-	-	175	4	-	-	-	-	-	-	1 933	-	5 554	Food, beverages and tobacco
Textil a koža	-	-	-	51	2	-	-	-	-	-	-	468	-	1 171	Textile and leather
Celulóza, papierenstvo a polygrafia	-	-	-	2734	14 531	-	3	-	-	-	-	2 599	-	22 085	Pulp, paper and print
Strojárstvo a dopravné zariadenia	-	-	-	230	211	-	-	17	-	-	-	8 273	-	15 545	Mach. and transport equipment
Inde nešpecifikované	-	-	-	79	2 116	-	-	-	-	-	-	4 032	-	9 244	Not elsewhere specified
Doprava	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2 167**	**-**	**90 828**	**Transport**
Ostatné	**-**	**229**	**55**	**21 847**	**1 587**	**550**	**1646**	**-**	**-**	**-**	**-**	**51 513**	**-**	**153 295**	**Other Sectors**
v tom: Domácnosti	-	195	-	18 961	1 021	-	-	-	-	-	-	18 126	-	83 219	of which: Households
Pôdohospodárstvo	-	-	29	29	466	-	1037	-	-	-	-	947	-	6 297	Agriculture
Obchod a služby	-	34	26	2 857	100	550	609	-	-	-	-	32 440	-	63 779	Commercial and public services