SLOVAK REPUBLIC

NATIONAL INVENTORY REPORT 2016

Greenhouse gas emission inventory 1990 – 2014

Submission 2016 under the UNFCCC
and for the years 2015 and 2016 under
the Kyoto Protocol

Slovak Hydrometeorological Institute
Ministry of Environment of the Slovak Republic

Bratislava, June 15, 2016

PREFACE

Title of report	**National Greenhouse Gas Inventory Report 1990 – 2014 to the UNFCCC and to the Kyoto Protocol**
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Version:	5. Version - Final
Date of submission:	June 15, 2016

In 2015, the Slovak Republic made an inventory submission under UNFCCC, but not under the Kyoto Protocol because the CRF Reporter could not deliver CRF tables for Kyoto Protocol LULUCF activities without errors. The present report is the official inventory submission of the Slovak Republic for the year 2016 under the UNFCCC and for the years 2015 and 2016 under the Kyoto Protocol, in spite of the remaining deficiencies in the CRF Reporter and underlying CRF tables. Slovakia should not be held liable for errors caused by the CRF Reporter in the review of the submitted information. The inventory data reported in the 2015 submission under the UNFCCC have been revised in this submission. Therefore, the 2016 submission should also be considered as a resubmission of the estimates with regard to the 2015 UNFCCC submission.

Recalling the invitation of the Conference of Parties for Parties to submit as soon as practically possible, and considering that CRF reporter 5.14.2 released on May 3rd, 2016 (and after) allows sufficiently accurate reporting under the UNFCCC Convention and the Kyoto Protocol, the present report is the official submission of Slovakia for the year 2015 under the UNFCCC and years 2015 and 2016 under the Kyoto Protocol.

The 2016 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 – 2014 including KP-LULUCF data tables for the years 2013 and 2014. The CFR tables were compiled using the CRF Reporter Inventory software (version 5.14.2).
- 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, 31.12.2015, and

transfers of the units during 2015. 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 and 2014 are included.

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

CONTENT

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 2016 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 (2014), several recalculations and reallocations were performed and reflected in the 2016 submission with the impacts on the previous inventory years 1991 – 2013 and the base year 1990. Due to the implementation of new IPCC guidelines and new methodologies, not all recommendations provided in the SVK ARR 2014 were relevant and were taken into consideration in current submission (due to obsolete).

On the other hand, recommendations provided in the EU internal review cycle 2015 and partly 2016 under the Effort Sharing Decision were implemented in this 2016 resubmission.

Total GHG emissions were 40 657.60 Gg of CO_2 equivalents in 2014 (without LULUCF). This represents a reduction by 45.4% against the base year 1990. In comparison with 2013, the emissions decreased by 5%. The decrease in total emissions of 2014 compared to 2013 was due to decrease in energy sector (heating) in the reaction to lower foreign trade and demand and higher use of renewable energy sources (RES). This trend was slightly corrected with the interannual decrease 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]

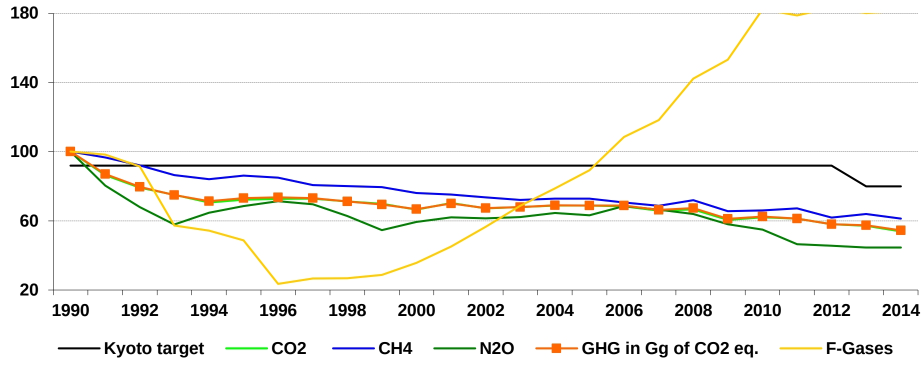
The major changes in the national inventory in the 2016 submission are caused by recalculations in energy and agriculture sectors for whole time series. The recalculations were made also in the harvested wood products, which affected LULUCF sector.

The emissions without LULUCF in 2014 are approximately on the lowest level during time series, which was expected also in the last available GHG emission projections and it is evidence of the successful implementation of the policies and measures and their effect on the improvement in energy intensity and industrial production efficiency. During the whole following period 1991 – 2014, 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 – 2014, 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 15.06.2016

Slovakia has decreased its emissions by around 19% between 2008 and 2014. 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.

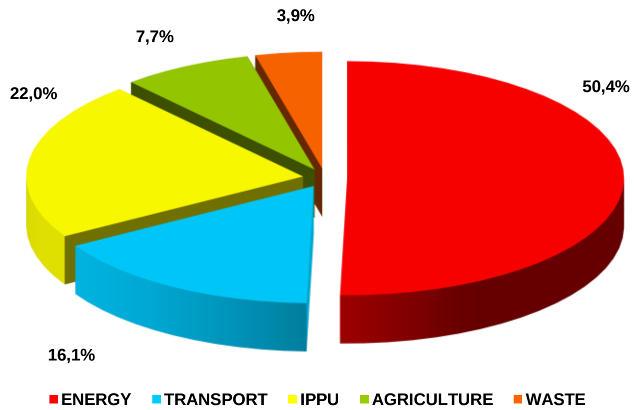
Reduction of emissions in Slovakia is conjunction of different impacts starting from impressive industrial and technological restructuring connected with the fuel switching of fossil fuels from coal and oil to the natural gas (air pollution legislation since 1991 was the main driving force), economy 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% was the main contributor to total GHG emissions in 2014. Within this sector, transport with 16% share contributes significantly to the GHG emissions. The transport sector in total emissions has decreased by 4% in comparison with previous year (2013). 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 2014 with its 22% share in total GHG emissions, producing mainly technological emissions from processing mineral products, chemical production and steel and iron production. The reduction of emissions from technological processes is very costly and there exist specific technical limits, therefore the emissions have not been changed since the reference year as significantly as for other categories. 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 2014, the share of agriculture sector on total GHG emissions was 8% 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 4% to total GHG emissions in 2014. 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 80% 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 2014 (%) in the Slovak Republic*



SECTOR/CATEGORY	CO_2 eq. (Gg)
1. Energy	20 496.25
1.3 Transport	6 532.88
2. Industrial Processes and Product Use	8 930.97
3. Agriculture	3 111.91
5. Waste	1 585.58

Emissions are determined as of 15.06.2016

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.

In 2014, total CO_2 removals from afforestation/reforestation activities were -441.81 Gg of CO_2 eq. (changes in 39.44 kha to the end of 2014). Total CO_2 emissions from deforestation were 62.80 Gg of CO_2 eq. (changes in 8.36 kha to the end of 2014). In 2014, 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 -4 924.15 Gg of CO_2 eq. with the changes on the area at the end of 2014 – 1 985.30 kha.

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

Activities	2013	2014	2015	2016	2017	2018	2019	2020	Total
Total 3.3 and 3.4	**-7 259.23**	**-5 303.16**							**-12 562.39**
A. Article 3.3 activities	**-400.03**	**-379.01**							**-779.04**
A.1 Afforestation/ Reforestation	-443.07	-441.81							-884.88
A.2 Deforestation	43.04	62.80							105.83
B. Article 3.4 activities	**-6 859.20**	**-4 924.15**							**-11 783.35**
B.1 Forest Management	-6 859.20	-4 924.15							-11 783.35

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

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	**2014**					
	CO_2 equivalent (Gg)					
	CO_2	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**
1. Energy	25 175.03	1 678.83	175.28	NO	NO	NO
2. Industrial Processes	8 132.67	1.71	225.26	546.02	11.15	14.17
3. Agriculture	73.57	1 236.23	1.802.10	NO	NO	NO
4. LULUCF	-6 166.40	17.15	27.50	NO	NO	NO
5. Waste	6.16	1 446.51	132.91	NO	NO	NO
KP LULUCF	*-4 952.59*	*0.69*	*0.04*	*NO*	*NO*	*NO*
Memo Items - International Transport	*135.54*	*0.07*	*3.06*	*NO*	*NO*	*NO*
Total (including LULUCF)	**27 221.03**	**4 380.44**	**2 363.05**	**546.02**	**11.15**	**14.17**
Total (excluding LULUCF)	**33 387.43**	**4 363.29**	**2 335.55**	**546.02**	**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 equivalent (Gg)							
CO_2 emissions excluding net CO_2 from LULUCF	61 837.57	53 447.44	48 979.13	46 467.55	43 638.49	44 679.54	44 978.91	45 040.27
CO_2 emissions including net CO_2 from LULUCF	52 759.22	43 641.28	38 469.50	35 944.17	33 809.29	35 330.85	35 673.38	35 854.89
CH_4 emissions excluding CH_4 from LULUCF	7 121.28	6 887.86	6 553.88	6 155.27	5 988.54	6 132.91	6 049.61	5 749.46
CH_4 emissions including CH_4 from LULUCF	7 128.72	6 893.79	6 559.89	6 162.99	5 993.92	6 139.01	6 056.54	5 756.58
N_2O emissions excluding N_2O from LULUCF	5 230.27	4 204.95	3 555.68	3 025.25	3 382.96	3 583.74	3 731.07	3 636.40
N_2O emissions including N_2O from LULUCF	5 309.93	4 278.89	3 627.96	3 096.85	3 449.93	3 642.19	3 786.24	3 686.83
HFCs	NO	NO	NO	NO	0.20	10.49	22.23	32.39
PFCs	314.86	309.73	288.24	180.32	153.23	132.65	40.72	40.16
SF_6	0.06	0.04	0.04	0.09	17.62	10.15	11.16	11.47
Total (excluding LULUCF)	**74 504.05**	**64 850.01**	**59 376.96**	**55 828.48**	**53 181.03**	**54 549.48**	**54 833.71**	**54 510.15**
Total (including LULUCF)	**65 512.79**	**55 123.72**	**48 945.63**	**45 384.42**	**43 424.19**	**45 265.35**	**45 590.28**	**45 382.32**

GREENHOUSE GAS EMISSIONS	1998	1999	2000	2001	2002	2003	2004	2005
	CO_2 equivalent (Gg)							
CO_2 emissions excluding net CO_2 from LULUCF	44 016.99	43 181.31	41 155.01	43 468.09	41 593.53	42 060.55	42 576.96	42 581.02
CO_2 emissions including net CO_2 from LULUCF	33 785.38	33 116.73	31 384.78	34 556.41	32 090.64	32 800.93	33 619.22	36 931.35
CH_4 emissions excluding CH_4 from LULUCF	5 708.47	5 657.97	5 422.74	5 358.11	5 237.54	5 138.51	5 183.93	5 184.37
CH_4 emissions including CH_4 from LULUCF	5 715.48	5 671.66	5 433.63	5 367.13	5 247.52	5 151.49	5 194.65	5 199.83
N_2O emissions excluding N_2O from LULUCF	3 280.48	2 860.26	3 108.03	3 243.20	3 215.28	3 250.65	3 376.96	3 309.17
N_2O emissions including N_2O from LULUCF	3 327.03	2 909.01	3 148.47	3 278.67	3 244.04	3 280.17	3 405.05	3 338.43
HFCs	42.62	61.63	84.73	112.83	146.23	175.02	208.94	240.67
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)	**53 090.30**	**51 790.09**	**49 798.47**	**52 211.58**	**50 224.55**	**50 666.24**	**51 385.86**	**51 355.78**
Total (including LULUCF)	**42 912.25**	**41 787.94**	**40 079.56**	**43 344.39**	**40 760.39**	**41 449.11**	**42 466.92**	**45 750.83**

GREENHOUSE GAS EMISSIONS	2006	2007	2008	2009	2010	2011	2012	2013
	CO_2 equivalent (Gg)							
CO_2 emissions excluding net CO_2 from LULUCF	42 320.48	40 725.30	41 236.32	37 433.43	38 385.94	37 880.85	35 867.90	35 395.15
CO_2 emissions including net CO_2 from LULUCF	33 945.80	32 622.00	34 251.36	30 567.15	32 333.79	31 432.34	28 210.75	27 293.26
CH_4 emissions excluding CH_4 from LULUCF	5 028.69	4 894.01	5 120.16	4 668.55	4 707.52	4 788.51	4 408.50	4 555.87
CH_4 emissions including CH_4 from LULUCF	5 040.88	4 907.71	5 133.79	4 682.94	4 722.45	4 803.40	4 420.74	4 564.89
N_2O emissions excluding N_2O from LULUCF	3 582.20	3 479.13	3 348.00	3 034.93	2 875.35	2 431.98	2 383.81	2 335.80
N_2O emissions including N_2O from LULUCF	3 608.11	3 505.10	3 373.21	3 060.06	2 899.95	2 456.53	2 407.04	2 357.38
HFCs	282.67	325.44	386.23	441.63	529.68	521.86	530.05	535.19
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)	**51 273.23**	**49 470.70**	**50 152.32**	**45 619.05**	**46 543.13**	**45 664.11**	**43 237.16**	**42 854.13**
Total (including LULUCF)	**42 936.64**	**41 407.07**	**43 206.20**	**38 792.29**	**40 530.51**	**39 255.04**	**35 615.49**	**34 782.84**

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 equivalent (Gg)							
1. Energy	56 572.15	50 017.08	45 788.32	41 895.31	39 244.90	39 470.07	39 629.78	39 430.71
2. Industrial Processes	9 813.65	7 601.41	7 222.10	8 238.14	8 454.10	9 377.21	9 684.90	9 718.47
4. Agriculture	6 653.54	5 765.16	4 913.35	4 246.85	4 058.07	4 281.81	4 097.46	3 931.11
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	1 464.71	1 466.36	1 453.18	1 448.19	1 423.96	1 420.39	1 421.57	1 429.86
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
	CO_2 equivalent (Gg)							
1. Energy	38 114.75	37 484.43	36 442.08	38 660.62	35 573.38	36 548.51	36 142.56	36 581.41
2. Industrial Processes	9 857.91	9 469.36	8 556.01	8 728.76	9 764.52	9 366.77	10 643.30	10 202.62
4. Agriculture	3 674.35	3 393.20	3 356.51	3 372.30	3 421.70	3 296.27	3 141.44	3 113.68
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	1 443.29	1 443.09	1 443.87	1 449.90	1 464.96	1 454.70	1 458.56	1 458.06
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
	CO_2 equivalent (Gg)							
1. Energy	35 624.25	33 955.86	34 878.87	32 001.97	32 597.94	32 094.92	29 635.00	29 474.16
2. Industrial Processes	11 059.95	10 912.91	10 780.55	9 215.85	9 519.04	9 102.71	9 019.52	8 717.92
4. Agriculture	3 082.50	3 138.61	3 029.86	2 910.56	2 927.82	2 935.30	3 018.44	3 111.60
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	1 506.53	1 463.31	1 463.04	1 490.67	1 498.33	1 531.19	1 564.20	1 550.45

Total aggregated GHGs emission, emissions are determined as of 15.06.2016, no indirect emissions are reported in the 2016 submission.

ES.5 INDIRECT EMISSIONS AND PRECURSORS OF GREENHOUSE GASES

The Slovak Republic is providing provisional emissions of CO, NO_x, SO_2 and NMVOC for the year 2014 and final data for the year 2013 as required in the Article 7 (1) (b). This information is included in the CRF tables 1990 – 2014 generated by the CRF Reporter software version 5.12.1 as a part of annual GHG inventory submitted on 15th January 2016.

In general, the national totals of CO, NO_x, SO_X and NMVOC emissions are below the national emission ceilings from 2010 and there is ongoing revision process of Directive 2001/81/EC for determination of new ceilings up to 2020 and 2030. 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. The overview NO_X, CO, NMVOC and SO_2 emissions for the year 2014 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 31st December 2015. 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.

- Recalculations of NMVOC emissions in transport sector were done. The category 1.A.3.a.i (i) was fulfilled by compiled values instead of notation key NE and category 1.A.3.a.ii (i) was recalculated too.
- The revision of methodology in solvents sector was performed. The major changes were in the NRF categories 2.D.3.a, 2.D.3.b, 2.D.3.c, 2.D.3.d, 2.D.3.e, 2.D.3.f, 2.D.3.g, 2.D.3.h, 2.D.3.i, and 2.G. Recalculations were applied throughout entire time series. The final values are higher compare to the previous reports due to completing of new activity data and removing of underestimations revealed by sector revision.
- The revision of methodology in agriculture sector was performed. For the first time, emission calculation of NH_3, NMVOC and NO_x from manure management and crop production have been performed. The estimation using methodology follow the current version of the EMEP/EEA Guidebook 2013. Emissions of NH_3, NMVOC and NOx were recalculated up to 2000.These changes were in NFR categories 3.B.1a, 3.B.1b, 3.B.2, 3.B.3, 3.B.4.a, 3.B.4.d, 3.B.4.e, 3.B.4.f, 3.B.4.g.i, 3.B.4.g.iii, 3.B.4.g.iii, 3.B.4.g.iv and 3.D.a.1.

Submission for the years 2000 – 2014 was uploaded via the EIONET Central Data Repository tool on webpage: http://cdr.eionet.europa.eu/sk/eu/nec on 15 March 2016 as preliminary version which will be updated in January 2016. Relevant, more detailed and updated methodological information on indirect gases such as NOx, SO_2 and NMVOC will be available in the Informative Inventory Report of the Slovak Republic under the Convention on Long-rage Transboundary Air Pollution on 15 March 2016.

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).

Further improvements were included in the GHG inventory submitted on 15th April 2016 after CLRTAP submission (15/3/2016). 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 2014 according to the gases and sectors*

EMISSIONS	TOTAL	ENERGY	INDUSTRY	AGRICULTURE	LULUCF	WASTE
	Gg in 2014					
NOx	**84.50**	80.12	0.82	3.09	0.44	0.03
CO	**240.53**	223.70	1.20	NE,NA,NO	15.61	0.01
NMVOC	**105.89**	33.88	46.08	19.77	NE,NA,NO	6.17
SO_2	**45.27**	44.87	0.37	NO	NE	0.001

The key sources and their percentage share on pollutant emissions are shown in the Table ES.6.

Table ES.6: *Summary of the key source analysis in 2014 according to the gases and sectors*

EMISSIONS	KEY CATEGORIES (SORTED FROM HIGH TO LOW FROM LEFT TO RIGHT)							TOTAL (%)
SOx	1.A.1.a	1.A.2.a	1.A.4.b.i					**85.7**
	(65.7%)	(14.0%)	(6.0%)					
NOx	1.A.3.b.iii	1.A.1.a	1.A.4.b.i	1.A.3.b.i	1.A.2.a	1.A.2.f	1.A.3.d.ii	**83.0**
	(34.9%)	(11.0%)	(10.4%)	(9.0%)	(7.4%)	(6.9%)	(3.2%)	
NMVOC	2.D.3.d	1.A.4.b.i	2.D.3.g	1.B.2.a.i	1.A.3.b.i	2.D.3.e		**82.2**
	(32.0%)	(19.2%)	(13.3%)	(6.2%)	(6.1%)	(5.5%)		
CO	1.A.2.a	1.A.4.b.i	1.A.3.b.i	1.A.1.c	1.A.2.b			**85.1**
	(39.9%)	(17.6%)	(14.9%)	(6.5%)	(6.3%)			

The composition of contributing categories is more-less stable during the time series and identifies clearly the major sources of emissions.

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 is now 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.[6]

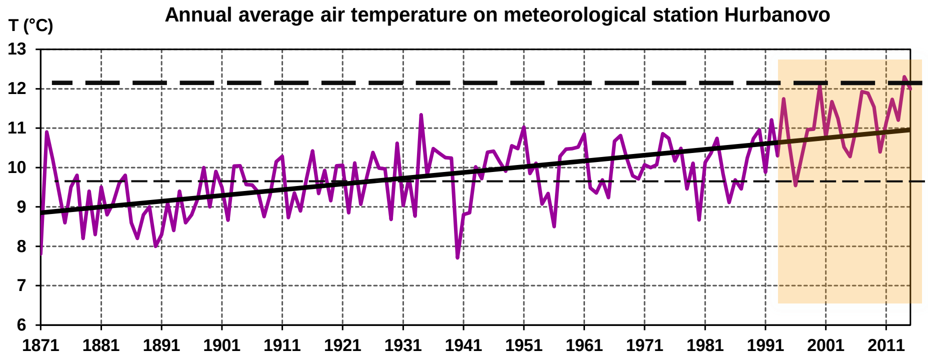
[6] World Data Centre for Greenhouse Gases (WDCGG) at the Japan Meteorological Agency (http://ds.data.jma.go.jp/gmd/wdcgg

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 – 2014 (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).[7]

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. The last two years (2014 and 2015) were the warmest since the beginning of meteorological measurements in Slovakia (Figure 1.1). Last 3 winters in Slovakia were abnormally warm and this consequence shows a systematic trend. 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*



[7] 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 2016 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 June 15, 2016, the Slovak Republic total anthropogenic emissions of greenhouse gasses expressed as CO_2 equivalent decreased by 45.4% 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.

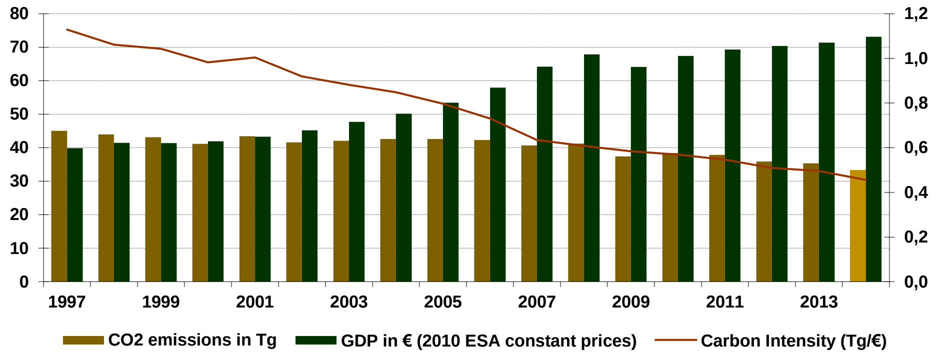
In May 2004, the Slovak Republic joined the European Union. Relevant European legislation has brought additional positive direct and indirect effects to the reduction of GHG emissions, mainly in energy sector. The introduction of emission trading scheme will allow the implementation of further reduction 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 1999*

Year	1999	2000	2001	2002	2003	2004	2005	2006
CO_2 emission in Tg	43.18	41.16	43.47	41.59	42.06	42.58	42.58	42.32
GDP in Bio € at ESA 2010 prices	41.39	41.90	43.28	45.24	47.69	50.20	53.41	57.95
Carbon Intensity (Tg/GDP)	1.04	0.98	1.00	0.92	0.88	0.85	0.80	0.73
Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
CO_2 emission in Tg	40.73	41.24	37.43	38.39	37.88	35.87	35.40	33.39
GDP in Bio € at ESA 2010 prices	64.22	67.85	64.13	67.39	69.30	70.36	71.36	73.16
Carbon Intensity (Tg/GDP)	0.63	0.61	0.58	0.57	0.55	0.51	0.50	0.46

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.[8]

The Slovak Republic and the former EU Member States ratified the Kyoto Protocol on 31st May 2002.[9] 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.[10]

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 2016 is reported the first and the second years (2013 and 2014) 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 are ready to sign the agreement at the signing ceremony on April 22, 2016 in New York. After that, we start 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.[11] 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

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

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

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

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

mechanism for monitoring Community GHG emissions and for implementing the Kyoto Protocol and Doha Amendment. Basic objectives of the Regulation are: [12]

- 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

[12] OJ L 165/13, 18.06.2013

commitments under the UNFCCC and the Kyoto Protocol and for Member States under the EU Effort Sharing Decision.

The Slovak Republic submitted the 2015 National Inventory Report to the European Commission based on Article 7 of the MMR on October 30, 2015 and the 2016 National Inventory Report to the UNFCCC and 2015 and 2016 NIR to the Kyoto Protocol on June 15, 2016.

1.2 DESCRIPTION OF THE NATIONAL INVENTORY ARRANGEMENTS

1.2.1 INSTITUTIONAL, LEGAL AND PROCEDURALS ARRANGEMENTS

The Ministry of Environment of the Slovak Republic (the MZP 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, Construction and Regional Development, 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. So far three reports have been submitted - the first in June 2012[13], another in April 2013,[14] in April 2014,[15] in April 2015[16] and the upcoming one will be published in April 2016.

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:

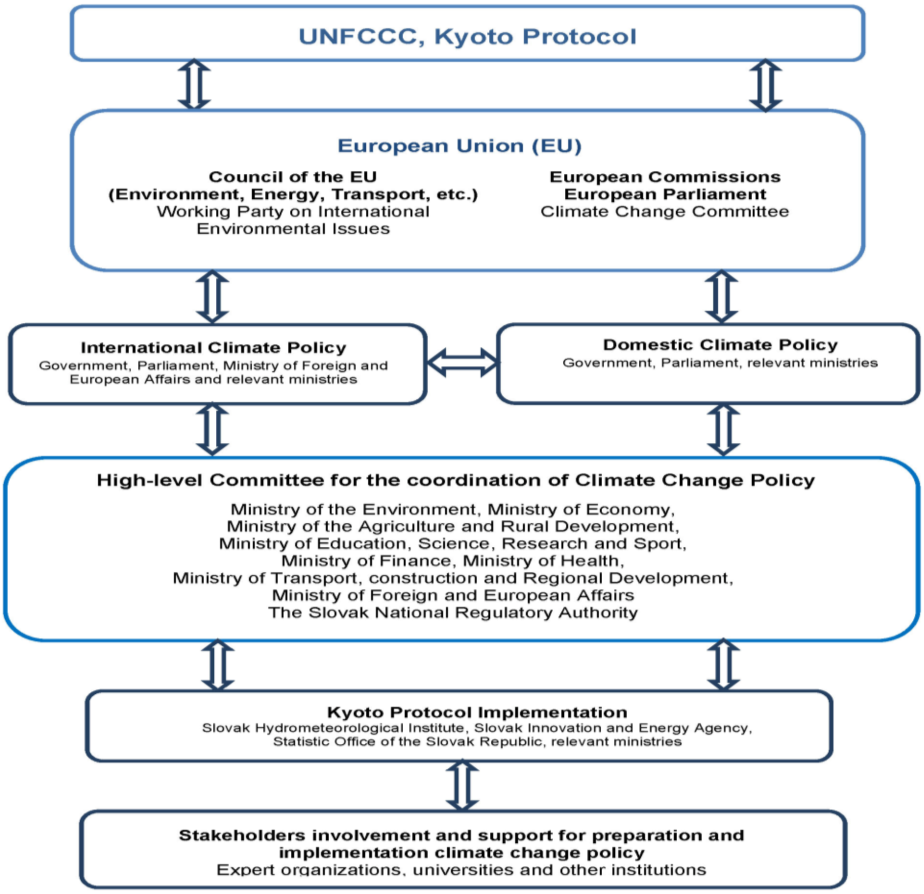
[13] http://www.rokovania.sk/Rokovanie.aspx/BodRokovaniaDetail?idMaterial=21144
[14] http://www.rokovania.sk/Rokovanie.aspx/BodRokovaniaDetail?idMaterial=22264
[15] http://www.rokovanie.sk/Rokovanie.aspx/BodRokovaniaDetail?idMaterial=23392
[16] http://www.rokovanie.sk/Rokovanie.aspx/BodRokovaniaDetail?idMaterial=24429

- reviewing and providing comments to the emission indicators calculated as obligatory part of the Annual Report 2014 prepared according to the Article 7 of the Regulation EU 525/2013 (January 2014),
- providing documents for relevant strategies, policies and measures to prepare 6th National Communication on Climate Change,
- drafting the Low Carbon Strategy of the Slovak Republic up to 2030.

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.[17]

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

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

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.

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.[18] 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. 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.

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

[18] "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

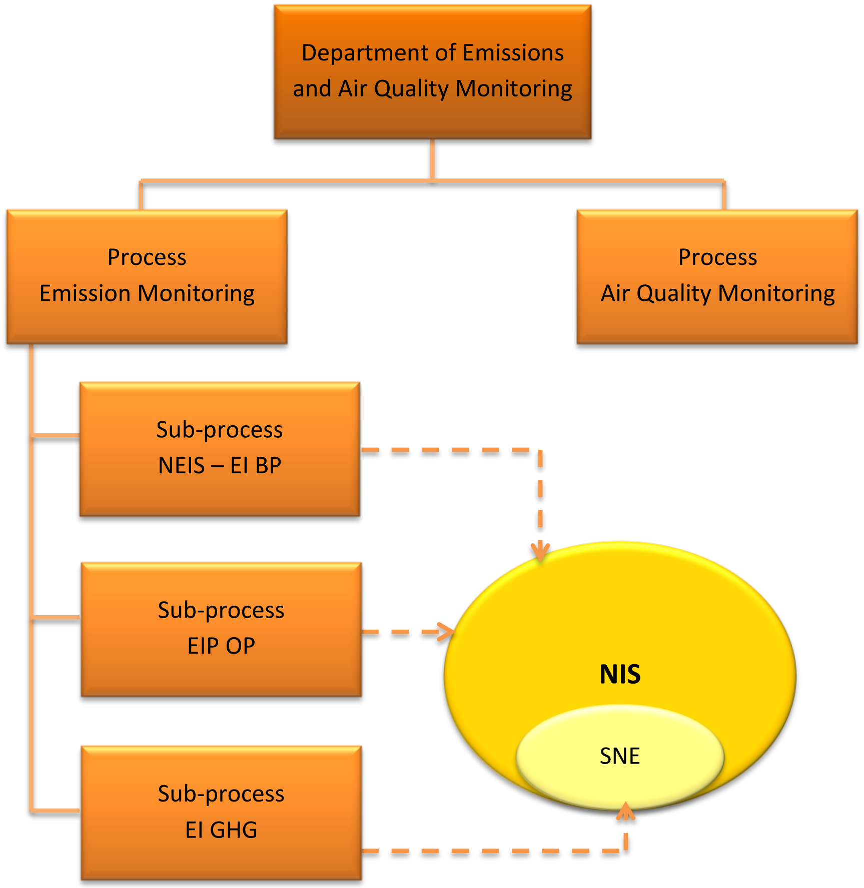
the Act No 137/2010 Coll. on Air Protection, competencies and decision-making process concerning large, medium and small pollution sources are given to regional and district levels and municipalities.

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 (the SHMU) 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 details of the SHMU activities are described in the Plan of Main Tasks. The plan, commented by all stakeholders is published after approval at the website of the SHMU 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.

Figure 1.4: *Structure and the processes within the Department of Emissions and Air Quality Monitoring*

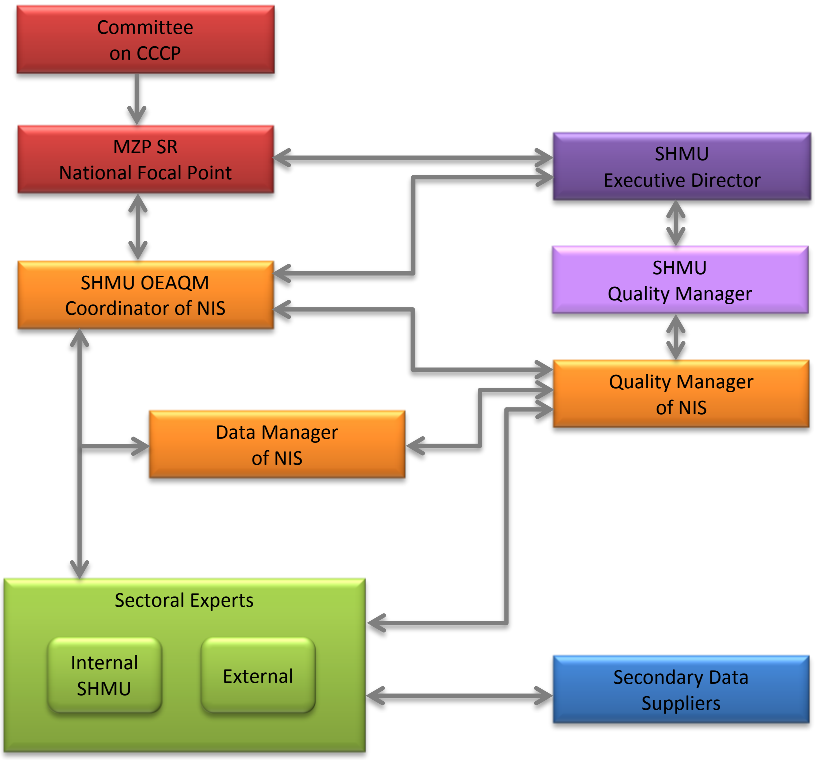


NEIS = National Emission Information System, EI BP = Emission inventory for Basic pollutants EIP OP = Emission inventory and projections for other pollutants, EI GHG = Emission inventory for GHG, SNE = Single National Entity, NIS = National Inventory System under the Article 5.1 KP

Organisational changes occurred after the year 2011 at the SHMU (the new structure of SHMU is presented at http://www.shmu.sk/File/organizacna%20struktura(1.1.2012).pdf). They resulted in establishment of the Department of Emissions and Air Quality Monitoring (the OMEaKO). The OMEaKO has two main tasks: the air quality monitoring and the emissions monitoring. The OMEaKO 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 (Figure 1.4).

The Single National Entity is a part of the OMEaKO 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 SHMU No 16/2011 in August 2011 and amended by the Decision of the Director General of the SHMU 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 quality manager (for a part-time job). 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 OMEaKO (Figure 1.5).

Figure 1.5: *Structure and responsibilities of the National Inventory System of the Slovak Republic*



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 MZP 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 MZP SR, SHMU 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 (Table 1.2):

- 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, Construction and Regional Development 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).

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

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. Rastislav Raši Mr. Tomas Hlásny	GHG inventory in Forest Land and KP LULUCF
Geodesy, Cartography and Cadastre 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
Ministry of Transport, Construction and Regional Development of the Slovak Republic		Preparation of projections, indicators and other parameters in transport
Animal Production Research Centre	Ms. Zuzana Palkovičová Mr. Vojtech Brestenský	GHG inventory in agriculture – animal production

External institutions/experts		
Institution	**Name**	**Responsibility**
Research Institute on Soil Protection Bratislava National Agricultural and Food Institute	Mr. Jozef Takáč 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
Ministry of Finance – Taxation and Custom Section		Data provider for bio fuels

Internal experts - SHMU		
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	Ms. Lýdia Ostradická	Energy expert
Dept. of Emissions and Air Quality Monitoring - SNE	Ms. Silvia Šrenkelová	Quality manager for NIS
Dept. of Emissions and Air Quality Monitoring	Mr. Marcel Zemko	Emission projections expert
Dept. of Emissions and Air Quality Monitoring	Ms. Ivana Duricova	Other pollutant expert
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

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:	Emission Registry Manager
E-mail address:	miroslav.hrobak@icz.sk

1.2.3 INVENTORY PLANNING, PREPARATION AND MANAGEMENT

The preparation of emission inventories within the 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 outcomes and experiences of the annual review under the UNFCCC and the KP are the main sources for the preparation of improvement plan. The improvement plan is 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. After preparation of the improvement plan, the prioritisation process is started based on expert's consultations. The improvement plan is prepared by sectors and delivered to the sectoral experts for consideration and prioritisation of planned activities for the next inventory cycle. The ranking of priority tasks is then summed up and prepared for the final approval of the planned activities to the NFP on the MZP SR. The approval is depends on the actual capacity situation and the need to reflect the review recommendations. The approved activities are included in the SNE (SHMU) annual contract and consequently the contracts of the sectoral experts.

During the last years the prioritisation of the improvement plan was last years focused on the energy sector and the harmonisation of different data sources for energy balance and implementation of the IPCC 2006 Guidelines. Now, the energy balance is completely recalculated and harmonised with the Eurostat and IEA reporting with the methodological explanations and description provided in the Chapter 3.

Currently, the priority is 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 in the next years.

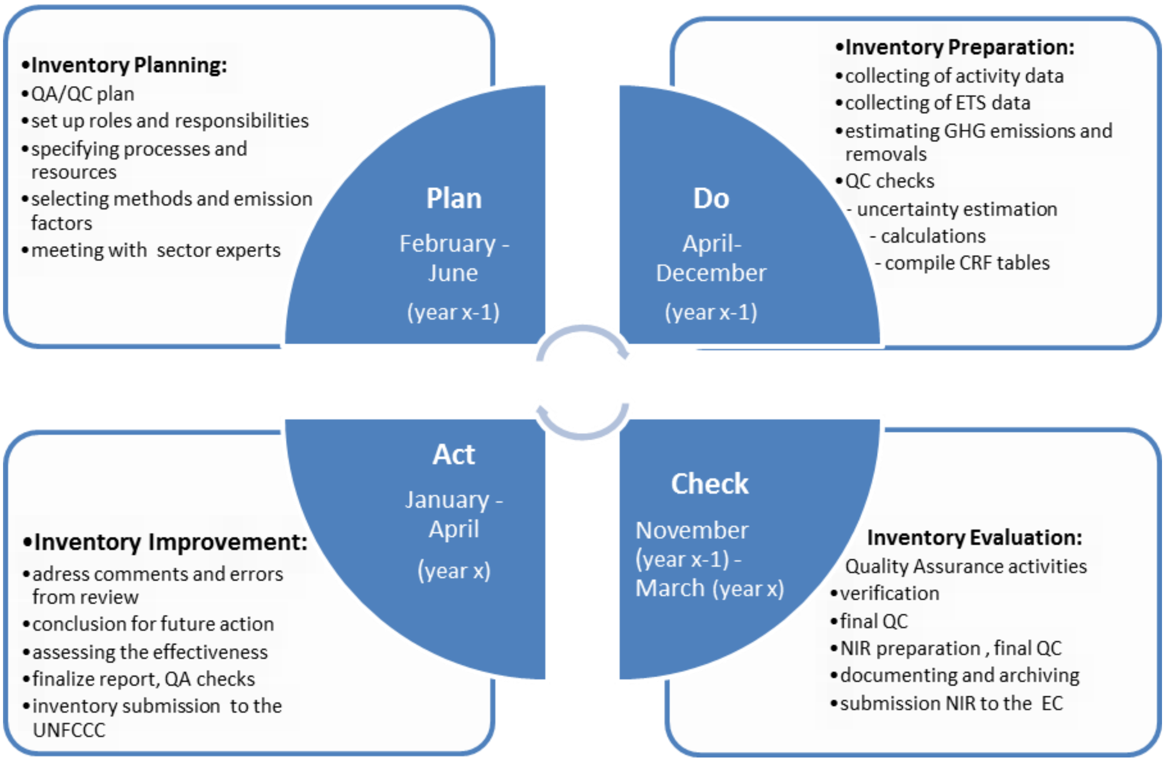
The compilation of the emission inventory starts with the collection of activity data, where the nominated sectoral experts cooperate with the Statistical Office of the Slovak Republic, major operators of air pollution sources, relevant ministries and their organizations, expert and professional associations. 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 OMEaKO of the SHMU.

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.).

Since 2005, the reports of participants in the scheme for GHG emission allowance trading integrated within the National Allocation Plan have been the most important sources of input data for the emission inventory. Sectoral experts for energy and industry have access to the reports of operators and auditors. Data received directly from measurements in operational units are harmonized with data entering the emission balance. Verified emissions are compared with the results of calculations and then they are harmonized.

Figure 1.6 shows a model proposed by the Certification Company for the timeline of steps provided in the inventory process, QA/QC activities and verification procedures. Experts involved in the NIS SR are nominated by the NFP. Nomination letters are included in the list of controlled documentation and administrated by the quality manager of the NIS.

Figure 1.6: *PDCA cycle (Plan, Do, Check, Act)*



Based upon the approved plan for improving emission inventories within the quality management, i.e. quality assurance and quality control (QA/QC), further improvements of emission factors and methodologies are planed annually. The majority of key sources are balanced according to higher methodologies (tier 2 and higher). Used emission factors are also re-evaluated and standard emission factors are replaced by the national specific ones. The national emission factors for the most important fuels in sectors energy and industry are updated annually. Certified measurements of emission factors are available also for natural gas (http://www.spp.sk/sk/velki-zakaznici/zemny-plyn/o-zemnom-plyne/emisie/), hard coal (energetic, coking coal, blast furnace coal), lignite, brown coal of various origin, gaseous fuels and others from monthly protocols.

The assessment of uncertainty of input data, emission factors and other input parameters is the final step in the preparation of emission inventory and important quality control activity. The assessment of uncertainty is done annually for all relevant categories by methodology tier 1 and for certain selected categories by methodology tier 2 – Monte Carlo (1.A Fuel combustion in energy and transport, 5.A Municipal waste disposal sites, sector 2 IPPU). The results are published annually in papers and in the National Inventory Report to the emission inventory (sectoral chapters).

The emission balances prepared by the external experts for individual sectors are gathered at the OMEaKO of the SHMU, where they are checked, reported and archived. Members of the Committee for the Climate Change Policy and other stakeholders can comment on the emission inventory each year.

Communicating the purpose of the inventory and results is also important. This activity includes priorities based on current activities or plans for raising awareness of GHG inventory efforts, continuous training process of staff, internal and external experts on the inventory system or practices.

These plans and activities include any of the following:

- Communicating inventory results to data providers;
- Scheduling stakeholder meetings;
- Raising awareness with government, academia, and the public;
- Providing feedback to government and associated institutions;
- Training or hiring inventory staff;
- Developing a transition plan to ensure a smooth transfer of inventory capacity when needed;
- Improving relationships with institutions.

1.2.4 QUALITY ASSURANCE/QUALITY CONTROL AND VERIFICATION PLANS

The Ministry of Environment of the Slovak Republic made a contract with consulting company ISO Management for the project "Implementation Process for QA/QC Model and QMS ISO 9001". The Project started in March 2009 and was separated into two parts: Part I Implementation Process for QA/QC Model and Part II Implementing QMS according to ISO 9001:2008. The QMS was certified in March 2010. Preparatory phase of Part I of the Project was aimed at the QA/QC plan for internal and external procedurals steps concerning GHG emission inventory. The project was finalized at the meeting and workshop for the experts involved in the National Inventory System on 13th January 2010. The QA/QC plans for sectors are updated and evaluated annually by the quality manager of the NIS and approved by the MZP SR.

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. These partial conclusions serve as a basis to estimate total uncertainties in emission inventories by a coordinator for uncertainties for all sectors. In some cases Tier 2 – Monte Carlo methodology (wastes, energy and industry) which requires detailed review of quality of each input parameter, works out uncertainty analysis.

Regarding QA/QC system, the SHMU implement a policy of continuous training process for internal and external experts. Experts are trained during workshops of the NIS SR which are held two times per year. The minutes of the workshop and all relevant documents are sent to sectoral experts of the NIS SR. The ways of communication within the NIS SR 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 on the webpage http://ghg-inventory.shmu.sk.

During the first half of 2013, the European Commission launched a project to assist Member States (MS) in the effective implementation of the reporting requirements under the Kyoto Protocol to the UNFCCC. The project aims at providing technical assistance and capacity building support to selected MS (included Slovakia) that have consistently exhibited difficulties in the preparation of their national inventories. Support is provided via a web-based tool wiki forum. This forum has been designed for the exchange of views and provision of advice and solutions for common GHG estimation and reporting problems under the UNFCCC Kyoto Protocol. Slovakia has obtained support in energy, F-gases, LULUCF and agriculture sectors including improvement in QA/QC activities. Some experts visit wiki forum to share information between MS, and between MS and the project support team experts.

The QA/QC plans (external and internal), proposed and approved in the phase of preparation for the certification, are included in Annex 4 in Tables A4.1 and A4.2 for internal and external assessments. Detailed information about QA/QC plans and activities inside sectors are included in the Chapters 3 – 7. Improvements plans and the implementation of the QC/QA procedures are enclosed as example in the Table A4.3 (Annex 4). Detailed improvements plans are elaborated for each sector and for the general part of the NIS SR separately on annual base. According to the ERT recommendations from the previous centralised review in 2014, prioritisation of improvements planned for the next submission was included into sectoral improvements plans.

1.2.5 QUALITY MANAGEMENT SYSTEM

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 for the following activities (http://www.shmu.sk/File/cert_slovak.gif):

- Monitoring of the determinants characterising the state of air and waters in the Slovak Republic;
- Assessment, archiving and interpretation of data and information on the state and regime of air and waters;
- Providing data and information on the state and regime of air and waters;
- Study and description of the atmosphere and hydrosphere phenomena;
- Education and training within the activity of the Institute.

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. Nowadays, the OMEaKO formally fulfils the QMS requirements in the area of controlled documents and records in accordance with the QMS of the SHMU. The controlled documents and records are available at the quality manager of NIS SR and Air Quality Monitoring in Slovak language. The quality manager has completed several trainings regarding the QMS. The recertification process is taking place every two years.

Within the continuous improvement process of the GHG inventory system, SHMU decided to make a substantial revision of the QA/QC procedures as an important part of the development of national greenhouse gas inventories. In the context of greenhouse gas inventories, high quality means that the structure of the national system (i.e. all institutional, legal and procedural arrangements) for estimating greenhouse gas emissions and removals and the content of the inventory submissions (i.e. inputs, outputs, products) comply with the requirements and principles.

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.

The annual inventory process set out in Figure 1.6 illustrates at a general level how the inventory is produced within the national system. The quality of the output is ensured by inventory experts during inventory preparation, compilation and reporting, which consists of four main stages: planning, preparation, evaluation and improvement. The quality control and quality assurance elements are integrated into the inventory production system, which means that each stage of the inventory process includes relevant procedures for quality management.

A clear set of documents is produced on the different work phases of the inventory. The documentation ensures the transparency of the inventory: it enables external evaluation of the inventory and, where necessary, its replication. A quality handbook includes all aspects of an organizational and technical level to set up the emission inventory of GHG.

The set of templates and checklist consists from these documents:

- QA/QC Plan (external, internal)
- Matrix of Responsibility
- General QC
- Source Category-specific QC
- Cross-cutting QC
- Quality Assurance
- Archive System
- Quality Improvement plan

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. All documents after filling out by experts are approved by responsible person of inventory system and 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.

1.2.6 QUALITY CONTROL PROCESS

QC procedures encourage quality in two ways:

- General procedures, which are intended for experts of individual sectors and used for documentation, data collection and emission calculation.
- Special activities to control and maintain data quality. Also, the procedures involve checks that should be carried out every year as part of QC activities. The checks involve verification of compliance with standardized procedures as well as provision of forms for documentation of non-compliance and corrective actions.

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. Also, additional procedures should be followed to ensure that the parameters and emission factors are correctly written down and that relevant conversion factors are used:

- Emission units, parameters and conversion factors shall not be directly included in the formulas; any value used for the calculations more than once shall be given in the spreadsheets (preferably at the top of the page and in bold) and in the calculations, where they should be taken from one cell as a reference.

- Units shall be properly marked and correctly maintained during the entire calculation.
- Correct conversion factors shall be used and updated annually.
- Temporary coefficients shall be used correctly.

The experts must ensure data consistency in the databases and spreadsheets.

- Confirm that respective data processing steps have been correctly represented in the spreadsheets (e.g. correct formulas have been used).
- Confirm that data relations have been properly presented (e.g. that the data is of the same year and given in the same units).
- Clearly distinguish between the input data and the calculable data in the spreadsheets (including formulas or macros).

General QC procedures include general quality checks to ensure data integrity, correctness and completeness, identify and address errors and omissions and document and archive inventory material. Experts are invited to fill in a check list of general QC during the compilation of inventory. The check list of general QC is designed equally to all sectors. The results of these QC activities and procedures are documented and archived. The form of check list of general QC is in Annex 4 of this report. Quality control involves the following steps:

1. Evaluation of the data collection procedure, to establish whether:
    - the necessary methods, activity data and emission factors (i.e. those in conformity with the IPCC Good Practice Guidance) have been used;
    - the calculations have been made correctly;
    - all-time series data has been provided and calculated;
    - the data and results for the current year have been compared with the data and results of the previous years;
    - the notes and comments contain all necessary information on the data sources, methods.
2. Evaluation of the emission calculation, to establish:
    - consistency of used emission factors;
    - correctness of used emission parameters, units, conversion factors;
    - correctness of the data transferred from spreadsheets to CRF tables;
    - correctness of recalculations.
3. Evaluation of the preparation of respective chapters of the National Inventory Report, to establish:
    - integrity of the structures of the inventory data;
    - completeness of the inventory;
    - consistency of time series;
    - whether the emission estimation have been compared with previous estimation;
    - whether the data tables of the National Inventory Report correspond to the text;
    - whether all necessary information on the data sources, assumptions and calculation methodology has been provided.

1.2.7 QUALITY ASSURANCE PROCESS

Good practice for QA procedures requires an objective review to assess the quality of the inventory, and to identify areas where improvements could be made. Part of the work on improving the quality of the inventory is carried out by general public review, expert peer review and internal audit, if is necessary. With uploading to the website of SHMU, 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.

Slovakia and Czech Republic began bilateral cooperation in the QA activities. First meeting was held in July 2013 at the SHMU (later also in July 2014 and 2015). Team of GHG inventory experts from the SHMU and the Czech Hydrometeorological Institute (CHMU) met to exchange information and experience relating to the preparation of GHG inventory. Main points of the meeting were:

- Uncertainty, QC check list
- Estimating emission of charcoal, F-gases
- Inventory completeness
- QA/QC and Improvement plans, verification

1.2.8 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).

1.2.9 CHANGES IN THE NATIONAL INVENTORY ARRANGEMENTS

The latest published Annual Review Report FCCC/ARR/2014/SVK of the individual review of the annual submission of the Slovak Republic was published in May 2015 at http://unfccc.int/resource/docs/2015/arr/svk.pdf. This report covers the centralised review of the 2014 annual submission of the Slovak Republic, coordinated by the UNFCCC secretariat, in accordance with decision 22/CMP.1. Recommendations from the SVK ARR 2014 were already implemented into 2015 official submission and are described in the SVK NIR 2015. The manager of NIS summarized and evaluated in terms of QA/QC system the list of main recommendations made by ERT and implemented further steps in line with the IPCC 2006 GL in the previous submission (2015). Several findings were implemented in this submission. List of recommendations and improvements was enclosed in the Annex 4, Table A4.4 of the SVK NIR 2015.

Due to the special circumstances with the malfunction of the CRF Reporter software, no UNFCCC review took place in 2015. Official submission of the annual GHG emissions inventory for the year 2015 to the UNFCCC was provided on November 11, 2015.

Based on annual EU review of the GHG emissions inventory provided in the years 2015 and 2016, several improvements, recalculations and changes were implemented in the 2016 submission. The overview GHG emissions recalculations for the year 2013 and also for time series are shown in the Chapter 10 of this report.

Since the November 2015 GHG submission of the Slovak Republic, no changes within the National Inventory System of the Slovak Republic took place. The National Inventory System of the Slovak Republic was reviewed by the ERT during the 2014 centralised review without significant recommendations. A completed improvement plan guides future efforts to increase the transparency, consistency, comparability, completeness and accuracy of future inventories. An inventory improvement plan paves the way for the next GHG inventory which will address some of the limitations identified in the current one. A comprehensive national improvement plan is established, identified and documented with all relevant contributors of the NIS. The template of national improvement plan describes the problem by categories, includes the potential improvements, evidence of implementation and identifies the level of priority associated with each (high, medium, or low).

1.2.10 INVENTORY PREPARATION, AND DATA COLLECTION, PROCESSING AND STORAGE AND ARCHIVING

The deadlines and responsibilities are described in the QA/QC external and internal plans. 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 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. Further most common sources of activity data are listed in the following table and in the sectoral chapters of this report.

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

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 OMEaKO.

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 OMEaKO.

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. The Archiving Coordinator is responsible for ensuring that all archiving procedures are performed for the inventory and all supporting documents and spreadsheets are retained appropriately.

1.2.11 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 for the first time in this submission. 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.*

1.2.12 BRIEF DESCRIPTION OF KEY CATEGORIES

Key categories were assessed by Approach 1 by the level of emissions in years 1990 and 2014 and the trend in emissions for the year 2014 with LULUCF categories and those key categories have been chosen, whose cumulative contribution is less than 95%. The identification includes all reported greenhouse gases CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 and all IPCC source categories with LULUCF categories (in absolute values) performed with the detailed categorization. The detailed key categories were assessed and are listed in Annex 1 of this report.

In 2014, the Slovak Republic determined using the Approach 1 methodology, 32 key categories by the level assessment with LULUCF in 2014 and 32 key categories by level assessment in 1990. List of key categories is almost identical for the base year and for the latest inventory year. The trend assessment determined using Approach 1 methodology 46 key categories with LULUCF in 2014. The most important key categories are fuel combustion in energy sector for CO_2, road transport, forest land, direct N_2O emissions from agricultural soil or methane emissions from SWDS.

1.2.13 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 10.11% level uncertainty and the 3.25% trend uncertainty in 2014.

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 (-2.32%; +3.04%) in 2014.

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 (-4.00%; +3.95%) in 2014. Results of the Monte Carlo method to estimate uncertainty were published in following papers[19,20] and detailed description is in Chapters 3 and 4 of this report.

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

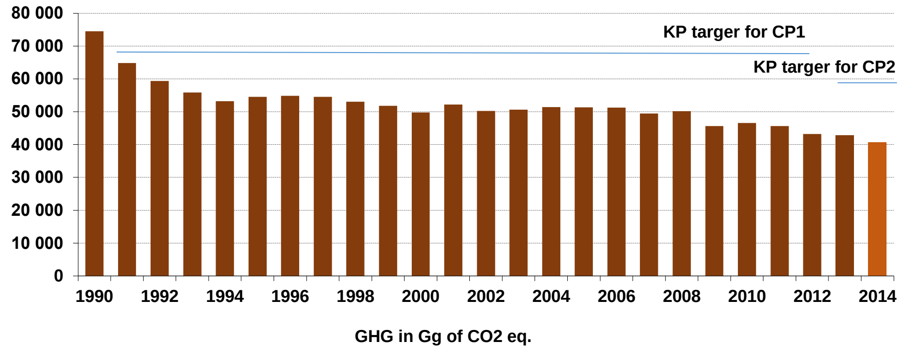
[20] Szemesová J., Gera M. Uncertainty analysis for estimation of landfill emissions and data sensitivity for the input variation, Climatic Change DOI 10.1007/s10584-010-9919-1, 2010

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 2016 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 were implemented in this submission. Total GHG emissions were 40 657.60 Gg CO_2 eq. in 2014 (without LULUCF). This represents a reduction by 45.4% in comparison with the reference (base) year 1990. In comparison with 2013, the emissions decreased by 5%. Total GHG emissions in the Slovak Republic significantly decreased in 2014 in comparison with the previous year, which was probably influence by decrease in energy sector as a result of implemented measures in energy efficiency a biomass use. 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 – 2014, 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 (%)*



CP1 = First Commitment Period, CP2 = Second Commitment Period
Aggregated GHG emissions without LULUCF; emissions are determined as of 15.06.2016

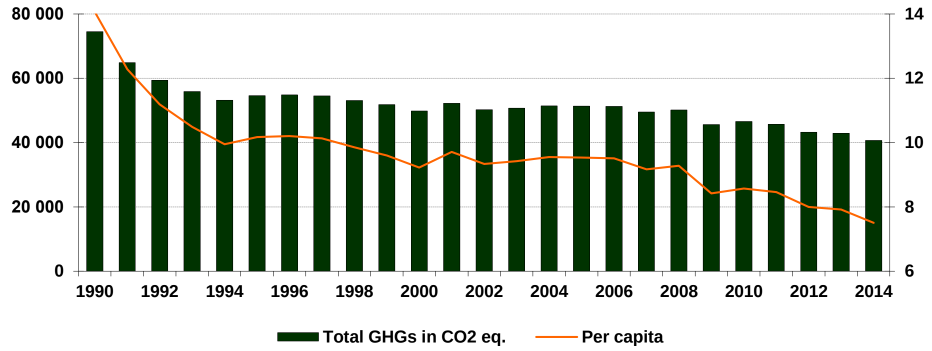
This important reduction of emissions has resulted above all from the strong although temporary decrease in economy activities, followed by restructuring of economy joined with implementing new and more effective technologies, reducing the share of the intensive energy industry and increasing share of 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 – 2014 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 equivalents per capita in 1990 – 2014*



2.2 DESCRIPTION AND INTERPRETATION OF EMISSION TRENDS BY GAS

Population of the Slovak Republic as of December 31, 2014 was 5 418 649. Average residential density is 110.5 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 419 678 inhabitants (as of 31st December 2014). It is the capital of the Slovak Republic.

Total anthropogenic emissions of carbon dioxide excluding LULUCF have decreased by 46.0% in 2014 compared to the base year (1990). Nowadays the amount is 33 387.43 Gg of CO_2. Compared to the previous inventory year 2013, the decrease is 6%. The reason for the decrease in CO_2 emissions in 2014 is caused mainly by decreasing CO_2 emissions in energy sector due to mild winter (lower heating emission). In 2014, CO_2 emissions including LULUCF sector are almost at the same level compared to the previous year and decreased by 49% compared to the base year.

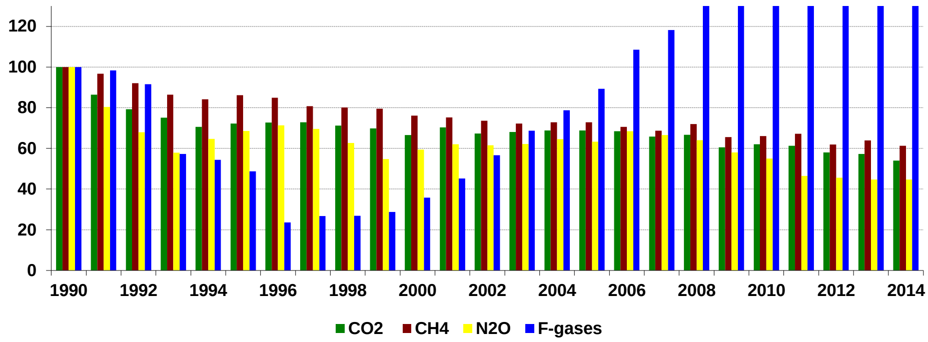
Total anthropogenic emissions of methane without LULUCF decreased compared to the base year (1990) by 38.7% and currently the emissions are 4 363.29 Gg of CO_2 equivalents. In absolute value, CH_4 emissions were 174.53 Gg without LULUCF. Methane emissions from LULUCF sector are 0.69 Gg of CH_4 caused by forest fires. The trend has been relatively stable during the last years with a slight increase in the last year 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 55.4% and currently the emissions are 2 335.55 Gg of CO_2 equivalents. Emissions of N_2O in absolute value were 7.84 Gg without LULUCF. Emissions of N_2O from LULUCF sector are 0.45 Gg from forest fires and cropland. Emissions decreased compared to the previous year 2013 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 546.02 Gg of HFCs, 11.15 Gg of PFCs and 14.17 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.

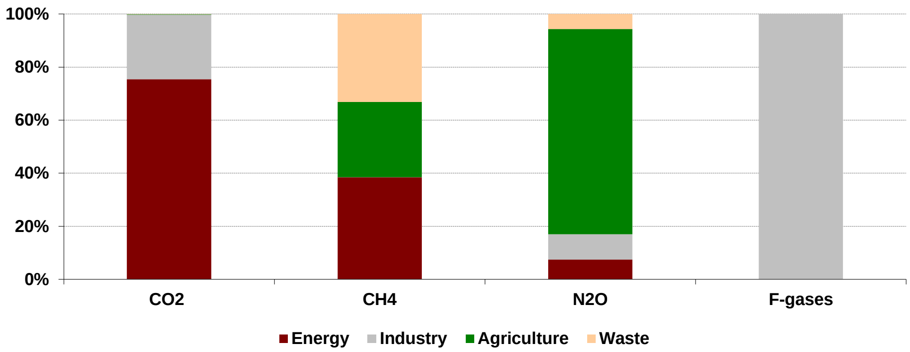
Figure 2.3: *Emission trends by gas for the years 2000 – 2014 relative to the 1990 level (relative in %)*



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 2014 inventory, 24% 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 33% of CH_4 emissions is produced in waste sector (SWDS), 38% of methane emissions is produced in energy sector and 28% in agriculture sector. More than 77% of N_2O emissions is produced in agriculture sector (nitrogen from soils), 10% in industrial processes sector (nitric acid production), 6% in wastewaters and 7% 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 2014*



Aggregated GHG emissions from energy sector based on sectoral approach data in 2014 were estimated to be 27 029.14 Gg of CO_2 equivalents including transport emissions (6 532.88 Gg of CO_2 equivalents), which represent the decrease by 52% compared to the base year and 83% decrease in comparison with 2013. Transport sub-sector decreased by 3% compared to 2013 and in comparison with the base year it declined by 5%.

Total emissions from industrial processes and product use sector were 8 930.97 Gg of CO_2 equivalents in 2014, which was decreased by 9% 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 3 111.91 Gg of CO_2 equivalents. It is 53% decrease in comparison with the base year and less than 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.

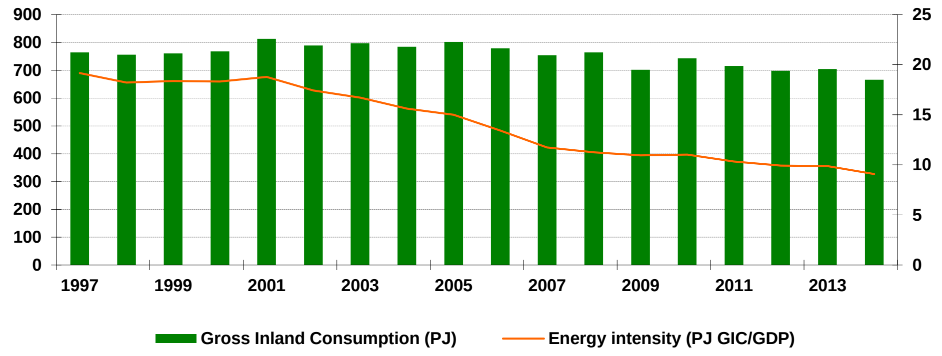
Emissions from waste sector were estimated to be 1 585.58 Gg of CO_2 equivalents. The increase is 2% compared to the previous inventory year and the time series are stable for last years. Compared to the base year, the increase was more than 8%, because of increased methane emissions from solid waste 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 – 2014 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 – 2014 (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 IV version 9.0. 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.

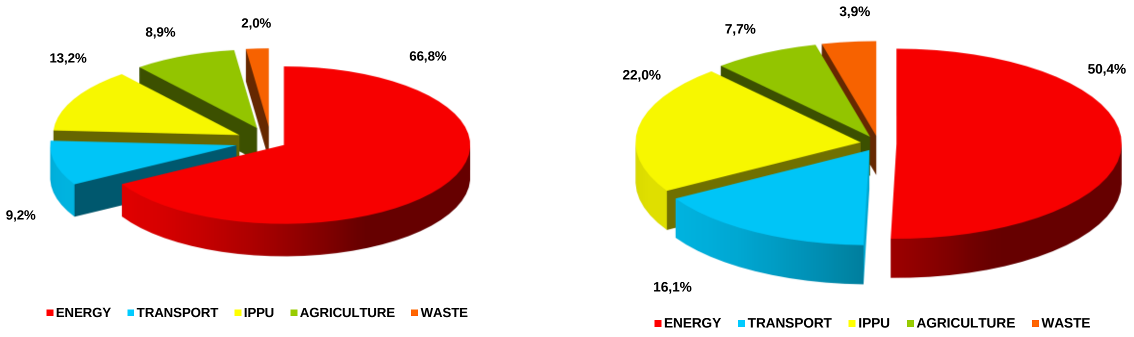
Several significant changes and re-evaluations of the applied methods have been carried out in sector waste, followed by recalculations in all categories of waste treatment. Methane emissions from solid waste disposal sites (SWDS) have the largest share in total emissions from the sector. Waste balance methodology has been revised and tier 2 approach FOD (First Order Decay) methodology has been used for the recalculations of the time series since 1960. 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 are described in the references.[21] 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.

[21] 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 2014 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 138.67 Gg of CO_2 equivalents in 2014. Emissions from international aviation have more than 95% share.

Figure 2.6: *The share of individual sectors in total GHG emissions in 1990 and 2014*



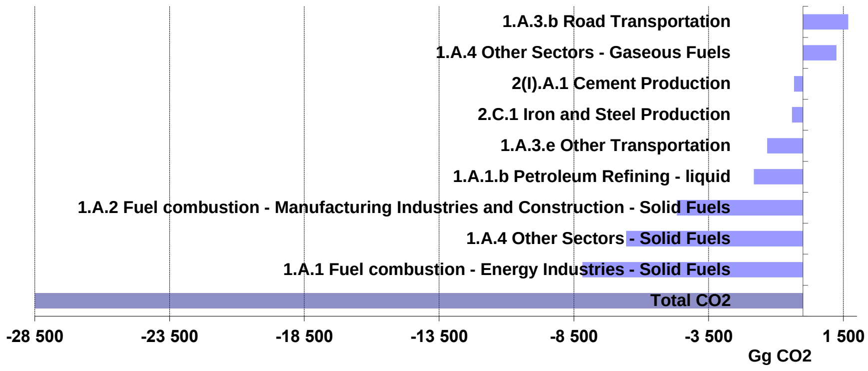
2.3.1 CHANGE IN EMISSIONS FROM KEY CATEGORIES

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 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 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 2014. Between 1990 and 2014, CO_2 emissions in road transportation increased by 1.7 Mt of CO_2, which is 138% 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, gaseous fuels from the category 1.A.4 Other Sectors is the second largest key category without LULUCF (15%) and the increase (134%) is between 1990 and 2014. The largest decrease in key category is recorded in the solid fuels of 1.A.4 Other Sectors. CO_2 emissions decreased between 1990 and 2014 by 91%. 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.

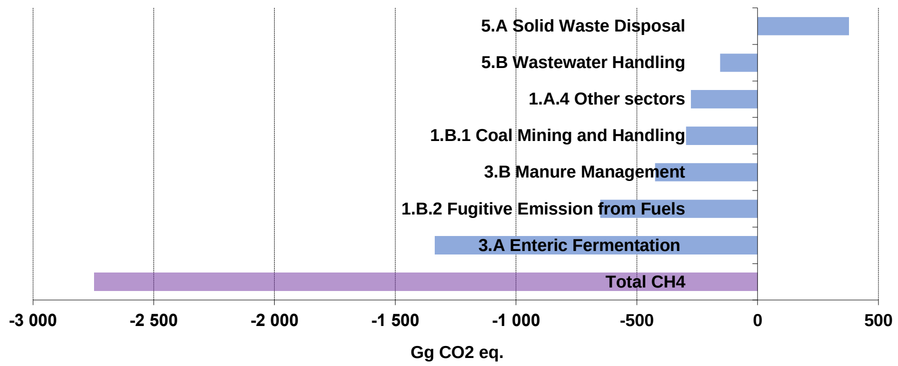
CO_2 emissions from fuels in the category 2.C.1 - Iron and Steel Production are the largest key category without LULUCF in the IPPU sector, accounting for 11% of total CO_2 emissions in 2014. CO_2 emissions from the category 1.A.2 in energy sector are the fourth largest key source in the Slovak Republic, accounting for 13% of total GHG emissions in 2014. Between 1990 and 2014, emissions from this category showed the decrease by 48%.

Figure 2.7: *Absolute change of CO_2 emissions by large key categories 1990 to 2014*



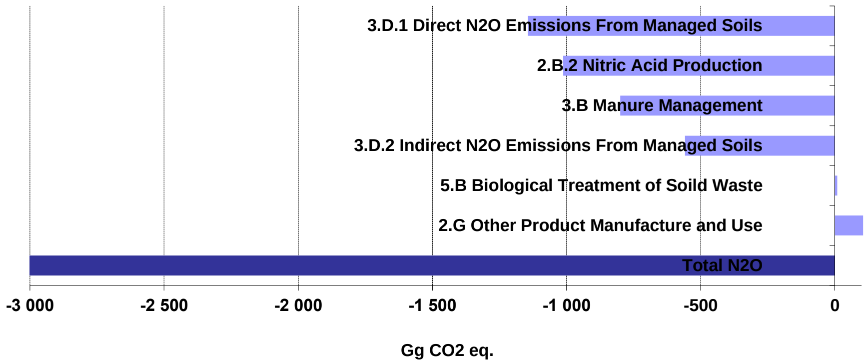
Methane emissions account for 13% of total GHG emissions in 2014 and decreased by 39% since 1990 to 174.53 Gg CH_4 in 2014. The two largest key sources (1.B.2 Fugitive Emissions at 24% and 3.A Enteric Fermentation at 24% of total CH_4 emissions in 2014) account for 50% of CH_4 emissions in 2014. Figure 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 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 2014*



N_2O emissions are responsible for 9% of total GHG emissions and decreased by 56% to 7.89 Gg of N_2O in 2014 (Figure 2.9). The two largest key sources causing this trend – 3.D.1 Direct N_2O Emissions from Managed Soils 60% and 3.B Manure Management at 19% of total N_2O emissions in 2014. The main reason for large N_2O emission cuts were reduction measures in the “nitric acid production” and decreasing agricultural activities (Figure 2.9).

Figure 2.9: *Absolute change of N_2O emissions by large key categories 1990 to 2014*



Fluorinated gas emissions account for 1.7% of total GHG emissions. In 2014, emissions were 571.33 Gg CO_2 equivalents, which was 45% above 1990 levels. The largest key source is 2.F.1 Refrigeration and Air Conditioning and accounts for 90% of fluorinated gas emissions in 2014. HFC emissions from the consumption of halocarbons showed large increases between 1990 and 2014. 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.

2.3.2 MAIN REASONS FOR EMISSION CHANGES IN 2013 – 2014

Total GHG emissions in the Slovak Republic significantly decreased by 5% in 2014 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 2013 – 2014 were as follows:

- CO_2 emissions decrease in energy industry (540 Gg of CO_2) caused by decrease in liquid, solid and also gaseous fuels and increase in biomass consumption.
- CO_2 emissions decrease in the transport category (150 Gg of CO_2) mainly caused by the higher efficiency of new cars and lower consumption of liquid fuels.
- CH_4 decrease in manure management caused by improvements in manure management systems.
- N_2O emissions decrease in the 2.G Other product manufacture of aerosols cans.
- Relative mild winter in 2013 – 2014.

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 -6 121.76 Gg of CO_2 equivalents in 2014 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 -4 633.25 Gg CO_2, Cropland with net removals of -802.82 Gg CO_2, Grassland with net removals of -184.65 Gg CO_2, Settlements with the emissions of 80.60 Gg CO_2 and Other Land with the emissions of 104.36 Gg CO_2. Total methane emissions were 0.69 Gg and total N_2O emissions were 0.09 Gg from LULUCF sector in 2014. 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 0.44 Gg and the estimated amount of CO emissions was 15.61 Gg in 2014 (Table 2.10).

Table 2.10: *Summary of total emissions and removals according to the categories in 2014*

CATEGORY		Net CO_2	CH_4	N_2O	NO_x	CO
	Emissions/Removals		Emissions			
	(Gg)					
5. LULUCF	**NO**	**-6 166.40**	**0.69**	**0.09**	**0.44**	**15.61**
A. Forest Land	NO	-4 633.25	0.69	0.04	0.44	15.61
B. Cropland	NO	-802.82	NO	0.03	NO	NO
C. Grassland	NO	-184.65	NO	0.001	NO	NO
D. Wetlands	NO	NO	NO	NO	NO	NO
E. Settlements	80.60	NO	NO	0.01	NO	NO
F. Other Land	104.36	NO	NO	0.01	NO	NO
G. HWP	NO	-730.64	NO	NO	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.

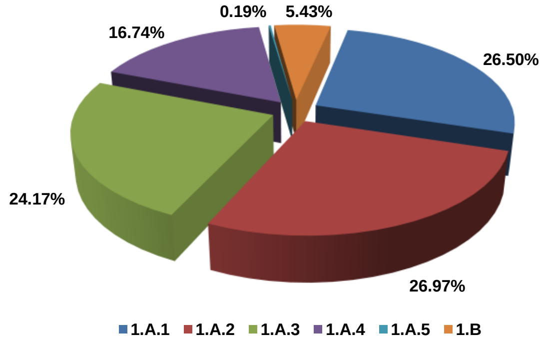
CHAPTER 3: ENERGY (CRF 1)

3.1 OVERVIEW OF THE SECTOR

Energy sector is the main contributor to overall GHG emissions with its share of 66.5% and 27 029.14 Gg of CO_2 equivalents in 2014. Within this sector, transport contributes 24% to the GHG emissions (in CO_2 equivalents). In addition to fuel combustion in the large and medium stationary sources of pollution, also the pollution from small sources of residential heating systems and fugitive methane emissions from transmission/transport/distribution, processing and storage of oil and natural gas contribute significantly to total GHG emissions.

Energy sector covers emissions from fossil fuel combustion (CRF 1.AA) and fugitive emissions from 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 from fuel combustion. Point sources, transport and other fuel combustion are included, too. The inventory of fugitive emissions from oil and natural gas includes CO_2, CH_4, N_2O and NMVOCs emissions from 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.

Figure 3.1: *The share of aggregated GHG emissions by categories within energy sector in 2014*



SECTOR 1: CATEGORY		CO_2 eq. (Gg)
1.A.1	Energy Industries	7 162.12
1.A.2	Manufacturing Industries and Construction	7 289.66
1.A.3	Transport	6 532.88
1.A.4	Other Sectors	4 523.64
1.A.5	Other (Not specified elsewhere)	52.70
1.B	Fugitive Emissions from Fuels	1 468.13

Figure 3.2: *Trend in aggregated emissions by categories within energy sector in 1990 – 2014 (in Gg of CO_2 eq.)*

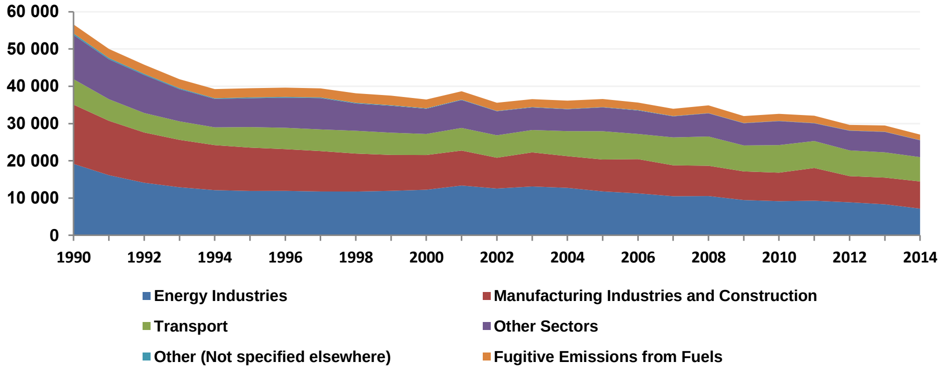


Table 3.1: GHG emissions by categories within Energy sector in 1990 – 2014

YEAR	CO_2 EMISSIONS			CH_4 EMISSIONS			N_2O EMISSIONS		
	(kt)								
	Energy	1.A	1.B	Energy	1.A	1.B	Energy	1.A	1.B
1990	53 377	53 353	24.18	116.92	21.38	95.54	0.91	0.91	0.000067
1991	46 863	46 839	24.79	116.76	20.55	96.21	0.79	0.79	0.000060
1992	42 682	42 656	25.29	116.03	18.86	97.16	0.69	0.69	0.000052
1993	38 901	38 876	24.12	112.18	16.45	95.74	0.64	0.64	0.000054
1994	36 278	36 253	25.13	111.34	14.39	96.95	0.61	0.61	0.000056
1995	36 482	36 456	26.41	112.11	14.55	97.56	0.62	0.62	0.000063
1996	36 597	36 570	27.22	113.80	15.60	98.19	0.63	0.63	0.000060
1997	36 505	36 477	27.46	109.56	13.71	95.85	0.63	0.63	0.000054
1998	35 122	35 095	27.15	112.42	11.44	100.98	0.61	0.61	0.000050
1999	34 494	34 466	27.40	112.55	11.04	101.51	0.59	0.59	0.000052
2000	33 661	33 636	25.18	104.12	11.30	92.82	0.60	0.60	0.000046
2001	35 949	35 924	25.04	100.80	12.33	88.48	0.64	0.64	0.000044
2002	33 017	32 992	25.34	95.25	8.73	86.52	0.59	0.59	0.000041
2003	34 039	34 012	26.31	93.42	9.26	84.16	0.58	0.58	0.000038
2004	33 504	33 478	26.13	98.30	10.40	87.90	0.61	0.61	0.000032
2005	33 928	33 905	23.24	98.31	12.53	85.78	0.66	0.66	0.000027
2006	33 164	33 144	20.05	90.91	11.60	79.31	0.63	0.63	0.000027
2007	31 589	31 570	18.57	87.47	10.49	76.98	0.61	0.61	0.000024
2008	32 190	32 170	20.86	99.15	16.88	82.27	0.70	0.70	0.000016
2009	29 779	29 756	22.56	81.93	8.78	73.15	0.59	0.59	0.000014
2010	30 336	30 314	21.21	83.95	8.93	75.02	0.55	0.55	0.000013
2011	29 751	29 731	20.05	86.79	8.99	77.80	0.59	0.59	0.000015
2012	27 737	27 718	19.05	69.02	9.91	59.11	0.58	0.58	0.000014
2013	27 424	27 404	19.63	75.12	9.43	65.69	0.58	0.58	0.000012
2014	25 175	25 147	27.65	67.15	9.53	57.62	0.59	0.59	0.000012

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 decrease interannual and 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 2014 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 72% in comparison with the base year 1990. The consumption of liquid fuels decreased more than 37% and the decline in gaseous fuels is 34%. By comparison, the consumption of biomass was 3.6 times higher in 2014 than in 1990. General trend in total consumption of fossil fuels is declining due to the increase in energy efficiency.

3.1.1 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 64% 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 25 521.06 Gg of CO_2 equivalents in 2014. The overview of sub-sectors and IPCC categories according to the IPCC 2006 Guidelines relevant for the Slovak Republic in sectoral approach is listed in the Table 3.2 below.

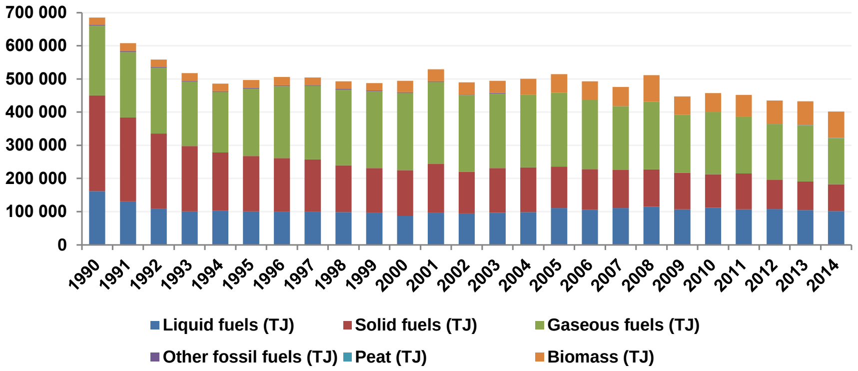
High level dependency on import of primary energy sources (PES) is a limiting factor for the energy sector and subsequently for the whole economic (mostly industrial) development in Slovakia. Net imports of PES are covered by almost 90%, together with nuclear fuel, from the Russian Federation as the 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, Slovenske elektrarne – a member of ENEL group was transformed and split up (http://www.seas.sk/en).

Since then, the Slovak electricity transmission system, Plc. (Slovenska elektrizacna prenosova sustava, 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).

Figure 3.3: *Trend in fuels consumption in TJ within 1.AA category in 1990 – 2014*



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. 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.

Table 3.2: *Reported emissions and methodological tiers in category 1.AA fuel combustion within energy sector in 2014*

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, charcoal production					
1.A.1.c.i	*Manufacture of solid fuels*	**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
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

CATEGORY		DESCRIPTION / EMISSIONS / METHODOLOGICAL TIERS					
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

Table 3.3: *GHG emissions by categories within category 1.AA Fuel combustion – sectoral approach in 1990 – 2014*

YEAR	1.A.1 ENERGY INDUSTRIES	1.A.2 MANUFACTURING INDUSTRIES AND CONSTRUCTION	1.A.3 TRANSPORT	1.A.4 OTHER SECTORS	1.A.5 OTHER (NOT SPECIFIED ELSEWHERE)
			CO_2 equivalent (kt)		
1990	19 161.17	15 890.35	6 838.13	11 855.35	414.56
1991	16 136.42	14 589.95	5 804.99	10 698.56	357.10
1992	14 105.54	13 491.46	5 231.91	10 200.54	304.48
1993	12 899.69	12 716.35	4 967.78	8 635.54	258.38
1994	12 121.35	12 085.77	4 769.33	7 621.88	197.74
1995	11 902.55	11 640.72	5 505.98	7 735.01	220.37
1996	11 929.23	11 200.83	5 733.38	8 065.77	218.51
1997	11 766.39	10 840.00	5 817.72	8 387.52	195.44
1998	11 748.24	10 192.07	6 117.64	7 319.31	185.85
1999	11 932.58	9 641.74	5 968.21	7 220.76	155.97
2000	12 228.44	9 313.75	5 656.02	6 765.87	132.31
2001	13 357.64	9 383.05	6 082.33	7 470.52	130.13
2002	12 559.69	8 264.10	6 015.92	6 456.81	88.42
2003	13 103.84	9 147.52	6 008.03	6 057.14	101.69
2004	12 738.42	8 504.24	6 724.02	5 863.76	88.38
2005	11 784.12	8 556.54	7 592.55	6 401.84	78.51
2006	11 259.31	9 184.51	6 761.12	6 301.45	114.96
2007	10 487.51	8 298.27	7 496.93	5 641.87	88.23
2008	10 541.93	8 122.15	7 849.88	6 230.64	56.57
2009	9 461.26	7 693.36	6 964.28	5 963.51	68.34
2010	9 164.10	7 645.83	7 406.85	6 428.84	55.63
2011	9 280.45	8 788.82	7 232.62	4 759.90	68.10
2012	8 860.34	7 024.82	6 903.46	5 282.71	66.86
2013	8 321.90	7 166.20	6 774.22	5 495.18	54.77
2014	7 162.12	7 289.66	6 532.88	4 523.64	52.70

3.1.2 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 previous submission. More information can be found in the Chapter 3.3.1 of this Report.

In 2014, total aggregated fugitive emissions in the category 1.B represented 1 468.13 Gg of CO_2 equivalents. 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 important because of the Slovak Republic is an important transit country for pipelines from east 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.

Fugitive methane emissions in the period 1990 – 2014 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.), and the Ministry of Economy of the Slovak Republic. According to the IPCC 2006 Guidelines, the following subcategories are relevant for national inventory within 1.B.

Table 3.4: *Reported emissions and methodological tiers in category 1.B within energy sector in 2014*

CATEGORY		DESCRIPTION / EMISSIONS / METHODOLOGICAL TIERS					
1.B.1	**Solid fuels**						
1.B.1.a	Coal mining and handling						
1.B.1.a.1	*Underground mines*						
1.B.1.a.1.i	*Mining activities*	underground mines for brown coal					
		CO_2	T1	**CH_4**	T2		
1.B.1.a.1.ii	*Post-mining activities*	brown coal processing					
				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

According to the several recommendations of the ERT during previous in-country reviews under UNFCCC in 2009 and 2011, the estimation of CH_4 fugitive emissions completed the estimation of CO_2 and N_2O fugitive emissions.

Table 3.5: *GHG emissions by categories within category 1.B.1 Solid fuels in 1990 – 2014*

YEAR	1.B.1.a COAL MINING AND HANDLING			1.B.1.b SOLID FUEL TRANSFORMATION
	1.B.1.a.1.i Mining activities		1.B.1.a.1.ii Post-mining activities	
	CO_2	CH_4	CH_4	CH_4
	Gg			
1990	19.0080	25.1137	2.0840	NO
1991	20.1465	26.6179	2.2088	NO
1992	21.1882	27.6388	2.2935	NO
1993	19.8965	26.4327	2.1794	0.0900
1994	20.7643	27.6538	2.2581	0.0900
1995	21.5416	27.4374	2.2667	0.0900
1996	22.5552	27.7602	2.3156	0.0900
1997	23.1881	28.2527	2.3603	0.0900
1998	23.1166	28.7852	2.3825	0.0900
1999	23.2650	27.2007	2.2953	0.1200
2000	21.5125	26.6203	2.2005	0.1500
2001	21.4451	24.2654	2.0647	0.1800
2002	21.9580	23.6430	2.0508	1.2300
2003	23.1564	19.2597	1.8544	1.3500
2004	23.3571	17.9926	1.7800	1.3800
2005	20.7805	14.6584	1.5142	1.4400
2006	17.6030	13.3405	1.3304	2.4900
2007	16.3849	12.2732	1.2449	2.5200
2008	19.1687	14.7035	1.4611	2.5500
2009	21.0704	15.3731	1.5509	2.4000
2010	19.7399	13.8616	1.4337	0.0906
2011	18.4591	14.7941	1.4327	0.1269
2012	17.6260	14.5817	1.3822	0.1290
2013	18.2808	14.7722	1.4187	0.1200
2014	26.4191	13.9029	1.3192	0.1260

Table 3.6: *GHG emissions by categories within category 1.B.2 Oil and natural gas and other emissions from energy production in 1990 – 2014*

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
1991	0.0252	0.5384	0.5093	43.2395	0.0068	0.0515	0.2282	23.5520
1992	0.0226	0.4742	0.4964	43.1585	0.0058	0.0443	0.2282	23.5520
1993	0.0239	0.4882	0.4808	42.9443	0.0063	0.0479	0.2282	23.5520
1994	0.0241	0.5125	0.4841	42.8306	0.0064	0.0484	0.2282	23.5520
1995	0.0254	0.5469	0.5338	43.6110	0.0071	0.0535	0.2282	23.5520
1996	0.0247	0.5398	0.5389	43.8817	0.0068	0.0514	0.2282	23.5520
1997	0.0221	0.5087	0.5312	42.1871	0.0061	0.0461	0.2170	22.4000
1998	0.0210	0.4993	0.5303	44.9526	0.0057	0.0432	0.2347	24.2240
1999	0.0223	0.5163	0.5171	46.2084	0.0063	0.0475	0.2434	25.1200
2000	0.0199	0.4857	0.4939	41.3668	0.0056	0.0425	0.2127	21.9520

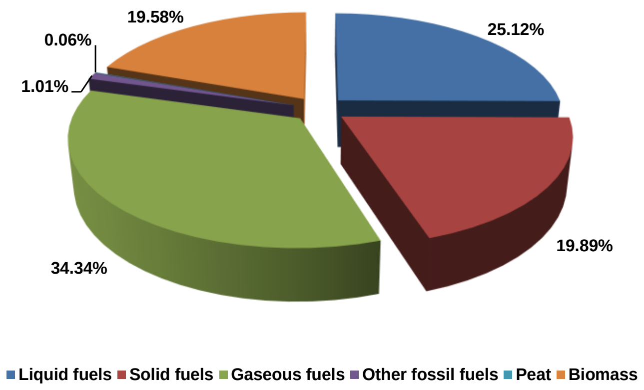
YEAR	1.B.2.a OIL		1.B.2.b NATURAL GAS		1.B.2.c.1 VENTING			
					1.B.2.c.1.i Oil		1.B.2.c.1.ii Gas	
	CO_2	CH_4	CO_2	CH_4	CO_2	CH_4	CO_2	CH_4
	Gg							
2001	0.0190	0.4750	0.5258	40.4936	0.0052	0.0396	0.2030	20.9558
2002	0.0181	0.4685	0.4965	38.8829	0.0049	0.0374	0.1958	20.2093
2003	0.0158	0.4367	0.5104	40.1392	0.0040	0.0302	0.2043	21.0870
2004	0.0149	0.4268	0.4733	42.9582	0.0036	0.0274	0.2261	23.3379
2005	0.0133	0.3987	0.5015	44.1017	0.0029	0.0223	0.2291	23.6480
2006	0.0127	0.3923	0.4907	40.3555	0.0027	0.0202	0.2072	21.3837
2007	0.0125	0.4024	0.4271	39.2163	0.0027	0.0202	0.2064	21.3014
2008	0.0099	0.3621	0.4221	40.8037	0.0017	0.0130	0.2168	22.3789
2009	0.0091	0.3454	0.3686	34.5966	0.0014	0.0108	0.1828	18.8685
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	0.2859	27.0764	0.0011	0.0086	0.1442	14.8800

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	0.000047	1.3320	0.0009	0.000020
1991	2.9322	0.0018	0.000046	0.9420	0.0006	0.000014
1992	2.5221	0.0015	0.000039	0.8310	0.0005	0.000013
1993	2.7265	0.0017	0.000043	0.7620	0.0005	0.000012
1994	2.7556	0.0017	0.000043	0.8670	0.0006	0.000013
1995	3.0441	0.0019	0.000048	1.0320	0.0007	0.000016
1996	2.9245	0.0018	0.000046	0.9420	0.0006	0.000014
1997	2.6240	0.0016	0.000041	0.8670	0.0006	0.000013
1998	2.4600	0.0015	0.000038	0.7800	0.0005	0.000012
1999	2.7060	0.0017	0.000042	0.6390	0.0004	0.000010
2000	2.4190	0.0015	0.000038	0.5190	0.0003	0.000008
2001	2.2550	0.0014	0.000035	0.5880	0.0004	0.000009
2002	2.1320	0.0013	0.000033	0.5310	0.0003	0.000008
2003	1.7220	0.0011	0.000027	0.7020	0.0005	0.000011
2004	1.5580	0.0010	0.000024	0.4950	0.0003	0.000008
2005	1.2710	0.0008	0.000020	0.4410	0.0003	0.000007
2006	1.1480	0.0007	0.000018	0.5820	0.0004	0.000009
2007	1.1480	0.0007	0.000018	0.3840	0.0003	0.000006
2008	0.7380	0.0005	0.000012	0.3060	0.0002	0.000005
2009	0.6150	0.0004	0.000010	0.3090	0.0002	0.000005
2010	0.5330	0.0003	0.000008	0.3120	0.0002	0.000005
2011	0.6150	0.0004	0.000010	0.3630	0.0002	0.000006
2012	0.4510	0.0003	0.000007	0.4500	0.0003	0.000007
2013	0.4100	0.0003	0.000006	0.3720	0.0002	0.000006
2014	0.4920	0.0003	0.000008	0.3000	0.0002	0.000005

3.2 FUEL COMBUSTION (CRF 1.AA)

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). The GHG emissions according to the relevant subcategories in 1990 – 2014 are presented in Table 3.7.

Figure 3.4: *The share of consumption of different fuels within category 1.AA Fuel combustion in 2014*



1.AA FUEL COMBUSTION	(TJ)
Liquid fuels	101 850.62
Solid fuels	80 668.54
Gaseous fuels	139 266.98
Other fossil fuels	4 092.37
Peat	256.32
Biomass	79 388.12
Total	**405 522.95**

Table 3.7: *GHG emissions by categories within category 1.AA Fuels combustion – sectoral approach in 1990 – 2014*

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	14 960.42	2 881.44	1 319.32	2 689.97	1 262.24	2 636.38
1991	12 656.47	2 163.73	1 316.23	2 376.83	1 067.04	2 987.48
1992	11 060.05	1 732.35	1 313.14	2 247.04	899.00	3 126.12
1993	9 886.90	1 702.74	1 310.05	2 311.35	755.70	3 186.70
1994	8 844.29	1 970.10	1 306.96	2 380.70	635.00	3 202.17
1995	8 564.19	2 034.49	1 303.87	2 454.58	534.77	3 041.57
1996	8 508.82	2 119.62	1 300.79	2 532.47	452.87	2 840.69
1997	8 368.76	2 099.92	1 297.70	2 621.48	387.17	2 576.32
1998	8 374.26	2 079.37	1 294.61	2 698.23	335.53	2 228.61
1999	8 558.00	2 083.06	1 291.52	2 785.08	295.83	1 940.82
2000	9 044.69	1 934.78	1 248.97	2 782.68	287.52	1 641.42
2001	10 028.09	2 132.48	1 197.08	3 082.26	277.67	1 444.85
2002	9 319.87	1 975.00	1 264.82	2 943.51	278.88	738.46
2003	9 808.49	1 937.44	1 357.91	3 331.07	242.61	742.40
2004	9 688.30	1 826.62	1 223.50	3 175.17	198.91	767.14
2005	8 699.89	1 735.36	1 348.87	3 398.16	188.49	854.31
2006	8 052.46	1 844.68	1 362.17	3 923.45	186.60	676.14
2007	7 377.52	1 734.21	1 375.78	3 402.49	174.17	752.76
2008	7 453.50	1 821.50	1 266.93	3 593.72	187.45	720.27
2009	6 533.62	1 724.87	1 202.77	3 648.17	158.20	613.38
2010	6 254.84	1 600.65	1 308.62	3 752.86	199.52	542.48
2011	6 414.62	1 588.65	1 277.18	4 787.85	247.28	574.43

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.					
2012	6 121.69	1 463.39	1 275.27	3 363.26	226.87	538.44
2013	5 662.15	1 473.31	1 186.44	3 182.86	187.65	555.31
2014	4 692.15	1 218.92	1 251.05	3 197.09	150.11	503.05

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	8.00	4 588.64	425.76
1991	2 039.59	1 043.83	2 759.01	2 316.16	7.44	3 893.64	320.27
1992	1 779.61	956.71	2 355.59	2 127.38	6.88	3 612.42	264.23
1993	1 557.94	881.45	2 033.03	1 990.18	6.69	3 621.76	226.85
1994	1 371.01	816.80	1 782.61	1 897.47	5.68	3 880.32	214.04
1995	1 215.24	761.53	1 695.28	1 937.75	5.67	4 114.55	230.51
1996	1 087.08	714.39	1 612.78	1 960.55	6.65	4 171.84	226.21
1997	1 034.67	697.02	1 562.56	1 960.77	5.89	4 355.22	212.57
1998	899.26	639.54	1 463.52	1 927.38	5.41	4 655.34	194.99
1999	832.47	609.35	1 312.96	1 865.22	5.49	4 555.50	178.49
2000	705.41	570.10	1 403.41	1 923.21	5.69	4 068.18	175.92
2001	619.16	560.46	1 364.75	2 033.90	5.41	4 631.43	173.51
2002	644.27	551.95	1 251.16	1 855.88	5.64	4 770.50	161.17
2003	615.12	496.67	1 649.09	2 070.56	7.23	4 911.38	128.90
2004	556.58	479.65	1 464.94	1 861.84	9.38	5 172.38	123.63
2005	548.88	436.91	1 389.92	1 739.86	8.87	6 133.95	120.45
2006	544.22	417.50	1 624.52	1 812.08	11.33	5 717.88	127.91
2007	509.49	359.92	1 418.28	1 681.17	13.71	6 318.67	118.41
2008	541.35	335.62	1 289.04	1 454.71	16.17	6 526.07	108.05
2009	648.28	304.23	1 163.48	1 157.61	11.86	5 994.32	92.77
2010	421.01	306.53	1 181.91	1 241.51	5.56	6 480.91	94.71
2011	403.28	312.56	1 223.31	1 240.09	4.69	6 225.50	90.80
2012	329.10	296.35	1 152.21	1 118.58	4.45	6 415.48	77.07
2013	447.39	310.14	1 244.84	1 238.02	3.80	6 189.77	94.42
2014	500.04	326.87	1 381.43	1 231.08	4.32	6 255.13	88.81

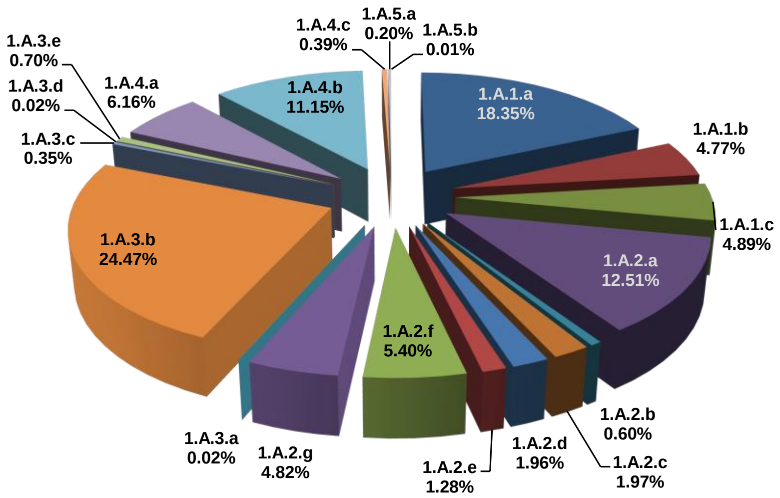
YEAR	1.A.3 TRANSPORT		1.A.4 OTHER SECTORS			1.A.5 OTHER	
	1.A.3.d	1.A.3.e	1.A.4.a	1.A.4.b	1.A.4.c	1.A.5.a	1.A.5.b
	Gg of CO_2 eq.						
1990	0.03	1 815.70	4 166.53	7 643.24	45.58	407.31	7.25
1991	0.02	1 583.63	3 720.00	6 935.65	42.91	350.89	6.21
1992	0.02	1 348.37	3 328.00	6 829.34	43.20	299.22	5.27
1993	0.02	1 112.46	3 039.84	5 549.53	46.18	252.05	6.33

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.						
1994	0.02	669.27	2 698.18	4 872.26	51.44	191.32	6.42
1995	0.02	1 155.23	2 433.72	5 242.74	58.55	213.73	6.64
1996	0.02	1 328.65	2 188.61	5 810.06	67.10	212.76	5.75
1997	0.03	1 244.02	2 724.65	5 586.22	76.65	192.63	2.81
1998	0.03	1 261.87	2 132.31	5 100.21	86.79	183.75	2.10
1999	0.03	1 228.70	1 899.97	5 223.70	97.10	154.59	1.38
2000	0.03	1 406.21	1 569.94	5 091.06	104.87	130.57	1.74
2001	0.03	1 271.95	1 618.90	5 735.86	115.76	127.44	2.69
2002	0.03	1 078.58	1 813.13	4 523.44	120.25	85.68	2.74
2003	0.03	960.49	1 367.02	4 586.87	103.25	100.05	1.64
2004	0.03	1 418.60	1 516.49	4 233.73	113.54	86.79	1.60
2005	0.04	1 329.25	2 259.35	4 022.11	120.38	76.58	1.93
2006	0.36	903.64	2 507.70	3 684.48	109.26	113.04	1.92
2007	0.38	1 045.75	2 454.17	3 097.71	89.99	85.74	2.49
2008	0.40	1 199.19	2 554.32	3 573.11	103.21	54.43	2.15
2009	0.37	864.97	2 598.48	3 265.39	99.64	66.75	1.59
2010	0.37	825.29	2 571.58	3 748.18	109.08	54.04	1.59
2011	0.95	910.68	1 566.33	3 100.91	92.66	66.45	1.64
2012	1.26	405.20	1 871.54	3 323.30	87.87	65.38	1.48
2013	3.91	482.32	2 102.97	3 287.37	104.83	53.33	1.44
2014	5.02	179.61	1 573.74	2 850.75	99.16	51.30	1.40

The share of fuels on total fuel consumption in energy sector within subsectors 1.AA.1, 1.AA.2, 1.AA.4 and 1.AA.5 was almost 74% in 2014. The highest share represents subcategory 1.AA.1.a – Public electricity and heat production followed by the subcategory 1.AA.2.a – Iron and steel and subcategory 1.AA.4.b – Residential. Detailed emission trends by subcategories are presented in Table 3.7. According to the detail analyses of the subcategories, the major share of emissions has subcategory 1.AA.1.a – Electricity and heat production (18.4%), followed by the subcategories 1.AA.2.a (12.5%) and 1.AA.4.b with the share of 11.2%. The category 1.AA.4.a – Commercial/Institutional represents 6.2% and the subcategory 1.AA.2.f Other represents 5.4% share on total GHG emissions in 1.AA. Transport was not included in this comparison, but the road transportation is the most important key source 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 – 2014. 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.

The Figure 3.5 shows the shares of emissions on all subcategories within category fuel combustion 1.AA.

Figure 3.5: *The share of emissions in CO_2 eq. on different subcategories within 1.AA in 2014*



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 sources 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. These categories are not key sources. For emission uncertainty assessment AD, caloric value, EFs and their uncertainties are available in the energy sector.

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

From expert analysis, the predetermined values for uncertainty are known. It helps us verify the rightness of computation of aggregated uncertainty. From the background data structure, the differences between the tier 1 and tier 2 methods for uncertainty estimation are concentrated to the correlation among inputs parameters. In our methodology, the tier 2 method is computed without direct correlation dependency; therefore tier 1 and tier 2 are well comparable despite of using the nonsymetric distributions for some activity data or emissions factors. Tier 2 method offers more reliable statistical results; it shows more information about statistical structure of analysed uncertainty. With tier 2 approach the category's uncertainty is constructed by Monte Carlo method and consecutive aggregate uncertainty is computed for energy sector – sectoral approach, combustion of fuel from 1.A.1, 1.A.2, 1.A.4 and 1.A.5. 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.

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

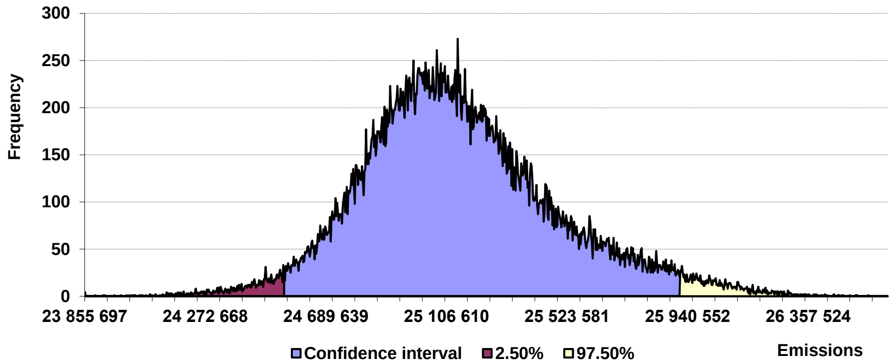
where Z represents the number of source inputs. The results for every category are generated from 60 000 trials, with random number generator of random numbers for adequate PDF.

From presented results obtained by Monte Carlo simulation (60 000 trials) it seems that the average value is 25 151 Gg of CO_2 while the estimated value is 25 147 Gg of CO_2 in 2014. Confidence interval (95%) is within the range: <23 856; 26 636>, which represents the uncertainty by relative values to the mean value: -2.32%; +3.04%. The following tables and graphs described calculated results of uncertainty analyses.

Table 3.8: *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
25 114.195	**25 150.539**	335.025	23 855.697	26 635.504	-2.32%	3.04%

Figure 3.6: *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 3.9: *Comparison of tier 2 and tier 1 (without CO_2 storage), emissions are in Gg per year*

APPROACH	ENERGY	1.A.1.a	1.A.1.b	1.A.1.c	1.A.2.a
Tier 2	25 110.6019	4 633.9495	1 216.4624	1 250.8068	3 189.4574
Tier 1	25 105.7642	4 632.4145	1 216.3978	1 250.6609	3 188.8604
Deviation Tier 2-Tier 1	4.8377	1.5350	0.0646	0.1459	0.5970

APPROACH	1.A.2.b	1.A.2.c	1.A.2.d	1.A.2.e	1.A.2.f
Tier 2	148.2657	501.9729	479.7900	326.4211	1 366.3069
Tier 1	148.2544	501.8660	479.6968	326.3014	1 366.2573
Deviation Tier 2-Tier 1	0.0112	0.1069	0.0932	0.1197	0.0496

APPROACH	1.A.2.g	1.A.3.a	1.A.3.b	1.A.3.c	1.A.3.d
Tier 2	1 224.4487	4.1706	6 147.6421	77.9217	4.4725
Tier 1	1 224.2016	4.1706	6 147.0087	77.9401	4.4736
Deviation Tier 2-Tier 1	0.2471	0.0000	0.6333	-0.0184	-0.0011

APPROACH	1.A.3.e	1.A.4.a	1.A.4.b	1.A.4.c	1.A.5
Tier 2	177.7634	1 560.9953	2 652.1070	95.6846	51.9635
Tier 1	177.7807	1 560.6235	2 651.2337	95.6683	51.9540
Deviation Tier 2-Tier 1	-0.0172	0.3718	0.8733	0.0163	0.0095

3.2.2 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 Statistical Office of the SR. A close cooperation of the NIS and the Statistical Office 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 sections 3.2.5 – 3.2.9 of this chapter.

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 2016 submission, time series consistency was improved and transparency increased. A difference between CO_2 emissions allocated in reference and sectoral approach was 0.815% in 2014. A difference in the total energy consumption was -1.008% in 2014.

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 Statistical Office of the Slovak Republic, 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 3.10 – 3.14. 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.

The information on the emission factors used in sectoral approach are presented in the sections 3.2.5 – 3.2.9 of this chapter. 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 – 2014 appeared. The balance of solid fuels consumption is complicated due to the calculation of the stock change. The Statistical Office of the Slovak Republic updates the fuel categories and methodology for stock fuel, annually.

Figure 3.7: *The difference between reference and sectoral approaches CO_2 emissions (in Gg) in 1990 – 2014*

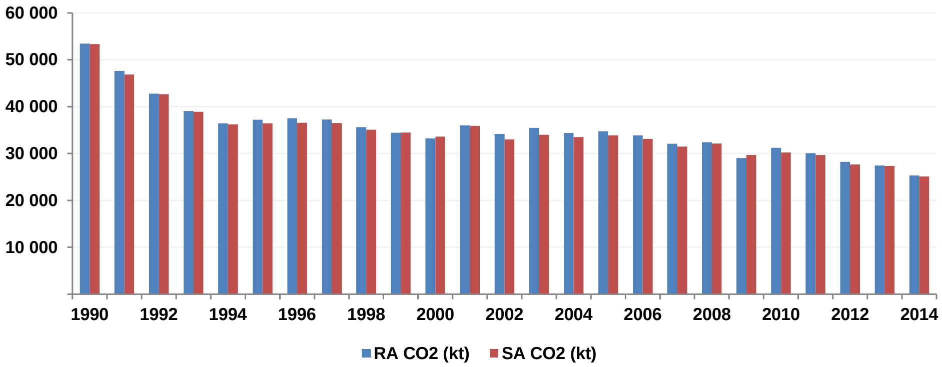


Table 3.10: *The comparison of RA and SA in total fuels consumption and CO_2 emissions in 1990 – 2014*

TOTAL FUELS							
YEAR	RA	SA	Apparent energy consumption	Energy consumption difference	RA	SA	Difference
	(PJ)	(PJ)	(PJ)	%	CO_2 (Gg)	CO_2 (Gg)	%
1990	764	663	650	-1.98	53 458	53 353	0.20
1991	677	584	583	-0.05	47 593	46 839	1.61
1992	625	537	533	-0.67	42 743	42 656	0.20
1993	587	494	489	-1.01	39 074	38 876	0.51
1994	561	463	457	-1.31	36 441	36 253	0.52
1995	591	474	481	1.54	37 194	36 456	2.03
1996	599	480	489	1.78	37 536	36 570	2.64
1997	599	481	490	1.84	37 265	36 477	2.16
1998	582	470	468	-0.37	35 623	35 095	1.50
1999	566	465	455	-2.23	34 420	34 466	-0.13
2000	545	460	448	-2.61	33 228	33 636	-1.21
2001	575	493	491	-0.39	36 030	35 924	0.29
2002	561	453	453	-0.04	34 160	32 992	3.54
2003	566	458	460	0.37	35 474	34 012	4.30
2004	554	454	441	-2.90	34 353	33 478	2.62
2005	565	460	458	-0.28	34 753	33 905	2.50
2006	549	438	436	-0.46	33 879	33 144	2.22
2007	529	420	416	-0.98	32 073	31 570	1.59
2008	531	433	424	-2.15	32 397	32 170	0.71
2009	481	394	377	-4.31	29 038	29 756	-2.42
2010	513	403	408	1.38	31 236	30 314	3.04
2011	490	390	388	-0.46	30 096	29 731	1.23
2012	464	367	365	-0.72	28 240	27 718	1.88
2013	464	364	360	-0.95	27 449	27 404	0.16
2014	424	326	323	-1.01	25 352	25 147	0.81

Table 3.11: *The comparison of RA and SA in liquid fuels consumption and CO_2 emissions in 1990 – 2014*

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	162	155	-4.44	11 624	12 096	-3.91
1991	168	131	137	4.45	10 168	9 748	4.32
1992	149	110	109	-0.32	8 319	8 202	1.43
1993	122	101	91	-10.25	6 929	7 523	-7.90
1994	134	103	99	-3.41	7 486	7 671	-2.42
1995	145	101	107	5.98	7 930	7 511	5.58
1996	143	99	105	5.99	8 039	7 366	9.14
1997	150	99	114	14.97	8 671	7 379	17.52
1998	146	98	105	6.53	8 031	7 318	9.74
1999	132	96	94	-2.28	7 176	7 088	1.25
2000	122	87	86	-0.37	6 504	6 425	1.23
2001	128	96	101	5.29	7 731	7 100	8.88
2002	135	95	105	11.18	8 140	6 999	16.31
2003	134	97	106	9.80	8 321	7 162	16.17
2004	134	98	103	4.93	8 127	7 270	11.80
2005	139	111	109	-2.08	8 517	8 214	3.69
2006	138	106	109	3.51	8 584	7 828	9.66
2007	143	111	110	-0.43	8 634	8 180	5.56
2008	147	115	117	1.79	9 108	8 498	7.17
2009	136	107	106	-1.24	8 215	7 918	3.75
2010	144	111	115	3.42	8 896	8 233	8.06
2011	141	107	111	4.43	8 618	7 889	9.24
2012	134	108	113	4.76	8 709	7 954	9.50
2013	129	105	107	2.53	8 045	7 742	3.91
2014	125	102	104	2.59	7 891	7 524	4.87

Table 3.82: *The comparison of RA and SA in solid fuels consumption and CO_2 emissions in 1990 – 2014*

SOLID FUELS							
YEAR	RA	SA	Apparent energy consumption	Energy consumption difference	RA	SA	Difference
	(PJ)	(PJ)	(PJ)	%	CO_2 (Gg)	CO_2 (Gg)	%
1990	343	288	287	-0.45	29 979	29 277	2.40
1991	296	253	250	-1.12	26 272	25 812	1.78
1992	262	226	225	-0.48	23 174	23 124	0.22
1993	256	197	200	1.77	20 970	20 333	3.13
1994	228	175	173	-1.23	18 595	18 242	1.94
1995	226	167	170	1.98	17 796	17 402	2.27
1996	224	162	168	3.47	17 431	17 002	2.52
1997	213	158	157	-1.15	16 360	16 660	-1.80
1998	196	142	139	-1.90	15 065	14 971	0.62
1999	191	135	134	-1.28	14 580	14 381	1.39
2000	179	138	135	-2.37	14 125	14 235	-0.77
2001	186	147	145	-1.70	14 646	15 086	-2.92
2002	177	126	116	-7.43	13 152	13 184	-0.24

SOLID FUELS							
YEAR	RA	SA	Apparent energy consumption	Energy consumption difference	RA	SA	Difference
	(PJ)	(PJ)	(PJ)	%	CO_2 (Gg)	CO_2 (Gg)	%
2003	191	134	129	-4.14	14 677	14 362	2.19
2004	189	135	125	-7.15	14 420	14 087	2.37
2005	178	125	123	-1.63	13 556	13 334	1.66
2006	185	123	119	-3.12	13 669	13 729	-0.43
2007	173	115	111	-3.68	12 546	12 670	-0.98
2008	168	112	108	-3.52	12 214	12 319	-0.86
2009	159	110	103	-6.14	11 410	12 052	-5.33
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

Table 3.13: *The comparison of RA and SA in gaseous fuels consumption and CO_2 emissions in 1990 – 2014*

GASEOUS FUELS							
YEAR	RA	SA	Apparent energy consumption	Energy consumption difference	RA	SA	Difference
	(PJ)	(PJ)	(PJ)	%	CO_2 (Gg)	CO_2 (Gg)	%
1990	224	210	208	-0.91	11 830	11 780	0.42
1991	213	197	196	-0.30	11 133	11 086	0.42
1992	214	198	199	0.23	11 232	11 143	0.80
1993	208	193	198	2.17	11 120	10 835	2.63
1994	199	182	184	0.92	10 298	10 167	1.29
1995	221	204	204	-0.05	11 400	11 379	0.18
1996	233	216	215	-0.57	11 992	12 044	-0.43
1997	236	221	219	-1.13	12 153	12 284	-1.06
1998	240	228	224	-1.69	12 441	12 652	-1.67
1999	243	232	227	-2.16	12 570	12 852	-2.19
2000	244	233	226	-2.93	12 507	12 817	-2.42
2001	261	247	243	-1.70	13 438	13 600	-1.19
2002	248	231	230	-0.28	12 700	12 669	0.24
2003	241	225	223	-0.72	12 331	12 356	-0.20
2004	230	219	211	-3.76	11 619	12 001	-3.18
2005	247	223	225	1.18	12 442	12 237	1.67
2006	226	208	206	-1.02	11 386	11 448	-0.55
2007	213	192	193	0.28	10 634	10 554	0.75
2008	216	204	197	-3.56	10 819	11 167	-3.12
2009	186	174	166	-4.79	9 166	9 578	-4.30
2010	210	187	192	2.87	10 659	10 310	3.39
2011	194	172	171	-0.21	9 494	9 464	0.31
2012	183	167	161	-3.92	8 933	9 250	-3.43
2013	191	169	166	-1.86	9 207	9 382	-1.87
2014	158	139	137	-1.78	7 662	7 761	-1.28

Table 3.14: *The comparison of RA and SA in other fossil fuels consumption and CO_2 emissions in 1990 – 2014*

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	2.90	0.18	-93.83	26	200	-87.17
1991	0.14	2.81	0.14	-94.96	20	193	-89.53
1992	0.13	2.73	0.13	-95.22	19	188	-90.08
1993	0.39	2.68	0.39	-85.60	55	185	-70.21
1994	0.43	2.51	0.43	-82.85	62	173	-64.43
1995	0.48	2.39	0.48	-80.06	68	164	-58.62
1996	0.52	2.29	0.52	-77.23	74	158	-52.79
1997	0.56	2.24	0.56	-74.80	81	155	-47.87
1998	0.61	2.21	0.61	-72.39	87	154	-43.30
1999	0.65	2.10	0.65	-68.84	94	146	-36.06
2000	0.64	2.23	0.64	-71.33	91	159	-42.46
2001	1.66	1.94	1.66	-14.46	215	137	56.34
2002	1.20	1.96	1.20	-38.81	168	140	19.95
2003	1.18	1.81	1.18	-35.01	146	132	10.24
2004	1.48	1.62	1.48	-8.48	186	120	54.81
2005	1.89	1.47	1.89	28.35	238	119	100.11
2006	1.94	1.70	1.94	13.78	239	140	71.42
2007	2.05	2.00	2.05	2.47	259	165	56.42
2008	2.06	2.22	2.06	-7.31	257	185	38.90
2009	1.97	2.50	1.97	-21.09	246	208	18.28
2010	1.53	2.59	1.53	-41.03	188	220	-14.61
2011	1.59	2.86	1.59	-44.33	199	243	-17.97
2012	1.65	3.28	1.65	-49.64	209	281	-25.64
2013	3.51	3.42	3.51	2.75	482	291	65.59
2014	4.23	4.09	4.23	3.26	551	347	58.88

3.2.3 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.

3.2.3.1 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. 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 – 2014 were used EUROCONTROL data on the number of flights, 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 and the expert estimation of the share in total national fuels. In 2014, the emissions in the international civil aviation represented 122.19 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 national civil aviation and is described in the section 3.2.7.2 of this chapter.

The Slovak Republic has used a tier 1 methodology based on fuel sold, both for aviation gasoline and jet kerosene for 1990 – 2004. Based on the expert estimation and after consultation with the airports, 90% of total jet kerosene sold was allocated in the international aviation and the opposite ratio was used for the consumption of aviation gasoline (10% allocated in international flights). The emission factors used for jet kerosene and aviation gasoline are provided in the section 3.2.7.2 of this chapter.

For time series 2005 – 2014 were used EUROCONTROL data on the number of flights, fuel consumption and division of domestic and international flights. The decision follows an analysis of the national data and data obtained from EUROCONTROL and the approval by the Ministry of Transport, Construction and Regional Development of the Slovak Republic. The data are available on the basis of work of the EEA in collaboration with EUROCONTROL and DG CLIMA. These aggregated national fuel and emissions data are calculated by EUROCONTROL using a TIER 3 methodology applying the Advanced Emissions Model (AEM). Considering the comparison between EUROCONTROL and national data on fuel consumption, emissions and implied emission factors, the following data were taken from EUROCONTROL file to the inventory:

- 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 emissions for all subcategories

The CH_4 and N_2O emissions for all subcategories were calculated separately by using corresponding national EF and fuel consumption taken from EUROCONTROL file for the years 2005 – 2014. Details of EF are in table 3.38. Net Calorific Value for Aviation Gasoline is 43.14 TJ/Gg and for Jet Kerosene 43.30 TJ/Gg. The converters were taken from EUROCONTROL file. For the years 1990 – 2004, we did not received better and more accurate data and that is why we did not recalculated these years. Total consumption of jet kerosene were 38 353.60 t and the total consumption of aviation gasoline were 43.60 t in international flights in 2014.

The overview of the aviation fuels consumption according to the type (aviation gasoline and jet kerosene) during 1990 – 2014 is presented in the Table 3.15. In the period 1994 – 2004, data are directly from the airports´ statistics and were provided annually. Information provided in the period 1990 – 1993 are based on expert estimation according to the real LTO cycles in this period. From 2005 to 2014 the fuel consumption and CO_2 emissions data are taken from EUROCONTROL file and CH_4 and N_2O emissions data are estimated by using national emission factors.

Table 3.9: *Fuels consumption and GHG emissions in international flights in 1990 – 2014*

YEAR	AVIATION GASOLINE					JET KEROSENE				
	Consumption		Emissions (t)			Consumption		Emissions (t)		
	(TJ)	(t)	CO_2	CH_4	N_2O	(TJ)	(t)	CO_2	CH_4	N_2O
1990	1.11	25.90	81.60	0.049	0.003	862.70	20 007.00	63 022.10	1.00	2.08
1991	1.03	24.05	75.80	0.046	0.002	802.16	18 603.00	58 599.50	0.93	1.94
1992	0.95	22.20	69.90	0.042	0.002	741.62	17 199.00	54 176.90	0.86	1.79
1993	0.87	20.35	64.10	0.039	0.002	726.49	16 848.00	53 071.20	0.84	1.75
1994	0.80	18.59	58.60	0.035	0.002	612.13	14 195.85	44 716.90	0.71	1.48
1995	0.73	17.14	54.00	0.033	0.002	615.85	14 282.23	44 989.00	0.71	1.49
1996	0.80	18.62	58.70	0.035	0.002	726.86	16 856.76	53 098.80	0.84	1.75
1997	0.71	16.55	52.10	0.031	0.002	643.77	14 929.80	47 028.90	0.75	1.55
1998	0.63	14.64	46.10	0.028	0.001	593.62	13 766.62	43 364.90	0.69	1.43

YEAR	AVIATION GASOLINE					JET KEROSENE				
	Consumption		Emissions (t)			Consumption		Emissions (t)		
	(TJ)	(t)	CO_2	CH_4	N_2O	(TJ)	(t)	CO_2	CH_4	N_2O
1999	0.67	15.66	49.30	0.030	0.002	598.96	13 890.60	43 755.40	0.70	1.45
2000	0.85	19.75	62.20	0.038	0.002	608.45	14 110.69	44 448.70	0.71	1.47
2001	0.88	20.61	64.90	0.039	0.002	572.18	13 269.57	41 799.20	0.66	1.38
2002	0.95	22.28	70.20	0.042	0.002	594.01	13 840.34	43 393.70	0.69	1.43
2003	0.92	21.56	67.90	0.041	0.002	785.58	18 218.41	57 388.00	0.91	1.90
2004	0.67	15.65	49.30	0.030	0.002	1 062.70	24 645.09	77 632.00	1.23	2.56
2005	2.60	60.22	183.67	0.114	0.006	1 941.93	44 848.32	141 272.21	2.24	4.66
2006	2.88	66.70	203.42	0.127	0.007	2 323.37	53 657.58	169 021.38	2.68	5.58
2007	2.97	68.86	210.03	0.131	0.007	2 429.50	56 108.66	176 742.25	2.81	5.84
2008	3.61	83.79	255.55	0.159	0.008	2 719.22	62 799.62	197 818.78	3.14	6.53
2009	2.59	60.08	183.24	0.114	0.006	2 007.23	46 356.37	146 022.56	2.32	4.82
2010	2.27	52.50	160.14	0.100	0.005	1 850.85	42 744.90	134 646.44	2.14	4.45
2011	2.22	51.46	156.94	0.098	0.005	1 896.40	43 796.86	137 960.12	2.19	4.55
2012	2.49	57.77	176.19	0.110	0.006	1 692.08	39 078.02	123 095.78	1.95	4.06
2013	2.12	49.22	150.12	0.094	0.005	1 582.17	36 539.81	115 100.42	1.83	3.80
2014	1.88	43.60	132.97	0.083	0.004	1 660.71	38 353.60	120 813.85	1.92	3.99

Uncertainties and time-series consistency

The information about uncertainty and time series consistency can be found in the section 3.2.1 and 3.2.7.3 of this chapter. Tier 1 uncertainty was included in total uncertainty assessment.

Category-specific QA/QC and verification

The Information can be found in the section 3.2.7.4 of this chapter.

Source specific recalculations

For the years 2005 – 2014 Slovakia decided to proceed to use the data from EUROCONTROL in this submission. The decision follows an analysis of the national data and data obtained from EUROCONTROL and the approval by the Ministry of Transport, Construction and Regional Development of the Slovak Republic. The data are available on the basis of work of the EEA in collaboration with EUROCONTROL and DG CLIMA. Recalculations were in:

- Aviation Gasoline for fuel consumption and emissions of CO_2, CH_4 and N_2O in 2005 – 2013;
- Jet Kerosene for fuel consumption and emissions of CO_2, CH_4 and N_2O in in 2005 – 2013.

Source specific planned improvements

More information can be found in the section 3.2.7.6 of this chapter.

3.2.3.2 International navigation (CRF 1.D.1.b)

GHG emissions inventory in navigation transport includes CO_2, CH_4 and N_2O emissions from shipping activities in the Slovak part of the Danube River. The inventory of GHG emissions from inland shipping transport has no direct methodological support in the IPCC 2006 Guidelines. For this reason and in view of the relationship between the river boats and diesel rail transport tractions, the same methodology and the same emission factors were chosen to calculate GHG emissions as in the case of railway transport. The consumption of diesel oil is determined indirectly from the 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 16.48 Gg of CO_2 equivalents in 2014. The decrease is significant in comparison with the base year but the interannual fluctuations are visible also in recent years.

Table 3.10: *Overview of the GHG emissions inventory in shipping in 2014*

SHIPPING COMPANIES	SALE OF DIESEL OIL		EMISSIONS		
	(TJ)	(t)	CO_2	CH_4	N_2O
Slovak Shipping and Ports (Danube)	158.61	3 732.00	11 897.62	0.71	5.11
Slovak Water Management Enterprise	0.00	0.00	0.00	0.00	0.00
Other companies	0.00	0.00	0.00	0.00	0.00
International shipping companies	35.87	844.00	2 690.67	0.16	1.16
TOTAL	**192.39**	**4 576.00**	**14 588.29**	**0.87**	**6.27**

The Slovak Republic used tier 1 methodology based on a transportation model (fuel consumption by transit transport) for the estimation of emission from inland shipping on the Danube River (included in international bunkers). According to the recommendations of the ERT final findings and the IPCC 2006 Guidelines, the emission estimation based on fuel consumption and the international rule for inland shipping on the Danube River was evaluated. The emissions of greenhouse gases are calculated from the weight of consumed fuel by diesel motor boats multiplied by emission factor. More information on methodology and emission factors can be found in the section 3.2.7.2 of this chapter.

The GHG emissions from diesel oil sold to international transportation in the important Slovak ports Bratislava and Komárno were balanced in the period 1990 – 2014. Table 3.17 shows this balance using EFs for the different type of ships known in the time of estimation, which is more realistic way of emission estimation and was recommended by the sectoral expert.

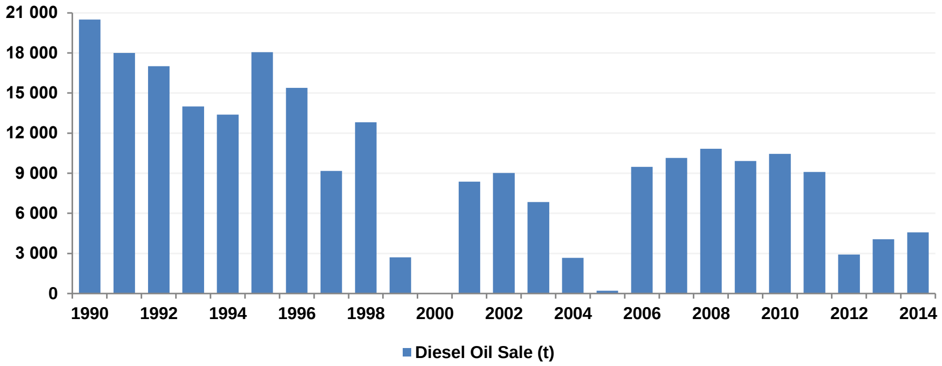
Table 3.11: *GHG emissions balance of diesel oil sold for shipping companies in the Slovak Republic in 1990 – 2014 based on historical EFs in particular years*

YEAR	DIESEL OIL SOLD (t)	EMISSIONS (t)		
		CO_2	CH_4	N_2O
	EFs for the boats kg/t of diesel oil:	***3 188***	***0.25***	***0.10***
1990	20 500	65 354.00	5.13	2.05
	EFs for the boats kg/t of diesel oil:	***3 188***	***0.20***	***1.37***
1995	18 066	57 594.40	3.61	24.75
2000	0	0.00	0.00	0.00
2001	8 366	26 670.81	1.67	11.46
	EFs for the boats kg/t of diesel oil:	***3 188***	***0.19***	***1.37***
2002	9 027	28 778.71	1.72	12.37
2003	6 836	21 793.17	1.30	9.37
2004	2 661	8 483.17	0.51	3.65
2005	213	678.09	0.04	0.29
2006	9 478	30 216.28	1.80	12.99
2007	10 136	32 314.08	1.93	13.89
2008	10 824	34 505.70	2.06	14.83
2009	9 917	31 616.26	1.88	13.59
2010	10 450	33 315.27	1.99	14.12
2011	9 101	29 014.69	1.73	12.47
2012	2 913	9 287.57	0.55	3.99
2013	4 050	12 912.36	0.77	5.55
2014	4 576	14 588.29	0.87	6.27

The sources of activity data for the period 1994 – 2014 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 estimation 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). More information is included in the section 3.2.7.2 of this chapter.

Figure 3.8: *Overview of diesel oil consumption (in t) for shipping transport in 1990 – 2014*



Uncertainties and time-series consistency

The inter-annual fluctuation of diesel oil consumption in motor traction of shipping activities is caused by the price policy of the Slovak Republic and fuel sale companies in ports on the Slovak Territory of Danube River. Similar trend can also be expected in the future. The time series are consistent with the consistent methodology, activity data collection and using default emission factors for diesel oil fuel. More information is included in the section 3.2.1 and 3.2.7.3 of this chapter.

Source specific QA/QC and verification

The Information can be found in the section 3.2.7.4 of this chapter.

Source specific recalculations

The Information can be found in the section 3.2.7.5 of this chapter.

Source specific planned improvements

The Information can be found in the section 3.2.7.6 of this chapter

3.2.4 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 1 922.03 Gg in 2014, which represents 7 047.43.29 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 (57.4% and 57.4%, respectively) The other significant source of carbon excluded is using of natural gas (19.5% in fuel consumption and 16.1% in quantity of carbon). Details on the share in fuel units and carbon units are presented on Figures 3.9 and 3.10. The CO_2 emissions excluded from the RA are presented in Figure 3.11 for the whole time series 1990 – 2014.

Figure 3.9: *The share of different fuels consumption for feedstocks and non-energy use in 2014*

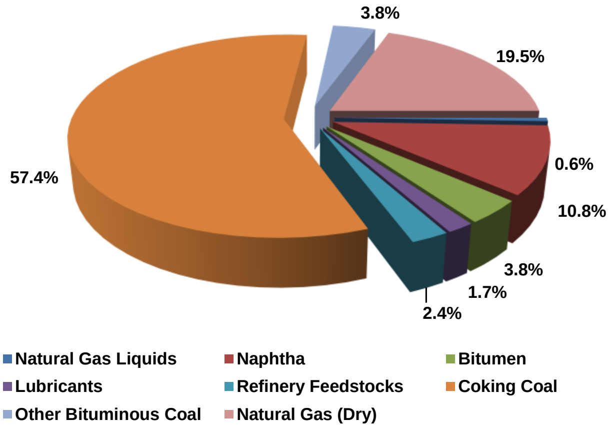


Figure 3.10: *The share of carbon for feedstocks and non-energy use in 2014*

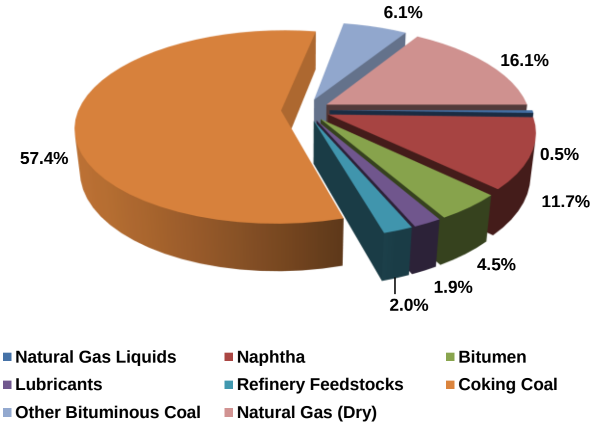
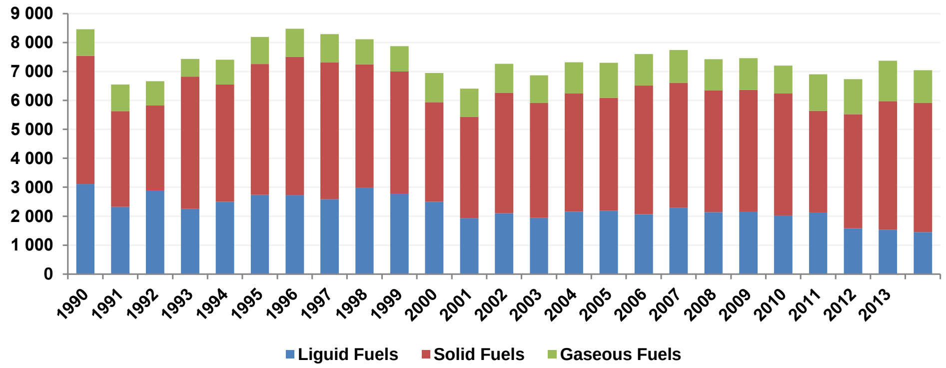


Figure 3.11: *The CO_2 emissions (in Gg) excluded from the reference approach in 1990 – 2014*



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 Table 3.18.

Table 3.12: *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 3.19. In this submission, carbon excluded from bitumen use is reported for the whole time series for first time. In previous submissions, amount of bitumen in TJ was reported without of content of carbon in it. In this submission, NCVs and carbon contents in bitumen were unified with RA on the basis of data of Statistical Office of the Slovak Republic. The non-energy use of bitumen was recalculated for the whole time series.

Table 3.13: *Total volume of carbon in different types of fuels excluded from the RA since 1990*

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
1991	250.59	NO	290.38	65.54	207.68	68.82	903.80	IE
1992	230.03	7.02	393.27	65.54	237.13	85.87	798.90	IE
1993	166.21	10.83	322.64	65.54	150.95	64.69	1 245.22	IE
1994	235.31	10.66	360.14	65.54	179.06	66.96	1 103.29	IE
1995	254.92	19.61	385.42	65.54	199.63	76.18	1 231.99	IE
1996	264.81	16.19	385.42	65.54	211.12	67.34	1 299.94	IE
1997	264.31	21.52	385.42	65.54	167.50	66.18	1 289.31	IE
1998	236.01	33.46	474.37	65.54	160.34	78.90	1 163.83	IE
1999	238.19	26.88	415.07	65.54	180.24	70.39	1 150.94	IE
2000	274.56	35.38	432.51	65.54	83.40	65.80	937.52	IE
2001	266.45	8.98	316.54	65.54	67.42	68.18	954.71	IE
2002	273.73	16.63	328.74	60.49	84.52	83.91	1 081.59	52.58
2003	261.12	20.00	303.46	46.21	87.70	72.31	1 030.52	52.37
2004	294.85	22.39	350.54	42.85	88.97	83.61	1 056.17	57.43
2005	329.10	15.49	348.80	39.49	126.88	67.55	1 025.05	37.72
2006	296.55	20.67	319.15	56.64	102.78	64.47	1 168.59	43.91
2007	308.78	27.57	345.31	58.06	127.12	66.79	1 130.18	48.39
2008	294.44	25.21	327.87	37.96	137.16	54.31	1 102.80	44.41

YEAR	CARBON EXCLUDED FROM RA (kt)							
	Natural Gas	Natural Gas Liquids	Naphtha	Lubricants	Bitumen	Refinery Feedstocks	Coking Coal	Other Bituminous Coal
2009	297.48	24.11	360.14	16.91	121.17	62.26	1 126.93	24.27
2010	263.78	18.67	340.08	16.90	112.07	63.64	1 111.31	37.91
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

IE - included in coking coal

3.2.5 ENERGY INDUSTRIES (CRF 1.A.1)

3.2.5.1 Source category description

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) - The subcategory 1.A.1.a 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 78 309.84 TJ in 2014. The most significant gas reported in this subcategory was carbon dioxide, which was represented by 4 632.41Gg of CO_2 in 2014. The decrease in CO_2 emissions in the comparison with the year 2013 is 17.5%. There were several different reasons explaining this significant decrease. Among others the major reasons were a mild winter 2013/2014 and a significant (and continuous) increase of biomass share on combustion in this subcategory. Total CH_4 emissions were 0.70 Gg and total N_2O emissions were 0.14 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 subcategory 1.A.1.a also the “other fuels” are reported. In this group were included following gases:

- 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 waste category 6.C.2 due to unavailability of the specific NCV of the industrial waste (which contains different materials). Methane emissions from waste incineration are not occurring in municipal and industrial waste incineration.

Petroleum refining (1.A.1.b) - GHG emissions from the refineries are allocated in the subcategory 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 5.2 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 the subcategory 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 the 1.A.1.b subcategory expressed in energy units represented 18 009.45 TJ in 2014. Total CO_2 emissions were 1 216.40 Gg. There is a decrease in CO_2 emissions, which is proportional to the decrease of crude oil processed (decrease of crude oil was 9.8% in comparison with year 2013). Total CH_4 emissions were 0.033 Gg and total N_2O emissions were 0.0057 Gg in this subcategory.

Manufacture of solid fuels and other energy industries (1.A.1.c) - Total volume of fuels allocated in the 1.A.1.c subcategory (Manufacture of solid fuels and other energy industries) expressed in energy units represented 6 940.22 TJ in 2014. Total CO_2 emissions were 1 250.66 Gg in 2014 and increase by 5.5% compared with the previous year. Total CH_4 emissions were 0.007 Gg and total N_2O emissions were 0.0007 Gg in this subcategory.

3.2.5.2 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 the subcategories 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 change in energy balance in sectoral approach was performed in 2013. Before year 2013 the primary source of activity data was the NEIS database[1].

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 IPPU chapter). 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 the categories 1.A.1, 1.A.2, 1.A.4 and 1.A.5.

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

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 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 SHMU 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 the categories 1.A.1, 1.A.2, 1.A.4 and 1.A.5. The major 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 subcategories 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

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

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, following table 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 3.20: *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 3.20 is visible, that the EU ETS share of CO_2 emissions in the category 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 a subcategory 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 Statistical Office of the Slovak Republic and the NEIS database.

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 the subcategory 1.A.1.a.iv Other. No emissions from the municipal solid waste incineration is reported in the category 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 category.

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 subcategory 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 the subcategory 1.A.1.a.

Volume of MSW incinerated and reported is comparable with the volume reported by the SU SR (and EUROSTAT) and was 189.93 kt (1870 GJ) in 2014. Following table shows the comparison of the MSW volume reported by the operators in the publication "Waste" and EUROSTAT in the period 2001 – 2014.

Table 3.21: *Comparison of MSW incinerated with energy use reported by the EUROSTAT and the Publication "Waste" of the Statistical Office of the Slovak Republic with the biogenic and C-fossil share*

MSW Incinerated	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
EUROSTAT in GJ														
biogenic	514	87	537	602	730	880	805	1 035	1 052	901	736	775	653	485
C-fossil	514	86	537	600	731	880	805	876	826	705	667	629	454	1 236
SU SR PUBLICATION "WASTE" in GJ														
biogenic	432	515	535	606	602	626	594	518	585	604	611	553	572	626
C-fossil	859	1 026	1 065	1 207	1 199	1 246	1 182	1 031	1 165	1 202	1 216	1 101	1 139	1 245

Incinerated MSW was divided into C-fossil and biogenic fraction using composition of waste generated in municipalities (and presented in waste chapter). Total C-fossil MSW incinerated was 63.52 kt in 2014 and total biogenic MSW incinerated was 126.42 kt in 2014.

There is not consistent approach in reporting C-fossil and biogenic share in energy units (TJ) in the energy balance of the Statistical Office of the 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 CRF tables http://enviroportal.sk/ovzdusie/zoznam-spalovni-a-zariadeni-na-spoluspalovanie.

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 the subcategory 1.A.1.a.iv – Other. Total C-fossil CO_2 was 49.18 Gg, CH_4 was 0.0188 and N_2O was 0.0025 in 2014 and total biogenic CO_2 was 97.88 Gg, CH_4 was 0.0374 and N_2O was 0.00498 in 2014.

3.2.5.3 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). 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 Statistical Office and the RA are not significantly different.

According to the direct information on the quantity of fuels combusted (in kt or mil. m^3) and their specific net calorific values, calculation of fuels consumption in energy unit (TJ) is provided.

For 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[4] (Tables 3.22 - 3.24). 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 20 900 Gg in 2014.

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 the category 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 the subcategory 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 3.22. The CO_2 emission factor of natural gas (55.72 t CO_2/TJ) is lower than the IPCC default value (56.1 t CO_2/TJ). Natural gas used in the Slovak Republic is imported from Russia Federation and consists almost totally (>95%) of methane.

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

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

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 3.14: *Composition of natural gas in 2104 published on-line by the Slovak Gas Industry*

2014	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.	96.119	1.9941	0.5759	0.0862	0.0945	0.0199	0.0005	0.0184	0.264	0.8125
II.	96.237	1.9171	0.5562	0.0832	0.0908	0.0188	0.0004	0.0158	0.2476	0.8186
III.	96.033	2.0358	0.5992	0.0934	0.1022	0.0228	0.0005	0.0205	0.2828	0.7936
IV.	95.592	2.3606	0.6437	0.1015	0.1073	0.0234	0.0009	0.0196	0.3615	0.7725
V.	94.965	2.7080	0.6884	0.1042	0.1141	0.0259	0.0012	0.0284	0.5065	0.8392
VI.	94.735	2.7559	0.7189	0.1046	0.1211	0.028	0.0013	0.0337	0.5642	0.9164
VII.	93.591	3.2987	0.845	0.1136	0.1428	0.0353	0.0017	0.0472	0.8336	1.0642
VIII.	93.672	3.3312	0.9342	0.1327	0.1564	0.0361	0.0014	0.0411	0.6901	0.9768
IX.	93.751	3.2967	0.7505	0.1003	0.1261	0.0299	0.0015	0.0389	0.8568	1.0249
X.	94.830	2.8041	0.5882	0.0861	0.0981	0.023	0.0015	0.0279	0.6318	0.8924
XI.	95.870	2.3596	0.523	0.0871	0.0856	0.0184	0.0011	0.0199	0.3231	0.6983
XII.	95.760	2.3313	0.5983	0.095	0.098	0.0212	0.0008	0.0214	0.3111	0.7476
Average	**95.096**	**2.599**	**0.668**	**0.099**	**0.111**	**0.025**	**0.001**	**0.028**	**0.489**	**0.863**

Table 3.15: *Overview of the EFs and NCVs for natural gas in 2014 [15°C; 101.325 kPa] published on-line by the Slovak Gas Industry*

2014	NATURAL GAS						
MONTH	Relative density (mol %)	Density (kg.m^{-3})	NCV (kWh.m^{-3})	Combustion heat (kWh.m^{-3})	Wobbe number (kWh.m^{-3})	Sulphur content (mg.m^{-3})	EF CO_2 (tCO_2/TJ)
I.	0.5797	0.7104	9.635	10.68	14.03	0.0372	55.53
II.	0.5789	0.7094	9.625	10.67	14.02	0.0474	55.49
III.	0.5807	0.7117	9.648	10.694	14.04	0.0514	55.55
IV.	0.5836	0.7152	9.676	10.724	14.04	0.0882	55.65
V.	0.5879	0.7205	9.695	10.744	14.01	0.1921	55.80
VI.	0.5897	0.7226	9.696	10.744	13.99	0.1766	55.85
VII.	0.5978	0.7327	9.731	10.782	13.94	0.3158	56.13
VIII.	0.6104	0.7321	9.773	10.827	14.01	0.1596	56.09
IX.	0.5961	0.7306	9.706	10.754	13.93	0.2911	56.09
X.	0.5882	0.7209	9.662	10.708	13.96	0.1865	55.84
XI.	0.5811	0.7121	9.658	10.705	14.04	0.034	55.58
XII.	0.5822	0.7135	9.67	10.717	14.05	0.0204	55.60
Average	**0.5880**	**0.7193**	**9.6668**	**10.7291**	**14.005**	**0.1333**	**55.681**

Table 3.24: *Overview of the CO_2 country or plant specific emission factors in 1.A.1 in 2014*

1.A.1a	WEIGHTED EF CO_2 (t/TJ)	FUEL TYPE	EF C (t/TJ)	EF CO_2 (t/TJ)
Liquid	78.16	Gas/Diesel oil	20.44	74.95
		Residual fuel oil	21.75	79.75
		Liquefied petroleum gases	17.22	63.15
Solid	101.72	Anthracite	26.52	97.17
		Other bituminous coal	26.25	96.25
		Lignite	27.91	102.32
Gaseous	55.58	Natural gas	15.16	55.58
Biomass	106.03	Other biogas	14.90	54.63
		Sludge gas	14.90	54.63
		Other primary solid biomass	27.30	100.10

1.A.1a	WEIGHTED EF CO_2 (t/TJ)	FUEL TYPE	EF C (t/TJ)	EF CO_2 (t/TJ)
		Wood/Wood waste	30.50	111.83
1.A.1b	**Weighted EF (CO_2) t/TJ**	**Fuel type**	**EF C (t/TJ)**	**EF CO_2 (t/TJ)**
Liquid	71.44	Residual fuel oil	21.52	78.84
		Petroleum coke	26.59	97.43
		Refinery gas	15.53	56.91
Gaseous	55.72	Natural gas	15.20	55.68
1.A.1c	**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
Solid	195.01	Lignite	27.91	102.32
		Coke oven gas	11.48	42.08
		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

3.2.5.4 Uncertainties and time-series consistency

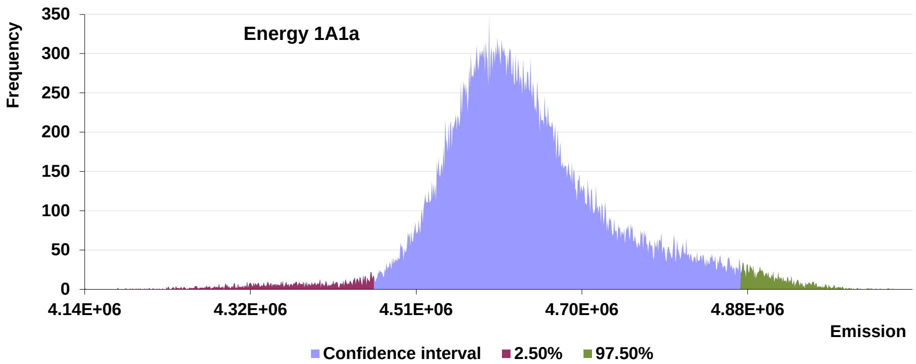
Time series is consistent in all aspects (methodological approach, country specific EFs and oxidation factor used, fuel characteristics, etc.) to the detailed level of disaggregation (on plant specific level).

The average mean value of GHG emissions for the 1.A.1.a subcategory obtained by the Monte Carlo simulation is 4 634 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 4 632 Gg. Confidence interval (95%) is within the range: <4 467; 4 874>, which represents the uncertainty by relative values to the mean value: -3.60%; +5.19%. The following table and graph described calculated results of uncertainty analyses.

Table 3.23: *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
4 619.49	**4 633.95**	100.68	4 138.26	5 068.23	-3.60%	5.19%

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

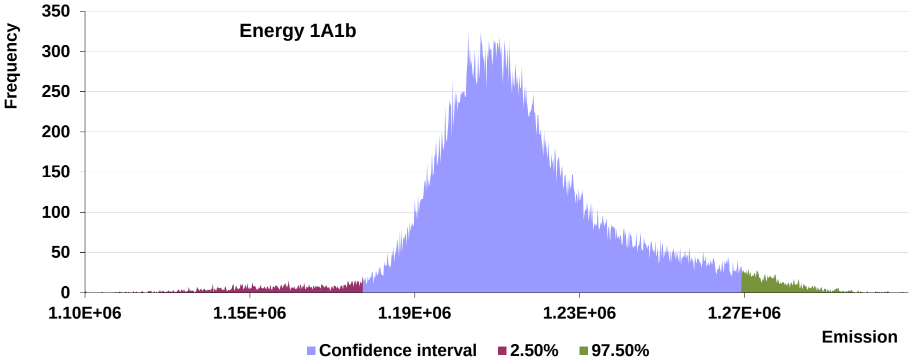


The average mean value of GHG emissions for the 1.A.1.b subcategory obtained by the Monte Carlo simulation is 1 216 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 1 216 Gg. Confidence interval (95%) is within the range: <1175; 1273>, which represents the uncertainty by relative values to the mean value: -3.35%; +4.70%. The following table and graph described calculated results of uncertainty analyses.

Table 3.24: *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
1 212.87	**1 216.46**	24.15	1 103.82	1 317.10	-3.35%	4.70%

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

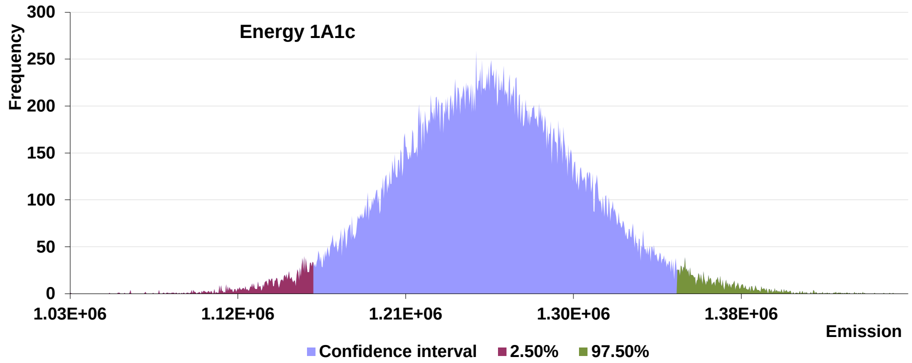


The average mean value of GHG emissions for the 1.A.1.c subcategory obtained by the Monte Carlo simulation is 1 251 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 1 251 Gg. Confidence interval (95%) is within the range: <1 157; 1 351>, which represents the uncertainty by relative values to the mean value: -7.51%; +7.98%. The following table and graph described calculated results of uncertainty analyses.

Table 3.25: *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
1 249.95	**1 250.81**	49.07	1 027.84	1 473.67	-7.51%	7.98%

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



3.2.5.5 Category-specific QA/QC and verification

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).

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 SHMU, 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 SHMU.

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.

3.2.5.6 Category-specific recalculations

Based on the suggestions provided during ESD review major improvements were performed in municipal waste incineration with energy use. Total amount of Municipal solid waste incineration with energy use is now reported in the subcategory 1.A.1.a.iv Other. No emissions from the municipal solid waste incineration is reported in the category 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. Basic reason for the reallocation/recalculation together with a detail description of methodology used is provided in chapter Methodological issues.

3.2.5.7 Category-specific planned improvements

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.

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

3.2.6.1 Category description

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 this subcategory (1.A.2.a) expressed in energy units represented 24 496.11TJ in 2014. Total CO_2 emissions were 3 188.87 Gg. Total CH_4 emissions were 0.12 Gg and total N_2O emissions were 0.02 Gg in this subcategory.

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 2 681.43TJ in 2014. Total CO_2 emissions were 148.25 Gg, total CH_4 emissions were 0.03 Gg and total N_2O emissions were 0.004 Gg in this subcategory.

Chemicals (1.A.2.c) - Subcategory 1.A.2.c Chemicals 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 12 use more than 70% of the energy according to the available activity data. Total volume of fuels expressed in energy units allocated in this subcategory was 8 688.73 TJ in 2014. Total CO_2 emissions were 501.87 Gg, total CH_4 emissions were 0.02 Gg and total N_2O emissions were 0.002 Gg in this subcategory.

Pulp, paper and print (1.A.2.d) - Subcategory 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 27 048.30TJ in 2014. Total CO_2 emissions were 479.70 Gg, total CH_4 emissions were 0.18 Gg and total N_2O emissions were 0.05 Gg in this subcategory.

Food processing, beverage and tobacco (1.A.2.e) - Total volume of fuels allocated in this subcategory expressed in energy units represented 5 557.53 TJ in 2014. Total CO_2 emissions were 326.30 Gg, total CH_4 emissions were 0.009 Gg and total N_2O emissions were 0.001 Gg in this subcategory. 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 19 714.44 TJ in 2014. Total CO_2 emissions were 1 366.25 Gg, total CH_4 emissions were 0.23 Gg and total N_2O emissions were 0.03 Gg in this subcategory. 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 21 675.78 TJ in 2014. Total CO_2 emissions were 1 224.20 Gg, total CH_4 emissions were 0.11 Gg and total N_2O emissions were 0.01 Gg in this subcategory. 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 and figure.

Table 3.25: *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	142.64	11.65%
1.A.2.g.ii Man. of transport equipment	157.08	12.83%
1.A.2.g.iii Mining and quarrying	16.37	1.34%
1.A.2.g.iv Wood and wood products	12.79	1.04%
1.A.2.g.v Construction	32.30	2.64%
1.A.2.g.vi Textile and leather	58.85	4.81%
1.A.2.g.viii Other	804.18	65.69%

3.2.6.2 Methodological issues

Detail general description of the methodological issues used for estimation of emissions from fuel combustion is given in the section 3.2.5.2 of this chapter.

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).

3.2.6.3 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 3.26.

Table 3.26: *Overview of the country or plant specific CO_2 emission factors in 1.A.2 in 2014*

1.AA.2.a	WEIGHTED EF CO_2 (t/TJ)	FUEL TYPE	EF C (t/TJ)	EF CO_2 (t/TJ)
Liquid	63.21	Residual Fuel Oil	20.93	76.74
		Liquefied Petroleum Gases	17.22	63.15
Solid	140.89	Gas Coke	29.48	108.10
		Other Bituminous Coal	26.81	98.29
		Coke Oven Gas	11.48	42.08
		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
		Charcoal	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	91.01	Gas/Diesel Oil	20.44	74.95
		Petroleum Coke	24.83	91.06
		Liquefied Petroleum Gases	17.22	63.15
Solid	97.25	Other Bituminous Coal	26.52	97.25
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	76.10	Residual Fuel Oil	20.93	76.74
		Gas/Diesel Oil	20.44	74.95
		Liquefied Petroleum Gases	17.22	63.15
Solid	97.50	Anthracite	26.72	97.97
		Coking Coal	25.62	93.93
		Lignite	27.91	102.32
		Other Bituminous Coal	26.52	97.25
Gaseous	55.72	Natural Gas	15.20	55.72
Biomass	100.17	Wood/Wood Waste	30.50	111.83
		Other Primary Solid Biomass	27.30	100.10
1.AA.2.d	**WEIGHTED EF CO_2 (t/TJ)**	**FUEL TYPE**	**EF C (t/TJ)**	**EF CO_2 (t/TJ)**
Liquid	75.39	Residual Fuel Oil	20.93	76.74
		Liquefied Petroleum Gases	17.22	63.15
Solid	98.74	Other Bituminous Coal	26.52	97.25
		Lignite	27.91	102.32
Gaseous	55.72	Natural Gas	15.20	55.72
Other	105.97	Peat	28.90	105.97
Biomass	97.55	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	64.28	Liquefied Petroleum Gases	17.22	63.15
		Gas/Diesel Oil	20.44	74.95
Solid	102.02	Anthracite	26.72	97.97
		Lignite	27.91	102.32
Gaseous	55.72	Natural Gas	15.20	55.72
Biomass	66.31	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	90.45	Residual Fuel Oil	20.93	76.74
		Petroleum Coke	24.83	91.06
		Liquefied Petroleum Gases	17.22	63.15
Solid	97.59	Anthracite	26.72	97.97
		Other Bituminous Coal	26.52	97.25
		Lignite	27.91	102.32
		Gas Coke	29.48	108.10
Gaseous	55.72	Natural Gas	15.20	55.72
Other	87.50	Municipal and Industrial Wastes	24.00	87.99
		Waste Oil	20.00	73.33
Biomass	111.83	Wood/Wood Waste	30.50	111.83

1.AA.2.g	WEIGHTED EF CO_2 (t/TJ)	FUEL TYPE	EF C (t/TJ)	EF CO_2 (t/TJ)
Liquid	65.47	Gas/Diesel Oil	20.44	74.95
		LPG	17.22	63.15
		Petroleum Coke	29.48	108.10
		White Spirit and SBP	20.00	73.33
		Other Kerosene	19.60	71.87
Solid	90.88	Blast Furnace Gas	71.24	261.21
		Coke oven Gas	11.54	42.31
		Lignite	27.91	102.32
		Other bituminous coal	26.52	97.25
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

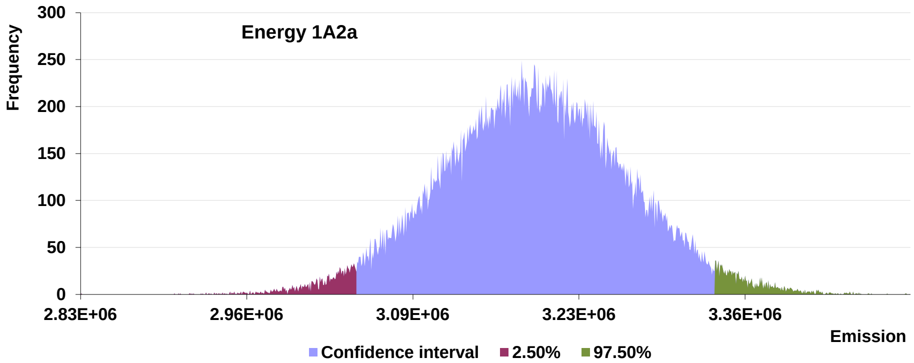
3.2.6.4 Uncertainties and time-series consistency

The average mean value of GHG emissions for the 1.A.2.a subcategory obtained by the Monte Carlo simulation is 3 189 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 3 189 Gg. Confidence interval (95%) is within the range: <3 047; 3 334>, which represents the uncertainty by relative values to the mean value: -4.47%; +4.54%. The following table and graph described calculated results of uncertainty analyses.

Table 3.27: *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
3 189.14	**3 189.46**	73.38	2 825.50	3 491.63	-4.47%	4.54%

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

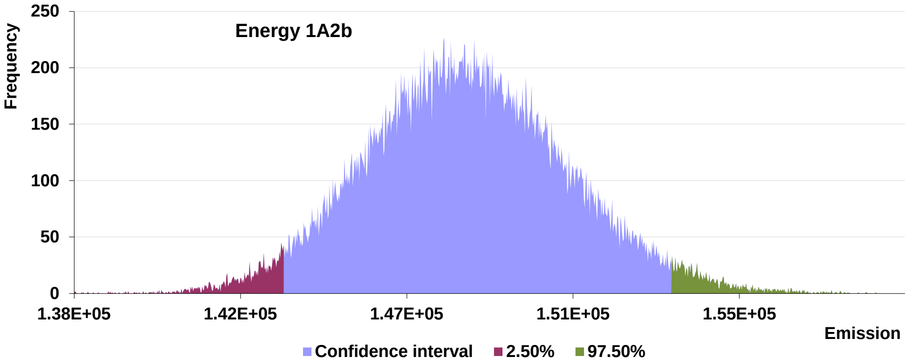


The average mean value of GHG emissions for the 1.A.2.b subcategory obtained by the Monte Carlo simulation is 148 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 148 Gg. Confidence interval (95%) is within the range: <143; 154>, which represents the uncertainty by relative values to the mean value: -3.31%; +3.61%. The following table and graph described calculated results of uncertainty analyses.

Table 3.28: *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
148.19	**148.27**	2.61	138.03	159.71	-3.31%	3.61%

__Figure 3.17:__ Probability density function for 1.A.2.b in tons of CO_2

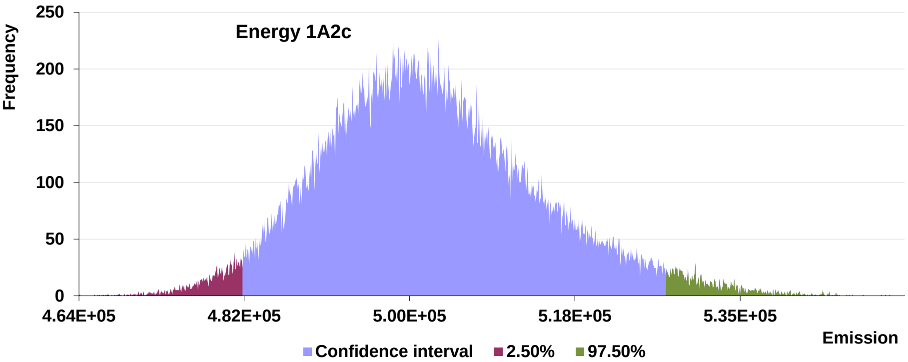


The average mean value of GHG emissions for the 1.A.2.c subcategory obtained by the Monte Carlo simulation is 502 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 502 Gg. Confidence interval (95%) is within the range: <482; 527>, which represents the uncertainty by relative values to the mean value: -4.00%; +5.06%. The following table and graph described calculated results of uncertainty analyses.

__Table 3.29:__ 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
501.00	**501.97**	11.49	464.21	553.07	-4.00%	5.06%

__Figure 3.18:__ Probability density function for 1.A.2.c in tons of CO_2

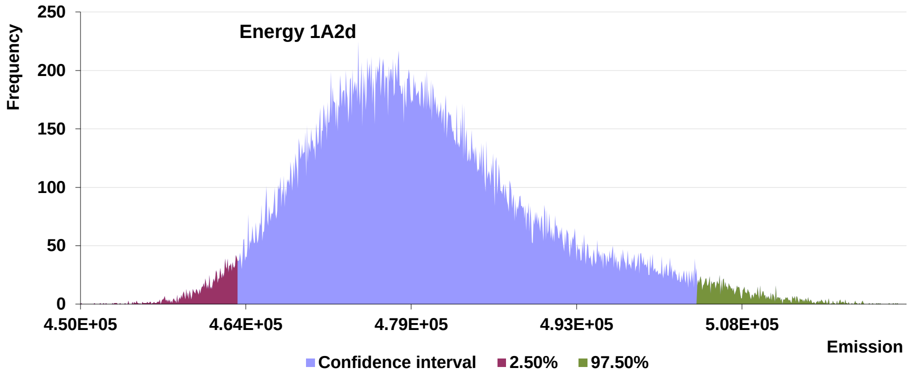


The average mean value of GHG emissions for the 1.A.2.d subcategory obtained by the Monte Carlo simulation is 480 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 480 Gg. Confidence interval (95%) is within the range: <464; 504>, which represents the uncertainty by relative values to the mean value: -3.37%; +4.98%. The following table and graph described calculated results of uncertainty analyses.

__Table 3.30:__ 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
478.40	**479.79**	10.11	449.87	522.11	-3.37%	4.98%

__Figure 3.19:__ Probability density function for 1.A.2.d in tons of CO_2

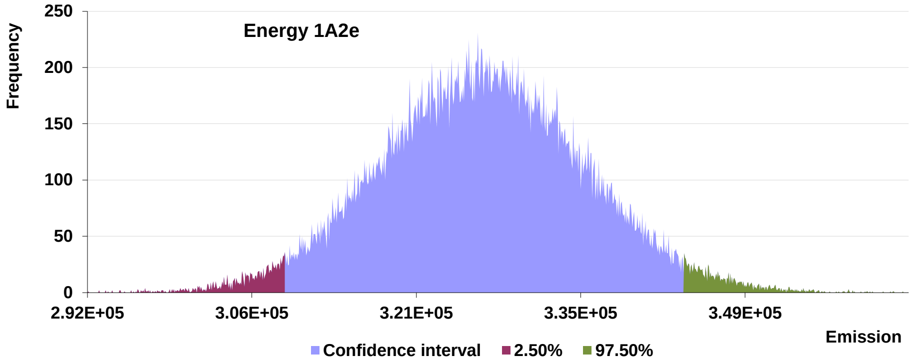


The average mean value of GHG emissions for the 1.A.2.e subcategory obtained by the Monte Carlo simulation is 326 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 326 Gg. Confidence interval (95%) is within the range: <309; 344>, which represents the uncertainty by relative values to the mean value: -5.30%; +5.41%. The following table and graph described calculated results of uncertainty analyses.

__Table 3.31:__ 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
326.38	**326.42**	8.91	291.78	363.88	-5.30%	5.41%

__Figure 3.20:__ Probability density function for 1.A.2.e in tonsof CO_2

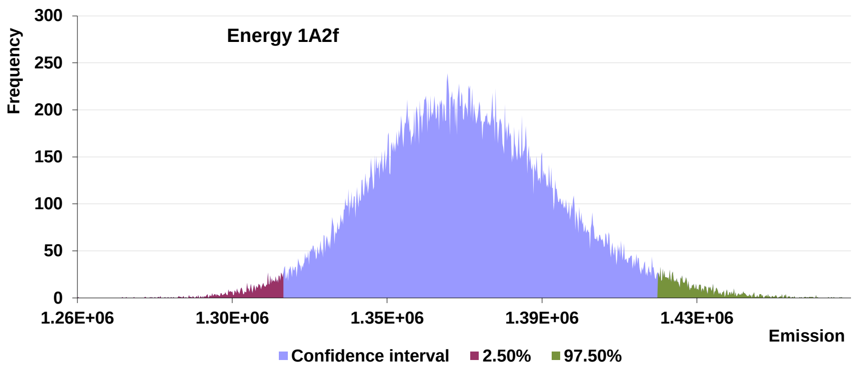


The average mean value of GHG emissions for the 1.A.2.f subcategory obtained by the Monte Carlo simulation is 1 366 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 1 366 Gg. Confidence interval (95%) is within the range: <1 320; 1 418>, which represents the uncertainty by relative values to the mean value: -3.35%; +3.81%. The following table and graph described calculated results of uncertainty analyses.

__Table 3.32:__ 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
1 365.18	**1 366.31**	24.70	1 261.57	1 470.58	-3.35%	3.81%

Figure 3.21: *Probability density function for 1.A.2.f in tons of CO_2*

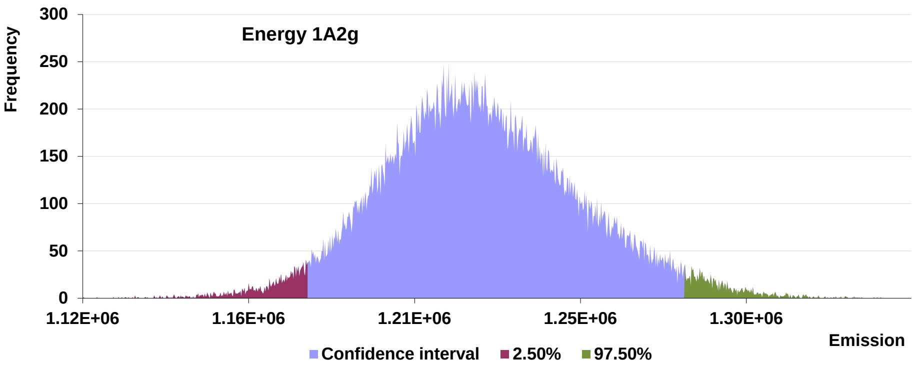


The average mean value of GHG emissions for the 1.A.2.g subcategory obtained by the Monte Carlo simulation is 1 224 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 1 224 Gg. Confidence interval (95%) is within the range: <1 176; 1 279>, which represents the uncertainty by relative values to the mean value: -3.92%; +4.49%. The following table and graph described calculated results of uncertainty analyses.

Table 3.33: *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
1 222.89	**1 224.45**	26.17	1 117.39	1 340.61	-3.92%	4.49%

Figure 3.22: *Probability density function for 1.A.2.g in tons of CO_2*



3.2.6.5 Category-specific QA/QC and verification

Sector specific QA/QC plan is based on the general QA/QC and it is quite identical to QA/QC plan in 1AA.1 (described in the section 3.2.5.4). Activity data are compared on plant level against three independent sources (EU ETS, SU SR and NEIS). If there are inconsistencies, the underlying data are checked and corrected if needed.

3.2.6.6 Category-specific recalculations

Several important recalculations were performed in previous submission. In current submission minor refinements in industrial waste incineration with energy use in category 1.A.2.f was performed.

Reallocation/revised data: Model of industrial waste incineration taking place in cement plants (1.A.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 SO 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 SO 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.A.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 2014 and total biogenic CO_2 (reported under biomass) was 201.55 Gg, CH_4 was 0.068 and N_2O was 0.00907 in 2014.

3.2.6.7 Category-specific planned improvements

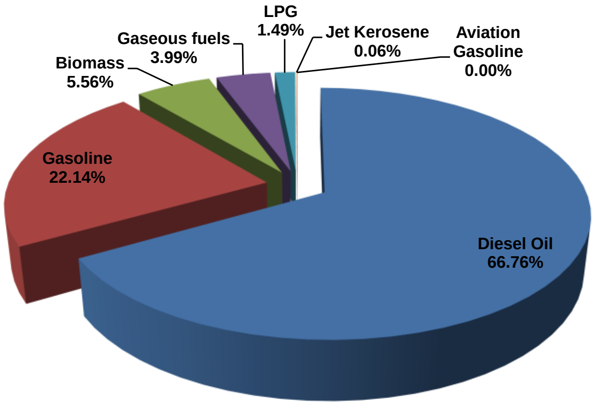
There are improvements listed in the section 3.2.5.7 also planned for this category.

3.2.7 TRANSPORT (CRF 1.A.3)

3.2.7.1 Category description

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), Pipeline transport (1.A.3.e.i) and the new subcategory reported first time in this submission – Other / Urea Based Catalysts (1.A.3.e.ii). The emissions from road and non-road transport were calculated by using models and default methodologies and the consistent data series from 1990 to 2014 are presented in the CRF tables. The GHG emissions inventory in 1.A.3 is connected with the estimation of basic pollutants (CO, NO_x, SO_2) and solid particles (TSP, PM_{10}, $PM_{2.5}$), ammonia emissions and heavy metals, emissions of persistent organic substances (POPs), non-methane volatile organic compounds (NMVOC) emitted in the Slovak Republic in the year 2014. The emissions balance of basic pollutants, NMVOC, NH_3, POPs and heavy metals was evaluated according to the EMEP/CORINAIR Emission Inventory Guidebook and by using the software product COPERT IV version 9.0. Total GHG emissions in the category transport were 6 532.88 Gg of CO_2 equivalents in 2014. The CO_2 emissions were 6 452.98 Gg, which represent the 98.8% share on total transport emissions, the CH_4 emissions were 15.98 Gg of CO_2 eq. with the 0.24% share and N_2O emission were 63.93 Gg of CO_2 eq. with the 0.98% share on total transport GHG emissions. The share of road transportation was 95.75%, pipeline transport 2.72%, railways 1.36%, domestic aviation represents 0.07%, domestic navigation 0.08% and Urea Based Catalysts 0.03% from the total emissions reported in transport category (in CO_2 eq.). Total energy consumption was 93 506 TJ of fuels in 2014. Among fuels, the most important are liquid fuels (diesel oil – 66.8%, gasoline – 22.1% and LPG – 1.5%, followed by jet kerosene – 0.06%, aviation gasoline – 0.002% and biomass – 5.6%) and gaseous fuel (CNG – 4.0%). No solid fuels are used in transport category. The complete time series of GHG emissions are presented in the Table 3.27.

Figure 3.12: *The share of fuels on different categories within transport in 2014*



1.A.3 FUEL COMBUSTION	(TJ)
Diesel oil	62 423.29
Gasoline	20 703.14
Biomass	5 199.50
Gaseous fuels (CNG)	3 727.34
LPG	1 395.40
Jet kerosene	55.60
Aviation gasoline	1.78

Transport has very special position in the energy sector, as it is not included in the EU ETS or other legislative regulations, emissions in this category are very difficult to regulate. 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 been increased by 36% in comparison with the base year and emissions in pipeline transport decreased accordingly and even emissions in railways decreased too.

Table 3.27: *Fuel consumption and GHG emissions in transport by subcategories in 1990 – 2014*

YEAR	1.A.3.a DOMESTIC AVIATION				1.A.3.b ROAD TRANSPORTATION			
	Fuels (TJ)	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)	Fuels (TJ)	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)
1990	105.83	7.74	0.000999	0.000801	61 027.37	4 503.02	1.1654	0.1895
1991	98.39	7.19	0.000928	0.000745	51 935.57	3 820.33	1.0799	0.1554
1992	90.95	6.65	0.000858	0.000689	48 227.70	3 544.54	1.0769	0.1374
1993	88.56	6.47	0.000816	0.000673	48 320.26	3 552.31	1.1593	0.1358
1994	75.17	5.50	0.000712	0.000569	51 655.42	3 804.83	1.2184	0.1511
1995	75.03	5.48	0.000690	0.000570	54 601.91	4 033.64	1.2323	0.1681
1996	87.94	6.43	0.000786	0.000673	55 655.00	4 089.46	1.1802	0.1774
1997	77.90	5.69	0.000698	0.000596	57 908.64	4 267.88	1.1673	0.1951
1998	71.60	5.23	0.000632	0.000548	62 014.20	4 562.40	1.1923	0.2119
1999	72.58	5.31	0.000654	0.000554	61 115.57	4 464.32	1.1149	0.2125
2000	75.21	5.50	0.000730	0.000567	54 574.15	3 989.01	0.9586	0.1852
2001	71.52	5.23	0.000722	0.000535	62 245.54	4 541.25	1.0559	0.2141
2002	74.58	5.45	0.000764	0.000556	64 107.64	4 686.24	0.9997	0.1989
2003	95.59	6.99	0.000875	0.000727	66 125.41	4 826.84	0.9817	0.2013
2004	124.11	9.07	0.000953	0.000972	69 550.75	5 090.84	0.9503	0.1939
2005	117.90	8.57	0.000787	0.000937	82 603.22	6 045.33	0.9352	0.2189
2006	150.61	10.95	0.000989	0.001199	76 969.11	5 636.49	0.8592	0.2011
2007	182.15	13.24	0.001168	0.001455	87 761.56	6 238.45	0.8343	0.1992
2008	214.89	15.63	0.001339	0.001722	90 666.75	6 440.89	0.8262	0.2165
2009	157.56	11.46	0.000986	0.001262	83 834.79	5 914.13	0.7326	0.2076
2010	73.94	5.37	0.000533	0.000582	90 910.52	6 409.25	0.7163	0.1804
2011	62.35	4.53	0.000478	0.000486	87 634.27	6 153.56	0.6300	0.1886
2012	59.25	4.30	0.000474	0.000459	90 183.18	6 343.82	0.6135	0.1890
2013	50.56	3.67	0.000378	0.000396	87 207.80	6 119.38	0.6206	0.1842
2014	57.38	4.17	0.000399	0.000454	89 101.70	6 186.95	0.6302	0.1759

YEAR	1.A.3.c RAILWAYS				1.A.3.d DOMESTIC NAVIGATION			
	Fuels (TJ)	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)	Fuels (TJ)	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)
1990	5 022.82	376.77	0.0295	0.1619	0.30	0.02	0.000001	0.000009
1991	3 778.29	283.42	0.0222	0.1218	0.26	0.02	0.000001	0.000008
1992	3 117.25	233.83	0.0183	0.1005	0.24	0.02	0.000001	0.000007
1993	2 676.24	200.75	0.0157	0.0863	0.25	0.02	0.000001	0.000007
1994	2 526.24	189.50	0.0113	0.0814	0.26	0.02	0.000001	0.000008
1995	2 720.51	204.07	0.0122	0.0877	0.27	0.02	0.000001	0.000008
1996	2 669.71	200.26	0.0119	0.0861	0.30	0.02	0.000001	0.000009
1997	2 508.63	188.18	0.0112	0.0809	0.31	0.02	0.000001	0.000009
1998	2 301.29	172.62	0.0103	0.0742	0.32	0.02	0.000001	0.000010
1999	2 106.64	158.02	0.0094	0.0679	0.32	0.02	0.000001	0.000010
2000	2 076.36	155.75	0.0093	0.0669	0.33	0.02	0.000001	0.000010
2001	2 047.83	153.61	0.0092	0.0660	0.34	0.03	0.000001	0.000010
2002	1 902.30	142.69	0.0085	0.0613	0.35	0.03	0.000001	0.000011
2003	1 521.51	114.13	0.0068	0.0490	0.37	0.03	0.000001	0.000011
2004	1 459.14	109.45	0.0065	0.0470	0.39	0.03	0.000002	0.000012
2005	1 420.98	106.59	0.0060	0.0460	0.47	0.04	0.000002	0.000014
2006	1 509.61	113.24	0.0067	0.0487	4.28	0.32	0.000017	0.000131
2007	1 432.33	104.33	0.0467	0.0065	4.50	0.34	0.000018	0.000137
2008	1 313.84	95.13	0.0429	0.0059	4.74	0.36	0.000019	0.000145
2009	1 131.03	81.64	0.0369	0.0051	4.35	0.33	0.000017	0.000133
2010	1 155.88	83.34	0.0377	0.0052	4.41	0.33	0.000018	0.000135
2011	1 114.30	79.82	0.0364	0.0051	11.20	0.85	0.000045	0.000342
2012	943.63	67.77	0.0308	0.0043	14.87	1.12	0.000060	0.000455
2013	1 156.05	82.98	0.0379	0.0053	45.93	3.48	0.000186	0.001410
2014	1 097.51	77.94	0.0361	0.0050	59.00	4.47	0.000239	0.001810

YEAR	1.A.3.e.i PIPELINE TRANSPORT			
	Fuels (TJ)	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)
1990	31 844.87	1 813.95	0.031845	0.003184
1991	27 896.91	1 582.10	0.027897	0.002790
1992	23 849.64	1 347.06	0.023850	0.002385
1993	19 751.03	1 111.38	0.019751	0.001975
1994	11 923.26	668.61	0.011923	0.001192
1995	20 644.81	1 154.10	0.020645	0.002064
1996	23 809.94	1 327.35	0.023810	0.002381
1997	22 347.84	1 242.80	0.022348	0.002235
1998	22 716.02	1 260.62	0.022716	0.002272
1999	22 158.09	1 227.49	0.022158	0.002216
2000	25 523.75	1 404.81	0.025524	0.002552
2001	23 111.32	1 270.68	0.023111	0.002311
2002	19 609.14	1 077.50	0.019609	0.001961
2003	17 469.25	959.53	0.017469	0.001747
2004	25 835.29	1 417.18	0.025835	0.002584
2005	24 168.60	1 327.92	0.024169	0.002417
2006	16 410.41	902.74	0.016410	0.001641
2007	19 012.10	1 044.71	0.019012	0.001901
2008	21 881.75	1 197.99	0.021882	0.002188
2009	15 720.70	864.11	0.015721	0.001572
2010	14 961.55	824.47	0.014962	0.001496
2011	16 506.95	909.78	0.016507	0.001651

YEAR	1.A.3.e.i PIPELINE TRANSPORT			
	Fuels (TJ)	CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)
2012	7 328.28	404.80	0.007328	0.000733
2013	8 669.94	481.84	0.008670	0.000869
2014	3 260.22	179.44	0.003190	0.000319

Domestic aviation (CRF 1.A.3.a) - The inventory evaluation of GHG emissions in the subcategory Domestic aviation was performed for all GHGs and precursors as well as air pollutants. In the absence of national data on the exact numbers of domestic LTO cycles (only total national + international numbers of LTO cycles is available), summary information from the Eurocontrol database was used. According to the recommendations of the ERT during previous reviews and following the IPCC 2006 Guidelines, the emissions estimation was based on the fuel sold to national and international civil flights (tier 1 method while this is not a key category for the Slovak Republic). 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, Ruzomberok, Lucenec) are operated by aero-clubs with predominating character of sport flights. Described approach is maintained for a time series from 1990 to 2004. For time series 2005 – 2014 were used EUROCONTROL data on the number of flights, fuel consumption and division of domestic and international flights.

The fuel consumption decreased in the period 1990 – 2014 by 46%. Total GHG emissions from domestic aviation represented 4.32 Gg of CO_2 equivalents in 2014. The extensive reconstruction and rebuilding of terminals of Bratislava airport finished in 2012 and aviation transport began to slightly increase in 2014.

The increasing trend of emissions was visible in 2002 – 2008 (Table 3.28). Since 2002, air transport in the Slovak Republic has been positively affected by the penetrating entry of low cost companies, like Sky Europe Airlines, Seagle Air and Danube Wings to the Slovak market. The airports in Bratislava and Kosice are the most important and the busiest airports. It is very difficult to estimate future development in air transport due to current unstable situation in this sector. The important objectives which influence this category are, that the Slovak Republic has no official national airlines since the Slovak Airlines was out of business since 2007 and close distance of other big international airports in Vienna and Budapest.

Road transportation (CRF 1.A.3.b) - Currently, COPERT IV model, version 9.0 was used for the preparation of emission estimation in road transportation. The version of the model distinguishes vehicle categories and emission factors reflecting the recent development and research. 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 2014, the transport network included 420 km of highways, 247 km of motorways and 3 291 km of the category 1st class roads. Total roads network included 17 970 km of roads in the Slovak Republic in 2014. Road transportation is the most important subcategory within transport category with the highest share of emissions and continually increasing trend. Total aggregated emissions from road transportation reached 6 255.13 Gg of CO_2 equivalents in 2014. The increase in emissions compared to 2013 is 1%, and compared to the base year, the increase is 36%. The major share belongs to heavy duty vehicles and passenger cars. Total blended CO_2 emissions were 6 642.35 Gg in 2014. After separation of biomass content, the final CO_2 balance was 6 186.95 Gg. The biomass content is increasing and actually represents 455.39 Gg of bio-CO_2.

Table 3.28: *Overview of total GHG emissions according to the type of vehicles without separation of fossil and biomass contents in fuels in 2014*

CATEGORY OF ROAD VEHICLE	EMISSIONS (t)			CATEGORY OF ROAD VEHICLEs	EMISSIONS (t)		
	CO_2	CH_4	N_2O		CO_2	CH_4	N_2O
Passenger cars	**2 541 881**	**274.50**	**74.97**	diesel >32 t	50 207	0.99	1.41
gasoline <1.4 l	847 477	151.59	22.59	diesel 14-20 t	222 725	17.98	6.91
gasoline 1.4 l–2.0 l	462 284	69.03	10.25	diesel 20-28 t	259 017	17.51	6.36
gasoline >2.0 l	133 197	15.28	2.26	diesel 28-34 t	144 439	9.30	4.70
diesel <2.0 l	789 600	13.53	30.07	diesel 34-40 t	159 743	4.21	4.63
diesel >2.0 l	217 552	3.13	6.17	**Buses**	**387 697**	**110.33**	**3.62**
LPG	91 718	21.93	3.64	City buses CNG	30 498	84.73	0.03
Two stroke engine	53	0.01	0.00	City buses Midi <=15t	20 926	1.83	0.25
Light duty vehicles	**536 606**	**15.54**	**16.33**	City buses Stand. 15-18t	116 833	7.98	1.04
gasoline <3.5 t	119 239	10.97	5.68	City buses >18t	64 021	3.40	0.44
diesel <3.5 t	417 367	4.58	10.65	Long-line buses	155 419	12.40	1.86
Heavy duty vehicles	**3 168 532**	**221.06**	**80.83**	**Motorcycles**	**7 632**	**8.78**	**0.16**
diesel <=7.5 t	552 794	43.57	19.53	<50 cm^3 (mopeds)	904	1.58	0.02
diesel 7.5-12 t	113 563	5.63	2.08	Two stroke engine >50 cm^3	3 439	3.39	0.08
diesel 12- 4 t	64 519	2.89	1.75	Four stroke engine <250 cm^3	771	1.31	0.02
diesel 14-20 t	520 874	46.47	11.66	Four stroke engine 250-750 cm^3	1 016	1.35	0.02
diesel 20-26 t	472 065	35.32	8.74	Four stroke engine >750 cm^3	1 502	1.15	0.02
diesel 26-28 t	282 157	18.53	5.36	**Total Road Transport**	**6 642 347**	**630.21**	**175.92**
diesel 28-32 t	326 431	18.66	7.70	***Total Fossil Emissions***	***6 186 953***	***NA***	***NA***

Railways (CRF 1.A.3.c) - Rail transport is modernising with the support of the EU funds. Improved quality and ecology of rail transport and the increase in passengers' number are the objectives of this modernisation. Modernisation of rail infrastructure results in an increase of operational speed to 160 km/h and increase of safety. In 2014, the length of managed railways was 3 631 km of which the length of electric railways was 1 586 km. The railways are the second important source of emissions in transport subsector (without pipeline transport), despite the decreasing character of this transport mode. The sharp decreasing trend was stabilized in 2003 and it occurs mostly in freight transportation. Total emissions from railways transport reached 88.81 Gg of CO_2 equivalents in 2014 and they decreased by 5.9% compared to 2013 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).

Table 3.29: *Overview of GHG emissions in railways without separation of fossil and biomass contents in fuel in 2014*

EFs for the motor locomotives and wagons in kg/t of diesel oil:			***3 188***	***0.19***	***1.37***
COMPANY	**Diesel oil consumption**		**Emissions (t)**		
	(TJ)	**(t)**	**CO_2**	**CH_4**	**N_2O**
ZSSK Kosice	166.74	3 966	12 643	0.75	5.43
ZSSK Zilina	91.90	2 186	6 968	0.42	2.99
ZSSK Zvolen	262.84	6 252	19 931	1.19	8.56
ZSSK Bratislava	104.56	2 487	7 928	0.47	3.41
REGIO JET	42.40	1 008	3 215	0.19	1.38
Total public	668.43	15 899	50 685	3.02	21.78
ZSSK CARGO Kosice	142.62	3 392	10 814	0.64	4.65
ZSSK CARGO Zilina	36.92	878	2 799	0.17	1.20
ZSSK CARGO Zvolen	180.76	4 299	13 706	0.82	5.89
ZSSK CARGO Bratislava	77.65	1 847	5 888	0.35	2.53
Total CARGO	437.94	10 416	33 208	1.98	14.27
Total SR	**1 106.37**	**26 315**	**83 893**	**5.00**	**36.05**
Total SR fossil	**1 027.87**	**24 448**	**77 940**	**NA**	**NA**

Domestic Navigation (CRF 1.A.3.d) - Major share of emissions from inland shipping in Slovakia are realized as transit on the Danube River. Therefore, emissions from this transport are included in the subcategory 1.D.1b Memo items/ International bunkers/ International navigations (see also section 3.2.3). Based on the information from the State Navigation Administration (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 subcategory.

Total aggregated emissions from inland shipping excluding international navigations (on Danube River) reached 5.02 Gg of CO_2 equivalents in 2014. The increasing trend was recognized compared to the previous years and compared to the base year. Overview of activity data and emissions is in the tables below.

Pipeline transport (CRF 1.A.3.e.i) - Total volume of fuels in this subcategory expressed in energy units represented 3 190.47 TJ and total GHG emissions represented 177.96 Gg of CO_2 equivalents in 2014. The share of this subcategory on total transport emissions is 2.74%. The decrease trend of fuel consumption is related with decrease of natural gas transit in the Slovak Republic.

3.2.7.2 Methodological issues

Domestic aviation (1.A.3.a) - the Slovak Republic was using the tier 1 methodology for the emissions estimation in aviation, both for aviation gasoline and jet kerosene for the time series 1990-2004. This methodology was based on fuel sold. These categories are not key categories. Total number of the LTO cycles was known and it was used for the air pollutants inventory, not divided into national and international flights. The GHG emissions estimation is based on international rules (based on the IPCC 2006 GL) for disaggregation to national and international flights. The share of flights in both regimes was further evaluated based on expert judgment.

The airport traffic in Slovakia is determined only by the origin of air operators. It means that no direct information about numbers of domestic and internationally operated flights was known in our statistics. Therefore, the average disaggregation of consumed fuels was provided by expert judgment and verified with the information provided in the EUROCONTROL database. This approach was also discussed and explained during the in-country review 2012. Total jet kerosene for domestic flights was estimated to be 5% and the international consumption was 95% from total quantity of fuels sold. Opposite ratio was applied in the consumption of aviation gasoline: 90% for domestic flights and 10% for international flights. The ration behind is, that the larger aircrafts (operate mostly on international flights) consume jet kerosene. In opposite, the aviation gasoline is mostly consumed by smaller aircrafts (operated on national flights - Bratislava – Poprad, Bratislava – Košice).

Emissions estimation was calculated based on data directly provided by the individual airports based on detailed statistics on LTO cycles, aircrafts type, their weights and fuel consumption and type of engines.

Emission factors for CO_2 (jet kerosene and aviation gasoline) are constant values taken from the EMEP/CORINAIR Emission Inventory Guidebook. Emission factors for CH_4 and N_2O represent the average emission factors, including all phases of flight (LTO cycles – climb, cruise and descent). The emission factors for CH_4 and N_2O are provided for a representative aircraft matching to the average flight distance in the international and domestic air traffic. Data on fuel consumption and emissions in different phases of the flight of the representative aircraft set out in the Annexes of the EMEP/CORINAIR EIG, are used for the determination of emission factors.

Table 3.30: *Starting conditions for the estimation of mixed EFs in civil aviation for jet kerosene*

PARAMETER	INTERNATIONAL FLIGHTS	NATIONAL FLIGHTS
Fuel	**Jet kerosene**	
Representative aircraft	B 737-500 (400,100)	Saab 340B, EMB-120
Average flight distance	1 365 km	375 km
Average flight duration	1.75 hour	0.75 hour
Average speed	780 km/hour	500 km/hour

According to the above presented starting information and other relevant facts from the EMEP/CORINAIR EIG the following mixed emission factors were used.

Table 3.31: *Mixed emission factors for the GHG emissions in civil aviation according to tier 1 method based on fuel consumption*

PARAMETER	EMISSIONS FACTORS (g/kg of fuel)	
	International flights	National flights
Emissions	**Jet kerosene**	
CO_2	3 150	3 150
CH_4	0.104	0.35
N_2O	0.05	0.25
Emissions	**Aviation gasoline**	
CO_2	3 150	
CH_4	0.1	
N_2O	1.9	

The number of realized LTO cycles during the year at the monitored airports, the types of aircrafts and the carrying capacity of the airports are basic input information used for the emissions estimation from civil aviation. The aircrafts were divided into two weight categories: under 5.7 t and over 5.7 t. The innovated method used the emission factors for the each aircraft type and weight category.

For the period 1994 – 2004, data were directly provided by the airports on annual basis. The data for the period 1990 – 1993 are not available and were based on the expert estimation according the real LTO cycles in this period.

For the years 2005-2014 Slovakia decided to proceed to use the data from Eurocontrol in this submission. The decision follows an analysis of the national data and data obtained from Eurocontrol and the approval by the Ministry of Transport. The data are available on the basis of work of the EEA in collaboration with EUROCONTROL and DG CLIMA. These aggregated national fuel and emissions data are calculated by EUROCONTROL using a TIER3 methodology applying the Advanced Emissions Model (AEM). Considering the comparison between EUROCONTROL and national data on fuel consumption, emissions and implied emission factors, the following data were taken from Eurocontrol file to the inventory:

- 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 emissions for all subcategories

The CH_4 and N_2O emissions for all subcategories were calculated separately by using corresponding national EF and fuel consumption taken from Eurocontrol file for the years 2005 – 2014. Details of EF are in table 3.31. Net Calorific Value for Aviation Gasoline is 43.14 TJ/Gg and for Jet Kerosene 43.30 TJ/Gg. The converters were taken from Eurocontrol file. Total consumption of jet kerosene was 1 284 t and the consumption of aviation gasoline was 41 t allocated in national aviation subcategory in 2014. For the years 1990 – 2004, we did not received better and more accurate data and that is why we did not recalculated these years. Data consistency is slightly broken in aviation gasoline 2004/2005 but due to the insignificant emissions from this source in Slovakia (7 Gg in 1990 and 4 Gg in 2014), it can be considered, and that this is in line with the QA/QC.

The overview of the fuels sold at the Slovak airports during 1990 – 2004 (responses from the questionnaires) and fuel consumption in 2005 – 2014 (Eurocontrol data) is shown in Table 3.32.

Table 3.32: *The quantity of fuels and GHG emissions during 1990 – 2014 for national flights*

YEAR	AVIATION GASOLINE					JET KEROSENE				
	Consumption		Emissions (t)			Consumption		Emissions (t)		
	(TJ)	(t)	CO_2	CH_4	N_2O	(TJ)	(t)	CO_2	CH_4	N_2O
1990	9.98	233.10	734.300	0.443	0.023	95.86	2 223.00	7 002.50	0.56	0.78
1991	9.26	216.45	681.800	0.411	0.022	89.13	2 067.00	6 511.10	0.52	0.72
1992	8.55	199.80	629.400	0.380	0.020	82.40	1 911.00	6 019.70	0.48	0.67
1993	7.84	183.15	576.900	0.348	0.018	80.72	1 872.00	5 896.80	0.47	0.66
1994	7.16	167.31	527.000	0.318	0.017	68.01	1 577.32	4 968.50	0.39	0.55
1995	6.60	154.25	485.900	0.293	0.015	68.43	1 586.91	4 998.80	0.40	0.56
1996	7.17	167.62	528.000	0.318	0.017	80.76	1 872.97	5 899.90	0.47	0.66
1997	6.37	148.93	469.100	0.283	0.015	71.53	1 658.87	5 225.40	0.42	0.58
1998	5.64	131.80	415.200	0.250	0.013	65.96	1 529.62	4 818.30	0.38	0.54
1999	6.03	140.95	444.000	0.268	0.014	66.55	1 543.40	4 861.70	0.39	0.54
2000	7.61	177.71	559.800	0.338	0.018	67.61	1 567.85	4 938.70	0.39	0.55
2001	7.94	185.53	584.400	0.353	0.019	63.58	1 474.40	4 644.40	0.37	0.52
2002	8.58	200.54	631.700	0.381	0.020	66.00	1 537.82	4 821.50	0.38	0.54
2003	8.30	194.01	611.100	0.369	0.019	87.29	2 024.27	6 376.40	0.51	0.71
2004	6.03	140.86	443.700	0.268	0.014	118.08	2 738.34	8 625.80	0.69	0.96
2005	2.78	64.36	196.289	0.122	0.006	115.12	2 658.74	8 375.05	0.66	0.93
2006	3.11	72.12	219.960	0.137	0.007	147.50	3 406.50	10 730.48	0.85	1.19
2007	3.04	70.38	214.648	0.134	0.007	179.11	4 136.59	13 030.26	1.03	1.45
2008	2.58	59.80	182.388	0.114	0.006	212.31	4 903.23	15 445.17	1.23	1.72
2009	1.99	46.16	140.803	0.088	0.005	155.57	3 592.75	11 317.17	0.90	1.26
2010	2.77	64.13	195.608	0.122	0.006	71.18	1 643.80	5 177.97	0.41	0.58
2011	3.09	71.60	218.370	0.136	0.007	59.26	1 368.56	4 310.95	0.34	0.48
2012	3.46	80.11	244.335	0.152	0.008	55.80	1 288.66	4 059.28	0.32	0.45
2013	2.24	51.95	158.445	0.099	0.005	48.32	1 115.89	3 515.05	0.28	0.39
2014	1.78	41.18	125.597	0.078	0.004	55.60	1 284.11	4 044.96	0.32	0.45

Road transportation (1.A.3.b) - calculation of GHG emissions in the annual inventory 2014 was made according to the EMEP/CORINAIR EIG methodology, with the software product COPERT IV version 9.0. Therefore, it is often referred to the name of the methodology consistently with the name of the program (methodology "COPERT"). The fuel based approach is used for the calculation of CO_2 emissions from road transport. The CO_2 emissions are calculated from the fuel consumptions and others variables: (H/C ratio, carbon content). There is a fuel balance – mass of statistical and calculated fuel consumption is equal. The COPERT IV defined new vehicle categories for the calculation of CH_4 and N_2O emissions with the disaggregation into the 6 base categories and 241 subcategories. Further disaggregation was applied according to the operation of road vehicles in the agglomeration, road and highway traffic mode. In COPERT IV buses were divided into 8 sub-districts and the 2 subgroups (urban and coaches). Heavy duty vehicles are divided into 2 basic groups (rigid and articulated) and rigid vehicles are further divided by weight into 8 subgroups and articulated into 6 subgroups. This methodology for the calculation of emissions uses the technical parameters on the types of vehicles and the 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 and additional information (age of vehicles), 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.

Table 3.33: *Overview of input data in COPERT IV version 9.0 program in 2014*

CATEGORY OF ROAD VEHICLES	ACTIVITY DATA		
	Number	**Average of fuel consumption (l/100 km)**	**Average mileage (km/veh)**
Passenger cars	**2 004 661**	**7.31**	**4 961.23**
gasoline < 1.4 l	788 679	7.21	3 404.96
gasoline 1.4-2.0 l	360 277	8.36	4 450.72
gasoline > 2.0 l	54 458	10.13	5 591.62
diesel < 2.0 l	610 738	6.19	6 611.39
diesel > 2.0 l	134 728	7.98	6 341.94
LPG	55 691	10.00	8 254.51
two stroke engine	90	10.90	2 245.52
Light duty vehicles	**180 758**	**10.06**	**9 583.96**
gasoline < 3.5 t	44 420	12.21	7 774.83
diesel < 3.5 t	136 338	9.36	10 173.39
Heavy duty vehicles	**153 267**	**27.64**	**50 851.81**
diesel <= 7.5 t	58 963	13.23	24 421.40
diesel 7.5-12 t	8 307	19.05	23 948.22
diesel 12-14 t	4 255	20.54	24 973.44
diesel 14-20 t	22 347	23.72	32 596.91
diesel 20-26 t	12 904	26.28	42 520.57
diesel 26-28 t	7 741	27.90	43 834.96
diesel 28-32 t	7 741	32.02	43 966.40
diesel > 32 t	2 580	30.65	21 687.46
diesel 14-20 t	14 783	21.80	23 724.77
diesel 20-28 t	7 107	26.71	46 122.01
diesel 28-34 t	3 412	27.65	50 866.96
diesel 34-40 t	3 127	30.82	37 164.43
Buses	**8 796**	**29.33**	**29 593.53**
City buses CNG	255	49.00	86 290.80
City buses Midi <=15 t	855	21.95	29 442.37
City buses Stand. 15-18 t	2 989	29.40	34 949.68
City buses >18 t	1 281	37.83	34 844.52
Long Line buses	3 416	26.46	18 743.23
Motorcycles	**81 851**	**3.49**	**1 119.51**

CATEGORY OF ROAD VEHICLES	ACTIVITY DATA		
	Number	Average of fuel consumption (l/100 km)	Average mileage (km/veh)
< 50 cm^3 (mopeds)	26 418	2.59	683.65
Two stroke engine > 50 cm^3	40 278	3.74	1 032.57
Four stroke engine < 250 cm^3	5 800	3.63	1 835.90
Four stroke engine 250-750 cm^3	4 475	4.21	2 148.31
Four stroke engine > 750 cm^3	4 880	5.49	2 401.89
Total road transportation	**2 429 333**	**8.30**	**6 897.41**

The EFs values for CH_4 and N_2O in COPERT IV version 9.0 are defined separately for the different types of fuels, types of vehicles and the different technological level of cars. In case of CH_4 emissions, the balance is based also on the average speed and drive mode for certain passenger cars. The emission factors for the group of 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 calculated automatically by the COPERT IV 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.

The accurate and more actual data on other distance-based values and parameter values those are necessary to run the COPERT IV model. 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 IV model, including consistency with fuel consumption. Main source for emissions estimation such as intensity on urban, rural and highways is the Traffic Census of Slovakia, conducted every five years (2000, 2005 and 2010).

Regarding non-CO_2 emissions, the values used for setting and calculating the emission factors and the corresponding emissions in the COPERT IV model, were verified and discussed in the previous years. The results of a comparative assessment of CH_4 and N_2O emissions, which showed that the emission estimates for Slovakia, were comparable with those of other European countries and therefore the used emission factors in the COPERT model are fully in agreement with the national circumstances.

The IEF used in the COPERT model consider average emissions from road transport vehicles in Europe and are in good agreement with the national circumstances. The IEF used in COPERT model are regularly updated and verified (as outcomes of the experimental studies).

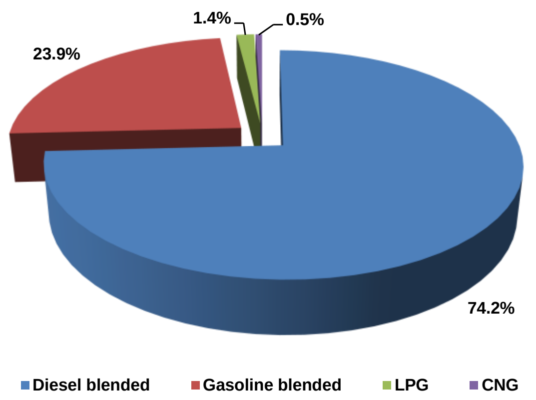
The emissions from this sector have an increasing trend and they are the key sources in level and trend assessment for uncertainty management. The emissions inventory includes also the emissions from light and heavy-duty vehicles, buses operated by CNG (compressed natural gas). The input parameters for CNG buses are known only since 2000. It is assumed, that before year 2000, CNG consumption was negligible. The consumption of CNG as fuel can neither be used for a diesel engine nor for a gasoline one 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 emission performance may vary significantly. Therefore CNG buses also need to fulfil a specific emission standard (Euro II, Euro III, etc.). Due to the low NO_x and PM performance compared to diesel, an additional emission 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 or Euro III, Euro IV and Euro V.

Table 3.34: Results from COPERT IV in distribution for agglomeration mode (CO_2 emissions are from blended fuels with bio-component) in 2014

TRAFFIC	EMISSIONS (t)		
	CO_2	CH_4	N_2O
City	2 796 305	412	79
Road	2 862 997	185	77
Highway	983 044	33	19
Total SR	**6 642 347**	**630**	**176**

Important information about the import, production, distribution and sale of gasoline and diesel oil were received from domestic producer of fuels – Slovnaft Ltd. Bratislava and 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. The data about the distribution and the sale of LPG and CNG fuels 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 SNE. The statistical information about fuels sold in the Slovak Republic is verified with the results of the COPERT IV model and the differences are not higher than 2%. According to the statistical information the diesel oil represents 74% share on fuel balance, followed by gasoline with 24% share, then LPG (1.4%) and CNG (0.5%).

Figure 3.13: Comparison of fuel´ balance from statistics and COPERT IV model results in 2014



1.A.3.b FUEL COMBUSTION (t)	
Diesel oil blended	1 570 321.70
Gasoline blended	505 047.79
LPG	30 334.89
CNG	11 047.38

According to the recommendations of the ERT in the previous review process, blending of biomass in liquid fuels was considered and the emission data were calculated since 2007. The information was obtained from 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 following share of biomass in liquid fuels in transport was calculated as bio-component percentage, by weight of the total weight of the fuel (as input data to the COPERT model are in the mass units):

- In 2005 and 2006, the content of bio-component in fuel was value near 0%.
- In 2007, it was 2.73% for gasoline and 3.99% for diesel.
- In 2008, it was 1.48% for gasoline and 4.63% for diesel.
- In 2009, it was 3.05% for gasoline and 4.97% for diesel.
- In 2010, it was 3.51% for gasoline and 5.09% for diesel.
- In 2011, it was 3.81% for gasoline and 5.80% for diesel.
- In 2012, it was 3.94% for gasoline and 5.53% for diesel.
- In 2013, it was 4.34% for gasoline and 6.00% for diesel.
- In 2014, it was 6.63% for gasoline and 7.10% for diesel

Table 3.35: Estimated activity data and emissions from biomass share in 2007 – 2014

YEAR	2007	2008	2009	2010
Biomass (TJ)	2 677.29	2 795.75	3 090.30	3 581.21
CO_2 emissions (Gg)	228.87	238.59	264.10	305.97
CH_4 emissions (Gg)	0.03	0.02	0.02	0.03
N_2O emissions (Gg)	0.01	0.01	0.01	0.01

YEAR	2011	2012	2013	2014
Biomass (TJ)	3 893.11	3 833.05	4 039.49	5 129.86
CO_2 emissions (Gg)	337.44	335.13	353.71	455.39
CH_4 emissions (Gg)	0.03	0.02	0.03	0.04
N_2O emissions (Gg)	0.01	0.01	0.01	0.01

In this submission, the biomass share correction were provided for the years 2007 – 2014. The share of biomass were calculated based on data on total weight of fuel blended and weight of bio-components. In calculations there were used NCV 36 TJ/Gg for ETBE, NCV 26 TJ/Gg for ethanol and NCV 37 TJ/Gg for Esters. ETBE (Ethyl tercbutylether) is only "bio" for its ethanol-part. According to the European Biofuels Directive, this means 47% of ETBE by volume and by energy. Because in our calculations data in mass unites are used, also 47% by weight were considered as bio ETBE. 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 of gasoline and diesel oil with their emissions and biomass share

GASOLINE	2007	2008	2009	2010
Biomass share % (energy)	2.26	1.22	2.53	2.90
Gasoline blended (TJ)	28 902.816	29 324.481	27 980.040	26 870.031
Biomass (TJ)	652.261	358.172	706.723	780.216
Gasoline fossil (TJ)	28 250.555	28 966.309	27 273.317	26 089.815
CO_2 Gasoline blended (Gg)	2 065.958	2 092.159	2 000.035	1 923.127
CO_2 Biomass (Gg)	56.400	30.975	61.085	67.408
CO_2 Gasoline fossil (Gg)	2 009.558	2 061.184	1 938.950	1 855.718
CH_4 Gasoline blended (Gg)	0.425	0.470	0.418	0.368
CH_4 Biomass (Gg)	0.012	0.007	0.013	0.013
CH_4 Gasoline fossil (Gg)	0.413	0.463	0.405	0.355
N_2O Gasoline blended (Gg)	0.092	0.118	0.117	0.060
N_2O Biomass (Gg)	0.003	0.002	0.004	0.002
N_2O Gasoline fossil (Gg)	0.089	0.116	0.113	0.058
DIESEL OIL	**2007**	**2008**	**2009**	**2010**
Biomass share % (energy)	3.52	4.08	4.38	4.49
Diesel oil blended (TJ)	57 610.417	59 734.866	54 397.252	62 430.566
Biomass (TJ)	2 025.029	2 437.576	2 383.580	2 800.991
Diesel oil fossil (TJ)	55 585.388	57 297.290	52 013.673	59 629.574
CO_2 Diesel oil blended (Gg)	4 321.789	4 484.513	4 085.524	4 689.557
CO_2 Biomass (Gg)	172.474	207.610	203.012	238.563
CO_2 Diesel oil fossil (Gg)	4 149.316	4 276.903	3 882.512	4 450.994
CH_4 Diesel oil blended (Gg)	0.341	0.295	0.240	0.269
CH_4 Biomass (Gg)	0.014	0.014	0.012	0.014
CH_4 Diesel oil fossil (Gg)	0.328	0.281	0.228	0.255
N_2O Diesel oil blended (Gg)	0.105	0.095	0.088	0.117

GASOLINE	2007	2008	2009	2010
N_2O Biomass (Gg)	0.004	0.004	0.004	0.006
N_2O Diesel oil fossil (Gg)	0.100	0.091	0.084	0.111

GASOLINE	2011	2012	2013	2014
Biomass share % (energy)	2.93	2.91	3.15	4.64
Gasoline blended (TJ)	24 494.293	24 476.654	23 069.519	21 710.305
Biomass (TJ)	716.583	711.351	727.558	1 007.164
Gasoline fossil (TJ)	23 777.710	23 765.303	22 341.962	20 703.141
CO_2 Gasoline blended (Gg)	1 755.913	1 758.401	1 651.805	1 569.881
CO_2 Biomass (Gg)	66.896	69.248	71.632	104.142
CO_2 Gasoline fossil (Gg)	1 689.017	1 689.153	1 580.173	1 465.738
CH_4 Gasoline blended (Gg)	0.332	0.309	0.294	0.256
CH_4 Biomass (Gg)	0.013	0.012	0.013	0.017
CH_4 Gasoline fossil (Gg)	0.319	0.297	0.281	0.239
N_2O Gasoline blended (Gg)	0.057	0.053	0.053	0.041
N_2O Biomass (Gg)	0.002	0.002	0.002	0.003
N_2O Gasoline fossil (Gg)	0.055	0.051	0.051	0.038
DIESEL OIL	**2011**	**2012**	**2013**	**2014**
Biomass share % (energy)	5.12	4.88	5.32	6.30
Diesel oil blended (TJ)	62 025.400	63 989.123	62 209.242	65 459.123
Biomass (TJ)	3 176.525	3 121.695	3 311.932	4 122.693
Diesel oil fossil (TJ)	58 848.875	60 867.428	58 897.309	61 336.430
CO_2 Diesel oil blended (Gg)	4 664.516	4 810.562	4 698.080	4 950.250
CO_2 Biomass (Gg)	270.547	265.878	282.080	351.251
CO_2 Diesel oil fossil (Gg)	4 393.968	4 544.684	4 415.999	4 598.999
CH_4 Diesel oil blended (Gg)	0.237	0.231	0.237	0.268
CH_4 Biomass (Gg)	0.014	0.013	0.014	0.019
CH_4 Diesel oil fossil (Gg)	0.223	0.218	0.223	0.249
N_2O Diesel oil blended (Gg)	0.129	0.132	0.127	0.131
N_2O Biomass (Gg)	0.008	0.007	0.008	0.009
N_2O Diesel oil fossil (Gg)	0.122	0.125	0.120	0.122

Railways (1.A.3.c) - railways transport represents the operation of diesel traction using the simple methodology tier 1 according to the IPCC 2006 Guidelines. The emissions of greenhouse gases are calculated from the consumed fuels by diesel rail traction multiplied by the appropriate emission factor.

The emission factor is the average value for the entire performance spectrum of the driving motor vehicles traction. The emission factors for CH_4 and N_2O are based on the EMEP/CORINAIR EIG - Other mobile sources and machinery.

The consumption of diesel oil for the motor traction in the Slovak Republic was obtained from the Railways Company, Ltd. for the whole 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 the Railways Company Ltd. of the Slovak Republic (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 the Railways Company Ltd. since 2002 (Bratislava, Zvolen, Zilina and Kosice). Tables 3.37 and 3.38 show activity data and statistical information for inventory preparation and Figure 3.14 shows diesel oil consumption. Fuel consumption of the new companies operated on the Slovak rails (REGIOJET) are also included in inventory.

Because of blending of biomass in liquid fuels was considered, the emission data were recalculated since 2007 in these submissions. The information was obtained from 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, by weight of the total weight of the fuel. More information is in the section Road Transportation.

Table 3.37: *Overview of activity data used in GHG inventory for railways transport in 2014*

DEPOTS	Kosice	Zilina	Zvolen	Bratislava	Total public	Total CARGO	REGIO JET	Total SR
Number of loco	166	89	155	100	266	255	11	521
km per year	4 665 224	2 964 683	7 283 305	3 293 757	14 618 740	4 893 788	1 129 551	19 512 528
Operations (hrtkm)x1000	459 530	251 898	1 422 841	331 584	1 353 432	1 224 360	112 111	2 577 792
Consumption (l) (blended)	8 759 614	3 647 404	12 560 800	5 159 315	18 927 028	12 400 563	1 117 418	31 327 591
Consumption (t) (blended)	7 358	3 064	10 551	4 334	15 899	10 416	939	26 315

Figure 3.14: *Overview of diesel oil consumption for railways transport in 1990 – 2014*

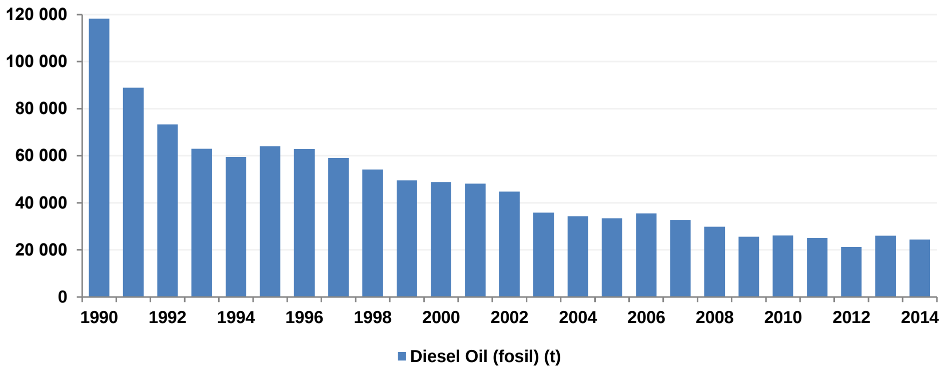


Table 3.38: *Overview of emission factors used in GHG inventory for railways transport*

YEAR	Number of loco (piece)	Annual mileage (km)	EMISSIONS (t) CO_2	CH_4	N_2O	Electricity consumption (kWhour)
		EFs (kg/t diesel oi)l since 1990:	***3 188***	***0.25***	***1.37***	
1990	1 192	63 432 669	376 771	29.50	161.91	988 025 749
		EFs (kg/t diesel oil) since 1995:	***3 188***	***0.19***	***1.37***	
1995	1 048	43 939 323	204 070	12.20	87.70	865 433 335
2000	942	33 107 441	155 752	9.30	66.90	771 684 905
2001	897	34 520 572	153 612	9.20	66.00	776 114 735
2002	827	32 487 038	142 695	8.50	61.30	750 479 518
2003	827	26 745 426	114 131	6.80	49.00	723 807 222
2004	745	28 181 618	109 452	6.52	47.04	691 844 644
2005	741	22 015 896	106 590	6.00	46.00	697 766 836
2006	710	26 694 902	113 239	6.75	48.66	679 141 999
2007	645	27 299 805	104 333	6.48	46.70	680 115 929
2008	677	25 950 301	95 132	5.94	42.87	591 114 612
2009	653	32 078 886	81 636	5.12	36.92	526 693 646
2010	619	21 223 547	83 337	5.23	37.73	564 500 847
2011	648	17 488 032	79 824	5.05	36.42	621 626 121
2012	520	19 306 859	67 772	4.28	30.83	616 337 159
2013	498	19 653 087	82 983	5.26	37.94	559 310 516
2014	521	19 512 528	77 940	5.00	36.05	619 889 695

Domestic navigation (1.A.3.d) – this subcategory includes emission from national shipping between ports on Danube River and domestic shipping on lakes and dams for touristic purposes.

Shipping between Slovak ports on Danube River: 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 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. The NIS expert was informed that they register a total number of ships and boats operated except the Danube River, but without information about their activity or fuel consumption. The expert was also informed about the web portal www.plavba.net, where information about national tourist shipping on rivers and dams in the Slovak Republic is registered. The emissions of greenhouse gases are calculated from the consumed fuel by diesel motor boats multiplied by emission factor.

Table 3.39: *Overview of GHG emission inventory in inland shipping in 1990 – 2014*

YEAR	CONSUMPTION		EMISSIONS (kg)			
	(TJ)	(t)	CO_2	CH_4	N_2O	Total CO_2 eq.
1990	0.30	7.14	22 750.68	1.21	9.21	25 524.36
1991	0.26	6.10	19 434.93	1.04	7.86	21 804.37
1992	0.24	5.69	18 128.68	0.97	7.34	20 338.87
1993	0.25	5.79	18 473.48	0.99	7.48	20 725.70
1994	0.26	6.15	19 619.76	1.05	7.94	22 011.73
1995	0.27	6.51	20 766.04	1.11	8.40	23 297.76
1996	0.30	6.97	22 207.79	1.18	8.99	24 915.29
1997	0.31	7.27	23 179.60	1.24	9.38	26 005.58
1998	0.32	7.59	24 197.82	1.29	9.79	27 147.94
1999	0.32	7.59	24 205.28	1.29	9.79	27 156.31
2000	0.33	7.70	24 533.92	1.31	9.93	27 525.01
2001	0.34	7.96	25 368.55	1.35	10.27	28 461.40
2002	0.35	8.34	26 574.09	1.42	10.75	29 813.92
2003	0.37	8.73	27 832.26	1.48	11.26	31 225.48
2004	0.39	9.18	29 266.98	1.56	11.84	32 835.11
2005	0.47	11.08	35 327.23	1.88	14.29	39 634.20
2006	4.28	101.48	323 525.76	17.25	130.91	362 968.91
2007	4.50	106.56	339 708.39	18.11	137.46	381 124.47
2008	4.74	112.20	357 699.21	19.07	144.74	401 308.67
2009	4.35	102.94	328 168.41	17.50	132.79	368 177.57
2010	4.41	104.49	333 114.15	17.76	134.79	373 726.28
2011	11.20	265.31	845 813.53	45.10	342.25	948 932.21
2012	14.87	352.35	1 123 280.58	59.90	454.53	1 260 227.08
2013	45.93	1 092.89	3 484 122.71	185.79	1 409.82	3 908 894.97
2014	59.00	1 403.26	4 473 606.47	238.55	1 810.21	5 019 013.19

Table 3.40: *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 – 2014*

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
	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**

The inland shipping except the Danube River occurs in the Slovak Republic, however in limited extent. There are four relevant shipping routes in the Slovak Republic:

- River – basin of the Vah (Piestany, Trencin, Liptovska Mara dam),
- The tributary river of the Vah (Oravska priehrada dam),
- River – basin of the Bodrog (Zemplinska Sirava dam).

While the public and tourist shipping activities in the Slovak Republic are not very frequent and have expanded only in the recent years, it was necessary to propose an appropriate methodological approach for emission 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 l of diesel oil per hour of work. The consumption of diesel oil in t was calculated using average density of 0.84 kg/dm^3.

- The average emission factors for CO_2, CH_4 and N_2O emissions:

According to the EMEP/CORINAIR Emission Inventory Guidebook, 2006, Table 8-1, Agriculture (Bulk emission factors for 'Other Mobile Sources and Machinery', diesel engines), the default for methane and N_2O are: EF (CH_4) is 0.17 g/kg and EF (N_2O) is 1.29 g/kg. The default emission factor for CO_2 was taken from the Revised 1996 IPCC GL, Reference Manual, Table 1-47: EF (CO_2) is 3 188 g/kg, which corresponds to the IPCC 2006 GL Table 3.5.2: EF(CO_2) is 74 100 kg/TJ.

Table 3.41: *The emission estimation for national shipping for touristic purposes (CRF 1.A.3.d) in 2014*

2014	LOCATION							
ACTIVITY DATA	**Piestany long trip**	**Piestany short trip**	**Trencin**	**Liptovska Mara**	**Oravska Priehrada short trip**	**Oravska Priehrada long trip**	**Zemplinska Sirava**	**TOTAL SR**
Number of Trips (per year)	205	74	36	262	112	90	258	**1 037**
Duration of Trip (hours)	1.42	0.92	0.35	1	0.5	1.5	0.75	
Total Duration (hours/year)	291	68	13	262	56	135	194	**1 018**
Fuel Consumption (l/hour)	12	12	12	12	12	12	12	
Total Consumption (l/year)	3 493	817	151	3 144	672	1 620	2 322	**12 219**
Total Consumption (kg/year)	2 934	686	127	2 641	564	1 361	1 950	**10 264**
EF CO_2 (g/kg):	***3 188***							
CO_2 Emissions (kg/year)	9 355	2 188	405	8 419	1 800	4 338	6 218	**32 722**
EF CH_4 (g/kg):	***0.17***							
CH_4 Emissions (kg/year)	0.50	0.12	0.02	0.45	0.10	0.23	0.33	**1.74**
EF N_2O (g/kg):	***1.29***							
N_2O Emissions (kg/year)	3.79	0.89	0.16	3.41	0.73	1.76	2.52	**13.24**
Total GHG in CO_2 eq. (t/year)	**10.49**	**2.45**	**0.45**	**9.45**	**2.02**	**4.87**	**6.98**	**36.71**

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. The tier 2 methodology and the country specific emission factor was used for the CO_2 emission estimation for pipeline transport. The emission factor for combustion of natural gas is 55.58 t (CO_2)/TJ in 2014. The fuel consumption and GHG emissions are shown in the Table 3.27.

Other/Urea Based Catalysts (1.A.3.e.ii) – The CO_2 emissions from urea based catalysts were estimated using COPERT model for vehicle category Heavy duty trucks Euro V 2008 Standards for the year 2014. The emissions of CO_2 for the year 2010 – 2013 are included in 1.A.3.b.iii. The fuel consumption of diesel oil corresponding heavy duty trucks with SCR are included in 1.A.3.b.iii as this is not energy emissions.

3.2.7.3 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.

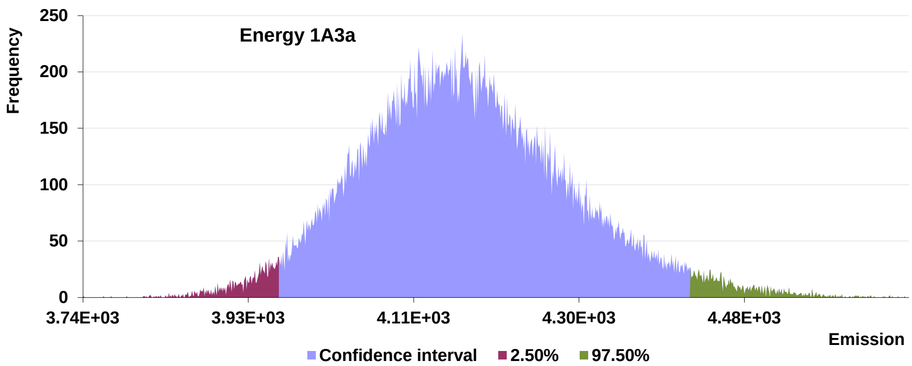
The Slovak Republic was using the tier 1 methodology for the emissions estimation in aviation, both for aviation gasoline and jet kerosene for the time series 1990 – 2004. For the years 2005 – 2014 the Slovak Republic decided to proceed to use the data from Eurocontrol using a tier 3 methodology applying the Advanced Emissions Model (AEM) in this submission. Data consistency is slightly broken in aviation gasoline 2004/2005 but due to the insignificant emissions from this source in Slovakia (7 Gg in 1990 and 4 Gg in 2014), it can be considered, and that this is in line with the QA/QC.

The average mean value of GHG emissions for the 1.A.3.a subcategory obtained by the Monte Carlo simulation is 4.17 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 4.17 Gg. Confidence interval (95%) is within the range: <3.96; 4.42>, which represents the uncertainty by relative values to the mean value: -5.02%; +6.06%. The following table and graph described calculated results of uncertainty analyses.

Table 3.49: *Selected statistical characteristics for 1.A.3.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
4.16	**4.17**	0.12	3.74	4.67	-5.02%	6.06%

Figure 3.26: *Probability density function for 1.A.3.a in tons of CO_2*



Road transportation (1.A.3.b) - trend in the production of CO_2 and N_2O emissions from road transportation corresponds with the consumption of the liquid fuels. Emission factors are different in individual years. The variability is caused by changes in inputs like vehicle fleet and fuel consumption. Until 2008, trend of gasoline consumption had fluctuated and after 2008, the trend is decreasing due to the improvement in fuel consumption. The trend of diesel consumption has been increasing since 1990, but it is more stable in the recent years. This was caused by the variation of fuel prices for transit transport, the development of construction, commercial, industrial activity, economic development and, of course, by the trend of increasing numbers of new cars within the commercial market of the Slovak Republic, which significantly determines the development of the emissions from transport.

In 2014, the number of new diesel passenger cars increased. Emissions of N_2O decreased, given that emission factors decreased in newer vehicles. Regarding CH_4 emissions, the alteration of vehicles to vehicles with better environmental and energetic parameters (mostly passenger cars with catalysts) is primarily important. The elimination of negative influences of road transport continues with the increase of LPG and CNG vehicles (mostly buses and duty vehicles). Increasing quality of the emission inventory from transport depends closely on the reduction and removal of the following uncertainties:

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

The quality of calculated results by COPERT IV 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 IV 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.

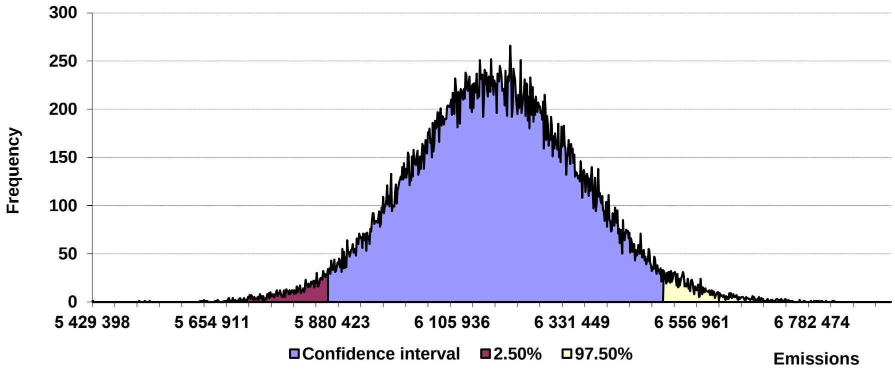
The consistency of time series was improved by the use of most updated version of COPERT version 9.0 model for the whole time series.

The average mean value of GHG emissions for the 1.A.3.b subcategory obtained by the Monte Carlo simulation is 6 188 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 6 187 Gg. Confidence interval (95%) is within the range: <5 429; 6 933>, which represents the uncertainty by relative values to the mean value: -4.93%; +5.10%. The following table and graph described calculated results of uncertainty analyses.

Table 3.50: *Selected statistical characteristics for 1.A.3.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
6 185.722	**6 187.579**	158.417	5 429.398	6 932.815	-4.93%	5.10%

Figure 3.27: *Probability density function for 1.A.3.b in tons of CO_2*



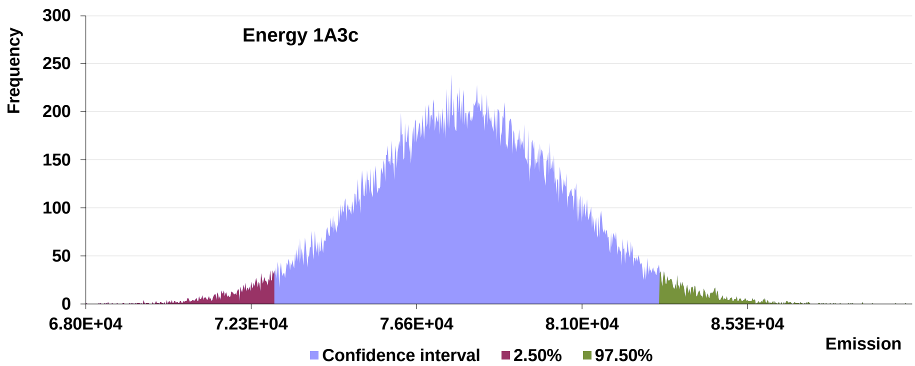
Railways (1.A.3.c) - methodology, activity data and used emission factors for diesel oil are consistent for the whole time series. The blending of biomass in liquid fuels was considered since 2007 in these submissions.

The average mean value of GHG emissions for the 1.A.3.c subcategory obtained by the Monte Carlo simulation is 77.92 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 77.94 Gg. Confidence interval (95%) is within the range: <72.91; 82.98>, which represents the uncertainty by relative values to the mean value: -6.43%; +6.50%. The following table and graph described calculated results of uncertainty analyses.

Table 3.51: *Selected statistical characteristics for 1.A.3.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
77.90	**77.92**	2.57	67.97	89.62	-6.43%	6.50%

Figure 3.28: *Probability density function for 1.A.3.c in tons of CO_2*



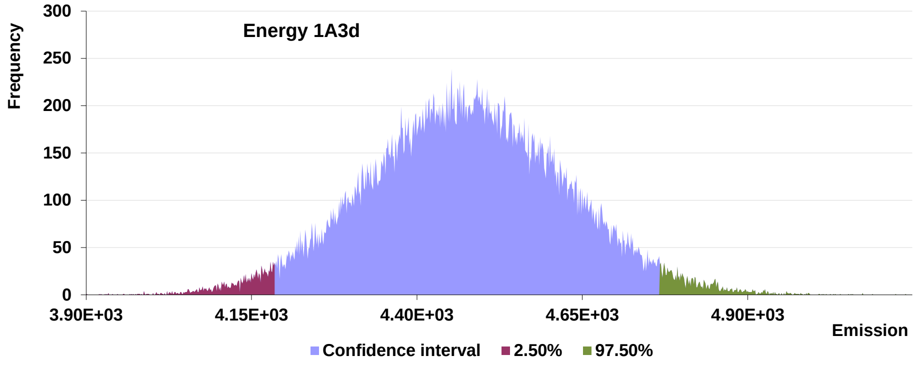
Domestic navigation (1.A.3.d) - emissions from domestic navigation represent emissions from shipping on lakes for the period 1990 – 2004 and emissions from shipping on lakes and movements between national ports on Danube River for the years 2005 – 2014. The time series consistency was improved in previous 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 subcategory obtained by the Monte Carlo simulation is 4.47 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 4.47 Gg. Confidence interval (95%) is within the range: <4.19; 4.76>, which represents the uncertainty by relative values to the mean value: -6.43%; +6.50%. The following table and graph described calculated results of uncertainty analyses.

Table 3.52: *Selected statistical characteristics for 1.A.3.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
4.47	**4.47**	0.15	3.90	5.14	-6.43%	6.50%

Figure 3.29: *Probability density function for 1.A.3.d in tons of CO_2*



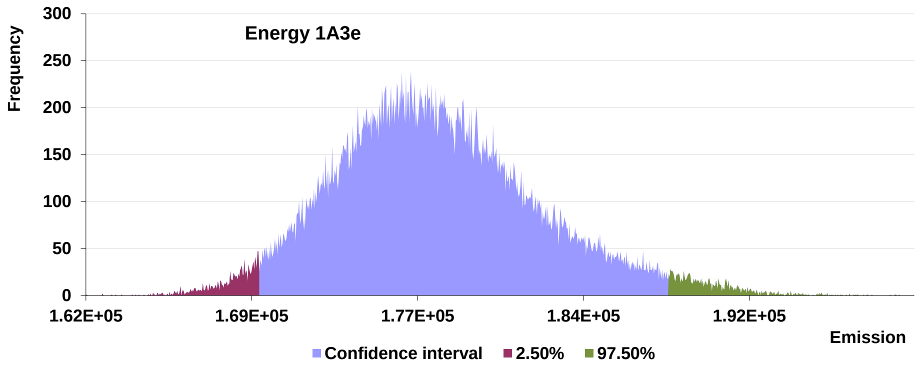
Pipeline transport (1.A.3.e.i) - methodology, activity data and used emission factors for natural gas are consistent in the time series and categories.

The average mean value of GHG emissions for the 1.A.3.e.i subcategory obtained by the Monte Carlo simulation is 178 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 178 Gg. Confidence interval (95%) is within the range: <170; 188>, which represents the uncertainty by relative values to the mean value: -4.55%; +5.90%. The following table and graph described calculated results of uncertainty analyses.

Table 3.53: *Selected statistical characteristics for 1.A.3.e.i, 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
177.34	**177.76**	4.65	161.81	199.45	-4.55%	5.90%

Figure 3.30: *Probability density function for 1.A.3.e.i in tons of CO_2*



3.2.7.4 Category-specific QA/QC and verification

Category specific QA/QC plan is based on the general QA/QC plan described in Chapter 1.6. The emission inventory of transport was 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 Environment, the Ministry of Transport and Regional Development and the SHMU to establish more formal frame for sustainable cooperation between ministries and their institutions (SHMU and the Transport Research Institute). The formal contract on bilateral cooperation was performed based on the EU ETS in aviation legislative (Directive No 101/2008/EC).

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 EUROCONTROL and the UNFCCC reporting data in aviation is provided by the individual 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 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 expert 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 SNE 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 emission inventory in the road transportation are based on the cooperation of several experts and institutions. The activity data and input parameters provided from the different data sources are collected and then checked for the basic quality criteria (consistency, transparency, etc.) and archived by the SNE and sectoral experts. The Transport Research Institute is responsible for the data collection from different subjects in transport. Data manager of the SNE is responsible for the verification of these input parameters. Transport sectoral expert is responsible for the emissions calculation by the COPERT model.

The preliminary results of emission inventory are sent to other subjects (SNE, Transport Research Institute, 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 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 (SNE, Transport Research Institute, Ministry of Transport, Construction and Regional Development of the Slovak Republic) for checking and QC activities. The QC verification process includes the exercise 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.

Pipeline transport (1.A.3.e.i) - information of category specific QA/QC and verification are described in section 3.2.5.4.

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

3.2.7.5 Category-specific recalculations

Domestic aviation (1.A.3.a) - For the years 2005-2014 Slovakia decided to proceed to use the data from Eurocontrol in this submission. The decision follows an analysis of the national data and data obtained from Eurocontrol and the approval by the Ministry of Transport, Construction and Regional Development of the Slovak Republic. The data are available on the basis of work of the EEA in collaboration with EUROCONTROL and DG CLIMA. Recalculations were in:

- Aviation Gasoline for fuel consumption and emissions of CO_2, CH_4 and N_2O in 2005 – 2013;
- Jet Kerosene for fuel consumption and emissions of CO_2, CH_4 and N_2O in in 2005 – 2013.

Road transportation (1.A.3.b) - In this submission, the biomass share correction were provided for the years 2007 – 2013. The share of biomass were calculated based on data on total weight of fuel blended and weight of bio-components. In calculations there were used NCV 36 TJ/Gg for ETBE, NCV 26.8 TJ/Gg for ethanol and NCV 37.3 TJ/Gg for esters. Recalculations of fuel consumption and emissions of CO_2, CH_4 and N_2O were in 1.A.3.b.i-iv for gasoline, diesel oil and biomass.

The next recalculations concerned allocation of fuel consumption and emissions of CO_2, CH_4 and N_2O from subcategory 1.A.3.b.i into subcategories 1.A.3.b.ii-iv for the 1990 – 2009 for gasoline and diesel oil and for the 2007 – 2009 for biomass.

The next recalculations concerned correction of NCV values based on statistical data. Recalculations were in fuel consumption (TJ):

- for gasoline in 1990 – 2013
- for diesel oil in 1990 – 2013
- for biomass in 2007 – 2013
- for LPG in 1994 – 2013
- for gaseous fuels in 2000 – 2013.

Railways (1.A.3.c) - In this category, the consideration of biomass share were provided for the years 2007 – 2013 for the first time in this submission. The share of biomass were calculated based on data on total weight of fuel blended and weight of bio-components. In calculations there were used NCV 37.3 TJ/Gg for esters. Recalculations of fuel consumption and emissions of CO_2, CH_4 and N_2O were for liquid fuels (diesel oil) and biomass for 2007 – 2013.

Domestic navigation (1.A.3.d) - Recalculations concerned correction of NCV values based on statistical data. Recalculations were in fuel consumption (TJ) for Gas diesel oil for 1990 – 2013.

Pipeline transport (1.A.3.e.i) – No recalculation were provided.

Other/Urea Based Catalysts (1.A.3.e.ii) – In this submission the emissions of CO_2 from urea based catalysts are estimated for the year 2014 in transport sector. The fuel consumption of diesel oil corresponding the heavy duty trucks with SCR are included in 1.A.3.b.iii as this is not energy emissions.

3.2.7.6 Category-specific planned improvements

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

Road transportation (1.A.3.b) – No specific improvements are 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 inventory submissions. A detailed analysis of the data on the content of bio-components in liquid fuels with the correction of CO_2 emissions will be ready for the next submission.

Domestic navigation (1.A.3.d) - the information about inland tourists shipping in the Slovak Republic can be collected in more details and updated data on small lakes and rivers can be collected.

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) –The reallocation of CO_2 emissions from urea based catalysts from transport sector into IPPU sector is planned in the next submissions. The estimation of CO_2 emission for the year 2010 – 2013 is planed also in the next submission.

3.2.8 OTHER SECTORS (CRF 1.A.4)

3.2.8.1 Category description

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 28 641.28 TJ in 2014. Total CO_2 emissions were 1 560.62 Gg, total CH_4 emissions were 0.40 Gg and total N_2O emissions in this subcategory were 0.011 Gg in 2014.

Residential (1.A.4.b) - Total volume of fuels in this subcategory expressed in energy units represented 66 171.35 TJ in 2014. Total CO_2 emissions were 2 651.23 Gg, total CH_4 emissions were 6.92 Gg and total N_2O emissions were 0.09 Gg in 2014. 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 2 680.77 TJ in 2014. Total CO_2 emissions were 95.67 Gg, total CH_4 emissions were 0.012 Gg and total N_2O emissions were 0.0016 Gg in 2014. The fuels are allocated among solid, liquid, gaseous and biomass fuels categories.

3.2.8.2 Methodological issues

A description of the general methodologies used for GHG emissions estimation from fuel combustion is given in the Section 3.2.5.2. Activity data (emission factors and NCVs) are collected from several sources (in agreement with the other energy subcategories):

- Annual energy balance (publication Energy,[5] published by the Statistical Office of the Slovak Republic, annually);
- Disaggregated data provided by the Statistical Office of the Slovak Republic (restricted from public, provided only for the SNE);
- The NEIS Central database.

The activity data allocated in the subcategory 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.

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

Table 3.42: *Overview of the country or plant specific CO_2 emission factors in 1.A.4 in 2014*

1.AA.4.a	WEIGHTED EF CO_2 (t/TJ)	FUEL TYPE	EF C (t/TJ)	EF CO_2 (t/TJ)
Liquid	65.47	Liquefied petroleum gases	17.22	63.15
		Gas/Diesel oil	20.44	74.95
		Residual fuel oil	21.36	78.34
		Other petroleum products	20.00	73.33
Solid	90.88	Lignite	27.91	102.32
		Brown coal briquettes	26.60	97.53
		Other bituminous coal	26.41	96.85
		Gas coke	22.00	80.67
Gaseous	55.72	Natural Gas	15.20	55.72
Biomass	77.15	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)**
Solid	99.98	Other bituminous coal	26.41	96.85
		Lignite	27.91	102.32
		Brown coal briquettes	26.60	97.53
		Gas coke	29.20	107.07
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	64.27	Liquefied petroleum gases	17.22	63.15
		Gas/Diesel oil	20.44	74.95
		Gasoline	18.10	66.37
		Diesel oil	20.44	74.95
Solid	97.48	Lignite	27.91	102.32
		Gas coke	22.00	80.67
		Other bituminous coal	26.41	96.85
		Brown coal briquettes	26.60	97.53
Gaseous	55.72	Natural gas	15.20	55.72
Biomass	69.67	Other biogas	14.90	54.63
		Wood/Wood waste	30.50	111.83
		Other primary Solid biomass	27.30	100.10

3.2.8.3 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.

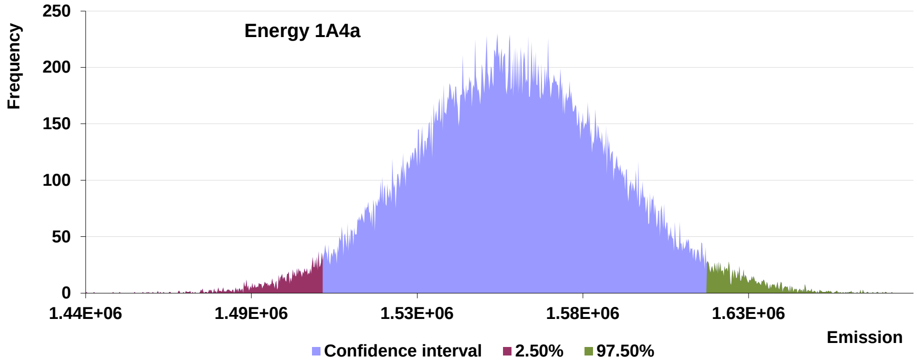
Since 2000, complete time series have been evaluated by checking in order to remove possible inconsistencies in earlier inventories caused by missing data of some plants, changing classifications and reallocation of fuels between energy and industrial processes sectors. Most of these corrections can be done on the basis of data from the EU ETS (from 2005 – 2007 and 2008 – 2014). 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 GHG emissions for the 1.A.4.a subcategory obtained by the Monte Carlo simulation is 1 561 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 1 561 Gg. Confidence interval (95%) is within the range: <1 509; 1 615>, which represents the uncertainty by relative values to the mean value: -3.36%; +3.44%. The following table and graph described calculated results of uncertainty analyses.

Table 3.55: *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
1 560.75	**1 561.00**	27.18	1 442.64	1 672.37	-3.36%	3.44%

Figure 3.31: *Probability density function for 1.A.4.a in tons of CO_2*

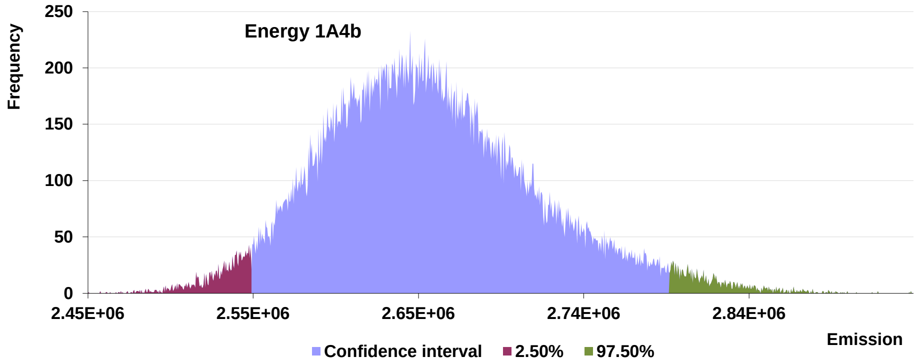


The average mean value of GHG emissions for the 1.A.4.b subcategory obtained by the Monte Carlo simulation is 2 652 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 2 651 Gg. Confidence interval (95%) is within the range: <2 542; 2 796>, which represents the uncertainty by relative values to the mean value: -4.16%; +5.42%. The following table and graph described calculated results of uncertainty analyses.

Table 3.56: *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
2 646.51	**2 652.11**	63.78	2 447.91	2 942.32	-4.16%	5.42%

Figure 3.32: *Probability density function for 1.A.4.b in tons of CO_2*



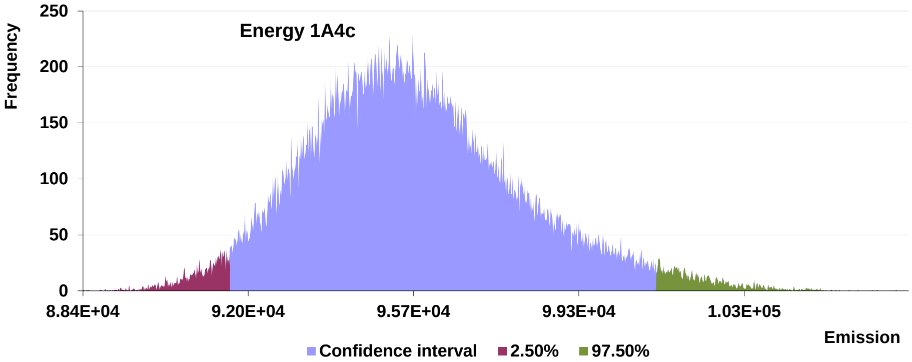
The average mean value of GHG emissions for the 1.A.4.c subcategory obtained by the Monte Carlo simulation is 96 Gg per year. The average mean value is comparable with the real result of the CO_2

emissions, which is 96 Gg. Confidence interval (95%) is within the range: <92; 101>, which represents the uncertainty by relative values to the mean value: -4.25%; +5.56%. The following table and graph described calculated results of uncertainty analyses.

Table 3.57: *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
95.46	**95.68**	2.36	88.40	106.59	-4.25%	5.56%

Figure 3.33: *Probability density function for 1.A.4.c in tons of CO_2*



3.2.8.4 Category-specific QA/QC and verification

Sector specific QA/QC plan is based on the general QA/QC and it is quite identical to QA/QC plan in 1AA.1 (described in chapter 3.2.4.4). Activity data are compared on plant level against three independent sources (EU ETS, SU SR and NEIS). If there are inconsistencies, the underlying data are checked and corrected if necessary.

3.2.8.5 Category-specific recalculations

There were several recalculation performed in sector 1.A.4. Gaseous and solid fuels were recalculated in categories 1.A.4.a and in 1.A.4.b. The recalculations were performed only for year 2013. The primary reason for this recalculation was modification of energy balance provided by the Statistical Office of the Slovak Republic. In solid fuels, an error with wrong categorization of lignite and other bituminous coal was identified and corrected in current submission.

During ESD review and problem with LPG was also identify. In previous submissions it was assumed, that the LPG consumption in households and in services is included in natural gas consumption. Based on our analysis this consumption was incorrect, therefore in current submission, the information about LPG consumption adopted from Eurostat energy statistic was included into NIR. Complete time series were recalculated. The information about the LPG consumption and appropriate emissions in 1.A.4.a and in 1.A.4.b are summarized in following table.

Table 3.43: LPG consumption and emissions in 1.A.4.a and 1.A.4.b based on EUROSTAT

YEAR	1.A.4.a SERVICES				1.A.4.b RESIDENTIAL			
	Consum (TJ)	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	Consum. (TJ)	CO_2 (kt)	CH_4 (kt)	N_2O (kt)
1990	1 472	92.9	0.007360	0.000147	0	0.0	0.000000	0.000000
1991	1 426	90.0	0.007130	0.000143	0	0.0	0.000000	0.000000
1992	1 472	92.9	0.007360	0.000147	0	0.0	0.000000	0.000000
1993	1 380	87.1	0.006900	0.000138	0	0.0	0.000000	0.000000
1994	1 288	81.3	0.006440	0.000129	322	20.7	0.001610	0.000032
1995	1 058	66.8	0.005290	0.000106	506	32.6	0.002530	0.000051

YEAR	1.A.4.a SERVICES				1.A.4.b RESIDENTIAL			
	Consum (TJ)	CO_2 (kt)	CH_4 (kt)	N_2O (kt)	Consum. (TJ)	CO_2 (kt)	CH_4 (kt)	N_2O (kt)
1996	1 151	72.6	0.005755	0.000115	368	23.7	0.001840	0.000037
1997	1 059	66.8	0.005295	0.000106	276	17.8	0.001380	0.000028
1998	1 059	66.8	0.005295	0.000106	276	17.8	0.001380	0.000028
1999	968	61.1	0.004840	0.000097	323	20.8	0.001615	0.000032
2000	552	34.8	0.002760	0.000055	276	17.8	0.001380	0.000028
2001	552	34.8	0.002760	0.000055	736	47.4	0.003680	0.000074
2002	874	55.1	0.004370	0.000087	1 518	97.7	0.007590	0.000152
2003	414	26.1	0.002070	0.000041	1 702	109.6	0.008510	0.000170
2004	230	14.5	0.001150	0.000023	1 886	121.4	0.009430	0.000189
2005	322	20.3	0.001610	0.000032	1 334	85.9	0.006670	0.000133
2006	690	43.5	0.003450	0.000069	1 150	74.0	0.005750	0.000115
2007	506	31.9	0.002530	0.000051	368	23.7	0.001840	0.000037
2008	736	46.4	0.003680	0.000074	92	5.9	0.000460	0.000009
2009	736	46.4	0.003680	0.000074	460	29.6	0.002300	0.000046
2010	552	34.8	0.002760	0.000055	828	53.3	0.004140	0.000083
2011	276	17.4	0.001380	0.000028	92	5.9	0.000460	0.000009
2012	460	29.0	0.002300	0.000046	506	32.6	0.002530	0.000051
2013	368	23.2	0.001840	0.000037	460	29.6	0.002300	0.000046
2014	184	11.6	0.000920	0.000018	414	26.7	0.002070	0.000041

Minor corrections were done in biomass consumption in sector 1.A.4 and 1.A.5 where an incorrect NCV values were used. This problem was identified only in previous submission therefore only year 2013 was recalculated.

3.2.8.6 Category-specific planned improvements

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.

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

3.2.9.1 Category description

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 1 401.61 TJ in 2014. Total CO_2 emissions were 51.95 Gg, total CH_4 emissions were 0.02 Gg and total N_2O emissions were 0.0005 Gg in 2014. In previous submission, the emissions arising from pipeline transport were reallocated from 1.AA.5.to to 1.AA.5.a.

3.2.9.2 Methodological issues

A description of the general methodology used for estimation of emissions from fuel combustion is given in the Section 3.2.5.2.

In the subcategory 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 the subcategory 1.A.5.b. These emissions were reallocated from the subcategory

1.A.3.e based on the ERT´s recommendation. 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 3.44: *Overview of the country or plant specific CO_2 emission factors in 1.A.5 in 2014*

1.AA.5	WEIGHTED EF CO_2 (t/TJ)	FUEL TYPE	EF C (t/TJ)	EF CO_2 (t/TJ)
Liquid	73.25	Liquefied petroleum gases	17.22	63.15
		Residual fuel oil	21.52	78.90
		Jet kerosene	19.51	71.55
Solid	100.74	Gas coke	22.00	80.67
		Lignite	27.91	102.32
		Other bituminous coal	26.41	96.85
Gaseous	55.72	Natural gas	15.20	55.72
Biomass	59.55	Sludge gas	14.90	54.63
		Other biogas	14.90	54.63
		Other primary solid biomass	27.30	100.10
		Wood/Wood waste	30.50	111.83

3.2.9.3 Uncertainties and time-series consistency

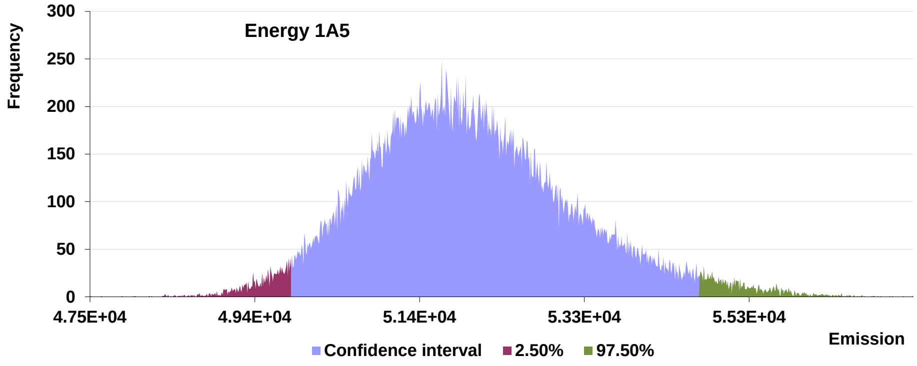
In accordance with the IPCC 2006 GL, natural gas consumption used for pipeline transport, which was previously reported under the subcategory 1.A.5 is now reported under subcategory 1.AA.3.e.i. This reallocation dramatically decreased emissions reported under the 1.A.5. This recalculation had no significant effect on timeline consistency. The consistency of time series of subcategory 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 GHG emissions for the 1.A.5 subcategory obtained by the Monte Carlo simulation is 51.96 Gg per year. The average mean value is comparable with the real result of the CO_2 emissions, which is 51.95 Gg. Confidence interval (95%) is within the range: <49.86; 54.68>, which represents the uncertainty by relative values to the mean value: -4.04%; +5.22%. The following table and graph described calculated results of uncertainty analyses.

Table 3.57: *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
51.86	**51.96**	1.21	47.48	57.21	-4.04%	5.22%

__Figure 3.33:__ Probability density function for 1.A.5 in tons of CO_2



3.2.9.4 Category-specific QA/QC and verification

Sector specific QA/QC plan is based on the general QA/QC and it is quite identical to QA/QC plan in 1AA.1 (described in chapter 3.2.4.4). Activity data are compared on plant level against three independent sources (EU ETS, SU SR and NEIS). If there are inconsistencies, the underlying data are checked and corrected if necessary.

3.2.9.5 Category-specific recalculations

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.A.5. In accordance with the IPCC 2006 GL this source is now reported under subcategory 1.AA.3.e.i.

3.2.9.6 Category-specific planned improvements

No further specific improvements are planned in this subcategories for the next submission.

No recalculations focused on the base year 1990 or the other inventory years were provided in the current submission.

3.3. FUGITIVE EMISSIONS FROM SOLID FUELS AND OIL AND NATURAL GAS AND OTHER EMISSIONS FROM ENERGY PRODUCTION (CRF 1.B)

Detailed description of the source category 1.B is included in the section 3.1 of this Chapter.

3.3.1 SOLID FUELS (CRF 1.B.1)

3.3.1.1 Category description

Coal mining and handling (CRF 1.B.1.a) - The Slovak Republic mined 2 187.72 kt of brown coal from underground mines in 2014, mostly for domestic consumption (industry and households). Total methane emissions from the underground coal mining were estimated to be 15.222 Gg (13.903 Gg of CH_4 from mining activities, 1.319 Gg of CH_4 from post-mining activity). Methane recovery is in practise since 2007 and was 0.026 Gg in 2014. Total CO_2 emissions from the underground coal mining were estimated to be 26.419 Gg in 2014.

__Table 3.45:__ Overview of fugitive emissions from mining and post-mining activities in 1990 – 2014

YEAR	Brown coal produced	CH_4 emissions from mining	CH_4 recovery from mining	CH_4 emissions from post-mining	Total CH_4 emissions	CO_2 emissions from mining
	(kt)			(Gg)		
1990	3 456.00	25.114	NO	2.084	27.198	19.008
1991	3 663.00	26.618	NO	2.209	28.827	20.147
1992	3 803.50	27.639	NO	2.294	29.932	21.188
1993	3 614.30	26.433	NO	2.179	28.612	19.896
1994	3 744.80	27.654	NO	2.258	29.912	20.764
1995	3 759.10	27.437	NO	2.267	29.704	21.542
1996	3 914.20	27.760	NO	2.316	30.076	22.555
1997	3 914.20	28.253	NO	2.360	30.613	23.188
1998	3 951.00	28.785	NO	2.382	31.168	23.117
1999	3 806.50	27.201	NO	2.295	29.496	23.265
2000	3 649.30	26.620	NO	2.201	28.821	21.513
2001	3 424.00	24.265	NO	2.065	26.330	21.445
2002	3 401.00	23.643	NO	2.051	25.694	21.958
2003	3 075.23	19.260	NO	1.854	21.114	23.156
2004	2 951.87	17.993	NO	1.780	19.773	23.357
2005	2 511.20	14.658	NO	1.514	16.173	20.781
2006	2 206.28	13.340	NO	1.330	14.671	17.603
2007	2 064.48	12.273	0.226	1.245	13.518	16.385
2008	2 423.07	14.704	0.182	1.461	16.165	19.169
2009	2 571.90	15.373	0.106	1.551	16.924	21.070
2010	2 377.53	13.862	0.032	1.434	15.295	19.740
2011	2 376.03	14.794	0.062	1.433	16.227	18.459
2012	2 292.21	14.582	0.027	1.382	15.964	17.626
2013	2 352.72	14.772	0.045	1.419	16.191	18.281
2014	2 187.72	13.903	0.026	1.319	15.222	26.419

Solid fuel transformation (CRF 1.B.1.b) - The Slovak Republic reported fugitive methane emissions from charcoal production in this subcategory in the 2014 submission. This activity is reported in the FAO database since 1993. The production of wood charcoal is included in this subcategory and CH_4 emissions are estimated for the years 1993 – 2014. Total volume of wood charcoal produced in Slovakia was 4 200 tonnes in 2014. Total CH_4 emissions were 0.126 Gg in 2014.

3.3.1.2 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

The 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, 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 Guidelines, 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 3.46.

Based on the expert judgment and in accordance with the conservative principle, it was decided to calculate fugitive methane emissions in the period 1990 – 2014 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 3.46, point 2).

Table 3.46: *Coal production, characteristics of mine and the emission factors for mining and post-mining in single mines in the Slovak Republic in 2014*

MINE	Coal Production (kt)	Depth of Mine (m)	EF CH_4 (m^3/t)					
			IPCC 2006 GL		IEA - CIAB		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 since 2007 in the east shaft of mine Handlova and it continued also in 2014. The amount of cogenerated methane was 39 492 m^3 in 2014. The estimation is based on the measurement of gaseous mixture and its concentration of methane. The GHG emissions from cogeneration are included into subcategory 1.A.1.a.iv – Other (methane cogeneration from mining) and represented 0.08 Gg of CO_2 equivalents in 2014. The cogeneration activities are expected also in the future. Flaring activity for reducing methane emissions from coal mining in the Slovak Republic did not occurred in 2014. 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 2014.

Table 3.47: *Cogeneration of methane from Mine Handlova, the east shaft during 2007 – 2015* (*predictions) (CH_4 density in 20°C is 0.67 kg/m^3)*

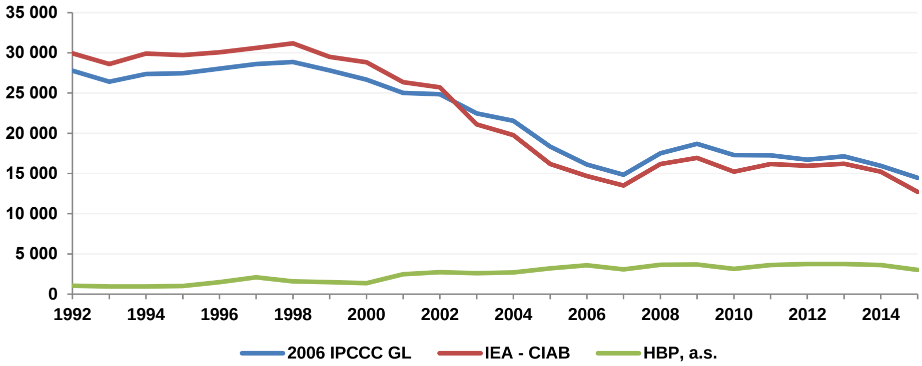
Methane cogenerated in Mine Handlova East Shaft	2008	2009	2010	2011	2012	2013	2014	2015
Mixture Methane + Air (m^3)	910 560	925 000	150 590	290 290	119 563	178 378	117 537	120 000
Average Concentration of CH_4 (%)	30	17	32	32	34	38	34	34
Quantity of CH_4 (m^3)	273 168	158 175	48 189	92 893	41 130	67 605	39 492	40 320
Quantity of Flared CH_4 (t)	182	106	32	62	27	45	26	27

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.

Figure 3.15 shows the comparison of trends in estimated CH_4 emissions in the Slovak Republic in the years 1990 – 2014 (2015 predictions) 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 3.15: *Comparison of trends in CH_4 emissions in the Slovak Republic in years 1990 – 2015* (*predictions)*



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 2014.

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 3.48: *Overview of CO_2 emission factors for single mines in the Slovak Republic in 2014*

MINE	COAL PRODUCTION (t)	EF (t CO_2/t)	EMISSIONS CO_2 (t)
Mine Novaky	1 210 000	0.011379	13 769
Mine Cigel	603 500	0.004749	2 866
Mine Handlova	271 500	0.002206	599
Mine Dolina	88 331	0.002206	195
Mine Cary	179 393	0.004749	852
Total	**2 352 724**		**18 281**

Solid fuel transformation (CRF 1.B.1.b) - The CH_4 fugitive emission from solid fuel transformation have been calculated with the IPCC tier 1 default methodology with using Revised 1996 IPCC Guidelines Table 1-13 Energy Content of Biomass Fuels: Default Net Calorific Values. 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. 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.

Table 3.49: *Charcoal production and fugitive emissions in 1993 – 2014*

YEAR	CHARCOAL PRODUCTION (kt)	CH_4 EMISSIONS (kt)
1993	3.00	0.09
1994	3.00	0.09
1995	3.00	0.09
1996	3.00	0.09
1997	3.00	0.09
1998	3.00	0.09
1999	4.00	0.12
2000	5.00	0.15
2001	6.00	0.18
2002	41.00	1.23
2003	45.00	1.35
2004	46.00	1.38
2005	48.00	1.44
2006	83.00	2.49
2007	84.00	2.52
2008	85.00	2.55
2009	80.00	2.40
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

3.3.1.3 Uncertainties and time-series consistency

The tier 1 uncertainty analysis was performed according to the IPCC 2006 Guidelines. Tier 2 uncertainty estimation was not performed due to lack of input data availability is the most facing issue. The methodology is consistent during time series and across the main types of fuels.

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 mining activities 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.

3.3.1.4 Category-specific QA/QC and verification

Sector specific QA/QC plan is based on the general QA/QC plan described in Chapter 1.6. The Slovak inventory team in cooperation with the sectoral expert prepare emissions estimation according to the consistent methodology and the official statistical data.

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

3.3.1.5 Category-specific recalculations

No recalculations in the 2014 submission focused on the base year 1990 or the other inventory years were provided.

3.3.1.6 Category-specific planned improvements

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.

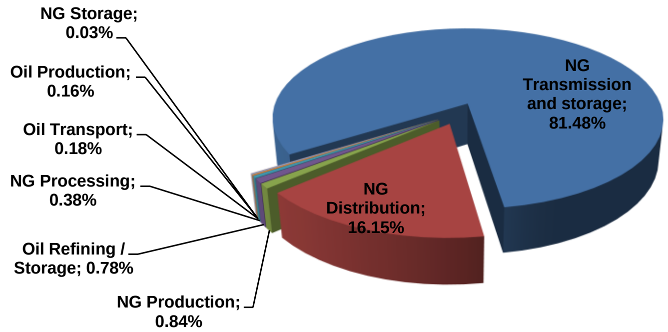
In previous submissions, Slovakia reported CO_2 emissions from coal mining and handling (1.B.1.a) as not occurring (“NO”) and included appropriate explanation. However, regarding the recommendation from Para 40 of the SVK ARR 2014 to change the notation key from “NO” to “NE” (not estimated), Slovakia decided to estimate CO_2 emissions from coal mining and handling (1.B.1.a) in 2015 inventory. Estimation was provided also for time series 1990 – 2014. The overview of CO_2 emissions and the emission factors can be found in the Table 3.48.

3.3.2. OIL AND NATURAL GAS AND OTHER EMISSIONS FROM ENERGY PRODUCTION (CRF 1.B.2)

3.3.2.1 Category description

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 1 058.01 Gg of CO_2 equivalents (42.27 Gg CH_4) in 2014. Total CO_2 emissions were 1.23 Gg in 2014 and the estimation was based on the composition of natural gas and carbon content. Total N_2O emissions were 12.3 kg in 2014. The major share belongs to the NG transmission and storage (81.5%) 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 3.16: *The share of individual activities in fugitive emissions of oil and natural gas in 2014*



1.B.2 CATEGORY	EMISSIONS Gg of CO_2 eq.
NG Transmission and storage	558.04
NG Distribution	110.59
NG Production	5.76
Oil Refining / Storage	5.35
NG Processing	2.61
Oil Transport	1.21
Oil Production	1.08
NG Storage	0.20

Total fugitive GHG emissions from oil activities (1.B.2.a) were 7.65 Gg of CO_2 equivalents (7.5 t of CO_2 and 305.5 t of CH_4) in 2014. Total GHG emissions are decreasing continuously since the base year due to decrease in production and storage (Table 3.50).

Table 3.50: *Trend in fugitive emissions from oil activities in 1990 – 2014*

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
1991	71.52	18.59	257.46	13 581.00	6.65	73.34	5 064.52	207.65
1992	61.51	15.99	221.45	13 581.00	6.65	73.34	4 377.09	179.46
1993	66.50	17.29	239.40	13 581.00	6.65	73.34	4 280.30	175.49
1994	67.21	17.47	241.96	13 581.00	6.65	73.34	4 809.54	197.19
1995	74.25	19.30	267.29	13 581.00	6.14	67.66	5 168.47	211.91
1996	71.33	18.55	256.79	12 530.00	6.14	67.66	5 252.51	215.35
1997	64.00	16.64	230.40	11 090.00	5.43	59.89	5 326.00	218.37
1998	60.00	15.60	216.00	11 090.00	5.43	59.89	5 450.00	223.45
1999	66.00	17.16	237.60	10 400.00	5.10	56.16	5 429.00	222.59
2000	59.00	15.34	212.40	9 300.00	4.56	50.22	5 442.00	223.12
2001	55.00	14.30	198.00	9 551.00	4.68	51.58	5 499.00	225.46
2002	52.00	13.52	187.20	9 446.00	4.63	51.01	5 617.00	230.30
2003	42.00	10.92	151.20	9 929.50	4.87	53.62	5 656.00	231.90
2004	38.00	9.88	136.80	10 324.78	5.06	55.75	5 713.00	234.23
2005	31.00	8.06	111.60	10 662.34	5.22	57.58	5 598.00	229.52
2006	28.00	7.28	100.80	11 145.45	5.46	60.19	5 641.00	231.28
2007	28.00	7.28	100.80	10 637.00	5.21	57.44	5 955.00	244.16
2008	18.00	4.68	64.80	10 656.74	5.22	57.55	5 847.00	239.73
2009	15.00	3.90	54.00	10 685.26	5.24	57.70	5 700.00	233.70
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

Total fugitive GHG emissions from natural gas activities (1.B.2.b) were 677.2 Gg of CO_2 equivalents (286 t of CO_2 and 27.08 Gg of CH_4) in 2014. 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 3.51: Trend in fugitive emissions from NG activities in 1990 – 2014

YEAR	1.B.2.b NATURAL GAS								
	1.B.2.b.2 Production			1.B.2.b.3 Processing			1.B.2.b.4 Transmission and storage		
	Production	Emissions		Processing	Emissions		Transfer	Emissions	
	(mil m³)	CO_2 (t)	CH_4 (t)	(mil m³)	CO_2 (t)	CH_4 (t)	(mil m³)	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
1991	314	25.75	722.20	314	100.48	323.42	73 600	64.77	35 328.00
1992	277	22.71	637.10	277	88.64	285.31	73 600	64.77	35 328.00
1993	254	20.83	584.20	254	81.28	261.62	73 600	64.77	35 328.00
1994	289	23.70	664.70	289	92.48	297.67	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
1996	314	25.75	722.20	314	100.48	323.42	73 600	64.77	35 328.00
1997	289	23.70	664.70	289	92.48	297.67	70 000	61.60	33 600.00
1998	260	21.32	598.00	260	83.20	267.80	75 700	66.62	36 336.00
1999	213	17.47	489.90	213	68.16	219.39	78 500	69.08	37 680.00
2000	173	14.19	397.90	173	55.36	178.19	68 600	60.37	32 928.00
2001	196	16.07	450.80	196	62.72	201.88	65 487	57.63	31 433.76
2002	177	14.51	407.10	177	56.64	182.31	63 154	55.58	30 313.92
2003	234	19.19	538.20	234	74.88	241.02	65 897	57.99	31 630.56
2004	165	13.53	379.50	165	52.80	169.95	72 931	64.18	35 006.88
2005	147	12.05	338.10	147	47.04	151.41	73 900	65.03	35 472.00
2006	194	15.91	446.20	194	62.08	199.82	66 824	58.81	32 075.52
2007	128	10.50	294.40	128	40.96	131.84	66 567	58.58	31 952.16
2008	102	8.36	234.60	102	32.64	105.06	69 934	61.54	33 568.32
2009	103	8.45	236.90	103	32.96	106.09	58 964	51.89	28 302.72
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

YEAR	1.B.2.b NATURAL GAS					
	1.B.2.b.5 Distribution			1.B.2.b.6 Other		
	Distribution	Emissions		Storage	Emissions	
	(mil m³)	CO_2 (t)	CH_4 (t)	(mil m³)	CO_2 (t)	CH_4 (t)
1990	6 666.00	339.97	7 332.60	1.00	0.00	0.025
1991	6 241.66	318.32	6 865.83	1.00	0.00	0.025
1992	6 280.07	320.28	6 908.08	1.00	0.00	0.025
1993	6 155.00	313.91	6 770.50	1.00	0.00	0.025
1994	5 944.00	303.14	6 538.40	71.40	0.01	1.785
1995	6 485.00	330.74	7 133.50	159.40	0.02	3.985
1996	6 822.00	347.92	7 504.20	157.00	0.02	3.925
1997	6 930.00	353.43	7 623.00	70.60	0.01	1.765
1998	7 043.00	359.19	7 747.30	141.00	0.02	3.525
1999	7 106.00	362.41	7 816.60	98.40	0.01	2.460
2000	7 136.00	363.94	7 849.60	524.30	0.06	13.108
2001	7 633.00	389.28	8 396.30	434.80	0.05	10.870
2002	7 250.00	369.75	7 975.00	181.50	0.02	4.538
2003	7 026.00	358.33	7 728.60	32.54	0.00	0.814
2004	6 720.00	342.72	7 392.00	393.00	0.04	9.825
2005	7 399.00	377.35	8 138.90	50.00	0.01	1.250
2006	6 940.00	353.94	7 634.00	NO	NO	NO

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)
2007	6 216.00	317.02	6 837.60	11.00	0.00	0.275
2008	6 266.00	319.57	6 892.60	126.00	0.01	3.150
2009	5 397.00	275.25	5 936.70	569.00	0.06	14.225
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	4 014.00	204.71	4 415.40	319.00	0.04	7.975

Total fugitive GHG emissions from flaring and venting activities (1.B.2.c) were 373.17 Gg of CO_2 equivalents (937.3 t of CO_2, 14.89 Gg of CH_4 and 12.28 kg of N_2O) in 2014 (Table 3.52). 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 (99.77%) in 2014.

Table 3.52: *Trend in fugitive emissions from venting and flaring activities in 1990 – 2014*

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	0.010
1991	6.79	51.49	228.16	23 552	2 932	1.79	0.046	942	0.62	0.007
1992	5.84	44.29	228.16	23 552	2 522	1.54	0.039	831	0.54	0.007
1993	6.32	47.88	228.16	23 552	2 727	1.66	0.043	762	0.50	0.006
1994	6.38	48.39	228.16	23 552	2 756	1.68	0.043	867	0.57	0.007
1995	7.05	53.46	228.16	23 552	3 044	1.86	0.048	1 032	0.67	0.008
1996	6.78	51.36	228.16	23 552	2 925	1.78	0.046	942	0.62	0.007
1997	6.08	46.08	217.00	22 400	2 624	1.60	0.041	867	0.57	0.007
1998	5.70	43.20	234.67	24 224	2 460	1.50	0.038	780	0.51	0.006
1999	6.27	47.52	243.35	25 120	2 706	1.65	0.042	639	0.42	0.005
2000	5.61	42.48	212.66	21 952	2 419	1.48	0.038	519	0.34	0.004
2001	5.23	39.60	203.01	20 956	2 255	1.38	0.035	588	0.38	0.005
2002	4.94	37.44	195.78	20 209	2 132	1.30	0.033	531	0.35	0.004
2003	3.99	30.24	204.28	21 087	1 722	1.05	0.027	702	0.46	0.005
2004	3.61	27.36	226.09	23 338	1 558	0.95	0.024	495	0.32	0.004
2005	2.95	22.32	229.09	23 648	1 271	0.78	0.020	441	0.29	0.003
2006	2.66	20.16	207.15	21 384	1 148	0.70	0.018	582	0.38	0.005
2007	2.66	20.16	206.36	21 301	1 148	0.70	0.018	384	0.25	0.003
2008	1.71	12.96	216.80	22 379	738	0.45	0.012	306	0.20	0.002
2009	1.43	10.80	182.79	18 868	615	0.38	0.010	309	0.20	0.002
2010	1.24	9.36	202.44	20 897	533	0.33	0.008	312	0.20	0.002
2011	1.43	10.80	211.09	21 790	615	0.38	0.010	363	0.24	0.003
2012	1.05	7.92	140.96	14 550	451	0.28	0.007	450	0.29	0.004
2013	0.95	7.20	163.62	16 890	410	0.25	0.006	372	0.24	0.003
2014	1.14	8.64	144.15	14 880	492	0.30	0.008	300	0.20	0.005

3.3.2.2 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 GUIDELINES, 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 GUIDELINES, 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 GUIDELINES, 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 3.53: *Overview of activity data, EFs and fugitive emissions in the subcategory 1.B.2 in 2014*

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	8 945	4.90E-07	5.40E-06		4.38	48.30	
Oil Refining / Storage	5 220		4.10E-05			214.02	
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	100	8.20E-05	2.30E-03		8.20	230.00	
NG Processing	100	3.20E-04	1.03E-03		32.00	103.00	
NG Transmission and storage	46 500	8.80E-07	4.80E-04		40.92	22 320.00	
NG Distribution	4 014	5.10E-05	1.10E-03		204.71	4 415.40	
NG Storage	319	1.10E-07	2.50E-05		0.04	7.98	
NG Venting	52 780	3.10E-06	3.20E-04		144.15	14 880.00	
NG Flaring (from production and processing)	100	1.20E-03	7.60E-07	2.10E-08	120.00	0.08	0.0021
		1.80E-03	1.20E-06	2.50E-08	180.00	0.12	0.0025

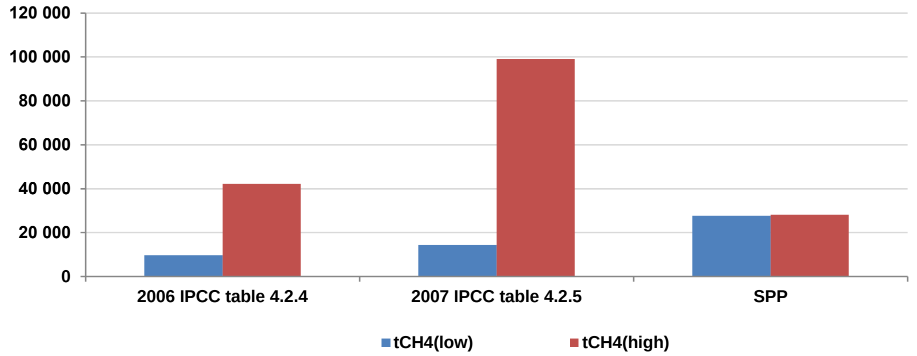
Activity data used in emissions estimation in oil production, transport and refining/storage are provided by the Transpetrol Company, the exclusive company for transit and inland oil transportation and storage for its customers and the State Resource Reserves. The activity data were compared with the 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 3.54: Activity data on production, export and import of NG in the Slovak Republic in 2014

ACTIVITY	NATURAL GAS (m^3)
Indigenous Production	100 000 000
Associated Gas	12 000 000
Non-associated Gas	88 000 000
Stock Changes	-319 000 000
Gas Vented	1 000 000
Gas Flared	5 000 000
Export	3 000 000
Import	4 236 000 000
INLAND CONSUMPTION	**4 014 000 000**

Despite the expansion of the distribution system, the trend in fugitive CH_4emissions from distribution of natural gas in the Slovak Republic is decreasing. This decrease is caused by the decrease of natural gas transit.

Figure 3.17: *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*



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 Guidelines 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).

3.3.2.3 Uncertainties and time-series consistency

Tier 1 uncertainty analyses were performed according to the IPCC 2006 GL. Tier 2 uncertainty estimation was not provided due to lack of available input data. The methodology is consistent during time series and across the activities in subcategories. New emission factors (IPCC 2006 GL, Table 4.2.4) were used for the entire time series.

3.3.2.4 Category-specific QA/QC and verification

Sector specific QA/QC plan is based on the general QA/QC plan described in Chapter 1.6. The Slovak inventory team in cooperation with external sectoral experts prepared the emission estimation according to the consistent methodology and official statistical data.

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

3.3.2.5 Category-specific recalculations

The N_2O emissions were recalculated in a category Flaring 1.B.2.c.2.ii Gas for the time series 1990 – 2013.

3.3.2.6 Category-specific planned improvements

No further specific improvements are planned in this subcategories for the next submission.

CHAPTER 4: INDUSTRIAL PROCESSES AND PRODUCT USE (CRF 2)

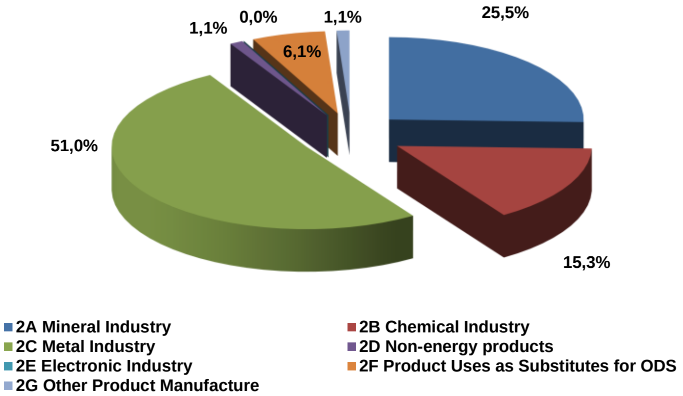
4.1 OVERVIEW OF THE SECTOR (CRF 2)

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 – 4.3 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 2014, total aggregated GHG net emissions from the sector of industrial processes and product use were 8 930.97 Gg of CO_2 equivalents and they increased compared with the previous year by approximately 2.4%. Compared to the base year 1990 the emissions decreased by 9.0%. CO_2 is the most important gas with the share of 91%, followed by F-gases (6%) and N_2O emissions (3%) shares. The most important emission sources are categories of metal production (51%), mineral products (26%), chemical industry (15%) and substituents for ODS (6%). 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 3:2.

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 2014 is presented in Table 4.1.

Figure 4.1: *The share in emissions of individual categories in sector industrial processes in 2014*



Category	CO_2 *eq.* (Gg)
2.A Mineral industry	2 277.12
2.B Chemical industry	1 364.75
2.C Metal industry	4 552.77
2.D Non-energy products	96.12
2.E Electronics industry	NO
2. F Product uses as substitutes for ODS	546.02
2.G Other product manufacture	94.20

Table 4.1: *GHG gases reported in IPPU sector according to the CRF categories in 2014*

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	**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	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
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

4.1.1 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 2014, substantial energy savings were made, while the sharp GDP growth was recorded in Slovakia. Also in 2014 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 2014, 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 2014.

Table 4.2: *GHG emissions according to the individual gases in IPPU sector in 1990 – 2014*

Year	Sector IPPU in CO_2 *eq.* (Gg) according to gases			
	CO_2 emissions	**CH_4 emissions**	**N_2O emissions**	**HFC, PFC and SF_6**
1990	8 340.10	0.32	1 158.31	314.92
1991	6 475.22	0.33	816.10	309.76
1992	6 200.16	0.33	733.32	288.28
1993	7 481.02	0.24	576.47	180.41
1994	7 285.59	0.31	997.15	171.05
1995	8 072.70	0.37	1 150.86	153.29
1996	8 275.27	0.38	1 335.13	74.12
1997	8 375.54	0.39	1 258.53	84.01
1998	8 698.30	0.65	1 074.60	84.37
1999	8 565.38	0.80	812.63	90.55
2000	7 405.55	0.66	1 037.12	112.68
2001	7 403.41	0.58	1 182.59	142.18

Year	Sector IPPU in CO_2 *eq.* (Gg) according to gases			
	CO_2 emissions	CH_4 emissions	N_2O emissions	HFC, PFC and SF_6
2002	8 505.49	1.46	1 079.37	178.19
2003	7 952.60	1.78	1 195.87	216.53
2004	9 011.18	1.61	1 382.50	248.00
2005	8 602.03	1.00	1 318.38	281.22
2006	9 115.18	0.91	1 602.01	341.85
2007	9 099.83	0.74	1 440.09	372.26
2008	8 992.12	0.77	1 339.82	447.84
2009	7 609.04	0.58	1 124.09	482.14
2010	7 996.66	1.20	946.86	574.31
2011	8 060.23	1.46	478.26	562.76
2012	8 062.47	1.40	378.69	576.96
2013	7 896.68	1.63	252.31	567.31
2014	8 132.66	1.71	225.26	571.33

Table 4.3: *GHG emissions in the IPPU individual categories in 1990 – 2014*

Year	Sector IPPU in CO_2 *eq.* (Gg) according to categories						
	2.A Mineral industry	2.B Chemical industry	2.C Metal industry	2.D Non-energy products	2.E Electronics industry	2.F Product uses as substitutes for ODS	2.G Other product manufact.
1990	2 714.02	2 019.80	4 900.90	162.48	NO	NO	16.45
1991	1 921.54	1 769.02	3 752.48	141.94	NO	NO	16.43
1992	2 002.06	1 740.39	3 337.96	125.26	NO	NO	16.43
1993	1 816.15	1 420.08	4 868.55	116.89	NO	NO	16.48
1994	1 911.42	2 084.32	4 305.98	118.39	NO	0.20	33.78
1995	2 070.94	2 383.51	4 749.59	122.72	NO	10.49	39.95
1996	2 007.08	2 499.97	4 998.10	114.43	NO	22.23	43.10
1997	2 091.10	2 463.20	4 990.94	102.82	NO	33.07	37.35
1998	2 818.75	2 314.87	4 541.04	105.37	NO	44.87	33.01
1999	2 854.08	2 021.25	4 395.14	100.71	NO	64.49	33.68
2000	2 230.10	2 392.92	3 717.46	96.97	NO	86.15	32.40
2001	2 318.90	2 418.43	3 732.04	101.92	NO	115.33	42.14
2002	2 358.46	2 411.43	4 671.76	103.11	NO	149.92	69.82
2003	2 036.94	2 475.31	4 508.40	97.31	NO	176.79	72.01
2004	2 481.71	2 824.51	4 938.51	96.24	NO	209.72	92.61
2005	2 631.81	2 719.87	4 413.45	96.99	NO	241.12	99.39
2006	2 700.99	2 904.62	4 964.32	111.27	NO	282.78	95.95
2007	2 807.85	2 841.89	4 729.88	113.60	NO	325.44	94.25
2008	2 964.44	2 672.72	4 563.51	98.92	NO	386.23	94.72
2009	2 253.25	2 485.62	3 858.67	82.77	NO	441.63	93.91
2010	2 041.27	2 172.89	4 597.96	79.95	NO	529.68	97.28
2011	2 448.16	1 969.15	3 973.15	96.68	NO	521.86	93.71
2012	2 220.57	1 654.97	4 412.13	92.80	NO	530.05	109.00
2013	2 132.25	1 600.55	4 204.48	100.91	NO	535.19	144.53
2014	2 277.12	1 364.75	4 552.77	96.12	NO	546.02	94.20

Figure 4.2: *Emission trend in IPPU sector in individual gases (Gg of CO_2 eq.) in 1990 – 2014*

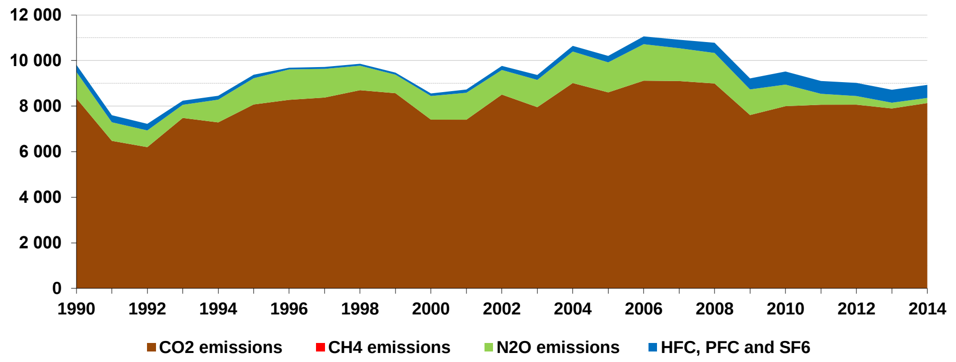
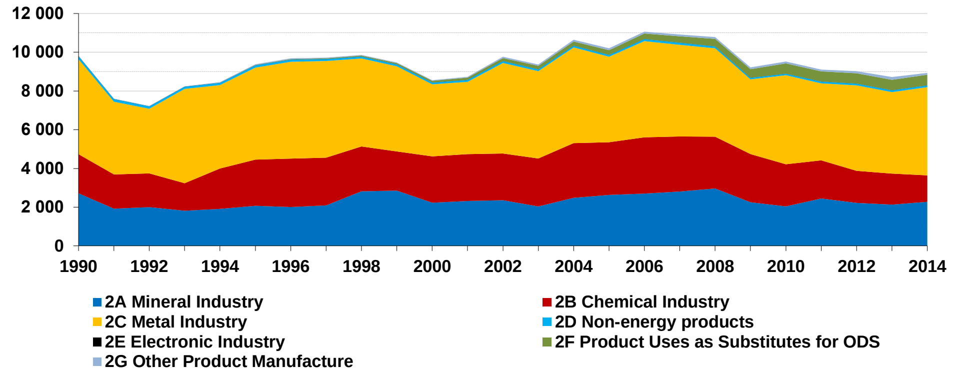


Figure 4.3: *Emission trend in IPPU sector in individual categories (Gg of CO_2 eq.) in 1990 – 2014*



4.1.2 SECTOR SPECIFIC QA/QC PROCEDURES AND VERIFICATION

Sector specific QA/QC plan is based on the general QA/QC plan of the National Inventory System as whole and is described in Chapter 1.2.4. Information used in the process of preparation of GHG emissions inventory in IPPU sector were obtained from different main data sources:

- information from the Statistical Office of the Slovak Republic;
- EU ETS reports;
- questionnaires that were sent to the producers;
- information from the NEIS database (see Chapter Energy) on consumption of non-energy fuels in ammonia production and production of metals.

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.

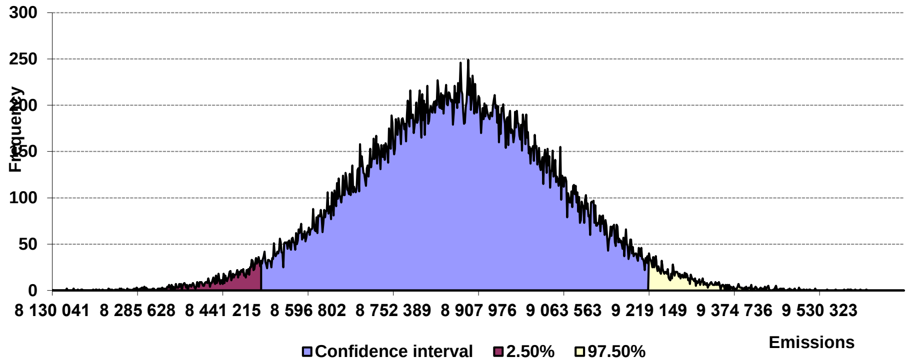
4.1.3 UNCERTAINTY ANALYSES

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 usually estimated by expert judgment. The results for industry sector and its subsectors following the mentioned assumptions it 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 (in t of CO_2 eq.)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
8 869 098	**8 868 335**	180 178	8 130 579	9 686 436	-4.00%	3.95%

Figure 4.4: *Probability density function for IPPU sector (in 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 sector obtained by the Monte Carlo simulation is 8 868 Gg in 2014. The average mean value is comparable with the tier 1 result of the GHG emissions expressed in CO_2 equivalents, which is 8 931 Gg. Confidence interval (95%) is represented by the relative values to the mean: (-4.00%; +3.95%). The utilizing of normal distributions almost for every subcategory 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 was reviewed and QA check was improved.

4.2 MINERAL PRODUCTS (CRF 2.A)

4.2.1 SOURCE CATEGORY DESCRIPTION

The major share of CO_2 emissions comes from the production and transformation of mineral products. Total emissions in this category were 2 277.12 Gg of CO_2 in 2014 (only CO_2 emissions are reported in this category), increased approximately by 6.8% against previous year 2013. Major increase was recorded in 2.A.4.d other category (carbonates used for desulphurization) (about 47%) and cement production (about 12%). 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.

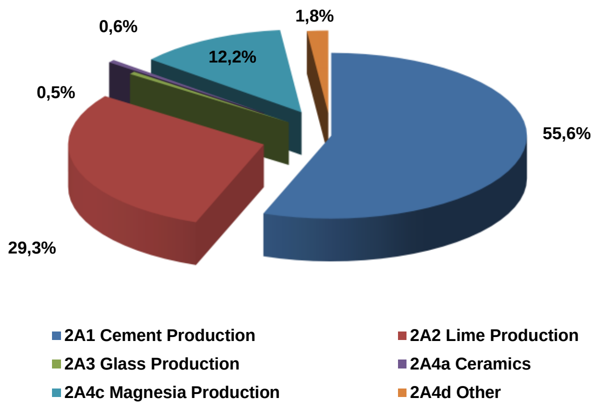
The major share of emissions in this category belongs to cement production (55.6%), lime production (29.3%) and dead burned magnesia production (12.2%). The ceramics production shared 0.6% and glass production is only 0.5%. The rest of emissions (1.8%) are reported in other category. Emissions in the subcategory 2.A.4.b are not occurring.

Table 4.5: *CO_2 emissions in the category 2.A by subcategories (Gg) in 1990 – 2014*

Category 2.A in CO_2 emissions (Gg) by subcategories						
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 prod.**	**2.A.4.d Other**
1990	1 464.50	794.92	7.88	14.79	431.94	0.00
1991	1 038.05	605.05	9.95	11.26	257.24	0.00
1992	1 306.85	455.08	12.03	8.59	219.50	0.00
1993	1 028.75	537.08	14.65	9.99	225.67	0.00
1994	1 115.12	565.16	16.31	10.52	204.31	0.00
1995	1 154.63	593.23	18.01	11.04	294.03	0.00
1996	1 100.41	564.42	20.06	10.51	301.12	10.56
1997	1 214.67	506.06	19.92	9.42	310.25	30.78
1998	1 822.40	549.58	18.99	10.23	376.51	41.04
1999	1 827.39	561.04	19.15	10.44	394.84	41.22
2000	1 190.45	556.73	22.82	10.36	409.82	39.92
2001	1 209.32	602.80	23.08	11.22	431.57	40.91
2002	1 165.24	678.92	21.42	12.64	438.53	41.72
2003	921.65	591.40	22.44	10.30	449.95	41.21
2004	1 216.84	693.54	24.37	5.69	499.68	41.60
2005	1 256.40	810.82	33.04	13.06	476.01	42.49
2006	1 389.15	881.17	32.06	16.23	340.62	41.76
2007	1 484.93	925.59	41.18	19.56	304.00	32.59
2008	1 603.86	887.53	23.44	41.19	377.20	31.22
2009	1 213.15	711.35	13.19	12.10	265.70	37.76
2010	859.92	751.98	13.15	12.75	376.35	27.13

Category 2.A in CO_2 emissions (Gg) by subcategories						
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 prod.**	**2.A.4.d Other**
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
2014	1 266.76	666.84	12.26	12.99	278.33	39.94

Figure 4.5: *The share in CO_2 emissions of individual subcategories in 2.A in 2014*



Subcategory	CO_2 (Gg)
Cement production	1 266.76
Lime production	666.84
Glass production	12.26
Ceramics	12.99
Magnesia production	278.33
Other	39.94

4.2.2 SOURCE SUBCATEGORY DESCRIPTION – 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 1 266.76 Gg in 2014 and were higher by ca 12% than the year before. In comparison with the base year 1990, the CO_2 emissions in this subcategory decreased by 14%. The reasons for declining trend are described in the previous section of this report.

Table 4.6: *Activity data and CO_2 emissions in the subcategory 2.A.1 (Gg) in 1990 – 2014*

Subcategory 2.A.1 cement production						
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
1991	2 010.00	64.60%	*	1.0184	**1 038.05**	0.5164
1992	2 530.50	64.60%	*	1.0184	**1 306.85**	0.5164
1993	1 992.00	64.60%	*	1.0184	**1 028.75**	0.5164
1994	2 159.25	64.60%	*	1.0184	**1 115.12**	0.5164
1995	2 235.75	64.60%	*	1.0184	**1 154.63**	0.5164
1996	2 130.75	64.60%	*	1.0184	**1 100.41**	0.5164
1997	2 352.00	64.60%	*	1.0184	**1 214.67**	0.5164
1998	3 528.77	64.60%	*	1.0184	**1 822.40**	0.5164
1999	3 538.43	64.60%	*	1.0184	**1 827.39**	0.5164
2000	2 313.71	64.36%	*	1.0184	**1 190.45**	0.5145
2001	2 367.29	63.90%	*	1.0184	**1 209.32**	0.5108
2002	2 259.79	64.50%	*	1.0184	**1 165.24**	0.5156
2003	1 754.73	65.70%	*	1.0184	**921.65**	0.5252
2004	2 271.13	67.02%	*	1.0184	**1 216.84**	0.5358
2005	2 352.68	64.31%	1.79%	1.0184	**1 256.40**	0.5340

Subcategory 2.A.1 cement production						
Year	Cement clink production (kt)	CaO content	MgO content	correction factor	CO_2 emissions (Gg)	IEF (CO_2) (t/t)
2006	2 589.08	64.04%	2.21%	1.0184	**1 389.15**	0.5365
2007	2 825.32	63.74%	1.44%	1.0184	**1 484.93**	0.5256
2008	3 045.25	63.23%	2.12%	1.0138	**1 603.86**	0.5267
2009	2 348.07	65.87%	2.38%	0.9514	**1 213.15**	0.5167
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

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

4.2.2.1 Methodological issues – methods

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). On the basis of 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 4.7 (C = confidential, but available for the sectoral experts).

Table 4.7: *Input data used for the CO_2 emissions estimation in subcategory 2.A.1 in 2014*

Plant/Operator	Cement clink	CaO content	MgO content	correction factor	CO_2
	(kt)	(%)	(%)		(Gg)
Cemmac	C	66.19	1.34	1.0031	203.47
VSH (Holcim)	C	64.31	4.28	0.7078	134.25
Holcim – Portland	C	64.79	2.49	1.0068	492.57
Holcim – white	C	66.72	2.28	1.0118	63.07
Považská cementáreň	C	68.32	1.31	1.0197	373.39
Total	**2 415.34**	**66.00**	**2.23**	**0.9668**	**1 266.76**

4.2.2.2 Methodological issues – emission factors and other parameters

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 0.5245 t CO_2/t of cement clink in 2014 (correction factor is also included in this value). Correction factors provided in Table 4.7 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.

$$Corr.factor = CKD * \frac{(0.785*\%CaO_c + 1.092*\%MgO_c)*m_c - (0.785*\%CaO_s + 1.092*\%MgO_s)*m_s}{(0.785*\%CaO_c + 1.092*\%MgO_c)*m_c}$$

where: $\%CaO_c$ is the fraction of CaO in cement clinker produced; $\%MgO_c$ is the fraction of MgO in cement clinker produced; m_c is the mass of cement clinker produced; $\%CaO_s$ is the fraction of CaO in slag entering; $\%MgO_s$ is the fraction of MgO in slag entering; m_s is the mass of slag entering.

4.2.2.3 Activity data

On the basis of data supplied by plants in the EU ETS reports, total CO_2 emissions from cement production were 1 266.76 Gg and the IEF was 0.5245 t/t of clinker. Total production of cement clinker was 2 415.34 kt in 2014.

4.2.2.4 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 Guidelines (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 taken into account 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 – 2014 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 subcategory. The overall uncertainty of CO_2 emissions was calculated in interval (-1.97%; +1.88%).

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

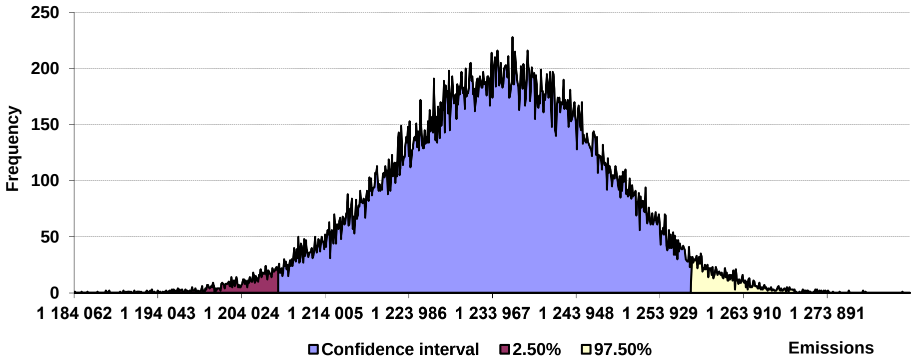
$$Emissions = (clinker \pm \Delta clinker) * \sum_{I} \left[(content of\ CaO \pm \Delta CaO) * 0.785 + \right.$$
$$\left. (content of\ MgO \pm \Delta MgO) * 1.092 \right] * \left(cor\_f \pm \Delta\Delta cor\_ \right)$$

The emissions of 5 sources from 3 cement producers enter to formula (in previous formula subscript "*I*" represent number of sources). 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 the subcategory 2.A.1 obtained by the Monte Carlo simulation is 1 235 Gg CO_2 per year. The average mean value is comparable with the real CO_2 emissions in this subcategory, which is 1 267 Gg CO_2.

Table 4.8: *Selected statistical characteristics for subcategory 2.A.1, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (in t of CO_2)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
1 234 779	**1 234 540**	12 180	1 184 062	1 283 872	-1.97%	1.88%

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



4.2.2.5 Source specific QA/QC and verification

Sector specific QA/QC activities were performed and are described in Chapter 4.2 of this report. Activity data are from the EU ETS reports and information provided by the Slovak Association of Cement Producers is verified according to the statistical information. Based on the information provided in the EU ETS reports it follows that CO_2 emission was 1 266.52 Gg. The emissions reported in the national inventory were nearly the same (difference +0.24 Gg). The difference is caused by rounding. All sources reported in this subcategory are included in the EU ETS.

4.2.2.6 Source specific recalculations

No recalculation was made in this submission.

4.2.2.7 Source specific planned improvements

No major or essential improvements are needed and planned for this subcategory for the next submission.

4.2.3 SOURCE SUBCATEGORY DESCRIPTION – 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 subcategory. Total CO_2 emissions from lime production were nearly the same as in the previous year and were 666.84 Gg in 2014.

Table 4.9: *Activity data and CO_2 emissions in subcategory 2.A.2 (Gg) in 1990 – 2000*

Subcategory 2.A.2 lime production			
Year	**Lime production (kt)**	**CO_2 emissions (Gg)**	**CaO Content**
1990	1 076.00	794.92	91.20%
1991	819.00	605.05	91.20%
1992	616.00	455.08	91.20%
1993	727.00	537.08	91.20%
1994	765.00	565.16	91.20%

Subcategory 2.A.2 lime production			
Year	Lime production (kt)	CO_2 emissions (Gg)	CaO Content
1995	803.00	593.23	91.20%
1996	764.00	564.42	91.20%
1997	685.00	506.06	91.20%
1998	743.92	549.58	91.20%
1999	759.43	561.04	91.20%
2000	753.59	556.73	91.20%

Table 4.9 cont.: *Activity data and CO_2 emissions in subcategory 2.A.2 (Gg) in 2001 – 2014*

Subcategory 2.A.2 lime production					
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%
2002	918.99	678.92	90.28%	0.66%	91.20%
2003	781.69	591.40	90.21%	2.30%	93.41%
2004	908.94	693.54	90.47%	2.69%	94.21%
2005	1 041.71	810.82	89.91%	4.45%	96.10%
2006	1 131.24	881.17	89.61%	4.72%	96.17%
2007	1 158.07	925.59	89.44%	6.64%	98.68%
2008	1 120.33	887.53	88.50%	6.48%	97.51%
2009	916.77	711.35	92.50%	2.37%	95.80%
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%	

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

4.2.3.1 Methodological issues – methods

Table 4.9 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 4.9 in 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 4.10.

4.2.3.2 Methodological issues – emission factors and other parameters

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 2014 (correction factor is included in the IEF). Total CO_2 emissions stayed approximately the same and were 666.84 Gg in 2014. 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.

4.2.3.3 Activity data

Total quantity of produced lime in Slovakia was 852.60 kt in 2014. Activity data used for inventory are summarized in Table 4.10. 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 4.10: *Activity data necessary for the CO_2 emissions estimation in subcategory 2.A.2 in 2014*

Plant	Lime production (kt)	CaO content	MgO content	LKD	CO_2 emissions (Gg)
Calmit	C	92.82%	1.28%	1.0235	105.97
Dolvap Varín	C	86.48%	10.89%	1.0201	99.81
Carmeuse	C	84.35%	8.86%	1.0381	333.26
Others*	C	92.50%	2.00%	1.0200	127.80
Total	**852.60**	**87.64%**	**6.56%**	**1.0296**	**666.84**

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

4.2.3.4 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 whole time series because no other data on LKD were available. In 2014, the country specific LKD factor was very close to the factor reported in 2013, 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 (-2.08%; +1.99%). Following formula was used for Monte Carlo simulation (uncertainties are represented by Δ symbol in formula):

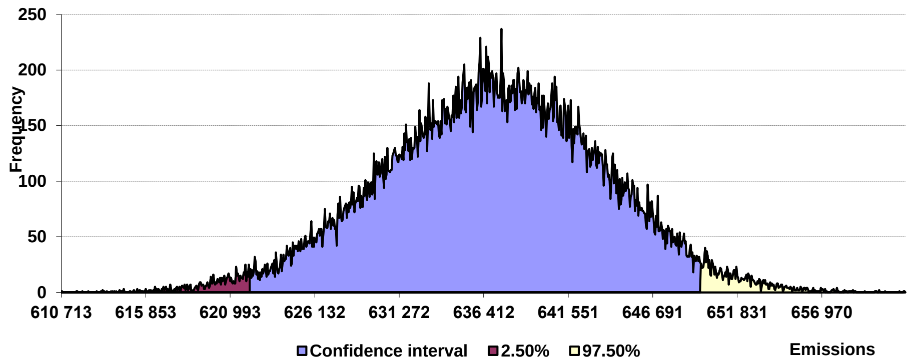
$$Emissions = (lime \pm \Delta lime) * \sum_{I} [(content of\ CaO \pm \Delta CaO) * 0.785 +$$
$$(content of\ MgO \pm \Delta MgO) * 1.092] * (cor\_f \pm \Delta\Delta cor)$$

The emissions from six sources from four lime producers enter the formula. 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 the subcategory 2.A.2 obtained by the Monte Carlo simulation is 637 Gg CO_2 per year. The average mean value is comparable with real CO_2 emissions, which is 667 Gg CO_2.

Table 4.11: *Selected statistical characteristics for subcategory 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
637 054	**636 962**	6 632	610 713	662 110	-2.08%	1.99%

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



4.2.3.5 Source specific QA/QC and verification

Sector specific QA/QC activities were performed and are described in Chapter 4.2 of this report. Activity data are from the EU ETS reports and information provided by the Slovak Association of Lime Producers are verified according to the statistical information provided by the Statistical Office of the Slovak Republic. 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 2014, 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 6 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). The amount of produced lime presented by the Statistical Office of the SR (826 923 t) does not include sugar plants and one of the pulp and paper plants. Otherwise, the data presented by the Statistical Office and in the submission are in agreement.

4.2.3.6 Source specific recalculations

No recalculation was made in this submission.

4.2.3.7 Source specific planned improvements

No improvements are planned for this subcategory for the next submission. Changes in LKD will be monitored and the whole time series will be recalculated, if the changes are significant.

4.2.4 SOURCE SUBCATEGORY DESCRIPTION – 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 subcategory (notation key “IE” was used). These emissions are allocated in the subcategory 1.A.2m. Only CO_2 emissions were estimated in this subcategory and were 12.26 kt in 2014. 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.

4.2.4.1 Methodological issues – methods

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.

4.2.4.2 Methodological issues – emission factors and other parameters

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 0.423 t/t of used carbonates mixture in 2014 or 0.040 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.

4.2.4.3 Activity data

Glass production based on direct information from producers was as follows: 213 753 t of white glass and 90 468 t of green glass in 2014. No leaded glass was produced in 2014. Total amount of produced glass was 304 221 t. $SrCO_3$ and Li_2CO_3 were not used for glass production. Total amounts of used carbonates were 28.97 kt in 2014 and time series is presented in Table 4.12.

Table 4.12: *Total amounts of used carbonates (kt) and CO_2 emissions (Gg) in 1990 – 2014*

Subcategory 2.A.3 glass production									
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**
1991	22.61	a)	a)	a)	a)	a)	a)	22.61	**9.950**
1992	27.34	a)	a)	a)	a)	a)	a)	27.34	**12.030**
1993	33.29	a)	a)	a)	a)	a)	a)	33.29	**14.646**
1994	37.06	a)	a)	a)	a)	a)	a)	37.06	**16.306**
1995	40.93	a)	a)	a)	a)	a)	a)	40.93	**18.007**
1996	45.60	a)	a)	a)	a)	a)	a)	45.60	**20.062**
1997	45.27	a)	a)	a)	a)	a)	a)	45.27	**19.918**
1998	43.15	a)	a)	a)	a)	a)	a)	43.15	**18.988**
1999	43.52	a)	a)	a)	a)	a)	a)	43.52	**19.147**
2000	51.87	a)	a)	a)	a)	a)	a)	51.87	**22.821**
2001	52.46	a)	a)	a)	a)	a)	a)	52.46	**23.081**
2002	48.68	a)	a)	a)	a)	a)	a)	48.68	**21.417**
2003	51.00	a)	a)	a)	a)	a)	a)	51.00	**22.438**
2004	40.59	2.01	13.71	0.83	NO	NO	NO	57.13	**24.371**
2005	55.45	2.75	16.00	0.89	1.76	0.01	0.01	76.87	**33.038**
2006	55.97	2.64	15.35	0.95	0.01	0.03	0.01	74.95	**32.062**
2007	70.70	2.05	19.48	0.96	2.13	0.04	NO	95.36	**41.183**
2008	29.43	1.72	21.27	0.83	1.78	NO	NO	55.03	**23.440**
2009	15.05	1.43	13.45	1.49	0.39	NO	NO	31.81	**13.193**
2010	15.89	0.48	13.62	1.52	0.01	NO	NO	31.52	**13.145**
2011	15.17	0.30	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**

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

4.2.4.4 Uncertainties and time-series consistency

There were several operators producing glass (from 3 to 7) in Slovakia during the time series 1990 – 2014. 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 subcategory. Based on calculation, the overall uncertainty of CO_2 emissions was calculated in interval (-0.83%; +0.83%). Following formula was used for Monte Carlo simulation (uncertainties are represented by Δ symbol in formula):

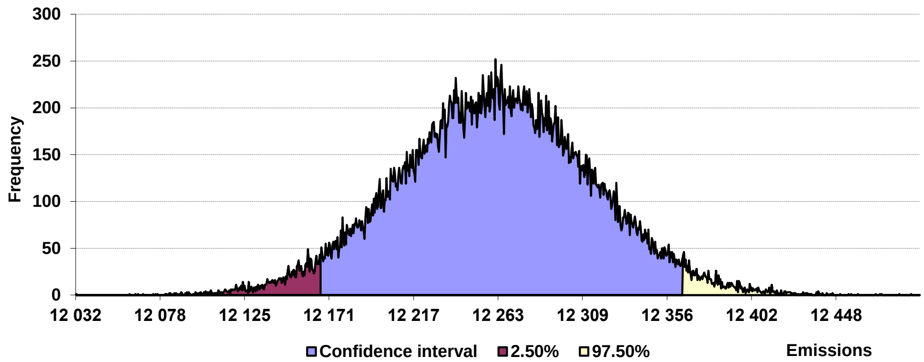
$$Emissions = \sum_{l} \left[(Na_2CO_3 \pm \Delta Na_2CO_3) * (0.415) + \right.$$
$$(K_2CO_3 \pm \Delta K_2CO_3) * 0.318 + (CaCO_3 \pm \Delta CaCO_3) * 0.44 +$$
$$\left. (BaCO_3 \pm \Delta BaCO_3) * 0.223 + (MgCO_3 \pm \Delta MgCO_3) * 0.522 \right]$$

The emissions from glass production from 3 producers are included to the calculating procedure (in the formula subscript "*l*" represents number of processes). 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 the subcategory 2.A.3 obtained by the Monte Carlo simulation is 12.26 Gg per year. The average mean value is comparable with the Tier.1 CO_2 emissions in this subcategory, which is 12.26 Gg CO_2.

Table 4.13: *Selected statistical characteristics for subcategory 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
12 262	**12 262**	52	12 032	12 494	-0.83%	0.83%

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



4.2.4.5 Source specific QA/QC and verification

Sector specific QA/QC activities were performed and are described in Chapter 4.2 of this report. Activity data are from the EU ETS reports and information provided by the operators in questionnaires (requested by the SNE) are verified by the statistical information provided by the Statistical Office of the Slovak Republic. All sources reported in this subcategory are included in the EU ETS and final emissions are identical with the GHG inventory.

4.2.4.6 Source specific recalculations

No recalculations focused on the base year 1990 or the other inventory years were provided in the 2015 submission.

4.2.4.7 Source specific planned improvements

No improvements are planned for this subcategory for the next submission.

4.2.5 SOURCE SUBCATEGORY DESCRIPTION – OTHER PROCESS USES OF CARBONATES – CERAMICS (CRF 2.A.4.a)

Subcategory 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 12.99 Gg CO_2 in 2014.

4.2.5.1 Methodological issues – methods

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.

4.2.5.2 Methodological issues – emission factors and other parameters

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 2014 was 0.464 t/t of used carbonates mixture. This approach was used for every year of time series.

4.2.5.3 Activity data

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 27.97 kt in 2014 and time series is presented in Table 4.14.

Table 4.14: *Total amounts of used carbonates (kt) and CO_2 emissions (Gg) in 1990 – 2014*

Subcategory 2.A.4.a ceramics				
Year	**$CaCO_3$**	**$MgCO_3$**	**total carbonates**	**CO_2 emissions**
	(kt)	(kt)	(kt)	(Gg)
1990	25.41	6.92	**32.33**	**14.79**
1991	18.35	6.10	**24.45**	**11.26**
1992	12.12	6.24	**18.36**	**8.59**
1993	14.98	6.52	**21.50**	**9.99**
1994	16.66	6.11	**22.77**	**10.52**
1995	17.19	6.66	**23.85**	**11.04**
1996	15.69	6.90	**22.59**	**10.51**
1997	13.56	6.62	**20.18**	**9.42**
1998	15.08	6.89	**21.97**	**10.23**
1999	16.38	6.20	**22.58**	**10.44**
2000	15.79	6.54	**22.33**	**10.36**
2001	18.38	6.00	**24.38**	**11.22**
2002	21.51	6.08	**27.59**	**12.64**
2003	16.09	6.16	**22.25**	**10.30**
2004	6.55	5.37	**11.92**	**5.69**

Subcategory 2.A.4.a ceramics				
Year	**$CaCO_3$**	**$MgCO_3$**	**total carbonates**	**CO_2 emissions**
	(kt)	(kt)	(kt)	(Gg)
2005	21.80	6.64	**28.44**	**13.06**
2006	30.65	5.25	**35.90**	**16.23**
2007	36.31	6.87	**43.18**	**19.56**
2008	72.47	17.82	**90.29**	**41.19**
2009	19.01	7.16	**26.17**	**12.10**
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	19.65	4.34	**27.97**	**12.99**

4.2.5.4 Uncertainties and time-series consistency

The same tier approach is used for the time period 1990 – 2014. 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 subcategory 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 subcategory. Based on calculation, the overall uncertainty of CO_2 emissions was calculated in interval (-1.24%; +1.24%). Following formula was used for Monte Carlo simulation (uncertainties are represented by Δ symbol in formula):

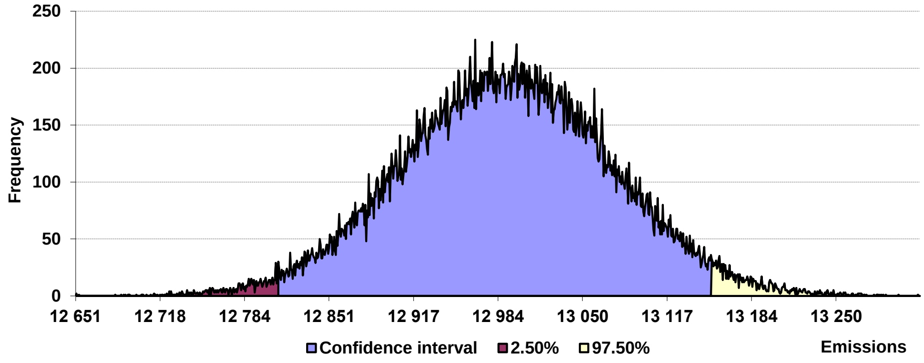
$$Emissions = \sum_{I} \left[(CaCO_3 \pm \Delta CaCO_3) * 0.44 + (MgCO_3 \pm \Delta MgCO_3) * 0.522 \right]$$

The emissions from ceramics production from 5 sources are included to the calculating procedure (in the formula subscript "*I*" represents number of processes). 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 the subcategory 2.A.4a obtained by the Monte Carlo simulation is 12.99 Gg CO_2 per year. The average mean value is comparable with the real CO_2 emissions in this subcategory, which is 12.99 Gg CO_2.

Table 4.15: *Selected statistical characteristics for subcategory 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
12 991	**12 991**	82	12 651	13 317	-1.24%	1.24%

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



4.2.5.5 Source specific QA/QC and verification

Sector specific QA/QC activities were performed and are described in Chapter 4.2 of this report. Activity data are from the EU ETS reports and information provided by the operators in questionnaires (requested by the SNE) are verified by the statistical information provided by the Statistical Office of the Slovak Republic. The EU ETS covers all operators reported in this subcategory. CO_2 emissions reported in the EU ETS reports are 12.99 Gg. The same value is reported also in the GHG inventory. All sources reported in this subcategory are included in the EU ETS.

4.2.5.6 Source specific recalculations

No recalculations focused on the base year 1990 or the other inventory years were provided in the 2016 submission.

4.2.5.7 Source specific planned improvements

No improvements are planned for this subcategory for the next submission.

4.2.6 SOURCE SUBCATEGORY DESCRIPTION – 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 subcategory where it is consumed (see subcategory 2.A.3 glass production).

4.2.7 SOURCE SUBCATEGORY DESCRIPTION – 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 subcategory. 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 278.33 Gg in 2014 and reached the same level as in the year 2012. When compared to 1990, the decrease is approximately 35%. 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).

4.2.7.1 Methodological issues – methods

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 – 2014 are summarized in Table 4.16. 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.

4.2.7.2 Methodological issues – emission factors and other parameters

CO_2 emission factors used for emissions estimation in this subcategory are as follows: 0.44 t / t $CaCO_3$; 0.522 t / t $MgCO_3$ and 0.38 t / t $FeCO_3$.

4.2.7.3 Activity data

Total consumption of magnesite raw materials in the Slovak Republic was 590.33 kt in 2014. The composition of raw materials is summarized in Table 4.16. It should be noted that $CaCO_3$ and $FeCO_3$ contents are included in $MgCO_3$ content on the basis of stoichiometry for the years before 1999, due to lack of input data.

Table 4.16: *Consumption and composition of magnesite raw materials (kt) and CO_2 emissions (Gg) in the years 2000 – 2014*

Subcategory 2.A.4.c non-metallurgical magnesia production						
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
1991	528.69	0.9321	*	*	257.24	0.487
1992	451.14	0.9321	*	*	219.50	0.487
1993	463.81	0.9321	*	*	225.67	0.487
1994	419.91	0.9321	*	*	204.31	0.487
1995	604.32	0.9321	*	*	294.03	0.487
1996	618.89	0.9321	*	*	301.12	0.487
1997	637.64	0.9321	*	*	310.25	0.487
1998	773.83	0.9321	*	*	376.51	0.487
1999	819.50	0.8852	0.0318	0.0151	394.84	0.482
2000	850.57	0.8850	0.0324	0.0147	409.82	0.482
2001	895.73	0.8854	0.0321	0.0145	431.57	0.482
2002	909.72	0.8864	0.0330	0.0127	438.53	0.482
2003	933.64	0.8849	0.0346	0.0126	449.95	0.482
2004	1 037.03	0.8825	0.0387	0.0109	499.68	0.482
2005	988.58	0.8804	0.0382	0.0135	476.01	0.482
2006	708.03	0.8772	0.0387	0.0162	340.62	0.481
2007	626.55	0.9173	0.0123	0.0025	304.00	0.485
2008	780.56	0.8931	0.0333	0.0063	377.20	0.483
2009	548.57	0.8873	0.0426	0.0064	265.70	0.484
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

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

4.2.7.4 Uncertainties and time-series consistency

There are three operators producing magnesite clinker in Slovakia continuously since 1990. Two new operators producing clinker entered the market in 2004 – 2007. One of them was closed in 2007, the second one in 2009 (the second operator has had very limited production of clinker).

The same tier is used for the whole time period 1990 – 2014. 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. 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 subcategory. Based on calculation, the overall uncertainty of CO_2 emissions was calculated in interval (-2.69%; +2.70%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by Δ symbol in formula):

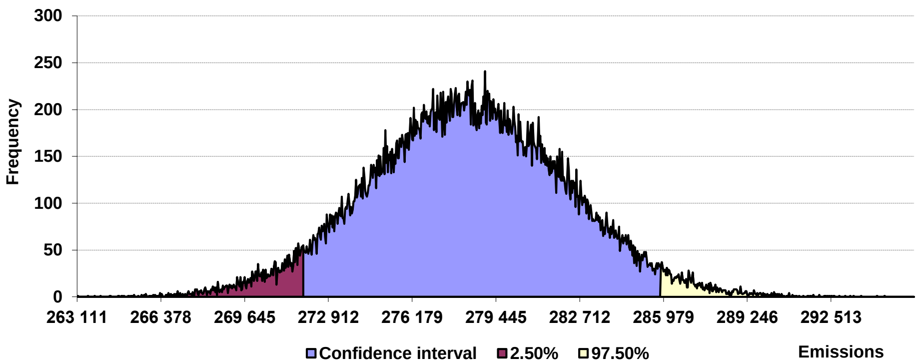
$$Emissions = (raw\ mat. \pm \Delta raw\ mat.) * \sum_i [(content of\ CaCO_3 \pm \Delta CaCO_3) * 0.440 +$$
$$(content of\ MgCO_3 \pm \Delta MgCO_3) * 0.522 + (content of\ FeCO_3 \pm \Delta FeCO_3) * 0.380]$$

Emissions from 2 producers (three sources) contributed to the calculation of overall uncertainty. The accumulated uncertainty and statistical characteristics for magnesite are presented in the following table and figure. The average mean value of GHG emissions in the subcategory 2.A.4.c obtained by the Monte Carlo simulation is 278 Gg CO_2 per year. The average mean value is comparable with the real CO_2 emissions, which is 278 Gg CO_2.

Table 4.17: *Selected statistical characteristics for subcategory 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
278 310	**278 336**	3 816	263 111	295 780	-2.69%	2.70%

Figure 4.10: *Probability density function for subcategory 2.A.4.c (t of CO_2)*



4.2.7.5 Source specific QA/QC and verification

Sector specific QA/QC activities were performed and are described in Chapter 4.2 of this report. Activity data are from the EU ETS reports and information provided by the operators in questionnaires (requested by the SNE) are verified according to the statistical information provided by the Statistical Office of the Slovak Republic. CO_2 emissions reported in the EU ETS reports were 275.308 Gg in

2014; the difference with the GHG inventory is caused only by rounding. All sources reported in this subcategory are included in the EU ETS.

4.2.7.6 Source specific recalculations

No recalculations focused on the base year 1990 or the other inventory years were performed in the submission.

4.2.7.7 Source specific planned improvements

No improvements are planned in this subcategory.

4.2.8 SOURCE SUBCATEGORY DESCRIPTION – 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 subcategory are based on limestone consumed in desulphurization process of coal. CO_2 emissions estimated by decomposition process of carbonates are reported in appropriate subcategories 4.A.

4.2.8.1 Methodological issues – methods

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 – 2014 are summarized in Table 4.18.

4.2.8.2 Methodological issues – emission factors and other parameters

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 2014 was 0.442 t/t of used carbonates mixture.

4.2.8.3 Activity data

Total volume of carbonates used at desulphurization was 90.40 kt in 2014, the activity data are summarized in Table 4.18. The consumption reached approximately the same level as in 2012. Significant decrease (42%) in 2013 was caused by no carbonates consumption at coal desulphurization in one power plant (in that plant only natural gas was consumed in 2013). It resulted in corresponding decrease of CO_2. In 2014, the plant again started using the coal and its desulphurization. Total CO_2 emissions estimated in this subcategory were 39.94 Gg.

Table 4.18: *Total carbonates used (kt) and CO_2 emissions (Gg) in subcategory 2.A.4.d in 1990 – 2014*

Subcategory 2.A.4.d other				
Year	**desulphurization ($CaCO_3$)**	**desulphurization ($MgCO_3$)**	**total carbonates**	**CO_2 emissions**
	(kt)	(kt)	(kt)	(Gg)
1990	NO	NO	NO	NO
1991	NO	NO	NO	NO
1992	NO	NO	NO	NO
1993	NO	NO	NO	NO
1994	NO	NO	NO	NO

Subcategory 2.A.4.d other				
Year	**desulphurization ($CaCO_3$)**	**desulphurization ($MgCO_3$)**	**total carbonates**	**CO_2 emissions**
	(kt)	(kt)	(kt)	(Gg)
1995	NO	NO	NO	NO
1996	23.48	0.44	23.92	10.56
1997	68.54	1.20	69.74	30.78
1998	91.26	1.69	92.95	41.04
1999	91.71	1.67	93.38	41.22
2000	88.86	1.58	90.44	39.92
2001	91.00	1.66	92.66	40.91
2002	92.89	1.63	94.52	41.72
2003	91.66	1.69	93.35	41.21
2004	92.49	1.73	94.22	41.60
2005	94.52	1.73	96.25	42.49
2006	92.84	1.75	94.59	41.76
2007	72.59	1.24	73.83	32.59
2008	69.75	1.02	70.76	31.22
2009	85.82	0.00	85.82	37.76
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

4.2.8.4 Uncertainties and time-series consistency

The same tier approach is used for the time period 1996 – 2014. Before 1996, no desulphurization technology was used in Slovakia. Data presented in Table 4.18 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 the subcategory 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 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 4 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 (-2.11%; +2.11%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by Δ symbol in formula):

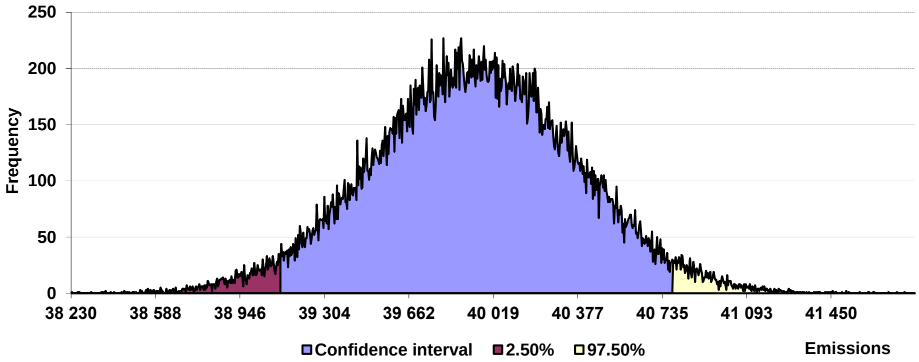
$$Emissions = \sum_{I} \left[(CaCO_3 \pm \Delta CaCO_3) * 0.440 + (MgCO_3 \pm \Delta MgCO_3) * 0.522 \right]$$

The emissions of desulphurization enter the calculation. Accumulated uncertainty and statistical characteristics for this subcategory are presented in the following figure and table. The average mean value of GHG emissions in the subcategory 2.A.4.d obtained by the Monte Carlo simulation are 39.94 Gg CO_2 per year. The average mean value is comparable with the real CO_2 emissions in this subcategory, which is 39.94 Gg CO_2.

Table 4.19: *Selected statistical characteristics for subcategory 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
39 940	**39 939**	428	38 230	41 808	-2.11%	2.11%

Figure 4.11: *Probability density function for subcategory 2.A.4.d (t of CO_2)*



4.2.8.5 Source specific QA/QC and verification

Sector specific QA/QC activities were performed and are described in Chapter 4.2 of this report. Activity data are from the EU ETS reports and information provided by the operators in questionnaires (requested by the SNE) are verified by the statistical information provided by the Statistical Office of the Slovak Republic. CO_2 emissions reported in the EU ETS reports were 39.94 Gg in 2014, which is the same value as was estimated in the GHG inventory. All sources reported in this subcategory are included in the EU ETS.

4.2.8.6 Source specific recalculations

No recalculations focused on the base year 1990 or the other inventory years were provided in the 2016 submission.

4.2.8.7 Source specific planned improvements

No improvements are planned for this subcategory for the next submission.

4.3 CHEMICAL INDUSTRY (CRF 2.B)

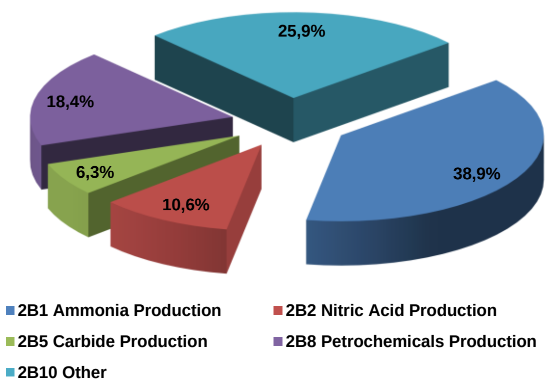
4.3.1 SOURCE CATEGORY DESCRIPTION

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 1 364.75 Gg of CO_2 equivalents in 2014. The decrease of emissions in the comparison with the previous year is approximately 15% and 33% in the comparison with the base year. The decrease is caused by lower production of ammonia (by 27% 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. Within category, major share (38.9%) in emissions belongs to ammonia production, 25.9% belongs to hydrogen production (other), 18.4% belongs to petrochemicals production, 10.6% belongs to nitric acid production and 6.3% to carbide production.

Table 4.20: *Emissions in 2.B according to the subcategories (in Gg of CO_2 eq.) in 1990 – 2014*

Category 2.B in CO_2 emissions eq. (Gg)					
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
1991	404.36	799.32	NO	427.84	137.50
1992	414.46	716.53	16.74	429.04	163.62
1993	243.69	559.79	82.05	349.17	185.37
1994	428.54	980.61	120.62	443.88	110.67
1995	488.47	1 120.62	139.01	459.91	175.50
1996	473.45	1 302.74	143.98	428.37	151.43
1997	472.06	1 232.19	159.61	434.91	164.43
1998	451.06	1 053.80	145.73	466.09	198.19
1999	476.01	791.15	139.69	413.30	201.11
2000	521.74	1 017.26	156.73	462.68	234.51
2001	523.70	1 153.30	174.67	366.01	200.75
2002	519.51	1 023.79	171.02	382.35	314.76
2003	460.12	1 138.40	176.89	352.70	347.21
2004	536.77	1 304.75	200.12	402.97	379.90
2005	573.24	1 234.79	176.72	371.40	363.73
2006	454.94	1 522.25	198.97	375.85	352.61
2007	463.85	1 362.69	197.82	420.13	397.41
2008	418.35	1 263.43	214.83	381.72	394.38
2009	484.19	1 049.17	199.57	398.63	354.06
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

Figure 4.12: *The share in CO_2 emissions of individual subcategories in 2.B in 2014*



Category	**CO_2 eq. (Gg)**
Ammonia production	530.30
Nitric acid production	144.69
Carbide production	85.51
Petrochemicals production	250.60
Other	353.39

4.3.2 SOURCE SUBCATEGORY DESCRIPTION – 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 4.21.

4.3.2.1 Methodological issues – methods

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 (34.800 in 2014); CCF is content of carbon in the fuel in t/TJ (15.197 in 2014) 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 Energy sector, transport category 1.A.3.b (using urea in urea-based catalytic converters).

4.3.2.2 Methodological issues – emission factors and other parameters

The implied emission factor is 1.530 t CO_2 per 1 t of ammonia produced in 2014 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 4.21 and 4.22.

4.3.2.3 Activity data

Production of ammonia decreased in 2014 by 27% in comparison with 2013 and 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 2014 that are necessary for the calculation of emissions. The presented data are based on direct measurements in plant.

Table 4.21: *Ammonia production (kt) and GHG emissions (Gg, t) in 1990 – 2014*

Category 2.B.1 ammonia production						
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
1991	351.60	608.44	10.73	1.07	315.02	10 726.39
1992	344.20	592.76	10.50	1.05	308.39	10 497.55
1993	206.90	353.38	6.28	0.63	185.37	6 278.60
1994	353.90	595.16	10.62	1.06	317.08	10 615.82
1995	383.80	654.14	11.70	1.17	343.87	11 698.41
1996	411.70	700.83	12.57	1.26	368.87	12 574.63
1997	409.90	695.36	12.50	1.25	367.25	12 501.29
1998	364.30	616.38	11.11	1.11	326.40	11 110.57
1999	364.00	617.04	11.14	1.11	326.13	11 137.29
2000	403.00	683.85	12.36	1.24	361.07	12 359.46
2001	411.80	696.84	12.61	1.26	368.96	12 610.98
2002	400.00	677.41	12.27	1.23	358.38	12 267.45

Category 2.B.1 ammonia production						
Year	Ammonia production	CO_2 emissions*	CH_4 emissions	N_2O emissions	NG consumption	
	(kt)	(Gg)	(t)		(mil. m^3)	(TJ)
2003	353.68	599.49	10.86	1.09	316.88	10 856.39
2004	407.90	690.73	12.52	1.25	365.46	12 517.07
2005	426.35	721.40	13.06	1.31	381.99	13 064.02
2006	354.56	602.65	10.90	1.09	317.67	10 899.22
2007	362.44	614.52	11.13	1.11	324.73	11 128.53
2008	328.20	556.57	10.08	1.01	293.94	10 079.12
2009	344.40	618.40	11.19	1.12	325.39	11 194.45
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

* CO_2 emissions without consideration of urea production

Table 4.22: *Urea production (kt), CO_2 used for the production and resulting CO_2 emissions (Gg, t) in 1990 – 2014*

Subcategory 2.B.1 ammonia production				
Year	Urea production (kt)	CO_2 consumed (Gg)	Net CO_2 emissions* (Gg)	IEF (t/t)
1990	C	285.20	331.77	0.922
1991	C	204.66	403.78	1.148
1992	C	178.88	413.88	1.202
1993	C	110.03	243.35	1.176
1994	C	167.20	427.96	1.209
1995	C	166.31	487.83	1.271
1996	C	228.06	472.76	1.148
1997	C	223.99	471.38	1.150
1998	C	165.92	450.45	1.236
1999	C	141.64	475.40	1.306
2000	C	162.79	521.06	1.293
2001	C	173.83	523.01	1.270
2002	C	158.57	518.84	1.297
2003	C	139.97	459.52	1.299
2004	C	154.65	536.09	1.314
2005	C	148.87	572.52	1.343
2006	C	148.31	454.34	1.281
2007	C	151.28	463.24	1.278
2008	C	138.78	417.79	1.273
2009	C	134.83	483.58	1.404
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

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

4.3.2.4 Uncertainties and time-series consistency

Consistent tier 3 method is used for whole time period 1990 – 2014. 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 equivalents) was calculated in interval (-8.63%; +8.90%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by Δ symbol in formula):

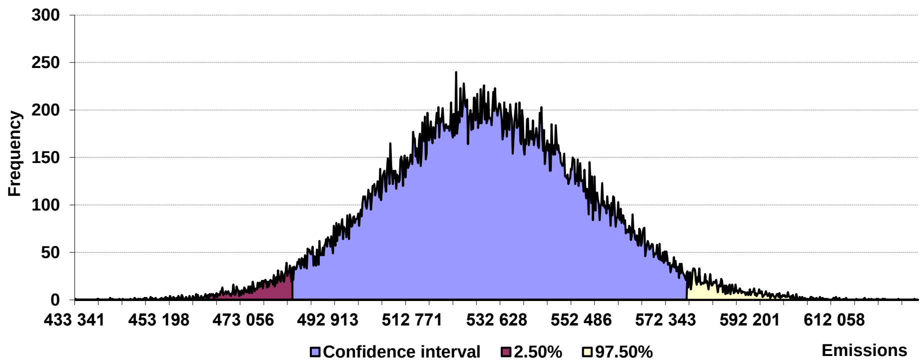
$$Emissions = (FR \pm \Delta FR) * (CCF \pm \Delta CCF) * \frac{44}{12} / 1000 - (R \pm \Delta R) * 1000 +$$
$$+ \sum_{I} (FR \pm \Delta FR) * (EF_I \pm \Delta EF_I) * CF_I / 1000000$$

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 equivalents. The accumulated uncertainty and statistical characteristics for ammonia are presented in the following table and figure. The average mean value of GHG emissions in the subcategory 2.B.1 obtained by the Monte Carlo simulation is 530 Gg CO_2 eq. per year. The average mean value is comparable with the real GHG emissions in this subcategory, which is 530 Gg CO_2 eq.

Table 4.23: *Selected statistical characteristics for subcategory 2.B.1, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2 equivalents)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
529 775	**530 137**	23 857	433 341	631 916	-8.63%	8.90%

Figure 4.13: *Probability density function for subcategory 2.B.1 (t of CO_2 equivalents)*



4.3.2.5 Source specific QA/QC and verification

Sector specific QA/QC activities were performed and are described in Chapter 4.2 of this report. Activity data are from the EU ETS reports and information provided by the operators in questionnaires (requested by the SNE) are verified by the statistical information provided by the Statistical Office of the Slovak Republic. All sources reported in this subcategory 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).

4.3.2.6 Source specific recalculations

No recalculation was made in this submission.

4.3.2.7 Source specific planned improvements

No improvements are planned in this subcategory.

4.3.3 SOURCE SUBCATEGORY DESCRIPTION – NITRIC ACID PRODUCTION (CRF 2.B.2)

Globally, nitric acid production consumes about 20% of all produced ammonia. Nitric acid production in the Slovak Republic is an important source of N_2O emissions and a key category in level and trend assessment. Total nitric acid production decreased inter-annually (2013/2014) by 5% and achieved the 2011 level. But the N_2O emissions increased by 12% in 2014 in comparison with 2013. 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.

4.3.3.1 Methodological issues – methods

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.

4.3.3.2 Methodological issues – emission factors and other parameters

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 4.24.

Table 4.24: *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 2014 is presented in Table 4.25. The overall EF = 0.84 kg N_2O/t of HNO_3 in 2014 was estimated as weighted average. N_2O emissions were 485.53 t in 2014. The detailed results are in Tables 4.25 and 4.26.

Table 4.25: *Detailed information on measured N_2O concentrations in 2014*

Plant	N_2O concentration (ppm)	Weighted average EF (kg/t)
medium pressure plant 1	141.49	0.477
medium pressure plant 2	158.74	0.662
high pressure plant	351.28	1.178

Table 4.26: *Estimated N_2O emissions (t) and IEFs (N_2O) in 1990 – 2014*

Subcategory 2.B.2 nitric acid production							
Year	**Nitric acid production (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	4 310.94
1991	301.83	8.887	989.37	1 692.92	NO	2 682.28	3 216.50
1992	278.44	8.636	747.36	1 657.12	NO	2 404.47	2 927.93
1993	233.62	8.041	298.74	1 579.76	NO	1 878.50	2 457.62
1994	360.82	9.120	1 381.64	1 909.01	NO	3 290.65	3 870.12
1995	398.80	9.429	1 818.70	1 941.77	NO	3 760.47	4 250.00
1996	446.78	9.785	2 412.67	1 958.94	NO	4 371.61	236.80
1997	421.33	9.814	2 304.38	1 830.50	NO	4 134.88	229.67
1998	377.35	9.371	1 668.94	1 867.30	NO	3 536.24	208.88
1999	306.51	8.662	554.58	1 371.88	728.40	2 654.86	185.26
2000	407.22	8.383	NO	1 256.58	2 157.06	3 413.64	202.78
2001	464.35	8.335	NO	1 545.02	2 325.11	3 870.14	202.04
2002	403.84	8.507	NO	995.28	2 440.26	3 435.54	189.15
2003	454.64	8.403	NO	1 357.93	2 462.20	3 820.13	193.76
2004	524.82	8.343	NO	1 725.29	2 653.06	4 378.34	230.38
2005	497.68	8.326	NO	1 584.29	2 559.28	4 143.57	265.15
2006	564.00	9.057	NO	2 470.33	2 637.90	5 108.23	252.46
2007	489.22	9.347	NO	1 934.70	2 638.07	4 572.77	228.32
2008	509.26	8.325	NO	1 845.09	2 394.62	4 239.71	215.00
2009	418.62	8.410	NO	1 259.34	2 261.35	3 520.69	287.14
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	337.67
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

4.3.3.3 Activity data

Total production of nitric acid in 2014 was 580.09 kt. N_2O emissions estimated from this subcategory was 485.53 t and the NO_x emissions were 344.56 t in 2014. Activity data and emissions are presented in Table 4.26.

4.3.3.4 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 subcategory. The production process generates N_2O emissions. Based on calculation, the overall uncertainty of CO_2 emissions (in equivalents) was calculated in interval (-5.37%; +5.40%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by Δ symbol, CF is a conversion factor to CO_2 equivalent):

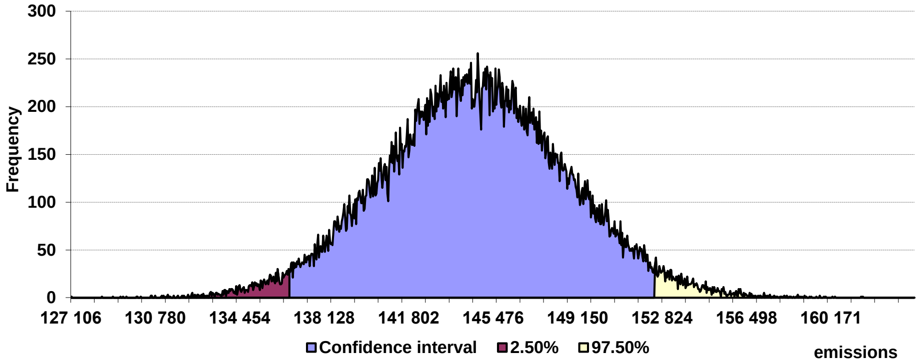
$$Emissions = \sum_{I} \left[(HNO_3\ amount \pm \Delta amount) * (EF \pm \Delta EF) * CF_i / 1000 \right]$$

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 the subcategory 2.B.2 obtained by the Monte Carlo simulation is 145 Gg CO_2 eq. per year 2014. The average mean value is comparable with the real GHG emissions (145 Gg CO_2 eq.).

Table 4.27: *Selected statistical characteristics for subcategory 2.B.2, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2 equivalents)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
144 676	**144 691**	3 977	127 106	163 845	-5.37%	5.40%

Figure 4.14: *Probability density function for subcategory 2.B.2 (t of CO_2 equivalents)*



4.3.3.5 Source specific QA/QC and verification

Sector specific QA/QC activities were performed and are described in Chapter 4.2 of this report. Activity data are from the EU ETS reports and information provided by the operators in questionnaires (requested by the SNE) are compared with the measurements protocols on N_2O concentration in output gases. All sources reported in this subcategory are included in the EU ETS.

4.3.3.6 Source specific recalculations

No recalculations focused on the base year 1990 or the other inventory years were provided in the 2016 submission.

4.3.3.7 Source specific planned improvements

No improvements are planned for this category for the next submission.

4.3.4 SOURCE SUBCATEGORY DESCRIPTION – ADIPIC ACID PRODUCTION (CRF 2.B.3)

Adipic acid is not produced in the Slovak Republic therefore notation key “NO” is used in this subcategory.

4.3.5 SOURCE SUBCATEGORY DESCRIPTION – CAPROLACTAM, GLYOXAL AND GLYOXYLIC ACID (CRF 2.B.4)

None of these products are produced in the Slovak Republic therefore notation key “NO” is used in this subcategory.

4.3.6 SOURCE SUBCATEGORY DESCRIPTION – CARBIDE PRODUCTION (CRF 2.B.5)

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

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

4.3.6.2 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. The production of carbide is stable since 2004. Total CO_2 emissions reached 85.76 Gg of CO_2 in 2014 and decreased by 10% in comparison with 2013. The decrease was caused by declining production of calcium carbide and improving of technology, by the reduction of the carbon content in the waste lime mud.

4.3.6.3 Methodological issues – methods

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 subcategory (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 4.28 (C = confidential data are available in the SNE archive).

Table 4.28: *Estimated CO_2 emissions (Gg), carbide production and export (kt) in 1990 – 2014*

Subcategory 2.B.5.b calcium carbide production								
Year	**Carbide production**	**Carbide export**	**Carbide for VCM production**	**$CaCO_3$ consumpt.**	**Coking coal consumpt.**	**Other bituminous coal consumpt.**	**IEF CO_2**	**Total CO_2 emissions**
	kt						**t/t**	**Gg**
1990	NO	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO	NO
1992	10.00	C	C	15.61	8.75	NO	1.67	16.74
1993	50.00	C	C	78.07	39.51	4.23	1.64	82.05
1994	73.50	C	C	114.76	58.11	6.19	1.64	120.62
1995	84.30	C	C	131.63	66.61	7.14	1.65	139.01
1996	90.00	C	C	140.53	71.20	7.53	1.60	143.98
1997	96.60	C	C	150.83	76.33	8.18	1.65	159.61
1998	88.60	C	C	138.34	70.05	7.46	1.64	145.73
1999	80.87	C	C	126.26	63.90	6.84	1.73	139.69
2000	88.82	C	C	138.68	70.26	7.44	1.76	156.73
2001	99.65	C	C	155.60	78.79	8.39	1.75	174.67
2002	100.13	C	C	156.34	79.22	8.37	1.71	171.02
2003	100.44	C	C	156.82	79.39	8.47	1.76	176.89
2004	100.00	C	C	156.14	79.09	8.39	2.00	200.12
2005	97.03	C	C	151.50	76.73	8.15	1.82	176.72
2006	97.26	C	C	151.86	76.95	8.13	2.05	198.97
2007	101.22	C	C	158.04	80.05	8.50	1.95	197.82
2008	107.52	C	C	167.90	84.96	9.11	2.00	214.83
2009	97.50	C	C	156.95	77.09	8.21	2.05	199.57
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

Subcategory 2.B.5.b calcium carbide production								
Year	**Carbide production**	**Carbide export**	**Carbide for VCM production**	**$CaCO_3$ consumpt.**	**Coking coal consumpt.**	**Other bituminous coal consumpt.**	**IEF CO_2**	**Total CO_2 emissions**
	kt						**t/t**	**Gg**
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

4.3.6.4 Methodological issues – emission factors and other parameters

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 2014 was 0.87 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 1.15 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.

4.3.6.5 Activity data

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 2014. The rest of produced calcium carbide was used for acetylene production for welding applications (conservative approach). No production of CaO occurred in 2014. 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 subcategory.

4.3.6.6 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 – 2014) 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 4.28). 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 subcategory. Based on calculation, the overall uncertainty of CO_2 emissions was calculated in interval (-9.24%; +9.20%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by Δ symbol in formula):

$$\text{Emissions} = \sum_i \Big[(\text{consum\_coal} \pm \Delta\text{consum\_coal})\cdot(\text{NCV} \pm \Delta\text{NCV})\cdot(\text{EF(C)} \pm \Delta\text{EF(C)})$$

$$-(\text{prod\_carbide} \pm \Delta\text{prod\_carbide})\cdot(\text{content\_C} \pm \Delta\text{content\_C})\Big]\cdot 44/12+$$

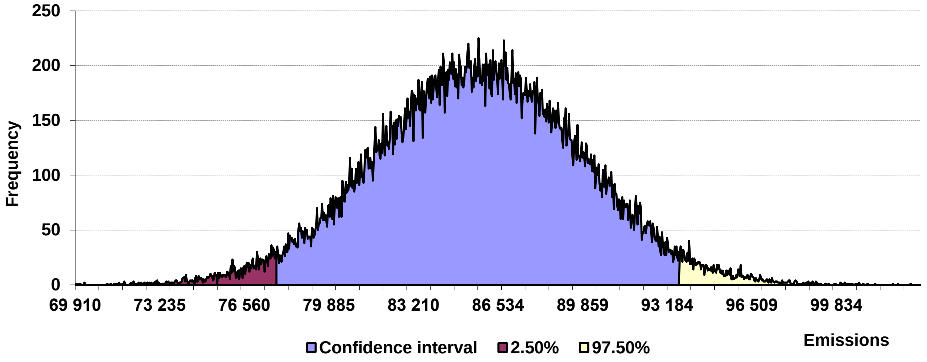
$$-(\text{consumed\_limestone} \pm \Delta\text{consumed\_limestone})\cdot 0.44 + (\text{carbide\_used} \pm \Delta\text{carbide\_used})\cdot(\text{EF} \pm \Delta\text{EF})\Big]$$

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 the subcategory 2.B.5.b obtained by the Monte Carlo simulation is 85.76 Gg CO_2 per year. The average mean value is comparable with the real CO_2 emissions in this subcategory, which is 85.76 Gg CO_2.

Table 4.29: *Selected statistical characteristics for subcategory 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
85 751	**85 759**	4 027	69 910	103 158	-9.24%	9.20%

Figure 4.15: *Probability density function for subcategory 2.B.5.b (t of CO_2)*



4.3.6.7 Source specific QA/QC and verification

Sector specific QA/QC activities were performed and are described in the Chapter 4.2 of this report. Activity data are provided by the operator in questionnaires (requested by the SNE). The EU ETS report contains only the CO_2 emissions from CaC_2 production. Comparing of the processing CO_2 emissions (64.41 Gg in inventory against 64.70 Gg in the EU ETS) results differenced by 0.4%. The difference is caused by using country specific NCV and EF for coals.

4.3.6.8 Source specific recalculations

No recalculations focused on the base year 1990 or the other inventory years were provided in the 2016 submission.

4.3.6.9 Source specific planned improvements

No improvements are planned for this subcategory for the next submission.

4.3.7 SOURCE SUBCATEGORY DESCRIPTION – TITANIUM DIOXIDE PRODUCTION (CRF 2.B.6)

Titanium dioxide is not produced in the Slovak Republic and “NO” notation key is used in this subcategory.

4.3.8 SOURCE SUBCATEGORY DESCRIPTION – SODA ASH PRODUCTION (CRF 2.B.7)

Soda ash is not produced in the Slovak Republic and “NO” notation key is used in this subcategory.

4.3.9 SOURCE SUBCATEGORY DESCRIPTION – 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 are used in these subcategories.

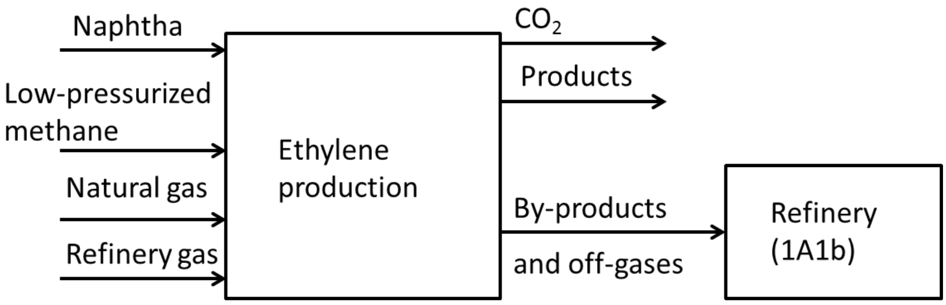
4.3.10 SOURCE SUBCATEGORY DESCRIPTION – ETHYLENE (CRF 2.B.8.b)

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 the subcategory 1.A.1.b. Total CO_2 emissions from ethylene production were 243.55 Gg in 2014, which represents the decrease by 24% in comparison with 2013. The decrease is caused by lowering the production.

4.3.10.1 Methodological issues – methods

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 (see 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 the subcategory 2.B.8.b*



4.3.10.2 Methodological issues – emission factors and other parameters

Ethylene is produced by one operator in Slovakia and therefore the NCVs and emission factors of all feedstock were provided directly (EU ETS reports).

4.3.10.3 Activity data

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 the subcategory 1.A.1.b. Detailed data are presented in the Table 4.30.

Table 4.30: *Activity data and related CO_2 emissions (Gg) from ethylene and propylene production in 1990 – 2014*

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
1991	14 518.8	2 874.1	4 581.9	0.0
1992	19 663.6	1 369.5	5 717.2	467.6
1993	16 132.0	1 086.0	4 307.0	721.6
1994	18 006.8	2 635.4	4 458.2	710.5
1995	19 271.2	1 714.1	5 071.7	1 306.4
1996	19 271.2	1 962.5	4 483.4	1 078.8
1997	19 271.2	1 796.3	4 405.9	1 433.5
1998	23 718.4	726.2	5 253.0	2 229.2
1999	20 753.6	806.4	4 686.5	1 790.5
2000	21 625.6	1 419.9	4 380.5	2 357.3
2001	15 826.8	1 213.4	4 539.2	598.3

Year	inputs in TJ			
	naphtha	natural gas	refinery gas	low-pressurized CH_4
2002	16 437.2	NO	5 586.5	1 108.1
2003	15 172.8	NO	4 814.2	1 332.4
2004	17 527.2	NO	5 566.8	1 491.8
2005	17 440.0	959.5	4 497.4	1 031.8
2006	15 957.6	896.2	4 292.3	1 376.8
2007	17 265.6	1 059.0	4 447.0	1 836.8
2008	16 393.6	1 404.5	3 615.9	1 679.8
2009	18 006.8	1 304.0	4 145.2	1 606.2
2010	17 004.0	1 610.6	4 237.1	1 244.2
2011	16 742.4	1 532.7	4 062.2	1 126.2
2012	10 900.0	1 487.9	2 928.5	612.1
2013	11 510.4	1 707.9	3 124.8	907.5
2014	11 264.0	1 319.6	2 522.0	584.2

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
1991	197.9	95.3	39.3	415.69	2.101
1992	188.6	85.7	158.7	416.86	2.210
1993	154.7	71.7	129.1	336.92	2.178
1994	209.5	90.3	103.6	431.90	2.062
1995	200.3	93.3	133.9	447.80	2.236
1996	190.0	91.1	144.6	416.27	2.191
1997	192.0	94.4	139.9	422.55	2.201
1998	204.2	97.9	215.6	452.80	2.217
1999	190.2	92.1	173.8	399.76	2.102
2000	207.4	92.9	175.5	449.28	2.166
2001	198.2	87.5	71.9	350.16	1.767
2002	210.9	92.1	69.6	367.73	1.744
2003	192.1	83.1	67.8	338.77	1.764
2004	221.2	101.6	74.0	389.33	1.760
2005	202.5	91.9	96.8	357.33	1.765
2006	199.9	88.9	71.9	361.59	1.809
2007	221.5	103.8	66.8	404.61	1.827
2008	205.4	95.1	70.6	369.24	1.798
2009	224.0	101.0	81.9	388.75	1.736
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

4.3.10.4 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). 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 4.30 were subtracted from the subcategory 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 (-36.11%; +36.32%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by Δ symbol in formula):

Emission = [(NG± ΔNG)*(NG_NCV± ΔNG_NCV)*(NG_EF± ΔNG_EF)/1000 +

+ (RG± ΔRG)*(RG_NCV± ΔRG_NCV)*(RG_EF± ΔRG_EF)/1000 +

+ (NMT± ΔNMT)*(NMT_NCV± ΔNMT_NCV)*(NMT_EF± ΔNMT_EF)/1000 +

+ (naphta±Δnaphta) *(naphtha_NCV±Δnaphta_NCV) *(naphtha_EF±Δnaphta_EF) -

- (ethylen±Δethylen)*0.856 – (propylene±Δpropylene)*0.8563 – (other± Δother)]*44/12

Table 4.31: *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%

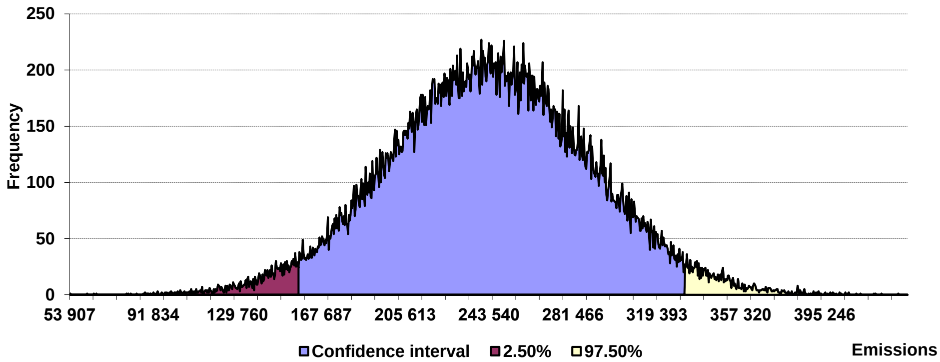
NMT (EF C)	ethylene production	propylene production	Other C	naphtha	naphtha (NCV)	naphtha (EF C)
2.00%	1.50%	1.50%	5.00%	2.00%	2.00%	10.00%

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 the subcategory 2.B.8.b obtained by the Monte Carlo simulation is 244 Gg CO_2 per year. The average mean value is comparable with the real CO_2 emissions in this subcategory, which is 244 Gg CO_2.

Table 4.32: *Selected statistical characteristics for subcategory 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
243 405	**243 651**	44 885	53 907	433 173	-36.11%	36.32%

Figure 4.17: *Probability density function for category 2.B.8.b (t of CO_2)*



4.3.10.5 Source specific QA/QC and verification

Sector specific QA/QC activities were performed and are described in Chapter 4.2 of this report. 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 subcategory are included in the EU ETS.

4.3.10.6 Source specific recalculations

No recalculation was made in this submission.

4.3.10.7 Source specific planned improvements

No improvements are planned for this subcategory in the next submission.

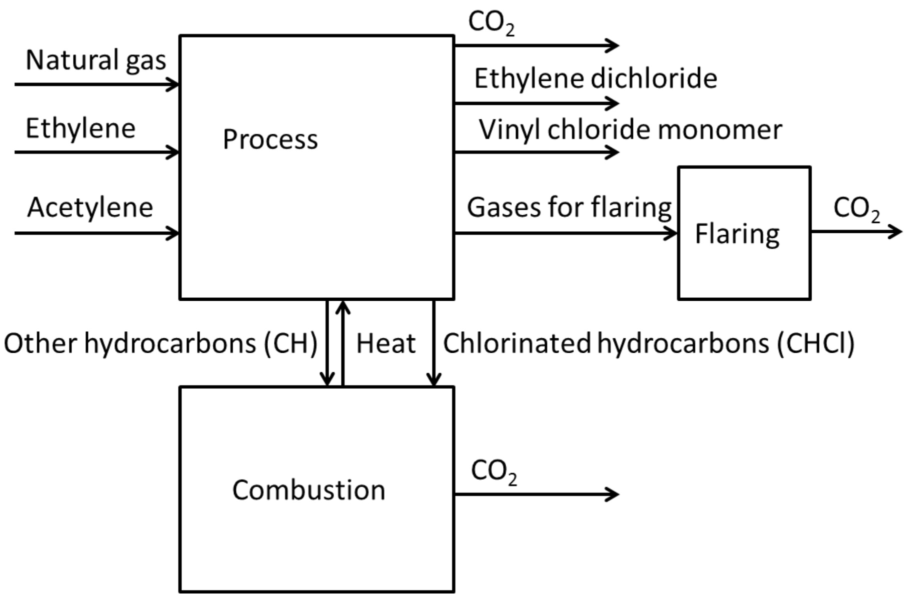
4.3.11 SOURCE SUBCATEGORY DESCRIPTION – ETHYLENE DICHLORIDE AND VINYL CHLORIDE MONOMER (CRF 2.B.8.c)

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 the subcategory 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 subcategory for whole time series. The emissions in 2014 were 7.05 Gg and decreased by 17% in comparison with the previous year 2013. The decrease was caused by the decrease in production.

4.3.11.1 Methodological issues – methods

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.).

Figure 4.18: *Carbon material balance used in emissions estimation of the subcategory 2.B.8.c*



4.3.11.2 Methodological issues – emission factors and other parameters

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.

4.3.11.3 Activity data

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 4.33.

***Table 4.33:** Activity data and related CO_2 emissions (Gg) from the EDC and VCM production in 1990 – 2014*

Subcategory 2.B.8.c ethylene dichloride and vinyl chloride monomer					
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
1991	5 167	10.320	12.848	NO	52.102
1992	5 138	11.727	12.235	NO	53.666
1993	5 117	17.356	5.203	NO	49.191
1994	4 965	17.356	7.283	NO	54.064
1995	4 935	17.356	8.177	NO	56.159
1996	5 001	17.331	6.581	NO	52.365
1997	5 070	18.493	6.740	NO	55.215
1998	5 667	17.332	6.663	NO	52.559
1999	5 678	18.951	6.682	NO	56.055
2000	5 302	21.003	9.471	NO	66.963
2001	6 649	21.515	8.071	NO	64.776
2002	6 257	18.420	7.111	NO	55.929
2003	5 870	19.175	6.415	NO	55.906
2004	5 746	18.213	7.505	NO	56.410
2005	5 850	18.807	9.166	NO	61.568
2006	6 010	19.479	6.209	NO	56.072
2007	6 560	21.102	6.590	NO	60.424
2008	5 165	20.112	3.370	NO	50.770
2009	4 158	13.545	4.909	NO	40.376
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

Subcategory 2.B.8.c ethylene dichloride and vinyl chloride monomer								
Year	NG for flaring (1 000 m^3)	CHCl (kt)*	CH (kt)**	process CO_2 (Gg)	combustion 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
1991	44.1	1.463	0.273	10.637	1.336	0.173	12.146	0.2331
1992	53.6	1.570	0.277	10.533	1.435	0.211	12.178	0.2269
1993	45.2	1.816	0.264	10.412	1.659	0.178	12.249	0.2490
1994	43.9	1.996	0.278	9.977	1.824	0.173	11.973	0.2215
1995	50.7	2.042	0.284	10.045	1.866	0.199	12.110	0.2156
1996	49.6	1.910	0.273	10.159	1.745	0.195	12.099	0.2310
1997	51.1	2.078	0.284	10.257	1.899	0.201	12.356	0.2238
1998	44.2	1.923	0.287	11.358	1.757	0.174	13.289	0.2528
1999	54	2.110	0.299	11.399	1.927	0.212	13.539	0.2415
2000	53.4	2.104	0.265	11.264	1.922	0.210	13.396	0.2000
2001	48.8	2.221	0.277	13.626	2.029	0.192	15.847	0.2446
2002	44.6	2.191	0.268	12.445	2.002	0.175	14.622	0.2614
2003	45.9	2.228	0.283	11.711	2.036	0.180	13.928	0.2491
2004	45.9	2.137	0.278	11.517	1.952	0.180	13.649	0.2420
2005	44.8	2.397	0.268	11.704	2.190	0.176	14.070	0.2285

Subcategory 2.B.8.c ethylene dichloride and vinyl chloride monomer								
Year	**NG for flaring (1 000 m^3)**	**CHCl (kt)***	**CH (kt)****	**process CO_2 (Gg)**	**combustion CO_2 (Gg)**	**flaring CO_2 (kt)**	**total CO_2 (Gg)**	**IEF (CO_2) (t/t VMC)**
2006	47.9	2.208	0.271	12.058	2.017	0.188	14.263	0.2544
2007	47.4	2.481	0.277	13.069	2.266	0.186	15.522	0.2569
2008	45.3	2.038	0.281	10.437	1.862	0.178	12.477	0.2458
2009	45.9	1.246	0.241	8.562	1.138	0.180	9.881	0.2447
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

*chlorinated hydrocarbons, **other hydrocarbons

4.3.11.4 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 the subcategory 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 (-15.07%; +14.88%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by ∆ in symbol formula):

Emission1 = [(NG± ∆NG)*(NG_NCV± ∆NG_NCV)*(NG_EF± ∆NG_EF)/1000 +

+ (ethylene± ∆ethylene)*0,856 + (acetylene± ∆acetylene)*0.9228 –

- (EDC± ∆ EDC)*0,245 – (VCM± ∆VCM)*0,384 – (flaring± ∆ flaring)*(flar_EF± ∆ flar_EF) –

- (ClU± ∆ ClU)*(ClU_NCV± ∆ ClU_NCV)*(ClU_EF± ∆ ClU_EF) /1000 –

- (CHU± ∆ CHU)*(CHU_C± ∆ CHU_C)]*3.6642

Emission2 = (flaring± ∆ flaring)*(flar_EF± ∆ flar_EF) *3.6642

Emission3 = (ClU± ∆ ClU)*(ClU_NCV± ∆ ClU_NCV)*(ClU_EF± ∆ ClU_EF) /1000

Emission = Emission1 + Emission2 + Emission3

Table 4.34: *Used uncertainties for inputs (fuels), NCV, carbon EFs and final production*

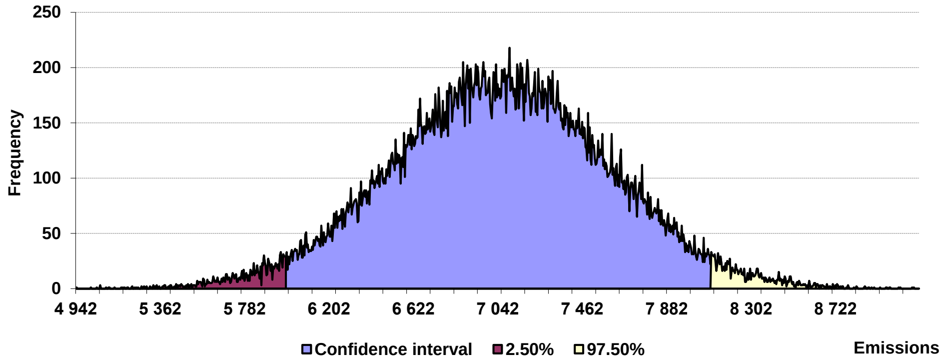
NG	**ethylene**	**acetylene**	**EDC**	**VCM**	**flaring (th. m^3)**	**ClU (t)**
2.00%	2.00%	2.00%	2.00%	2.00%	5.00%	2.00%
CHU (t)	**NG (NCV)**	**NG (EF C)**	**Flaring (EF C)**	**ClU (NCV)**	**ClU (EF C)**	**CHU (w C)**
2.00%	2.00%	2.00%	10.00%	5.00%	5.00%	5.00%

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 the subcategory 2.B.8.c obtained by the Monte Carlo simulation is 7.05 Gg CO_2 per year. The average mean value is comparable with the real CO_2 emissions in this subcategory, which is 7.05 Gg CO_2.

Table 4.35: *Selected statistical characteristics for subcategory 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
7 053	**7 052**	538	4 942	9 141	-15.07%	14.88%

Figure 4.19: *Probability density function for subcategory 2.B.8.c (t of CO_2)*



4.3.11.5 Source specific QA/QC and verification

Sector specific QA/QC activities were performed and are described in Chapter 4.2 of this report. 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 subcategory are included in the EU ETS.

4.3.11.6 Source specific recalculations

No recalculation was made in this submission.

4.3.11.7 Source specific planned improvements

No improvements are planned for this subcategory for the next submission.

4.3.12 SOURCE SUBCATEGORY DESCRIPTION – OTHER (CRF 2.B.10)

Hydrogen production in refinery is included in this subcategory. 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 subcategory. 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 2014 were 353.04 Gg and they decreased by 4% in comparison with the previous year 2013.

4.3.12.1 Methodological issues – methods

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) (34.800 in 2014); CCF is content of carbon in the fuel (in t/TJ) (15.197 in 2014) 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).

4.3.12.2 Methodological issues – emission factors and other parameters

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.

4.3.12.3 Activity data

Total hydrogen production in 2014 was 39.41 kt. Detailed activity data are presented in the Table 4.36. The volume of used natural gas presented in this subcategory was subtracted from the energy sector in order to avoid the double-counting.

Table 4.36: *Activity data and related CO_2 emissions (Gg) from the subcategory 2.B.10 hydrogen production in 1990 – 2014*

Year	hydrogen production (kt)	natural gas consumption (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
1991	14.43	2 422.28	137.37	9.52	2.42	0.24
1992	17.71	2 893.97	163.46	9.23	2.89	0.29
1993	20.09	3 291.13	185.19	9.22	3.29	0.33
1994	12.47	1 971.56	110.56	8.87	1.97	0.20
1995	19.93	3 136.38	175.33	8.80	3.14	0.31
1996	16.29	2 713.67	151.28	9.29	2.71	0.27
1997	17.79	2 953.90	164.27	9.23	2.95	0.30
1998	22.40	3 567.75	197.99	8.84	3.57	0.36
1999	23.42	3 626.74	200.91	8.58	3.63	0.36
2000	27.09	4 256.60	234.28	8.65	4.26	0.43
2001	23.04	3 647.56	200.55	8.70	3.65	0.36
2002	36.55	5 722.61	314.45	8.60	5.72	0.57
2003	40.30	6 314.97	346.86	8.61	6.31	0.63
2004	44.49	6 918.63	379.52	8.53	6.92	0.69
2005	43.25	6 613.48	363.37	8.40	6.61	0.66
2006	40.40	6 403.61	352.26	8.72	6.40	0.64
2007	45.65	7 224.96	397.01	8.70	7.22	0.72
2008	45.18	7 196.34	393.99	8.72	7.20	0.72
2009	39.29	6 434.92	353.71	9.00	6.43	0.64
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

4.3.12.4 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.

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):

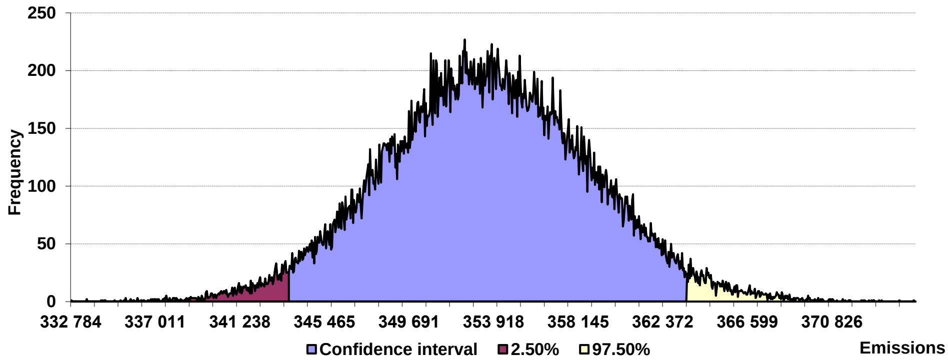
$$Emissions = (FR \pm \Delta FR) * (CCF \pm \Delta CCF) * \frac{44}{12} / 1000 +$$
$$+ \sum_{i} (FR \pm \Delta FR) * (EF_i \pm \Delta EF_i) * CF_i / 1000000$$

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 the subcategory 2.B.10 obtained by the Monte Carlo simulation is 354 Gg CO_2 eq. per year. The average mean value is comparable with the real CO_2 emissions in this subcategory, which is 354 Gg CO_2 eq.

Table 4.37: *Selected statistical characteristics for subcategory 2.B.10, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2 equivalents)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
353 534	**353 575**	5 095	332 784	375 052	-2.78%	2.82%

Figure 4.20: *Probability density function for subcategory 2.B.10 (t of CO_2 equivalents)*



4.3.12.5 Source specific QA/QC and verification

Sector specific QA/QC activities were performed and are described in Chapter 4.2 of this report. 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 subcategory are included in the EU ETS.

4.3.12.6 Source specific recalculations

No recalculation was made in this submission.

4.3.12.7 Source specific planned improvements

No improvements are planned for this subcategory for the next submission.

4.4 METAL PRODUCTION (CRF 2.C)

4.4.1 SOURCE CATEGORY DESCRIPTION

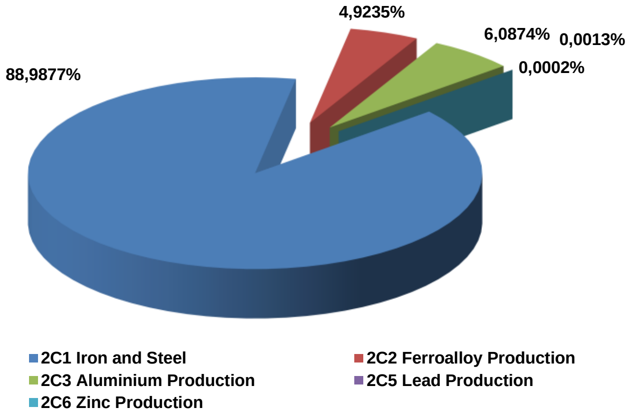
This category produces emissions of CO_2, CH_4 and PFCs emissions (aluminium production). Total emissions were 4 552.77 Gg of CO_2 equivalents in 2014 and increased by approximately 8% compared with the previous year. Comparing with the base year, the decrease is more than 7%. This trend is mostly caused by the decrease in CO_2 emissions from iron and steel production with respect to the base year and by increase in CO_2 emissions from iron and steel production and from ferroalloys production with respect to the previous 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 4.38: *Emissions in the 2.C according to the subcategories (Gg of CO_2 eq.) in 1990 – 2014*

Category 2.C in CO_2 emissions equivalents (Gg)					
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
1991	3 033.79	289.62	429.07	0.00	0.00
1992	2 657.66	281.00	399.30	0.00	0.00
1993	4 355.36	263.39	249.80	0.00	0.00
1994	3 834.15	259.57	212.27	0.00	0.00
1995	4 322.63	235.64	191.33	0.00	0.00
1996	4 552.01	226.25	219.83	0.00	0.00
1997	4 565.28	209.03	216.64	0.00	0.00
1998	4 093.29	247.27	200.49	0.00	0.00
1999	3 985.68	220.47	188.98	0.00	0.00
2000	3 344.72	182.69	190.05	0.00	0.00
2001	3 375.50	166.07	190.48	0.00	0.00
2002	4 147.04	334.67	190.05	0.00	0.00
2003	3 974.88	329.39	204.14	0.00	0.00
2004	4 291.21	372.19	275.10	0.00	0.00
2005	3 907.36	228.16	277.94	0.00	0.00
2006	4 405.47	276.14	282.71	0.00	0.00
2007	4 161.42	301.60	266.86	0.00	0.00
2008	4 013.73	263.38	286.40	0.00	0.00
2009	3 496.89	115.65	246.12	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

The major share of emissions (89.0%) belongs to the iron and steel production, 4.9% belongs to the ferroalloy production and 6.1% 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 of individual subcategories of the 2.C in 2014*

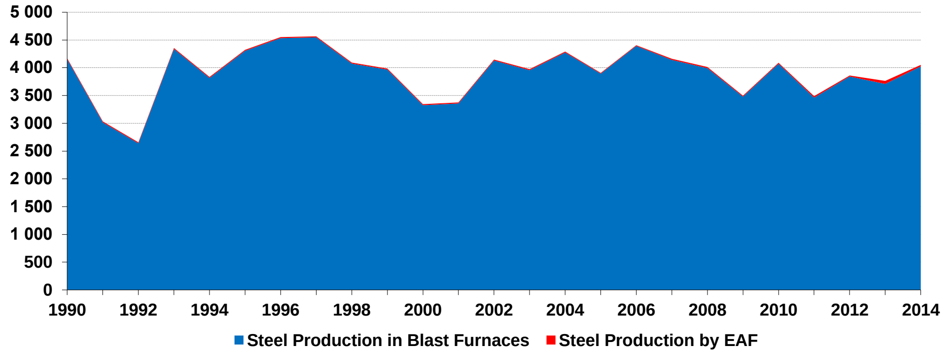


Subcategory	CO_2 eq. (Gg)
Iron and steel production	4 051.40
Ferroalloy production	224.15
Aluminium production	277.14
Lead production	0.06
Zinc production	0.01

4.4.2 SOURCE SUBCATEGORY DESCRIPTION – IRON AND STEEL PRODUCTION (CRF 2.C.1)

Total CO_2 emissions in this subcategory were 4 051.40 Gg in 2014, increased by ca 8% when compared with the year 2013. The increase is caused by the increase of production. 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 subcategories. The CO_2 emissions from the EAF steel production are reported separately in the 2.C.1.f subcategory.

Figure 4.22: *Emission trend in individual subcategories 2.C.1 (in Gg of CO_2 equivalents) in 1990 – 2014*



4.4.2.1 Methodological issues – methods

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 A4.2.1 in Annex 4.2 of this Report).

All streams were recalculated 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 4.2. The used method corresponds to tier 2 as described in the IPCC 2006 GL.

The CO_2 emissions were calculated by using following equation:

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

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

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

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.1f.) are included in this subcategory. Due to application of tier 2 methodology, methane emissions were not balanced in line with the IPCC 2006 GL.

4.4.2.2 Methodological issues – emission factors and other parameters

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 2014 was 2.832 kg/t, in pig iron it was 44.50 kg/t and 0.777 kg/t in steel (data supplied directly). Emission factors and other parameters are summarized in Tables 4.39 – 4.41. The CO_2 emissions from the EAF process are estimated based on carbon balance, where all material flows are taken into account.

4.4.2.3 Activity data

Iron and steel is produced by several plants (U.S.Steel Kosice, 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 24.15 kt of pig iron (which was sold) and 4 439.48 kt of steel in 2014. Total production of steel produced by the EAF technology was 527.85 kt in 2014. The plant UNEX Prakovce did not produced steel in 2013. New plant, Slovakia Steel Mills, started their production by the EAF technology in 2013. Activity data on produced pig iron, what is sold to customers and not processed to steel are presented in the subcategory 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 4.39: *Activity data, emission factors and CO_2 emissions in integrated iron and steel production in 2005 – 2014*

Year	coal con.	coke balance	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

Year	coal con.	coke balance	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)
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

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

Table 4.40: *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 4.41: *Activity data (t), emission factors (t/t) (below) and CO_2 emissions (t) in individual plants with EAF steel production in 1990 – 2014*

Year	Železiarne Podbrezová			Slovakia Steel Mills			Metalurg Steel		
	steel production by EAF	carbon	CO_2	steel production by EAF	carbon	CO_2	steel production by EAF	carbon	CO_2
1990	C	3 810.00	13 970.00	NO	NO	NO	C	1 096.60	4 021.00
1991	C	3 928.00	14 403.00	NO	NO	NO	C	1 117.40	4 097.00
1992	C	3 735.00	13 695.00	NO	NO	NO	C	1 076.50	3 947.00
1993	C	3 729.00	13 673.00	NO	NO	NO	C	1 053.50	3 863.00
1994	C	3 884.00	14 241.00	NO	NO	NO	C	1 102.40	4 042.00
1995	C	3 878.00	14 219.00	NO	NO	NO	C	1 044.30	3 829.00
1996	C	3 797.00	13 922.00	NO	NO	NO	C	1 102.10	4 041.00
1997	C	3 841.00	14 084.00	NO	NO	NO	C	1 097.70	4 025.00
1998	C	3 876.00	14 212.00	NO	NO	NO	C	1 047.80	3 842.00
1999	C	3 952.00	14 491.00	NO	NO	NO	C	1 022.70	3 750.00
2000	C	3 879.00	14 223.00	NO	NO	NO	C	1 117.10	4 096.00
2001	C	3 900.00	14 300.00	NO	NO	NO	C	1 105.90	4 055.00
2002	C	3 765.00	13 805.00	NO	NO	NO	C	1 091.50	4 002.00
2003	C	3 953.00	14 494.00	NO	NO	NO	C	1 088.50	3 991.00
2004	C	4 583.00	16 804.00	NO	NO	NO	C	226.10	829.00
2005	C	3 409.00	12 490.00	NO	NO	NO	C	242.20	888.00
2006	C	3 232.00	11 843.00	NO	NO	NO	C	495.00	1 815.00
2007	C	4 982.00	18 254.00	NO	NO	NO	C	604.90	2 218.00
2008	C	4 986.00	18 269.00	NO	NO	NO	C	684.00	2 508.00
2009	C	4 597.00	16 856.00	NO	NO	NO	C	211.60	776.00
2010	C	4 465.00	16 372.00	NO	NO	NO	C	335.20	1 229.00

Year	Železiarne Podbrezová			Slovakia Steel Mills			Metalurg Steel		
	steel production by EAF	carbon	CO_2	steel production by EAF	carbon	CO_2	steel production by EAF	carbon	CO_2
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
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

Year	UNEX, Prakovce		Total		
	steel production by EAF (t)	emissions CO_2 (t)	steel production by EAF (t)	emissions CO_2 (t)	IEF (t/t)
1990	C	162.00	310 729.00	18 153.00	0.0584
1991	C	162.00	319 963.00	18 662.00	0.0583
1992	C	161.00	304 644.00	17 803.00	0.0584
1993	C	166.00	303 750.00	17 702.00	0.0583
1994	C	166.00	316 433.00	18 449.00	0.0583
1995	C	164.00	314 641.00	18 212.00	0.0579
1996	C	160.00	309 851.00	18 123.00	0.0585
1997	C	167.00	313 155.00	18 276.00	0.0584
1998	C	166.00	314 601.00	18 220.00	0.0579
1999	C	159.00	319 660.00	18 400.00	0.0576
2000	C	167.00	316 358.00	18 486.00	0.0584
2001	C	166.00	317 710.00	18 521.00	0.0583
2002	C	171.00	307 356.00	17 978.00	0.0585
2003	C	134.00	320 863.00	18 619.00	0.0580
2004	C	46.00	347 605.00	17 679.00	0.0509
2005	C	83.00	356 900.00	13 461.00	0.0377
2006	C	94.00	376 581.00	13 752.00	0.0365
2007	C	69.00	389 435.00	20 541.00	0.0527
2008	C	62.00	382 609.00	20 839.00	0.0545
2009	C	23.00	348 065.00	17 655.00	0.0507
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

4.4.2.4 Uncertainties and time-series consistency

Subcategory 2.C.1 Iron and steel production is the significant source of GHG emissions and key subcategory 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 – 2014. 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.
- 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 2015.

The above mentioned assumptions used for Metalurg Steel company 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 (-7.90%; +7.81%). Following formula was used for Monte Carlo simulation (uncertainties for AD and EF are represented by Δ in symbol formula):

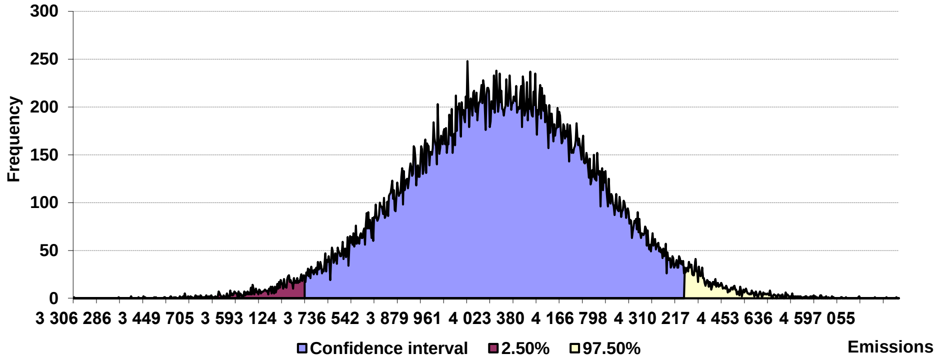
$$\text{Emissions} = \sum_{j}((\text{production} \pm \Delta\text{production}) * (\text{caloric} \pm \Delta\text{caloric}) * (EF\_C \pm \Delta EF\_C)) * \frac{44}{12}$$
$$+ \sum_{I}(\text{amount of C} \pm \Delta C) * (EF \pm \Delta EF)$$

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 the subcategory 2.C.1 obtained by the Monte Carlo simulation is 4 051 Gg CO_2 per year. The average mean value is comparable with the Tier 1. CO_2 emissions in this category, which is 4 051 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 in this category is higher in the comparison with other categories in IP sector due to the more input parameters and their uncertainties entered in the calculation.

Table 4.42: *Selected statistical characteristics for subcategory 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
4 051 436	**4 050 666**	162 126	3 306 286	4 740 473	-7.90%	7.81%

Figure 4.23: *Probability density function for subcategory 2.C.1 (t of CO_2)*



4.4.2.5 Source specific QA/QC and verification

Sector specific QA/QC activities were performed and are described in the Chapter 4.2 of this report. A 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 4.2 of this report. The difference between emissions calculated from these two sources is 0.07% in 2014.

4.4.2.6 Source specific recalculations

No recalculation was made in this submission for this subcategory.

4.4.2.7 Source specific planned improvements

No improvements of the used approach are planned in the next submission.

4.4.3 SOURCE SUBCATEGORY DESCRIPTION – 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 2014 were 222.89 Gg of CO_2 and 50.36 t of CH_4. According to the IPCC 2006 GL, also limestone used for the production was included in this estimation.

4.4.3.1 Methodological issues – methods

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 4.43 – 4.45.

4.4.3.2 Methodological issues – emission factors and other parameters

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).

4.4.3.3 Activity data

Information on activity data was taken directly from producers of ferroalloys provided in questionnaires and they are summarized in Table 4.43.

Table 4.43: *Activity data (t) used for carbon balance and CO_2 emissions (t) in ferroalloys production in 2014*

carbon in "raw materials" (t)	carbon in coals (t)	limestone consumed (t)	carbon in products (t)	CO_2 emissions (Gg)
53.127	57 358.500	41 893.409	1 649.455	222.894

Table 4.44: *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 4.45: *Activity data (t), CO_2 (t) and CH_4 emissions in ferroalloys production in 2002 – 2014*

subcategory 2.C.2 – ferroalloys production								
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
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

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

4.4.3.4 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 equivalents) is in interval (-2.84%; +2.85%). Formula can be written in the following form:

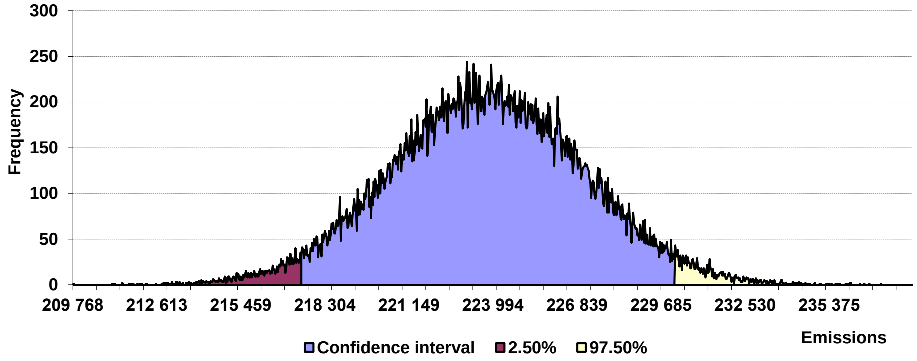
$$\text{Emissions} = \left[(C\_coal\_mat \pm \Delta C\_coal\_mat) + (C\_raw\_mat \pm \Delta C\_raw\_mat) - (C\_products \pm \Delta C\_products)\right] *$$
$$* \, 44/12/1E3 + (limestone \pm \Delta limestone) * 0.44/1E3 + CF * (alloys \pm \Delta alloys) * EF/1E6$$

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 equivalents in the subcategory 2.C.2 obtained by the Monte Carlo simulation is 224 Gg CO_2 eq. per year. The average mean value is comparable with the real CO_2 emissions in this subcategory, which is 224 Gg CO_2 eq.

Table 4.46: *Selected statistical characteristics for subcategory 2.C.2, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2 equivalents)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
223 790	**223 789**	3 256	209 768	238 220	-2.84%	2.85%

Figure 4.24: *Probability density function for subcategory 2.C.2 (t of CO_2 equivalents)*



4.4.3.5 Source specific QA/QC and verification

Sector specific QA/QC activities were performed as described in Chapter 4.2 of this report. 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.

4.4.3.6 Source specific recalculations

No recalculation was made in this submission.

4.4.3.7 Source specific planned improvements

No improvements are planned in this subcategory.

4.4.4 SOURCE SUBCATEGORY DESCRIPTION – 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.

4.4.4.1 Methodological issues – methods

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, 67 924 t of graphite anodes were used in 2013 with the sulphur and ash contents 1.06% and 0.14%, 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 (241.10 Gg CO_2 in 2014). The CO_2 emissions from pitch volatiles combustion and from bake furnace packing material were calculated by the tier 3 method (eqns. 4.22 and 4.23 of the IPCC 2006 GL, Volume 3, Chapter 4) and were as follows: 10.95 Gg and 8.98 Gg, respectively. The total PFC emissions were 1.41 t (11.15 Gg of CO_2 *eq.*) in 2014 and it was calculated according to the Slope method (tier 2).

4.4.4.2 Methodological issues – emission factors and other parameters

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).

4.4.4.3 Activity data

According to the data from the plant operator, the number of anode effects per pot day equals to 0.046 and their average duration was 1.14 min in 2014. It follows that the emission of CF_4 was 1.257 t and C_2F_6 emission was 0.152 t. Production of aluminium in 2014 was 167 667 t. Consumption of graphite in electrolysis was 67 924 t and from 89 245 tons of "green" anodes 85 499 t of anodes was produced. SF_6 is not used in aluminium castings in the Slovak Republic.

4.4.4.4 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.

Table 4.47: *The overview of CO_2 emissions (Gg) and EFs (t/t) in aluminium production in 1990 – 2014*

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
1991	66.30	119.34	NE	119.34	1.8000
1992	61.70	111.06	NE	111.06	1.8000
1993	38.60	69.48	NE	69.48	1.8000
1994	32.80	59.04	NE	59.04	1.8000
1995	32.60	58.68	NE	58.68	1.8000
1996	111.40	162.64	16.46	179.11	1.6078
1997	110.19	160.88	16.29	177.16	1.6078
1998	108.00	157.68	15.96	173.64	1.6078
1999	109.20	159.43	16.14	175.57	1.6078
2000	109.81	160.33	16.23	176.56	1.6078
2001	110.06	160.69	16.27	176.96	1.6078
2002	109.81	160.33	16.23	176.56	1.6078

Year	Aluminium production (kt)	CO_2 (electrolysis) (kt)	CO_2 (anode production) (kt)	total CO_2 (Gg)	EF per aluminium (t/t)
2003	111.62	162.96	16.50	179.46	1.6078
2004	156.89	229.07	23.19	252.25	1.6078
2005	159.20	230.69	23.53	254.22	1.5968
2006	158.29	216.95	23.40	240.35	1.5184
2007	160.46	213.72	23.72	237.43	1.4797
2008	163.00	219.55	24.09	243.64	1.4948
2009	149.60	203.01	22.11	225.12	1.5048
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

Table 4.48: *The overview of PFC emissions (t) and EFs (kg/t) in aluminium production in 1990 – 2014*

Year	CF_4 (t)	EF per aluminium (kg/t)	C_2F_6 (t)	EF per aluminium (kg/t)	Total PFC emissions (Gg of CO_2 *eq.*)
1990	36.60	0.5430	3.64	0.0540	314.86
1991	36.00	0.5430	3.58	0.0540	309.73
1992	33.50	0.5430	3.33	0.0540	288.24
1993	20.96	0.5430	2.08	0.0540	180.32
1994	17.81	0.5430	1.77	0.0540	153.23
1995	15.42	0.4730	1.53	0.0470	132.65
1996	4.63	0.0416	0.53	0.0048	40.72
1997	4.47	0.0406	0.53	0.0048	39.48
1998	2.99	0.0277	0.39	0.0036	26.85
1999	1.51	0.0139	0.18	0.0017	13.41
2000	1.52	0.0139	0.18	0.0017	13.49
2001	1.52	0.0139	0.18	0.0017	13.52
2002	1.52	0.0139	0.18	0.0017	13.49
2003	2.78	0.0249	0.34	0.0030	24.68
2004	2.58	0.0164	0.31	0.0020	22.85
2005	2.67	0.0168	0.32	0.0020	23.72
2006	4.78	0.0302	0.58	0.0037	42.36
2007	3.32	0.0207	0.40	0.0025	29.42
2008	4.82	0.0296	0.58	0.0036	42.76
2009	2.37	0.0158	0.29	0.0019	21.00
2010	2.82	0.0173	0.34	0.0021	25.01
2011	2.27	0.0139	0.28	0.0017	20.11
2012	2.90	0.0180	0.35	0.0022	25.66
2013	1.11	0.0068	0.13	0.0008	9.81
2014	1.26	0.0075	0.15	0.0009	11.15

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 equivalents was calculated in interval (-3.67%; +3.69%). 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

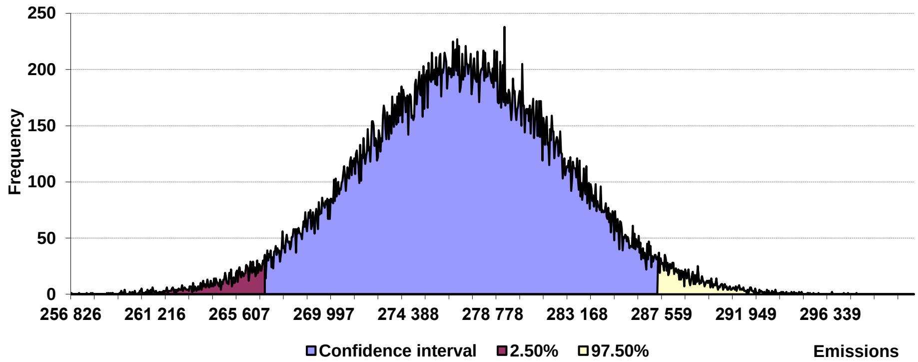
Emission5 = Emission4*(EF± ΔEF)

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 equivalents in the subcategory 2.C.3 obtained by the Monte Carlo simulation is 277 Gg per year. The average mean value is comparable with the real CO_2 emissions in this subcategory, which is 277 Gg CO_2.

Table 4.49: *Selected statistical characteristics for subcategory 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
277 160	**277 152**	5 207	256 826	300 730	-3.67%	3.69%

Figure 4.25: *Probability density function for subcategory 2.C.3 (t of CO_2 eq.)*



4.4.4.5 Source specific QA/QC and verification

Sector specific QA/QC activities were performed as described in Chapter 4.2 of this report. 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.

4.4.4.6 Source specific recalculations

No recalculation was made in this submission.

4.4.4.7 Source specific planned improvements

In the next submissions further improvements are planned in pitch volatiles combustion from anode baking and from bake furnace packing material. Availability of the background activity data will be repeatedly checked. If data will be not available, the average emission factors based on wider time series will be estimated.

4.4.5 SOURCE SUBCATEGORY DESCRIPTION –MAGNESIUM PRODUCTION (CRF 2.C.4)

This production does not occur in the Slovak Republic, therefore the notation key “NO” for time series in this category was used.

4.4.6 SOURCE SUBCATEGORY DESCRIPTION – 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 58.54 t in 2014.

4.4.6.1 Methodological issues – methods

This subcategory is not key category and therefore tier 1 methodology based on the IPCC 2006 GL was used for whole time series.

4.4.6.2 Methodological issues – emission factors and other parameters

Default EF (0.2 t/t) for CO_2 emissions from treatment of secondary raw materials was used for whole time series.

4.4.6.3 Activity data

According to the direct information from the plant operator, 292.7 t of lead was produced from the secondary raw materials in 2014.

Table 4.50: *The overview of activity data and CO_2 emissions from lead production in 1990 – 2014*

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

4.4.6.4 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 for this subcategory. The uncertainties of CO_2 emissions were calculated. Based on calculation, the overall uncertainty of CO_2 emissions in equivalents 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):

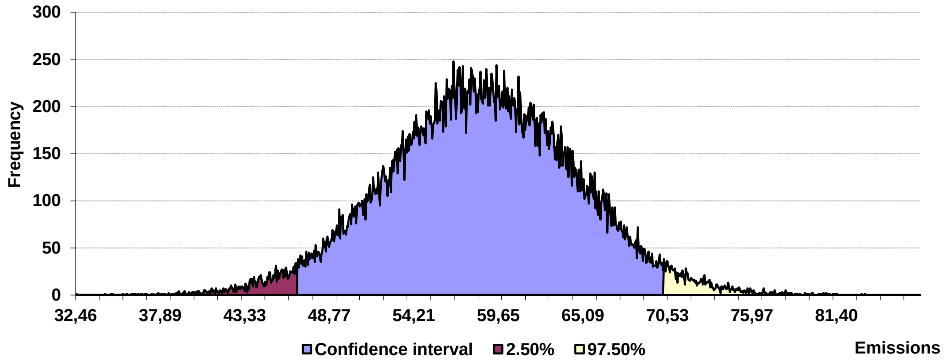
Emissions = (prod_lead± Δ prod_lead)*(EF ± ΔEF)

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 equivalents in the subcategory 2.C.5 obtained by the Monte Carlo simulation is 58.53 Gg CO_2 per year. The average mean value is comparable with the real CO_2 emissions in this subcategory, which is 58.54 Gg CO_2.

__Table 4.51:__ Selected statistical characteristics for subcategory 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
58.51	**58.53**	6.01	32.46	86.84	-20.16%	20.12%

__Figure 4.26:__ Probability density function for subcategory 2.C.5 (t of CO_2)



4.4.6.5 Source specific QA/QC and verification

Sector specific QA/QC activities were performed as described in Chapter 4.2 of this report. This production is not covered by the EU ETS, therefore data was provided directly by the operators.

4.4.6.6 Source specific recalculations

No recalculation was needed in this submission.

4.4.6.7 Source specific planned improvements

No improvements are planned in future submissions.

4.4.7 SOURCE SUBCATEGORY DESCRIPTION – 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. The CO_2 emission was 10.29 t in 2014.

4.4.7.1 Methodological issues – methods

This subcategory is not key category and therefore tier 1 methodology based on the IPCC 2006 GL was used for whole time series.

4.4.7.2 Methodological issues – emission factors and other parameters

Default EF (0.43 t/t) for CO_2 emissions from pyrometallurgical process was used for whole time series.

4.4.7.3 Activity data

According to the direct information from the plant operator, 23.94 t of zinc was produced from the secondary raw materials in 2014.

Table 4.52: The overview of activity data and CO_2 emissions from zinc production in 1990 – 2014

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

4.4.7.4 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 zinc (1.5%) and EF (20%) were used in uncertainty analyses by Monte Carlo method for this subcategory. The uncertainties of CO_2 emissions were calculated. Based on calculation, the overall uncertainty of CO_2 emissions in equivalents 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):

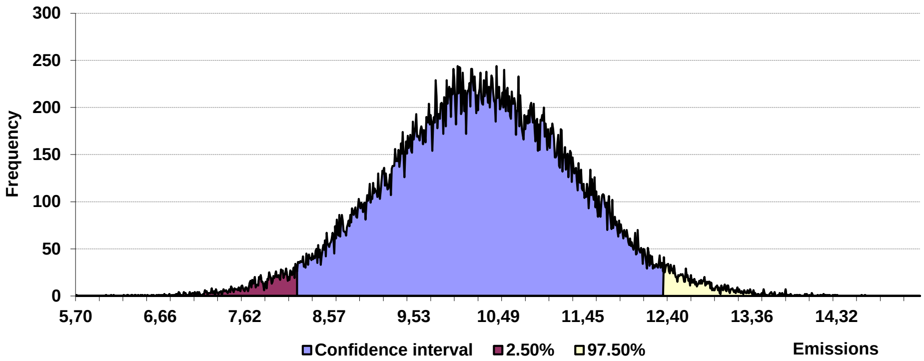
Emissions = (prod_zinc± Δ prod_zinc)*(EF ± ΔEF)

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 equivalents in the subcategory 2.C.6 obtained by the Monte Carlo simulation is 10.29 Gg CO_2 per year. The average mean value is comparable with the real CO_2 emissions in this subcategory, which is 10.29 Gg CO_2.

Table 4.53: Selected statistical characteristics for subcategory 2.C.6, 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
10.29	**10.29**	1.06	5.71	15.27	-20.16%	20.12%

Figure 4.27: Probability density function for subcategory 2.C.6 (t of CO_2)



4.4.7.5 Source specific QA/QC and verification

Sector specific QA/QC activities were performed as described in Chapter 4.2 of this report. This production is not covered by the EU ETS, therefore data was provided directly by the operators.

4.4.7.6 Source specific recalculations

No recalculation was needed in this submission.

4.4.7.7 Source specific planned improvements

No improvements are planned in future submissions.

4.5 NON-ENERGY PRODUCTS FROM FUELS AND SOLVENT USE (CRF 2.D)

4.5.1 SOURCE CATEGORY DESCRIPTION

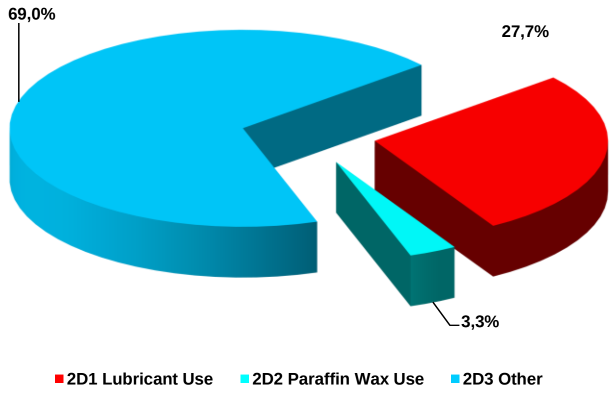
This category produces emissions of CO_2 and NMVOC. Based on known composition of NMVOC emissions also indirect (potential) CO_2 emissions were calculated in this submission. Total CO_2 emissions in 2014 were 96.12 Gg and decreased by ca 5% compared with the previous year. When comparing with the base year, the decrease is more than 40%. 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 Guidelines, 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 subcategories (Gg of CO_2 equivalents) in 1990 – 2014*

category 2.D in CO_2 emissions equivalents (Gg)			
Year	**2.D.1 Lubricant use**	**2.D.2 Paraffin wax use**	**2.D.3 Other**
1990	48.02	2.46	111.99
1991	48.02	2.46	91.45
1992	48.02	2.46	74.77
1993	48.02	2.46	66.40
1994	48.02	2.46	67.90
1995	48.02	2.46	72.23
1996	48.02	2.46	63.94
1997	48.02	2.46	52.33
1998	48.02	2.46	54.88
1999	48.02	2.46	50.22
2000	48.02	2.46	46.48
2001	48.02	2.46	51.43
2002	44.33	2.46	56.32
2003	33.86	3.69	59.75
2004	31.40	0.00	64.84
2005	28.94	1.23	66.82
2006	41.51	0.00	69.77
2007	42.55	3.17	67.88
2008	27.82	1.89	69.21
2009	12.39	1.89	68.49
2010	12.39	2.54	65.03
2011	18.52	1.90	76.26
2012	27.11	2.52	63.17
2013	32.51	2.54	65.86
2014	26.58	3.17	66.37

The major share (69.1%) in emissions belongs to the solvent use subcategory, 27.7% belongs to the lubricant used subcategory and 3.3% to the paraffin wax use subcategory.

Figure 4.28: *The share in GHG emissions of individual subcategories of the 2.D in 2014*



Subcategory	CO_2 eq. (Gg)
Lubricant use	26.58
Paraffin wax use	3.17
Other (Solvents)	66.37

4.5.2 SOURCE SUBCATEGORY DESCRIPTION – LUBRICANT USE (CRF 2.D.1)

Lubricants are mostly used in industrial and transportation applications. The CO_2 emission estimated from this subcategory in Slovakia were 26.58 Gg in 2014.

4.5.2.1 Methodological issues – methods

This subcategory is not key category and therefore tier 1 methodology based on the IPCC 2006 GL was used for whole time series.

4.5.2.2 Methodological issues – emission factors and other parameters

Default carbon content (20 t CO_2 / TJ) and ODU (Oxidized During Use) factor (0.2) according to the IPCC 2006 GL was used.

4.5.2.3 Activity data

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 1 813.4 TJ in 2014. Due to technical reasons, the activity data in this subcategory 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 the subcategory lubricant non-energy use in 1990 – 2014*

Year	Lubricant use (kt)	Lubricants use (TJ)	CO_2 emissions (Gg)
1990	78	3 276.8	48.024
1991	78	3 276.8	48.024
1992	78	3 276.8	48.024
1993	78	3 276.8	48.024
1994	78	3 276.8	48.024
1995	78	3 276.8	48.024
1996	78	3 276.8	48.024
1997	78	3 276.8	48.024
1998	78	3 276.8	48.024
1999	78	3 276.8	48.024
2000	78	3 276.8	48.024

Year	Lubricant use (kt)	Lubricants use (TJ)	CO_2 emissions (Gg)
2001	78	3 276.8	48.024
2002	72	3 024.7	44.330
2003	55	2 310.6	33.863
2004	51	2 142.5	31.401
2005	47	1 974.5	28.938
2006	66	2 832.1	41.507
2007	69	2 903.2	42.549
2008	45	1 898.2	27.820
2009	20	845.3	12.388
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

4.5.2.4 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 subcategory. The uncertainties of CO_2 emissions were calculated. Based on calculation, the overall uncertainty of CO_2 emissions in equivalents 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):

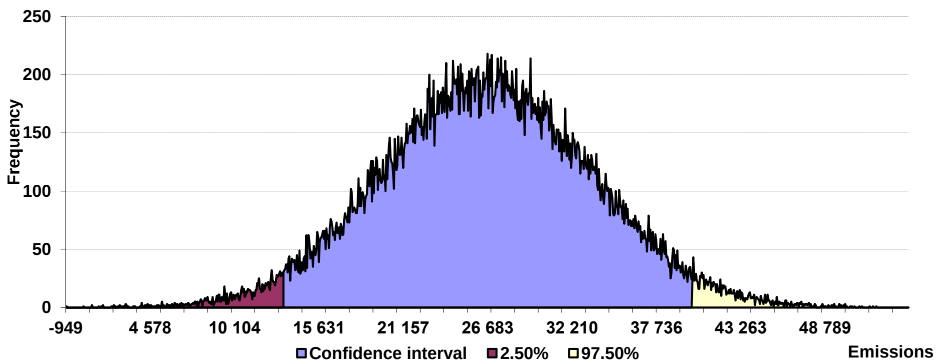
Emissions = (consum_lub± Δ consum_lub)*(EF ± ΔEF)* (NCV ± ΔNCV) *(ODU ± ΔODU)*3.664

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 equivalents in the subcategory 2.D.1 obtained by the Monte Carlo simulation is 26.61 Gg CO_2 per year. The average mean value is comparable with the real CO_2 emissions in this subcategory, which is 26.58 Gg CO_2.

Table 4.56: *Selected statistical characteristics for subcategory 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
26 591	**26 612**	6 857	-949	54 316	-49.90%	50.68%

Figure 4.29: *Probability density function for subcategory 2.D.1 (t of CO_2)*



4.5.2.5 Source specific QA/QC and verification

Sector specific QA/QC activities were performed as described in Chapter 4.2 of this report. This subcategory is not covered by the EU ETS, therefore data was provided directly by the operators.

4.5.2.6 Source specific recalculations

No recalculation was needed in this submission.

4.5.2.7 Source specific planned improvements

No improvements are planned in future submissions.

4.5.3 SOURCE SUBCATEGORY DESCRIPTION – 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 subcategory in Slovakia were 3.17 Gg in 2014.

4.5.3.1 Methodological issues – methods

This subcategory is not key category and therefore tier 1 methodology based on the IPCC 2006 GL was used for whole time series.

4.5.3.2 Methodological issues – emission factors and other parameters

Default carbon content (20 t CO_2 / TJ) and ODU factor (0.2) according to the IPCC 2006 GL was used.

4.5.3.3 Activity data

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 216.5 TJ in 2014 (5 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 2004 and 2006 (based on the statistical data.

Table 4.57: *The overview of activity data and CO_2 emissions in the subcategory paraffin wax non-energy use in 1990 – 2014*

Year	Paraffin wax use (kt)	CO_2 emissions (Gg)
1990	4	2.46
1991	4	2.46
1992	4	2.46
1993	4	2.46
1994	4	2.46
1995	4	2.46
1996	4	2.46
1997	4	2.46
1998	4	2.46
1999	4	2.46
2000	4	2.46
2001	4	2.46
2002	4	2.46
2003	6	3.69
2004	NO	NO

Year	Paraffin wax use (kt)	CO_2 emissions (Gg)
2005	2	1.23
2006	NO	NO
2007	5	3.17
2008	3	1.89
2009	3	1.89
2010	4	2.54
2011	3	1.90
2012	4	2.52
2013	4	2.54
2014	5	3.17

4.5.3.4 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 subcategory. The uncertainties of CO_2 emissions were calculated. Based on calculation, the overall uncertainty of CO_2 emissions in equivalents was calculated in interval (-99.52%; +99.37%). 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):

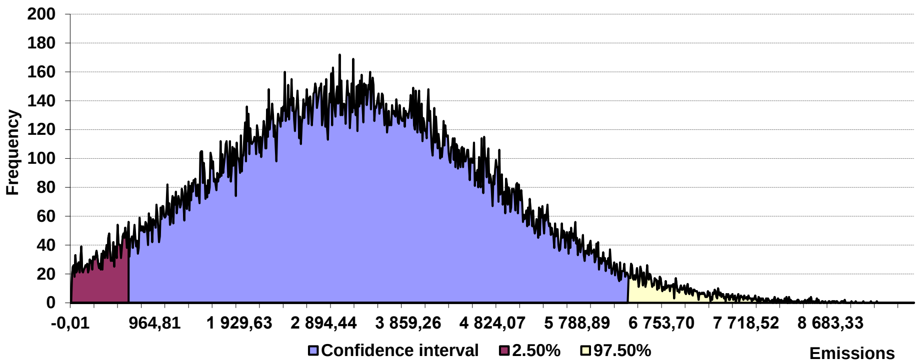
Emissions = (consum_paraf± Δ consum_paraf)*(EF ± ΔEF)* (NCV ± ΔNCV) *(ODU ± ΔODU)*3.664

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 equivalents in the subcategory 2.D.2 obtained by the Monte Carlo simulation is 3.20 Gg CO_2 per year. The average mean value is comparable with the real CO_2 emissions in this subcategory, which is 3.17 Gg CO_2.

Table 4.58: *Selected statistical characteristics for subcategory 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
3 178.33	**3 196.60**	1 591.76	0.00	9 648.14	-99.52%	99.37%

Figure 4.30: *Probability density function for subcategory 2.D.2 (t of CO_2)*



4.5.3.5 Source specific QA/QC and verification

Sector specific QA/QC activities were performed as described in Chapter 4.2 of this report. This subcategory is not covered by the EU ETS, therefore data was provided directly by the operators.

4.5.3.6 Source specific recalculations

No recalculation was needed in this submission.

4.5.3.7 Source specific planned improvements

No improvements are planned in future submissions.

4.5.4 SOURCE SUBCATEGORY DESCRIPTION – OTHER (CRF 2.D.3)

This subcategory 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.

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 subcategory were 66.37 Gg of CO_2 equivalents in 2014 Total NMVOC and CO emissions were 32.25 kt and 0.176 t, respectively. CO emissions are reported in 1.A.2.c subcategory. Following table summarized CO_2, CO and NMVOC emissions in the subcategory.

Table 4.59: *CO_2, NMVOC and CO emissions in 2.D.3 subcategory in 1990 – 2014*

Year	Total CO_2 (Gg)	Total NMVOC (Gg)	Total CO (t)
1990	111.994	52.823	1.237
1991	91.452	44.398	0.790
1992	74.771	37.904	0.800
1993	66.401	34.750	0.480
1994	67.903	36.117	0.591
1995	72.235	36.803	0.626
1996	63.938	33.591	0.573
1997	52.330	28.985	0.545
1998	54.879	29.888	0.480
1999	50.222	28.136	0.595
2000	46.484	26.720	0.441
2001	51.431	28.567	0.308
2002	56.317	30.821	0.395
2003	59.750	32.148	0.254
2004	64.840	32.657	0.267
2005	66.816	33.416	0.307
2006	69.768	34.536	0.306
2007	67.880	33.473	0.281
2008	69.211	33.691	0.303
2009	68.489	33.206	0.134
2010	65.028	31.737	0.240
2011	76.262	36.762	0.267
2012	63.175	30.920	0.262
2013	65.858	32.080	IE
2014	66.369	32.250	IE

4.5.4.1 Methodological issues – methods

This subcategory use was divided into 3 parts: (i) coating applications; (ii) degreasing and dry cleaning; and (iii) chemical products, manufactured and processing. The CO_2 emissions estimation is based on the NMVOC emissions in this subcategory.

Thorough survey of used solvents for (i) coating applications was provided and results were published in previous submissions. 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 – 2005. The carbon content in each class is summarized in the Table 4.60. In the period 2006 – 2014, more detailed information was available and the appropriate carbon content is listed in Table 4.61. Activity data for (i) coating applications represents the amount of used paints and glues.

Table 4.60: *Carbon content in solvents used for (i) coating applications in 1990 – 2005*

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 2006 – 2014*

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 this subcategory, 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 subcategory. The NMVOC emissions were taken directly from CLRTAP inventory in this subcategory. The NMVOC emissions from road paving with asphalt were estimated in this subcategory based on the EMEP/CORINAIR Guidebook (2013 Guidebook) in previous submissions. In this submission, the national methodology from the frame of the National Program for Emission Reduction of Non-Methane Volatile Organic Compounds in the Slovak Republic was adopted and the NMVOC emissions were recalculated accordingly since 1990. Asphalt roofing is produced by saturation without spray (by rolling). The NMVOC and CO emissions were estimated in this subcategory based on the 2013 EMEP/CORINAIR Guidebook methodology. The NMVOC emissions from blowing of asphalt were also estimated according to the 2013 Guidebook. The CO_2 emissions from these three subcategories were not estimated due to the non-availability of methodology and therefore notation key “NE” was used for the whole time series.

4.5.4.2 Methodological issues – emission factors and other parameters

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).

4.5.4.3 Activity data

The volume of paints and glues used in Slovakia with resulting NMVOC emissions were based on the content of solvents in them. The resulting emissions are presented in the Tables 4.63 and 4.64. Activity data for degreasing and dry cleaning subcategory were consistent with the consumption of solvents (EF(NMVOC) = 1). The resulting emissions are presented in the Table 4.65. The NMVOC emissions from chemical products are presented in the Table 4.66 and they are estimated in the frame of the National Program for Emission Reduction of Non-Methane Volatile Organic Compounds in the Slovak Republic. Total quantity of asphalt used for paving the roads was 79.2 kt in 2014. The data were obtained from the Slovak Association for Asphalt Roads http://www.vuis-cesty.sk/en/). Total amount of asphalt used for roofs was 18.5 kt in 2014. This activity data were obtained from producer. The same activity data were used in the subcategory asphalt for blowing. NMVOC and CO emissions together with the activity data are summarized in the Table 4.67.

Table 4.63: *NMVOC and CO_2 emissions (t) in the subcategory solvents use for coating applications in 1990 – 2005*

Year	activity data	NMVOC emissions (t)								CO_2 (t)
		Solvent naphtha	Aromatic	Ester	Alcohols	Acetone	Dichloro methane	Cyclo hexane	Others	
1990	56 907	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	56 907	9 801.00	8 370.00	5 130.00	2 295.00	999.00	54.00	216.00	135.00	77 714.10
1992	56 907	7 986.00	6 820.00	4 180.00	1 870.00	814.00	44.00	176.00	110.00	63 322.50
1993	35 306	7 023.70	5 998.20	3 676.30	1 644.70	715.90	38.70	154.80	96.70	55 692.20
1994	36 306	7 332.60	6 262.00	3 838.00	1 717.00	747.40	40.40	161.60	101.00	58 141.50
1995	38 462	7 509.40	6 413.00	3 930.50	1 758.40	765.40	41.40	165.50	103.40	59 543.30
1996	35 406	6 941.30	5 927.80	3 633.20	1 625.40	707.50	38.20	153.00	95.60	55 038.80
1997	31 122	5 682.20	4 852.60	2 974.10	1 330.50	579.20	31.30	125.20	78.30	45 055.30
1998	28 951	5 820.70	4 970.90	3 046.70	1 363.00	593.30	32.10	128.30	80.20	46 153.80
1999	24 937	5 214.50	4 453.20	2 729.40	1 221.00	531.50	28.70	114.90	71.80	41 346.90
2000	24 642	4 796.70	4 096.30	2 510.70	1 123.20	488.90	26.40	105.70	66.10	38 033.90
2001	25 356	5 091.10	4 347.80	2 664.80	1 192.10	518.90	28.10	112.20	70.10	40 368.30
2002	26 971	5 484.90	4 684.10	2 870.90	1 284.40	559.10	30.20	120.90	75.60	43 491.20
2003	29 533	5 941.90	5 074.40	3 110.10	1 391.40	605.70	32.70	131.00	81.80	47 115.00
2004	32 612	6 699.90	5 721.70	3 506.80	1 568.80	682.90	36.90	147.70	92.30	53 124.70
2005	34 064	6 867.20	5 864.60	3 594.40	1 608.00	700.00	37.80	151.30	94.60	54 451.40

Table 4.64: *NMVOC and CO_2 emissions (t) in the subcategory solvents use for coating applications in 2006 – 2014*

Year		2006	2007	2008	2009	2010	2011	2012	2013	2014
Activity data (t)		35 562	36 405	36 690	36 805	36 830	36 930	37 135	36 950	37 105
NMVOC emissions (t)	**Total**	**19 522**	**20 003**	**20 205**	**20 367**	**20 279**	**20 106**	**20 106**	**20 217**	**20 101**
	Solvent Naphtha	7 223	7 232	7 183	7 386	7 383	7 337	7 337	7 284	7 308
	Xylene	2 310	2 774	2 889	2 817	2 840	2 677	2 677	2 651	2 674
	Toluene	2 789	2 725	2 987	3 035	3 028	3 047	3 047	3 027	3 017
	Styrene	872	849	825	816	810	810	810	819	805
	Ethyl acetate	1 110	1 131	1 122	1 144	1 131	1 135	1 135	1 106	1 117
	Butyl acetate	2 135	2 155	2 185	2 110	2 100	2 201	2 201	2 153	2 131
	Methyl acetate	262	243	230	236	237	234	234	233	233
	Methoxypropyl acetate	192	201	168	121	104	0	0	114	81

Year		2006	2007	2008	2009	2010	2011	2012	2013	2014
	Ethyl alcohol	696	917	919	929	928	931	931	918	921
	Butyl alcohol	310	232	250	307	262	465	465	477	415
	Isopropanol	193	185	148	154	148	156	156	146	149
	Isobutanol	426	410	388	394	407	98	98	407	327
	Acetone	702	741	760	763	769	780	780	770	769
	Dichlormethane	39	39	31	34	22	28	28	17	23
	Cyclohexane	164	42	45	46	45	48	48	45	46
	Others	99	127	75	75	65	160	160	50	85
CO_2 emissions (t)		**56 153**	**57 710**	**58 534**	**59 047**	**58 883**	**58 580**	**58 295**	**58 509**	**58 239**

Table 4.65: *NMVOC and CO_2 emissions (t) in the subcategory solvents use for degreasing and dry cleaning in 1990 – 2014*

Year	NMVOC emissions (t)					CO_2 emissions (t)
	Trichloro-ethylene	Tetrachloro-ethylene	Acetone	Isopropanol	Total	
1990	3 105.00	2 070.00	6 210.00	115.00	11 500.00	17 554.40
1991	2 430.00	1 620.00	4 860.00	90.00	9 000.00	13 738.20
1992	2 025.00	1 350.00	4 050.00	75.00	7 500.00	11 448.50
1993	1 910.80	1 275.70	3 766.80	83.90	7 037.20	10 708.30
1994	3 339.10	1 098.30	2 717.90	344.70	7 500.00	9 761.40
1995	1 689.30	1 195.00	4 606.60	204.60	7 695.50	12 691.20
1996	1 804.00	1 113.30	2 261.40	889.00	6 067.70	8 899.10
1997	1 499.10	889.70	1 966.40	602.30	4 957.50	7 274.20
1998	1 481.40	694.30	2 543.70	718.00	5 437.40	8 725.30
1999	1 302.60	697.90	2 703.20	674.70	5 378.40	8 874.60
2000	1 318.60	551.60	2 524.20	697.10	5 091.50	8 450.10
2001	1 287.70	481.50	3 526.20	875.70	6 171.10	11 062.80
2002	1 833.10	484.00	4 172.60	842.30	7 332.00	12 826.00
2003	2 142.90	404.50	3 933.20	927.60	7 408.20	12 635.10
2004	563.50	315.00	4 004.20	939.30	5 822.00	11 714.80
2005	461.40	394.90	4 175.60	1 069.50	6 101.40	12 365.00
2006	529.80	258.60	4 578.70	1 233.20	6 600.30	13 614.90
2007	409.20	340.30	3 254.50	1 052.80	5 056.80	10 170.10
2008	225.50	211.00	3 519.70	1 095.90	5 052.10	10 676.10
2009	179.80	132.30	3 164.70	934.80	4 411.60	9 441.90
2010	168.00	200.70	1 721.21	914.60	3 004.51	6 144.60
2011	166.89	213.13	6 421.27	1 299.50	8 100.79	17 681.91
2012	119.39	160.06	857.61	1 256.87	2 393.93	4 879.96
2013	100.27	136.98	1 966.77	1 244.48	3 448.50	7 349.09
2014	2.88	146.63	2 697.05	872.32	3 718.88	8 130.29

Table 4.66: *NMVOC emissions (kt) in solvents use in chemical products in 1990 – 2014*

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
NMVOC (kt)	8.346	8.306	8.304	8.302	8.343	8.339	8.32	8.305	8.351	8.318	8.371	8.339
Year	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
NMVOC (kt)	8.337	8.337	8.343	8.35	8.356	8.367	8.381	8.398	8.418	8.367	8.382	8.391
Year	**2014**											
NMVOC (kt)	8.400											

Table 4.67: *NMVOC and CO emissions (t) in solvents use from asphalt using in 1990 – 2014*

Year	Asphalt use (kt)		NMVOC emissions (t)			CO emissions (t)
	road paving with asphalt	Asphalt roofing	Road paving with asphalt	Asphalt roofing	Asphalt blowing	Asphalt roofing
1990	366.8	130.2	5.869	5.988	85.912	1.237
1991	163.3	83.2	2.613	3.826	54.892	0.790
1992	197.2	84.2	3.155	3.874	55.585	0.800
1993	128.7	50.5	2.059	2.322	33.316	0.480
1994	150.3	62.2	2.405	2.862	41.063	0.591
1995	171.0	65.9	2.736	3.033	43.510	0.626
1996	190.2	60.3	3.044	2.774	39.799	0.573
1997	141.4	57.4	2.263	2.639	37.860	0.545
1998	139.8	50.5	2.236	2.323	33.335	0.480
1999	151.3	62.6	2.421	2.879	41.303	0.595
2000	52.5	46.5	0.840	2.138	30.670	0.441
2001	47.6	32.4	0.762	1.491	21.396	0.308
2002	58.7	41.6	0.939	1.915	27.473	0.395
2003	73.6	26.7	1.177	1.228	17.623	0.254
2004	73.6	28.2	1.177	1.295	18.580	0.267
2005	113.0	32.3	1.808	1.485	21.305	0.307
2006	85.5	32.2	1.368	1.480	21.239	0.306
2007	115.5	29.6	1.848	1.362	19.535	0.281
2008	123.8	31.9	1.980	1.465	21.021	0.303
2009	123.3	14.2	1.972	0.651	9.342	0.134
2010	102.4	25.3	1.638	1.162	16.670	0.240
2011	121.0	28.1	1.936	1.293	18.547	0.267
2012	102.3	27.6	1.636	1.269	18.207	0.262
2013	86.0	6.6	1.376	0.306	4.384	0.063
2014	79.2	18.5	1.267	0.853	12.236	0.176

4.5.4.4 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 2006). This approach ensured consistency in time series and transparency in resulted emissions.

In 2011, based on the information provided in the NECD and CLRTAP inventories, import of acetone significantly increased. Because of consistency and conservative approach we included all this amount of solvents into the 2.D.3 category.

Content of carbon in NMVOC emissions was used for the uncertainty analyses in the subcategory 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 equivalents) is in interval (-2.23%; +2.24%). Formula can be written in the following form:

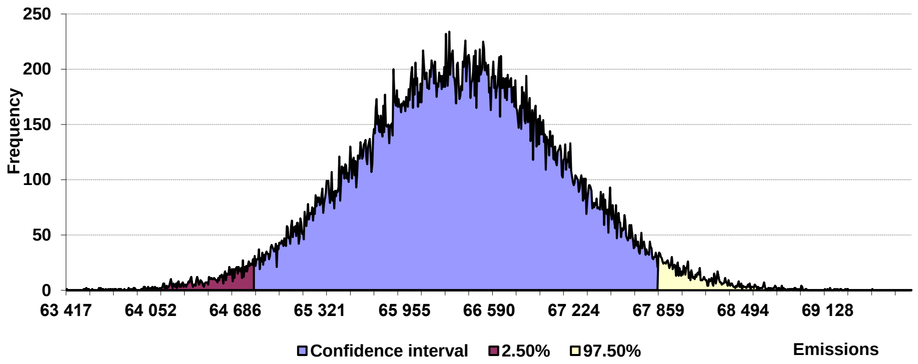
$$Emissions = \sum_{I} (NMVOC \pm \Delta NMVOC) * (content of\ C \pm \Delta\_content of\ C) * \frac{44}{12}$$

First row of formula is related to CO_2 emissions, second row is related to CO_2 equivalents. 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 equivalents in this subcategory obtained by the Monte Carlo simulation is 66.37 Gg CO_2 per year. The average mean value is comparable with the real CO_2 emissions in equivalents in this subcategory, which is 66.37 Gg CO_2.

Table 4.68: *Selected statistical characteristics for subcategory 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
66 368	**66 368**	758	63 417	69 763	-2.23%	2.24%

Figure 4.31: *Probability density function for subcategory 2.D.3 (t of CO_2)*



4.5.4.5 Source specific QA/QC and verification

Due to the lack of appropriate statistical information and methodological advises in the IPCC 2006 Guidelines, 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. Sector specific QA/QC activities were performed as described in Chapter 4.2 of this report and results are verified with the emission inventory under the CLRTAP.

4.5.4.6 Source specific recalculations

Recalculations focused on the NMVOC emissions from road paving with asphalt have been done since the base year 1990. The NMVOC emissions were taken from the frame of the National Program for Emission Reduction of Non-Methane Volatile Organic Compounds in the Slovak Republic. Also NMVOC emissions from (iii) chemical products, manufactured and processing have been recalculated. The NMVOC emissions were taken directly from CLRTAP inventory in this subcategory. Because no GHG emissions were recalculated no comparison table is reported. More information can be found in the Chapter 1 of this Report.

4.5.4.7 Source specific planned improvements

Improvements are planned based on results of CLRTAP inventory review what will take place in 2016.

4.6 ELECTRONIC INDUSTRY (CRF 2.E)

No halocarbons, SF_6 or NF_3 were used in the Slovak Republic in 1990 – 2014 in this category, therefore notation key “NO” was used in all 2.E subcategories.

4.7 PRODUCT USES AS SUBSTITUTES FOR ODS (CRF 2.F)

4.7.1 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 considered to be included into inventory submission of the Slovak Republic:

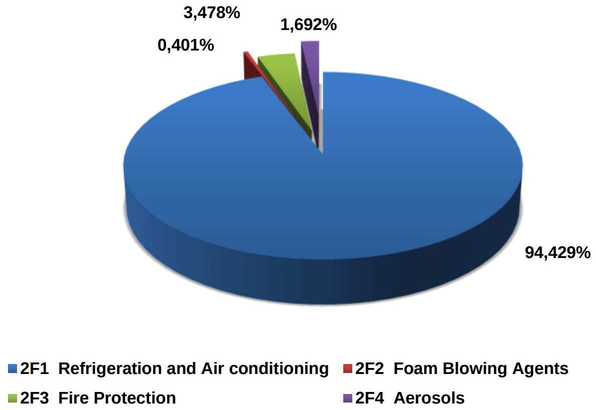
- HFCs – hydrofluorocarbons (23, 32, 125, 134a, 152a, 143a, 227ea, 236fa, 245fa, 365mfc);
- SF_6 – sulphur hexafluoride;
- PFCs – per fluorocarbons (CF_4 for the period 1997 – 2005).

The PFC emissions (CF_4 and C_2F_6) from metal production are reported in the subcategory 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 4.69: *The overview of actual HFCs and PFCs emissions in 1990 – 2014*

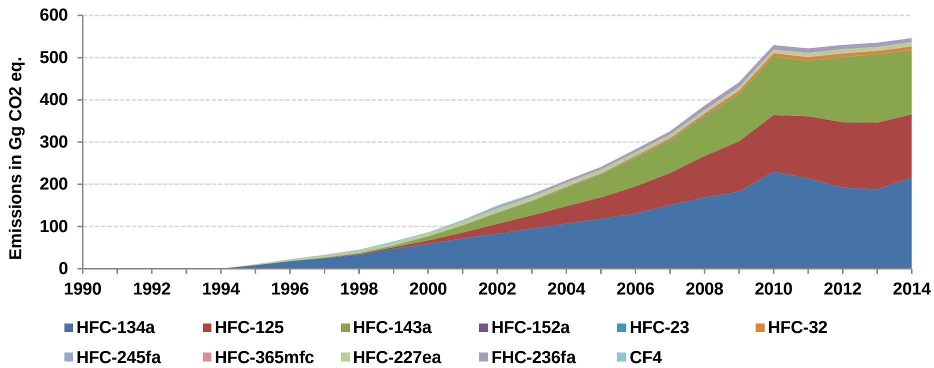
Year	2.F.1	2.F.2	2.F.3	2.F.4	2.F.5	2.F.6	Total 2.F
	Gg CO_2 eq.						
1990	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO
1994	NO	NO	0.196	NO	NO	NO	0.196
1995	8.396	NO	2.095	NO	NO	NO	10.491
1996	18.623	NO	3.609	NO	NO	NO	22.231
1997	26.858	NO	5.527	NO	0.680	NO	33.065
1998	37.378	NO	5.243	NO	2.253	NO	44.875
1999	49.280	5.892	6.463	NO	2.857	NO	64.492
2000	68.157	6.157	7.745	2.667	1.420	NO	86.145
2001	91.479	5.891	9.864	5.598	2.501	NO	115.334
2002	120.916	7.334	11.981	5.999	3.695	NO	149.925
2003	149.223	6.725	12.807	6.263	1.774	NO	176.792
2004	182.903	5.964	13.548	6.528	0.776	NO	209.719
2005	214.635	5.280	13.959	6.800	0.443	NO	241.117
2006	256.550	4.545	14.515	7.064	0.111	NO	282.784
2007	298.436	4.312	15.500	7.193	NO	NO	325.441
2008	358.874	2.446	17.687	7.222	NO	NO	386.229
2009	412.983	2.315	18.981	7.347	NO	NO	441.627
2010	500.988	2.324	18.550	7.816	NO	NO	529.679
2011	491.166	2.410	19.905	8.376	NO	NO	521.856
2012	499.705	2.764	19.118	8.466	NO	NO	530.053
2013	505.200	2.343	18.752	8.899	NO	NO	535.192
2014	515.598	2.190	18.990	9.238	NO	NO	546.016

Figure 4.32: *The emission share in individual subcategories in the 2.F category in 2014*



Subcategory	CO_2 eq. (Gg)
Refrigeration and air conditioning	515.60
Foam blowing agents	2.19
Fire protection	18.99
Aerosols	9.24
Solvents	NO
Other applications	NO

Figure 4.33: *Trend in individual gases categories in the 2.F category in 1990 – 2014*



Total actual HFCs emissions reported in the category 2.F Product uses as substitutes for ODS were 546.02 Gg of CO_2 equivalents in 2014 and they increased by 2% compared to the previous year. Increasing trend is visible since the base year and is caused by supplying HCFCs gases by the HFCs. However, the emissions of F-gases are 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 2014.

4.7.2 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 analyzing 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 4.3 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.

4.7.3 EMISSION FACTORS

Emission factors were evaluated in each subcategory for each individual product (or using of gas) to ensure the best available accuracy of inventory. EFs are described in each subcategory.

4.7.4 METHODOLOGICAL ISSUES – 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.

4.7.5 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.

Monte Carlo method for the uncertainty analyses was implemented for F-gases for the first time in this submission. The IPCC default values for uncertainty of activity data and emission factors were used.

4.7.6 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 4.3 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.

4.7.7 SOURCE SPECIFIC RECALCULATIONS

In this submission, the recalculation of reported recovery (in CRF reporter) has been done. 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. Another recalculation has been made in 2.F.1.d subcategory, where differentiating of imported products between empty products and filled products was corrected. The change in emissions in 2.F was only a minor, up to 0.04%.

4.7.8 SOURCE SPECIFIC PLANNED IMPROVEMENTS

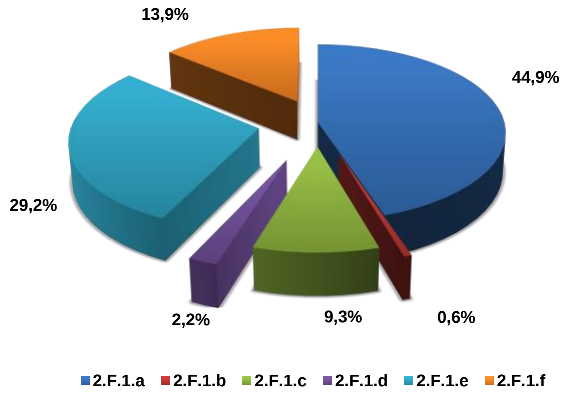
No improvements are planned in the next submission.

4.7.9 SOURCE SUBCATEGORY DESCRIPTION – REFRIGERATION AND AIR CONDITIONING EQUIPMENT (CRF 2.F.1)

The emissions originating from refrigeration and AC equipment represent more than 94% of emissions from the 2.F category. Therefore these emissions are significant source. Total actual emissions of HFCs were 515.60 Gg of CO_2 equivalents in 2014 and they increased by 2% in comparison with the previous year. The emissions of PFCs and SF_6 are not occurring in this subcategory. The following gases and subcategories are reported in this subcategory 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 4.34: *The share of individual subcategories in 2.F.1 in 2014*

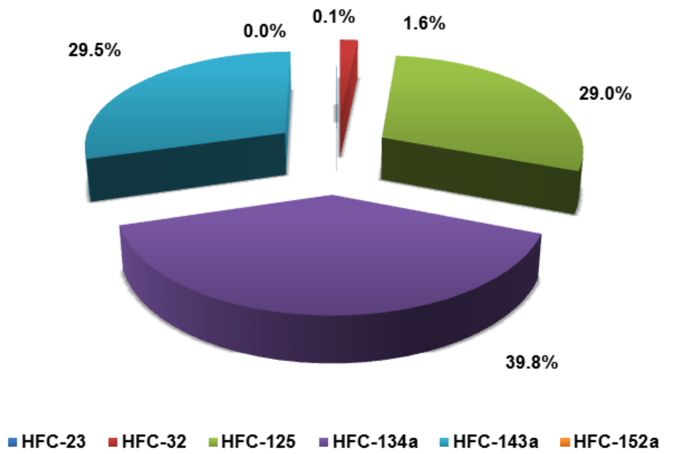


Subcategory	CO_2 eq. (Gg)
Commercial refrigeration	231.27
Domestic refrigeration	2.97
Industrial refrigeration	48.19
Transport refrigeration	11.14
Mobile AC	150.44
Stationary AC	71.59

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 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 are approximately constant since 2010.

Figure 4.35: *The share of individual gases in 2.F.1 in 2014*



HFCs	CO_2 eq. (Gg)
HFC-23	0.26
HFC-32	8.45
HFC-125	149.77
HFC-134a	205.00
HFC-143a	152.07
HFC-152a	0.02

Approximately 45% of total F-gases emissions (in CO_2 eq.) are allocated in the subcategory 2.F.1.a – Commercial refrigeration in 2014 followed by the subcategory 2.F.1.e – Mobile AC (29%) (Figure 4.34). This is connected with the high share of automotive industry in last years in Slovakia. About 14% emissions are allocated in the subcategory 2.F.1.f – Stationary AC, 9% in the subcategory 2.F.1c, 2% in the subcategory 2.F.1.d and below 1% in the subcategory 2.F.1.b – Domestic refrigeration. Time series of F-gases consumption in the category 2.F.1 is summarized in the following Tables 4.70 - 4.75. 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 4.70: *Aggregated data on HFCs using (Gg CO_2 eq.) in 2.F.1.a in 1990 – 2014*

Year	New fillings	New additions to bank	Bank	Retired equipment	Emissions from:			Recovery	Total emissions
					new fillings	bank	disposal		
	Gg CO_2 eq.								
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	2.535	4.470	4.470	NO	0.025	0.752	NO	NO	0.778
1996	4.464	12.747	17.217	NO	0.045	2.419	NO	NO	2.463
1997	5.392	8.398	25.616	NO	0.054	3.579	NO	NO	3.632
1998	10.142	16.606	42.222	NO	0.101	5.737	NO	NO	5.838
1999	12.773	21.226	63.447	NO	0.128	8.512	NO	NO	8.640
2000	33.933	59.330	122.778	NO	0.339	15.943	NO	NO	16.283
2001	47.140	78.684	201.461	NO	0.471	25.751	NO	NO	26.223
2002	64.546	105.687	307.149	NO	0.645	38.962	NO	NO	39.607
2003	62.612	93.805	400.954	NO	0.626	50.707	NO	NO	51.333
2004	82.283	119.685	519.521	0.894	0.823	65.386	0.438	0.456	66.647
2005	83.295	109.242	624.459	3.443	0.833	78.383	1.687	1.756	80.903

Year	New fillings	New additions to bank	Bank	Retired equipment	Emissions from: new fillings	Emissions from: bank	Emissions from: disposal	Recovery	Total emissions
	Gg CO_2 eq.								
2006	114.339	160.720	778.775	5.123	1.143	97.476	2.510	2.613	101.130
2007	97.637	118.106	886.325	8.444	0.976	110.867	4.138	4.307	115.981
2008	151.633	212.840	1084.421	11.795	1.516	135.618	5.780	6.016	142.914
2009	159.502	205.548	1263.580	21.112	1.595	157.855	10.345	10.767	169.795
2010	116.909	137.032	1356.650	35.169	1.169	184.970	17.233	17.936	203.372
2011	85.433	135.156	1425.574	52.985	0.854	166.158	25.963	27.023	192.975
2012	73.018	141.758	1482.956	67.501	0.730	184.299	33.076	34.426	218.105
2013	80.593	154.303	1537.793	79.572	0.806	192.451	38.990	40.582	232.247
2014	101.614	91.842	1522.530	85.684	1.016	188.267	41.985	43.699	231.269

Table 4.71: *Aggregated data on HFCs using (Gg CO_2 eq.) in 2.F.1.b in 1990 – 2014*

Year	New fillings	New additions to bank	Bank	Retired equipment	Emissions from: new fillings	Emissions from: bank	Emissions from: disposal	Recovery	Total emissions
	Gg CO_2 eq.								
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	NO	NO	NO	NO	NO	NO	NO	NO	NO
1996	NO	NO	NO	NO	NO	NO	NO	NO	NO
1997	NO	NO	NO	NO	NO	NO	NO	NO	NO
1998	23.595	23.595	23.595	NO	0.236	0.047	NO	NO	0.283
1999	24.882	24.882	48.477	NO	0.249	0.096	NO	NO	0.345
2000	14.443	14.298	62.775	NO	0.144	0.125	NO	NO	0.269
2001	10.911	10.723	73.498	NO	0.109	0.146	NO	NO	0.255
2002	4.447	4.227	77.725	NO	0.044	0.155	NO	NO	0.199
2003	4.076	3.843	81.567	NO	0.041	0.162	NO	NO	0.203
2004	1.845	1.600	83.167	NO	0.018	0.166	NO	NO	0.184
2005	1.745	1.495	84.663	NO	0.017	0.168	NO	NO	0.186
2006	1.816	1.562	86.225	NO	0.018	0.172	NO	NO	0.190
2007	NO	0.254	86.479	NO	NO	0.172	NO	NO	0.172
2008	NO	0.258	86.737	NO	NO	0.173	NO	NO	0.173
2009	NO	0.232	86.969	NO	NO	0.173	NO	NO	0.173
2010	NO	0.208	81.278	4.129	NO	0.167	1.239	2.890	1.406
2011	NO	6.357	75.516	8.483	NO	0.150	2.545	5.938	2.695
2012	NO	10.523	70.345	10.986	NO	0.135	3.296	7.690	3.430
2013	NO	13.734	65.705	12.862	NO	0.121	3.859	9.003	3.979
2014	0.017	1.844	54.016	9.473	0.000	0.123	2.842	6.631	2.965

Table 4.72: *Aggregated data on HFCs using (Gg CO_2 eq.) in 2.F.1.c in 1990 – 2014*

Year	New fillings	New additions to bank	Bank	Retired equipment	Emissions from: new fillings	Emissions from: bank	Emissions from: disposal	Recovery	Total emissions
	Gg CO_2 eq.								
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO	NO	NO

Year	New fillings	New additions to bank	Bank	Retired equipment	Emissions from: new fillings	bank	disposal	Recovery	Total emissions
	Gg CO_2 eq.								
1994	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	3.766	0.721	0.721	NO	0.038	0.105	NO	NO	0.143
1996	6.086	1.441	2.162	NO	0.061	0.303	NO	NO	0.364
1997	6.914	1.238	3.400	NO	0.069	0.470	NO	NO	0.539
1998	12.360	2.368	5.768	NO	0.124	0.780	NO	NO	0.903
1999	15.493	3.050	8.819	NO	0.155	1.180	NO	NO	1.335
2000	39.539	8.608	17.426	NO	0.395	2.285	NO	NO	2.680
2001	54.659	11.410	28.836	NO	0.547	3.749	NO	NO	4.295
2002	74.479	15.401	44.238	NO	0.745	5.717	NO	NO	6.462
2003	72.469	13.355	57.593	NO	0.725	7.425	NO	NO	8.150
2004	94.811	17.370	74.962	NO	0.948	9.643	NO	NO	10.591
2005	96.033	15.966	90.928	NO	0.960	11.681	NO	NO	12.641
2006	131.238	23.286	114.215	NO	1.312	14.647	NO	NO	15.959
2007	112.465	16.470	130.685	NO	1.125	16.742	NO	NO	17.867
2008	173.555	30.202	160.887	NO	1.736	20.571	NO	NO	22.307
2009	182.691	28.520	189.406	NO	1.827	24.178	NO	NO	26.005
2010	134.236	13.852	203.114	0.115	1.342	25.870	0.057	0.059	27.269
2011	146.067	142.687	345.368	0.346	1.461	33.208	0.169	0.176	34.838
2012	95.305	77.158	421.846	0.544	0.953	53.782	0.267	0.277	55.002
2013	86.625	57.588	478.281	0.923	0.866	56.163	0.452	0.471	57.482
2014	53.384	55.605	532.122	1.411	0.534	46.969	0.691	0.720	48.194

Table 4.73: *Aggregated data on HFCs using (Gg CO_2 eq.) in 2.F.1.d in 1990 – 2014*

Year	New fillings	New additions to bank	Bank	Retired equipment	Emissions from: new fillings	bank	disposal	Recovery	Total emissions
	Gg CO_2 eq.								
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	NO	1.271	1.271	NO	NO	0.176	NO	NO	0.176
1996	NO	1.605	2.876	NO	NO	0.390	NO	NO	0.390
1997	0.860	1.434	4.310	NO	0.009	0.573	NO	NO	0.581
1998	1.232	1.947	6.256	NO	0.012	0.802	NO	NO	0.814
1999	1.473	2.365	8.622	NO	0.015	1.078	NO	NO	1.093
2000	2.895	4.414	13.036	NO	0.029	1.527	NO	NO	1.556
2001	3.688	5.818	18.854	NO	0.037	2.105	NO	NO	2.142
2002	5.349	7.570	26.424	NO	0.053	2.831	NO	NO	2.885
2003	5.514	7.613	33.402	0.318	0.055	3.486	0.254	0.064	3.796
2004	6.480	9.495	41.459	0.719	0.065	4.194	0.575	0.144	4.834
2005	6.708	9.689	49.629	0.760	0.067	4.918	0.608	0.152	5.593
2006	8.896	12.635	60.574	0.845	0.089	5.877	0.676	0.169	6.642
2007	8.429	11.288	69.705	1.078	0.084	6.686	0.862	0.216	7.633
2008	13.155	16.449	82.765	1.695	0.132	7.812	1.356	0.339	9.300
2009	13.258	17.300	94.949	2.558	0.133	8.863	2.046	0.512	11.042
2010	10.539	13.034	101.348	3.317	0.105	11.023	2.654	0.663	13.782
2011	13.163	18.316	112.158	3.753	0.132	10.131	3.002	0.751	13.265
2012	11.273	15.661	119.370	4.225	0.113	10.964	3.380	0.845	14.457

Year	New fillings	New additions to bank	Bank	Retired equipment	Emissions from:			Recovery	Total emissions
					new fillings	bank	disposal		
	Gg CO_2 eq.								
2013	5.184	6.413	116.322	4.731	0.052	9.919	3.785	0.946	13.756
2014	1.803	1.795	106.476	5.820	0.018	6.467	4.656	1.164	11.141

***Table 4.74:** Aggregated data on HFCs using (Gg CO_2 eq.) in 2.F.1.e in 1990 – 2014*

Year	New fillings	New additions to bank	Bank	Retired equipment	Emissions from:			Recovery	Total emissions
					new fillings	bank	disposal		
	Gg CO_2 eq.								
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	23.627	65.128	65.128	NO	0.236	4.761	NO	NO	4.997
1996	23.627	75.359	140.487	NO	0.236	10.270	NO	NO	10.506
1997	47.254	59.151	199.638	NO	0.473	14.594	NO	NO	15.066
1998	47.254	64.827	264.466	NO	0.473	19.332	NO	NO	19.805
1999	70.880	76.306	340.772	NO	0.709	24.910	NO	NO	25.619
2000	70.880	84.504	425.276	NO	0.709	31.088	NO	NO	31.796
2001	70.880	99.109	524.385	NO	0.709	38.333	NO	NO	39.041
2002	70.880	104.883	629.267	NO	0.709	45.999	NO	NO	46.708
2003	94.507	116.052	745.319	NO	0.945	54.483	NO	NO	55.428
2004	118.134	124.676	869.995	NO	1.181	63.597	NO	NO	64.778
2005	118.134	127.856	997.851	NO	1.181	72.943	NO	NO	74.124
2006	146.270	131.340	1129.191	NO	1.463	82.544	NO	NO	84.007
2007	270.613	134.569	1247.478	8.141	2.706	91.191	6.513	1.628	100.410
2008	301.433	143.182	1355.538	17.561	3.014	99.090	14.049	3.512	116.153
2009	285.295	149.641	1455.270	24.955	2.853	106.380	19.964	4.991	129.197
2010	264.693	128.391	1517.545	33.058	2.647	145.460	26.447	6.612	174.553
2011	302.645	143.363	1591.997	34.455	3.026	124.224	27.564	6.891	154.815
2012	438.012	76.648	1597.448	35.599	4.380	104.962	28.479	7.120	137.821
2013	454.154	62.491	1578.752	40.593	4.542	93.608	32.475	8.119	130.624
2014	357.195	62.297	1549.849	45.600	3.572	110.386	36.480	9.120	150.438

***Table 4.75:** Aggregated data on HFCs using (Gg CO_2 eq.) in 2.F.1.f in 1990 – 2014*

Year	New fillings	New additions to bank	Bank	Retired equipment	Emissions from:			Recovery	Total emissions
					new fillings	bank	disposal		
	Gg CO_2 eq.								
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO	NO	NO	NO	NO
1995	13.982	13.982	13.982	NO	0.140	2.162	NO	NO	2.302
1996	16.729	16.729	30.711	NO	0.167	4.732	NO	NO	4.899
1997	14.369	14.369	45.080	NO	0.144	6.896	NO	NO	7.040
1998	17.951	17.951	63.031	NO	0.180	9.555	NO	NO	9.734
1999	21.458	17.015	80.046	NO	0.215	12.034	NO	NO	12.248
2000	35.474	23.322	103.369	NO	0.355	15.217	NO	NO	15.572

Year	New fillings	New additions to bank	Bank	Retired equipment	Emissions from:			Recovery	Total emissions
					new fillings	bank	disposal		
	Gg CO_2 eq.								
2001	44.285	28.421	131.790	NO	0.443	19.080	NO	NO	19.523
2002	60.941	40.495	172.285	NO	0.609	24.445	NO	NO	25.055
2003	64.329	39.335	211.620	NO	0.643	29.671	NO	NO	30.314
2004	74.571	41.788	253.407	NO	0.746	35.123	NO	NO	35.869
2005	78.509	40.914	294.322	NO	0.785	40.402	NO	NO	41.187
2006	101.479	56.955	351.276	NO	1.015	47.608	NO	NO	48.623
2007	99.179	54.146	401.927	2.796	0.992	54.012	1.370	1.426	56.374
2008	143.129	84.823	479.072	6.142	1.431	63.587	3.010	3.133	68.027
2009	148.507	73.493	541.295	9.016	1.485	70.868	4.418	4.598	76.771
2010	116.843	40.231	565.768	12.606	1.168	73.261	6.177	6.429	80.606
2011	116.089	109.959	659.211	13.213	1.161	84.943	6.474	6.739	92.578
2012	132.554	125.023	766.069	14.532	1.326	62.444	7.120	7.411	70.890
2013	98.089	88.265	832.656	17.342	0.981	57.633	8.498	8.844	67.111
2014	50.715	94.492	899.835	21.851	0.507	60.377	10.707	11.144	71.591

4.7.9.1 Methodological issues – methods

The IPCC 2006 Guidelines 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 2014, the corrections were made as follow: (i) the difference of 6.3981 t of R134.a was added to operational emissions in 2.F.1.e subcategory; (ii) the difference of 0.1634 t of R404A divided between new fillings and operational emissions in 2.F.1.a subcategory; (iii) the difference of 0.0900 t of R437A was divided among the operational emissions in 2.F.1.a, 2.F.1.d and 2.F.1.f subcategories; (iv) the difference 0.1650 t of R438A was added to operational emissions in 2.F.1.f subcategory. 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 2.6 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 represent 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.

Disposal emissions represent the emissions from the retired equipment.

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*

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.*

4.7.9.2 Methodological issues – emission factors and other parameters

Emissions factor from the filling chemicals into new equipment (product manufacturing factor) is assumed to be 1% (based on the producers' data) for all subcategories 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 survey of recycling companies. For the subcategories 2.F.1.a, 2.F.1.c, 2.F.1.d and 2.F.1.f, the efficiency of recovering was assumed to be 51% from the initial charge remaining in the equipment during retiring (80%). The 70% efficiency of recovering and 70% charge remaining at retiring were assumed for subcategory 2.F.1.b, based on the results from recycling company in Slovenská Ľupča. In Mobile AC subcategory (2.F.1.e), the remaining charge was assumed to be 50% with 20% efficiency of recovering.

4.7.9.3 Activity data

Activity data were collected via web reporting system and treated as described above and in the Annex 4.3.

2.F.1.a – Commercial refrigeration: This subcategory 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. Chemicals in retired equipment were 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

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. Lifetime of domestic refrigeration equipment was assumed to be 12-15 years. Chemicals in retired equipment were 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

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. Chemicals in retired equipment were 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

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. Chemicals in retired equipment were 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

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. In 2014, 71 417 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 4 999 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. Chemicals in retired equipment were 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

2.F.1.f – Stationary AC: This subcategory includes stationary air conditions, room air conditions and heat pumps. Plants for waste heat recovery are included in this subcategory, 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. Chemicals in retired equipment were 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

4.7.9.4 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. 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 4.76 and they are within the range presented in the IPCC 2006 Guidelines. 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.1e subcategory 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. It is assumed that 70% of total charge in produced cars is HFC-134a, the rest is HFO1234ye or they are not filled (mobile AC is not used). This value is based on the data provided by car producers.

A specific recalculation of the subcategory 2.F.1.d was performed in this submission. More detailed data were obtained on imported systems (differentiation between import of already filled equipment and import of empty equipment that was installed in Slovakia). The recalculation has influenced the emissions only in a small degree; changes in emissions were up to 0.04 %

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 4.76: *Product life factors of individual gases in the 2.F.1 subcategories in 1990 – 2009*

Category	**HFC-125**	**HFC-134a**	**HFC-143a**	**HFC-152a**	**HFC-23**	**HFC-32**
	%					
2.F.1.a	13.23	17.07	11.76	10.92	10	NO
2.F.1.b	0.2	NO	NO	NO	NO	NO
2.F.1.c	12.43	14.79	12.88	NO	NO	9.11
2.F.1.d	8.34	13.87	7.75	NO	NO	10
2.F.1.e	7.31	NO	NO	NO	NO	NO
2.F.1.f	12.61	15.48	7.99	NO	NO	9.5

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 equivalents) is in interval (-6.99%; +15.17%). It was computed by Monte Carlo simulation with next formula (uncertainties for AD and EF are represented by Δ):

$$\text{Emission} = \sum_{c}\sum_{g}[\,(\text{New fillings} \pm \Delta\text{New\_fillings})*(\text{EF\_new} \pm \Delta\,\text{EF\_new}) +$$

$$+\,(\text{Oper\_emissions} \pm \Delta\,\text{Oper\_emissions})+(\text{Disposed\_equipment} \pm \Delta\,\text{Disposed\_equipment})\;*$$

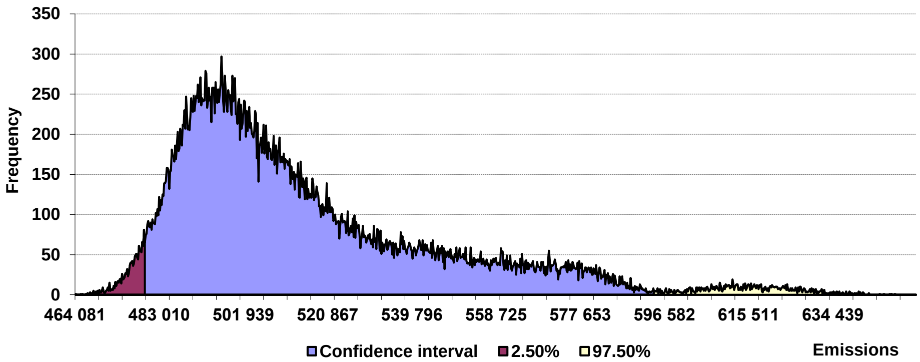
$$*\,(\text{fraction\_gas} \pm \Delta\,\text{fraction\_gas})*\,(\text{EF\_disposed} \pm \Delta\,\text{EF\_disposed})]$$

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 equivalents in 2.F.1 subcategory obtained by the Monte Carlo simulation is 516 Gg CO_2 eq. per year. The average mean value is comparable with the real CO_2 emissions in equivalents in this subcategory, which is 515.60 Gg CO_2 eq.

Table 4.77: *Selected statistical characteristics for subcategory 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
506 696	**515 949**	30 487	464 081	653 368	-6.99%	15.17%

Figure 4.36: *Probability density function for subcategory 2.F.1 (t of CO_2 eq.)*



4.7.9.5 Source specific QA/QC and verification

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.

4.7.9.6 Source specific recalculations

In this submission a recalculation of the subcategory 2.F.1.d was performed. More detailed data were obtained on imported systems (differentiation between import of already filled equipment and import of empty equipment that was installed in Slovakia). The recalculation has influenced the emissions only in a small degree; changes in emissions were up to 0.04%. Effect of the recalculations on the total HFC emissions in the 2.F.1 is presented in the Table 4.78.

A recalculation of reported recovery (in CRF reporter) has been done, as well. 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.

Table 4.78: *The recalculations changes and comparison of the submissions 2015 and 2016*

Year	HFCs emissions		2015/2016 changes
	submission 2015	submission 2016	
	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	8.396	0.00%
1996	18.623	18.623	0.00%
1997	26.850	26.858	0.03%
1998	37.366	37.378	0.03%
1999	49.266	49.280	0.03%
2000	68.128	68.157	0.04%
2001	91.442	91.479	0.04%
2002	120.862	120.916	0.04%
2003	149.168	149.223	0.04%
2004	182.838	182.903	0.04%
2005	214.568	214.635	0.03%
2006	256.461	256.550	0.03%
2007	298.352	298.436	0.03%
2008	358.742	358.874	0.04%
2009	412.851	412.983	0.03%
2010	500.883	500.988	0.02%
2011	491.034	491.166	0.03%
2012	499.592	499.705	0.02%
2013	505.148	505.200	0.01%

4.7.9.7 Source specific planned improvements

Feasibility of the Monte Carlo method for uncertainties analyses will be considered in the future, this method is limited by the input data availability. A special QA/QC process on recovering process in recycling factories in planned in future submissions.

4.7.10 SOURCE SUBCATEGORY DESCRIPTION – FOAM BLOWING (CRF 2.F.2)

This subcategory 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 subcategory were 2.19 Gg CO_2 eq. in 2014 (Table 4.79).

4.7.10.1 Methodological issues – methods

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 Guidelines, 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 Guidelines (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.

4.7.10.2 Methodological issues – emission factors and other parameters

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 Guidelines.

4.7.10.3 Activity data

Activity data were collected via the web reporting system as described in the Annex 4.3. 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 4.79: *Aggregated data on HFCs using (Gg CO_2 eq.) in subcategory 2.F.2 in 1990 – 2014*

Year	New fillings	Bank	Retired equipment	Emissions from:			Recovery	Total emissions
				new fillings	bank	disposal		
	Gg CO_2 eq.							
1990	NO	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO	NO

Year	New fillings	Bank	Retired equipment	Emissions from:			Recovery	Total emissions
				new fillings	bank	disposal		
	Gg CO_2 eq.							
1993	NO	NO	NO	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO	NO	NO	NO
1995	NO	NO	NO	NO	NO	NO	NO	NO
1996	NO	NO	NO	NO	NO	NO	NO	NO
1997	NO	NO	NO	NO	NO	NO	NO	NO
1998	NO	NO	NO	NO	NO	NO	NO	NO
1999	58.916	NO	NO	5.892	NO	NO	NO	5.892
2000	58.916	53.024	NO	5.892	0.265	NO	NO	6.157
2001	53.625	105.784	NO	5.363	0.529	NO	NO	5.891
2002	65.663	153.517	NO	6.566	0.768	NO	NO	7.334
2003	56.654	211.847	NO	5.665	1.059	NO	NO	6.725
2004	46.551	261.776	NO	4.655	1.309	NO	NO	5.964
2005	37.685	302.363	NO	3.769	1.512	NO	NO	5.280
2006	28.711	334.768	NO	2.871	1.674	NO	NO	4.545
2007	25.171	358.934	NO	2.517	1.795	NO	NO	4.312
2008	5.472	379.793	NO	0.547	1.899	NO	NO	2.446
2009	4.013	382.819	NO	0.401	1.914	NO	NO	2.315
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

4.7.10.4 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 equivalents) is in interval (-10.07%; +10.58%). It was computed by Monte Carlo simulation with next formula (uncertainties for AD and EF are represented by Δ):

$$\text{Emission} = \sum_{g} [\,(\text{New fillings} \pm \Delta\text{New\_fillings})*(\text{EF\_new} \pm \Delta\,\text{EF\_new}) + (\text{Stock} \pm \Delta\,\text{Stock}) *$$

$$* (\text{EF\_stock} \pm \Delta\,\text{EF\_stock})+(\text{Disposed\_equipment} \pm \Delta\,\text{Disposed\_equipment}) *$$

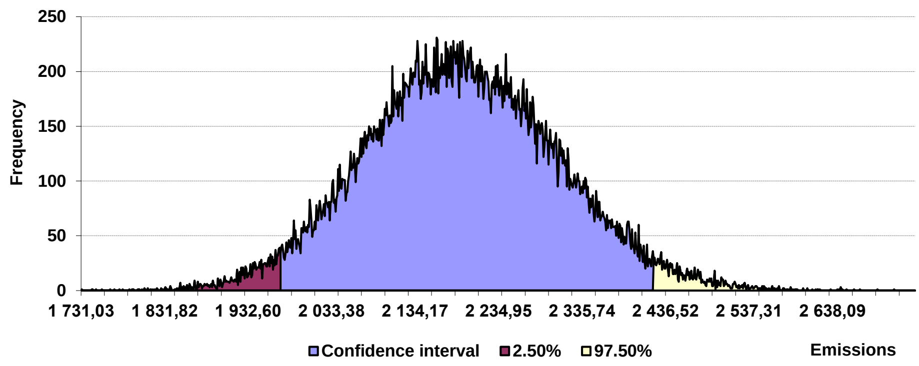
$$* (\text{fraction\_gas} \pm \Delta\,\text{fraction\_gas})]$$

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 equivalents in 2.F.2 subcategory obtained by the Monte Carlo simulation is 2.19 Gg CO_2 eq. per year. The average mean value is comparable with the real CO_2 emissions in equivalents in this subcategory, which is 2.19 Gg CO_2 eq.

Table 4.80: *Selected statistical characteristics for subcategory 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
2 187.91	**2 190.24**	115.65	1 731.04	2 738.87	-10.07%	10.58%

Figure 4.37: *Probability density function for subcategory 2.F.2 (t of CO_2 eq.)*



4.7.10.5 Source specific QA/QC and verification

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.

4.7.10.6 Source specific recalculations

No recalculation has been made in this submission.

4.7.10.7 Source specific planned improvements

Feasibility of the Monte Carlo method for uncertainties analyses will be considered in the future, this method is limited by the availability of input data. No other improvements are planned in the future submissions.

4.7.11 SOURCE SUBCATEGORY DESCRIPTION – FIRE PROTECTION (CRF 2.F.3)

This subcategory 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 (aprox. 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 subcategory were 18.99 Gg CO_2 eq. in 2014.

4.7.11.1 Methodological issues – methods

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.

4.7.11.2 Methodological issues – emission factors and other parameters

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 country specific and it is slightly higher than the default value provided in the IPCC 2006 Guidelines for installed flooding systems (1-3% per year).

4.7.11.3 Activity data

Activity data were collected via web reporting system as described the Annex 4.3 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 4.81: *Aggregated data on HFCs used (Gg CO_2 eq.) in subcategory 2.F.3 in 1990 – 2014*

Year	New fillings	New additions to bank	Bank	Retired equipment	Emissions from:			Recovery	Total emissions
					new fillings	bank	disposal		
	Gg CO_2 eq.								
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO	NO	NO	NO	NO
1994	3.439	3.230	3.230	NO	0.034	0.162	NO	NO	0.196
1995	32.499	32.361	35.395	NO	0.325	1.770	NO	NO	2.095
1996	32.551	32.361	65.661	NO	0.326	3.283	NO	NO	3.609
1997	40.540	40.379	102.432	NO	0.405	5.122	NO	NO	5.527
1998	6.962	6.569	103.473	NO	0.070	5.174	NO	NO	5.243
1999	25.940	25.841	124.071	NO	0.259	6.204	NO	NO	6.463
2000	31.170	31.057	148.665	NO	0.312	7.433	NO	NO	7.745
2001	47.095	46.950	187.870	NO	0.471	9.393	NO	NO	9.864
2002	51.862	51.250	229.255	NO	0.519	11.463	NO	NO	11.981
2003	32.978	32.272	249.546	NO	0.330	12.477	NO	NO	12.807
2004	28.737	28.479	265.218	NO	0.287	13.261	NO	NO	13.548
2005	22.969	22.908	274.578	NO	0.230	13.729	NO	NO	13.959
2006	24.905	24.693	285.312	NO	0.249	14.266	NO	NO	14.515
2007	32.772	32.650	303.447	NO	0.328	15.172	NO	NO	15.500
2008	55.010	54.791	342.738	NO	0.550	17.137	NO	NO	17.687
2009	46.084	45.356	370.407	NO	0.461	18.520	NO	NO	18.981
2010	16.616	16.255	367.681	NO	0.166	18.384	NO	NO	18.550

Year	New fillings	New additions to bank	Bank	Retired equipment	Emissions from:			Recovery	Total emissions
					new fillings	bank	disposal		
	Gg CO_2 eq.								
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

4.7.11.4 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 equivalents) is in interval (-21.93%; +22.71%). It was computed by Monte Carlo simulation with next formula (uncertainties for AD and EF are represented by Δ):

$$\text{Emission} = \sum_g [\,(\text{New fillings} \pm \Delta\text{New\_fillings})*(\text{EF\_new} \pm \Delta\ \text{EF\_new}) + (\text{Stock} \pm \Delta\ \text{Stock}) *$$

$$* (\text{EF\_stock} \pm \Delta\ \text{EF\_stock}) + (\text{Disposed\_equipment} \pm \Delta\ \text{Disposed\_equipment}) *$$

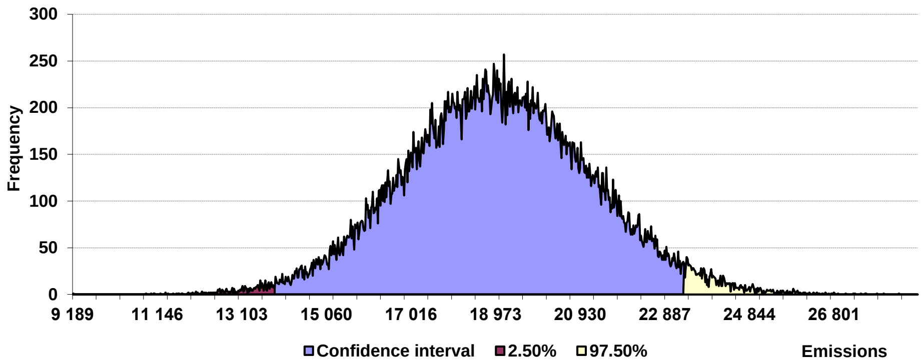
$$* (\text{fraction\_gas} \pm \Delta\ \text{fraction\_gas})]$$

The sum in formula for emission is done by gases (HFC-134a, HFC-227ea, HFC-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 equivalents in 2.F.3 subcategory obtained by the Monte Carlo simulation is 19.01 Gg CO_2 eq. per year. The average mean value is comparable with the real CO_2 emissions in equivalents in this subcategory, which is 18.99 Gg CO_2 eq.

Table 4.82: *Selected statistical characteristics for subcategory 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
18 987.69	**19 013.42**	2 159.66	9 188.77	28 757.94	-21.93%	22.71%

Figure 4.38: *Probability density function for subcategory 2.F.3 (t of CO_2 eq.)*



4.7.11.5 Source specific QA/QC and verification

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.

4.7.11.6 Source specific recalculations

No recalculation has been made in this submission.

4.7.11.7 Source specific planned improvements

There are no further principal improvements planned in this activity.

4.7.12 SOURCE SUBCATEGORY DESCRIPTION – 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 subcategory are not significant and were 9.24 Gg CO_2 eq. in 2014. The reporting in CRF reporter was corrected in this submission. In “Filled into new manufactured products” row there were amounts of F-gases imported into Slovakia reported. The following emissions were “first year” emissions, not the emissions from production. “First year” emissions were assumed to be a half of the imported F-gases while the rest came to the bank and escaped in the next year. The production of MDI does not occur in Slovakia. In this submission, the reporting in CRF reporter is corrected. The correction has not influence on the emissions.

4.7.12.1 Methodological issues – methods

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.

4.7.12.2 Methodological issues – emission factors and other parameters

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.

4.7.12.3 Activity data

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 4.83: *Aggregated data on HFCs using (Gg CO_2 eq.) in the subcategory 2.F.4 in 1990 – 2014*

Year	Filled into new products	Bank	emissions from: new fillings	emissions from: bank	Total emissions
	Gg CO_2 eq.				
1990	NO	NO	NO	NO	NO
1991	NO	NO	NO	NO	NO
1992	NO	NO	NO	NO	NO
1993	NO	NO	NO	NO	NO
1994	NO	NO	NO	NO	NO
1995	NO	NO	NO	NO	NO
1996	NO	NO	NO	NO	NO
1997	NO	NO	NO	NO	NO
1998	NO	NO	NO	NO	NO
1999	NO	NO	NO	NO	NO
2000	NO	2.667	NO	2.667	2.667
2001	NO	5.598	NO	5.598	5.598
2002	NO	5.999	NO	5.999	5.999
2003	NO	6.263	NO	6.263	6.263
2004	NO	6.528	NO	6.528	6.528
2005	NO	6.800	NO	6.800	6.800
2006	NO	7.064	NO	7.064	7.064
2007	NO	7.193	NO	7.193	7.193
2008	NO	7.222	NO	7.222	7.222
2009	NO	7.347	NO	7.347	7.347
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

4.7.12.4 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 equivalents) is in interval (-20.99%; +21.11%). It was computed by Monte Carlo simulation with next formula (uncertainties for AD and EF are represented by Δ):

$$\text{Emission} = \sum_{g} [\,(\text{gas\_sales\_current} \pm \Delta\ \text{gas\_sales\_current}) * (\text{EF\_current} \pm \Delta\ \text{EF\_current}) +$$

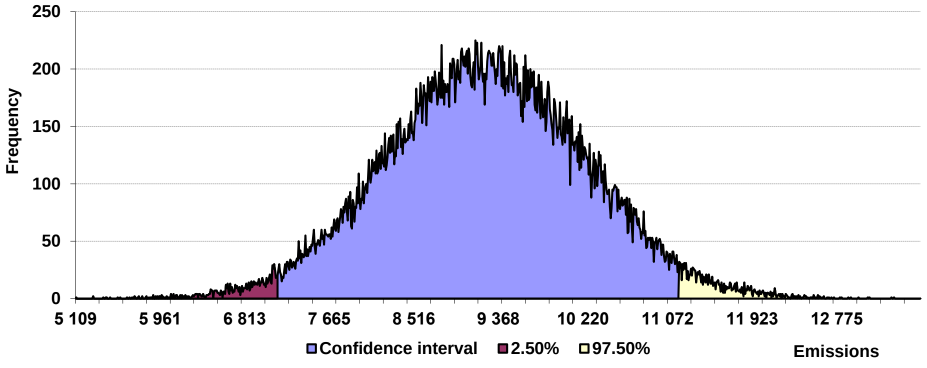
$$+ (\text{gas\_sales\_prev} \pm \Delta\ \text{gas\_sales\_prev}) * (1-(\text{EF\_prev} \pm \Delta\ \text{EF\_prev}))]$$

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 equivalents in 2.F.4 subcategory obtained by the Monte Carlo simulation is 9.24 Gg CO_2 eq. per year. The average mean value is comparable with the real CO_2 emissions in equivalents in this subcategory, which is 9.24 Gg CO_2 eq.

Table 4.84: *Selected statistical characteristics for subcategory 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
9 232.36	**9 236.69**	997.78	5 109.30	13 626.74	-20.99%	21.11%

Figure 4.39: *Probability density function for subcategory 2.F.4 (t of CO_2 eq.)*



4.7.12.5 Source specific QA/QC and verification

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.

4.7.12.6 Source specific recalculations

No recalculation of emissions was necessary in this submission.

4.7.12.7 Source specific planned improvements

No improvements are planned in the next submission.

4.7.13 SOURCE SUBCATEGORY DESCRIPTION – SOLVENTS (CRF 2.F.5)

The HFCs emissions are not occurring in this subcategory, 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 subcategory 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. The reporting was corrected in the same way as in 2.F.4 subcategory.

Table 4.85: *PFC14 emissions in the subcategory 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
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.

4.7.14 SOURCE SUBCATEGORY DESCRIPTION – OTHER APPLICATIONS (CRF 2.F.6)

Emissions in this subcategory are not occurring for the time series 1990 – 2014.

4.8 OTHER PRODUCT MANUFACTURE (CRF 2.G)

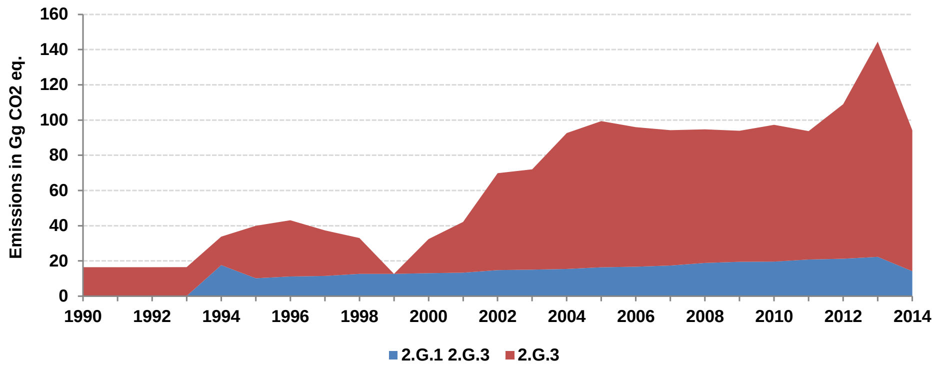
4.8.1 SOURCE CATEGORY DESCRIPTION

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 equivalents in 2014 were 94.20 Gg and decreased by ca 35% 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 600%. This increase is mostly caused by the increase in N_2O emissions from aerosol cans.

Table 4.86: Emissions in 2.G according to the subcategories (Gg of CO_2 equivalents) in 1990 – 2014

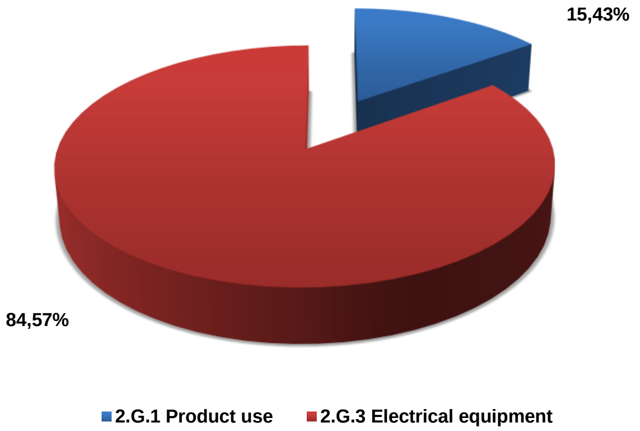
Category 2.G in CO_2 emissions equivalents (Gg)			
Year	2.G.1 Electrical equipment	2.G.2 SF_6 and PFCs from other product use	2.G.3 N_2O from product use
1990	0.06	NO	16.39
1991	0.04	NO	16.39
1992	0.04	NO	16.39
1993	0.09	NO	16.39
1994	17.62	NO	16.16
1995	10.15	NO	29.79
1996	11.16	NO	31.93
1997	11.47	NO	25.87
1998	12.65	NO	20.36
1999	12.64	NO	21.04
2000	13.04	NO	19.36
2001	13.33	NO	28.81
2002	14.78	NO	55.04
2003	15.06	NO	56.96
2004	15.43	NO	77.18
2005	16.38	NO	83.01
2006	16.71	NO	79.24
2007	17.39	NO	76.85
2008	18.85	NO	75.87
2009	19.51	NO	74.40
2010	19.62	NO	77.66
2011	20.80	NO	72.91
2012	21.24	NO	87.76
2013	22.30	NO	122.23
2014	14.17	NO	80.03

Figure 4.40: The trend of individual categories in emissions (Gg of CO_2 equivalents) in category 2.G in 1990 – 2014



The major share (85.0%) in emissions belongs to the N_2O emissions from the product use (79.4% from aerosol cans, the rest from the anaesthesia using), 15.0% belongs to SF_6 emissions from electrical equipment.

Figure 4.41: *The share in GHG emissions of individual subcategories of the 2.G in 2014*



Subcategory	CO_2 eq. (Gg)
Electrical equipment	14.17
SF_6 and PFCs from other product use	NO
N_2O from product use	80.03

4.8.2 SOURCE SUBCATEGORY DESCRIPTION – 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 subcategory. 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%. 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 14.17 Gg CO_2 eq. (0.62 t SF_6) in 2014 and are summarized in the Table 4.87. In 2013, old equipment started to be disposed.

Table 4.87: *SF_6 emissions in the subcategory 2.G.1 in 1990 – 2014*

Year	New fillings	Bank	Retired equipment	emissions from:			Recovery	total emissions
				new fillings	bank	disposal		
	Gg CO_2 eq.							
1990	2.918	2.918	NO	0.029	0.029	NO	NO	0.058
1991	0.296	3.215	NO	0.003	0.032	NO	NO	0.035
1992	0.524	3.739	NO	0.005	0.037	NO	NO	0.043
1993	2.622	6.361	NO	0.026	0.064	NO	NO	0.090

Year	New fillings	Bank	Retired equipment	emissions from:			Recovery	total emissions
				new fillings	bank	disposal		
	Gg CO_2 eq.							
1994	878.005	884.366	NO	8.780	8.844	NO	NO	17.624
1995	69.973	945.498	NO	0.700	9.455	NO	NO	10.155
1996	90.174	1026.219	NO	0.902	10.262	NO	NO	11.164
1997	65.664	1081.623	NO	0.657	10.816	NO	NO	11.473
1998	96.991	1167.800	NO	0.970	11.678	NO	NO	12.648
1999	54.082	1210.206	NO	0.541	12.102	NO	NO	12.643
2000	53.147	1251.253	NO	0.531	12.513	NO	NO	13.044
2001	47.173	1285.915	NO	0.472	12.859	NO	NO	13.331
2002	102.463	1375.522	NO	1.025	13.755	NO	NO	14.780
2003	71.888	1433.657	NO	0.719	14.337	NO	NO	15.055
2004	61.993	1481.316	NO	0.620	14.813	NO	NO	15.433
2005	85.956	1552.461	NO	0.860	15.525	NO	NO	16.384
2006	67.055	1603.994	NO	0.671	16.040	NO	NO	16.710
2007	75.764	1663.721	NO	0.758	16.637	NO	NO	17.395
2008	119.016	1766.102	NO	1.190	17.661	NO	NO	18.851
2009	101.346	1849.789	NO	1.013	18.498	NO	NO	19.511
2010	67.511	1898.805	NO	0.675	18.949	NO	NO	19.624
2011	99.271	1979.090	NO	0.993	19.809	NO	NO	20.802
2012	82.627	2041.929	NO	0.826	20.417	NO	NO	21.244
2013	62.472	2079.321	10.488	0.625	21.500	0.178	10.31	22.303
2014	45.809	2006.765	133.419	0.458	11.442	2.268	131.15	14.168

4.8.2.1 Methodological issues – methods

The IPCC 2006 Guidelines 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 4.3);
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 2014);
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 d omestically 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:

$Bank_{in\ year\ t} = Bank_{in\ year\ t\text{-}1}$ + 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.*

4.8.2.2 Methodological issues – emission factors and other parameters

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 SF6 is recovered for repeated used or destroyed. (in 2014 3.65 t was destroyed). Thus, the disposal loss factor is 1.7%.

4.8.2.3 Activity data

The activity data are collected together with the other F-gases data as described in the category 2.F and in the Annex 4.3 of this report. Amount of SF_6 in disposed systems was taken directly from recycling factories.

4.8.2.4 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 Guidelines.

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 equivalents) is in interval (-6.46%; +6.59%). 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) +

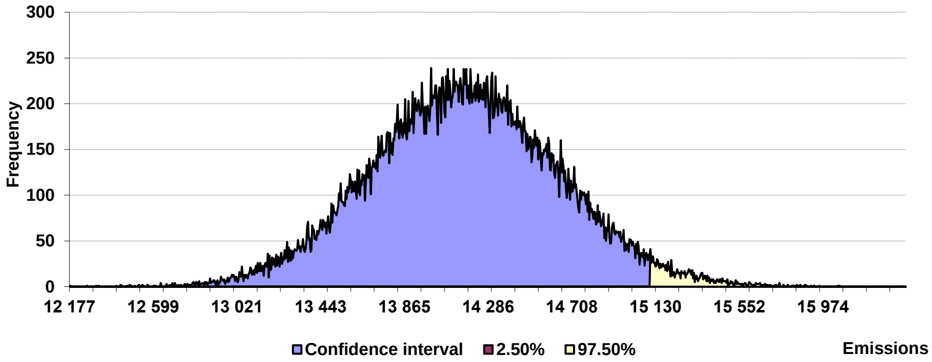
+ (Disposed_equipment ± Δ Disposed_equipment) * (EF_disposed ± Δ EF_disposed).

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 equivalents in 2.G.1 subcategory obtained by the Monte Carlo simulation is 14.17 Gg CO_2 eq. per year. The average mean value is comparable with the real CO_2 emissions in equivalents in this subcategory, which is 14.17 Gg CO_2 eq.

Table 4.88: *Selected statistical characteristics for subcategory 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
14 164	**14 168**	471	12 177	16 396	-6.46%	6.59%

Figure 4.42: *Probability density function for subcategory 2.G.1 (t of CO_2 eq.)*



4.8.2.5 Source specific QA/QC and verification

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.

4.8.2.6 Source specific recalculations

Recovery of SF_6 in 2013 was recalculated. In previous submission the recovery represented the amount of SF_6 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. SF_6 emissions were not influenced by this correction.

4.8.2.7 Source specific planned improvements

Feasibility of the Monte Carlo method for uncertainties analyses will be considered in the future, this method is limited by the input data availability. No other improvements are planned in the next submission.

4.8.3 SOURCE SUBCATEGORY DESCRIPTION – USE OF SF_6 AND PFC_S IN OTHER PRODUCTS (CRF 2.G.2)

SF_6 can be used as an extinguishing medium in electronics, protection against explosion, isolation, sterilization, detection gas, alloying of Al and Mg and in tobacco production. SF_6 gas is rather expensive and therefore 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. Emissions in this subcategory are not occurring for the time series 1990 – 2014.

4.8.4 SOURCE SUBCATEGORY DESCRIPTION – N_2O FROM PRODUCT USES (CRF 2.G.3)

Medicine (anaesthesia) and food industry (aerosol cans) N_2O emissions are reported in this subcategory in 2014. 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 251.0 t and total N_2O emissions from anaesthesia were 17.6 t in 2014.

4.8.4.1 Methodological issues – methods

The methodology is based on the default tier 1 method due to less significant of this subcategory (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 4.89.

Table 4.89: *N_2O emissions from product uses in 1990 – 2014*

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
1991	0.0550	0.0550	NO
1992	0.0550	0.0550	NO
1993	0.0550	0.0550	NO
1994	0.0542	0.0542	NO
1995	0.1000	0.1000	NO
1996	0.1072	0.1072	NO
1997	0.0868	0.0868	NO
1998	0.0683	0.0683	NO
1999	0.0706	0.0706	NO
2000	0.0650	0.0650	NO
2001	0.0967	0.0810	0.0157
2002	0.1847	0.0762	0.1085
2003	0.1911	0.0733	0.1178
2004	0.2590	0.0706	0.1884
2005	0.2785	0.0656	0.2129
2006	0.2659	0.0598	0.2061
2007	0.2579	0.0609	0.1970
2008	0.2546	0.0522	0.2024
2009	0.2497	0.0476	0.2020
2010	0.2606	0.0528	0.2078
2011	0.2447	0.0490	0.1957
2012	0.2945	0.0445	0.2500
2013	0.4102	0.0190	0.3912
2014	0.2686	0.0176	0.2510

4.8.4.2 Methodological issues – emission factors and other parameters

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.

4.8.4.3 Activity data

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.

4.8.4.4 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 the subcategory 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 equivalents) is in interval (-2.96%; +2.96%). Formula can be written in the following form:

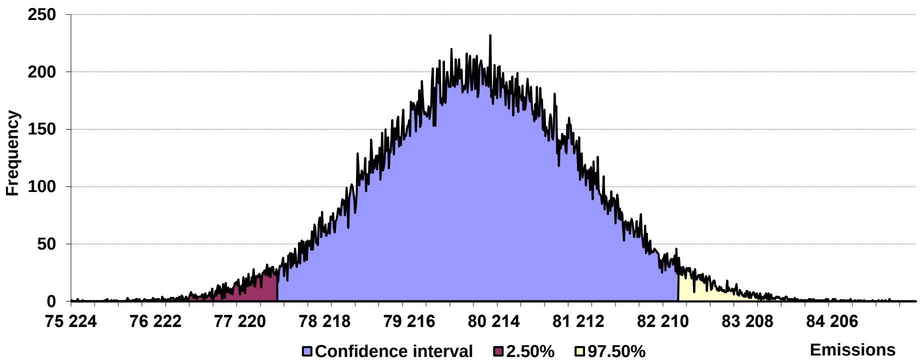
$$Emissions = \sum_{i} \left(CF_i * (AD \pm \Delta AD) * (EF \pm \Delta EF)\right)$$

The process is related to N_2O emissions. The CO_2 equivalent 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 equivalents in this subcategory obtained by the Monte Carlo simulation is 80.03 Gg CO_2 eq. per year. The average mean value is comparable with the real CO_2 emissions in equivalents in this subcategory, which is 80.03 Gg CO_2 eq.

Table 4.90: *Selected statistical characteristics for 2.G.3, median, mean value, standard deviation, minimum, maximum of emissions and percentiles (t of CO_2 equivalents)*

Median	**Average**	St. dev.	Min	Max	Per_2.5	Per_97.5
80 027	**80 031**	1 206	75 224	85 204	-2.96%	2.96%

Figure 4.43: *Probability density function for subcategory 2.G.3 (t of CO_2 equivalents)*



4.8.4.5 Source specific QA/QC and verification

Due to the lack of appropriate statistical information and methodological advises in this subcategory, inputs were taken directly from the questionnaires sent to distributors of N_2O liquid gas in the Slovak Republic. Sector specific QA/QC activities were performed as described in Chapter 4.2 of this report.

4.8.4.6 Source specific recalculations

No recalculations focused on the base year 1990 or the other inventory years were provided in the 2016 submission.

4.8.4.7 Source specific planned improvements

No improvements are planned for this subcategory in the next submission.

4.9 OTHER PRODUCTION (CRF 2.H)

The NMVOC emissions from food industry were reported in this category in 2014. Total emissions of NMVOC were 282.3 t and are consistent with the CLRTAP inventory. No GHG emissions occurred in the time series 1990 – 2014.

ANNEX 4.1: RECONSTRUCTION OF THE TIME SERIES IN NON-METALLURGICAL MAGNESIA PRODUCTION (CRF 2.A.4.c)

Magnesite clinker for refractory materials is produced in Slovakia. All data for emissions estimation in the production of magnesite clinker and its composition are available for the whole time series. These emissions shall be allocated in the subcategory production of deadburned magnesia based on the IPCC 2006 GL. The amount of used carbonates should be used for reporting. These data are available since 2008. Therefore, the time series 1990 – 2007 was reconstructed based on the magnesite clinker production.

The following data for the period 2008 – 2013 are available: (i) consumption of raw materials at magnesite clinker production and respective carbonates content; (ii) magnesite clinker production and its composition. Raw materials contain $MgCO_3$, $CaCO_3$ and $FeCO_3$ from which the magnesite clinker contains MgO, CaO and Fe_2O_3. Detailed data are presented in Table A4.1.1 and A4.1.2.

Table A4.1.1: *Consumption and composition of raw materials for 2008 – 2013*

Year	Raw materials used (kt)	$MgCO_3$ content	$CaCO_3$ content	$FeCO_3$ content
2008	780.56	0.8931	0.0333	0.0063
2009	548.57	0.8873	0.0426	0.0064
2010	820.32	0.8424	0.0400	0.0038
2011	724.27	0.9193	0.0444	0.0077
2012	634.97	0.9090	0.0436	0.0189
2013	603.38	0.8418	0.0489	0.0063

Table A4.1.2: *Production and composition of magnesite clinker for 2008 – 2013*

Year	Magnesite clinker (kt)	MgO content	CaO content	Fe_2O_3 content
2008	404.18	0.8245	0.0361	0.0084
2009	283.43	0.8209	0.0462	0.0085
2010	399.34	0.8272	0.0460	0.0054
2011	384.58	0.8276	0.0469	0.0100
2012	316.13	0.8728	0.0489	0.0292
2013	265.56	0.9143	0.0623	0.0109

Comparison of CO_2 emissions estimated on the basis of both data sets is shown in Table A4.1.3.

Table A4.1.3: *Comparison of CO_2 emissions estimated from both data sets above for 2008 – 2013*

Year	Based on magnesite clinker		Based on carbonates		ratio
	magnesite clinker (kt)	CO_2 emissions (Gg)	raw materials used (kt)	CO_2 emissions (Gg)	
2008	404.18	377.23	780.56	377.20	0.9999
2009	283.43	265.68	548.57	265.70	1.0001
2010	399.34	376.33	820.32	376.35	1.0000
2011	384.58	363.84	724.27	363.83	1.0000
2012	316.13	318.53	634.97	318.04	0.9985
2013	265.56	279.72	603.38	279.56	0.9994

As can be seen from the Table A4.1.3 above, the estimated CO_2 emissions are so close that the differences can be considered as negligible. They can be caused only by rounding. Based on this verification, the whole time series can be reconstructed on the basis of magnesite clinker production (Table A4.1.4).

Table A4.1.4: *Production and composition of magnesite clinker and CO_2 emissions for 1990 – 2013*

Year	Magnesite clinker (kt)	MgO content	CaO content	Fe_2O_3 content	MgO hyp. content	CO_2 (Gg)	EF (t/t)
1990	460.05	0.8598	*	*	0.8598	431.94	0.939
1991	273.98	0.8598	*	*	0.8598	257.24	0.939
1992	233.79	0.8598	*	*	0.8598	219.50	0.939
1993	240.36	0.8598	*	*	0.8598	225.67	0.939
1994	217.61	0.8598	*	*	0.8598	204.31	0.939
1995	313.17	0.8598	*	*	0.8598	294.03	0.939
1996	320.72	0.8598	*	*	0.8598	301.12	0.939
1997	330.44	0.8598	*	*	0.8598	310.25	0.939
1998	401.01	0.8598	*	*	0.8598	376.51	0.939
1999	420.54	0.8246	0.0347	0.0203	0.8598	394.84	0.939
2000	436.49	0.8244	0.0354	0.0197	0.8598	409.82	0.939
2001	459.71	0.8247	0.0351	0.0195	0.8598	431.61	0.939
2002	467.06	0.8253	0.0360	0.0171	0.8598	438.52	0.939
2003	479.23	0.8241	0.0378	0.0169	0.8598	449.95	0.939
2004	524.93	0.8334	0.0429	0.0148	0.8717	499.68	0.952
2005	481.88	0.8634	0.0439	0.0191	0.9046	476.01	0.988
2006	346.49	0.8569	0.0443	0.0228	0.9002	340.63	0.983
2007	320.05	0.8584	0.0135	0.0034	0.8698	304.00	0.950
2008	404.18	0.8245	0.0361	0.0084	0.8547	377.23	0.933
2009	283.43	0.8209	0.0462	0.0085	0.8584	265.68	0.937
2010	399.34	0.8272	0.0460	0.0054	0.8630	376.33	0.942
2011	384.58	0.8276	0.0469	0.0100	0.8663	363.84	0.946
2012	316.13	0.8728	0.0489	0.0292	0.9227	318.53	1.008
2013	265.56	0.9143	0.0623	0.0109	0.9646	279.72	1.053

*CaO and Fe_2O_3 are included in "*MgO hypothetic*" by formula:
MgO = MgO + CaO / 50.079 * 40.304 + + Fe_2O_3 * 2 / 159.697 * 40.304

Based on the data shown in the Table A4.1.4 quantity of used carbonates was estimated in following way:

$m(MgCO_3) = m(clinker) * w(MgO) * M(MgCO_3) / M(MgO)$

$m(CaCO_3) = m(clinker) * w(CaO) * M(CaCO_3) / M(CaO)$

$m(FeCO_3) = m(clinker) * w(Fe_2O_3) * 2* M(FeCO_3) / M(Fe_2O_3)$

where m(i) – mass (weight); w(i) – mass fraction and M(i) is the molar weight of "*i*".

Total amount of raw materials was estimated as a ratio of raw materials to sum of pure carbonates (volumes), where the average ratio for the period 2008 – 2013 was 0.9321. The reconstructed time series is shown in Table A4.1.5.

Table A4.1.5: *Reconstructed consumption and composition of raw materials for 1990 – 2013*

Subcategory 2.A.4.3 Non-metallurgical magnesia production						
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
1991	528.69	0.9321	*	*	257.24	0.487
1992	451.14	0.9321	*	*	219.50	0.487
1993	463.81	0.9321	*	*	225.67	0.487
1994	419.91	0.9321	*	*	204.31	0.487
1995	604.32	0.9321	*	*	294.03	0.487
1996	618.89	0.9321	*	*	301.12	0.487
1997	637.64	0.9321	*	*	310.25	0.487
1998	773.83	0.9321	*	*	376.51	0.487
1999	819.50	0.8852	0.0318	0.0151	394.84	0.482
2000	850.57	0.8850	0.0324	0.0147	409.82	0.482
2001	895.73	0.8854	0.0321	0.0145	431.57	0.482
2002	909.72	0.8864	0.0330	0.0127	438.53	0.482
2003	933.64	0.8849	0.0346	0.0126	449.95	0.482
2004	1 037.03	0.8825	0.0387	0.0109	499.68	0.482
2005	988.58	0.8804	0.0382	0.0135	476.01	0.482
2006	708.03	0.8772	0.0387	0.0162	340.62	0.481
2007	626.55	0.9173	0.0123	0.0025	304.00	0.485
2008	780.56	0.8931	0.0333	0.0063	377.20	0.483
2009	548.57	0.8873	0.0426	0.0064	265.70	0.484
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

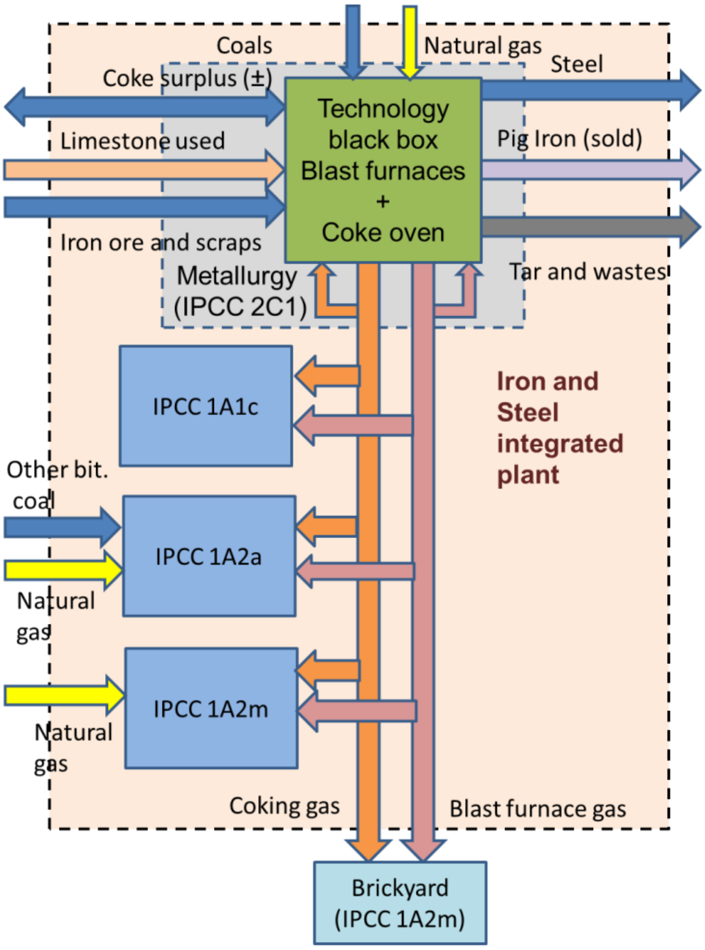
* Carbonates are included in $MgCO_3$ on the basis of stoichiometry

ANNEX 4.2: CO_2 REFERENCE APPROACH AND COMPARISON WITH THE SECTORAL APPROACH, AND RELEVANT INFORMATION ON THE NATIONAL ENERGY BALANCE:

A4.2.1 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 A4.2.1). 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 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 A4.2.1: *The simplified distribution scheme of the complex plant for pig iron and steel production*



Carbon balance consists of four steps: (1) balance of the subcategory 2.C.1, (2) balance of the subcategory 1.A.1.c, (3) balance of the subcategory 1.A.2.a and (4) balance of the subcategory 1.A.2.m.

Table A4.2.1: *Balance of the subcategory 2.C.1 in 2014*

Stream	Activity data (kt; mil. m^3)	NCV (TJ /m.j.)	EF(C) (t/TJ; mass fraction)	Carbon (kt)
Coking coal	2 542.17	29.718	25.557	1 930.79
Anthracite	64.19	27.320	28.294	49.62
Coke surplus	74.98	28.351	29.992	63.75
Natural gas	20.13	34.800	15.197	10.64
Tar	-2 435.04		0.036	-88.05
Coking gas	-604.21	16.380	11.477	-113.59
Blast furnace gas	-3 958.03	3.150	71.240	-888.20
Iron ore	7 462.63		2.832E-03	21.13
Steel	-4 439.48		7.769E-04	-3.45
Pig iron sold	-24.15		4.450E-02	-1.07
Limestone used	973.80		1.201E-01	116.94
Total				**1 098.50**

CO_2 emissions estimation in the subcategory 2.C.1 is based on the carbon balance (from that plant) and represents the value 4 024.91 Gg (total carbon × 3.664).

Table A4.2.2: *Balance of the subcategory 1.A.1.c in 2014*

Stream	Activity data (kt; mil. m^3)	NCV (TJ /m.j.)	EF(C) (t/TJ; mass fraction)	Carbon (kt)
Natural gas	0.14	34.800	15.197	0.07
Coking gas	113.97	16.380	11.477	21.43
Blast furnace gas	1 373.73	3.150	71.240	308.27
Total				**329.70**

CO_2 emissions estimation in the subcategory 1.A.1.c is based on the carbon balance (from that plant, not total subcategory 1.A.1.c) and represents the value 1 208.28 Gg (total carbon × 3.664).

Table A4.2.3: *Balance of the subcategory 1.A.2.a in 2014*

Stream	Activity data (kt; mil. m^3)	NCV (TJ /m.j.)	EF(C) (t/TJ; mass fraction)	Carbon (kt)
Other bituminous coal	390.22	26.270	26.806	274.79
Natural gas	27.16	34.800	15.197	14.36
Coking gas	247.91	16.380	11.477	46.61
Blast furnace gas	2 227.03	3.150	71.240	499.76
Total				**835.52**

CO_2 emissions estimation in the subcategory 1.A.2.a is based on the carbon balance (from that plant, not total subcategory 1.A.2.a) and represents the value 3 061.36 Gg (total carbon × 3.664).

Table A4.2.4: *Balance of the subcategory 1.A.2.m in 2014*

Stream	Activity data (kt; mil. m^3)	NCV (TJ /m.j.)	EF(C) (t/TJ; mass fraction)	Carbon (kt)
Natural gas	104.25	34.800	15.20	55.13
Coking gas	242.08	16.38	11.48	45.51
Blast furnace gas	357.27	3.15	71.24	80.17
Total				**180.82**

CO_2 emissions estimation in the subcategory 1.A.2.m is based on the carbon balance (from that plant, not total subcategory 1.A.2.f) and represents the value 662.51 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 2014. In the years, when output is reported from the iron and steel plant, it means, that gases are sold to nearby brickyard and they are balanced in the category 1.A.2.m.

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 1.A.2.m. 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 0.07% (NIR: 8 956.80 Gg CO_2; EU ETS (*de-minimis* included): 8 962.74 Gg CO_2).

ANNEX 4.3: 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.

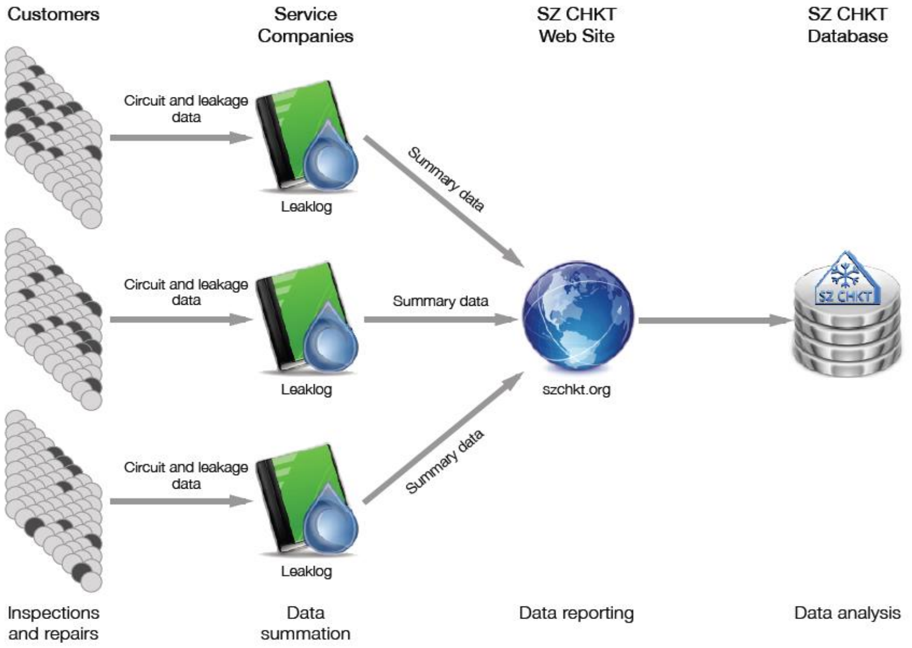
In the year 2003 Slovakia started software with access to the processing and data assessment. This software system is based on the activities of the Slovak Association for Cooling and Air-conditioning Technology (SZCHKT). The electronically led documentations have been developed from the previous paper 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 A4.3.1: *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.

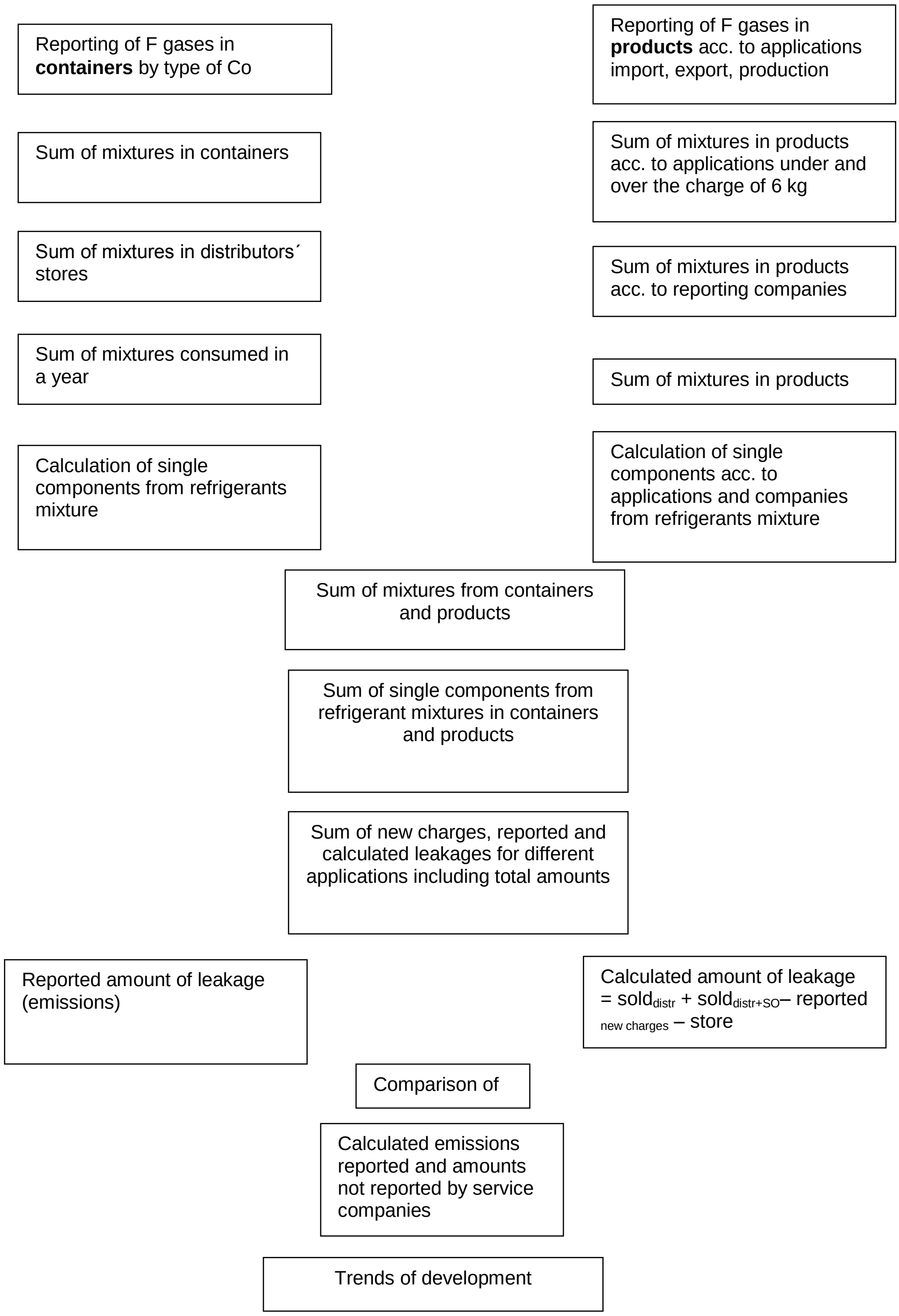
All companies dealing with the F-gases have access to the electronic system based on certificate provided by the Notified Body. Advantages of electronic data logging and reporting are in the possibilities of automatic analysis, fault detection and comparison of, fast access to the full history of leak 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 analyzing important data in a chosen period in connection with the internet (Figure A4.3.2). 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 includes 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.

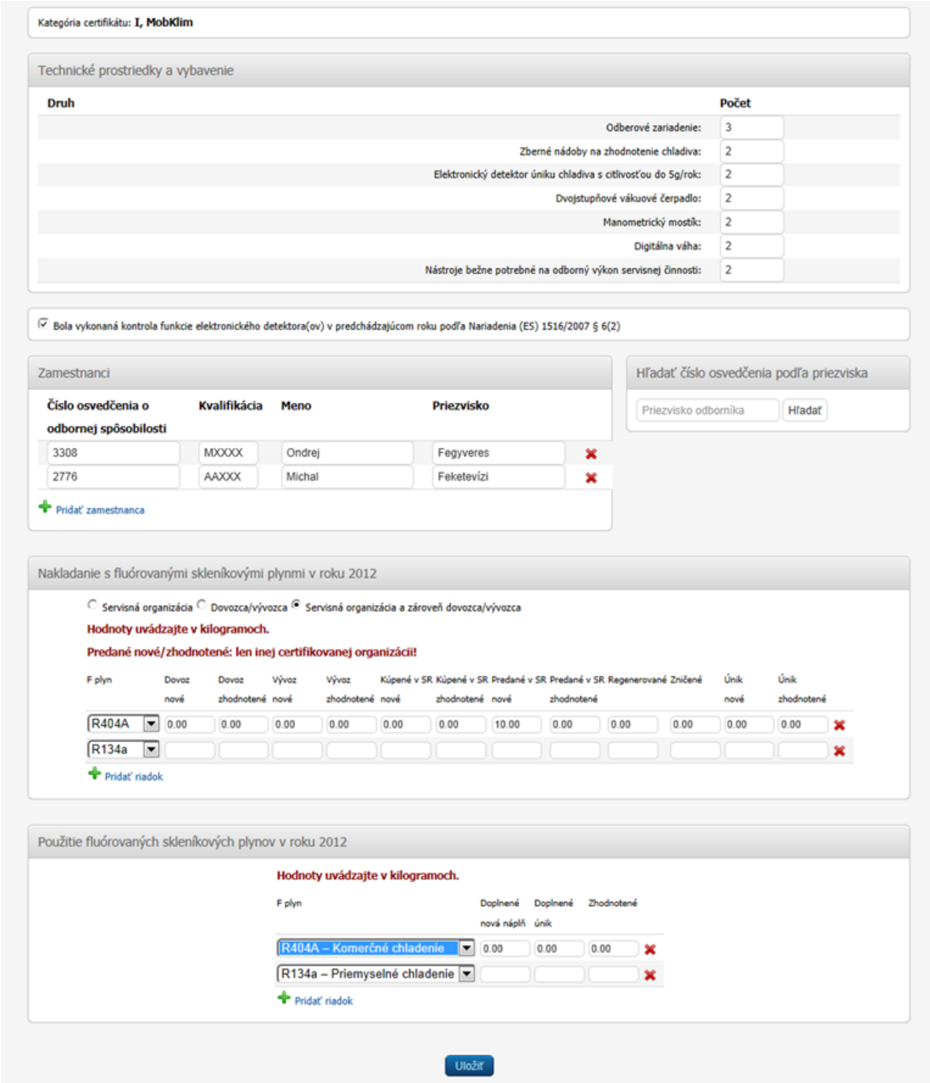
Figure A4.3.2: *Diagram of data flow in reporting (data flow direction: top to down)*



A4.3.1 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 A4.3.3 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 A4.3.3: *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*

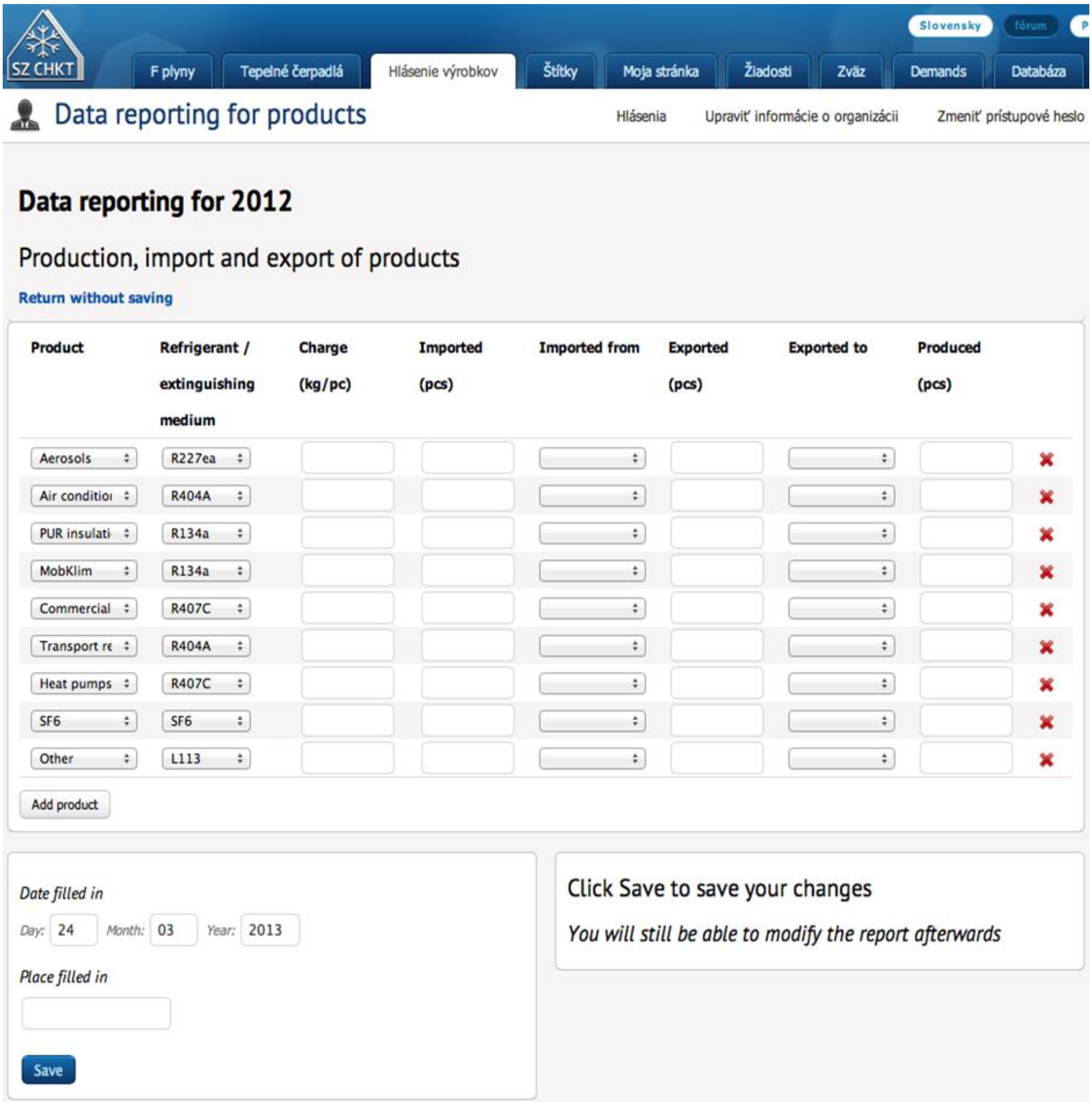


A4.3.2 REPORTING OF F-GASES IMPORTED IN PRODUCTS

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 A4.3.4 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 A4.3.4: *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.

A4.3.3 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 A4.3.5 and A4.3.6).

Figure A4.3.5: *Main outputs of logbook*

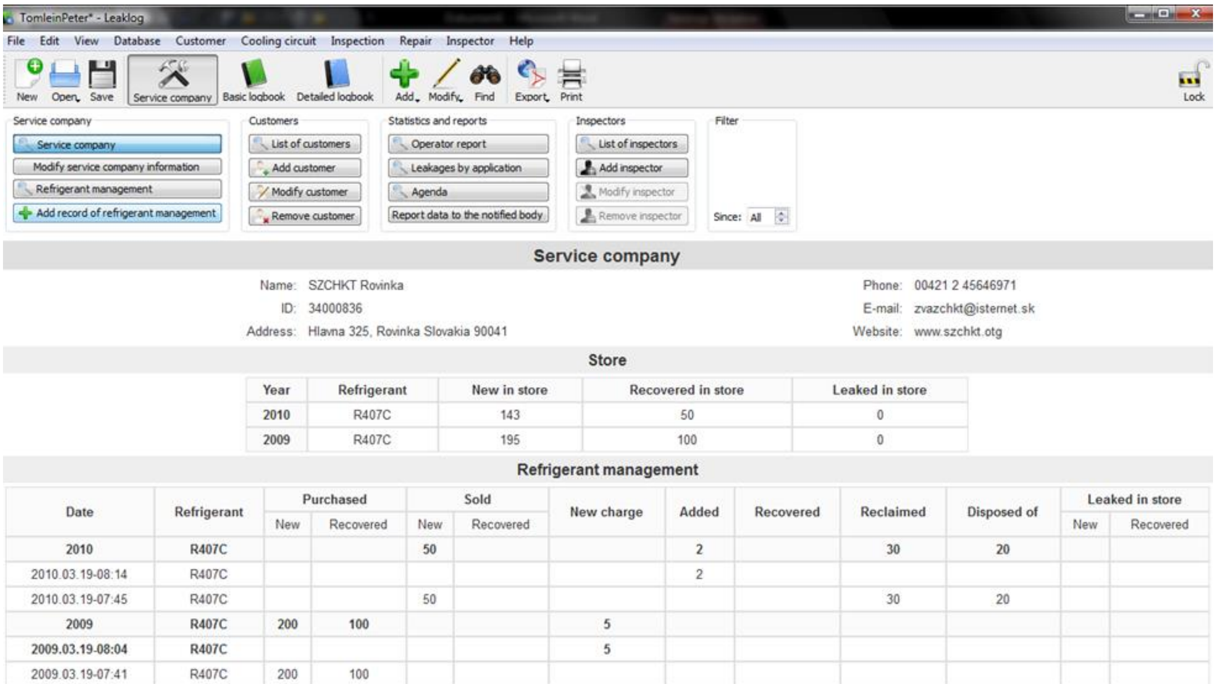
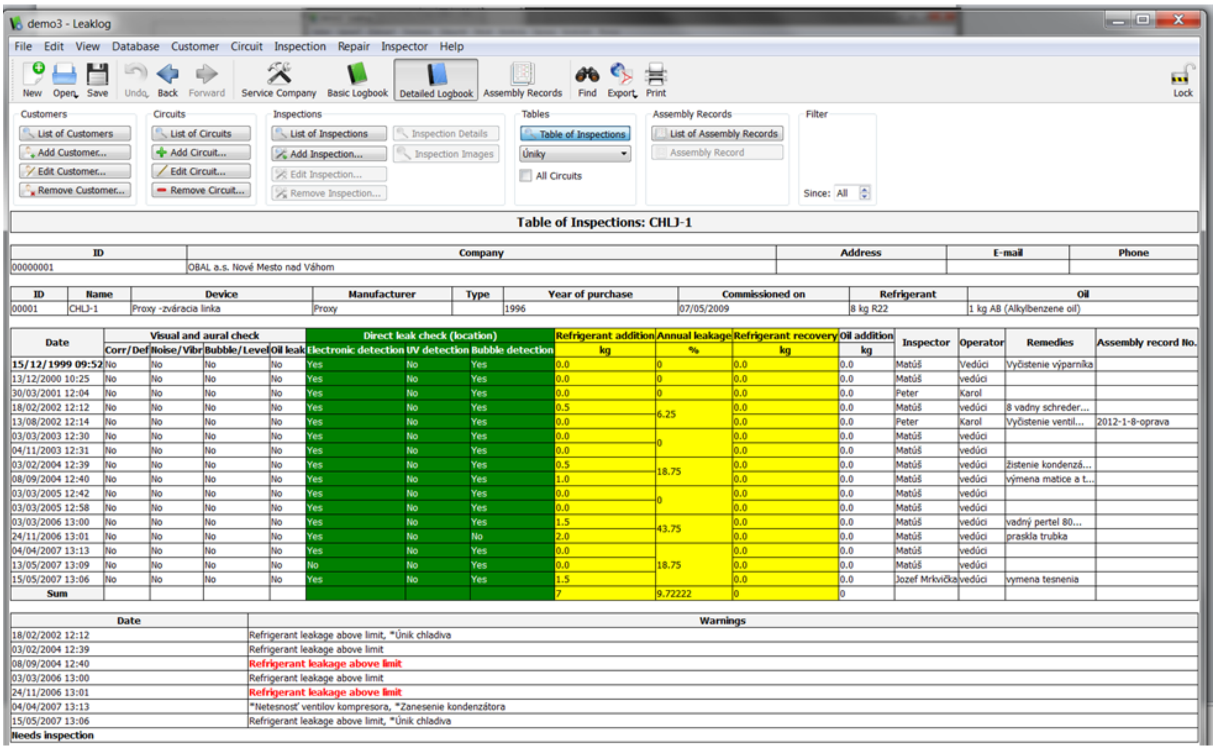
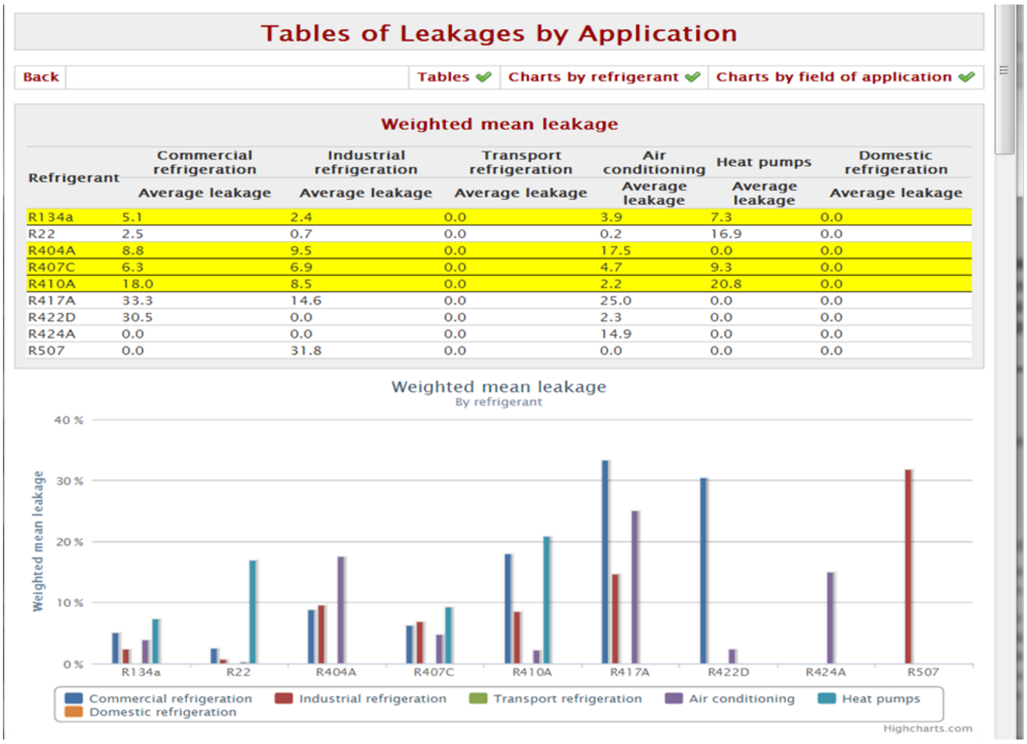


Figure A4.3.6: *Procedure of data reporting of F-gases*



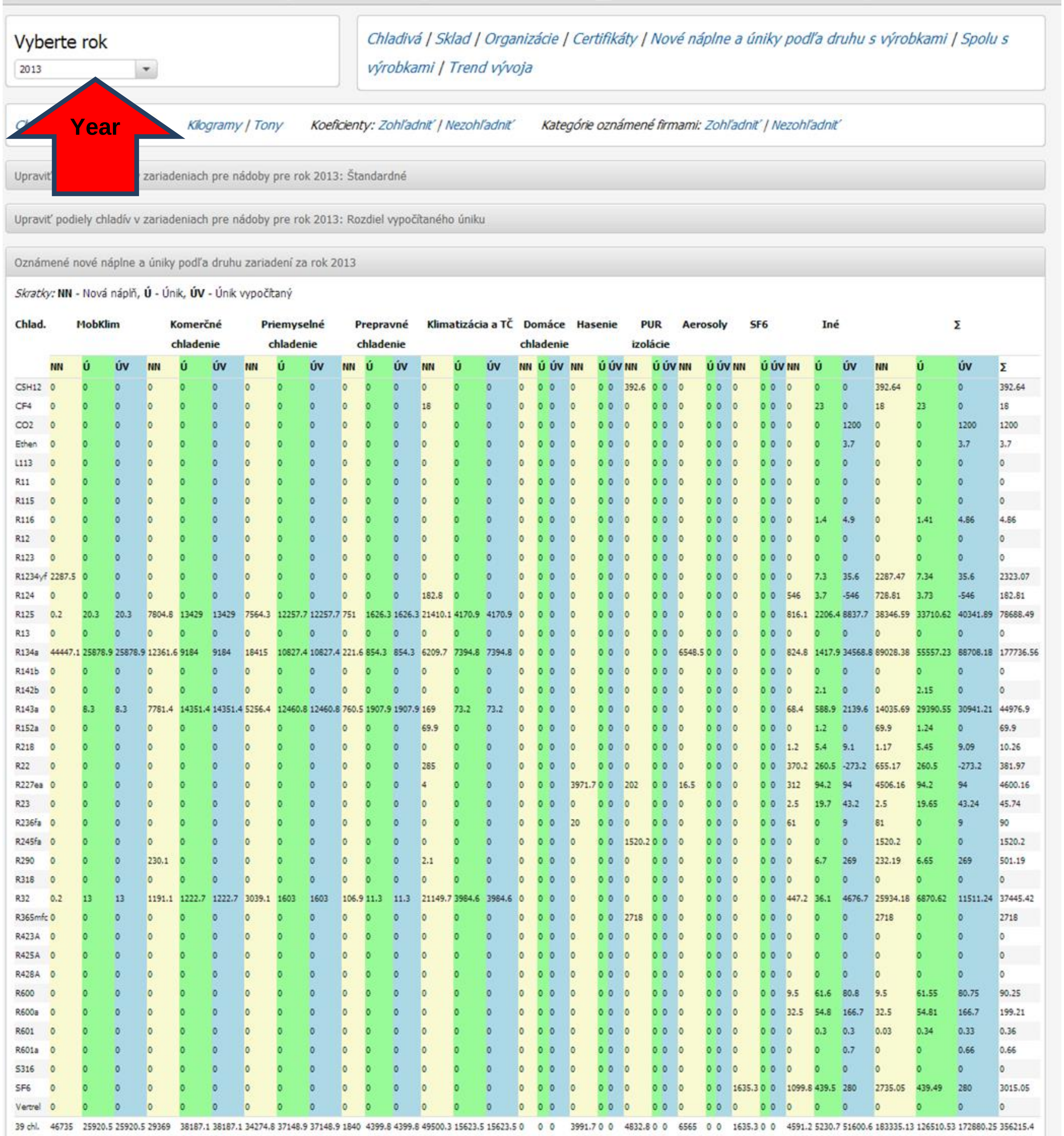
The inserted data can be presented in table with differentiation by subcategory (Figure A4.3.7).

Figure A4.3.7: *Table of leakages by application*



After the completing of input data, the blends are converted into single substances according to the appliances (Figure A4.3.8).

Figure A4.3.8: *Conversion of mixtures to single substances according to the new charges (NN), leaks (Ú) and calculated leaks (ÚV) for different subcategories – Leaklog*



Chlad.	MobKlim			Komerčné chladenie			Priemyselné chladenie			Prepravné chladenie			Klimatizácia a TČ			Domáce chladenie			Hasenie			PUR izolácie			Aerosoly			SF6			Iné			Σ			
	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	NN	Ú	ÚV	Σ
CSH12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	392.6	0	0	0	0	0	0	0	0	0	0	0	392.64	0	0	392.64
CF4	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0	18	23	0	18
CO2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1200	0	0	1200	1200
Ethen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.7	0	0	3.7	3.7
L113	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.4	4.9	0	1.41	4.86	4.86
R12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R123	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R1234yf	2287.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.3	35.6	2287.47	7.34	35.6	2323.07
R124	0	0	0	0	0	0	0	0	0	0	0	0	182.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	546	3.7	-546	728.81	3.73	-546	182.81
R125	0.2	20.3	20.3	7804.8	13429	13429	7564.3	12257.7	12257.7	751	1626.3	1626.3	21410.1	4170.9	4170.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	816.1	2206.4	8837.7	38346.59	33710.62	40341.89	78688.49
R13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R134a	44447.1	25878.9	25878.9	12361.6	9184	9184	18415	10827.4	10827.4	221.6	854.3	854.3	6209.7	7394.8	7394.8	0	0	0	0	0	0	0	0	0	6548.5	0	0	0	0	0	824.8	1417.9	34568.8	89028.38	55557.23	88708.18	177736.56
R141b	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R142b	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.1	0	0	2.15	0	0
R143a	0	8.3	8.3	7781.4	14351.4	14351.4	5256.4	12460.8	12460.8	760.5	1907.9	1907.9	169	73.2	73.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	68.4	588.9	2139.6	14035.69	29390.55	30941.21	44976.9
R152a	0	0	0	0	0	0	0	0	0	0	0	0	69.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	0	69.9	1.24	0	69.9
R218	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	5.4	9.1	1.17	5.45	9.09	10.26
R22	0	0	0	0	0	0	0	0	0	0	0	0	285	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	370.2	260.5	-273.2	655.17	260.5	-273.2	381.97
R227ea	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	3971.7	0	0	202	0	0	16.5	0	0	0	0	0	312	94.2	94	4506.16	94.2	94	4600.16
R23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.5	19.7	43.2	2.5	19.65	43.24	45.74
R236fa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	61	0	9	81	0	9	90
R245fa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1520.2	0	0	0	0	0	0	0	0	0	0	0	1520.2	0	0	1520.2
R290	0	0	0	230.1	0	0	0	0	0	0	0	0	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.7	269	232.19	6.65	269	501.19
R318	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R32	0.2	13	13	1191.1	1222.7	1222.7	3039.1	1603	1603	106.9	11.3	11.3	21149.7	3984.6	3984.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	447.2	36.1	4676.7	25934.18	6870.62	11511.24	37445.42
R365mfc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2718	0	0	0	0	0	0	0	0	0	0	0	2718	0	0	2718
R423A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R425A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R428A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9.5	61.6	80.8	9.5	61.55	80.75	90.25
R600a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32.5	54.8	166.7	32.5	54.81	166.7	199.21
R601	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.3	0.03	0.34	0.33	0.36
R601a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0.66	0.66
S316	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SF6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1635.3	0	0	1099.8	439.5	280	2735.05	439.49	280	3015.05
Vertrel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39 chl.	46735	25920.5	25920.5	29369	38187.1	38187.1	34274.8	37148.9	37148.9	1840	4399.8	4399.8	49500.3	15623.5	15623.5	0	0	0	3991.7	0	0	4832.8	0	0	6565	0	0	1635.3	0	0	4591.2	5230.7	51600.6	183335.13	126510.53	172880.25	356215.4

A4.3.4 DATA PROCESSING – INVENTORY PREPARATION

The 2006 IPCC Guidelines 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:

7. Using the bottom-up approach based on the Logbook Leaklog;
8. Calculation of the total consumptions of individual gases in Slovakia based on the Leaklog;
9. 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);
10. Comparing of the total consumptions calculated by these two approaches;
11. 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;

12. 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 represent the consumption of gases for servicing and container management (these data are reported in the Leaklog). It is assumed, that the chemicals used for servicing restocks the emissions from the bank and thus the bank of the chemical is not affected by leakage (by operational emissions).

Disposal emissions represent the emissions from the retired equipment.

For the consistency of operational emissions the bank of chemical is necessary to follow. The bank is calculated as follows:

$Bank_{in\ year\ t} = Bank_{in\ year\ t-1}$ *+ New additions to bank – Chemical in retired equipment*

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.

CHAPTER 5: AGRICULTURE (CRF 3)

5.1 OVERVIEW OF THE SECTOR (CRF 3)

In comparison with other sectors, the generation of emissions and sinks of greenhouse gases in agriculture has not been investigated thoroughly. Some sources are difficult to quantify, the others are hidden. Besides significant climate differences, there are also different types of soil due to indented ground of the Slovak Republic. This fact affects sowing procedures, manure applications and the management in agriculture.

The humankind activities in agriculture sector significantly contribute to the changes of concentration of some gases in atmosphere what 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 when principles of good practice in GHGs inventory in agriculture were taken into account. Some national data from research projects were utilized too. The emissions of N_2O, CH_4 and NH_3 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. The area of histosols is very limited in the Slovak Republic and those soils have not been cultivated due to the landscape protection during recent years. This source is not evaluated in the GHG inventory. Methane and nitrous oxide are the most important gases emitted from agriculture. Agriculture produces about 27% of total methane and more than 80% of total nitrous oxide emissions in the Slovak Republic.

The share of agriculture and the food industry in the macro-economic indicators of the national economy has slightly decreased in most indicators in 2014. 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. Gross value added in agriculture upsurge as a result of the increase in gross agricultural output, more so in animals than in crops, with a concurrent in intermediate consumption and a significant upsurge in product subsidies (based on references published in the Green Report 2015). Regressive development of gross agricultural output was driven by increase in output for nearly every major crop (with the largest volume growth recorded wheat, barley and grain maize) and favourable weather conditions that caused increase in per-hectare harvest yields. Animal product output dropped within the major types of livestock (except for cattle, swine and poultry) even as the livestock populations increased (except for non-dairy cattle). The drop in animal product output was driven by changes in internal structure, i.e. changes in the category counts within individual types of livestock, in particular animals for slaughter.

Total utilized agricultural area decreased by 2 911 hectares (-0.2%) in 2014 compared with previous year. The production area of agricultural plants decreased to 1 359 thousand ha.[1] From the main crops, an increase was recorded for cultivating areas of legume (22%), soya (14.89%) and industrial

[1] Statistical Yearbook of the Slovak Republic. 2014: Agriculture T16-3.

[1]http://www.mpsr.sk/en/index.php?navID=16&id=44

sugar beet (8.87%). The areas of almost cereals increased. The acreage of densely sown cereals increased for nearly 1.6%. Crop yield decreased by 3.3% despite of annual increase of all important crops. Year 2014 had very good conditions for crop production (temperature above 25°C, enough rain etc.).

The extent of sowing was influenced by domestic consumption prices of commodities, the number of livestock and in recent years graduating by changing of climatic conditions. The area of one-year fodder plants decreased (-0.10%). The area of double-crop red clover increased (10.42%). The area of lantern (0.21%) and perennial grasses (11.5%) increased. The area of leguminous plants (21.57%) increased and oil plants (-4.47%) decreased. The areas of edible leguminous and edible pea plants increased by 11.5% and 25.78%, respectively. On the other hand, the bean plants decreased by -11.6%.

Production increased for nearly all of the monitored plants. The production of edible peas (29.44%), wheat (19.21%), sugar-beet (23.98%), rape (30.29%), seasoning cabbage (13.89%), grain maize (65.48%), kohlrabi (77.4%) and early potatoes (7.2%) increased. The production of vegetables namely: cucumbers (-0.1%) carrots (-4.5%), grape (-17%) and rye (-4.9%) decreased. In cereal production declined for rye (-4.9%). Garlic (-62.7%), cauliflower (-44.6%) and parsley (-32.8%) decreased the most.[2]

Sector agriculture with its share of 7.7% on total GHG emissions (without LULUCF) represented 3 127.93 Gg of CO_2 equivalents in 2014. 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. This year we cooperate with external institute – Research Institute for Animal Production in Nitra. This Institute has been provided activity data and improved methodology for recalculations and revisions included and described in this sector.[3]

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, and the restricted use of fertilizers. In recent years, the good emission balances have been achieved also owing to the introduction of new procedures in cattle stabling and animal waste management (waste recovery by incineration and bio-gas utilisation). The largest share of methane emissions was generated by enteric fermentation of cattle, which produced 36.80 Gg (70.54%) of methane within sector in 2014. Regarding N_2O emissions, direct emissions from synthetic fertilization of agricultural soils were the most important sources, and they produced 1.87 Gg of N_2O (29.6%) within N_2O emissions in sector in 2014. The major GHG emissions source is category 3.D with the share 51%, followed by the category 3.A with the share 33%. The category 3.B represents 14% from the total sector emissions. Categories 3.C, 3.E and 3.F are not reported.

Emissions of CO_2 were reported in this submission in the categories 3.H – Liming (15.63 Gg) and 3.G – Urea Application (57.94 Gg) in 2014. Entire time series were completed since 1990 (Figure 5.1 and Figure 5.2).

[2] http://www.mpsr.sk/en/index.php?navID=16&id=4/4

[3] http://www.vuzv.sk/pdf/metodiky_pre_prax/urcenie_emisii.pdf (in Slovak)

Figure 5.1: *Trend in aggregated emissions (in Gg of CO_2 eq.) by categories within agriculture sector in 1990 – 2014*

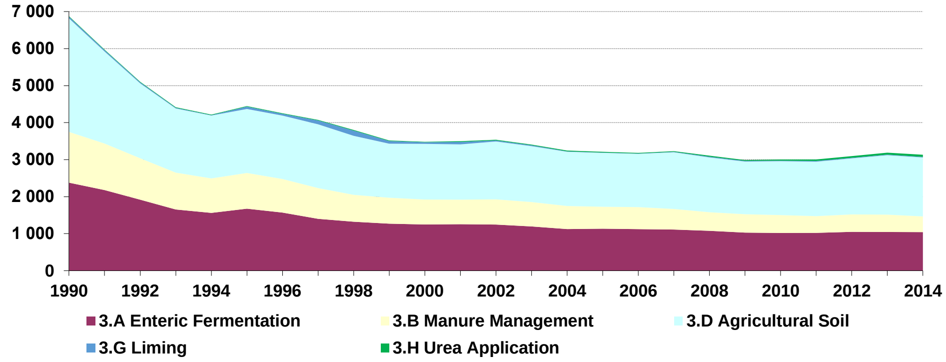


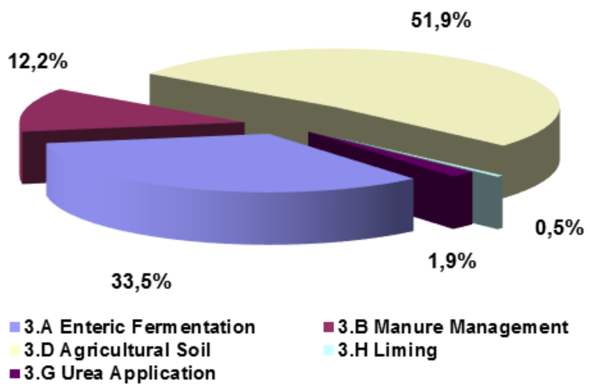
Table 5.1: *Trend of GHG emissions in individual categories in the agriculture sector in 1990 – 2014*

YEAR	SECTOR 3 AGRICULTURE ACCORDING TO GASES (in Gg)				
	CO_2	CH_4	N_2O	NOx	NMVOC
1990	59.91	119.83	12.07	NE,NO	NE,NO,IE
1991	51.33	110.07	9.94	NE,NO	NE,NO,IE
1992	42.75	97.29	8.18	NE,NO	NE,NO,IE
1993	34.17	85.07	7.00	NE,NO	NE,NO,IE
1994	25.59	80.12	6.81	NE,NO	NE,NO,IE
1995	78.44	85.10	6.97	NE,NO	NE,NO,IE
1996	63.34	79.92	6.83	NE,NO	NE,NO,IE
1997	119.44	71.70	6.78	NE,NO	NE,NO,IE
1998	158.46	66.52	6.22	NE,NO	NE,NO,IE
1999	87.11	63.97	5.73	NE,NO	NE,NO,IE
2000	55.77	62.41	5.84	NE,NO	NE,NO,IE
2001	86.30	62.64	5.77	1.98	25.79
2002	46.48	62.98	6.04	2.29	26.23
2003	42.83	60.44	5.85	2.11	24.76
2004	33.66	57.02	5.65	2.08	22.96
2005	29.01	56.67	5.60	2.11	22.68
2006	26.33	56.39	5.53	2.05	21.47
2007	29.42	54.90	5.83	2.31	21.10
2008	48.10	52.20	5.63	2.28	19.84
2009	40.55	50.13	5.43	2.00	20.30
2010	46.33	49.36	5.53	2.26	19.80
2011	60.32	48.70	5.56	2.42	18.90
2012	60.86	50.18	5.71	2.63	19.97
2013	68.22	50.04	6.01	2.95	19.00
2014	73.57	49.45	6.05	3.09	19.77

YEAR	SECTOR 3 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	2 379.31	1 197.56	3 016.76	44.62	15.29
1991	2 179.10	1 097.92	2 436.81	36.04	15.29
1992	1 919.72	975.18	1 975.71	27.46	15.29
1993	1 654.92	871.51	1 686.24	18.88	15.29
1994	1 562.62	815.15	1 654.71	10.30	15.29
1995	1 676.52	843.30	1 683.55	63.15	15.29

YEAR	SECTOR 3 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
1996	1 571.22	792.99	1 669.91	48.05	15.29
1997	1 402.55	725.60	1 683.52	104.15	15.29
1998	1 324.26	631.91	1 559.72	140.48	17.98
1999	1 271.63	608.80	1 425.65	71.33	15.78
2000	1 249.95	582.82	1 467.97	43.67	12.10
2001	1 257.32	574.77	1 453.91	65.63	20.67
2002	1 247.56	595.98	1 531.68	28.20	18.28
2003	1 196.79	576.68	1 479.98	25.24	17.59
2004	1 125.60	546.06	1 436.11	11.17	22.49
2005	1 135.89	518.79	1 429.98	8.70	20.31
2006	1 124.02	520.41	1 411.74	9.23	17.10
2007	1 112.85	485.42	1 510.92	11.17	18.25
2008	1 078.70	436.66	1 466.40	20.12	27.98
2009	1 030.08	432.17	1 407.75	17.83	22.72
2010	1 020.29	419.15	1 442.06	15.39	30.94
2011	1 023.27	390.74	1 460.97	20.61	39.71
2012	1 050.66	406.58	1 500.33	15.44	45.42
2013	1 046.79	404.57	1 592.02	16.23	51.99
2014	1 043.51	379.92	1 614.91	15.63	57.94

Figure 5.2: *The share of aggregated emissions by main categories within agriculture sector in 2014*



AGRICULTURE CATEGORY	CO_2 eq. (Gg)
3.A Enteric Fermentation	1 043.51
3.B Manure Management	379.92
3.D Agricultural Soils	1 614.91
3.G Liming	15.63
3.H Urea Application	57.94

Table 5.2: *Overview of the GHG gases and tiers reported in Agriculture according to the CRF categories in 2014*

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

CATEGORY (CODE AND NAME)	METHODOLOGY/TIER	GHG GASES REPORTED
3.B.1.3 Swine	T1/D	**CH_4**
3.B.1.4 Goats	T1/D	**CH_4**
3.B.1.4 Horses	T1/D	**CH_4**
3.B.1.4 Poultry	T1/D	**CH_4**
3.B.2.1 Dairy Cattle	T2/CS	**N_2O**
3.B.2.1 Non-Dairy Cattle	T2/CS	**N_2O**
3.B.2.2 Mature Ewes	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	NO
3.D.1.1 Inorganic N fertilizers	T1/CS	**N_2O**
3.D.1.2.a Animal Manure Applied to Soils	T1/CS	**N_2O**
3.D.1.2.b Sewage Sludge Applied to Soils	T1	**N_2O**
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 ENTERIC FERMENTATION (CRF 3.A)

5.2.1 SOURCE CATEGORY DESCRIPTION

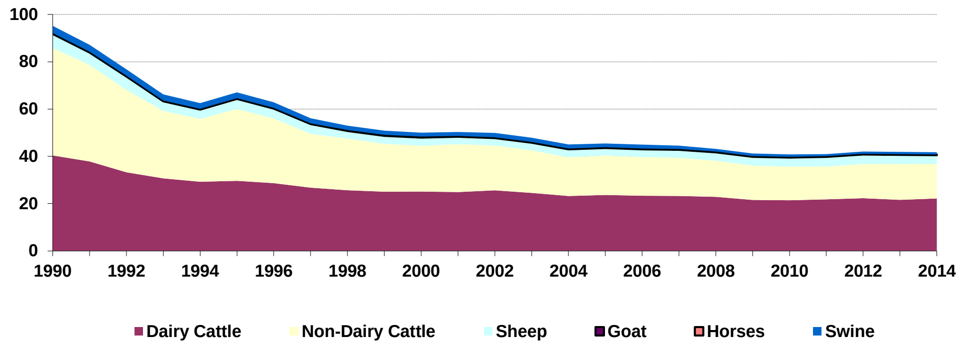
Among all domestic livestock, the cattle are the most important producer of methane due to its digestive tract, weight and a relatively high number compared with other population of livestock in the Slovak Republic. Therefore, the trends in total CH_4 emissions reflect a number of animals in this category. The number of dairy cattle has increased by more than a 1.4% and non-dairy cattle decreased by 1.9% during the evaluated period. Except for population of domestic livestock, the amount of emitted methane is 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 produce 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 2014. Total methane emissions from enteric fermentation decreased from 95.17 Gg in 1990 to 41.74 Gg in 2014, which is the decrease by 56.4% and decrease by nearly 0.3% compared to the previous year. According to the projections, in 2015, a decreasing number of dairy cattle (calculated according to milk productivity and limits of milk production for the Slovak Republic) and a number of sheep and goats will reduce the emissions from this source to 39.7 Gg per year which is less than one third of emissions of 1990. From the following figures it is visible that dairy and non-dairy cattle are the key categories within the enteric fermentation.

Table 5.3: *Methane emissions from enteric fermentation according to the livestock in 1990 – 2014*

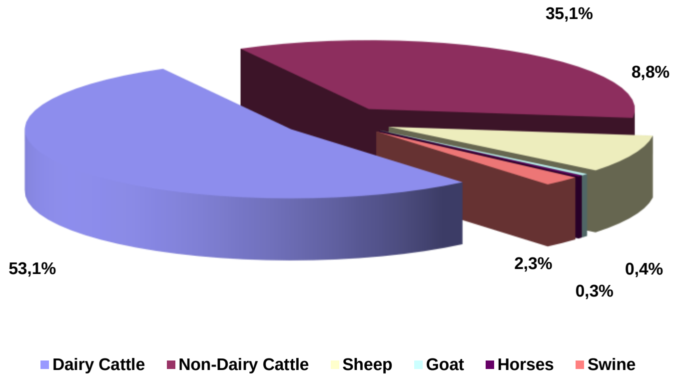
YEAR	CATEGORY 3.A ENTERIC FERMENTATION - CH_4 (Gg)					
	DAIRY CATTLE	NON-DAIRY CATTLE	SHEEP	GOAT	HORSES	SWINE
1990	40.368	45.443	5.932	0.125	0.252	3.053
1991	37.832	40.811	5.250	0.125	0.234	2.913
1992	33.245	34.849	5.655	0.125	0.216	2.699
1993	30.678	28.537	4.063	0.125	0.198	2.596
1994	29.243	26.594	3.925	0.125	0.198	2.420
1995	29.638	30.420	4.230	0.125	0.182	2.467
1996	28.650	27.390	4.141	0.131	0.175	2.362
1997	26.746	22.773	4.126	0.134	0.172	2.152
1998	25.648	21.842	3.225	0.255	0.172	1.830
1999	25.041	20.248	3.365	0.255	0.168	1.787
2000	25.105	19.375	3.440	0.257	0.171	1.649
2001	24.883	20.265	3.127	0.202	0.142	1.674
2002	25.613	18.963	3.124	0.201	0.146	1.855
2003	24.529	18.005	3.218	0.196	0.146	1.776
2004	23.216	16.368	3.374	0.195	0.148	1.724
2005	23.642	16.690	3.188	0.198	0.150	1.567
2006	23.328	16.388	3.247	0.192	0.148	1.657
2007	23.236	16.144	3.373	0.189	0.144	1.428
2008	22.861	15.290	3.537	0.185	0.152	1.123
2009	21.550	14.536	3.697	0.179	0.130	1.111
2010	21.406	14.222	3.848	0.176	0.128	1.031
2011	21.796	13.889	4.080	0.170	0.125	0.871
2012	22.285	14.491	3.999	0.174	0.130	0.947
2013	21.585	15.185	3.839	0.177	0.129	0.956
2014	22.167	14.632	3.680	0.176	0.123	0.963

Figure 5.3: *Trend in methane emissions (Gg) by animals within enteric fermentation in 1990 – 2014*



Dairy and non-dairy cattle methane emissions represent the major share of enteric fermentation emissions (53% and 35%). More than 8.8% 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.

Figure 5.4: *The share of aggregated emissions by categories within enteric fermentation in 2014*



ANIMAL CATEGORY	CH_4 (Gg)
3.A.1 Dairy cattle	22.167
3.A.1 Non-dairy cattle	14.632
3.A.2 Sheep	3.680
3.A.3 Swine	0.963
3.A.4 Goats	0.176
3.A.4 Horses	0.123

5.2.2 METHODOLOGICAL ISSUES – METHODS

In this year the Slovak Republic prepared and implemented new improvement in methodology based on the approved improvement plans 2014 and 2015. Cooperation with external research organisations was extended to 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 and methodological improvements in enteric fermentation were prepared with the cooperation of the Research Institute for Animal Production in Nitra. Changes and improvements are fully in agreement with the IPCC 2006 GL tier 2 approach. For other insignificant animals (goats, horses, and swine), the IPCC 2006 GL tier 1 approach was used, but national parameters were taking into consideration. Overview of tier used in enteric fermentation is provided in Table 5.4.

Used methodology is based on detailed national data about animal number (based on more advanced livestock characteristics and more divided number of livestock). This data was provided by the Statistical Office of the Slovak Republic (the SU SR) firstly in this form for 2014. In the next submission, also full time series of more divided number of livestock will be provided by the SU SR and processed by the NIS experts. While the total animal population will not be changed, this approach does not influence consistency or completeness of inventory. These improvements increased quality of inventory in previous years.

The regional input data about feeding situation, weight, milk production, wool production and other which are available in the Tables (5.6 - 5.9) were provided by the CVZV. New parameters and input data were implemented in dairy cattle, non-dairy cattle and sheep (significant animal categories in Slovakia). In addition also inventory of other animals' categories was improved.

5.2.3 METHODOLOGICAL ISSUES – EMISSION FACTORS AND OTHER PARAMETERS

Cattle:

In terms of increased transparency in methodology and activity data of dairy cattle, estimation was completed by the parameters for average animal weight (596.15 kg), share of pregnancy (41.43%) and share of digestibility of feed (65.81%). Typical feeding situation for cattle is stall, 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 5.4 - 5.7).

Table 5.4: *The overview of used country specific parameters for dairy (milk) cattle in 2014*

DAIRY (MILK) CATTLE						
COUNTRY SPECIFIC DATA	**Dairy cows**	**Calves 6 months**	**Heifer**	**Heifer pregnant**	**Fattening**	**Oxen**
Body weight (kg)	598	104	429	615	354	700
Milk yield l/day	17.21	-	-	-	-	-
Milk yield kg/day	17.74	-	-	-	-	-
Fat milk (%)	3.91	-	-	-	-	-
Digestibility (%) lactating animal	72.20	-	-	-	-	-
Digestibility (%) non-lactating animal	68.06	-	-	-	-	-
DE (%) weighted average	67.06	67.88	61.99	62.73	69.49	60.00
Methane conversion factor/100	0.060	0.057	0.060	0.062	0.057	0.065
Maintenance NE_m (MJ/day)	45.58	10.46	23.8	35.17	30.18	43.82
Activity NE_a (MJ/day)	0.94	-	1.206	0.79	-	-
Lactation N_{El} (MJ/day)	53.76	-	-	-	-	-
Draft power Ne_{work} (MJ/day)	-	-	-	-	-	21.91
Wool production Ne_{wool} (MJ/day)	-	-	-	-	-	-
Growth (NE_g) (MJ/day)	-	10.54	12.38	14.60	10.28	-
Pregnancy NEp (MJ/day)	4.56	-	-	3.52	-	-
Ratio of net energy (REM)	0.52	0.52	0.50	0.50	0,52	0.49
Ratio of net energy (REG)	0.32	0.32	0.28	0.29	0.33	0.28
Gross energy (MJ/head/day)	300.21	77.70	151.54	209.99	129.38	221.46
Emission factors (kg/head/year)	113.99	29.14	63.62	87.16	49.01	94.41

Table 5.5: *The overview of used country specific parameters for non-dairy (beef) cattle in 2014*

NON-DAIRY (BEEF) CATTLE							
COUNTRY SPECIFIC DATA	**Suckling cow**	**Calves 6 months**	**Heifer**	**Heifer pregnant**	**Fattening**	**Oxen**	**Breeding bull**
Body weight (kg)	592	200	437	578	528	700	800
Milk yield l/day	6.26	-	-	-	-	-	-
Milk yield kg/day	6.60	-	-	-	-	-	-
Fat milk (%)	4.00	-	-	-	-	-	-
DE (%) weighted average	62.74	70.00	62.74	62.75	69.49	60.00	65.00
Methane conversion factor/1000	0.065	0.055	0.07	0.065	0.057	0.065	0.06
Maintenance NE_m (MJ/day)	41.95	11.65	24.23	34.40	30.95	43.82	55.66
Activity NE_a (MJ/day)	8.27	1.19	4.780	6.780	-	-	4.94
Lactation N_{El} (MJ/day)	19.83	-	-	-	-	-	-
Draft power Ne_{work} (MJ/day)	-	-	-	-	-	21.91	-
Wool production Ne_{wool} (MJ/day)	-	-	-	-	-	-	-
Growth (NE_g) (MJ/day)	-	13.32	9.59	11.4	10.58	-	-
Pregnancy NEp (MJ/day)	4.19	-	-	3.44	-	-	-
Ratio of net energy (REM)	0.51	0.53	0.51	0.51	0.52	0.49	0.51
Ratio of net energy (REG)	0.30	0.33	0.30	0.30	0.33	0.28	0.31
Gross energy (MJ/head/day)	233.99	91.91	143.14	200.13	132.85	221.46	181.44
Emission factors (kg/head/year)	99.79	16.23	61.01	85.32	50.41	94.41	71.40

Table 5.6: *The overview of used country specific parameters for dairy cattle in 2014*

ACTIVITY DATA DISTRICT	Pop. in heads	from dairy cows	from suckling cows	Energy MJ/head/ average	EFs kg/head/yr average	CH_4 in tons
Bratislava	**6 654**	5 124	1 530	305.86	113.91	757.93
Trnava	**27 411**	25 696	1 715	309.30	112.56	3 085.27
Trenčín	**18 089**	14 097	3 992	284.32	105.93	1 916.21
Nitra	**25 621**	24 155	1 466	299.63	108.97	2 792.03
Žilina	**30 733**	23 474	7 259	276.54	110.62	3 399.79
Banská Bystrica	**33 020**	20 224	12 796	266.45	107.84	3 560.94
Prešov	**39 731**	20 320	19 411	262.48	107.04	4 252.69
Košice	**20 536**	9 993	10 543	274.35	116.96	2 401.97
Slovak Republic	**201 795**	143 083	58 712	**280.95**	**109.85**	**22 166.82***

Table 5.7: *The overview of used country specific parameters for non-dairy cattle in 2014*

ACTIVITY DATA DISTRICT	Pop. in heads	from calves	from heifer	from fattening	from breeding bull	Energy MJ/head/ average	EFs kg/head/yr average	CH_4 in tons
Bratislava	**7 292**	2 119	4 562	536	75	130.09	46.96	342.46
Trnava	**42 180**	12 477	18 877	10 393	347	119.89	43.32	1 827.10
Trenčín	**24 656**	7 729	11 835	4 667	212	128.16	48.32	1 191.45
Nitra	**38 906**	11 794	19 097	7 430	576	124.61	45.02	1 751.37
Žilina	**37 697**	9 743	21 511	5 248	671	162.53	70.72	2 665.76
Banská Bystrica	**44 092**	10 708	25 297	6 787	1 261	154.55	64.74	2 854.70
Prešov	**44 104**	12 983	24 867	5 287	958	141.08	55.10	2 430.11
Košice	**24 821**	6 286	14 747	3 258	504	152.30	63.23	1 569.53
Slovak Republic	**263 748**	**73 839**	**140 793**	**43 606**	**4 604**	**140.12***	**55.48***	**14 632.48**

Note: Oxen (in total 906 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. Breed structure of dairy cattle is divided on heavy and light breed (Table 5.8). Milk production is taken from the Statistical Yearbook. DE is calculated as weighted average of measured values. Methane conversion factor was based on expert judgment 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:

$$EF = \left[\frac{GE * \left(\frac{Y_m}{100}\right) * 365}{55.65} \right]$$

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 each animal category.

Table 5.8: *Breed structure of dairy cattle in the Slovak Republic (in %)*

BREED/ DISTRICT	Banská Bystrica	Bratislava	Košice	Nitra	Poprad	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, specific average methane conversion rate) and other country specific information.

Table 5.9: *The overview of used country specific parameters for sheep in 2014*

COUNTRY SPECIFIC DATA*	DAIRY SHEEP				BEEF SHEEP			
	Mature ewes	Growing lambs	Growing lambs pregnant	Other mature sheep	Mature ewes	Growing lambs	Growing lambs pregnant	Other mature sheep
Body weight (kg)	60	32.5	55	80	70	47.5	65	90
Milk yield l/day	0.40	-	-	-	0.27	-	-	-
Milk yield kg/day	0.41	-	-	-	0.27	-	-	-
DE of feed (%)	65.04	65.00	65.00	65.04	65.48	65.48	65.48	65.50
Methane conversion factor/100	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Maintenance NE_m (MJ/day)	4.68	3.15	4.38	6.68	5.25	4.19	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)	1.89	-	-	-	1.26	-	-	-
Draft power Ne_{work} (MJ/day)	-	-	-	-	-	-	-	-
Wool production Ne_{wool} (MJ/day)	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.12
Growth (NE_g) (MJ/day)	-	1.201	1.790	-	-	1.64	2.9	-
Pregnancy NEp (MJ/day)	0.450	-	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)	24.52	16.36	26.40	22.67	25.1	21.87	30.25	24.57
Emission factors (kg/head/year)	9.65	6.44	10.39	9.92	9.84	8.61	11.90	9.67

* country specific data calculated as weighted average from the eight district of the Slovak Republic

Table 5.10: *The overview of used country specific parameters for mature ewes in 2014*

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	829	0.347	0.357	20.47	9.40	8.17
Trnava	1 554	0.347	0.357	20.62	9.47	15.48
Trenčín	22 341	0.347	0.357	20.66	9.49	216.03
Nitra	8 335	0.347	0.357	20.34	9.34	82.524
Žilina	62 391	0.347	0.357	20.95	9.62	603.86
Banská Bystrica	88 199	0.347	0.357	20.99	9.64	858.64
Prešov	51 050	0.347	0.357	21.04	9.66	495.23
Košice	30 746	0.347	0.357	20.72	9.51	301.46
Weighted average SR	**265 445***	**0.347**	**0.357**	**20.91**	**9.72**	**2 581.38***

***Table 5.11:** The overview of used country specific parameters for growing lambs in 2014*

ACTIVITY DATA/DISTRICT	Population in heads	Energy MJ/head/day	EFs kg/head/year	CH_4 in tons
Bratislava	114	23.84	9.38	1.07
Trnava	1 076	22.93	9.02	9.71
Trenčín	11 345	20.80	8.19	92.90
Nitra	3 120	21.92	8.63	26.92
Žilina	27 150	21.48	8.45	229.52
Banská Bystrica	38 037	22.82	8.98	341.59
Prešov	21 875	21.84	8.60	188.05
Košice	15 131	22.78	8.97	135.67
Weighted average (SR)	**117 848***	**22.11**	**8.74**	**1 025.43***

***Table 5.12:** The overview of used country specific parameters for other mature sheep in 2014*

ACTIVITY DATA/DISTRICT	Population in heads	Energy MJ/head/day	EFs kg/head/year	CH_4 in tons
Bratislava	22	24.40	9.60	0.21
Trnava	52	24.27	9.55	0.50
Trenčín	666	23.11	9.09	6.06
Nitra	235	24.11	9.49	2.23
Žilina	1 838	23.10	9.10	16.71
Banská Bystrica	2 641	23.56	9.27	24.49
Prešov	1 493	23.18	9.12	13.62
Košice	911	23.82	9.37	8.54
Weighted average (SR)	**7 858***	**23.40**	**8.91**	**72.35***

* values are sums

Activity data for sheep are available for detailed categories such as mature ewes, growing lambs and other mature sheep also on district level (Tables 5.10 – 5.12).

Emission factors for cattle and sheep were estimated on the basis of weight, milk production, fat of milk, average gross energy intake, and methane conversion factor. These parameters are country specific. Methane emissions from enteric fermentation of dairy cattle reflect milk production for the period 1997 – 2014. The extrapolation of a linear function was used back to the base year 1990 for the emission factors 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 and sheep categories. Other input parameters such as milk production, fat of milk (3.91%), average gross energy intake and detailed population statistics according to the age of cattle are available since the year 1997 in regional disaggregated form (from eight districts).

***Table 5.13:** Activity data, EFs and methane emissions for dairy cattle in 1990 – 2014*

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	549.000	6.34	211.12	73.530	40.3681
1991	501.000	6.86	216.77	75.512	37.8315
1992	429.000	7.38	222.42	77.494	33.2448
1993	386.000	7.91	228.08	79.476	30.6776
1994	359.000	8.43	233.73	81.457	29.2432
1995	355.200	8.95	239.39	83.439	29.6376
1996	335.400	9.48	245.04	85.421	28.6502
1997	309.742	9.65	243.80	86.350	26.7461
1998	284.165	10.65	254.83	90.256	25.6475

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
1999	274.065	10.94	257.98	91.370	25.0414
2000	271.184	11.49	261.38	92.575	25.1050
2001	259.269	12.43	270.98	95.975	24.8834
2002	259.873	13.07	278.28	98.559	25.6129
2003	245.802	13.32	278.28	99.794	24.5294
2004	231.874	13.45	282.69	100.122	23.2157
2005	229.607	14.24	290.73	102.969	23.6424
2006	218.653	15.30	301.24	106.691	23.3284
2007	215.659	16.00	304.20	107.742	23.2355
2008	211.185	16.15	305.64	108.250	22.8609
2009	204.133	15.39	298.07	105.569	21.5501
2010	204.386	15.16	295.71	104.735	21.4064
2011	201.307	15.81	305.70	108.273	21.7961
2012	202.589	16.62	310.58	110.001	22.2851
2013	198.978	16.06	306.28	108.479	21.5850
2014	201.795	14.46	280.95	109.848	22.1668

* weighted average

Table 5.14: *Activity data, EFs and methane emissions for non-dairy cattle and sheep in 1990 – 2014*

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	1 014.000	122.03	44.82	45.44
1991	896.000	123.05	45.55	40.81
1992	753.000	124.06	46.28	34.85
1993	607.000	125.08	47.01	28.54
1994	557.000	126.09	47.75	26.59
1995	627.500	127.11	48.48	30.42
1996	556.600	128.12	49.21	27.39
1997	493.656	129.88	46.13	22.77
1998	420.627	141.89	51.93	21.84
1999	390.990	141.53	51.79	20.25
2000	374.964	141.84	51.67	19.38
2001	365.921	144.65	55.38	20.26
2002	347.944	144.30	54.50	18.96
2003	347.380	134.99	51.83	18.01
2004	308.272	137.51	53.10	16.37
2005	298.282	143.67	55.95	16.69
2006	289.167	145.27	56.67	16.39
2007	286.158	143.98	56.42	16.14
2008	277.252	142.27	55.15	15.29
2009	267.834	141.26	54.27	14.54
2010	262.739	140.78	54.13	14.22
2011	262.051	139.42	53.00	13.89
2012	268.502	140.74	53.97	14.49
2013	268.842	144.66	56.48	15.19
2014	263.748	140.12	55.48	14.63

* Weighted average

YEAR	ACTIVITY DATA FOR SHEEP IN ENTERIC FERMENTATION			
	Population in 1 000 heads	AGEI MJ/head/day*	EFs kg/head/year*	CH_4 emissions Gg
1990	600.000	21.533	9.89	5.932
1991	531.000	21.533	9.89	5.250
1992	572.000	21.533	9.89	5.655
1993	411.000	21.533	9.89	4.063
1994	397.000	21.533	9.89	3.925
1995	427.844	21.533	9.89	4.230
1996	418.823	21.533	9.89	4.141
1997	417.337	21.533	9.89	4.126
1998	326.199	21.533	9.89	3.225
1999	340.346	21.533	9.89	3.365
2000	347.983	21.533	9.89	3.440
2001	316.302	21.533	9.89	3.127
2002	316.028	21.533	9.89	3.124
2003	325.521	21.533	9.89	3.218
2004	321.227	22.876	10.50	3.374
2005	320.487	21.667	9.95	3.188
2006	332.571	21.266	9.76	3.247
2007	347.179	21.162	9.72	3.373
2008	361.634	21.431	9.78	3.537
2009	376.978	21.359	9.81	3.697
2010	394.175	21.263	9.76	3.848
2011	393.927	22.854	10.36	4.080
2012	409.569	21.271	9.76	3.999
2013	399.908	20.910	9.60	3.839
2014	391.151	24.71	9.41	3.680

* 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 5.15).

Table 5.15: *Activity data, EFs and methane emissions for other animal in 1990 – 2014*

YEAR	GOATS			HORSES			SWINE		
	Pop. in 1 000 heads	EFs kg/head/ year	CH_4 Gg	Pop. in 1 000 heads	EFs kg/head/ year	CH_4 Gg	Pop. in 1 000 heads	EFs kg/head/ year	CH_4 Gg
1990	25.000	5.000	0.125	14.000	18.000	0.252	2 035.00	1.500	3.053
1991	25.000	5.000	0.125	13.000	18.000	0.234	1 942.00	1.500	2.913
1992	25.000	5.000	0.125	12.000	18.000	0.216	1 799.20	1.500	2.699
1993	25.000	5.000	0.125	11.000	18.000	0.198	1 730.80	1.500	2.596
1994	25.000	5.000	0.125	11.000	18.000	0.198	1 613.10	1.500	2.420
1995	25.000	5.000	0.125	10.109	18.000	0.182	1 644.40	1.500	2.467
1996	26.100	5.000	0.131	9.722	18.000	0.175	1 574.80	1.500	2.362
1997	26.778	5.000	0.134	9.533	18.000	0.172	1 434.70	1.500	2.152
1998	50.905	5.000	0.255	9.550	18.000	0.172	1 220.00	1.500	1.830
1999	51.075	5.000	0.255	9.342	18.000	0.168	1 191.66	1.500	1.787
2000	51.419	5.000	0.257	9.516	18.000	0.171	1 099.40	1.500	1.649
2001	40.386	5.000	0.202	7.883	18.000	0.142	1 115.70	1.500	1.674
2002	40.194	5.000	0.201	8.122	18.000	0.146	1 236.90	1.500	1.855
2003	39.225	5.000	0.196	8.114	18.000	0.146	1 184.33	1.500	1.776

YEAR	GOATS			HORSES			SWINE		
	Pop. in 1 000 heads	EFs kg/head/ year	CH_4 Gg	Pop. in 1 000 heads	EFs kg/head/ year	CH_4 Gg	Pop. in 1 000 heads	EFs kg/head/ year	CH_4 Gg
2004	39.012	5.000	0.195	8.209	18.000	0.148	1 149.28	1.500	1.724
2005	39.566	5.000	0.198	8.328	18.000	0.150	1 044.98	1.500	1.567
2006	38.352	5.000	0.192	8.222	18.000	0.148	1 104.83	1.500	1.657
2007	37.873	5.000	0.189	8.017	18.000	0.144	951.93	1.500	1.428
2008	37.088	5.000	0.185	8.421	18.000	0.152	748.52	1.500	1.123
2009	35.866	5.000	0.179	7.199	18.000	0.130	740.86	1.500	1.111
2010	35.292	5.000	0.176	7.111	18.000	0.128	687.26	1.500	1.031
2011	34.053	5.000	0.170	6.937	18.000	0.125	580.39	1.500	0.871
2012	34.823	5.000	0.174	7.249	18.000	0.130	631.46	1.500	0.947
2013	35.457	5.000	0.177	7.161	18.000	0.129	637.17	1.500	0.956
2014	35.178	5.000	0.176	6.828	18.000	0.123	641.83	1.500	0.963

5.2.4 ACTIVITY DATA

The Research Institute for Animal Production in Nitra has taken responsibility for emissions inventory of enteric fermentation and manure management as apart 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 provides national data of annual livestock numbers on a detailed level. These data are based on livestock counts held on 31st December of each year. For more detailed separation the questionnaire survey from the Research Institute for Animal Production in Nitra was used.

Detailed information on cattle has been available since 1997 and on sheep since 2004. The time series have been reconstructed by the extrapolation since 1990. In the period of 1990 – 1996 (2003) only simple animal number statistics is available. Activity data used for methane emissions estimation for dairy cattle is summarized in the Table 5.16. Detailed statistical information is available at the district level and emissions are estimated by bottom-up tier 2 methodology.

In a cooperation with the Research Institute for Animal Production in Nitra the results of a questionnaire survey were used in better classification and disaggregation of cattle categories. Based on survey data, cattle were divided into dairy cattle and beef cattle. Dairy cattle are estimated separately from beef cattle. Dairy cows are defining in this method as cows that producing milk for human consumption (high producing cows) and for nutrition of calves (low producing cows). Other category of cattle as for example breeding bull, oxen, calves, heifer are in category beef cattle.

Table 5.16: Animal population in enteric fermentation according to the districts for the year 2014

CATEGORY		NUMBER OF LIVESTOCK							
DISTRICT		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
DAIRY CATTLE	Dairy cows	5 124	25 696	14 097	24 155	23 474	20 224	20 320	9 993
	Calves in 6 month	1 620	12 001	6 114	11 674	6 814	6 867	6 330	3 104
	Heifer	2 140	10 687	5 659	10 862	10 730	10 996	9 680	5 135
	Heifer (pregnant)	1 783	7 528	4 219	8 127	5 974	6 576	5 479	3 155
	Fattening	322	10 033	1 925	7 401	4 337	4 565	4 166	2 220
	Oxen	0	12	209	6	473	9	1	12
BEEF CATTLE	Suckling cows	1 530	1 715	3 992	1 466	7 259	12 796	19 411	10 543
	Calves in 6 month	499	476	1 615	120	2 929	3 841	6 653	3 182
	Heifer	406	420	1 260	69	3 058	4 822	6 263	4 065
	Heifer (pregnant)	233	242	697	39	1 749	2 903	3 445	2 392
	Fattening	214	360	2 742	29	911	2 222	1 121	1 038
	Oxen	0	74	4	3	51	30	8	14
	Breeding bull	75	347	212	576	671	1 261	958	504
DAIRY SHEEP	Mature ewes	105	423	15 383	3 376	46 173	44 074	37 648	14 322
	Growing lambs	3	379	6 051	1 212	12 616	12 498	9 112	4 416
	Growing lambs (pregnant)	1	360	3 637	622	8 757	10 585	5 986	2 659
	Other mature sheep	3	20	476	100	1 373	1 366	1 091	425
BEEF SHEEP	Mature ewes	724	1 131	6 958	4 959	16 218	44 125	13 402	16 424
	Growing lambs	82	173	1 035	850	3 410	8 097	4 090	5 028
	Growing lambs (pregnant)	28	164	622	436	2 367	6 857	2 687	3 028
	Other mature sheep	19	32	190	135	465	1 275	402	486
SWINE	Market swine	13 194	24 947	8 576	21 472	846	14 020	9 396	8 091
	Breeding swine	11 419	196 916	50 607	130 698	14 036	53 573	43 054	40 982
HORSES	Horses (0-3 year)	116	109	124	529	151	362	237	172
	Stallions	64	75	74	202	162	241	292	111
	Mares	123	114	226	324	212	528	437	206
	Castrated stallions	88	88	101	240	269	316	386	149
GOATS	Goats (mothers)	493	1 495	2 336	3 077	4 350	7 041	3 462	3 557
	Growing goats (pregnant)	78	312	713	870	938	1 854	917	937
	Other mature goats	135	176	166	387	468	743	294	379
POULTRY	Laying hens and cocks	716 664	528 672	613 816	1 798 180	507 519	653 208	427 359	559 935
	Broilers	261 885	887 337	763 826	1 810 112	472 271	344 601	1 447 231	388 590
	Turkeys	1 914	12 286	3 386	81 955	6 969	7 103	3 532	1 026
	Ducks	6 488	30 043	10 362	66 224	7 383	27 301	14 621	4 201
	Geese	1 405	5 915	1 939	7 685	2 944	4 505	1 661	2 020

5.2.5 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 next year. The productivity of different categories of domestic livestock varies in conditions of the Slovak Republic significantly 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).

5.2.6 SOURCE SPECIFIC QA/QC AND VERIFICATION

Sector specific QA/QC plan is based on the general QA/QC plan described in Chapter 1.6. Information used in the process of preparation GHG emissions inventory of the energy sector was obtained from different data sources and compared during the inventory preparation (QC activity). The capacity and institutional arrangement was strengthening in this sector. This was also recommended by the ERT during previous reviews. The Ministry of Environment and the Ministry of Agriculture and Rural Development agreed on the cooperation of the Research Institute on Soil Protection with the SHMU on inventory preparation of agriculture sector. This cooperation is more robust and formal for ensuring sustainability. The independent sectoral expert is contracted by the SHMU as verifier and consultant for independent expertise (QA activity).

The principal source of all agricultural sector data used for GHG emission estimations is based on official numbers published by the Statistical Office of the Slovak Republic and official information from the Ministry of Agriculture and Rural Development of the Slovak Republic (Green Reports). The information used for the preparation of this report is archived by the author and by the SNE.

5.2.7 SOURCE SPECIFIC RECALCULATIONS

No recalculations were provided for the time series 1990 – 2013 in this submission.

5.2.8 SOURCE SPECIFIC PLANNED IMPROVEMENTS

In this submission, new methodological approach based on national parameters was implemented for the year 2014. Used methodology is based on detailed national data about animal number (based on more advanced livestock characteristics and more divided number of livestock). This data was provided by the Statistical Office of the Slovak Republic (the SU SR) firstly in this form for 2014. In the next submission, also full time series of more divided number of livestock will be provided by the SU SR and processed by the NIS experts. If the country specific parameters will be not available for particular year, expert judgement will be used. These improvements will increase quality of inventory in following years.

5.3 MANURE MANAGEMENT (CRF 3.B.1) – CH_4 EMISSIONS

5.3.1 SOURCE CATEGORY DESCRIPTION

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 dairy cattle, fattening pigs, 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 manure management of dairy and non-dairy cattle are not key source categories according level or trend assessment for the base year and for 2014.

Methane emissions from this source decreased from 24.66 Gg in 1990 to 7.71 Gg in 2014. 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 condition. This situation consequently influenced methane emissions from manure management. Emissions decreased by 69% in this category in comparison with the base year, however cattle are key source by the trend. Methane emissions in manure management decreased in comparison with the previous year by 6%, caused by decreasing of cattle population. Figure 5.5 shows the increases in swine and poultry methane emissions from manure management category.

Figure 5.5: *Trend in CH_4 emissions (Gg) by categories within manure management in 1990 – 2014*

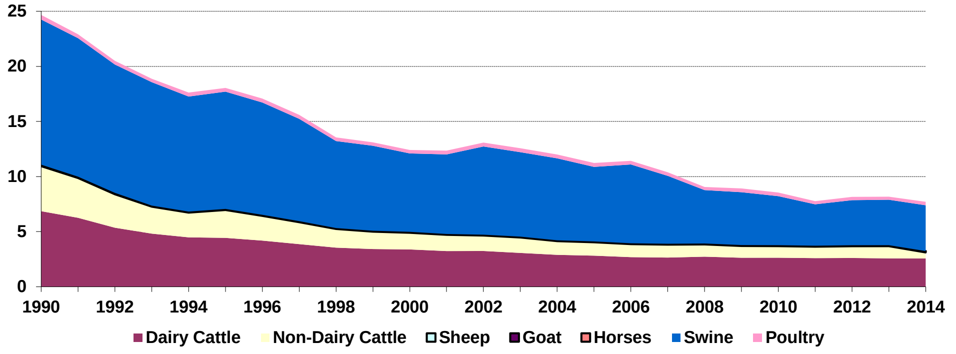


Table 5.17: *Methane emissions from manure management according to the animals in 1990 – 2014*

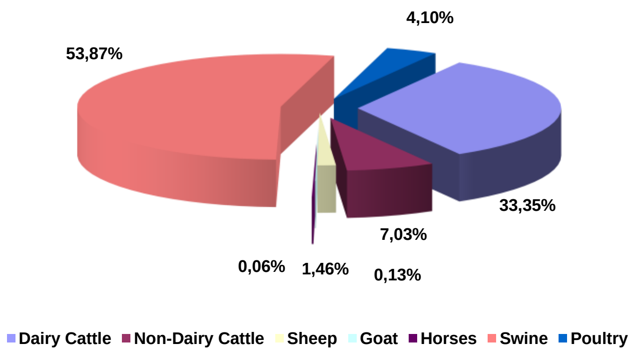
YEAR	CATEGORY 3.B.1 MANURE MANAGEMENT - CH_4 (Gg)						
	Dairy cattle	Non-dairy cattle	Sheep	Goat	Horses	Swine	Poultry
1990	6.856	4.083	0.114	0.003	0.022	13.166	0.417
1991	6.257	3.608	0.101	0.003	0.020	12.565	0.351
1992	5.357	3.032	0.109	0.003	0.019	11.641	0.336
1993	4.820	2.444	0.078	0.003	0.017	11.198	0.310
1994	4.483	2.243	0.075	0.003	0.017	10.437	0.361
1995	4.436	2.526	0.081	0.003	0.016	10.639	0.339
1996	4.189	2.241	0.080	0.003	0.015	10.189	0.358
1997	3.868	1.988	0.079	0.003	0.015	9.282	0.360
1998	3.549	1.694	0.062	0.007	0.015	7.893	0.332
1999	3.423	1.574	0.065	0.007	0.015	7.710	0.310
2000	3.387	1.510	0.066	0.007	0.015	7.113	0.315
2001	3.238	1.473	0.060	0.005	0.012	7.219	0.344
2002	3.245	1.401	0.060	0.005	0.013	8.003	0.353
2003	3.070	1.399	0.062	0.005	0.013	7.663	0.360
2004	2.896	1.241	0.061	0.005	0.013	7.436	0.347
2005	2.822	1.213	0.061	0.005	0.013	6.761	0.356
2006	2.687	1.179	0.063	0.005	0.013	7.148	0.330
2007	2.648	1.172	0.066	0.005	0.013	6.159	0.326
2008	2.729	1.111	0.069	0.005	0.013	4.843	0.284
2009	2.632	1.065	0.072	0.005	0.011	4.793	0.344

YEAR	CATEGORY 3.B.1 MANURE MANAGEMENT - CH_4 (Gg)						
	Dairy cattle	Non-dairy cattle	Sheep	Goat	Horses	Swine	Poultry
2010	2.635	1.047	0.075	0.005	0.011	4.447	0.329
2011	2.598	1.036	0.075	0.004	0.011	3.755	0.288
2012	2.611	1.065	0.078	0.005	0.011	4.086	0.300
2013	2.577	1.103	0.076	0.005	0.011	4.122	0.278
2014	2.571	0.542	0.113	0.005	0.010	4.153	0.316

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, Banská Bystrica, Prešov and Košice districts. Every 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 5.6 shows the share of individual categories in the production of manure methane emissions. Major share is represented by swine (54%). The important animal categories are also dairy cattle (33%) and non-dairy cattle (7%).

Figure 5.6: *The share of methane emissions by animals within manure management in 2014*



ANIMAL CATEGORY	CH_4 (Gg)
3.B.1.1 Dairy cattle	2.5710
3.B.1.1 Non-dairy cattle	0.5418
3.B.1.2 Sheep	0.1127
3.B.1.3 Goats	0.0046
3.B.1.4 Horses	0.0100
3.B.1.4 Swine	4.1526
3.B.1.4 Poultry	0.3162

5.3.2 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 5.18). The country specific regional data are available since 2005. The time series were extrapolated back to the base year using weighted average values for VS, MCF and emission factors. 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. Before the year 2005, the extrapolation method for determination of EFs.

$$EF = (VS * 365) * \left[B_o * \frac{0,67kg}{m^3} * \sum \frac{MCF}{100} * MS\right]$$

Where:

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 5.18: *Overview of country specific parameters for cattle and sheep in 2014*

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	0.17	0.19	0.19	0.19
Typical animal mass average (kg)	596.15	302.91	63.92	46.09	83.82
Ash content (%)	8	8	8	8	8
VS daily excretion (kg dm/head/day)	4.76	2.52	0.43	0.39	0.41
MCF values (average):					
Anaerobic lagoon	67.75	-	-	-	-
Liquid system	11.13	11.13	-	-	-
Solid storage and dry lot	2	2	1	1	1
Pasture range and paddock	1	1	2	2	-
Burned for fuel or as waste	10	-	-	-	-

Table 5.19: *Overview of country specific parameters for other animals in 2014*

PARAMETERS	SWINE	GOATS	HORSES	POULTRY
B_o Maximum methane-producing capacity of the manure (m^3/kg VS)	-	0.17	0.33	-
Typical animal mass average (kg)	60.01	50.97	500.87	2
Ash content (%)	-			
VS daily excretion (kg dm/head/day)	NE	0.30	1.74	NE
MCF values:				
Liquid system	10	-	-	10
Solid storage and dry lot	2	2	2	2
Pasture range and paddock	-	1	1	-

5.3.3 METHODOLOGICAL ISSUES – EMISSION FACTORS AND OTHER PARAMETERS

VS daily excretion for dairy cattle decreased from the value 6.40 kg dm/head/year in 1990 – 2013 up to the 4.76 in 2014. This value in 2014 was influenced by introducing more accurate country specific data such as the gross energy intake (GE in MJ/head/day), digestibility of feed (DE in %) of dairy cattle and ash content (8%). Value of maximal methane producing capacity for dairy cattle is 0.24 m^3/kg VS. Typical animal weight was 550 kg for the years 1990 – 2013 and was updated up to 596.15 kg/head (in weighted average) in 2014 and this value will be updated annually. Also revision of previously used parameters is planned for next submission.

VS daily excretion for non-dairy cattle decreased from the value 3.05 kg dm/head/year in 1990 – 2013 up to the 2.52 kg dm/head/year in 2014. This value in 2014 was influenced by introducing more accurate country specific data such as the gross energy intake (GE in MJ/head/day), digestibility of feed (DE in %) of non-dairy cattle and ash content (8%). Typical animal weight was 302.91kg/head (in weighted average) in 2014 and this value is updated annually. Also revision of previously used parameters is planned for next submission.

VS daily excretion for sheep was firstly calculated in 2014. Due to more accurate disaggregation of sheep based on survey 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 = 0.43 kg dm/head/year), VS can be calculated separately. This value in 2014 was influenced by introducing more accurate country specific data such as the gross energy intake (GE in MJ/head/day), digestibility (DE in %) of dairy cattle and ash content (8%). Value of maximum methane producing capacity for all sheep subcategories is 0.19 m^3/kg VS. Typical animal weight was calculated (see Table 5.18) and this value will be updated annually. Also revision of previously used parameters is planned for next submission.

MCF for manure management systems in cool climate condition were used according to the Table 10.17 of the IPCC 2006 GL. Allocation of animals into AWMS is described in the following Chapter 5.4.

Table 5.20: *The overview of used country specific parameters for livestock in 2014*

VOLATILE SOLID EXCRETION PER DAY ON A DRY-ORGANIC MATTER BASIS									
DISTRICT		**Bratislava**	**Trnava**	**Trenčín**	**Nitra**	**Žilina**	**Banská Bystrica**	**Prešov**	**Košice**
DAIRY CATTLE	**Dairy cows**	4.8866	4.6997	4.4747	4.5420	5.0698	4.9990	5.0640	6.3224
	Calves in 6 month	1.1268	1.1134	1.1220	1.1755	1.3589	1.4241	1.4269	1.3711
	Heifer	1.8843	1.8726	2.3592	1.9040	3.9868	3.9615	3.0682	3.9357
	Heifer (pregnant)	2.6503	2.6445	3.3074	2.6753	5.6216	5.5613	4.3401	5.5659
	Fattening	2.2497	1.5154	1.5024	1.9394	3.7235	1.8228	1.8157	2.3169
	Oxen	4.4192	4.4192	4.4192	4.4192	4.4192	4.4192	4.4192	4.4192
BEEF CATTLE	**Suckling cows**	4.3993	4.4333	4.3223	4.3889	4.3088	4.3689	4.3427	4.3505
	Calves in 6 month	1.5172	1.4105	1.3919	1.5101	1.3985	1.3649	1.3882	1.3086
	Heifer	2.7385	2.6936	2.7299	2.7214	2.7221	2.6480	2.6599	2.6011
	Heifer (pregnant)	3.7803	3.6582	3.8007	3.7332	3.7883	3.6793	3.7293	3.6841
	Fattening	2.3739	1.5871	1.5652	2.0131	3.9618	1.8942	1.8854	2.3877
	Oxen	4.4192	4.4192	4.4192	4.4192	4.4192	4.4192	4.4192	4.4192
	Breeding bull	3.1685	3.1685	3.1685	3.1685	3.1685	3.1685	3.1685	3.1685
DAIRY SHEEP	**Mature ewes**	0.4313	0.4374	0.4278	0.4358	0.4286	0.4292	0.4296	0.4320
	Growing lambs	0.2872	0.2872	0.2872	0.2872	0.2872	0.2872	0.2872	0.2872
	Growing lambs (pregnant)	0.4641	0.4702	0.4606	0.4686	0.4614	0.4620	0.4624	0.4648
	Other mature sheep	0.3991	0.4051	0.3955	0.4035	0.3964	0.3969	0.3973	0.3998
BEEF SHEEP	**Mature ewes**	0.4339	0.4398	0.4305	0.4383	0.4313	0.4318	0.4322	0.4346
	Growing lambs	0.3784	0.3784	0.3784	0.3784	0.3784	0.3784	0.3784	0.3784
	Growing lambs (pregnant)	0.5241	0.5299	0.5206	0.5284	0.5214	0.5220	0.5224	0.5247
	Other mature sheep	0.4263	0.4322	0.4229	0.4307	0.4237	0.4242	0.4246	0.4270

EMISSIONS FACTORS in kg/head/year									
DISTRICT		Bratislava	Trnava	Trenčín	Nitra	Žilina	Banská Bystrica	Prešov	Košice
DAIRY CATTLE	Dairy cows	86.5660	37.2162	9.1846	12.6607	10.6710	8.7898	7.2735	11.5304
	Calves in 6 month	0.9369	0.9258	0.9329	0.9774	1.1299	1.1841	1.1864	1.1401
	Heifer	1.5532	1.5435	1.9445	1.5694	3.2860	3.2652	2.5290	3.2440
	Heifer (pregnant)	2.1845	2.1797	2.7261	2.2051	4.6336	4.5839	3.5773	4.5876
	Fattening	2.7123	1.9531	1.8114	2.4995	4.3343	2.1219	2.1136	2.7933
	Oxen	3.6744	3.6744	3.6744	3.6744	3.6744	3.6744	3.6744	3.6744
BEEF CATTLE	Suckling cows	3.7492	3.7782	3.6836	3.7404	3.6721	3.7233	3.7010	3.7077
	Calves in 6 month	0.4309	0.4340	0.4245	0.4309	0.4217	0.3971	0.3918	0.3643
	Heifer	1.6532	1.6261	1.6480	1.6428	1.6433	1.5985	1.6057	1.5702
	Heifer (pregnant)	2.2821	2.2084	2.2943	2.2536	2.2869	2.2211	2.2513	2.2240
	Fattening	3.7503	2.7712	2.4727	3.5150	5.9295	2.8350	2.8218	3.7720
	Oxen	3.6744	3.6744	3.6744	3.6744	3.6744	3.6744	3.6744	3.6744
	Breeding bull	2.3097	2.3097	2.3097	2.3097	2.3097	2.3097	2.3097	2.3097
DAIRY SHEEP	Mature ewes	0.2998	0.3040	0.2973	0.3029	0.2979	0.2983	0.2986	0.3003
	Growing lambs	0.1996	0.1996	0.1996	0.1996	0.1996	0.1996	0.1996	0.1996
	Growing lambs (pregnant)	0.3226	0.3268	0.3202	0.3257	0.3207	0.3211	0.3214	0.3231
	Ot. mature sheep	0.3708	0.3764	0.3676	0.3750	0.3683	0.3689	0.3692	0.3715
BEEF SHEEP	Mature ewes	0.2927	0.2967	0.2904	0.2957	0.2910	0.2913	0.2916	0.2932
	Growing lambs	0.2553	0.2553	0.2553	0.2553	0.2553	0.2553	0.2553	0.2553
	Growing lambs (pregnant)	0.3536	0.3575	0.3513	0.3565	0.3518	0.3522	0.3524	0.3540
	Other mature sheep	0.3962	0.4016	0.3930	0.4002	0.3937	0.3943	0.3946	0.3968

A strong reduction of methane emissions of non-dairy cattle in 2014 was caused by the different allocation of cattle subcategories in comparison with the previous years. The decline of emission factor resulted in reduction of emissions compared to previously year. The biggest differences (reduction of EFs) are visible in categories: heifers, calves, breeding bulls (more than 50%).

Table 5.21: *The overview of used EFs and non-dairy categories in 1990 – 2013 and 2014*

EFs USED IN 2015 SUBMISSION - OLD METHODOLOGY IN 1990 – 2013		EFs USED IN 2016 SUBMISSION – NEW METHODOLOGY IN 2014		
(kg CH_4/head/year)				
Young Male<6 month (calves) =	1.9		milk	beef
Young Female<6 month (calves) =	2.1	Calves <6 month	1.10	0.42
Young Male 6 month 1year (calves) =	3.6	Heifers	2.57	1.70
Young Female 6 month 1year (calves) =	3.9	Heifers pregnant	3.50	3.50
Heifers =	6.2	Fattening	2.60	3.37
Young bull =	5.7	Oxen	3.89	3.89
Fattening =	3.8	Breeding bulls	-	2.45
Breeding bull =	5.9			

5.3.4 ACTIVITY DATA

Decreasing number of domestic livestock, especially in categories dairy cattle and swine (as mentioned above) and causes lower production of nitrogen (swine, non-dairy cattle and goats). 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 ducks, geese, turkeys, laying hens and broilers categories. More information on animal population can be found in the Table 5.20 above.

5.3.5 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 5.2.5 of this Report.

Regarding implementation of new country specific approach in 2014, time series consistency needs to be improved in the next submission. This improvement is connected with more accurate disaggregation of animal population for full time series (1990 – 2013) and further introduction of country specific parameters such as animal weight and VS daily excretion for non-dairy and sheep (see Chapter 5.2.8). These steps will improve time series consistency.

5.3.6 SOURCE SPECIFIC QA/QC AND VERIFICATION

Sector specific QA/QC plan is based on the general QA/QC plan described in Chapter 1.6. More detailed information is provided in the Chapter 5.2.6 of this Report.

5.3.7 SOURCE SPECIFIC RECALCULATIONS

In this category a revision of emission factors based on the IPCC 2006 GL for poultry, goats, horses and swine was implemented for the time series 1990 – 2013. In addition, the time series of methane emissions was recalculated. Recalculations led to emissions increase in swine, goats and horses and decrease in poultry. In total, CH_4 emissions in manure management increased due to provided recalculations by 13.9%.

Figure 5.7: *Comparison of CH_4 emissions (in Gg) between 2015 and 2016 submissions*

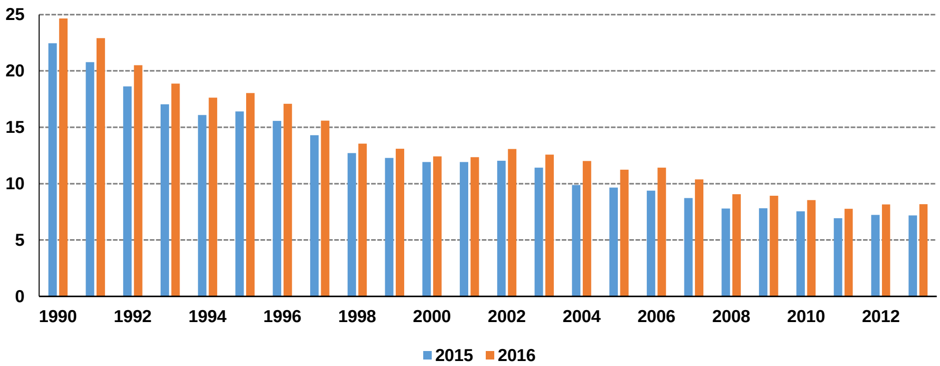


Table 5.22: *The overview of recalculated methane emissions and EFs for 1990 – 2013*

CATEGORY	SWINE		GOATS		HORSES		POULTRY	
EF (kg/head) in 2013	***4.00***	***6.47***	***0.12***	***0.13***	***1.40***	***1.47***	***0.08***	***0.03***
SUBMISSION	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
1990	10.08	13.17	0.003	0.003	0.020	0.022	1.285	0.417
1991	9.71	12.56	0.003	0.003	0.018	0.020	1.082	0.351
1992	9.08	11.64	0.003	0.003	0.017	0.019	1.035	0.336
1993	8.72	11.20	0.003	0.003	0.015	0.017	0.954	0.310
1994	8.15	10.44	0.003	0.003	0.015	0.017	1.111	0.361
1995	8.31	10.64	0.003	0.003	0.014	0.016	1.044	0.339
1996	7.94	10.19	0.003	0.003	0.014	0.015	1.103	0.358
1997	7.24	9.28	0.003	0.003	0.013	0.015	1.109	0.360
1998	6.37	7.89	0.006	0.007	0.013	0.015	1.023	0.332
1999	6.25	7.71	0.006	0.007	0.013	0.015	0.955	0.310
2000	5.95	7.11	0.006	0.007	0.013	0.015	0.971	0.315

2001	6.07	7.22	0.005	0.005	0.011	0.012	1.062	0.344
2002	6.22	8.00	0.005	0.005	0.011	0.013	1.089	0.353
2003	5.77	7.66	0.005	0.005	0.011	0.013	1.109	0.360
2004	4.60	7.44	0.005	0.005	0.011	0.013	1.070	0.347
2005	4.43	6.76	0.005	0.005	0.012	0.013	1.099	0.356
2006	4.42	7.15	0.005	0.005	0.012	0.013	1.017	0.330
2007	3.81	6.16	0.005	0.005	0.011	0.013	1.005	0.326
2008	2.99	4.84	0.004	0.005	0.012	0.013	0.876	0.284
2009	2.96	4.79	0.004	0.005	0.010	0.011	1.059	0.344
2010	2.75	4.45	0.004	0.005	0.010	0.011	1.013	0.329
2011	2.32	3.76	0.004	0.004	0.010	0.011	0.887	0.288
2012	2.53	4.09	0.004	0.005	0.010	0.011	0.924	0.300
2013	2.55	4.12	0.004	0.005	0.010	0.011	0.856	0.278
2016/2015 (2013)		**62%**		**8%**		**11%**		**-68%**

5.3.8 SOURCE SPECIFIC PLANNED IMPROVEMENTS

Further improvements are planned in the next submission. Except of the mentioned improvements in animal categories disaggregation (see chapter 5.2.8), further improvements are planned in a revision of the VS values and better evaluation of sheep category within the years 1990 – 2013.

5.4 MANURE MANAGEMENT (CRF 3.B.2) – N_2O EMISSIONS

5.4.1 SOURCE CATEGORY DESCRIPTION

Because domestic livestock produces different kinds 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 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 0.63 Gg of N_2O in 2014 and total decrease was about 68% compared to the base year.

Figure 5.9 shows the share of individual categories in the production of nitrogen from manure. Major share represents dairy cattle (39%), non-dairy cattle (19%), sheep (13%) and swine (14%). The important animal category is also poultry (12%).

Figure 5.8: *Trend in nitrogen excretion (kt) by categories within manure management in 1990 – 2014*

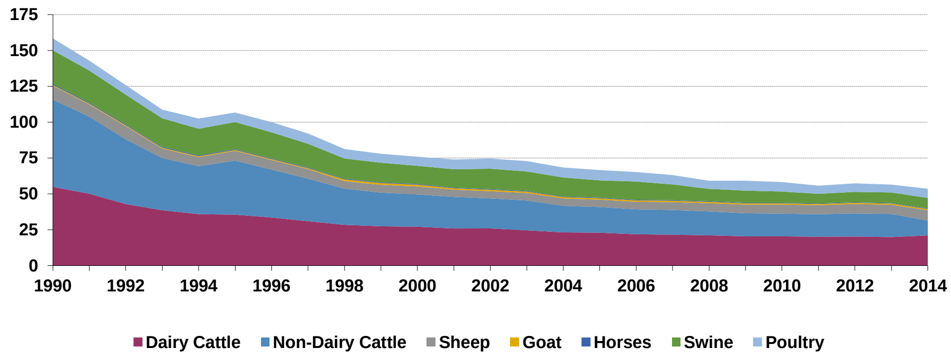


***Table 5.23:** N-excretions in manure management according to the animal categories in 1990 – 2014*

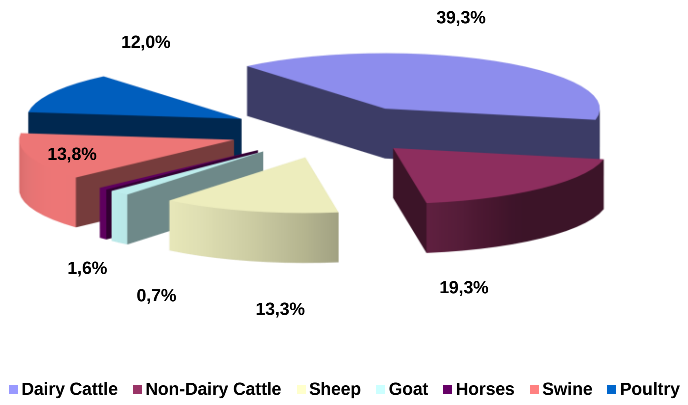
YEAR	CATEGORY 3.B.2 MANURE MANAGEMENT N-EXCRETIONS (kt)						
	Dairy Cattle	Non-Dairy Cattle	Sheep	Goat	Horses	Swine	Poultry
1990	54.90	60.84	9.60	0.60	0.77	23.40	8.29
1991	50.10	53.76	8.50	0.60	0.71	22.33	6.89
1992	42.90	45.18	9.15	0.60	0.66	20.69	6.66
1993	38.60	36.42	6.58	0.60	0.60	19.90	6.06
1994	35.90	33.42	6.35	0.60	0.60	18.55	7.10
1995	35.52	37.65	6.85	0.60	0.55	18.91	6.65
1996	33.54	33.40	6.70	0.62	0.53	18.11	7.11
1997	30.97	29.62	6.68	0.64	0.52	16.50	7.16
1998	28.42	25.24	5.22	1.21	0.52	14.03	6.65
1999	27.41	23.46	5.45	1.22	0.51	13.70	6.21
2000	27.12	22.50	5.57	1.22	0.52	12.64	6.35
2001	25.93	21.96	5.06	0.96	0.43	12.83	6.81
2002	25.99	20.88	5.06	0.96	0.45	14.22	7.07
2003	24.58	20.84	5.21	0.93	0.45	13.62	7.23
2004	23.19	18.50	5.14	0.93	0.45	13.22	7.00
2005	22.96	17.90	5.13	0.94	0.46	12.02	7.20
2006	21.87	17.35	5.32	0.91	0.45	12.71	6.62
2007	21.57	17.17	5.55	0.90	0.44	10.95	6.52
2008	21.12	16.64	5.79	0.88	0.46	8.61	5.65
2009	20.41	16.07	6.03	0.85	0.39	8.52	6.90
2010	20.44	15.76	6.31	0.84	0.39	7.90	6.58
2011	20.13	15.72	6.30	0.81	0.38	6.67	5.71
2012	20.26	16.11	6.55	0.83	0.40	7.26	5.94
2013	19.90	16.13	6.40	0.84	0.39	7.33	5.48
2014	21.08	10.35	7.15	0.84	0.37	7.38	6.42

***Table 5.24:** N-excretions in manure management according to the AWMS in 1990 – 2014*

YEAR	Anaerobic Lagoons	Liquid System	Solid Storage and Dry Lot	Pasture, Range and Paddocks	Burned for fuel or as waste
	N-excretion in kt				
1990	2.35	32.66	105.28	16.17	1.94
1991	2.14	30.22	94.28	14.47	1.77
1992	1.84	27.42	81.76	13.30	1.51
1993	1.65	25.58	69.42	10.75	1.36
1994	1.54	24.37	65.25	10.11	1.27
1995	1.52	24.66	68.57	10.73	1.25
1996	1.44	23.73	63.60	10.07	1.18
1997	1.33	21.90	58.31	9.46	1.09
1998	1.22	18.97	51.74	8.36	1.00
1999	1.17	18.30	49.31	8.20	0.97
2000	1.16	17.35	48.30	8.15	0.96
2001	1.11	17.55	46.82	7.58	0.92
2002	1.11	18.93	46.18	7.48	0.92
2003	1.05	18.39	45.14	7.42	0.87
2004	0.99	17.71	41.87	7.03	0.82
2005	0.98	16.76	41.09	6.95	0.81
2006	0.94	17.03	39.60	6.88	0.77
2007	0.92	15.53	38.95	6.94	0.76
2008	0.90	12.96	37.57	6.97	0.75

YEAR	Anaerobic Lagoons	Liquid System	Solid Storage and Dry Lot	Pasture, Range and Paddocks	Burned for fuel or as waste
	N-excretion in kt				
2009	0.87	13.40	37.26	6.94	0.72
2010	0.87	12.72	36.87	7.04	0.72
2011	0.86	11.33	35.84	6.99	0.71
2012	0.87	11.83	36.77	7.18	0.72
2013	0.85	11.73	36.11	7.08	0.70
2014	0.90	11.49	33.56	6.89	0.74

Figure 5.9: *The share of aggregated N-excretion by animals within manure management in 2014*



ANIMAL CATEGORY	N-excretion (kt)
3.B.2.1 Dairy cattle	21.077
3.B.2.1 Non-dairy cattle	10.346
3.B.2.2 Mature ewes	5.264
3.B.2.2 Growing lambs	1.685
3.B.2.2 Other sheep	0.204
3.B.2.3 Swine	7.381
3.B.2.4 Goats	0.838
3.B.2.4 Horses	0.375
3.B.2.4 Poultry	6.418

5.4.2 METHODOLOGICAL ISSUES – METHODS

Information on animal housing, pasture and production of manure and slurry was based on expert estimation. Duration of pasture is limited by specific climatic conditions. According to the IPCC methodology, the Animal Waste Management Systems (AWMS) applied in the Slovak Republic for manure management are as follows:

- Anaerobic lagoons (only dairy cattle);
- Liquid system;
- Solid storage and dry lot;
- Pasture range and paddock;
- Burned for fuel or as waste (only dairy cattle).

Solid storage of manure was found as the most frequent AMWS (more than 80% of utilisation) in the conditions of the Slovak Republic mostly for cattle. Liquid storage of slurry is also frequently used especially in category pigs. 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 tier 2 IPCC methodology using country specific parameters and activity data for cattle, sheep, horses, goats, poultry and swine.

5.4.3 METHODOLOGICAL ISSUES – EMISSION FACTORS AND OTHER PARAMETERS

N_2O emissions from manure storage in the AWMS were based on the analysis of housing practices in the farm of the Slovak Republic. New questionnaire survey was performed with the cooperation of the Research Institute for Animal Production in Nitra and other research institutions. Results of this survey were implemented also in the inventory submission 2016. This survey also defined more accurate days for non-dairy 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 5.25 below. Allocation according to the climate conditions is 100% for cool climate for all animals based on the IPCC methodology and climate data.

Table 5.25: *N_{EX} and share (%) for different domestic livestock and share in AWMS in 2014*

CATEGORY	SUBCATEGORY	N_{EX}	Liquid system	Solid system	PRP	Burned for fuel	Anaerobic Lagoons
		kg/head/y	share (%)				
Dairy cattle	Dairy cows	104.75	11.85	71.68	8.66	3.53	4.28
	Suckling cows	103.72		45	55	-	-
	Weighted average in 2014	**104.45**	**11.85**	**71.68**	**8.66**	**3.53**	**4.28**
Beef cattle	Calves (6 month)	14.41	-	100	-	-	-
	Heifer	35.87	-	98.26	1.74	-	-
	Heifer pregnant	62.88	-	98.26	1.74	-	-
	Fattening	42.62	10	90	-	-	-
	Oxen	84.32	-	100	-	-	-
	Calves (6 month)	7.07		58.52	41.48	-	-
	Heifer	38.28	-	45.21	54.79	-	-
	Heifer pregnant	61.05	-	45.21	54.79	-	-
	Fattening	44.07	20	80	-	-	-
	Oxen	84.32	-	100	-	-	-
	Breeding bull	96.36	-	75.34	24.66	-	-
	Weighted average in 2014	**39.23**	**5**	**85**	**10**	**-**	**-**
Sheep	Mature ewes	19.83	-	49.59	50.41	-	-
	Growing lambs	14.30	-	49.59	50.41	-	-
	Other mature sheep	26.01	-	100.00	-	-	-
	Weighted average in 2014	**23.90**	**-**	**49.59**	**50.41**	**-**	**-**
Other animals	Swine	11.50	79.99	20.1	0	-	-
	Goats	23.81	0	49.60	50.40	-	-
	Poultry	0.51	40	60	0	-	-
	Horses	54.85	0	70	30	-	-

Nitrogen excretion rates for animals' categories were calculated based on the IPCC 2006 GL, equation 10.30 using different animal weights of different animal subcategories. The N_{EX} values calculated for the year 2014 differ from the previously used mostly default values (1990 – 2013). N_{EX} increased for cattle and sheep categories. There are further improvements planned for the next submission to revise N_{EX} for the previous years of time series in these categories. This revision is depending on data availability for specific animal categories and previously used AWMS and manure practises. Weighted average of the N_{EX} and AWMS share were used according to this formula:

$$NEX_T = N_{rate(T)} * \frac{TAM}{1000} * 365$$

Where: NEX_T = annual N excretion for each livestock spices respectively category, kg N $animal^{-1}.yr^{-1}$; $N_{RATE(T)}$ = default N excretion rate, kg N (100 kg per animal $mass)^{-1}day^{-1}$ and TAM = country specific animal mass for each livestock spices/category (kg per $animal^{-1}$).

Annual nitrogen excretion rates were determined for each livestock species respectively category of farm animals. Calculations were on bases country specific animal weight. This data has been provided of Research Institute for Animal Production in Nitra.

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 yr^{-1}); N = number of livestock species respectively category; N_{EX} = annual average N excretion per head of species respectively category (kg N per $animal^{-1}$ per yr^{-1}); 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-N kg 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. The weighted average per animal is calculated based on AWMS share and nitrogen excretion of animals in different management systems. Liquid and solid AWMS 0.005 kg/head/year, for pasture, range and paddocks it is 0.02 kg/head/year for cattle and 0.01 kg/head/year for other animals on pasture. Other animal systems have EF = 0 kg/head/year.

5.4.4 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.

5.4.5 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. Dry storage of animal excreta is the most frequent way of AWMS, especially in category cattle.

Due to a revision of national data and methodologies, the process is not finished, yet. In the next submission, in line with the improvement plan in this category, further increase of accuracy in N_{EX} estimation for the time series since the base will be implemented. This process is very complicated due to availability of input information and data, mostly from the beginning of the time series.

5.4.6 SOURCE SPECIFIC QA/QC AND VERIFICATION

Sector specific QA/QC plan is based on the general QA/QC plan described in Chapter 1.6. More detailed information is provided in the Chapter 5.2.6 of this Report.

5.4.7 SOURCE SPECIFIC RECALCULATIONS

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 in 2013 by 47.6% due to decrease in cattle, sheep, goats and poultry. An increase was recorded in swine and horses' categories. Decrease is mainly caused by changes in AWMS share for all animal categories. For example, in dairy cattle also AWMS like anaerobic lagoons and burned for fuel or as waste are applied (with the EF = 0 kg/head) which led to lower N_2O emissions. In addition, also EFs for other AWMS decrease by application of the IPPC 2006 GL.

Figure 5.10: Comparison of N_2O emissions (in Gg) between 2015 and 2016 submissions

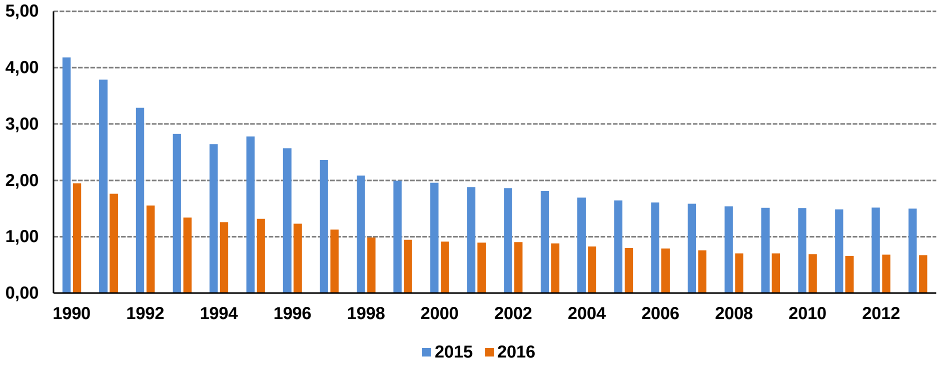


Table 5.26: The overview of recalculated N_2O emissions in manure management for 1990 – 2013

CATEGORY	DAIRY CATTLE		NON-DAIRY CATTLE		SHEEP		SWINE	
EF (kg/head) in 2013	***2.99***	***0.69***	***1.80***	***0.28***	***0.48***	***0.21***	***0.089***	***0.090***
Year of submission	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
1990	1.64	0.36	1.82	0.43	0.29	0.11	0.20	0.18
1991	1.50	0.33	1.61	0.38	0.26	0.10	0.20	0.18
1992	1.28	0.28	1.35	0.32	0.28	0.11	0.19	0.16
1993	1.16	0.25	1.09	0.26	0.20	0.08	0.18	0.16
1994	1.07	0.24	1.00	0.24	0.19	0.07	0.17	0.15
1995	1.06	0.23	1.13	0.27	0.21	0.08	0.17	0.15
1996	1.00	0.22	1.00	0.24	0.20	0.08	0.16	0.14
1997	0.93	0.20	0.89	0.21	0.20	0.08	0.15	0.13
1998	0.85	0.19	0.76	0.18	0.16	0.06	0.14	0.11
1999	0.82	0.18	0.70	0.17	0.16	0.06	0.13	0.11
2000	0.81	0.18	0.67	0.16	0.17	0.07	0.13	0.10
2001	0.78	0.17	0.66	0.16	0.15	0.06	0.13	0.10
2002	0.78	0.17	0.62	0.15	0.15	0.06	0.13	0.11
2003	0.74	0.16	0.62	0.15	0.16	0.06	0.12	0.11
2004	0.69	0.15	0.55	0.13	0.16	0.06	0.11	0.10
2005	0.69	0.15	0.54	0.13	0.16	0.06	0.10	0.09
2006	0.65	0.14	0.52	0.12	0.16	0.06	0.10	0.10
2007	0.65	0.14	0.51	0.12	0.17	0.07	0.08	0.09
2008	0.63	0.14	0.50	0.12	0.17	0.07	0.07	0.07
2009	0.61	0.13	0.48	0.11	0.18	0.07	0.06	0.07
2010	0.61	0.13	0.47	0.11	0.19	0.07	0.06	0.06
2011	0.60	0.13	0.47	0.11	0.19	0.07	0.05	0.05
2012	0.61	0.13	0.48	0.11	0.19	0.08	0.06	0.06
2013	0.60	0.13	0.48	0.11	0.19	0.08	0.06	0.06
2016/2015 (2013)		**-78%**		**-77%**		**-58%**		**0%**

CATEGORY	HORSES		GOATS		POULTRY		TOTAL	
EF (kg/head) in 2013	**0.79**	**0.30**	**0.48**	**0.09**	**0.0134**	**0.0040**	**2015**	**2016**
Year of submission	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**		
1990	0.011	0.004	0.012	0.002	0.199	0.07	4.181	1.950
1991	0.010	0.004	0.012	0.002	0.201	0.05	3.788	1.763
1992	0.009	0.004	0.012	0.002	0.165	0.05	3.286	1.553
1993	0.009	0.003	0.012	0.002	0.181	0.05	2.826	1.341
1994	0.009	0.003	0.012	0.002	0.185	0.06	2.641	1.257
1995	0.008	0.003	0.012	0.002	0.189	0.05	2.778	1.316
1996	0.008	0.003	0.013	0.002	0.181	0.06	2.570	1.229

CATEGORY	HORSES		GOATS		POULTRY		TOTAL	
EF (kg/head) in 2013	0.79	0.30	0.48	0.09	0.0134	0.0040	2015	2016
Year of submission	2015	2016	2015	2016	2015	2016		
1997	0.007	0.003	0.013	0.003	0.178	0.06	2.363	1.127
1998	0.008	0.003	0.025	0.005	0.153	0.05	2.084	0.984
1999	0.007	0.003	0.025	0.005	0.142	0.05	1.995	0.944
2000	0.007	0.003	0.025	0.005	0.146	0.05	1.957	0.914
2001	0.006	0.002	0.020	0.004	0.145	0.05	1.882	0.893
2002	0.006	0.002	0.019	0.004	0.154	0.06	1.863	0.903
2003	0.006	0.002	0.019	0.004	0.151	0.06	1.812	0.881
2004	0.006	0.002	0.019	0.004	0.152	0.05	1.693	0.826
2005	0.007	0.003	0.019	0.004	0.140	0.06	1.643	0.799
2006	0.006	0.002	0.019	0.004	0.146	0.05	1.608	0.788
2007	0.006	0.002	0.018	0.004	0.148	0.05	1.584	0.757
2008	0.007	0.003	0.018	0.003	0.139	0.04	1.538	0.706
2009	0.006	0.002	0.017	0.003	0.151	0.05	1.512	0.702
2010	0.006	0.002	0.017	0.003	0.151	0.05	1.508	0.689
2011	0.005	0.002	0.016	0.003	0.154	0.04	1.486	0.660
2012	0.006	0.002	0.017	0.003	0.157	0.05	1.518	0.680
2013	0.006	0.002	0.017	0.003	0.147	0.04	1.499	0.672
2016/2015 (2013)		-67%		-82%		-73%		-55%

5.4.8 SOURCE SPECIFIC PLANNED IMPROVEMENTS

Improvements planned in this category are connected with the improvements mentioned above. There are plans for better categorisation and reallocation of animal subcategories and changes in AWMS share also for the time series 1990 – 2013. The most important parameter for nitrogen estimation – N_{EX} will be also revised in the next submission. More information can be found also in the chapters 5.2.8 and 5.3.8 of this report.

5.5 INDIRECT N_2O EMISSIONS FROM MANURE MANAGEMENT (CRF 3.B.2.5)

5.5.1 SOURCE CATEGORY DESCRIPTION

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 lesser degree 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.

5.5.2 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 some farm animals, because $Frac_{GasMS}$ was not available for all farm animals. 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 (%).

5.5.3 ACTIVITY DATA

Volatilized nitrogen (NH_3 and NO_x) from animal wastes was 13 822 836 kg N which represents 0.22 Gg of N_2O in 2014. Activity data in this category are in consistency with the activity data in animal manure applied to soil 3.D.1.2. Table 5.27 shows the time series of parameters and emissions. This category is estimated for the first time in this inventory.

Table 5.27: *Input parameters and EFs in category 3.B.2.5 atmospheric deposition in 1990 – 2014*

YEAR	Volatilized N from animal manure (kg)	Total volatilized N (kg)	EFs (kg N_2O-N/kg N)	N_2O emissions (Gg)
1990	50 302 890.65	77 245 345.00	0.010	0.790
1991	45 682 383.23	71 370 570.00	0.010	0.718
1992	39 655 965.63	63 695 655.00	0.010	0.623
1993	34 579 622.78	57 806 830.00	0.010	0.543
1994	32 025 939.94	53 970 410.00	0.010	0.503
1995	33 735 069.40	54 209 224.06	0.010	0.530
1996	31 169 601.66	51 596 254.69	0.010	0.490
1997	28 246 112.86	47 721 002.65	0.010	0.444
1998	24 630 521.77	42 564 816.93	0.010	0.387
1999	23 527 776.84	41 459 239.62	0.010	0.370
2000	22 583 559.71	40 217 141.06	0.010	0.355
2001	22 081 540.57	38 910 840.01	0.010	0.347
2002	22 353 335.27	40 362 375.89	0.010	0.351
2003	21 672 412.34	38 586 289.78	0.010	0.341
2004	20 194 204.85	36 927 037.36	0.010	0.317
2005	19 333 729.37	35 533 786.82	0.010	0.304
2006	19 159 512.24	35 338 285.68	0.010	0.301
2007	18 185 766.68	33 420 380.57	0.010	0.286
2008	16 755 033.72	30 810 006.29	0.010	0.263
2009	16 312 527.20	30 164 046.07	0.010	0.256
2010	15 924 466.32	29 697 202.77	0.010	0.250
2011	15 237 249.90	28 174 450.25	0.010	0.239
2012	15 713 859.93	29 020 621.26	0.010	0.247
2013	15 646 115.62	28 696 004.86	0.010	0.246
2014	13 822 836.37	30 219 671.47	0.010	0.219

5.6 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 – 2014.

5.7 AGRICULTURAL SOILS (CRF 3.D)

5.7.1 SOURCE CATEGORY DESCRIPTION

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 SU SR materials for the Slovak Republic. The selection of emission coefficients reflects climatic and soil conditions of the Slovak Republic, when the climate in Central Europe was defined as cool (ECOTEC, 1994) with prevailing acidic soils.

N-inputs from symbiotic fixation of leguminous crops in the conditions of the Slovak Republic vary in the range of 20-30 $kg.ha^{-1}$ (Bielek, 1998). 26 kg $N.ha^{-1}$ can be accepted as an average value (Vostál at all. cit. in Bielek, 1998). 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 (Jurčová, 1998). The yield of field crops can vary in range ±20% from year to year.

Total N_2O emissions from agricultural soils were 5.42 Gg of N_2O in 2014. The emissions increased by almost 1% in comparison with 2013 and decreased by 46% in comparison with the base year 1990. 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 5.28, Figure 5.11). Since 1999, trend is stable with the small fluctuations caused by the changes in animal population. Subcategory 3.D.1.4 Crop residues included also N-fixing crops.

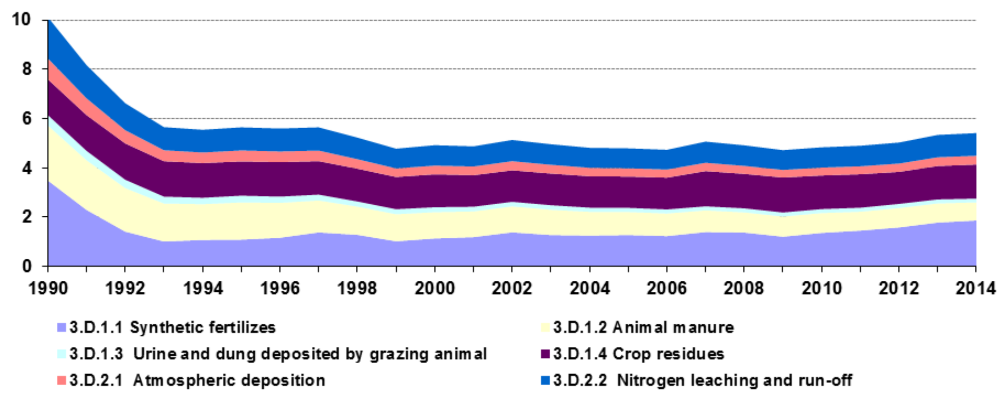
No emissions are reported in the categories 3.D.1.2.c Other organic fertilizers applied to soils, 3.D.1.5 Mineralization/immobilization associated with loss/gain of soil organic matter and 3.D.1.6 Cultivation of organic soils (not occurring in Slovakia).

Table 5.28: *N_2O emissions (in Gg) in agricultural soils according to the subcategories in 1990 – 2014*

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 Animal manure	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	2.235	0.424	1.452	0.847	1.673
1991	2.300	2.018	0.380	1.451	0.679	1.349
1992	1.417	1.768	0.338	1.473	0.537	1.095
1993	1.019	1.540	0.279	1.439	0.444	0.938
1994	1.079	1.452	0.260	1.409	0.430	0.922
1995	1.094	1.509	0.276	1.390	0.445	0.936

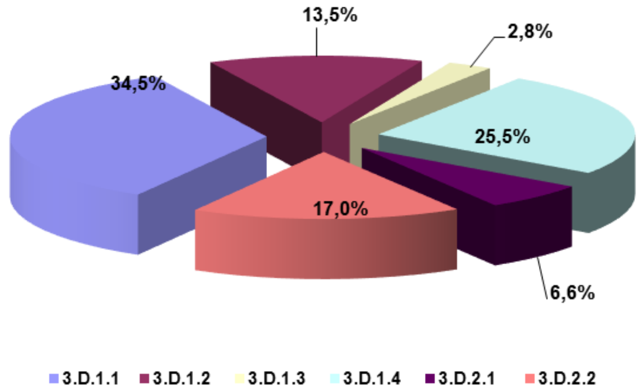
YEAR	3.D.1 DIRECT N_2O EMISSIONS FROM MANAGED SOILS (Gg)				3.D.2 INDIRECT N_2O EMISSIONS FROM MANAGED SOILS (Gg)	
	3.D.1.1 Synthetic fertilizes	3.D.1.2 Animal manure	3.D.1.3 Urine and dung deposited by grazing animal	3.D.1.4 Crop residues	3.D.2.1 Atmospheric deposition	3.D.2.2 Nitrogen leaching and run-off
1996	1.170	1.413	0.256	1.401	0.431	0.932
1997	1.383	1.298	0.237	1.360	0.428	0.943
1998	1.286	1.146	0.210	1.332	0.384	0.876
1999	1.028	1.096	0.203	1.308	0.348	0.801
2000	1.142	1.065	0.200	1.340	0.353	0.827
2001	1.195	1.043	0.189	1.281	0.352	0.819
2002	1.387	1.055	0.186	1.276	0.373	0.863
2003	1.278	1.028	0.183	1.286	0.357	0.835
2004	1.256	0.965	0.171	1.276	0.341	0.811
2005	1.278	0.937	0.169	1.269	0.337	0.809
2006	1.236	0.917	0.165	1.291	0.329	0.799
2007	1.398	0.882	0.165	1.428	0.338	0.859
2008	1.379	0.820	0.164	1.400	0.324	0.834
2009	1.211	0.821	0.162	1.421	0.307	0.802
2010	1.365	0.804	0.163	1.366	0.320	0.820
2011	1.461	0.766	0.162	1.360	0.321	0.832
2012	1.587	0.789	0.166	1.301	0.339	0.853
2013	1.785	0.776	0.164	1.355	0.356	0.906
2014	1.871	0.734	0.153	1.384	0.355	0.922

Figure 5.11: *Trend in N_2O emissions (Gg) by categories within agricultural soils in 1990 – 2014*



The major share belongs to synthetic fertilizers use (35%) and crop residue (26%). Animal manure use (14%) and nitrogen leaching and run-off (17%) are influenced by manure management and the number of animals (Figure 5.12).

Figure 5.12: *The share of aggregated emissions by categories within agricultural soils in 2014*



Category	N_2O (Gg)
3.D.1.1 Synthetic fertilizes	1.871
3.D.1.2.a Animal manure	0.734
3.D.1.2.b Sewage sludge	$4{,}16.10^{-6}$
3.D.1.3 Urine and dung deposited by grazing animal	0.153
3.D.1.4 Crop residues	1.384
3.D.2.1 Atmospheric deposition	0.355
3.D.2.2 Nitrogen leaching and run-off	0.922

5.7.2 UNCERTAINTY ASSESSMENT 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 (Bielek, 1998). 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.

5.7.3 SOURCE SPECIFIC RECALCULATIONS

Recalculations were connected with the methodological changes and improvements implemented in enteric fermentation and manure management categories. In addition, emission factors were harmonised in line with the IPCC 2006 GL. In total. N_2O emissions for 2013 decreased by 12.7%.

Figure 5.13: *Comparison of N_2O emissions (in Gg) between 2015 and 2016 submissions*

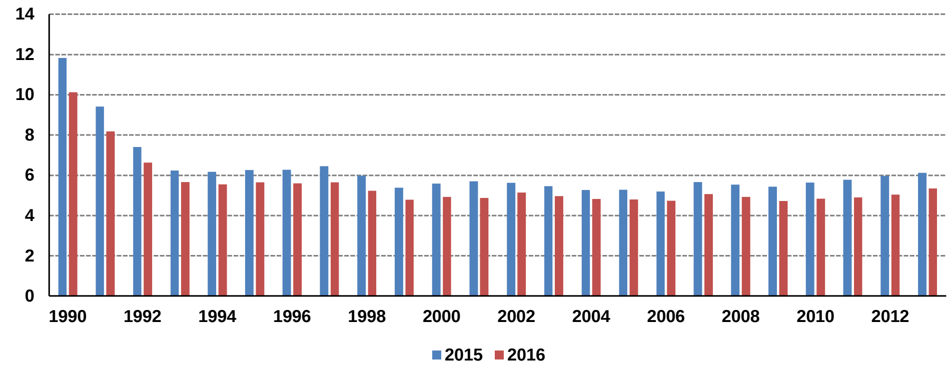


Table 5.29: *The overview of recalculated N_2O emissions in agricultural soils for 1990 – 2013*

CATEGORY	3.D.1.1 Inorganic N Fertilizers		3.D.1.2.a Animal Manure Applied to Soils		3.D.1.3 Urine and Dung Deposited by Grazing Animals	
EFs in 2013	***0.0125***	***0.010***	***0.0125***	***0.010***	***0.020***	***0.015***
Year of submission	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
1990	3.93	3.49	2.16	2.24	0.72	0.42
1991	2.59	2.30	2.12	2.02	0.64	0.38
1992	1.59	1.42	1.87	1.77	0.58	0.34
1993	1.15	1.02	1.65	1.54	0.48	0.28
1994	1.21	1.08	1.56	1.45	0.45	0.26
1995	1.23	1.09	1.62	1.51	0.47	0.28
1996	1.32	1.17	1.52	1.41	0.44	0.26
1997	1.56	1.38	1.40	1.30	0.41	0.24
1998	1.45	1.29	1.23	1.15	0.37	0.21
1999	1.16	1.03	1.17	1.10	0.36	0.20
2000	1.28	1.14	1.14	1.07	0.36	0.20
2001	1.44	1.20	1.15	1.04	0.33	0.19
2002	1.56	1.39	0.82	1.06	0.33	0.19
2003	1.44	1.28	0.86	1.03	0.32	0.18
2004	1.41	1.26	0.76	0.97	0.31	0.17
2005	1.44	1.28	0.75	0.94	0.30	0.17
2006	1.39	1.24	0.72	0.92	0.30	0.17
2007	1.57	1.40	0.71	0.88	0.30	0.17
2008	1.55	1.38	0.68	0.82	0.30	0.16
2009	1.36	1.21	0.87	0.82	0.30	0.16
2010	1.54	1.37	0.85	0.80	0.30	0.16
2011	1.64	1.46	0.80	0.77	0.30	0.16
2012	1.79	1.59	0.84	0.79	0.30	0.17
2013	2.01	1.80	0.82	0.78	0.30	0.16
2016/2015 (2013)		**-11%**		**-5%**		**-47%**

CATEGORY	3.D.1.4 Crop Residues		3.D.2.1 Atmospheric deposition		3.D.2.2 Nitrogen leaching and run-off		TOTAL	
EFs in 2013	***0.0125***	***0.010***	***0.010***	***0.010***	***0.025***	***0.0075***		
Year of submission	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
1990	1.81	1.45	0.89	0.85	2.32	1.67	11.830	10.123
1991	1.81	1.45	0.72	0.68	1.53	1.35	9.414	8.177
1992	1.84	1.47	0.57	0.54	0.94	1.10	7.404	6.630
1993	1.80	1.44	0.48	0.44	0.68	0.94	6.232	5.659
1994	1.76	1.41	0.46	0.43	0.72	0.92	6.168	5.553
1995	1.74	1.39	0.48	0.45	0.73	0.94	6.266	5.650
1996	1.75	1.40	0.47	0.43	0.78	0.93	6.272	5.604
1997	1.70	1.36	0.46	0.43	0.92	0.94	6.449	5.649
1998	1.66	1.33	0.41	0.38	0.86	0.88	5.978	5.234
1999	1.64	1.31	0.38	0.35	0.68	0.80	5.383	4.784
2000	1.67	1.34	0.38	0.35	0.76	0.83	5.589	4.926
2001	1.60	1.28	0.38	0.35	0.79	0.82	5.698	4.879
2002	1.60	1.28	0.40	0.37	0.92	0.86	5.629	5.140
2003	1.61	1.29	0.38	0.36	0.85	0.84	5.463	4.966
2004	1.59	1.28	0.37	0.34	0.84	0.81	5.273	4.819
2005	1.59	1.27	0.36	0.34	0.85	0.81	5.286	4.799
2006	1.61	1.29	0.35	0.33	0.82	0.80	5.198	4.737

2007	1.78	1.43	0.36	0.34	0.93	0.86	5.660	5.070
2008	1.75	1.40	0.34	0.32	0.92	0.83	5.538	4.921
2009	1.78	1.42	0.32	0.31	0.81	0.80	5.436	4.724
2010	1.71	1.37	0.34	0.32	0.91	0.82	5.638	4.839
2011	1.70	1.36	0.32	0.32	1.01	0.83	5.777	4.903
2012	1.63	1.30	0.34	0.34	1.07	0.85	5.963	5.035
2013	1.65	1.36	0.37	0.36	0.96	0.91	6.120	5.342
2016/2015 (2013)		**-18%**		**-3%**		**-5%**		**-12.71%**

5.7.4 SOURCE SPECIFIC PLANNED IMPROVEMENTS

There are no further improvements specifically planned in this category. Improvements mentioned in enteric fermentation and manure management will influence also emissions in this category in the next submissions, therefore recalculations are expected also in future.

5.7.5 SOURCE CATEGORY DESCRIPTION –INORGANIC N FERTILIZERS (CRF 3.D.1.1)

The consumption of synthetic fertilizers decreased during the last decade of 20^{th} century, from 222 kt in 1990 to 119 kt in 2014. The synthetic fertilizers have been applied on 60.7% of area of arable soils and only on 62.3% of sowing area of cereals in 2014. Especially sugar beet and fodder crops were short of nutrient during the last decade in the conditions of the Slovak agriculture. Despite these facts the consumption of synthetic fertilizers increased by about 51% in 2014 compared with 2006 and the increase is almost 28% in the comparison with the year 2011. Because of decreasing numbers of domestic livestock in some categories (ongoing 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, 2015).

Recalculations in this subcategory were connected with the update of the IPCC default emission factor used in estimation (Table 5.29). As the result, emissions decreased in time series, in 2013 by 11% in a comparison with the previous submission (15.11.2015).

5.7.5.1 Methodological issues – methods

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. Having used the IPCC 2006 GL default emission factor 0.01 kg N_2O–N/kg N. total emissions of N_2O from using the synthetic fertilizers were 1.87 Gg in 2014. Tier 1 methodology was applied in combination with IPCC default EF.

5.7.5.2 Methodological issues – emission factors and other parameters

The loss by volatilization is 10% and default emission factor 0.01 kg N_2O-N/kg N was used for the calculation.

5.7.5.3 Activity data

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 cropland and grassland is summarized in the Table 5.30.

Table 5.30: *Input parameters and EFs in category 3.D.1.1 Inorganic N fertilizers in 1990 – 2014*

YEAR	CATEGORY 3.D.1.1 INORGANIC N FERTILIZERS			
	N-INPUT IN FERTILIZERS (kg/year)	N-INPUT TO THE SOIL (kg/year)	EFs (kg N_2O-N/kg N)	N_2O EMISSIONS (Gg)
1990	222 255 000	222 255 000	0.01	3.493
1991	146 341 000	146 341 000	0.01	2.300
1992	90 186 000	90 186 000	0.01	1.417
1993	64 852 000	64 852 000	0.01	1.019
1994	68 669 000	68 669 000	0.01	1.079
1995	69 587 000	69 587 000	0.01	1.094
1996	74 464 000	74 464 000	0.01	1.170
1997	88 017 000	88 017 000	0.01	1.383
1998	81 842 000	81 842 000	0.01	1.286
1999	65 392 000	65 392 000	0.01	1.028
2000	72 653 000	72 653 000	0.01	1.142
2001	76 032 000	76 032 000	0.01	1.195
2002	88 260 000	88 260 000	0.01	1.387
2003	81 300 000	81 300 000	0.01	1.278
2004	79 911 000	79 911 000	0.01	1.256
2005	81 317 000	81 317 000	0.01	1.278
2006	78 681 120	78 681 120	0.01	1.236
2007	88 935 400	88 935 400	0.01	1.398
2008	87 736 950	87 736 950	0.01	1.379
2009	77 058 450	77 058 450	0.01	1.211
2010	86 873 000	86 873 000	0.01	1.365
2011	92 969 000	92 969 000	0.01	1.461
2012	101 004 000	101 004 000	0.01	1.587
2013	113 581 390	113 581 390	0.01	1.785
2014	119 036 050	119 036 050	0.01	1.871

5.7.6 SOURCE CATEGORY DESCRIPTION – ANIMAL MANURE APPLIED TO SOIL (CRF 3.D.1.2)

As domestic livestock produce 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.

This category is estimated in the connection with the category manure management therefore more information can be found there.

5.7.6.1 Methodological issues – methods

The direct inputs of nitrogen slightly vary according to the applied methodology. Based on the IPCC 2006 GL total nitrogen excretion per liquid (11 486.2 t/N/year) and solid system (33 560.8 t/N/year) in manure management in 2014 were used for the estimation of total nitrogen input of manure applied to soils.

5.7.6.2 Methodological issues – emission factors and other parameters

Calculated amount of nitrogen input from animal waste applied to soils was 46 693.06 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 0.733 Gg in 2014.

5.7.6.3 Activity data

Activity data are summarized in Table 5.31. 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.

Table 5.31: *Input parameters and EFs in category 3.D.1.2 Animal manure in 1990 – 2014*

CATEGORY 3.D.1.2 ANIMAL MANURE					
YEAR	**N-input from liquid system (kg/year)**	**N-input from solid system (kg/year)**	**N-input from lagoon (kg/year)**	**N-input from manure (kg/year)**	**N_2O emissions (Gg)**
1990	32 661 564	105 284 091	2 349 720	142 233 345	2.235
1991	30 220 113	94 276 665	2 144 280	128 409 587	2.018
1992	27 416 511	81 763 524	1 836 120	112 530 525	1.768
1993	25 575 627	69 415 575	1 652 080	98 005 862	1.540
1994	24 369 980	65 245 398	1 536 520	92 419 168	1.452
1995	24 659 030	68 567 251	1 520 256	96 000 393	1.509
1996	23 728 704	63 597 375	1 435 512	89 945 553	1.413
1997	21 895 575	58 313 260	1 325 696	82 627 921	1.298
1998	18 971 528	51 742 309	1 216 226	72 933 165	1.146
1999	18 300 894	49 310 745	1 172 998	69 752 087	1.096
2000	17 351 774	48 303 676	1 160 668	67 773 397	1.065
2001	17 548 211	46 824 632	1 109 671	66 397 733	1.043
2002	18 934 160	46 178 945	1 112 256	67 142 713	1.055
2003	18 387 632	45 137 079	1 052 033	65 444 424	1.028
2004	17 712 822	41 865 316	992 421	61 389 074	0.965
2005	16 763 982	41 094 453	982 718	59 651 666	0.937
2006	17 034 079	39 603 229	935 835	583 44 988	0.917
2007	15 525 001	38 949 359	923 021	56 158 657	0.882
2008	12 958 386	37 572 121	903 872	52 179 862	0.820
2009	13 397 298	37 258 757	873 689	52 250 333	0.821
2010	12 720 254	36 867 741	874 772	51 184 249	0.804
2011	11 327 675	35 842 078	861 594	48 741 961	0.766
2012	11 828 488	36 766 969	867 081	50 177 678	0.789
2013	11 730 904	36 110 025	851 626	49 394 947	0.776
2014	11 486 202	33 560 764	902 082	46 693 055	0.734

5.7.7 SOURCE CATEGORY DESCRIPTION – 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 source to resolve this issue. The sludge is a potential source of nutrients and organic matter. Sewage sludge must be stabilized, then will 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 health risks and save the environment. Application of sludge to agricultural soils regulates law No 188/2003 Coll. It is possible pursuant to law No 188/2003 Coll. apply to only cropland from sewage sludge treatment plants cleaning wastewater from domestic or urban waste water.

5.7.7.1 Methodological issues – methods

Default methodology tier 1 and default emission factors were used for the estimation of direct N_2O emissions from sewage sludge applied to soils. Methodology was accordance with IPCC Guidelines

2006. Percentage of pure nitrogen in sewage sludge was provided from the Soil Science and Conservation Research Institute.[4]

5.7.7.2 Methodological issues – emission factors and other parameters

Calculated amount of input nitrogen from sewage sludge applied to soils was 264.8 kg/N/year and default EF was 0.01 kg N_2O-N/kg N. Total amount of N_2O emissions from sewage sludge applied to soils was 4.16.10^{-6} Gg in 2014.

$$N_2O - N_{sewage\ sludge} = N_{sewage\ sludge} * P_N$$

$$N_2O_{sewage\ sludge} = N_2O - N_{sewage\ sludge} * \frac{44}{28}$$

N_2O-$N_{sewage\ sludge}$: Input of pure nitrogen from sewage sludge applied in to the soil in kg, $N_{sewage\ sludge}$: amount of sludge from waste water treatment in kg, P_N: Weight percentage of nitrogen from sewage sludge (3.31%).

5.7.7.3 Activity data

Activity data on sewage sludge consumption in agriculture is based on the data provided by the Ministry of Environment of the Slovak Republic and our research institute: the Water Research Institute. Sewage sludge was applied into the soil even before year 2010, but there are no data available.

YEAR	Input in to the soil (kg/year)	N-input from sewage sludge (kg/year)	N_2O emissions (Gg)
2010	9230 00	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

5.7.8 SOURCE CATEGORY DESCRIPTION – URINE AND DUNG DEPOSITED BY GRAZING ANIMALS (CRF 3.D.1.3)

Production of slurries is typical for domestic livestock in swine category. Pasture is typical for sheep, goats, horses and part of cattle during spring, summer and autumn. N_2O emissions from AWMS were based on the analysis of housing systems at the territory of the Slovak Republic that was made by the Research Institute for Animal Production in Nitra (Brestenský, 1998).

5.7.8.1 Methodological issues – methods

It is supposed that sheep, goats and horses can stay at pasture for 200 days a year (it represents 55% of animals on pasture), 40% of dairy cattle stay 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 manures is probably more frequent than the questionnaires showed and the emissions from AWMS will be higher. Housing at grasslands from April to October is frequent for sheep, goats and horses. The duration of grazing period can vary

[4] Guideline for sewage sludge application *(In Slovak)*: http://www.vupop.sk/dokumenty/prv/prirucka_pre_aplikaciu_kalu.pdf

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.

5.7.8.2 Methodological issues – emission factors and other parameters

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 animals in AWMS was 6 893.9 t in 2014. Total emissions of N_2O from pasture of animals were 0.153 Gg of N_2O in 2014. This category is estimated in the connection with the category manure management.

5.7.8.3 Activity data

Activity data are summarized in Table 5.32. 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 5.32: *Input parameters and EF in category 3.D.1.3 Urine and dung deposited by grazing animals in 1990 – 2014*

CATEGORY 3.D.1.3 URINE AND DUNG DEPOSITED BY GRAZING ANIMALS			
YEAR	**N-excretion on pasture (kg)**	**EFs (kg N_2O-N/kg N)**	**N_2O emissions (Gg)**
1990	16 166 335	0.020	0.424
1991	14 474 200	0.020	0.380
1992	13 304 225	0.020	0.338
1993	10 751 390	0.020	0.279
1994	10 105 570	0.020	0.260
1995	10 727 753	0.020	0.276
1996	10 065 444	0.020	0.256
1997	9 458 655	0.020	0.237
1998	8 357 392	0.020	0.210
1999	8 203 881	0.020	0.203
2000	8 150 830	0.020	0.200
2001	7 581 722	0.020	0.189
2002	7 478 545	0.020	0.186
2003	7 417 583	0.020	0.183
2004	7 026 994	0.020	0.171
2005	6 950 055	0.020	0.169
2006	6 880 979	0.020	0.165
2007	6 944 785	0.020	0.165
2008	6 965 546	0.020	0.164
2009	6 936 064	0.010	0.162
2010	7 036 980	0.010	0.163
2011	6 986 590	0.010	0.162
2012	7 175 835	0.010	0.166
2013	7 075 415	0.010	0.164
2014	6 893 902	0.010	0.153

5.7.9 SOURCE CATEGORY DESCRIPTION – 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 1.384 Gg of N_2O from the 88 090 295 kg of nitrogen in crop residues returned to soils in 2014.

Table 5.33: *Input parameters and EF in the category 3.D.1.4 crop residue in 1990 – 2014*

YEAR	CATEGORY 3.D.1.4 CROP RESIDUE			
	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
1991	1 188 937	92 360 478	0.01	1.451
1992	1 183 686	93 761 330	0.01	1.473
1993	1 153 657	91 588 332	0.01	1.439
1994	1 159 134	89 649 436	0.01	1.409
1995	1 184 530	88 475 897	0.01	1.390
1996	1 196 868	89 123 897	0.01	1.401
1997	1 185 919	86 544 233	0.01	1.360
1998	1 202 416	84 739 029	0.01	1.332
1999	1 179 262	83 257 300	0.01	1.308
2000	1 139 329	85 242 436	0.01	1.340
2001	1 149 184	81 527 462	0.01	1.281
2002	1 152 764	81 194 752	0.01	1.276
2003	1 156 021	81 859 165	0.01	1.286
2004	1 144 607	81 177 362	0.01	1.276
2005	1 149 857	80 763 018	0.01	1.269
2006	1 116 456	82 156 952	0.01	1.291
2007	1 139 880	90 859 745	0.01	1.428
2008	1 150 765	89 074 385	0.01	1.400
2009	1 135 231	90 449 760	0.01	1.421
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

5.7.9.1 Methodological issues – methods

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 (Jurčová, 2000). The estimation of nitrogen from residual crops was calculated according to the growing areas of crops and vegetable.

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 5.33 - 5.35 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. Anyway, 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. 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.

5.7.9.2 Methodological issues – emission factors and other parameters

Total growing area of crops (wheat, ray, barley, oat, maize, potato, sugar beet, oil plants, tobacco, vegetable, fodder crops, grassland and other) increased in comparison with the previous year and was 1 138 151 ha in 2014 and the direct inputs of nitrogen from crop residues were 68 196.93 t in 2014. The used default emission factor was 0.01 kg N_2O-N/kg N and total N_2O emissions from crops residues were 1.38 Gg in 2014.

5.7.9.3 Activity data

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 started 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. Anyway, 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 5.34: *Growing areas and total nitrogen amount (kg) of crops and leguminous in 2014*

CROP		Average nitrient potential of crop residues (kg N/ha)	Area of crops (ha)	Nitrogen fixed total (kg)
Cereals	Wheat	52.5	379 283	19 912 354
	Ray	45.0	29 369	1 321 619
	Barley	45.0	138 826	6 108 334
	Oat	55.0	15 367	845 211
	Maize	39.0	216 186	8 431 267
Potato		59.0	9 105	537 201
Sugar beet		20.0	22 212	444 231
Oil plants		107.0	241 659	25 857 468
Tobacco		45.0	8	368
Fodder crops		20.0	350	20 667
Maize for silage		55.0	85 786	4 718 212
2014 TOTAL		-	**1 138 151**	**68 196 931**

Table 5.35: *Nutrition potential in crop residues in kg of nitrogen per hectare according to the study of the Research Institute of Plant Production (Jurčová, 2000)*

CROP	PARAMETER	CROP	PARAMETER	CROP	PARAMETER	CROP	PARAMETER
			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

5.7.9.4 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.

5.7.9.5 Methodological issues – methods

Nitrogen inputs from symbiotic fixation are within the range of 20 – 30 kg/ha (Bielek, 1998), 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 (Jurčová, 2000) at national conditions and recalculated for the growing areas of N-fixing crops and average harvest.

5.7.9.6 Methodological issues – emission factors and other parameters

Total growing areas of N-fixing crops (peas, lens, beans, mix of fodder beans and cereals, soybeans, alfalfa and clover) slightly increased and were 95 489 ha in 2014 due to increase of area of soya been and alfalfa production. On the other hand, the area of peas, lens and beans decreased. The direct inputs of nitrogen from N-fixing crops (higher than in previous year) were 19 893 t of N in 2014. 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 0.313 Gg including biologic fixation in 2014.

5.7.9.7 Activity data

Total N_2O emissions from N–fixing crops (residues + biologic fixation) were 0.313 Gg in 2014. 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 5.36: *Crops characteristics in category 3.D.1.4 for N-fixing crops in 2014*

CROP	Area of N-fixing crops	Harvested residues	Content of N in dry matter	Nitrogen in soil	Nitrogen fixed
	(ha)	(t/ha)	(%)	(kg/ha)	Total (kg)
Peas	2 477.99	6.51	1.66	0.11	267.79
Lens	179.86	7.00	2.42	0.17	30.47
Beans	59.68	7.00	2.96	0.21	12.37
Mix of fodder beans and cereals	3 330.90	10.94	2.96	0.32	1 078.63
Soybeans	33 227.33	3.44	4.19	0.14	4 789.25
Alfalfa	48 169.05	7.00	2.42	0.17	8 159.84
Clover	8 044.19	6.00	1.97	0.12	950.82
Other Fodder Crops*	38 952.65	6.00	1.97	0.12	4 604.20
2014 TOTAL	**95 489.00**				**19 893.36**

*permanent (not including in total harvested area)

Table 5.37: *Input parameters and EFs in category 3.D.1.4 for N-fixing crops in 1990 – 2014*

YEAR	CATEGORY 3.D.1.4 FOR N-FIXING CROPS			
	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
1991	200 889	30 843 953	0.01	1.451
1992	215 542	31 138 436	0.01	1.473
1993	198 563	32 272 384	0.01	1.439
1994	172 386	29 211 274	0.01	1.409

YEAR	CATEGORY 3.D.1.4 FOR N-FIXING CROPS			
	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)
1995	156 809	25 815 160	0.01	1.390
1996	140 056	23 645 793	0.01	1.401
1997	124 154	21 255 833	0.01	1.360
1998	112 960	18 837 557	0.01	1.332
1999	112 793	17 952 705	0.01	1.308
2000	100 886	17 543 586	0.01	1.340
2001	94 616	15 732 782	0.01	1.281
2002	92 572	14 511 772	0.01	1.276
2003	92 028	14 169 250	0.01	1.286
2004	88 371	14 285 517	0.01	1.276
2005	90 577	14 163 138	0.01	1.269
2006	81 036	15 884 972	0.01	1.291
2007	99 136	22 711 072	0.01	1.428
2008	82 893	19 305 014	0.01	1.400
2009	88 717	20 344 762	0.01	1.421
2010	89 716	19 508 495	0.01	1.366
2011	83 934	21 293 990	0.01	1.360
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

5.7.10 SOURCE CATEGORY DESCRIPTION – 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 0.355 Gg in 2014 which is more than 58% below 1990 baseline.

5.7.10.1 Methodological issues – methods

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.

5.7.10.2 Methodological issues – emission factors and other parameters

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 (0.010 kg 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.

5.7.10.3 Activity data

Activity data in this category are in consistency with the activity data in categories synthetic fertilizers and animal manure applied to soil 3.D.1.1 and 3.D.1.2. Table 5.38 shows the time series of parameters and emissions.

Table 5.38: Input parameters and EF in category 3.D.2.1 Atmospheric deposition in 1990 – 2014

CATEGORY 3.D.2.1 ATMOSPHERIC DEPOSITION					
YEAR	Volatilized N from Synthetic Fertilizers (kg)	Volatilized N from Animal Manure (kg)	Total Volatilized N (kg)	EFs (kg N_2O-N/kg N)	N_2O emissions (Gg)
1990	22 225 500	142 233 345	53 905 436	0.010	0.847
1991	14 634 100	128 409 587	43 210 857	0.010	0.679
1992	9 018 600	112 530 525	34 185 550	0.010	0.537
1993	6 485 200	98 005 862	28 236 650	0.010	0.444
1994	6 866 900	92 419 168	27 371 848	0.010	0.430
1995	6 958 700	96 000 393	28 304 329	0.010	0.445
1996	7 446 400	89 945 553	27 448 599	0.010	0.431
1997	8 801 700	82 627 921	27 219 015	0.010	0.428
1998	8 184 200	72 933 165	24 442 311	0.010	0.384
1999	6 539 200	69 752 087	22 130 394	0.010	0.348
2000	7 265 300	67 773 397	22 450 145	0.010	0.353
2001	7 603 200	66 397 733	22 399 091	0.010	0.352
2002	8 826 000	67 142 713	23 750 252	0.010	0.373
2003	8 130 000	65 444 424	22 702 401	0.010	0.357
2004	7 991 100	61 389 074	21 674 314	0.010	0.341
2005	8 131 700	59 651 666	21 452 044	0.010	0.337
2006	7 868 112	583 44 988	20 913 305	0.010	0.329
2007	8 893 540	56 158 657	21 514 228	0.010	0.338
2008	7 705 845	52 179 862	20 602 777	0.010	0.324
2009	8 687 300	52 250 333	19 543 125	0.010	0.307
2010	9 2969 00	51 184 249	20 337 656	0.010	0.320
2011	10 100 400	48 741 961	20 444 980	0.010	0.321
2012	10 100 400	50 177 678	21 579 404	0.010	0.339
2013	11 358 130	49 394 947	22 655 641	0.010	0.356
2014	11 903 605	46 693 055	22 621 049	0.010	0.355

5.7.11 SOURCE CATEGORY DESCRIPTION – NITROGEN LEACHING AND RUN-OFF (CRF 3.D.2.2)

The following nitrogen losses 5–10 (7% of N-inputs) kg per ha per year are caused by soil erosion and runoff (Bielek, 1998). Total losses in soils were about 14% of nitrogen input due to leaching, runoff and erosion in climatic condition of the Slovak Republic. Total indirect emissions from nitrogen leaching and run-off were 0.922 which is more than 45% below 1990.

5.7.11.1 Methodological issues – methods

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.

5.7.11.2 Methodological issues – emission factors and other parameters

The IPCC default emission factor (0.0075 kg N_2O-N/kg N) was used during the time series. It was assumed, that 14% of nitrogen input from synthetic fertilizers and manure applied to soil is lost through leaching and run off.

5.7.11.3 Activity data

Activity data in this category are in consistency with the activity data in categories synthetic fertilizers and animal manure applied to soil 3.D.1.1 and 3.D.1.2. Table 5.39 shows time series of parameters and emissions.

Table 5.39: *Input parameters and EF in category 3.D.2.2 Nitrogen leaching and run-off in 1990 – 2014*

CATEGORY 3.D.2.2 LEACHING AND RUN-OFF					
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	47 519 904	141 910 960,56	0.0075	1.673
1991	43 902 300	42 865 136	114 475 579,58	0.0075	1.349
1992	27 055 800	37 750 425	92 934 623,70	0.0075	1.095
1993	19 455 600	32 627 176	79 559 275,10	0.0075	0.938
1994	20 600 700	30 757 421	78 252 952,23	0.0075	0.922
1995	20 876 100	32 018 444	79 437 312,70	0.0075	0.936
1996	22 339 200	30 003 299	79 079 668,13	0.0075	0.932
1997	26 405 100	27 625 973	79 994 342,69	0.0075	0.943
1998	24 552 600	24 387 167	74 361 475,93	0.0075	0.876
1999	19 617 600	23 386 790	67 981 580,43	0.0075	0.801
2000	21 795 900	22 777 268	70 145 898,90	0.0075	0.827
2001	22 809 600	22 193 836	69 461 675,04	0.0075	0.819
2002	26 478 000	22 386 378	73 222 803,20	0.0075	0.863
2003	24 390 000	21 858 602	70 806 351,49	0.0075	0.835
2004	23 973 300	20 524 820	68 851 328,91	0.0075	0.811
2005	24 395 100	19 980 516	68 604 521,79	0.0075	0.809
2006	23 604 336	19 567 790	67 819 211,61	0.0075	0.799
2007	26 680 620	18 931 032	72 869 575,76	0.0075	0.859
2008	26 321 085	17 743 623	70 787 023,05	0.0075	0.834
2009	23 117 535	17 755 919	68 008 382,11	0.0075	0.802
2010	26 061 900	17 475 534	69 614 658,00	0.0075	0.820
2011	27 890 700	16 722 120	70 585 040,21	0.0075	0.832
2012	30 301 200	17 218 506	72 353 390,84	0.0075	0.853
2013	34 074 417	16 946 252	76 892 049,61	0.0075	0.906
2014	35 710 815	16 076 167	78 214 070,18	0.0075	0.922

5.8 PRESCRIBED BURNING OF SAVANNAS (CRF 3.E)

The category Prescribed burning of savannas 3.E does not occur in the Slovak Republic.

5.9 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.

5.10 LIME APPLICATION (CRF 3.G)

The limestone (or dolomite) fertilizers are applied on the most acidic agricultural soils in the Slovak Republic. The CO_2 emissions from liming can be calculated according to the equation:

CO_2 emissions from liming = Total amount of limestone (dolomite) x EF

Data on liming of agricultural soils (cropland) come from summary of the Central Controlling and Testing Institute in Agriculture (UKSUP). For the years 1998 – 2014 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 materials (besides limestone also burnt lime and other materials) 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 5.40: *The results for limestone fertilizers in category 3.G in 1990 – 2014*

YEAR	TOTAL AMOUNT OF $CACO_3$ (t)	CARBON CONVERSION FACTOR	CO_2 EMISSIONS (Gg)
1990	101 400.00	0.12	44.62
1991	81 900.00	0.12	36.04
1992	62 400.00	0.12	27.46
1993	42 900.00	0.12	18.88
1994	23 400.00	0.12	10.30
1995	143 520.00	0.12	63.15
1996	109 200.00	0.12	48.05
1997	236 700.00	0.12	104.15
1998	319 279.80	0.12	140.48
1999	162 104.70	0.12	71.33
2000	99 248.70	0.12	43.67
2001	149 170.20	0.12	65.63
2002	63 675.60	0.12	28.20
2003	57 352.90	0.12	25.24
2004	25 379.80	0.12	11.17
2005	19 772.00	0.12	8.70
2006	20 982.70	0.12	9.23
2007	25 375.80	0.12	11.17
2008	45 737.70	0.12	20.12
2009	40 528.10	0.12	17.83
2010	34 988.01	0.12	15.39
2011	46 842.36	0.12	20.61
2012	35 089.00	0.12	15.44
2013	36 886.36	0.12	16.23
2014	35 529.55	0.12	15.63

5.11 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 emissions from urea application = Total amount of urea (tons per year) x EF for tier 1 (0.20).

Data on urea application of agricultural soils (cropland) come from summary of the Central Controlling and Testing Institute in Agriculture. For the years 1998 – 2014 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.

Table 5.41: *The results for urea application in category 3.H in 1990 – 2014*

YEAR	TOTAL AMOUNT OF UREA (t)	UREA CONVERSION FACTOR	CO_2 EMISSIONS (Gg)
1990	20 846.74	0.20	15.29
1991	20 846.74	0.20	15.29
1992	20 846.74	0.20	15.29
1993	20 846.74	0.20	15.29
1994	20 846.74	0.20	15.29
1995	20 846.74	0.20	15.29
1996	20 846.74	0.20	15.29
1997	20 846.74	0.20	15.29
1998	24 515.23	0.20	17.98
1999	21 524.31	0.20	15.78
2000	16 500.69	0.20	12.10
2001	28 185.47	0.20	20.67
2002	24 930.94	0.20	18.28
2003	23 980.76	0.20	17.59
2004	30 674.81	0.20	22.49
2005	27 699.02	0.20	20.31
2006	23 312.40	0.20	17.10
2007	24 891.41	0.20	18.25
2008	38 154.97	0.20	27.98
2009	30 981.41	0.20	22.72
2010	42 189.25	0.20	30.94
2011	54 146.88	0.20	39.71
2012	61 934.09	0.20	45.42
2013	70 899.73	0.20	51.99
2014	79 009.80	0.20	57.94

CHAPTER 6: LULUCF (CRF 4)

6.1 OVERVIEW OF 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 category 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 -6 121.76 Gg of CO_2 equivalent in 2014 is very important sector and comprises several key categories. The major share represents CO_2 removals (-6 166.40 Gg) with the contributions of following categories: Forest land with removals of -4 633.25 Gg CO_2, Cropland with removals of -802.82 Gg CO_2, Grassland with removals of -184.65 Gg CO_2, Settlements with the emissions of 80.60 Gg CO_2 and Other land with the emissions of 104.36 Gg CO_2. Total methane emissions were 0.69 Gg and total N_2O emissions were 0.092 Gg from LULUCF sector in 2014. The emissions of other pollutants originate from forest fires and controlled burning in forests. The estimated amount of NOx emissions was 0.44 Gg and the estimated CO emissions were 15.61 Gg in 2014.

Table 6.1: *Summary of total emissions and removals according to the LULUCF categories in 2014*

CATEGORY	Net CO_2		CH_4	N_2O	NO_x	CO
	Emissions/Removals (Gg)		Emissions (Gg)			
4. LULUCF	**NO**	**-6 166.40**	**0.69**	**0.092**	**0.44**	**15.61**
A. Forest Land	NO	-4 633.25	0.69	0.04	0.44	15.61
B. Cropland	NO	-802.82	NO	0.03	NO	NO
C. Grassland	NO	-184.65	NO	NO	NO	NO
D. Wetlands	NO	NO	NO	0.002	NO	NO
E. Settlements	80.60	NO	NO	0.01	NO	NO
F. Other Land	104.36	NO	NO	0.01	NO	NO

Figure 6.1: *CO_2 emissions and removals (in Gg) according to the LULUCF land use categories except Forest Land in 1990 – 2014 (out of scale)*

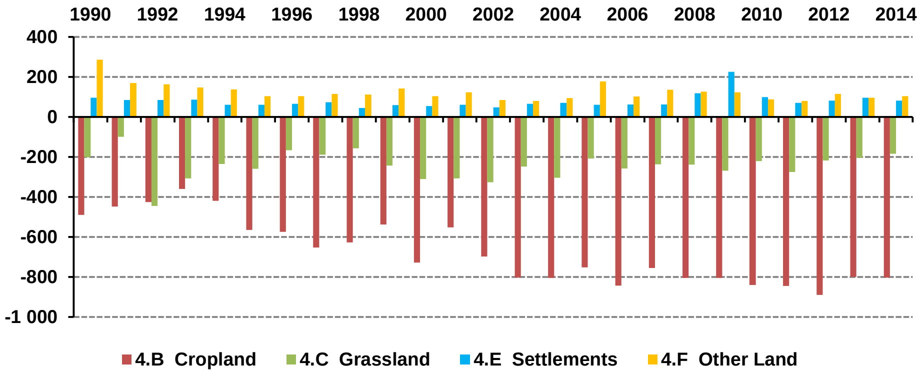
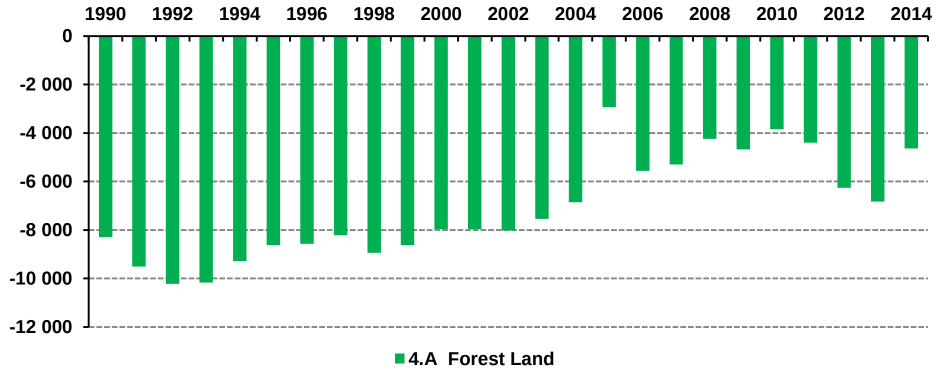


Table 6.2: *Summary of GHG emissions and removals (in Gg) according to the LULUCF categories in the period 1990 – 2014*

YEAR	Forest land	Cropland	Grassland	Settlements	Other land	LULUCF (CO_2, CH_4, N_2O)		
	Net CO_2 (Gg)					Gg		
1990	-8 297.98	-489.12	-202.29	96.06	285.40	-9 078.35	0.30	0.27
1991	-9 515.19	-447.12	-98.73	83.99	169.01	-9 806.16	0.24	0.25
1992	-10 224.18	-426.11	-444.50	84.30	163.14	-10 509.63	0.24	0.24
1993	-10 165.43	-359.40	-306.52	86.06	146.58	-10 523.38	0.31	0.24
1994	-9 290.43	-419.60	-235.45	59.81	136.84	-9 829.20	0.22	0.22
1995	-8 629.47	-565.19	-259.06	60.66	103.13	-9 348.69	0.24	0.20
1996	-8 576.95	-573.78	-166.47	66.13	104.46	-9 305.53	0.28	0.19
1997	-8 217.74	-652.21	-189.51	74.06	114.73	-9 185.38	0.28	0.17
1998	-8 935.07	-626.36	-157.36	44.65	112.27	-10 231.61	0.28	0.16
1999	-8 628.17	-537.13	-243.32	59.09	142.51	-10 064.59	0.55	0.16
2000	-7 968.66	-727.83	-310.72	53.79	103.26	-9 770.23	0.44	0.14
2001	-7 962.25	-551.23	-307.39	59.77	123.20	-8 911.68	0.36	0.12
2002	-8 013.89	-696.84	-326.06	47.23	83.76	-9 502.90	0.40	0.10
2003	-7 540.67	-802.71	-247.59	65.84	80.37	-9 259.62	0.52	0.10
2004	-6 856.10	-804.36	-303.49	70.52	93.56	-8 957.74	0.43	0.09
2005	-2 931.75	-750.84	-208.70	61.04	177.03	-5 649.68	0.62	0.10
2006	-5 564.82	-842.35	-257.34	62.86	102.85	-8 374.68	0.49	0.09
2007	-5 297.52	-755.59	-236.35	61.88	135.98	-8 103.30	0.55	0.09
2008	-4 247.79	-804.23	-238.34	117.47	125.98	-6 984.96	0.55	0.08
2009	-4 681.17	-805.15	-269.55	225.82	123.69	-6 866.28	0.58	0.08
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

__Figure 6.2:__ CO_2 removals (in Gg) in Forest Land in 1990 – 2014



6.2 ACTIVITY DATA

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 sow specific crops or just crops for green manure, eventually it is covered by spontaneous vegetation, which would be plough 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 6.3.

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.

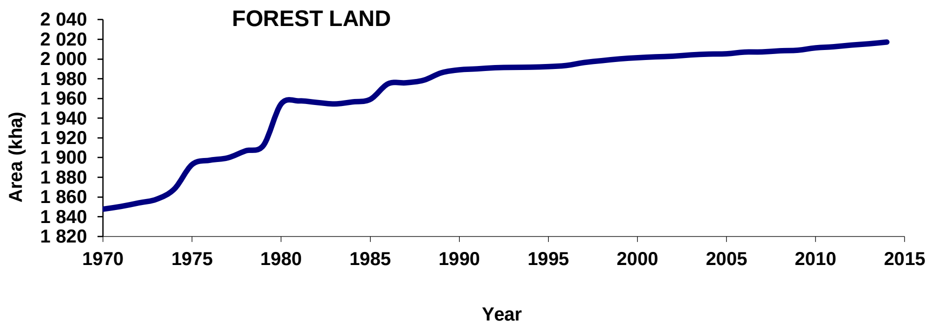
Table 6.3: *The areas (kha/year) of land-use categories remaining in category since 1990*

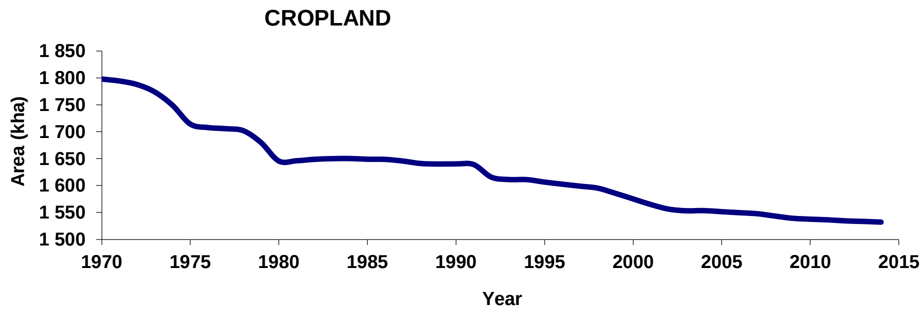
YEAR	Area (kha/year)				
	4.A.1 FL remaining FL	4.B.1 CL remaining CL	4.C.1 GL remaining GL	4.E.1 S remaining S	4.F.1 OL remaining OL
1990	1 809.15	1 492.15	685.50	94.69	190.37
1991	1 813.81	1 500.32	687.96	95.96	193.47
1992	1 817.65	1 481.32	692.53	97.65	193.26
1993	1 822.29	1 480.45	702.51	98.89	195.59
1994	1 833.68	1 486.41	718.62	100.62	198.07
1995	1 861.77	1 502.19	740.79	102.63	203.45
1996	1 868.44	1 505.90	746.10	104.18	137.04
1997	1 873.39	1 512.27	750.71	105.02	113.93
1998	1 881.17	1 517.60	754.25	106.05	115.15
1999	1 887.29	1 512.20	769.54	107.60	118.79
2000	1 929.76	1 517.42	766.82	109.57	128.14
2001	1 935.71	1 513.24	765.36	111.25	126.23
2002	1 938.38	1 508.33	764.87	112.30	126.71
2003	1 939.25	1 509.34	765.49	113.71	126.29
2004	1 941.98	1 510.76	762.43	114.28	126.43
2005	1 945.13	1 513.92	762.47	116.75	128.01
2006	1 961.95	1 517.26	763.01	118.47	127.15
2007	1 963.90	1 517.84	765.72	119.96	128.59
2008	1 968.27	1 517.13	767.44	119.40	130.27
2009	1 978.45	1 513.16	768.00	116.96	130.66

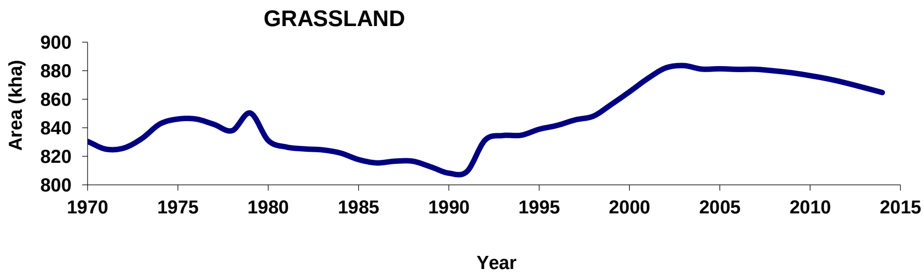
YEAR	Area (kha/year)				
	4.A.1 FL remaining FL	4.B.1 CL remaining CL	4.C.1 GL remaining GL	4.E.1 S remaining S	4.F.1 OL remaining OL
2010	1 981.89	1 511.70	766.40	116.85	130.80
2011	1 983.77	1 510.36	766.97	117.40	130,65
2012	1 985.11	1 508.36	786.60	117.59	131.46
2013	1 985.74	1 507.23	787.84	117.18	131.36
2014	1 986.15	1 505.97	785.35	117.37	131.13

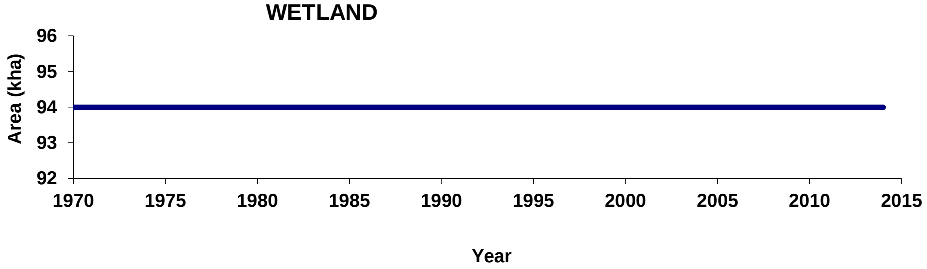
The land-use matrixes shown in Table A6.1 represent the areas of land-use change among the major land use categories from 1990 to 2014 for individual years. The annual totals for individual years in the matrices do not correspond to the areas referred to in the CRF Tables. These areas account for the progressing for 20 years transition period beginning in 1970. This approach represents tier 1 assumption of IPCC 2006 Guidelines for National Greenhouse Gas Inventories (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.

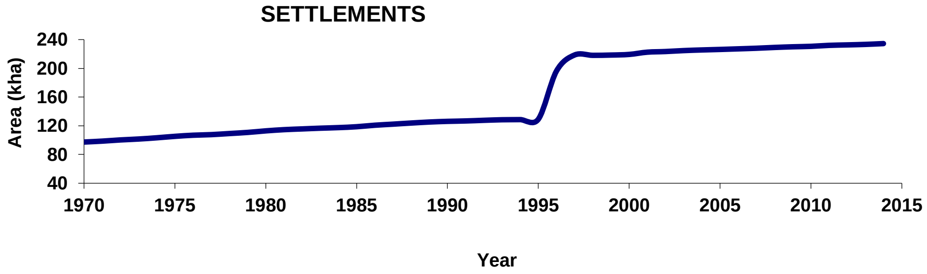
Figure 6.3: *Overall trends in the areas of the land-use categories from 1970 – 2014 (based on information from the GCCA of the Slovak Republic)*

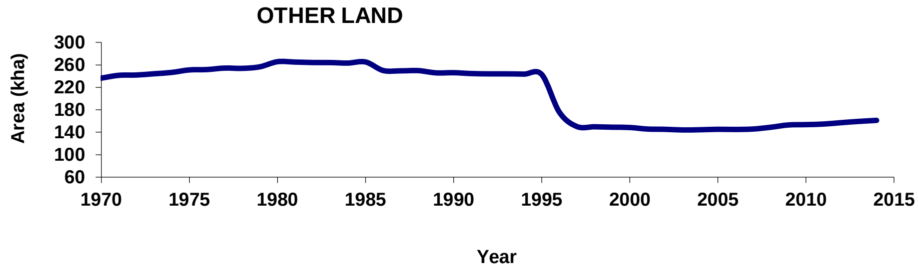








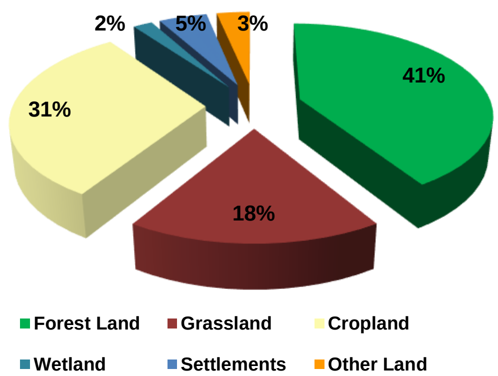




Land-use matrixes identifying annual land-use conversions among the categories for the period 1990 – 2014 and describing initial and final areas of particular land-use categories are listed in the Table A6.1.

The distribution of the land-use categories in Slovakia in 2014 is shown in Figure 6.4. Forest land represents the dominant land-use category, accounting for 41.1% of the total area, followed by the Cropland with 31.3%, Grassland with 17.6%, Settlements with 4.8%, Other land with 3.3% and Wetlands category with 1.9% of the total country area.

Figure 6.4: *Distribution of land-use categories in Slovakia in 2014*



LULUCF CATEGORY	AREA (kha)
Forest Land	2 017.105
Cropland	864.681
Grassland	1 532.359
Wetland	94
Settlements	234.416
Other Land	160.959

6.3 METHODOLOGICAL ISSUES – METHODS

The methodology of GHG inventory is built up on the principles of the 2006 IPCC Guidelines for National greenhouse gas inventories – Volume IV Agriculture, Forestry and Other Land Use 2006 (IPCC 2006 GL). Based on the previous results there are two main sources/sinks in this sector:

- Changes in living biomass – Forest land;
- Land use conversion – Changes in soil organic carbon.

6.4 COMPLETENESS

The completeness of inventory is determined by several factors, especially by importance of the processes and data availability.

Slovak inventory submission in 2016 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 6.4.

6.5 QA/QC PROCEDURES IN THE LULUCF SECTOR

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, e.g. the Soil Science and Conservation Research Institute (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.

Complete inventory submissions are considered according to the rules for QA on the EU level annually. More information in general part of this report.

Table 6.4: *Completeness of LULUCF sector in the Slovak Republic*

LULUCF		NK	CARBON POOLS		
4.A	**Forest Land**				
4.A.1	Forest Land Remaining Forest Land	*Y*	Living biomass	DOM	Soil C
4.A.2	Land Converted to Forest Land	*Y*	Living biomass		Soil C
4.A.2.1	Cropland Converted to Forest Land	*Y*	Living biomass		Soil C
4.A.2.2	Grassland Converted to Forest Land	*Y*	Living biomass		Soil C
4.A.2.3	Wetlands Converted to Forest Land	*NO*			
4.A.2.4	Settlements Converted to Forest Land	*NO*			
4.A.2.5	Other Land Converted to Forest Land	*Y*	Living biomass		Soil C
4.B	**Cropland**				
4.B.1	Cropland remaining Cropland	*Y*	Living biomass		
4.B.2	Land Converted to Cropland	*Y*			Soil C
4.B.2.1	Forest Land Converted to Cropland	*Y*	Living biomass	DOM	Soil C
4.B.2.2	Grassland Converted to Cropland	*Y*			Soil C
4.B.2.3	Wetlands Converted to Cropland	*NO*			
4.B.2.4	Settlements Converted to Cropland	*NO*			
4.B.2.5	Other Land Converted to Cropland	*Y*			Soil C
4.C	**Grassland**				
4.C.1	Grassland Remaining Grassland	*NE*			
4.C.2	Land Converted to Grassland	*Y*			Soil C
4.C.2.1	Forestland Converted to Grassland	*Y*	Living biomass	DOM	Soil C
4.C.2.2	Cropland Converted to Grassland	*Y*			Soil C
4.C.2.3	Wetlands Converted to Grassland	*NO*			
4.C.2.4	Settlements Converted to Grassland	*NO*			
4.C.2.5	Other Land Converted to Grassland	*Y*			Soil C
4.D	**Wetlands**				
4.D.1	Wetlands Remaining Wetlands	*NE*			
4.D.1	CO_2 emissions from peat lands remaining peat lands	*NE*			
4.D.1	CO_2 emissions from flooded land remaining flooded land	*NE*			
4.D.2	Land Converted to Wetlands	*NE*			
4.D.2	CO_2 emissions from land being converted for peat extraction	*NE*			
4.D.2	CO_2 emissions from land converted to flooded land	*NE*			
4.E	**Settlements**				
4.E.1	Settlements Remaining Settlements	*NE*			
4.E.2	Land Converted to Settlements	*Y*			Soil C
4.E.2.1	Forest Land Converted to Settlements	*Y*	Living biomass	DOM	Soil C
4.E.2.2	Cropland Converted to Settlements	*Y*			Soil C
4.E.2.3	Grassland Converted to Settlements	*Y*			Soil C
4.E.2.4	Wetlands Converted to Settlements	*NO*			
4.E.2.5	Other Land Converted to Settlements	*Y*			Soil C

4.F	Other Land				
4.F.1	Other Land Remaining Other Land	*NE*			
4.F.2	Land Converted to Other Land	*Y*			Soil C
4.F.2.1	Forest Land Converted to Other Land	*Y*	Living biomass	DOM	Soil C
4.F.2.2	Cropland Converted to Other Land	*Y*			Soil C
4.F.2.3	Grassland Converted to Other Land	*Y*			Soil C
4.F.2.4	Wetlands Converted to Other Land	*NO*			
4.F.2.5	Settlements Converted to Other Land	*Y*			Soil C
4(I)	Direct nitrous oxide (N_2O) emissions from nitrogen (N) inputs to managed soils	*NO*			
4(II)	Emissions and removals from drainage and rewetting and other management of organic and mineral soils	*NO*			
4(III)	Direct nitrous oxide (N2O) 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	*Y*			
4(IV)	Indirect nitrous oxide (N2O) emissions from managed soils	*NO*			
4(V)	Biomass Burning	*Y*			
4.G	**Harvested wood products**	**Y**			
4.H	**Other**	**NE**			

DOM = Dead Organic Matter, Soil C = Soil Carbon

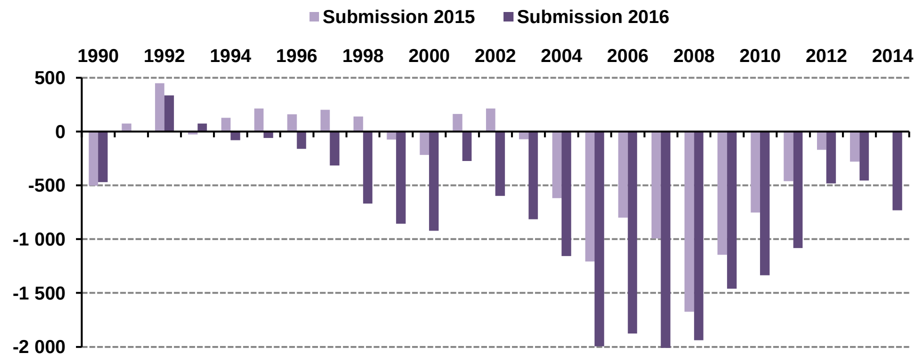
6.6 SOURCE SPECIFIC RECALCULATIONS

Recalculations in 4.G - Harvested wood products (HWP):

The HWP category was recalculated for whole time period since 1990. The main reason was recalculation according to the IPCC methods described in the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (IPCC 2013 GL). The calculation in the 2015 submission was provided by external service and was not fully traceable. Recent calculation of HWP uses inputs from the FAO forestry database on three HWP subcategories – sawn wood, wood based panels, paper and paperboards, see also Chapter 6.18. The common statistics of former Czechoslovakia are split between Czech Republic and Slovak Republic. The detailed description of calculation is in Rasi et al., 2015.

The recalculation in the category HWP affected the amount of losses and gains in individual years, as well as the summary emissions and removals of GHGs for the whole LULUCF sector The comparison of the 2015 and 2016 submission in the category 4.G is presented on the following figure.

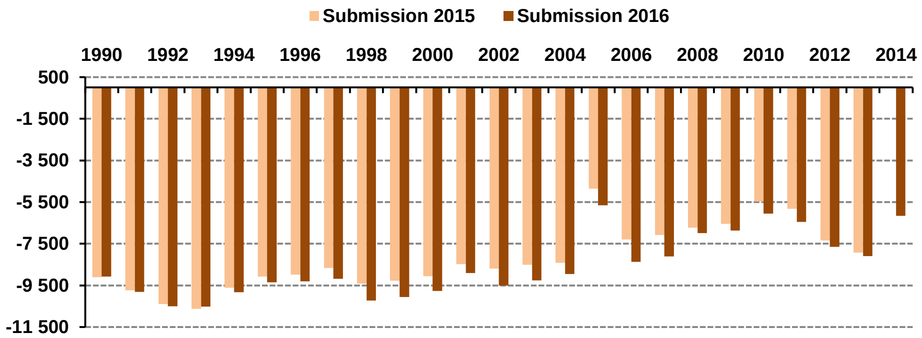
Figure 6.5: *Comparison of CO_2 emissions/removals (Gg) in the 2015 and 2016 submissions for category 4.G Harvested wood products*



Impact of the recalculation on the whole LULUCF sector:

The Forest land is spatially the largest category in Slovakia (41.1%), forests are actively managed and wood is processed. The recalculation of HWP increased gains of CO_2 in the LULUCF sector by 6% in the average. The gains in the HWP had increasing trend in the pre-crisis period, however since 2008 the trend is decreasing. The comparison of the 2015 and 2016 submission in the LULUCF sector is presented on the following figure.

Figure 6.6: Comparison of CO_2 equivalents (Gg) in the 2015 and 2016 submissions for the whole LULUCF sector



6.7 FOREST LAND (CRF 4.A)

6.7.1 Source category description

Forests currently cover 41.1% 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 (33.0%) followed by Norway spruce (23.7%) and oaks (10.6%) (Green Report, 2015). 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 476.61 mil. m^3 (merchantable volume, defined as tree stem and branch volume under bark with minimum diameter threshold of 7 cm) in 2014. Average hectare growing stock was 246 m^3.

The total volume of harvested timber reached 9 417.45 thousand m^3 in 2014, which represented 1 580.38 thousand m^3 (20.2%) increase compared to 2013. The volume of incidental felling was 54.4% 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 usually 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, are recorded and yearly reported 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.

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 6.7: *Development of activity data in kha for category 4.A Forest land in the period 1990–2014*

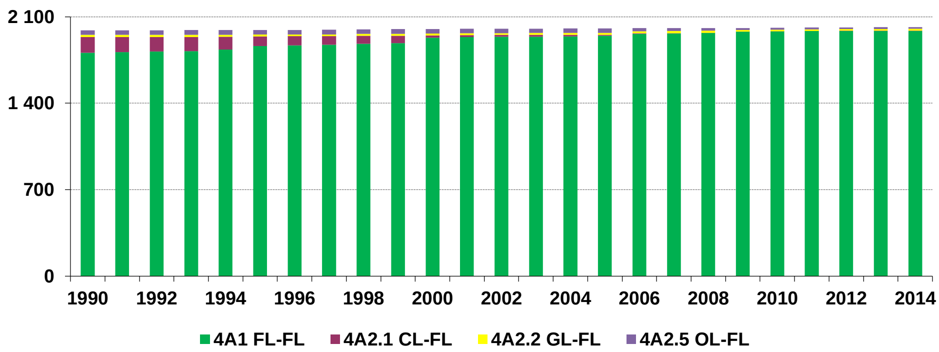
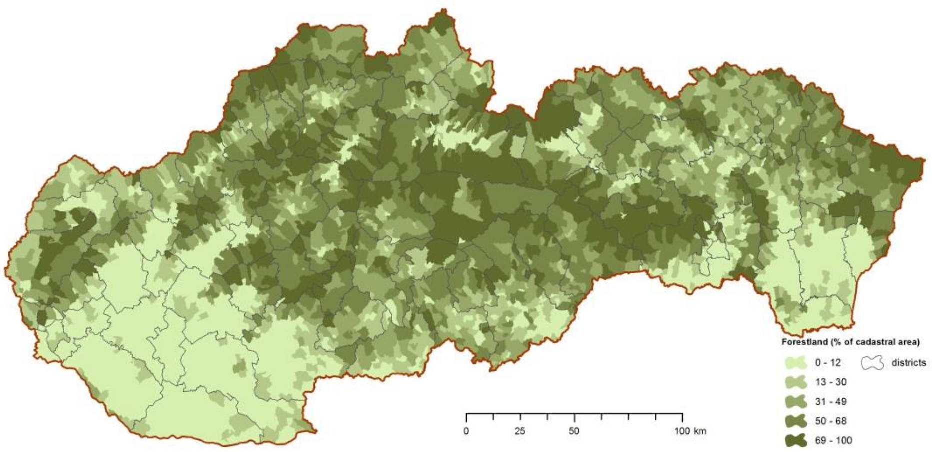


Figure 6.8: *Forest Land in Slovakia – distribution calculated as a spatial share of the category within individual cadastral units*



6.7.2 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 2014. 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 1 986.15 kha, the changes in the FL were following: CL converted to FL 1.56 kha, GL converted to FL 15.43 kha, and OL converted to FL 13.97 kha in 2014. Total forest area in 2014 was 2 017.105 kha.

6.7.2.1 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:

- GTOTAL = GW * (1 + R)
- GW = IV * BCEFI

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: *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	GTOTAL t dm/ha/yr
Spruce	8.13	0.45	3.66	0.2	4.39
Fir	7.13	0.45	3.22	0.2	3.87
Pine	6.21	0.68	4.21	0.2	5.05
Larch	6.41	0.81	5.22	0.2	6.26
Other conifer	2.59	0.54	1.41	0.2	1.69
Oak	4.50	0.88	3.98	0.2	4.78
Beech	6.15	0.79	4.86	0.2	5.83
Hornbeam	6.10	0.93	5.67	0.2	6.80
Maple	5.73	0.73	4.19	0.2	5.03
Ash	7.31	0.73	5.35	0.2	6.42
Elm	5.96	0.75	4.50	0.2	5.40
Turkey oak	4.51	0.95	4.30	0.2	5.15
Robinia	3.14	0.93	2.92	0.2	3.50

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	GTOTAL t dm/ha/yr
Birch	2.87	0.70	2.00	0.2	2.40
Alder	2.50	0.70	1.74	0.2	2.09
Linden	7.38	0.52	3.86	0.2	4.63
Breeding poplars	9.93	0.51	5.09	0.2	6.11
Poplar	2.61	0.45	1.17	0.2	1.40
Willow	2.71	0.77	2.08	0.2	2.50
Other broad	1.84	0.70	1.28	0.2	1.54
AVERAGE	**5.19**	**0.70**	**3.53**	**0.2**	**4.24**

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 dm/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 and 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 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.

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 dm/ha	(kt/dm/yr)	(tC/tdm)	(kt C yr)
Spruce	471.114	4.39	2 066.33	0.5	1 033.17
Fir	79.843	3.87	308.77	0.5	154.39
Pine	135.257	5.05	683.56	0.5	341.78
Larch	49.455	6.26	309.58	0.5	154.79
Other conifer	22.046	1.69	37.18	0.5	18.59
Oak	210.929	4.78	1 007.31	0.49	493.58
Beech	655.230	5.83	3 817.59	0.49	1870.62
Hornbeam	116.388	6.80	791.30	0.49	387.74
Maple	47.072	5.03	236.74	0.49	116.00
Ash	31.580	6.42	202.62	0.49	99.28
Elm	0.596	5.40	3.22	0.49	1.58
Turkey oak	50.448	5.15	260.03	0.49	127.41
Robinia	34.360	3.50	120.25	0.49	58.92

TREE SPECIES	Area of tree species for FL remaining FL	Average annual biomass growth above- and below-ground	Annual increase in biomass due to biomass growth	Carbon fraction of dry matter	Annual increase in biomass carbon stocks due to biomass growth
	kha	t dm/ha	(kt/dm/yr)	(tC/tdm)	(kt C yr)
Birch	30.189	2.40	72.43	0.49	35.49
Alder	14.896	2.09	31.13	0.49	15.25
Linden	8.143	4.63	37.68	0.49	18.46
Breeding poplars	9.136	6.11	55.81	0.49	27.35
Poplar	7.547	1.40	10.60	0.49	5.20
Willow	1.986	2.50	4.97	0.49	2.43
Other broad	9.931	1.54	15.27	0.49	7.48
TOTAL	**1 986.146**		**10 072.378**		**4 969.520**

The annual increase in carbon stocks due to biomass increment in the category 4.A.1 FL remaining FL represents 4 969.52 kt C in 2014.

The annual decrease in carbon stocks due to biomass loss in FL remaining FL follows equations 2.12 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, CAI and total harvest during the reporting period 1990 – 2014 in Slovakia are presented on the following figures.

Figure 6.9: *The statistics of forest harvest (coniferous and broadleaved) (mil. m^3 volume >7 cm under bark) in 1990 – 2014*

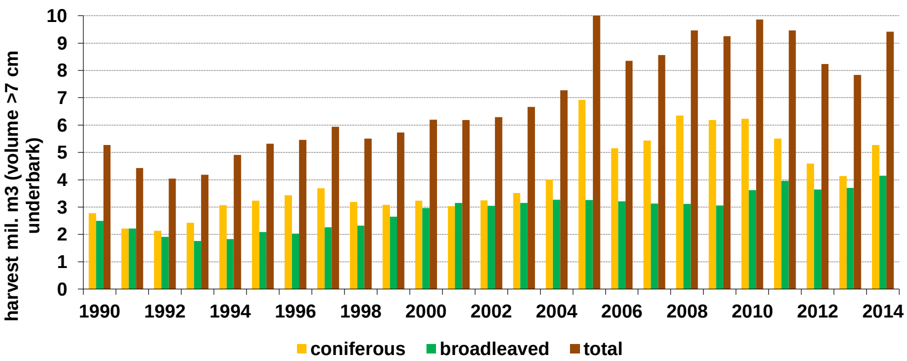
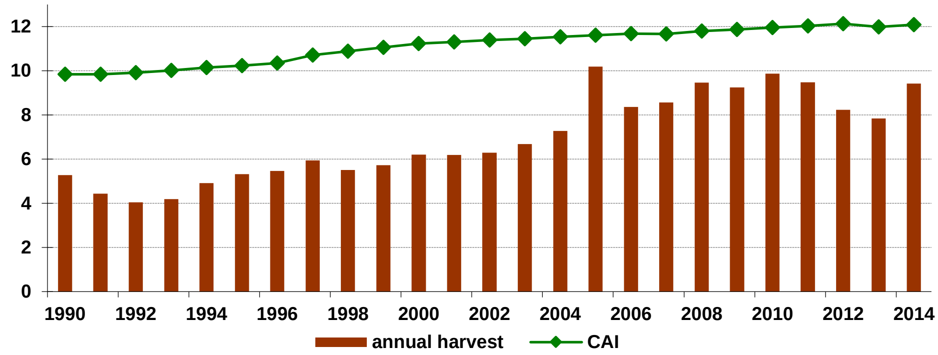


Figure 6.10: *Current annual increment (CAI) and total annual harvest (mil. m³) in 1990 – 2014*



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 (m³) 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: http://publications.jrc.ec.europa.eu/repository/handle/111111111/14708

Table 6.7: *Activity data and $BCEF_R$ used in calculation of carbon losses in 2014*

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 (tdm/y)	Carbon fraction of dry matter (tC/tdm)	Lwood-removals including fuelwood
	H (m³/y)	$BCEF_R$	t dm/y	R	t dm/y	CF tC/tdm	ktC /y
Spruce	4 375 791	0.625	2 735 769	0.2	3 282 923	0.5	1 641.46
Fir	379 982	0.625	2 375 67	0.2	285 080	0.5	142.54
Pine	364 983	0.526	191 910	0.2	230 292	0.5	115.15
Larch	143 993	0.526	75 712	0.2	90 855	0.5	45.43
Other conifer	4 000	0.526	2 103	0.2	2 524	0.5	1.26
Oak	586 957	0.833	489 081	0.2	586 898	0.49	287.58
Beech	3 049 778	0.750	2 286 125	0.2	2 743 350	0.49	1 344.24
Hornbeam	155 989	0.750	116 930	0.2	140 316	0.49	68.75
Robinia	67 995	0.750	50 969	0.2	61 163	0.49	29.97
Poplar	97 993	0.750	73 456	0.2	88 147	0.49	43.19
Other broad	189 986	0.750	142 414	0.2	170 897	0.49	83.74
TOTAL	**9 417 446**		**6 402 037**		**7 682 444**		**3 803.31**

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 3 803.31 kt C in 2014.

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 laying dead wood and small-sized laying dead wood not included in litter or soil carbon pools. 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.

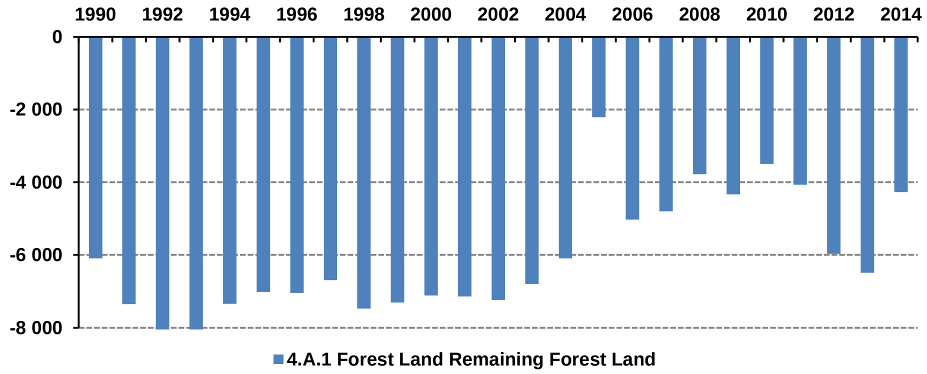
The mean carbon stock in forest litter is 8.3 MgC/ha. The value is derived from datasets of the Forest Monitoring System (FMS) and the National Forest Inventory (NFI). The changes of forests management that would dramatically change litter properties and litter carbon changes do not occur, i.e. no significant 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.

Figure 6.11: *Summary results of CO_2 removals (Gg) from 4.A.1 in 1990 – 2014*



The net CO_2 removal in the FL remaining FL represents 4 276.08 Gg of CO_2 in 2014. 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, 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 the 2014 the loss of carbon was higher than in 2013 due to harvested volume higher by 20% compared to the year 2013.

6.7.3 Biomass burning (CRF 4.A.1 - 4(V))

6.7.3.1 Source category description

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. Activity data from controlled burning and forest fires has been summarized by the National Forest Centre – Forest Protection Service 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 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 188.74 ha in 2014. This number decreased in comparison to the previous year 2013, when the total burnt area was 266.23 ha. The average burnt forest area per one fire was 1.25 ha. The largest forest area damaged by fire was 22 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 6.8: *Activity data used for estimation of emissions from wildfires and controlled burning of the FL remaining FL (4.A.1) in 2014*

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.		tons			
Forest Fires	188.74	-	1	CH_4	4.7	17.56			
				CO_2	107		5 863.48		
				N_2O	0.26			0.97	
				NO_x	3				11.21
Controlled Burning	-	229 254.8	0.62	CH_4	4.7	668.05			
				CO_2	107		IE		
				N_2O	0.26			36.96	
				NO_x	3				426.4
					TOTAL	685.61	5 863.48	37.93	437.51

Table 6.9: *Biomass burned in 4.A.1, CO_2, CH_4 and N_2O emissions from wildfires and controlled burning in 1990 – 2014*

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
1991	74 785.4	3 718	IE	5.83	217.92	17.48	12.06	0.97
1992	67 338.9	8 490	IE	13.32	196.23	39.9	10.86	2.21
1993	69 191.7	20 728	IE	32.52	201.62	97.42	11.15	5.39
1994	72 696.7	688	IE	1.08	211.84	3.23	11.72	0.18
1995	81 573.4	1 297	IE	2.03	237.7	6.09	13.15	0.34
1996	88 312.6	3 972	IE	6.23	257.34	18.67	14.24	1.03
1997	96 645.5	648	IE	1.02	281.62	3.04	15.58	0.17
1998	95 196.2	594	IE	0.93	277.4	2.79	15.35	0.15
1999	108 227.0	46 477	IE	72.92	315.37	218.44	17.45	12.08
2000	119 889.4	17 679	IE	27.74	349.36	83.09	19.33	4.6
2001	118 743.9	3 043	IE	4.77	346.02	14.3	19.14	0.79
2002	117 873.2	11 396	IE	17.88	343.48	53.56	19	2.96
2003	128 068.9	30 005	IE	47.08	373.19	141.02	20.64	7.8
2004	142 684.6	2 660	IE	4.17	415.78	12.5	23	0.69
2005	195 422.8	10 131	IE	15.89	569.46	47.61	31.5	2.63
2006	161 641.5	3 447	IE	5.41	471.02	16.2	26.06	0.9
2007	166 330.3	13 169	IE	20.66	484.69	61.89	26.81	3.42
2008	183 447.1	2 289	IE	3.59	534.56	10.76	29.57	0.6
2009	181 242.6	9 942	IE	15.6	528.14	46.73	29.22	2.58
2010	198 795.9	3 745	IE	5.88	579.29	17.6	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

* = 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.

6.7.3.2 Controlled burning

Total methane emissions from controlled burning were 668.05 t in 2014 and total emissions of N_2O were 36.96 t in 2014. CO emissions were included in the total biomass loss associated with harvesting and reported in the CRF Table 4.A – Carbon stock change.

6.7.3.3 Wildfires

Total methane emissions from wildfires were 17.56 t in 2014 and total emissions of N_2O were 0.97 t in 2014. CO_2 emissions were 5.86 Gg in 2014.

6.7.3.4 Uncertainties and time-series consistency

No uncertainty analysis has been made in this particular category. The time series are consistent, estimated by the consistent methodology, activity data collection way and using consistent emission factors and other parameters.

The time series are consistent, estimated by the consistent methodology, activity data collection way and using consistent emission factors and other parameters.

6.7.3.5 Source specific QA/QC and verification

The QC checks (e.g. consistency check between CRF data and national statistics) were done during the CRF and NIR compilation. 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.

6.7.3.6 Source specific recalculations

No recalculation was applied to this category since the last submission.

6.7.3.7 Source specific planned improvements

There are no short term plans concerning improvements in this land-use category.

6.7.4 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.

6.7.4.1 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/ha/yr, pine 3.17 t/ha/yr, beech 2.32 t/ha/yr, oak 1.23 t/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/ha/yr, pine 0.40 t/ha/yr, beech 0.57 t/ha/yr and oak 0.90 t/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 55% for spruce, 9% for pine, 33% for beech and 3% for oak in 2014.

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.

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., 1997, 2002, Pavlenda, 2008) with the default assumption of 20 years period for carbon stock equilibrium in „new land-use“ conditions. The mean value 8.3 tC/ha/year 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 tC/ha/year. 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. We calculate the soil carbon stocks to the depth 30 cm. The significant changes in soil carbon caused by land use change during decades are only in topsoil (soil layers near the soil surface).

Results from the latest soil survey on agricultural soil have been used.

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 tC/ha/year
- Cropland 60.11 tC/ha/year
- Grassland 74.95 tC/ha/year
- Settlements 53.85 tC/ha/year
- Other Land 53.85 tC/ha/year

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 (tC/ha/year) * 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 tC/ha/year
- GL converted to FL 0.704 tC/ha/year
- S converted to FL 1.758 tC/ha/year
- OL converted to FL 1.758 tC/ha/year

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 1994 to 2014 is provided in the Table 6.10.

Table 6.10: *The land-use matrix from 1994 to 2014*

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 (1994)**
	kha										
Forest Land (managed)	1986.146	0.000	0.344	2.202	0.000	0.000	0.000	0.961	2.018	**0.000**	**1991.671**
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	1.561	0.000	1505.968	76.204	0.000	0.000	0.000	14.815	12.655	**0.000**	**1611.203**
Grassland (managed)	15.425	0.000	24.513	785.350	0.000	0.000	0.000	5.474	4.064	**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	117.373	11.090	**0.000**	**128.463**
Other Land	13.973	0.000	1.534	0.925	0.000	0.000	0.000	95.793	131.132	**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 (2014)	**2017.105**	**0.000**	**1532.359**	**864.681**	**0.000**	**94.000**	**0.000**	**234.416**	**160.959**	**0.000**	**4903.520**
Net change	**25.434**	**0.000**	**-78.844**	**29.855**	**0.000**	**0.000**	**0.000**	**105.953**	**-82.398**	**0.000**	

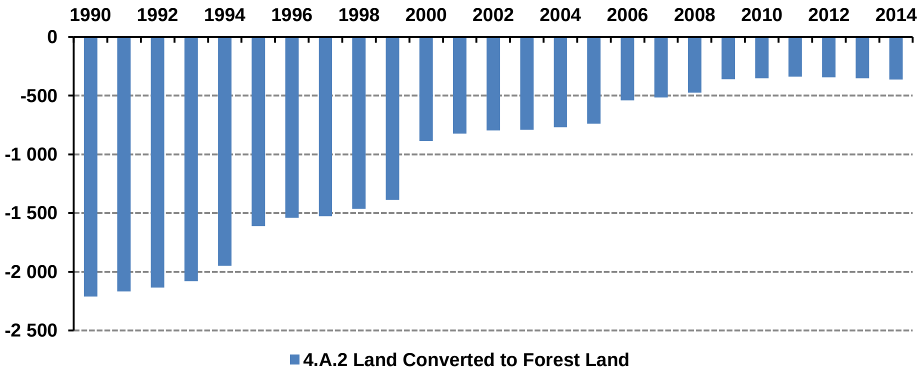
The results from the category 4.A.2 Land converted to Forest land are summarized in the following Table.

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	**48.51**	**NO**	**48.51**	**12.85**	**37.68**	**-363.13**
GL - FL	24.17	NO	24.17	6.40	10.86	-151.90
CL - FL	2.45	NO	2.45	0.65	2.26	-19.62
WL - FL	NO	NO	NO	NO	NO	NO
S - FL	NO	NO	NO	NO	NO	NO
OL - FL	21.89	NO	21.89	5.80	24.56	-191.60

The estimated removals for Land converted to Forest land were 363.13 Gg CO_2 in 2014. In the 2014 the net carbon stock change in living biomass, DOM and soil from Land converted to Forest land represented gains of 48.51, 12.85 and 37.68 Gg C respectively.

Figure 6.12: Summary results of CO_2 removals (Gg) in the category 4.A.2 in 1990 – 2014



6.7.4.2 Uncertainties and time-series consistency

Information on uncertainties cover information on completeness and accuracy. With respect to the accuracy, the estimated values correspond to the accuracy of inputs. 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 accuracy of tree biomass (dry mass) annual increment on new afforested areas represented by standard deviation was following: spruce ±1.56 $t*ha^{-1}*yr^{-1}$, pine ±1.61 $t*ha^{-1}*yr^{-1}$, beech ±2.04 $t*ha^{-1}*yr^{-1}$and oak ±1.05 $t*ha^{-1}*yr^{-1}$. Accuracy of dead wood volume for different parts of DW and tree species: standing dead trees is following: coniferous ±0.03 m^3*ha^{-1}, broadleaves ±0.02 m^3*ha^{-1}, stumps – coniferous ±0.01 m^3*ha^{-1}, broadleaves ±0.01 m^3*ha^{-1}, coarse laying dead wood – coniferous ±0.07 m^3*ha^{-1}, broadleaves ±0.04 m^3*ha^{-1} and small-sized laying dead wood – coniferous ±0.02 m^3*ha^{-1}, broadleaves ±0.03 m^3*ha^{-1} (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 time series are consistent, estimated by the consistent methodology, activity data collection way and using consistent emission factors and other parameters.

6.7.4.3 Source specific QA/QC and verification

The QC checks (e.g. consistency check between CRF data and national statistics) have been done during the CRF and NIR compilation. The QA is conducted by another LULUCF expert from the National

Forest Centre and in the next step by independent expert from the Ministry of Agriculture and Rural Development of the Slovak Republic.

6.7.4.4 Source specific recalculations

No recalculation was applied to this category since the last submission.

6.7.4.5 Source specific planned improvements

Following improvements are planned for this category in the next submission:

Slovakia has applied for the research project C-FORLAND (Assessment and modelling of carbon stocks in forest ecosystems for greenhouse gas inventory in landscape). The results of the project should be generalized and considered for the implementation in the national GHG inventory in next submissions.

The project C-FORLAND is financed by SRDA (Slovak Research and Development Agency, in Slovak: APVV *"Agentúra pre podporu vedy a vývoja"*). Experts from the National Forest Centre and the Soil Science and Conservation Research Institute are involved in this project. The project duration is from July 2012 to December 2015. The project analyses input data and procedures for the determination of carbon stocks and changes in forests for the purpose of GHG inventory in the LULUCF sector. The main objective is to acquire new knowledge on carbon stocks in forest ecosystems from representative plots and identification of factors of carbon stocks changes and the updating and improvement of methods for carbon balance. Dominant part of the project is oriented to the improvement of the knowledge on carbon stocks in soils. Existing databases of monitoring of forests, national forests inventory and information layers on the soil including information on agricultural land are used and complemented with additional new samples in specific territories. The project integrates also other components of forest ecosystems (aboveground and belowground biomass, dead wood, litter, soil).

6.7.5 Biomass burning (CRF 4.A.2 - 4(V))

6.7.5.1 Source category description

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. Activity data from forest fires (wildfires) has been summarized by the National Forest Centre – Forest Protection Service since 1999. Activity of controlled burning is not occurring in this category.

Table 6.12: *Biomass burned in Land converted to Forest land (4.A.2), CO_2, CH_4 and N_2O emissions from wildfires in 1990 – 2014*

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.		tons			
Forest Fires	2.989	-	1	CH_4	4.7	0.28			
				CO_2	107		92.84		
				N_2O	0.26			0.016	
				NO_x	3				
Controlled Burning	NO	-	0.62	CH_4	4.7	NO			
				CO_2	107		NO		
				N_2O	0.26			NO	
				NO_x	3				
					TOTAL	**0.28**	**92.84**	**0.016**	

YEAR	Biomass burned (ha)	CO_2 emissions (t)	CH_4 emissions (t)	N_2O emissions (t)
1990	23.06	716.46	2.15	0.12
1991	20.20	627.58	1.88	0.10
1992	45.23	1405.26	4.21	0.23
1993	107.13	3328.12	9.97	0.55
1994	3.27	101.72	0.30	0.02
1995	4.94	153.33	0.46	0.03
1996	14.38	446.59	1.34	0.07
1997	2.30	71.38	0.21	0.01
1998	1.99	61.89	0.19	0.01
1999	149.20	4635.21	13.88	0.77
2000	34.35	1067.21	3.20	0.18
2001	5.46	169.66	0.51	0.03
2002	19.78	614.35	1.84	0.10
2003	52.43	1628.74	4.88	0.27
2004	4.50	139.84	0.42	0.02
2005	16.31	506.78	1.52	0.08
2006	4.09	126.96	0.38	0.02
2007	14.98	465.23	1.39	0.08
2008	2.40	74.48	0.22	0.01
2009	7.83	243.40	0.73	0.04
2010	2.84	88.34	0.26	0.01
2011	5.80	180.10	0.54	0.03
2012	24.55	762.62	2.28	0.13
2013	4.03	125.29	0.38	0.02
2014	2.99	92.84	0.28	0.02

6.7.5.2 Wildfires

Total methane emissions from wildfires were 0.28 t in 2014 and total emissions of N_2O were 0.02 t in 2014. CO_2 emissions were 92.844 t in 2014.

6.8 CROPLAND (CRF 4.B)

6.8.1 Source category description

The GHGs emissions and removals in this category were estimated by using the 2006 IPCC GL and national data on area of Cropland and Land converted to Cropland in 2014. The total area of cropland represented 1 532.36 kha in 2014, this is approximately 31% 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 1 505.97 kha, the changes in the Cropland were following: FL converted to CL 0.34 kha, GL converted to CL 24.51 kha and OL converted to the CL 1.53 kha in 2014

Figure 6.13: *Development of activity data in kha for category 4.B Cropland in the period 1990 – 2014*

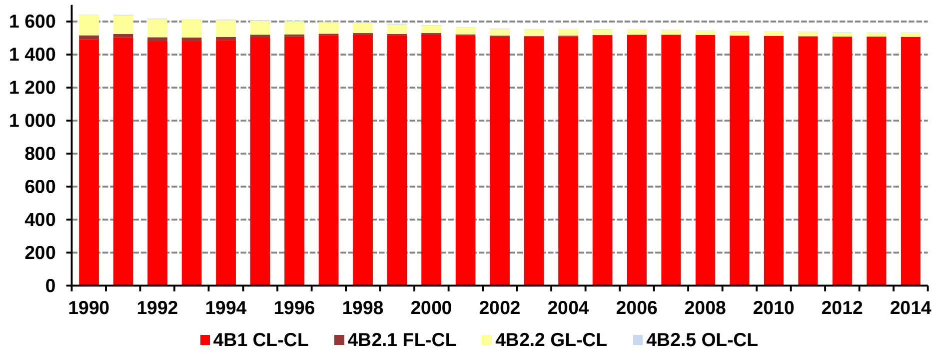
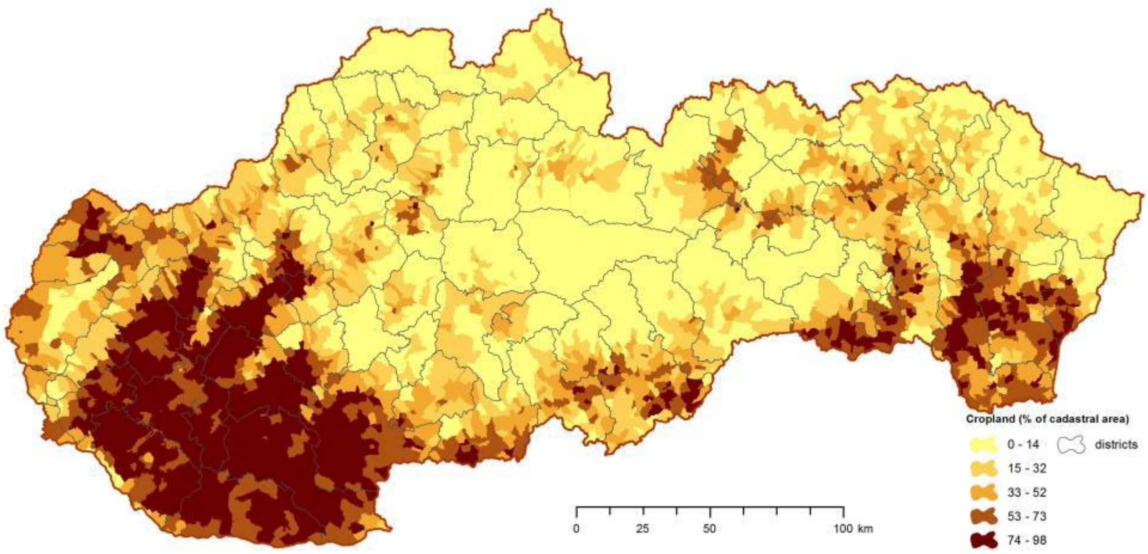


Figure 6.14: *Distribution of Cropland in Slovakia – calculated as a spatial share of the category within individual cadastral units*



6.8.2 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 include vineyards, orchards and gardens and represented 119.62 kha in 2014.

6.8.2.1 Methodological issues – methods, activity data, emission factors and parameters

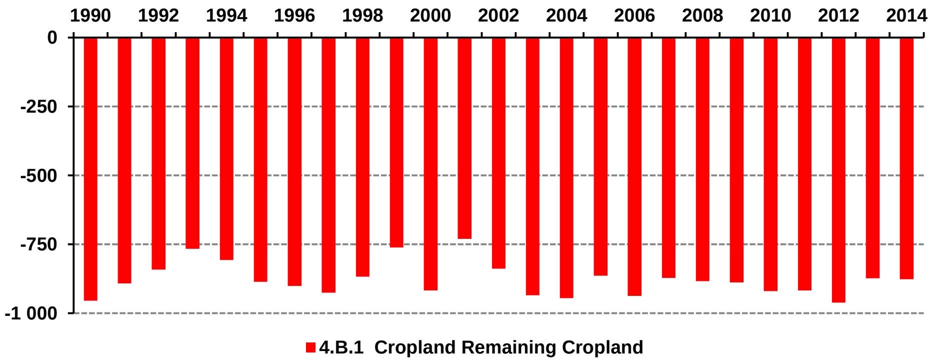
Change in biomass carbon stocks of Cropland remaining Cropland were estimated by tier 1 method (IPCC 2006 GL). The annual change of carbon stocks in biomass was calculated using equation 2.7 from 2006 IPCC GL. The immature perennial woody cropland area accumulates carbon at a rate of approximately 2.1 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. The organic soils do not occur on Cropland in Slovakia. 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 F_{LU} = 0.80, stock change factors for management regime F_{MG} = 1.0 and 1.1 respectively (full vs. no till.) and stock change factor for input of organic matter F_{I} = 1.0 were applied. However, country specific value for reference soil carbon stock for cropland was used (as for other calculation of carbon stock change in mineral soils). The changes in soil carbon stock associated with the annually changing proportion of cropland areas with different management result in emissions/removals. These are calculated after redistribution of estimated carbon stock change over a 20-year rolling period.

The net CO_2 removals in the category 4.B.1 Cropland remaining Cropland are 877.15 Gg in 2014.

Figure 6.15: *Summary results of CO_2 removals (Gg) in the category 4.B.1 in 1990 – 2014*



6.8.3 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.

6.8.3.1 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 broadleaves trees in the following categories: standing dead trees, stumps, coarse laying dead wood and small-sized laying dead wood. Each of the mentioned categories was classified in 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., 1997, 2002, Pavlenda, 2008). The mean value of 8.3 t C ha^{-1} 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 annual changes in carbon stocks in litter for Land converted to CL. 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 section 6.7.4.1.

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 (Mg C/ha/year) 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 tC/ha/yr
- GL converted to CL -0.742 tC/ha/yr
- S converted to CL +0.313 tC/ha/yr
- OL converted to CL +0.313 tC/ha/yr

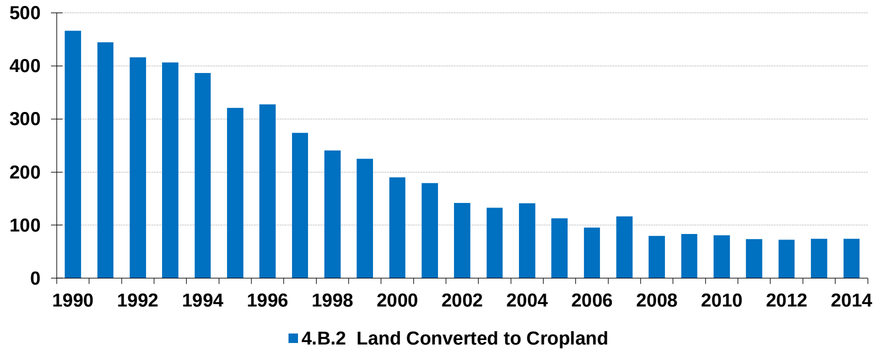
The change in soil carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category of land use associated with Land converted to Cropland. The land-use matrix from 1991 to 2014 is provided in the Table 6.10. The results from the category 4.B.2 Land converted to Cropland are summarized in the following Table 6.13.

Table 6.13: *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**	**-1.55**	**-1.55**	**-0.53**	**-18.20**	**74.33**
FL – CL	NO	-0.40	-0.40	-0.53	-0.49	5.22
GL – CL	NO	-1.14	-1.14	NO	-18.19	70.87
WL – CL	NO	NO	NO	NO	NO	NO
S – CL	NO	NO	NO	NO	NO	NO
OL – CL	NO	NO	NO	NO	0.48	-1.76

The category 4.B.2 Land converted to Cropland represents net emission 74.33 Gg of CO_2 in 2014. The net carbon stock change in living biomass, DOM and soil from Land converted to Cropland represented losses of -1.55, -0.53 and -18.20 Gg C in 2014.

Figure 6.16: *Summary of CO_2 emissions (in Gg) in the category 4.B.2 in 1990-2014*



6.8.3.2 Uncertainties and time-series consistency

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). This error range represents a nominal estimate of error, equivalent to two times standard deviation, as a percentage of the mean. Uncertainty estimation is not required at tier 1 since the DOM stocks are assumed to be stable (IPCC 2006 GL). Three broad sources of uncertainty exist in soil C inventories: 1) uncertainties in land-use and management activity, and environmental data; 2) uncertainties in reference soil C stocks if using a tier 1 approach (mineral soils only); and 3) uncertainties in the stock change/emission factors for tier 1 approaches (IPCC 2006 GL). The uncertainty for soil category was calculated using default relative stock change factor F_{LU} 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 time series are consistent, estimated by the consistent methodology, activity data collection way and using consistent emission factors and other parameters.

6.8.3.3 Category-specific QA/QC and verification

The QC checks (e.g. consistency check between CRF data and national statistics) have been done during the CRF and NIR compilation. The QA is conducted by another LULUCF expert from the National Forest Centre and National Agricultural and Food Centre and in the next step by independent expert from the Ministry of Agriculture and Rural Development of the Slovak Republic.

6.8.3.4 Category-specific recalculations

The recalculations in this land-use category were not applied.

6.8.3.5 Category-specific planned improvements

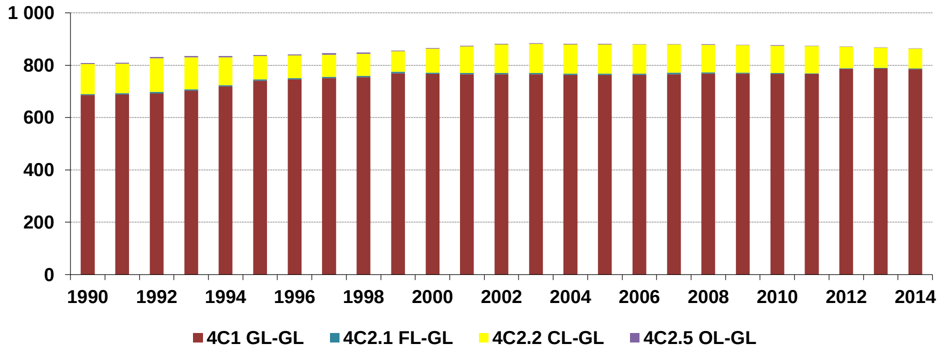
Estimation of more accurate soil carbon stocks data for soils representing Cropland is planned for the next submission.

6.9 GRASSLAND (CRF 4.C)

6.9.1 Category description

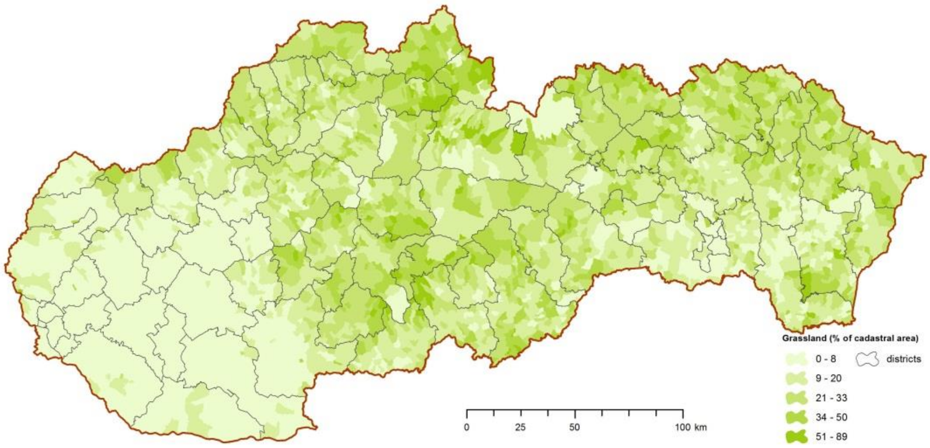
The emissions and removals of GHGs in this category were obtained by using the IPCC 2006 GL for LULUCF and national data on Grassland and Land converted to Grassland area in 2014. The total area of Grassland represented 864.681 kha in 2014; this is approximately 17.63% of the total country area. Grassland area decreased from 1980 to beginning of 1990 and since this year increased up to 2005. Since 2005 shows moderately decreasing trend.

Figure 6.17: *Development of activity data in kha for category 4.C Grassland in the period 1990 – 2014*



The total area of Grassland remaining Grassland was 785.35 kha in 2014, the changes in the Grassland were following: Forest land converted to Grassland 2.20 kha, Cropland converted to the Grassland 76.20 kha, Other land converted to Grassland 0.93 kha in 2014.

Figure 6.18: *Distribution of Grassland in Slovakia – calculated as a spatial share of the category within individual cadastral units*



6.9.2 Grassland remaining Grassland (CRF 4.C.1)

Tier 1 approach 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.

6.9.3 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 (IPCC 2013 GL). 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.

6.9.3.1 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., 1997, 2002, 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 annual changes in carbon stocks in litter for FL converted to GL. 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 section 6.7.4.1 of this chapter. 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) x 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/year
- CL converted to GL +0.742 t C/ha/year
- OL converted to GL +1.055 t C/ha/year

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 1991 to 2014 is provided in the Table A6.1 (Annex). The results of balance of the category 4.C.2 Land converted to Grassland are summarized in the following Table 6.14.

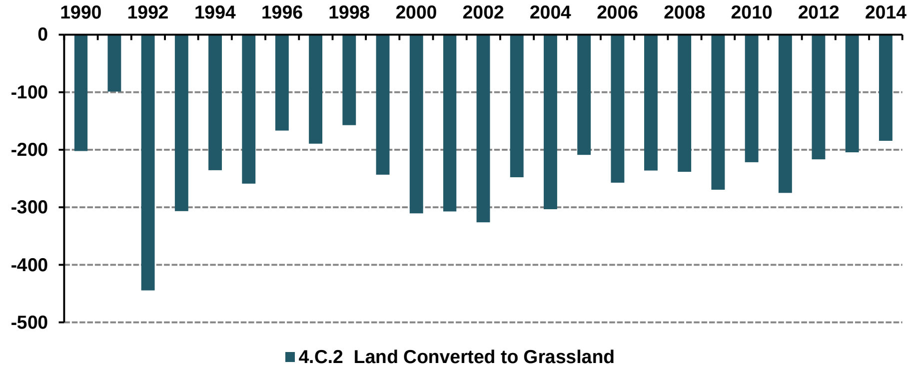
Table 6.14: *Results for the category 4.C.2 Land converted to Grassland*

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	**0.19**	**-5.11**	**-4.92**	**-0.69**	**55.97**	**-184.65**
FL - GL	NO	-5.11	-5.11	-0.69	-1.55	26.95
CL - GL	0.19	NO	0.19	NO	56.54	-208.02
WL - GL	NO	NO	NO	NO	NO	NO
S - GL	NO	NO	NO	NO	NO	NO
OL - GL	NO	NO	NO	NO	0.98	-3.58

Total removals estimated in this category were 184.65 Gg CO_2 in 2014. The net carbon stock change in living biomass and net carbon stock change in soil for this category represented losses of -4.92 and

55.97 Gg C, but the DOM from Land converted to Grassland represented the losses of -0.69 Gg C in the reporting year 2014.

Figure 6.19: *Summary of CO_2 removals (in Gg) in the category 4.C.2 in 1990 – 2014*



6.9.3.2 Uncertainties and time-series consistency

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 default uncertainty for biomass accumulation rate and biomass carbon loss in Grassland ±75% was used, according to tier 1 method (IPCC 2013 GL). This error range represents a nominal estimate of error, equivalent to two times standard deviation, as a percentage of the mean. 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%. The accuracy of dead wood (DW) volume for different parts of DW and tree species was published by Šmelko et al. (2008). More information is in the section Forest land of this chapter.

The time series are consistent, estimated by the consistent methodology, activity data collection way and using consistent emission factors and other parameters.

6.9.3.3 Source specific QA/QC and verification

The QC checks (e.g. consistency check between CRF data and national statistics) have been done during the CRF and NIR compilation. The QA is conducted by another LULUCF expert from the National Forest Centre and in next step by independent expert from the Ministry of Agriculture and Rural Development of the Slovak Republic.

6.9.3.4 Source specific recalculations

No recalculation was applied to this category since the last submission.

6.9.3.5 Source specific planned improvements

Following improvements are planned for this category for the next submission:

- Estimation of more accurate soil carbon stocks data for soils representing grassland.

6.10 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.

6.11 SETTLEMENTS (CRF 4.E)

6.11.1 Source category description

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 234.416 kha in 2014. The increasing trend of settlements area is visible for the time series data. 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 117.37 kha, the changes in the Settlements were following: FL converted to S 0.96 kha, CL converted to S 14.82 kha, GL converted to S 5.47 kha and OL converted to S 95.79 kha in 2014.

Figure 6.20: *Development of activity data in kha for category 4.E Settlements in the period 1990 –2014*

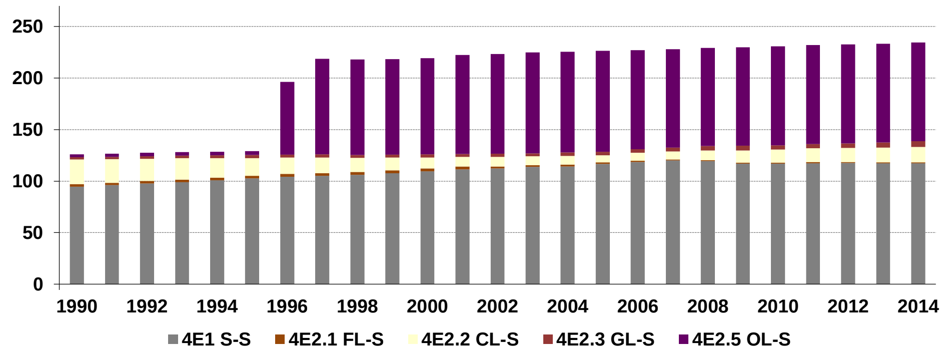
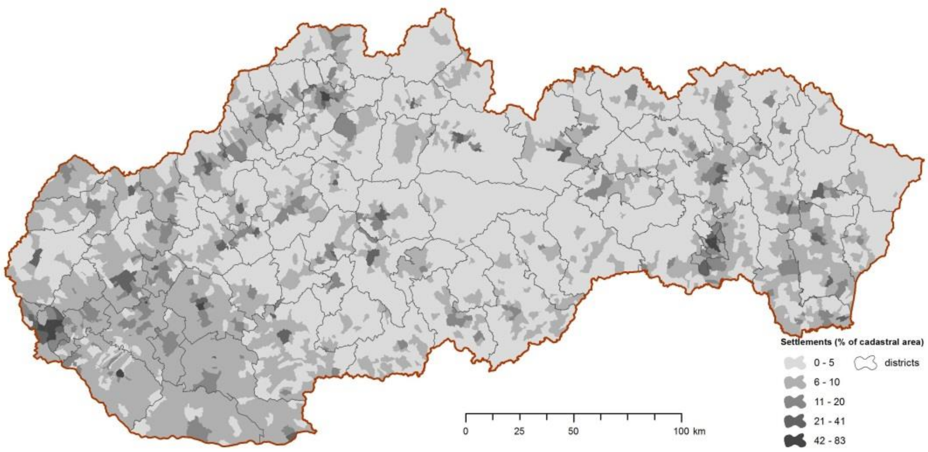


Figure 6.21: *Distribution of Settlements in Slovakia – calculated as a spatial share of the category within individual cadastral units*



6.11.2 Settlements remaining Settlements (CRF 4.E.1)

For this category 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). This is a conservative assumption, if the country did not expected significant changes in land use types, disturbance or management regimes within the reporting year.

6.11.3 Land converted to Settlements (CRF 4.E.2)

This category includes all processes connected with conversion of Land into Settlements.

6.11.3.1 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., 1997, 2002 and Pavlenda, 2008) and loss of carbon in the year of conversion. The mean value is 8.3 Mg C ha^{-1} 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.

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.

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 (Mg 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 Mg C/ha/yr
- CL converted to S -0.313 Mg C/ha/yr
- GL converted to S -1.055 Mg C/ha/yr

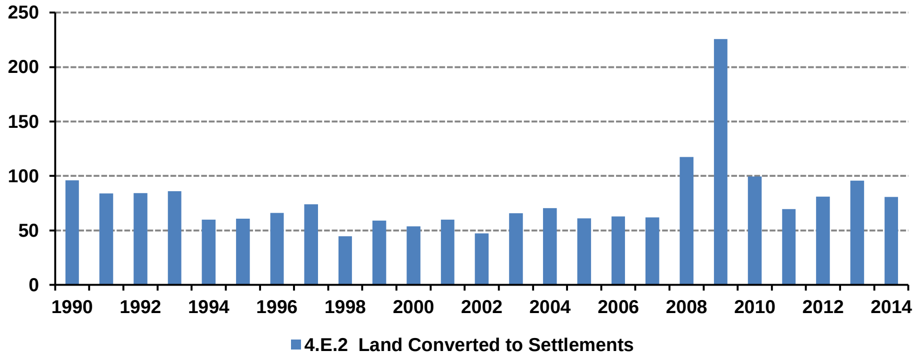
The change in soil carbon stock in each year was calculated as the sum of annual changes in carbon stocks for each category of land use associated with Land converted to Settlements. The land-use matrix from 1992 to 2014 is provided in the Table A6.1 (Annex). The results from the category 4.E.2 Land converted to Settlements in 2014 are summarized in the following Table 6.15.

***Table 6.15:** Results for the category 4.E.2 Land converted to Settlements in 2014*

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**	**-9.39**	**-9.39**	**-0.49**	**-12.10**	**80.60**
FL - S	NO	-3.87	-3.87	-0.49	-1.69	22.17
CL - S	NO	-2.84	-2.84	NO	-4.64	27.41
GL - S	NO	-2.68	-2.68	NO	-5.78	31.02
WL - S	NO	NO	NO	NO	NO	NO
OL - S	NO	NO	NO	NO	NO	NO

In the reporting year 2014 total emissions estimated in this category were 80.60 Gg CO_2, the net carbon stock change in living biomass, DOM and in soil for this category represented losses of -9.39, -0.49 and -12.10 Gg C respectively.

***Figure 6.22:** Summary of CO_2 emissions (in Gg) in the category 4.E.2 in 1990 – 2014*



6.11.3.2 Uncertainties and time-series consistency

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 default uncertainty ±75% for biomass accumulation rate was used, according to tier 1 method published by IPCC 2006 GL. This error range represents a nominal estimate of error, equivalent to two times standard deviation, as a percentage of the mean. 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 15-20%. The accuracy of dead wood volume for different parts of DW and tree species was published by Šmelko et al. (2008).

The time series are consistent, estimated by the consistent methodology, activity data collection way and using consistent emission factors and other parameters.

6.11.3.3 Source specific QA/QC and verification

The QC checks (e.g. consistency check between CRF data and national statistics) were done during the CRF and NIR compilation. The QA is conducted by another LULUCF expert from the National Forest Centre and in next step by independent expert from the Ministry of Agriculture and Rural Development of the Slovak Republic.

6.11.3.4 Source specific recalculations

No recalculation was applied to this category since the last submission.

6.11.3.5 Source specific planned improvements

There are no short term plans concerning improvements in this land use category.

6.12 OTHER LAND (CRF 4.F)

6.12.1 Source category description

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 2014. The total area of Other land represented 160.96 kha in 2014 which is 3.3% 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 131.13 kha, the changes in Other land were following: FL converted to OL 2.02 kha, CL converted to OL 12.66 kha, GL converted to OL 4.06 kha, S converted to OL11.09 kha in 2014.

Figure 6.23: *Development of activity data in kha for category 4.F Other Land in the period 1990 – 2014*

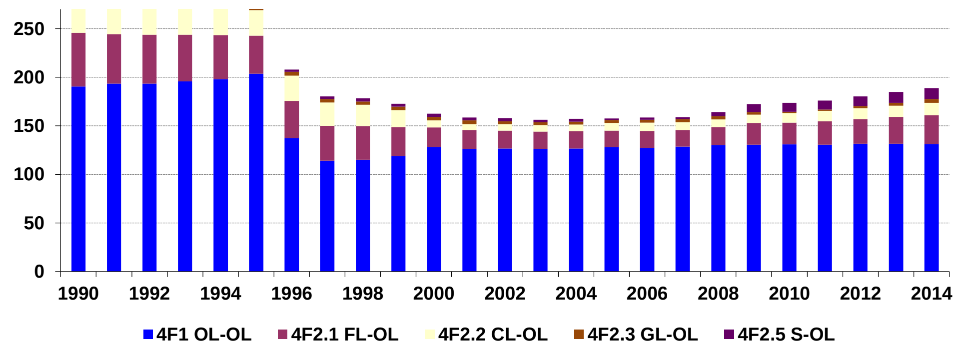
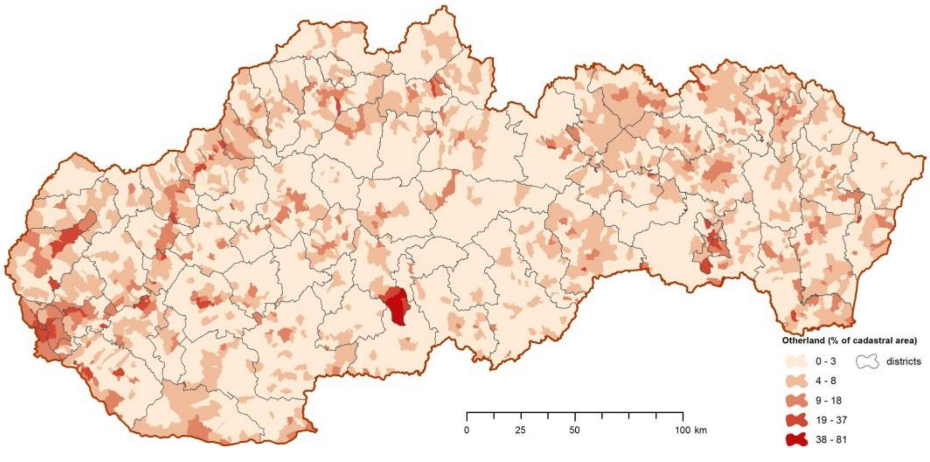


Figure 6.24: *Distribution of Settlements in Slovakia – calculated as a spatial share of the category within individual cadastral units*



6.12.2 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 organic 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.

6.12.3 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.

6.12.3.1 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., 1997, 2002, Pavlenda, 2008) and total loss of litter in the year of conversion. The mean value 8.3 Mg C/ha/year 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 (Mg C/ha/year) * 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.

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 section 6.7.4.1 of this chapter. 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 (Mg 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 Mg C/ha/yr
- CL converted to OL -0.313 Mg C/ha/yr
- GL converted to OL -0.704 Mg 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 1992 to 2014 is provided in the Table 6.11.

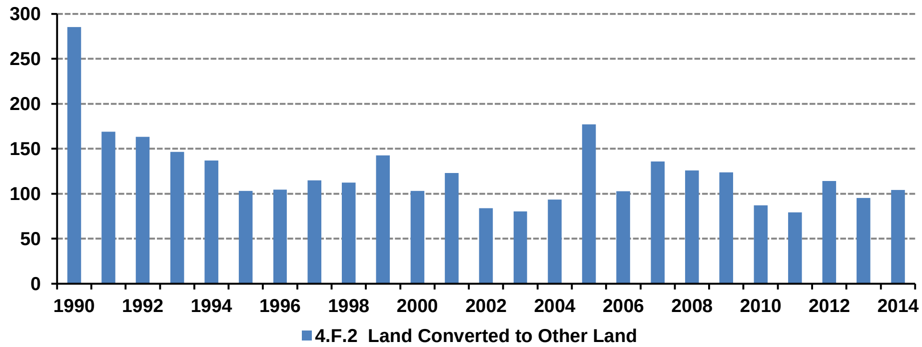
The results from the category 4.F.2 Land converted to Other land are summarized in the following Table 6.16.

Table 6.16: Results for the category 4.F.2 Land converted to Other land in 2014

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**	**-15.93**	**-15.93**	**-0.74**	**-11.80**	**104.36**
FL – OL	NO	-5.57	-5.57	-0.74	-3.55	36.14
CL – OL	NO	-5.81	-5.81	NO	-3.96	35.82
GL – OL	NO	-4.55	-4.55	NO	-4.29	32.40
WL – OL	NO	NO	NO	NO	NO	NO
S - OL	NO	NO	NO	NO	NO	NO

In the reporting year 2014 total emissions estimated in this category were 104.36 Gg CO_2 , the net carbon stock change in living biomass, DOM and soil for this category represented losses of -15.93, -0.74 and -11.80 Gg C respectively.

Figure 6.25: Summary of CO_2 emissions (in Gg) in the category 4.F.2 in 1990 – 2014



6.12.3.2 Uncertainties and time-series consistency

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 default uncertainty ±75% for biomass accumulation rate was used, according to tier 1 method published by IPCC 2006 GL. This error range represents a nominal estimate of error, equivalent to two times standard deviation, as a percentage of the mean. 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 15-20%. The accuracy of dead wood volume for different parts of DW and tree species was published by Šmelko et al. (2008).

The time series are consistent, estimated by the consistent methodology, activity data collection way and using consistent emission factors and other parameters.

6.12.3.3 Source specific QA/QC and verification

The QC checks (e.g. consistency check between CRF data and national statistics) were done during the CRF and NIR compilation. 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.

6.12.3.4 Source specific recalculations

No recalculation was applied to this category since the last submission.

6.12.3.5 Source specific planned improvements

No improvements are planned for this category for the next submission.

6.13 DIRECT N_2O EMISSIONS FROM N FERTILIZATION OF FOREST LAND AND OTHER (CRF 4(I))

6.13.1 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.

6.14 NON CO_2 EMISSIONS FROM DRAINAGE OF SOILS AND WETLANDS (CRF 4(II))

6.14.1 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).

6.15 DIRECT NITROUS OXIDE (N_2O) EMISSIONS FROM NITROGEN (N) MINERALIZATION/IMMOBILIZATION ASSOCIATED WITH LOSS/GAIN OF SOIL ORGANIC MATTER RESULTING FROM CHANGE OF LAND USE OR MANAGEMENT OF MINERAL SOILS (CRF 4(III))

The 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 IPCC 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.

Table 6.17: *Results for the category 4(III) – Direct N_2O emissions from N mineralization/Immobilization in 2014*

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA	IMPLIED EMISSION FACTORS	EMISSIONS
Land-use category	**Land area converted (kha)**	**N_2O-N emissions per area converted (kg N_2O-N/ha)**	**N_2O (Gg)**
Total all land-use categories	**161.04**	**0.21**	**0.05**
B. Cropland	**24.85**	**0.71**	**0.03**
2. Lands converted to Cropland	26.39	1.11	0.03
Organic Soils	NO	NO	NO
Mineral Soils	26.39	1.11	0.03
2.1 Forest Land converted to Cropland	0.34	2.55	0.001
Organic Soils	NO	NO	NO
Mineral Soils	0.34	2.55	0.001
2.2 Grassland converted to Cropland	24.51	1.08	0.03
Organic Soils	NO	NO	NO
Mineral Soils	24.51	1.08	0.03
2.3 Wetlands converted to Cropland	NO	NO	NO

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	ACTIVITY DATA	IMPLIED EMISSION FACTORS	EMISSIONS
Land-use category	**Land area converted (kha)**	**N_2O-N emissions per area converted (kg N_2O-N/ha)**	**N_2O (Gg)**
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	1.53	NO	NO
Organic Soils	NO	NO	NO
Mineral Soils	1.53	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.

6.16 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.

6.17 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.

6.18 HARVESTED WOOD PRODUCTS (HWP) (CRF 4.G)

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: 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 Category 4.A (Forest land).

6.18.1 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 next Table 6.18.

Table 6.18: *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	1 872	0.834	0.166	0.868	0.132	0.723	0.277	35
Wood based boards	1 873	0.716	0.284	0.719	0.281	0.851	0.149	25
Paper and paperboards	1 876	0.655	0.345	0.772	0.228	0.598	0.402	2

The change in carbon stocks was estimated separately for each product category by applying equation 2.8.4 in IPCC 2013 GL. 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 were recalculated (see also Chapter 6.6) and are provided in the next Table 6.19 and Figure 6.26.

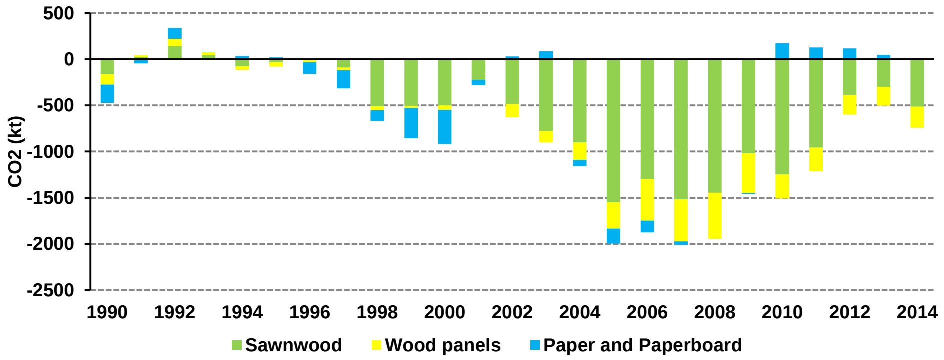
Table 6.19: *Greenhouse gas emissions (positive signs) and removals (negative signs) from HWP from forest land under Forest management.*

CO_2 EMISSIONS AND REMOVALS FROM HWP	1990	1991	1992	1993	1994	1995	1996	1997	1998
	Net CO_2 equivalent emissions/removals (kt CO_2)								
4.G (UNFCCC) / Art. 3.4 (KP)	**-470.41**	**1.88**	**337.73**	**75.33**	**-80.37**	**-58.77**	**-158.91**	**-314.70**	**-669.73**
gains sawnwood	644.3	477.6	357.6	453.8	572.5	528.7	511.6	590.8	1016.9
gains wood panels	381.9	256.9	198.4	245.2	315.1	327.9	298.1	306.7	320.1
gains paper	606.8	497.0	322.2	419.1	380.4	382.8	551.1	677.5	653.9
losses sawnwood	-482.8	-501.0	-499.3	-497.5	-497.8	-498.8	-499.2	-500.3	-506.2
losses wood panels	-268.6	-279.2	-277.8	-276.3	-276.4	-277.6	-278.6	-279.2	-280.2
losses paper	-411.2	-453.1	-438.9	-419.7	-413.6	-404.2	-424.0	-480.8	-534.8

CO_2 EMISSIONS AND REMOVALS FROM HWP	1999	2000	2001	2002	2003	2004	2005	2006	2007
	Net CO_2 equivalent emissions/removals (kt CO_2)								
4.G (UNFCCC) / Art. 3.4 (KP)	**-857.56**	**-920.07**	**-273.78**	**-597.09**	**-814.86**	**-1 157.87**	**-1 996.46**	**-1 875.88**	**-2 011.7**
gains sawnwood	1 021.1	1 027.0	755.5	1 025.2	1 328.4	1 471.7	2 144.2	1 916.8	2 169.0
gains wood panels	304.4	330.0	275.3	427.4	414.0	478.1	582.4	763.2	775.1
gains paper	944.0	1107.8	866.9	781.2	704.7	860.0	993.8	1008.1	948.2
losses sawnwood	-516.3	-526.2	-533.4	-540.4	-552.9	-569.5	-593.8	-622.0	-649.9
losses wood panels	-281.0	-282.0	-282.6	-284.5	-288.2	-292.5	-299.0	-309.3	-321.8
losses paper	-614.6	-736.5	-807.9	-811.9	-791.1	-789.8	-831.1	-881.0	-908.9

CO_2 EMISSIONS AND REMOVALS FROM HWP	2008	2009	2010	2011	2012	2013	2014
	Net CO_2 equivalent emissions/removals (kt CO_2)						
4.G (UNFCCC) / Art. 3.4 (KP)	**-1 938.06**	**-1 459.91**	**-1 334.52**	**-1 083.35**	**-480.21**	**-455.50**	**-730.64**
gains sawnwood	2 123.3	1 723.3	1 972.9	1 704.9	1 147.8	1 066.0	1 289.1
gains wood panels	835.7	778.1	619.5	620.6	583.4	581.0	611.8
gains paper	907.5	924.9	710.3	702.7	670.7	714.8	740.5
losses sawnwood	-679.2	-703.6	-726.0	-747.8	-761.1	-767.9	-775.9
losses wood panels	-335.1	-348.0	-357.5	-364.7	-371.2	-377.0	-383.0
losses paper	-914.1	-914.9	-884.6	-832.4	-789.4	-761.5	-751.8

Figure 6.26: *CO_2 emissions (positive values) and removals (negative values) from HWP in Slovakia in 1990 and 2014 originating from forest land under forest management in kt CO_2 eq.*



6.18.2 Uncertainties and time series consistency

For the input data following information on relative uncertainty was used:

Roundwood harvest is ±5% (national activity data from reporting of forest managers), sawnwood, wood panels and paper are ±10% based on statistical survey. Conversion factor for wood density is ±25% (default from the IPCC 2006 GL). Carbon contents in wood products is estimated as ±10% (assessment of carbon content in wood). Emission factors (half-life estimates) are ±50% (default from the IPCC 2006 GL). The total relative uncertainty of carbon losses and gains in HWP can be calculated as:

$U_{HWP} = \sqrt{(5^2 + 10^2 + 25^2 + 10^2 + 50^2)} = 58\%$

Time series for HWP is considered consistent.

6.18.3 Category-specific QA/QC and verification

The general QA/QC measures were applied (please see also in previous chapters). No category-specific QA/QC activities have been carried out.

6.18.4 Category-specific recalculations

There was the recalculation applied, the reason is described in Chapter 6.6.

A6.1: 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*

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	**Initial area (1989)**
Forest Land (managed)	1 985.219	0.000	0.010	0.353	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 unmanaged 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 unmanaged 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**	**-4.380**	**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 unmanaged 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**

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	Initial area (1993)
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 unmanaged 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 unmanaged 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**

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)**
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 unmanaged 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 unmanaged 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**

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)**
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**

Category	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	**Initial area (1999)**
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 unmanaged 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 unmanaged 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**

CATEGORY	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetland (managed)	Wetland (unmanaged)	Settlements	Other Land	Total unmanaged land	**Initial area (2001)**
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 unmanaged 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**

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 (2006)**
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	0.000	0.000	0.000	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	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	225.811	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 unma-naged 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**	**-1.660**	**-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 unma-naged 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**

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 (2010)**
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**	**-2.260**	**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**

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)**
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 unma-naged land	**Initial area (2013)**
Forest Land (managed)	2 015.219	0.000	0.004	0.052	0.000	0.000	0.000	0.037	0.056	0.000	**2 015.368**
Forest Land (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**
Cropland	0.168	0.000	1 531.511	0.113	0.000	0.000	0.000	0.604	1.236	0.000	**1 533.632**
Grassland (managed)	1.582	0.000	0.675	864.516	0.000	0.000	0.000	0.420	0.868	0.000	**868.061**
Grassland (unmanaged)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**
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	233.305	0.000	0.000	**233.305**
Other Land	0.136	0.000	0.169	0.000	0.000	0.000	0.000	0.05	158.799	0.000	**159.154**
Total unmanaged land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**
Final area (2014)	**2 017.105**	**0.000**	**1 532.359**	**864.681**	**0.000**	**94.000**	**0.000**	**234.416**	**160.959**	0.000	**4 903.52.**
Net change	**1.737**	**0.000**	**-1.273**	**-3.380**	**0.000**	**0.000**	**0.000**	**1.111**	**1.805**	**0.000**	

CHAPTER 7: WASTE

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 2016 submission is presented in this chapter:

- 5.A Solid waste disposal;
- 5.B Biological treatment of solid waste;
- 5.C Incineration and open burning of waste;
- 5.D Wastewater treatment and discharge;
- 5.F Memo Items (HWP).

Total aggregated emissions from waste were 1 585.58 Gg of CO_2 eq. in 2014 and they remained almost stable compared to previous year. Compared to reference year 1990, emissions increased by 8.25%. Increase of emissions in waste disposal was compensated by decrease of emissions in biological treatment, incineration and waste water treatment. Emissions from waste (municipal and industrial) incineration with energy use were allocated to the energy sector (in subcategories 1.A.1.a.iv, 1.A.2.f, see Chapter 3).

7.2 QUANTITATIVE OVERVIEW

Majority of GHG emissions from waste sector are in form of CH_4 with 91.2% share, followed by 8.4% of N_2O and 0.4% of CO_2. The most important source of GHG emissions is solid waste disposal (66.08%), followed by waste water treatment (22.71%), biological treatment (10.43%) and incineration of waste without energy recovery (0.78%). Waste sector contributed 3.9% to total GHG emissions without LULUCF in year 2014.

Table 7.1: *The share of categories in Waste sector*

Category	GHG (Gg CO_2 eq.)	Share (%)
5.A Solid waste disposal	1 047.75	66.08
5.B Biological treatment	165.36	10.43
5.C Incineration	12.36	0.78
5.D Waste water treatment	360.12	22.71

7.3 TRENDS OF EMISSIONS IN SECTOR WASTE

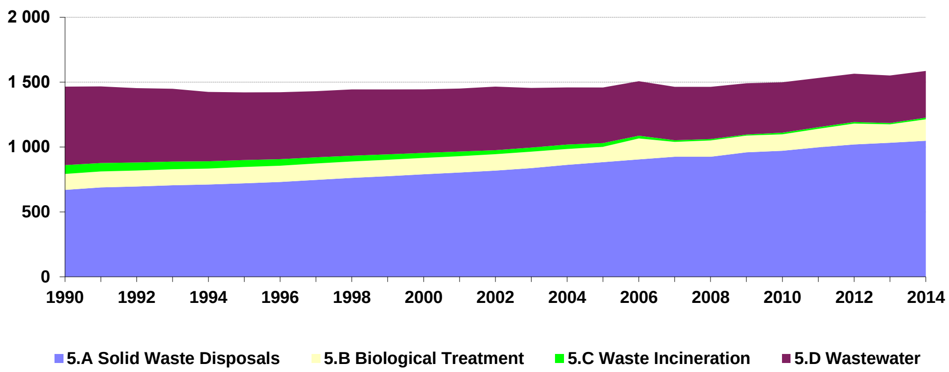
Emissions from waste are relatively stable over the entire period 1990 – 2014. Emissions from waste disposal (5.A) are increasing in long term, due to improvement of disposal practice. Emissions from waste water treatment (5.D) are decreasing also due to modernisation of waste water treatment plants. Emissions from biological treatment (5.B) do not vary significantly. Emissions from incineration of waste without energy recovery (5.C) are decreasing. However, trends on biological treatment and incineration should be taken with caution, because more than half of time series had to be extrapolated due to missing data.

Table 7.2: GHG emissions in Waste sector according to the gases and categories 1990 – 2014

Year	Total CO_2	Total CH_4	Total N_2O	GHG	Total 5.A	Total 5.B	Total 5.C	Total 5.D
	Gg			Gg of CO_2 eq.				
1990	60.25	48.08	0.68	1 464.71	669.48	122.92	67.83	604.48
1991	57.45	48.67	0.64	1 466.36	688.63	122.92	64.93	589.88
1992	54.66	48.83	0.60	1 453.18	695.73	122.92	62.02	572.52
1993	51.86	48.95	0.58	1 448.19	705.13	123.19	59.12	560.75
1994	49.06	48.07	0.58	1 423.96	711.05	122.73	56.20	533.98
1995	46.26	48.09	0.58	1 420.39	720.23	125.84	53.30	521.02
1996	43.46	48.25	0.58	1 421.57	730.78	125.08	50.38	515.53
1997	40.66	48.71	0.58	1 429.86	746.45	126.46	47.48	509.46
1998	37.86	49.37	0.57	1 443.29	762.08	126.33	44.59	510.30
1999	35.06	49.77	0.55	1 443.09	775.03	126.57	41.69	499.81
2000	32.26	50.35	0.51	1 443.87	789.75	126.01	38.76	489.35
2001	29.46	50.85	0.50	1 449.90	803.35	125.65	35.87	485.03
2002	24.71	51.21	0.54	1 464.96	818.05	126.57	30.48	489.85
2003	26.42	51.61	0.46	1 454.70	837.20	126.84	31.46	459.19
2004	28.00	51.97	0.44	1 458.56	862.38	122.17	34.23	439.79
2005	21.86	52.36	0.43	1 458.06	883.18	118.22	28.62	428.05
2006	14.69	53.81	0.49	1 506.53	904.35	161.43	21.03	419.72
2007	7.52	53.36	0.41	1 463.31	924.78	114.39	12.78	411.36
2008	5.71	53.42	0.41	1 463.04	924.83	125.64	10.39	402.18
2009	5.04	54.67	0.40	1 490.67	958.85	129.07	8.01	394.74
2010	7.31	54.94	0.39	1 498.33	970.75	126.75	12.66	388.16
2011	9.58	55.99	0.41	1 531.19	997.45	142.50	12.29	378.94
2012	7.92	57.09	0.43	1 564.20	1 019.48	160.85	11.91	371.97
2013	6.64	57.01	0.40	1 550.45	1 032.40	142.14	10.00	365.91
2014	6.16	57.86	0.45	1 585.58	1 047.75	165.36	12.36	360.12

Methane emissions from municipal waste disposal sites (SWDS) have the largest share on total emissions from the sector. Waste balance methodology has been revised to accommodate for the 2006 IPCC GL, waste model and tier 2 approach FOD (First Order Decay) methodology has been used for non-municipal waste emission estimation. Analysis of landfill database resulted in new assignment of MCF parameter and there are no SWDS marked as "uncategorised". A more detailed description of the methodology as well as with the Monte Carlo uncertainty analysis are described in the references (see Annex – References, Waste).

Figure 7.1: Waste sector emissions by trends 1990 – 2014



Activity data for emissions estimation of waste incineration were disaggregated into two groups, i.e. waste incineration with and without energy utilisation. Each group was further divided into biogenic waste incineration and non-biogenic (C-fossil) waste incineration. This 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, subcategory 1.A.1.a.iv (other fuels) and in subcategory 1.A.2.f. The emissions from waste incineration without energy utilisation are reported under waste sector (5.C).

Emissions from waste composting are reported under biological treatment and no anaerobic digestion of solid waste at biogas facilities 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.

7.4 METHODOLOGICAL TIERS

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 7.3: *Overview of tiers used in waste sector*

Emission category	Tier used	Note (responses to Decision Tree)
5.A Solid waste disposal	Tier 2	Good quality CS AD are available; CS models and parameters not available.
5.B Biological treatment	default method Tier 1 parameters	CS data on waste available; CS emission factors not available.
5.C Incineration and open burning – CO_2	Tier 2a	Plant specific data not available; CS data on waste available; CS emission factors not available.
5.C Incineration and open burning – CH_4 and N_2O	Tier 2	Plant specific data not available; CS data on waste available.
5.D Waste water	Tier 2	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.

Note to use of the IPCC 2006 Guidelines:

Introduction of the IPCC 2006 Guidelines for National Greenhouse Gas Inventories was connected with full review of the waste sector. Activity data, parameters and emission factors were fully reviewed and new information on situation in the waste sector was incorporated in models.

Completeness of emissions estimation for the entire sector ensured use of the EU waste classification[2] for division of waste. This classification divides waste to 20 waste groups and covers all waste types for which emission estimations are required by the IPCC 2006 Guidelines.

- 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.

[1] Governmental Regulation No. 268/2010, as amended No. 491/2002 Z.z. and No.242/1993 Z.z

[2] The European List of Waste (Commission Decision 2000/532/EC) incorporated into Slovak legal system as the Decree of the Ministry of Environment No. 284/2001

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). Statistical data on waste generation, disposal, incineration and recovery 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.

7.5 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 41.91 Gg (1 047.75 Gg of CO_2 eq.) in 2014 and they increased by 1.5% compared to previous year. This increase was caused by improvement of disposal practice in the past which enhanced generation of landfill gas from disposed waste. Emissions from solid waste disposal increased in comparison with the base year by 1.5 times due to improvement of disposal practices and increase of the amount of disposed waste. The emissions of NMVOC were estimated to be 5.87 kt in 2014.

Table 7.4: *GHG emissions in individual categories of Solid waste disposal in 1990 – 2014*

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	26.78	NO	0.00	20.07	6.71
1991	27.55	NO	0.00	20.59	6.96
1992	27.83	NO	0.00	20.70	7.13
1993	28.21	NO	0.00	20.93	7.27
1994	28.44	NO	0.00	21.10	7.34
1995	28.81	0.13	0.04	21.23	7.40
1996	29.22	0.40	0.11	21.31	7.41
1997	29.86	0.83	0.22	21.41	7.41
1998	30.48	1.37	0.36	21.38	7.38
1999	31.00	1.97	0.51	21.21	7.31
2000	31.59	2.69	0.69	20.99	7.22
2001	32.13	3.46	0.90	20.65	7.13
2002	32.72	4.31	1.14	20.25	7.02
2003	33.49	5.29	1.42	19.87	6.90
2004	34.50	6.53	1.74	19.45	6.77
2005	35.33	7.76	2.01	18.95	6.61
2006	36.17	8.95	2.38	18.39	6.46
2007	36.99	10.04	2.88	17.77	6.30
2008	36.99	10.43	3.34	17.11	6.12
2009	38.35	12.16	3.88	16.39	5.92
2010	38.83	13.18	4.21	15.71	5.73
2011	39.90	14.92	4.38	15.07	5.53
2012	40.78	16.47	4.52	14.44	5.35
2013	41.30	17.50	4.77	13.85	5.17
2014	41.91	18.49	5.13	13.28	5.01

Disposal of solid waste on land covers two subcategories: Managed waste disposal sites (4.A.1) and Unmanaged waste disposal sites (4.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.

In 2014, there were 95 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 in mostly uncontrolled manner in dumps. The State Geological Institute (Statny geologicky ustav Dionyza Stura (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 SOURCE CATEGORY DESCRIPTION – MUMINICPAL WASTE DISPOSAL SITES

7.5.1.1 Methodological issues – methods

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.

7.5.1.2 Methodological issues – emission factors and parameters

Parameters used in the IPCC 2006 Waste model are of two types. Those 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 was analysed to divide disposal sites by altitude. 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	1950	1960	1970	1980	1990	1995	2000	2005	2010	2014
DOC	0.089	0.093	0.100	0.111	0.123	0.127	0.127	0.124	0.118	0.112

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 (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. Modern landfills are after completion 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.

7.5.1.3 Activity data

Total MSW disposed to 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, this is not sufficient 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 Kosice). These two incinerators burned in average 150 Gg MSW per year in the period 1993 – 2014 (Bratislava 100 Gg/yr, Kosice 50 Gg/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 – 2014: Real data on MSW disposed were used

Overview of activity data for the entire timeline 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

The increase of MSW per capita in 2014 corresponds with the increase of IRW.

4.5.1.4 Completeness

Emissions from municipal waste disposed to SWDSs were estimated from unmanaged disposal sites, created before 1995, managed landfills developed after 1995 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.

4.5.1.5 Time series consistency

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.

4.5.1.6 Uncertainties

The default IPCC uncertainties were used and where possible were adjusted to reflect country-specific data.

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 – 2014
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)

4.5.1.7 Source specific QA/QC and verification

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 analysing of the National Waste Management Plan and the National Strategy on Biodegradable Waste Management.

4.5.1.8 Source specific recalculations

Emissions from waste disposed to SWDSs were recalculated since 2003 due to incorrectly assigned recovery of landfill gas to unmanaged SWDSs (5.A.2). In this submission recovery of landfill gas is assigned to managed SWDSs (5.A.1). This recalculation does not have impact of sectoral emission totals. Impact of recalculation (or more correctly redistribution) on time series is shown in the Table 7.9 below.

Table 7.9: *Comparison of emissions after re-assigning recovery of landfill gas from unmanaged SWDS to managed SWDS*

Year	2015 submission		2016 submission	
	5.A.1	5.A.2	5.A.1	5.A.2
	Emissions CH_4 (Gg)			
2003	6.83	26.66	6.71	26.78
2004	8.41	26.09	8.27	26.23
2005	9.93	25.39	9.77	25.56
2006	11.67	24.50	11.33	24.84
2007	13.65	23.34	12.92	24.07
2008	15.69	21.30	13.77	23.22
2009	17.99	20.36	16.04	22.31
2010	20.05	18.78	17.39	21.44
2011	21.84	18.05	19.30	20.60
2012	23.35	17.43	20.99	19.79
2013	24.86	16.44	22.27	19.02

4.5.1.9 Source specific improvements

Probably the most important change having an impact on estimating emissions from the SWDS is using waste composition based on modelling. It is planned to review the model on composition of municipal solid waste and verify modelled results by using other waste composition studies.

7.5.2 SOURCE CATEGORY DESCRIPTION – NON-MUNICIPAL DISPOSAL SITES

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.

Waste streams containing biodegradable waste were selected from industrial waste statistics.

7.5.2.1 Methodological issues – methods

The estimation of methane emissions by FOD method from non-MSW disposed to SWDSs were calculated using the IPCC 2006 spreadsheet 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 biodegradable waste (Table 7.10). According to 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.

7.5.2.2 Methodological issues – emission factors and parameters

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 7.10: *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	0.4	0.06	sludge

7.5.2.3 Activity data

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 – 2014, 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.

Time series for industrial waste groups (02, 03, 04, 15) were correlated to index of gross production of relevant industrial sector for the period 1950 – 1989 and to the final energy consumption in industry for the period 1990 – 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 treated wastewater. 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 and number of hospital beds per 1 000 people back to the 1950. Waste water treatment data was linearly extrapolated.

7.5.2.4 Completeness

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.

7.5.2.5 Time series consistency

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.

7.5.2.6 Uncertainties

The default IPCC uncertainties were used and adjusted (where possible) to reflect country-specific data or circumstances.

Table 7.11: *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 – 2014
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	IPCC default values used –10%, +0%

Activity data and emission factors	Uncertainty range
= 0.8	±20%
= 0.4	±30%
Fraction of CH_4 in generated Landfill Gas (F) = 0.5	±5% IPCC default values used
k-rate	Default value (range)
Paper/textile	0.04 (0.03 – 0.05)
Garden and park waste	0.05 (0.04 – 0.06)
Food waste	0.06 (0.05 – 0.08)
Wood	0.02 (0.01 – 0.03)

7.5.2.7 Source specific QA/QC and verification

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.

7.5.2.8 Source specific recalculations

There were no recalculation made in emissions of non-MSW waste.

7.5.2.9 Source specific improvements

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 agricultural and industrial waste in the period 2005 – 2012 were used. A longer time series are needed, therefore extrapolations will be regularly reviewed and updated.

7.6 BIOLOGICAL TREATMENT OF SOLID WASTE (CRF 5.B)

7.6.1 SOURCE CATEGORY DESCRIPTION

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. 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 72.5% in 2014. 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 7.13: *The overview of municipal and industrial composting in 1990 – 2014*

Year	MSW (CRF 5.B.1.a)			Non-MSW (CRF 5.B.1.b)		
	Waste treated	CH_4	N_2O	Waste treated	CH_4	N_2O
	kt (wet)	Gg	Gg	kt (wet)	Gg	Gg
1990	20.00	0.080	0.0060	629.00	2.516	0.1887
1991	20.00	0.080	0.0060	629.00	2.516	0.1887
1992	20.00	0.080	0.0060	629.00	2.516	0.1887
1993	21.46	0.086	0.0064	629.00	2.516	0.1887
1994	19.07	0.076	0.0057	629.00	2.516	0.1887
1995	35.46	0.142	0.0106	629.00	2.516	0.1887
1996	31.41	0.126	0.0094	629.00	2.516	0.1887

Year	MSW (CRF 5.B.1.a)			Non-MSW (CRF 5.B.1.b)		
	Waste treated	CH_4	N_2O	Waste treated	CH_4	N_2O
	kt (wet)	Gg	Gg	kt (wet)	Gg	Gg
1997	38.79	0.155	0.0116	629.00	2.516	0.1887
1998	38.02	0.152	0.0114	629.00	2.516	0.1887
1999	39.34	0.157	0.0118	629.00	2.516	0.1887
2000	36.35	0.145	0.0109	629.00	2.516	0.1887
2001	34.48	0.138	0.0103	629.00	2.516	0.1887
2002	39.36	0.157	0.0118	629.00	2.516	0.1887
2003	40.66	0.163	0.0122	629.00	2.516	0.1887
2004	40.89	0.164	0.0123	604.07	2.416	0.1812
2005	45.00	0.180	0.0135	579.15	2.317	0.1737
2006	51.58	0.206	0.0155	800.77	3.203	0.2402
2007	76.09	0.304	0.0228	527.96	2.112	0.1584
2008	80.17	0.321	0.0241	583.12	2.332	0.1749
2009	88.92	0.356	0.0267	592.42	2.370	0.1777
2010	90.72	0.363	0.0272	578.54	2.314	0.1736
2011	99.84	0.399	0.0300	652.55	2.610	0.1958
2012	122.76	0.491	0.0368	726.56	2.906	0.2180
2013	130.67	0.523	0.0392	619.85	2.479	0.1860
2014	145.11	0.580	0.0435	728.11	2.912	0.2184

7.6.2 METHODOLOGICAL ISSUES – METHODS

The default IPCC 2006 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.

7.6.3 METHODOLOGICAL ISSUES – EMISSION FACTORS AND PARAMETERS

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 0.3 g N_2O/kg of waste treated.

7.6.4 ACTIVITY DATA

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 – 2014 data was used for linear extrapolation.

7.6.5 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 ±100% uncertainties. The highest uncertainty come from CH_4 and N_2O emission factors.

Table 7.14: 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	0.3 (0.06-6)

7.6.6 SOURCE SPECIFIC QA/QC AND VERIFICATION

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.

7.6.7 SOURCE SPECIFIC RECALCULATIONS

No changes were made to estimation of methane emissions from composting.

7.6.8 SOURCE SPECIFIC PLANNED IMPROVEMENTS

No specific improvements are planned for the next submission.

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)

7.7.1.1 Source category description (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 2014:

- 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 7.2. No changes to these data was observed in 2014.

Figure 7.2: *Location of individual waste incineration and co-incineration facilities in 2013 and 2014*

Legend:

- Red square – hospital waste incinerator;
- Yellow circle – municipal waste incinerator;
- Red circle – hazardous waste incinerator;
- Blue circle – co-incineration facility.

Estimation of emissions from waste incineration was reviewed with the aim to increase coordination between the Waste and Energy sectors. 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 fuels for cement industry.
- Emission factors 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*

Year	Emissions from incineration without energy recovery		
	CO_2 (Gg)	N_2O (Gg)	CH_4 (Gg)
1990	60.25	0.0196	0.0696
1991	57.45	0.0194	0.0681
1992	54.66	0.0191	0.0667
1993	51.86	0.0189	0.0652
1994	49.06	0.0186	0.0638
1995	46.26	0.0184	0.0624
1996	43.46	0.0181	0.0609
1997	40.66	0.0179	0.0595
1998	37.86	0.0177	0.0580
1999	35.06	0.0175	0.0566
2000	32.26	0.0172	0.0551

Year	Emissions from incineration without energy recovery		
	CO_2 (Gg)	N_2O (Gg)	CH_4 (Gg)
2001	29.46	0.0170	0.0537
2002	24.71	0.0157	0.0438
2003	26.42	0.0134	0.0420
2004	28.00	0.0172	0.0440
2005	21.86	0.0175	0.0618
2006	14.69	0.0163	0.0593
2007	7.52	0.0134	0.0508
2008	5.71	0.0124	0.0395
2009	5.04	0.0085	0.0174
2010	7.31	0.0131	0.0579
2011	9.58	0.0072	0.0226
2012	7.92	0.0100	0.0405
2013	6.64	0.0083	0.0354
2014	6.16	0.0180	0.0336

Total CO_2 emissions reported in the category 5.C.1 from waste incineration without energy recovery were 6.16 Gg in 2014. This is a decrease compared to the previous year caused by a decreasing volume of incinerated industrial 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 0.0336 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 1990 – 2014*

Year	BIOGENIC							
	MSW (CRF 5.C.1.1.a reported in 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	113.15	87.61	0.004458	0.03344	75.34	112.00	0.0127	0.0452
1991	113.15	87.61	0.004458	0.03344	74.82	111.00	0.0128	0.0449
1992	114.81	88.90	0.004524	0.03393	74.31	110.00	0.0128	0.0446
1993	123.31	95.47	0.004858	0.03644	73.79	110.00	0.0128	0.0443
1994	107.63	83.33	0.004241	0.03180	73.28	109.00	0.0128	0.0440
1995	100.39	77.73	0.003955	0.02966	72.76	108.00	0.0129	0.0437
1996	98.47	76.24	0.003880	0.02910	72.25	107.00	0.0129	0.0434
1997	107.30	83.08	0.004227	0.03171	71.73	107.00	0.0130	0.0430
1998	119.70	92.68	0.004716	0.03537	71.22	106.00	0.0130	0.0427
1999	116.14	89.92	0.004576	0.03432	70.70	105.00	0.0131	0.0424
2000	138.73	107.42	0.005466	0.04100	70.19	104.23	0.0131	0.0421
2001	87.24	67.55	0.003437	0.02578	69.67	103.47	0.0132	0.0418
2002	104.16	80.65	0.004104	0.03078	56.32	83.63	0.0121	0.0338
2003	108.16	83.75	0.004262	0.03196	52.23	77.55	0.0100	0.0313
2004	122.54	94.88	0.004828	0.03621	54.51	80.95	0.0128	0.0327
2005	121.70	94.23	0.004795	0.03596	88.22	131.01	0.0150	0.0529
2006	126.46	97.91	0.004982	0.03737	88.94	132.07	0.0147	0.0534
2007	119.95	92.87	0.004726	0.03545	79.52	118.09	0.0126	0.0477
2008	104.69	81.06	0.004125	0.03094	62.03	92.12	0.0117	0.0372
2009	118.31	91.60	0.004661	0.03496	25.52	37.89	0.0075	0.0153
2010	121.99	94.45	0.004806	0.03605	91.53	135.92	0.0124	0.0549

Year	BIOGENIC							
	MSW (CRF 5.C.1.1.a reported in 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)
2011	123.47	95.60	0.004865	0.03648	31.27	46.43	0.0060	0.0188
2012	111.77	86.54	0.004404	0.03303	62.14	92.27	0.0092	0.0373
2013	115.59	89.50	0.004554	0.03416	54.58	81.05	0.0077	0.0328
2014	126.42	97.88	0.004981	0.03736	51.76	76.87	0.0171	0.0311

Year	NON-BIOGENIC WASTE							
	MSW (CRF 5.C.1.2.a reported in 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	56.85	44.02	0.002240	0.016799	40.58	60.25	0.0069	0.0244
1991	56.85	44.02	0.002240	0.016799	38.69	57.45	0.0066	0.0232
1992	57.69	44.66	0.002273	0.017046	36.80	54.66	0.0063	0.0221
1993	61.95	47.97	0.002441	0.018307	34.92	51.86	0.0061	0.0210
1994	54.08	41.87	0.002131	0.015979	33.03	49.06	0.0058	0.0198
1995	50.44	39.05	0.001987	0.014904	31.15	46.26	0.0055	0.0187
1996	49.47	38.31	0.001949	0.014620	29.26	43.46	0.0052	0.0176
1997	53.91	41.74	0.002124	0.015930	27.38	40.66	0.0049	0.0164
1998	60.14	46.56	0.002370	0.017771	25.49	37.86	0.0047	0.0153
1999	58.35	45.18	0.002299	0.017243	23.61	35.06	0.0044	0.0142
2000	69.70	53.97	0.002746	0.020597	21.72	32.26	0.0041	0.0130
2001	43.83	33.94	0.001727	0.012952	19.84	29.46	0.0038	0.0119
2002	52.33	40.52	0.002062	0.015465	16.64	24.71	0.0036	0.0100
2003	54.34	42.08	0.002141	0.016059	17.79	26.42	0.0034	0.0107
2004	61.57	47.67	0.002426	0.018193	18.86	28.00	0.0044	0.0113
2005	61.15	47.34	0.002409	0.018069	14.72	21.86	0.0025	0.0088
2006	63.53	49.19	0.002503	0.018775	9.89	14.69	0.0016	0.0059
2007	60.27	46.66	0.002374	0.017809	5.06	7.52	0.0008	0.0030
2008	52.60	40.73	0.002072	0.015544	3.85	5.71	0.0007	0.0023
2009	59.44	46.02	0.002342	0.017564	3.39	5.04	0.0010	0.0020
2010	61.29	47.45	0.002415	0.018111	4.92	7.31	0.0007	0.0030
2011	62.03	48.03	0.002444	0.018331	6.45	9.58	0.0012	0.0039
2012	56.16	43.48	0.002213	0.016595	5.33	7.92	0.0008	0.0032
2013	58.07	44.96	0.002288	0.017161	4.47	6.64	0.0006	0.0027
2014	63.52	49.18	0.002503	0.018769	4.15	6.16	0.0009	0.0025

7.7.1.2 Source category description – MSW (CRF 5.C.1.1.a & 5.C.1.1.b)

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 (Chapter 3).

7.7.1.3 Methodological issues – methods

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 included in biomass fuel. Tier 2 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%.

7.7.1.4 Methodological issues – emission factors and parameters

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%. CO_2 emission factors were estimated from average waste composition in Slovakia, resulting in weighted EF of 0.77 kg CO_2/kg waste. CO_2 emissions from biogenic waste were estimated as a difference between total and non-biogenic emissions.

Default EF for methane emissions from MSW incineration with energy use reported in energy sector (30 kg/TJ) was used for entire time series.

N_2O emissions from MSW with energy use were estimated using IPCC default EF for continuous incineration on stoker 4 kg/TJ of waste in 2014.

More information on EFs used in energy sector and conversion values for activity data can be found in energy sector.

7.7.1.5 Activity data

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.

Data on composition of MSW used in CO_2 emission factors estimation are based on averages of MSW analyses and are kept constant for the entire time series.

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.

7.7.1.6 Completeness

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.

7.7.1.7 Uncertainties

The default IPPC uncertainties for activity data were used. These are summarised in the Table 7.18.

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%	

7.7.1.8 Time series consistency

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.

7.7.1.9 Source specific QA/QC and verification

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.

Management practice distribution is 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.

7.7.1.10 Source specific recalculations

No specific recalculations were made for incineration of MSW. Estimation of CH_4 was included into existing spreadsheet model.

7.7.1.11 Source specific planned improvements

Development of time series for the composition of MSW prepared for disposal model indicates significant changes in waste composition. Also research article referring to Košice incinerator shows decreasing heating value in year-by-year assessment, which indicates changing of MSW composition. Therefore, the model on MSW incineration will be modified to reflect changes in composition of MSW.

7.7.2 SOURCE CATEGORY DESCRIPTION – NON-MSW (CRF 5.C.1.1.b & 5.C.1.2.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.

All of these co-incineration facilities are with energy use and therefore are included in energy sector (Chapter 3). The remaining 6 facilities are incinerating hospital waste and are reported in waste sector with disaggregation on biogenic and non-biogenic 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. 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.

7.7.2.1 Methodological issues – methods

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.

7.7.2.2 Methodological issues – parameters

For CO_2 emissions estimation, default IPCC parameters were used for total carbon content and fossil carbon fraction. Oxidation factor was set to be 0.9 in order to compensate older incineration facilities, which may not operate with full effectiveness.

CH_4 emissions were estimated for the first time in this submission and emission factor for semi-continuous incineration in stoker (0.6 kg/t) was used, because data on incinerated non-MSW exceed installed capacities.

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).

7.7.2.3 Activity data

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 linear extrapolation. Published activity data allow disaggregation into incineration with and without energy use. Since 2008, detail data on source category level is available from the EU ETS reports. More information can be found in energy sector (Chapter 3).

7.7.2.4 Completeness

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 guidelines.

7.7.2.5 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 were estimated to be ±56%. Main source of uncertainty is N_2O emission factor, ranging ±100%.

7.7.2.6 Time series consistency

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.

7.7.2.7 Source specific QA/QC and verification

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.

Management practice distribution is available from the Statistical yearbook “Odpady”. Default emission factors were used and these were verified to be fully in compliance with IPCC 2006 Guidelines.

Because dry matter content is not monitored in Slovak incinerators, parameters for wet weight were used consistently for all calculations.

7.7.2.8 Source specific recalculations

New extrapolation of activity data for the period 1990 – 2001 was performed. Estimation of CH_4 emissions was included into existing spreadsheet model in this submission. Data are provided in the tables above.

7.7.2.9 Source specific planned improvements

No improvements are planned in the approach to emission estimation from non-MSW incineration.

Due to increased exchange of data on incinerated amounts and generated emissions, QA/QC procedures for non-MSW incineration need to be reviewed and if needed strengthened to ensure good cooperation between Energy Sector and Waste Sector.

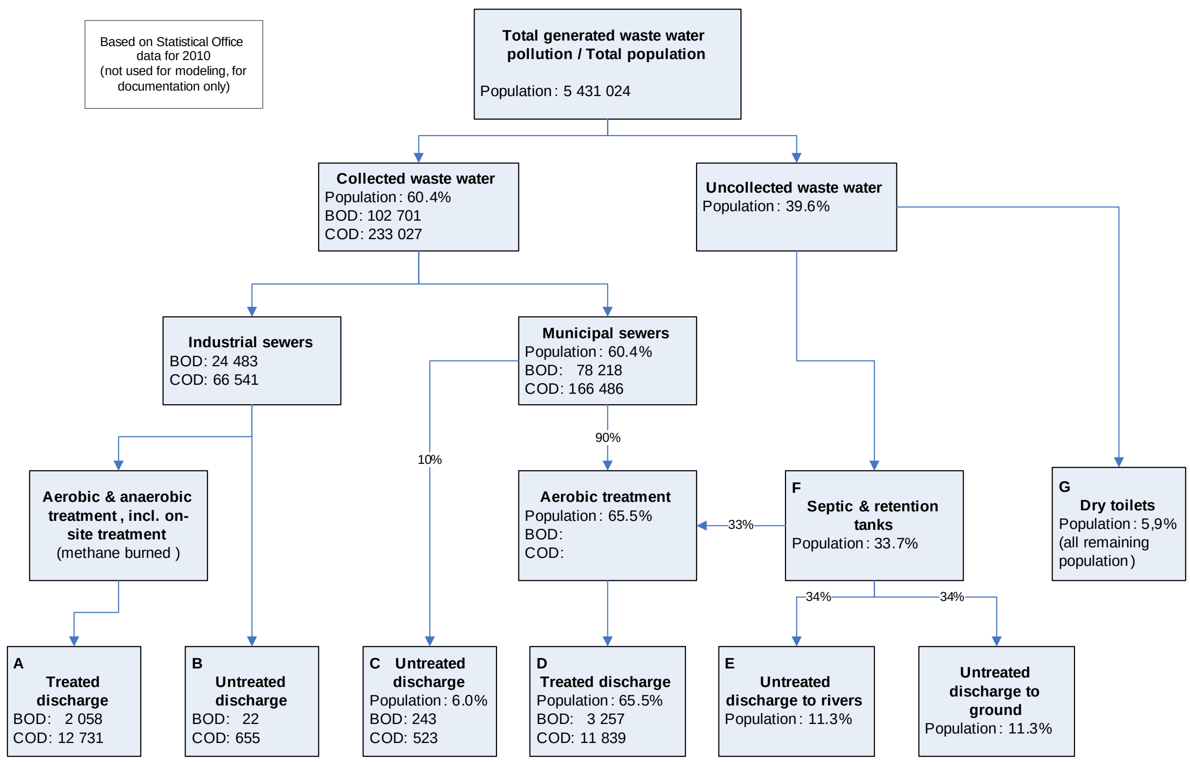
7.8 WASTEWATER TREATMENT AND DISCHARGE (CRF 5.D)

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 12.43 Gg in 2014. 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 2014. The decreasing trend is caused by increasing volume of water treated in advanced WWT plants and decreasing consumption of proteins.

The typical balance of wastewater pathways for domestic and industrial waste water in Slovakia was prepared as follows:



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. 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.

According to the UNFCCC Reporting Guidelines, transparency means that the assumptions and methodologies used for an inventory should be clearly explained to facilitate replication and assessment of the inventory by users of the reported information. We believe, that the facts stated above sufficiently explain our assumption that methane emissions from sludge stabilisation are not occurring in Slovakia.

The reporting of methane recovery would be an issue of transparency, if methane generation is higher than methane recovery and the amount of recovered methane has influence on total methane emissions. In case of sludge stabilisation, generated methane is equal to recovered methane and regardless to its amount it would not influence the total amount of emissions nor improve the transparency of the inventory.

Table 7.19: *GHG emissions in individual categories in wastewater handling in 1990 – 2014*

Year	Domestic waste water				Industrial waste water			
	BOD in effluent and ret. tanks	CH_4	N in effluent and ret. tanks	N_2O	COD in effluent	CH_4	N in effluent	N_2O
	Gg							
1990	108.76	17.471	50.92	0.4001	46.746	1.169	6.020	1.169
1991	106.63	17.342	46.53	0.3656	44.709	1.118	6.080	1.118
1992	105.48	17.272	42.30	0.3324	42.672	1.067	4.690	1.067
1993	101.95	17.059	41.35	0.3249	40.757	1.019	3.750	1.019
1994	84.92	16.036	41.65	0.3273	37.286	0.932	3.830	0.932
1995	79.65	15.719	40.76	0.3202	33.814	0.845	3.600	0.845
1996	78.03	15.620	40.48	0.3181	28.112	0.703	3.960	0.703
1997	75.30	15.455	40.46	0.3179	26.49	0.662	3.700	0.662
1998	75.92	15.491	40.16	0.3155	26.751	0.669	3.840	0.669
1999	74.51	15.405	37.73	0.2964	25.22	0.631	3.310	0.631
2000	73.13	15.322	33.81	0.2657	29.035	0.726	2.810	0.726
2001	73.29	15.330	32.36	0.2543	27.254	0.681	2.810	0.681
2002	71.81	15.132	31.73	0.2493	25.473	0.637	6.680	0.637
2003	66.94	14.732	27.83	0.2187	26.555	0.664	2.850	0.664
2004	61.56	14.300	24.35	0.1913	22.049	0.551	3.600	0.551
2005	59.20	14.050	22.81	0.1792	16.88	0.422	4.020	0.422
2006	57.60	13.846	22.87	0.1797	12.947	0.324	3.730	0.324
2007	55.10	13.587	22.07	0.1734	12.772	0.319	3.770	0.319
2008	53.96	13.410	20.82	0.1636	13.149	0.329	3.110	0.329
2009	52.63	13.221	20.03	0.1574	13.916	0.348	2.690	0.348
2010	51.41	13.040	19.27	0.1514	13.386	0.335	2.720	0.335
2011	47.99	12.792	18.81	0.1478	10.747	0.269	2.620	0.269
2012	46.58	12.617	18.28	0.1436	10.08	0.252	2.330	0.252
2013	46.37	12.424	18.06	0.1419	9.919	0.248	2.140	0.248
2014	44.63	12.198	17.97	0.1412	9.072	0.227	2.325	0.227

7.8.1 SOURCE CATEGORY DESCRIPTION – 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 12.20 Gg in 2014. Main share on these emissions have retention tanks with 10.99 Gg in 2014. Total N_2O emissions from domestic wastewater treatment were 0.14 Gg. Majority of N_2O emissions is generated from retention tanks (0.08 Gg).

Table 7.20: *Summary of methane emissions from the domestic and commercial WW by pathways in 1990 – 2014*

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
1991	0.911	2.111	0.834	12.638	0.848	0.000
1992	0.790	2.167	0.834	12.636	0.845	0.000
1993	0.678	2.078	0.834	12.635	0.835	0.000
1994	0.599	1.139	0.834	12.633	0.831	0.000
1995	0.477	0.957	0.834	12.632	0.819	0.000
1996	0.491	0.869	0.834	12.631	0.796	0.000
1997	0.508	0.712	0.834	12.629	0.772	0.000
1998	0.540	0.744	0.833	12.628	0.746	0.000
1999	0.549	0.680	0.833	12.627	0.716	0.000
2000	0.551	0.625	0.833	12.625	0.687	0.000
2001	0.557	0.669	0.833	12.624	0.646	0.000
2002	0.573	0.586	0.825	12.499	0.649	0.002
2003	0.389	0.526	0.817	12.373	0.623	0.003
2004	0.226	0.410	0.808	12.248	0.602	0.005
2005	0.171	0.372	0.800	12.122	0.578	0.007
2006	0.114	0.368	0.792	11.997	0.566	0.009
2007	0.142	0.250	0.784	11.872	0.530	0.011
2008	0.147	0.236	0.775	11.746	0.493	0.012
2009	0.137	0.196	0.767	11.621	0.486	0.014
2010	0.129	0.195	0.759	11.495	0.445	0.016
2011	0.143	0.179	0.750	11.370	0.332	0.018
2012	0.124	0.164	0.742	11.245	0.323	0.019
2013	0.119	0.175	0.734	11.119	0.258	0.020
2014	0.087	0.164	0.726	10.994	0.206	0.022

Table 7.21: *Summary of N_2O emissions from the domestic and commercial WW by pathways in 1990 – 2014*

Year	Untreated discharge and retention tanks	Direct from WWT plants	Treated discharge	Total
	Gg			
1990	0.1803	0.0000	0.2198	0.4001
1991	0.1629	0.0000	0.2028	0.3656
1992	0.1474	0.0000	0.1850	0.3324
1993	0.1429	0.0000	0.1820	0.3249
1994	0.1397	0.0000	0.1876	0.3273
1995	0.1385	0.0000	0.1818	0.3202
1996	0.1369	0.0000	0.1811	0.3181
1997	0.1357	0.0000	0.1822	0.3179
1998	0.1322	0.0001	0.1832	0.3155
1999	0.1300	0.0013	0.1651	0.2964
2000	0.1220	0.0024	0.1413	0.2657
2001	0.1203	0.0035	0.1305	0.2543
2002	0.1212	0.0047	0.1234	0.2493
2003	0.1117	0.0056	0.1013	0.2187
2004	0.1041	0.0062	0.0810	0.1913
2005	0.1053	0.0068	0.0672	0.1792
2006	0.1056	0.0074	0.0667	0.1797
2007	0.1021	0.0076	0.0637	0.1734
2008	0.0979	0.0081	0.0576	0.1636
2009	0.0957	0.0085	0.0532	0.1574
2010	0.0920	0.0091	0.0503	0.1514
2011	0.0904	0.0096	0.0478	0.1478
2012	0.0876	0.0099	0.0461	0.1436
2013	0.0843	0.0101	0.0475	0.1435
2014	0.0814	0.0104	0.0494	0.1412

7.8.1.1 Methodological issues – method

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 the SR.

7.8.1.2 Methodological issues – parameters and emission factors

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.

7.8.1.3 Activity data

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).

7.8.1.4 Uncertainties

Uncertainties were calculated using the IPCC 2006 GL default method and values. Country specific uncertainties are provided in the following table.

Table 7.22: *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%.

7.8.1.5 Time series consistency

The time series consistency is ensured by the consistent methodology and sources of activity data.

7.8.1.6 Source specific QA/QC and verification

Data on population were obtained from the demographic information updated by the Statistical Office of the SR, from the Report on Water Management prepared by the Water Research Institute (VUVH) 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 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.

7.8.1.7 Source specific recalculations

Previous year estimates of BOD and protein consumption were replaced by reported figures. This recalculation has minimal impact on sectoral emissions.

7.8.1.8 Source specific planned improvements

No improvements to the waste water model are planned for the next submission.

7.8.2 SOURCE CATEGORY DESCRIPTION – 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 – 2014. 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 0.227 Gg and total N_2O emissions were 0.025 Gg from industrial wastewater treatment in 2014. The pathways A and B are included in the estimation of methane emissions. The following table shows the activity data and resulting emissions estimation.

Table 7.24: *GHG emissions from wastewater treatment in 1990 – 2014*

Year	Total organic product	Sludge removed	N in effluent	CH_4 emissions	CH_4 flared	CH_4 for energy recovery	N_2O
	(kt DC)		Gg				
1990	46.746	NE	6.020	1.169	NO	IE	0.065
1991	44.709	NE	6.080	1.118	NO	IE	0.065
1992	42.672	NE	4.690	1.067	NO	IE	0.050
1993	40.757	NE	3.750	1.019	NO	IE	0.040
1994	37.286	NE	3.830	0.932	NO	IE	0.041
1995	33.814	NE	3.600	0.845	NO	IE	0.039
1996	28.112	NE	3.960	0.703	NO	IE	0.043
1997	26.490	NE	3.700	0.662	NO	IE	0.040
1998	26.751	NE	3.840	0.669	NO	IE	0.041
1999	25.220	NE	3.310	0.631	NO	IE	0.036
2000	29.035	NE	2.810	0.726	NO	IE	0.030
2001	27.254	NE	2.810	0.681	NO	IE	0.030
2002	25.473	NE	6.680	0.637	NO	IE	0.072
2003	26.555	NE	2.850	0.664	NO	IE	0.031
2004	22.049	NE	3.600	0.551	NO	IE	0.039
2005	16.880	NE	4.020	0.422	NO	IE	0.043
2006	12.947	NE	3.730	0.324	NO	IE	0.040
2007	12.772	NE	3.770	0.319	NO	IE	0.040
2008	13.149	NE	3.110	0.329	NO	IE	0.033
2009	13.916	NE	2.690	0.348	NO	IE	0.029
2010	13.386	NE	2.720	0.335	NO	IE	0.029
2011	10.747	NE	2.620	0.269	NO	IE	0.028
2012	10.080	NE	2.330	0.252	NO	IE	0.025
2013	9.919	NE	2.140	0.248	NO	IE	0.023
2014	9.072	NE	2.325	0.227	NO	IE	0.025

7.8.2.1 Methodological Issues –methods

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 ISI methodology is used for N_2O emissions estimation in industrial wastewater. The ISI methodology expects that wastewater treatment plant without biological nitrification has no N_2O emissions. Only data for treatment plant where biological nitrification and denitrification take place were used for N_2O emissions balance. Numbers of this type of treatment for industrial wastewater have increased, but implemented improvements at the plant level not lead in emissions rise. Emission factor for N_2O estimation is dynamic and changing from year to year. It depends on direct measurement of industrial wastewater treatment operators. The list of emission factors for N_2O emission from industrial wastewater treatment is shown in Table 7.25.

Table 7.25: *Summary of wastewater treatment in industry in 1990 – 2014*

Year	Fertilizers		Food and Beverages		Organic Chemicals		Other Streams	
	WW output (m^3/y)	COD (kg/m^3)	WW output (m^3/y)	COD (kg/m^3)	WW output (m^3/y)	COD (kg/m^3)	WW output (m^3/y)	COD (kg/m^3)
1990	62 208.00	0.20	NO	NO	10 143.80	0.40	NO	NO
1991	63 849.60	0.20	NO	NO	9 739.70	0.40	NO	NO
1992	46 125.40	0.20	NO	NO	9 055.30	0.40	NO	NO
1993	33 722.00	0.20	NO	NO	8 837.30	0.40	NO	NO
1994	34 014.20	0.20	NO	NO	9 241.80	0.40	NO	NO
1995	28 215.40	0.20	NO	NO	10 566.70	0.40	NO	NO
1996	32 601.40	0.20	NO	NO	10 839.20	0.40	NO	NO
1997	32 324.30	0.20	NO	NO	9 149.80	0.40	NO	NO
1998	35 699.40	0.20	NO	NO	8 467.20	0.40	NO	NO
1999	28 022.20	0.20	NO	NO	8 683.10	0.40	NO	NO
2000	22 086.00	0.20	NO	NO	8 209.00	0.40	NO	NO
2001	NO	NO	3 439.00	0.04	9 184.00	0.82	NO	NO
2002	21 524.00	0.41	3 291.00	0.05	9 763.00	0.95	NO	NO
2003	19 697.00	0.24	4 131.40	0.05	10 717.70	0.28	3 217.20	0.03
2004	19 506.00	0.38	3 999.45	0.04	7 742.00	0.30	3 049.30	0.03
2005	17 122.91	0.47	6 064.56	0.04	5 393.18	0.49	3 050.99	0.03
2006	19 865.12	0.44	5 001.07	0.04	5 393.18	0.22	2 606.03	0.02
2007	18 967.80	0.47	5 565.50	0.04	5 393.18	0.22	2 497.81	0.05
2008	17 090.67	0.46	5 524.05	0.04	4 169.78	0.12	1 817.26	0.05
2009	16 821.15	0.38	5 098.52	0.05	4 904.38	0.16	1 287.40	0.05
2010	15 633.70	0.40	4 897.40	0.04	6 335.10	0.17	1 649.58	0.03
2011	14 903.20	0.43	4 278.30	0.04	3 861.50	0.15	1 404.90	0.03
2012	13 305.39	0.44	4 099.02	0.03	3 620.52	0.11	1 977.92	0.01
2013	15 940.30	0.32	3 977.30	0.03	4 974.60	0.08	3 621.10	0.05
2014	13 931.65	0.41	3 638.83	0.02	3 124.01	0.08	8 678.22	0.04

7.8.2.2 Methodological issues – emission factors and parameters

For CH_4 emissions estimation, 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.

7.8.2.3 Activity data

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.

7.8.2.4 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 ±100%. Main source of uncertainty is MCF parameter, ranging ±100%.

7.8.2.5 Time series consistency

The time series consistency is ensured by using the consistent methodology and activity data sources.

7.8.2.6 Source specific QA/QC and verification

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 SHMU, the Department of Water Quality. Complete time series from major polluters are known since 1990. Actual decrease in N_2O emissions is reasoning from the decreasing industrial production and decreasing volume of treated wastewater.

7.8.2.7 Source specific recalculations

No recalculations were made for industrial wastewater in this submission. Previous year (2013) estimates of COD were replaced by reported values.

7.8.2.8 Source specific planned improvements

No improvements to the waste water model are planned for the next submission.

7.9 SOURCE CATEGORY DESCRIPTION - 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 7.26. (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 and the main contradiction is that long-term stored carbon remains as carbon.) The following table shows results of long-term stored carbon in CRF structure.

Table 7.26: *Long-term stored C in SWDS*

Year	C in Gg
1990	1 669.17
1991	1 781.12
1992	1 833.86
1993	1 833.86
1994	1 891.35
1995	1 950.60
1996	2 017.71
1997	2 085.51
1998	2 150.58
1999	2 218.78
2000	2 286.82
2001	2 357.07
2002	2 437.80
2003	2 524.91
2004	2 608.07
2005	2 697.30
2006	2 793.34
2007	2 890.95
2008	2 996.27
2009	3 099.70
2010	3 196.39
2011	3 286.55
2012	3 377.75
2013	3 466.11
2014	3 548.52

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 Guidelines 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 2016 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 Guidelines. 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 (2015) 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

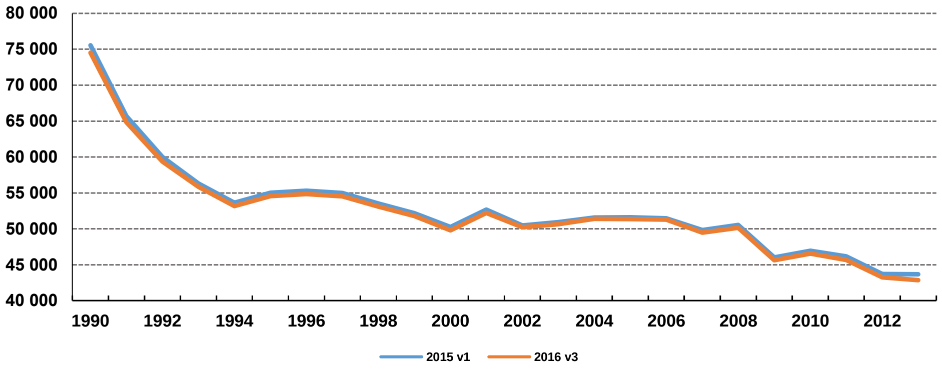
Reflecting the QA/QC activities for improving the emission inventory of GHG and recommendations provided by the experts during the review process for inventory submissions under UNFCCC and under the EU ESD, the experts involved in the National Inventory System of the Slovak Republic proposed the recalculations 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 2016, version 3 against previous inventory submission from November 2015, version 1 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 decreased in 2016 submission for the year 1990 by 1.4%, and decrease in 2013 by 1.9% (Table 10.1). Regarding total GHG emissions with LULUCF, increasing of recalculated removals caused decreasing of GHG emissions in 2016 submission in all years of time series (Table 10.2).

Table 10.1: *Comparison of GHG emission trend without LULUCF of the 2015 and 2016 submissions*

National GHG Inventory without LULUCF in Gg of CO_2 eq.			
Year	**Submission 2015 v1**	**Submission 2016 v3**	**2016 v3/2015 v1 (%)**
1990	75 533.16	74 504.05	98.64%
1991	65 683.37	64 850.01	98.73%
1992	59 988.91	59 376.96	98.98%
1993	56 312.38	55 828.48	99.14%
1994	53 639.71	53 181.03	99.14%
1995	55 032.82	54 549.48	99.12%
1996	55 302.95	54 833.71	99.15%
1997	55 002.85	54 510.15	99.10%
1998	53 537.36	53 090.30	99.16%
1999	52 182.67	51 790.09	99.25%
2000	50 243.58	49 798.47	99.11%
2001	52 662.39	52 211.58	99.14%

National GHG Inventory without LULUCF in Gg of CO_2 eq.			
Year	**Submission 2015 v1**	**Submission 2016 v3**	**2016 v3/2015 v1 (%)**
2002	50 483.45	50 224.55	99.49%
2003	50 932.52	50 666.24	99.48%
2004	51 585.57	51 385.86	99.61%
2005	51 600.76	51 355.78	99.53%
2006	51 473.60	51 273.23	99.61%
2007	49 847.58	49 470.70	99.24%
2008	50 540.83	50 152.32	99.23%
2009	46 018.30	45 619.05	99.13%
2010	46 948.35	46 543.13	99.14%
2011	46 170.24	45 664.11	98.90%
2012	43 706.55	43 237.16	98.93%
2013	43 679.16	42 854.13	98.11%

Figure 10.1: *Comparison of GHG emission trend without LULUCF of the 2015 and 2016 submissions in Gg of CO_2 eq.*



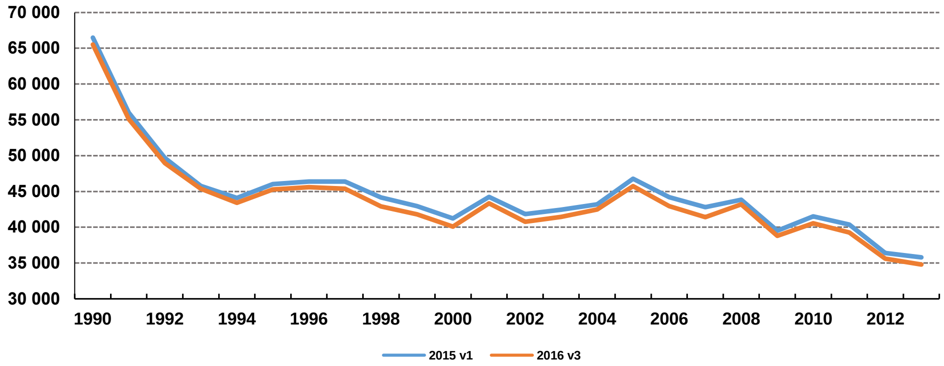
submission 2015, version 1, submission 2016 version 3, in Gg of CO_2 equivalents, 15.06.2016

Table 10.2: *Comparison of GHG emission trend with LULUCF of the 2015 and 2016 submissions*

National GHG Inventory with LULUCF in Gg of CO_2 eq.			
Year	**Submission 2015 v1**	**Submission 2016 v3**	**2016 v3/2015 v1 (%)**
1990	66 495.02	65 512.79	98.52%
1991	56 017.63	55 123.72	98.40%
1992	49 656.26	48 945.63	98.57%
1993	45 753.27	45 384.42	99.19%
1994	44 079.80	43 424.19	98.51%
1995	46 010.73	45 265.35	98.38%
1996	46 368.88	45 590.28	98.32%
1997	46 379.89	45 382.32	97.85%
1998	44 158.94	42 912.25	97.18%
1999	42 952.44	41 787.94	97.29%
2000	41 219.29	40 079.56	97.23%
2001	44 223.84	43 344.39	98.01%
2002	41 821.57	40 760.39	97.46%
2003	42 451.33	41 449.11	97.64%
2004	43 196.79	42 466.92	98.31%
2005	46 777.82	45 750.83	97.80%
2006	44 206.68	42 936.64	97.13%
2007	42 794.62	41 407.07	96.76%
2008	43 849.52	43 206.20	98.53%

National GHG Inventory with LULUCF in Gg of CO_2 eq.			
Year	**Submission 2015 v1**	**Submission 2016 v3**	**2016 v3/2015 v1 (%)**
2009	39 498.73	38 792.29	98.21%
2010	41 513.00	40 530.51	97.63%
2011	40 377.38	39 255.04	97.22%
2012	36 390.40	35 615.49	97.87%
2013	35 777.88	34 782.84	97.22%

Figure 10.2: *Comparison of GHG emission trend with LULUCF of the 2015 and 2016 submissions in Gg of CO_2 eq.*



submission 2015, version 1, submission 2016 version 3, in Gg of CO_2 equivalents, 15.06.2016

10.3 RECALCULATIONS, INCLUDING IN RESPONSE TO THE REVIEW PROCESS, AND PLANNED IMPROVEMENTS TO THE INVENTORY

The latest published Annual Review Report FCCC/ARR/2014/SVK of the individual review of the annual submission of the Slovak Republic was published in May 2015 at http://unfccc.int/resource/docs/2015/arr/svk.pdf. This report covers the centralised review of the 2014 annual submission of the Slovak Republic, coordinated by the UNFCCC secretariat, in accordance with decision 22/CMP.1. This SVK ARR 2014 was prepared based on recalculated and resubmitted GHG inventory 1990 – 2012 in November 2014. More information on recalculations provided based on the ERT recommendations from the latest UNFCCC and KP review cycle can be found in the SVK NIR 2015 submitted in November 2015.

In term to further improve GHG emissions inventory, the NIS SR planned in the frame “Improvement and Prioritisation Plan 2015” recalculations also for the 2016 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 A4.4 of this report.

Table 10.3: *List of recalculations in January 15, 2016 submission (version 1) against November 11, 2015 submission with short explanation*

Recalculated category (submission 2015 versus submission 2016 v1)		Year	GHG Affected	Explanation
1. ENERGY SECTOR				
1.A.1	Energy Industries	1990-2013	CO_2, N_2O, CH_4	-model of **industrial and municipal waste** was significantly modified in the sector 1.A.1.a and in waste sector. Complete time series back to 1990 were recalculated.
1.A.2	Manufacturing Industries and Construction	1990-2013	CO_2, N_2O, CH_4	-model of **industrial waste incineration** taking place in cement plants (1.A.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.
1.AA.3.a	Transport – Civil Aviation	2005-2013	CO_2, N_2O, CH_4	-**aviation gasoline**: Data on fuel consumption based on EUROCONTROL; -**jet kerosene:** Data on fuel consumption based on EUROCONTROL.
1.AA.3.b i-iv	Transport – Road Transportation	1990-2013	CO_2, N_2O, CH_4	-**gasoline:** 1990 – 2013 correction of NCV values based on statistical data, recalculation of fuel consumption in TJ; 2007 – 2013 biomass share correction, recalculation of fuel consumption; 1990 – 2009 reallocation into subcategories 1.A.3.b.ii – iv. -**diesel oil:** 1990 – 2013 correction of NCV values based on statistical data, recalculation of fuel consumption in TJ; 2007 – 2013 biomass share correction, recalculation of fuel consumption; 1990 – 2009 reallocation into subcategories 1.A.3.b.ii – iv. -**LPG:** 1994 – 2013 correction of NCV values based on statistical data, recalculation of fuel consumption in TJ. -**biomass:** 1990 – 2013 correction of NCV values based on statistical data, recalculation of fuel consumption in TJ; 2007 – 2013 biomass share correction, recalculation of fuel consumption; 1990 – 2009 reallocation into subcategories 1.A.3.b.ii – iv. -**CNG:** 1990 – 2013 correction of NCV values based on statistical data, recalculation of fuel consumption in TJ.
1.AA.3.c	Transport – Railways	2007-2013	CO_2, N_2O, CH_4	-**diesel oil:** 2007 – 2013 biomass share correction, recalculation of fuel consumption; -**biomass:** 2007 – 2013 biomass share correction, recalculation of fuel consumption.
1.A.4	Other Sectors	1990-2013	CO_2, N_2O, CH_4	-**natural gas and solid fuels** in category 1.A.4.a and 1.A.4.b were recalculated for year-3 (2013). The reason for this recalculation was modification of the energy balance (fuel consumptions) provided by the Statistical Office of the Slovak Republic. -**LPG consumption** in sectors 1.A.4.a and in 1.A.4.b was not included in report. In current submission, the information about LPG consumption adopted from Eurostat energy statistic was included into NIR. Complete time series were recalculated. -**biomass consumption** in 1.A.4.a and 1.A.5 was recalculated. Only the year 2013 was modified, because a wrong NCV value was used in previous submission.

Recalculated category (submission 2015 versus submission 2016 v1)		Year	GHG Affected	Explanation
1.A.5	Other	1990-2013	CO_2, N_2O, CH_4	-**biomass** consumption in 1.A.5 was recalculated. Only the year 2013 was modified, because a wrong NCV value was used in previous submission.
1.B.2	Oil and natural gas and other emissions from energy production	1990-2013	N_2O	-**1.B.2.c.2.ii:** flaring NG correction of formula
2. INDUSTRIAL PROCESSES SECTOR				
2.F.1	Product uses as substitutes for ODS	2013	HFCs	-**refrigeration and air conditioning:** Correction of distinguishing between import of filled products and filling of empty imported products.
3. AGRICULTURE				
3.B.1	Manure Management	1990-2013	CH_4	Revision of emission factors for poultry, goats, horses and swine based on national data.
3.B.2.1-3.B.2.4	Manure Management	1990-2013	N_2O	Revision of AWMS allocation of cattle, swine, sheep and other animals based on national data. Revision of emission factors and Nex for AWMS based on national data and the recommendations from the IPCC 2006 GL.
3.B.2.5	Manure Management	1990-2013	N_2O	Completing of the indirect N_2O emissions into inventory (previously not reported).
4.D.1.1	Agricultural Soils – Synthetic Fertilizers	1990-2013	N_2O	Revision of emission factors for synthetic fertilizers based on the IPCC 2006 GL. Revision is connected also with the revision in the category 3.B.2.
4.D.1.2.a	Agricultural Soils – Animal Manure Applied to Soil	1990-2013	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	1990-2013	N_2O	Revision of emission factors for grazing based on the IPCC 2006 GL. Revision is connected also with the revision in the category 3.B.2.
4.D.1.4	Agricultural Soils – Crops Residues	1990-2013	N_2O	Revision of emission factors for N_2O emissions based on the IPCC 2006 GL.
4.D.2	Agricultural Soils – Indirect N_2O Emissions from Managed Soils	1990-2013	N_2O	Revision of emission factors 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.
4. LULUCF				
4.G	Harvested Wood Products	1990-2013	CO_2	New calculation of the HWP based on national data.
5. WASTE				
5.A	Solid waste disposal	2003-2013	CH_4	Revision due to double counting of recovered methane previously reported in the CRF Reporter.
5.C	Incineration and open burning of waste	1990-2013	CH_4	Methane emission factor for industrial waste incineration was revised and updated in connection with the energy sector.
5.D	Wastewater treatment and discharge	2013	N_2O	Input data on population and protein consumption were updated based on Statistical Yearbook 2015.

Table 10.4: *List of recalculations in June 15, 2016 submission (version 3) against January 15, 2016 submission with short explanation*

Recalculated category (submission 2016 v1 versus submission 2016 v3)		Year	GHG Affected	Explanation
1. ENERGY SECTOR				
1.A.3.a	Domestic Aviation	2005-2014	CH_4, N_2O	CH_4 and N_2O emissions were recalculated based on national EFs and consumption provided by EUROCONTROL for the years 2005 – 2014, as EUROCONTROL emissions data appear to be unreliable.
1.A.3.b	Road Transportation - gasoline	1990	no	The NCV for gasoline reported in 1990 was found as outlier and was corrected with the extrapolation tool taking into consideration time series 1991 - 2014. In connection also gasoline consumption in energy unit was recalculated for 1990 for road transportation.
1.A.3.b	Road Transportation – gasoline and diesel oil	2007-2009	no	The fuel consumptions of gasoline (in subcategories 1.A.3.b.i and 1.A.3.b.ii) and diesel oil (1.A.3.b.i) for the years 2007, 2008, 2009 were recalculated, because there were found an error in calculation.
1.A.3.b	Road Transportation – gaseous fuels	2000-2014	no	Time series of consumption of gaseous fuels was recalculated for 2000 – 2014 taking into consideration real annual NCV values based on RA for this fuel. This change didn't affected emissions.
1.A.3.b	Road Transportation – LPG	1994-2006	no	Time series for liquefied petroleum gas (LPG) consumption was recalculated for time series 1994 – 2006 taking into consideration real annual NCV values based on RA for this fuel.
1.A.3.c	Railways – liquid fuels and biomass	2007-2013	CH_4, N_2O	Emissions of CH_4 and N_2O were reported wrongly, correction of copying error
1.A.3.e.ii	Urea-based Catalysts	2014	CO_2	CO_2 emissions from urea-based catalysts were included into inventory.
1.A.3.d	Domestic Navigation	1990-2013	no	Time series for gas/diesel oil consumption was recalculated for the time series 1990 - 2013 taking into consideration real annual NCV values based on RA for this fuel. This change didn't affected emissions.
1.D.1.a	International Aviation	2005-2014	CH_4, N_2O	CH_4 and N_2O emissions were recalculated based on default EFs and consumption provided by EUROCONTROL for the years 2005 – 2014, as EUROCONTROL emissions data appear to be unreliable.
3. AGRICULTURE				
3.A.1 3.A.2	Enteric Fermentation - cattle	1990-2014	no	Values for Gross energy reported in MJ/head/day instead of MJ/day. This change didn't affected emissions.
3.A.3	Enteric Fermentation - swine	1990-2003	CH_4	Time series was recalculated for 1990 - 2003 with the consistent methodology and EF.
3.B.1.4	Manure Management - poultry	1990-2014	CH_4	Time series for poultry implied emission factor was recalculated for 1990 - 2014 with the consistent methodology and weighted average of EF based on poultry subcategories using the IPCC 2006 GL.
3.B.2	Manure Manegement – cattle, sheep, goats and horses	1990-2014	N_2O	Recalculation of nitrogen due to incorrect formula
3.B.2.4	Manure Management - poultry	1990-2014	N_2O	Incorrect application of Nex for poultry in all years was corrected considered typical animal weight.

Recalculated category (submission 2016 v1 versus submission 2016 v3)		Year	GHG Affected	Explanation
3.B.2.4	Manure Management - horses	1990-2013	N_2O	Nex for horses was recalculated in 1990 -2013 using national value reported in 2014.
3.B.2.5	Indirect N_2O Emissions	1990-2014	N_2O	Due to recalculations in the categories 3.B.2.4, recalculations also in the category 2.B.2.5 were necessary.
3.D.1.2.a	Animal Manure Applied to Soils	1990-2014	N_2O	Due to recalculations in the categories 3.B.2.4, recalculations in nitrogen applied to soils also in the category 2.D.1.2.a were necessary.
3.D.1.2.b	Sewage sludge applied to soils	2010-2014	N_2O	Completed estimate for sewage sludge
3.D.1.3	Urine and Dung Deposited by Grazing Animals	1990-2014	N_2O	Due to recalculations in the categories 3.B.2.4, recalculations in nitrogen applied to soils also in the category 2.D.1.3 were necessary.
3.D.2.1	Atmospheric Deposition	1990-2014	N_2O	Values of volatilized nitrogen in agricultural input included in the CRF Reporter were corrected.
3.D.2.2	N-Leaching and Run-off	1990-2014	N_2O	Values of nitrogen from fertilizers and other agricultural input that is lost through leaching and run-off included in the CRF Reporter were corrected.
4. LULUCF				
4.C.2.4.(III)	Direct N_2O Emissions from N Mineralization/Immobilization	1990-2014	N_2O	The assessment of direct nitrous oxide emissions from nitrogen mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use of mineral soil was updated according to the 2006 IPCC Guidelines. The N_2O emissions are now estimated using the equations 11.1, 11.2 and 11.8 of the 2006 IPCC Guidelines.
4.E.2.4(III)	Direct N_2O Emissions from N Mineralization/Immobilization	1990-2014	N_2O	The assessment of direct nitrous oxide emissions from nitrogen mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use of mineral soil was updated according to the 2006 IPCC Guidelines. The N_2O emissions are now estimated using the equations 11.1, 11.2 and 11.8 of the 2006 IPCC Guidelines.
4.F.2.4(III)	Direct N_2O Emissions from N Mineralization/Immobilization	1990-2014	N_2O	The assessment of direct nitrous oxide emissions from nitrogen mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use of mineral soil was updated according to the 2006 IPCC Guidelines. The N_2O emissions are now estimated using the equations 11.1, 11.2 and 11.8 of the 2006 IPCC Guidelines.
7. KP LULUCG				
7. 4 (KP-I) B.1-FM	Land-use Matrix	2014	no	Total area subject to the activity reported in tables (4(KP-I)B.1)-FM should correspond to figures in table NIR2. L2 1985.444 1985.295 for 2013 and 2014 respectively, L3 1985.444 1985.295 for 2013 and 2014 respectively. We corrected table 4(KP-I) B.1 - FM in this way.

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. More information on KP-LULUCF estimations and methodologies will be officially submitted in the next submission.

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).

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 values
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 period (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 as well as for the second commitment period.

For the second commitment period the Slovak Republic reports also on the activity forest management under Article 3.4 as it became mandatory. The Slovak Republic has decided not to elect any additional activity under Article 3.4 (Cropland management, Grazing land management Revegetation and Wetland drainage and rewetting) for meeting its commitment under the second commitment period of the KP.

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 activities is based on the data from the Geodesy, Cartography and Cadastre 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 on 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

Because only Forest Management is accounts under Article 3.4 activities by Slovakia, is not necessary to build up the hierarchy between the FM and other Article 3.4 activities.

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

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, the 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 and D 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

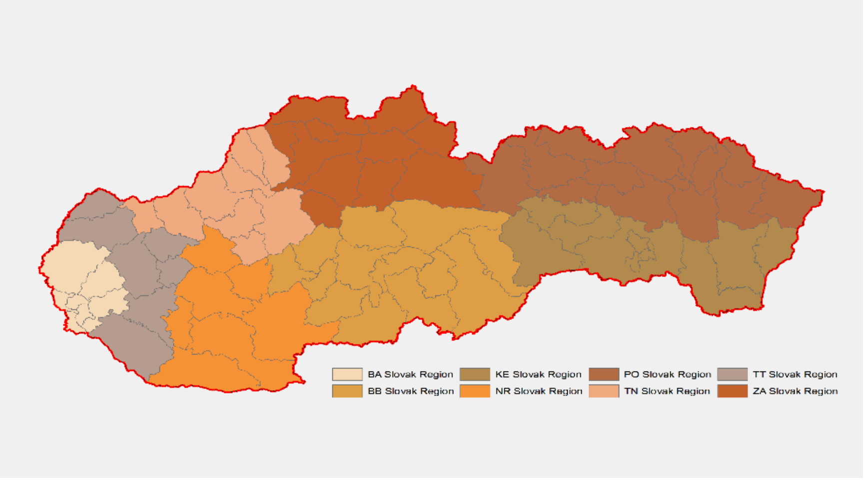
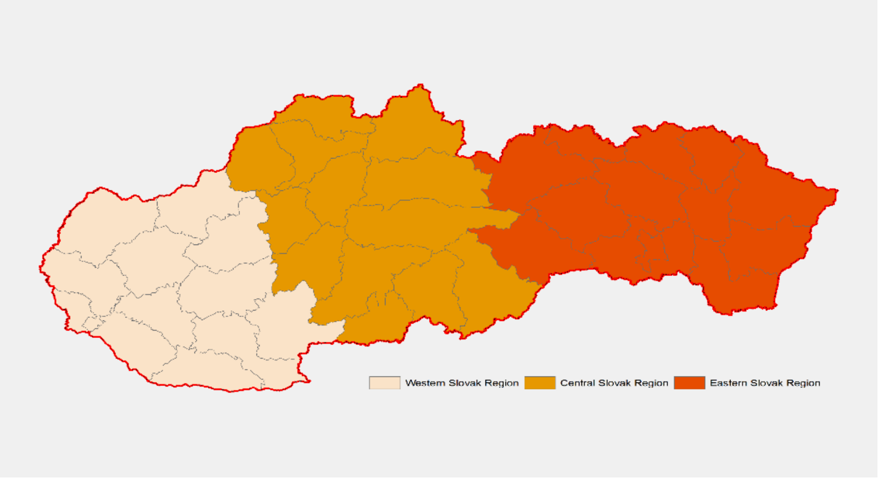


__Figure 11.2:__ Three Slovak regional districts used for the assessment of ARD activities since 1990



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 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 – 2014 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

Figure 11.3: *The cadastral units with afforestation/reforestation activity in Slovakia (2014)*

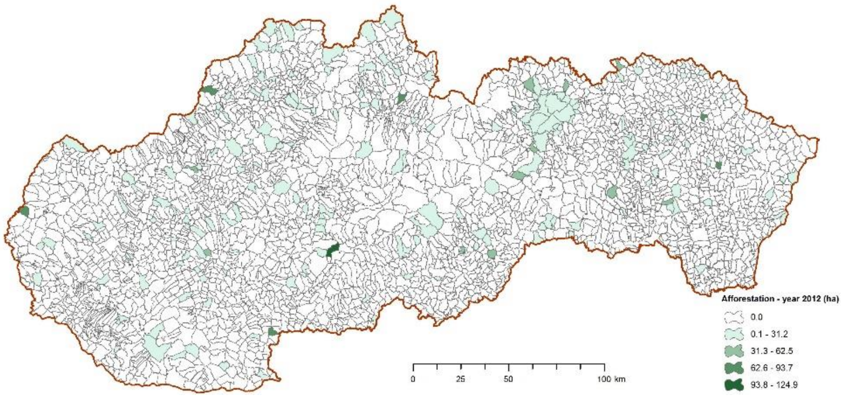


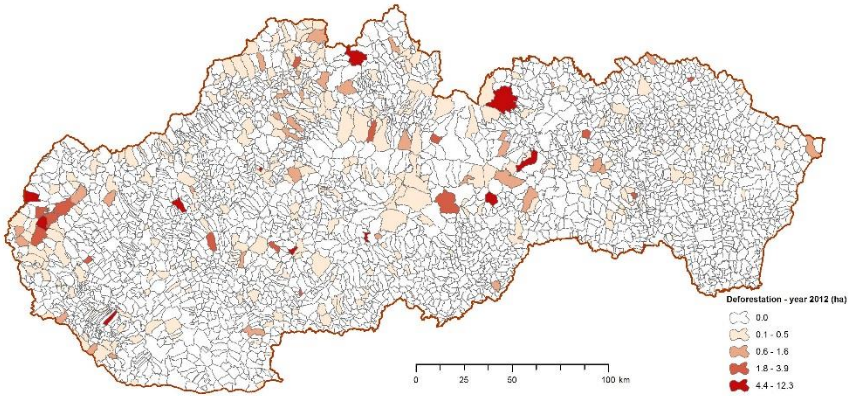
Table 11.4: *The areas of D activities during 1996 – 2014 for whole country and different Slovak districts*

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
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

<table>
<tr><th rowspan="2">DEF</th><th>SK</th><th>BA</th><th>TT</th><th>TN</th><th>NR</th><th>ZA</th><th>BB</th><th>PO</th><th>KE</th></tr>
<tr><th colspan="9">(kha)</th></tr>
<tr><td>2007</td><td>0.454</td><td>0.026</td><td>0.052</td><td>0.047</td><td>0.066</td><td>0.061</td><td>0.023</td><td>0.161</td><td>0.018</td></tr>
<tr><td>2008</td><td>0.323</td><td>0.026</td><td>0.029</td><td>0.033</td><td>0.017</td><td>0.059</td><td>0.091</td><td>0.026</td><td>0.041</td></tr>
<tr><td>2009</td><td>0.462</td><td>0.199</td><td>0.023</td><td>0.053</td><td>0.044</td><td>0.049</td><td>0.010</td><td>0.043</td><td>0.041</td></tr>
<tr><td>2010</td><td>0.326</td><td>0.034</td><td>0.018</td><td>0.027</td><td>0.006</td><td>0.087</td><td>0.025</td><td>0.091</td><td>0.038</td></tr>
<tr><td>2011</td><td>0.087</td><td>0.008</td><td>0.005</td><td>0.008</td><td>0.011</td><td>0.014</td><td>0.020</td><td>0.012</td><td>0.009</td></tr>
<tr><td>2012</td><td>0.122</td><td>0.007</td><td>0.027</td><td>0.006</td><td>0.003</td><td>0.019</td><td>0.030</td><td>0.013</td><td>0.017</td></tr>
<tr><td>2013</td><td>0.098</td><td>0.013</td><td>0.002</td><td>0.001</td><td>0.015</td><td>0.014</td><td>0.017</td><td>0.021</td><td>0.015</td></tr>
<tr><td>2014</td><td>0.149</td><td>0.005</td><td>0.004</td><td>0.004</td><td>0.065</td><td>0.014</td><td>0.014</td><td>0.039</td><td>0.004</td></tr>
</table>

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 cadastral units with deforestation activity in Slovakia (2014)*



In the following table 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 – 2014 from whole country and different Slovak districts*

<table>
<tr><th rowspan="2">A/R</th><th>SK</th><th>BA</th><th>TT</th><th>TN</th><th>NR</th><th>ZA</th><th>BB</th><th>PO</th><th>KE</th></tr>
<tr><th colspan="9">%</th></tr>
<tr><td>1996</td><td>0.03</td><td>0.00</td><td>0.00</td><td>0.00</td><td>0.00</td><td>0.03</td><td>0.08</td><td>0.04</td><td>0.03</td></tr>
<tr><td>1997</td><td>0.07</td><td>0.03</td><td>0.05</td><td>0.00</td><td>0.00</td><td>0.22</td><td>0.02</td><td>0.16</td><td>0.00</td></tr>
<tr><td>1998</td><td>0.05</td><td>0.00</td><td>0.02</td><td>0.00</td><td>0.00</td><td>0.12</td><td>0.09</td><td>0.06</td><td>0.00</td></tr>
<tr><td>1999</td><td>0.04</td><td>0.00</td><td>0.03</td><td>0.03</td><td>0.01</td><td>0.07</td><td>0.05</td><td>0.04</td><td>0.07</td></tr>
<tr><td>2000</td><td>0.03</td><td>0.00</td><td>0.00</td><td>0.00</td><td>0.00</td><td>0.10</td><td>0.02</td><td>0.04</td><td>0.01</td></tr>
<tr><td>2001</td><td>0.02</td><td>0.00</td><td>0.00</td><td>0.03</td><td>0.00</td><td>0.09</td><td>0.00</td><td>0.01</td><td>0.04</td></tr>
<tr><td>2002</td><td>0.02</td><td>0.01</td><td>0.00</td><td>0.02</td><td>0.00</td><td>0.07</td><td>0.01</td><td>0.00</td><td>0.02</td></tr>
<tr><td>2003</td><td>0.03</td><td>0.00</td><td>0.00</td><td>0.03</td><td>0.01</td><td>0.11</td><td>0.04</td><td>0.01</td><td>0.05</td></tr>
<tr><td>2004</td><td>0.02</td><td>0.00</td><td>0.01</td><td>0.05</td><td>0.00</td><td>0.04</td><td>0.01</td><td>0.03</td><td>0.01</td></tr>
<tr><td>2005</td><td>0.02</td><td>0.00</td><td>0.02</td><td>0.00</td><td>0.00</td><td>0.09</td><td>0.01</td><td>0.01</td><td>0.00</td></tr>
<tr><td>2006</td><td>0.04</td><td>0.04</td><td>0.01</td><td>0.01</td><td>0.02</td><td>0.11</td><td>0.00</td><td>0.09</td><td>0.01</td></tr>
<tr><td>2007</td><td>0.01</td><td>0.01</td><td>0.00</td><td>0.01</td><td>0.01</td><td>0.00</td><td>0.02</td><td>0.02</td><td>0.01</td></tr>
<tr><td>2008</td><td>0.03</td><td>0.00</td><td>0.00</td><td>0.10</td><td>0.03</td><td>0.02</td><td>0.03</td><td>0.02</td><td>0.03</td></tr>
<tr><td>2009</td><td>0.02</td><td>0.01</td><td>0.00</td><td>0.02</td><td>0.00</td><td>0.00</td><td>0.02</td><td>0.06</td><td>0.02</td></tr>
<tr><td>2010</td><td>0.06</td><td>0.05</td><td>0.00</td><td>0.10</td><td>0.02</td><td>0.00</td><td>0.12</td><td>0.07</td><td>0.03</td></tr>
<tr><td>2011</td><td>0.02</td><td>0.02</td><td>0.01</td><td>0.05</td><td>0.01</td><td>0.05</td><td>0.02</td><td>0.01</td><td>0.03</td></tr>
<tr><td>2012</td><td>0.04</td><td>0.04</td><td>0.01</td><td>0.04</td><td>0.03</td><td>0.03</td><td>0.04</td><td>0.04</td><td>0.05</td></tr>
<tr><td>2013</td><td>0.03</td><td>0.01</td><td>0.02</td><td>0.01</td><td>0.01</td><td>0.02</td><td>0.07</td><td>0.02</td><td>0.04</td></tr>
<tr><td>2014</td><td>0.04</td><td>0.00</td><td>0.01</td><td>0.01</td><td>0.02</td><td>0.11</td><td>0.05</td><td>0.02</td><td>0.01</td></tr>
</table>

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 39.440 kha in total and 1.578 kha yearly in average in Slovak conditions from 1990 to 2014. In the same time period the total deforestation area reached 8.363 kha in total resp. 0.342 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).

The identified land-use change from Cropland, Grassland or Other Land converted to Forest Land, 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 – 2014.

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. The European Union within the framework of PHARE project has supported KAPOR operation also. KAPOR enables the access of users to the real estate cadastre data.

Table 11.6: *The differences between AR and DEF activities during 1990 – 2014*

Year	Afforestation/Reforestation				Deforestation					Differ.
	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**

Year	Afforestation/Reforestation				Deforestation					Differ.
	C to FL	G to FL	OL - FL	Total	FL to C	FL to G	FL to S	FL - OL	Total	
	(kha)				(kha)					(kha)
Total 90-14	**1.890**	**17.902**	**19.648**	**39.44**	**0.417**	**3.74**	**1.223**	**2.983**	**8.363**	**31.077**
Aver. 90-14	**0.08**	**0.75**	**0.82**	**1.64**	**0.02**	**0.16**	**0.05**	**0.12**	**0.35**	**0.29**

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.

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

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 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, tonnes C yr^{-1}, $\Delta C_{LFGROWTH}$ - annual increase in carbon stocks in living biomass due to growth in land converted to forest land, tonnes C yr^{-1}, 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, tonnes C yr^{-1}

- 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^{-1}, 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^{-1} yr^{-1}, CF = carbon fraction of dry matter (default = 0.5), t C $(t\ d.m.)^{-1}$

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 dm /ha/y, pine 3.17 t dm/ha/y, beech 2.32 t dm/ha/y, oak 1.23 t dm/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.

The annual increment of the below-ground biomass for the four main tree species included in the inventory are following: spruce 0.56 t dm/ha/y, pine 0.40 t dm/ha/y, beech 0.90 t dm/ha/y and oak 0.57 t dm/ha/y. The proportion of main tree species of total artificial reforestation areas for accounting years were selected from database of the Statistical Office of the Slovak Republic (www.statistics.sk) and represented 46% for spruce, 22% for pine, 29% for beech and 3% for oak in 2013. In 2014, the shares were as follows: spruce 55%, pine 9%, oak 3%, beech 33%.

- 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^{-1}, $L_{fellings}$ - biomass loss due to harvest of industrial wood and saw logs in land converted to forest land, t C yr^{-1}, $L_{fuelwood}$ - biomass loss due to fuelwood gathering in land converted to forest land, t C yr^{-1}, $L_{other\ losses}$ - biomass loss due to fires and other disturbances in land converted to forest land, t C yr^{-1}

The carbon loss connected with living biomass (caused by silvicultural cuttings) in the afforested/reforested land was assumed to be insignificant (zero). First argument for such approach is that the first thinning (with removing the biomass from forests) occurs in older age forest stands in the conditions of Slovakia. Second, is that in case of clearings the wood is not extracted from forest. It means that no losses of living biomass have occurred on AR areas in Slovakia. Beside this, the data on the amount of living biomass felled in forests until to the extraction of merchantable dimensions of wood are not available in the Slovak conditions and in general are considered zero.

- Change in carbon stocks in living biomass for deforestation.

The method requires the estimates of carbon in living biomass stocks prior to deforestation, based on the estimates of the areas of land deforested during the period between land-use surveys. Because of deforestation, it is assumed that the dominant vegetation is removed entirely, resulting in no carbon remaining in living biomass after deforestation. The difference between initial and final living biomass carbon pools is used to calculate change in carbon stocks due to deforestation (equation 2.16, IPCC 2006 GL).

The average change in carbon stocks estimated on a per area basis is to be equal to the change in carbon stocks due to the removal of living biomass from initial forests. Given the definition of the deforestation, the default assumption is that carbon stock after this activity is zero.

Annual change in carbon stocks in living biomass in land converted to other land

$$\Delta C_{Conv.} = A_{Conv.} \bullet (B_{After} - B_{Before}) \bullet CF$$

Where:

$\Delta C_{Conv.}$ - annual change in carbon stocks in living biomass in land converted to another land, tonnes C yr^{-1}, $A_{Conv.}$ - area of annually deforested land from some initial land uses, ha yr^{-1}, B_{After} - amount of living biomass immediately after deforestation, t d.m. ha^{-1}, B_{Before} - amount of living biomass immediately before deforestation, t d.m. ha^{-1}, CF = carbon fraction of dry matter (default = 0.5), t C $(td.m.)^{-1}$

Tier 1 and tier 2 methods were used for calculation. It follows the approach in the IPCC 2006 GL LULUCF, 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 based on 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 GL).

- Change in carbon stocks in dead organic matter for ARD

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).

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. 1997, 2002, 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^{-1} for C stocks in litter (representing surface organic layer) as well as 0.415 t C ha^{-1} yr^{-1} 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^{-1} yr^{-1}) x 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 ARD.

- Change in carbon stocks in soils for ARD

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 (4.A.2) for AR activity and chapters (4.B.2, 4.C.2, 4.E.2, 4.F.2) concerning Forest land converted to other land use categories for D activity. Calculations of carbon stock changes in mineral soils because of ARD activities carried out as follows IPCC 2006 GL. The net carbon stock change in mineral soils was estimated using the country specific tier 2 method described in detail in Chapter 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 previous report, we have changed the approach to calculation of soil organic carbon stocks in soil as for the soil depth. In order to have results that are more precise 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). In addition, pedotransfer function for soil bulk density estimation calibrated at national level was used to get more precise results of soil carbon stock change. For respective land use categories following values were used in calculations of carbon stock changes in mineral soils (0-30 cm):

- Forest Land 89.02 t C ha^{-1}
- Cropland 60.11 t C ha^{-1}
- Grassland 74.95 t C ha^{-1}
- Other Land 53.85 t C ha^{-1}

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^{-1} yr^{-1}) 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^{-1} yr^{-1}, Aff/Ref of Grassland +0.704 t C ha^{-1} yr^{-1}, Aff/Ref of Other land +1.758 t C ha^{-1} yr^{-1}.

Def to Cropland -1.446 tC ha^{-1} yr^{-1}, Def to Grassland -0.704 t C ha^{-1} yr^{-1}, Def to Settlements and Other land -1.758 t C ha^{-1} yr^{-1}.

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 GL). 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 2014.

- GHG emissions from wildfires associated with Afforestation/Reforestation activities

The emissions of greenhouse gases from wildfires were calculated based on known areas burnt annually and the average biomass stock in forests according to the equation 2.27 (IPCC 2006 GL). The burnt area connected to AR activities was estimated as percentage of total burnt area. This percentage was calculated from areas of FL remaining FL and areas of AR activities in corresponding year. Total CH_4, N_2O emissions on AR areas from wildfires represent 0.467 t, 0.026 t in 2013, and the emissions of CH_4, N_2O were 0.347 t and 0.019 t in 2014.

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 in the 2014 and onwards submissions on the basis of the recommendations of the ERT.

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 2015 submission, new GPG methods are applied (IPCC 2006 GL and, IPCC 2013 Supplements).

11.3.1.5 Uncertainty estimate

Uncertainties are already presented in chapters concerning conversion of Forest land (CL, GL, S, OL to FL and FL to CL, GL, S, OL). According to the expert estimation and based on statistical approach for the estimation of wood stocks in the Slovak forest published by Šmelko et al. (2003) the uncertainty represented 15 - 20%. The accuracy of above ground biomass annual increment on new afforested areas represented by standard deviation was following spruce ±1.37 t dm/ha/y, pine ± 1.50 t dm/ha/y, beech ±1.56 t dm/ha/y and oak ±0.91 t dm/ha/y. The accuracy of below ground biomass annual increment on new afforested areas represented by standard deviation was following spruce ±0.22 t dm/ha/y, pine ± 0.12 t dm/ha/y, beech ±0.55 t dm/ha/y and oak ±0.24 t dm/ha/y.

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 annually updated cadastral 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. Landowners always initiate the change of land use classification 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 these reasons, 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.

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 equivalents for the first commitment period.

The estimated removals from afforestation/reforestation activities represented -443.07 Gg CO_2 equivalents in 2013 and -441.81 Gg CO_2 in 2014.

Emissions from deforestation were 43.04 Gg CO_2 in the year 2013 and 62.80 Gg CO_2 in 2014. The activities under Article 3.3 of Kyoto Protocol represent the net removal of -400.03 Gg CO_2 equivalents in 2013 and -379.01 Gg CO_2 equivalents in 2014. The details are noted in the corresponding CRF tables of KP LULUCF.

11.4.5 INFORMATION ON HARWESTED 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 $f_{j(i)}$ is a share of harvest originating from the particular activity *j* in year *i, j* is an activity FM or D in year *i*.

In years, 2013 and 2014 the share of D was 0.0030 and 0.0036 respectively.

11.5 ARTICLE 3.4

The Slovak Republic has not elected reporting under Article 3.4 of the KP in the 1.CP.

In the second CP the Forest Management (FM) became mandatory. The CO_2 removals from FM were related to the changes in living biomass. The net removals in this activity were 6 874.15 Gg CO_2 in 2013 and 4 952.59 Gg CO_2 in 2014. The emissions from biomass burning are associated with FM as well. The emissions of CH_4 and N_2O in 2013 were 0.36 Gg and 0.02 Gg, in 2014 CH_4 and N_2O emissions were 0.69 Gg and 0.04 Gg respectively. The net CO_2 equivalent removals in 2013 and 2014 were -6 859.20 Gg and -4 924.15 Gg respectively.

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.

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 2013. Following Table 11.7 shows domestic production of sawn wood, wood based panels and paper (including paper board) as used for HWP stocks changes.

Table 11.7: *Domestic production of sawn wood, wood based panels and paper (including paper board) as used for HWP stocks changes in 1990 – 2014*

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

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 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 choice 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

[1] Declaration made in footnote to Annex B of the Doha Amendment.

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 equivalent		
	75 533 161	0	75 533 161

Pursuant to Article 3, paragraphs 7bis, 8 and 8bis of the Kyoto Protocol, the assigned amount for the second commitment period is equal to the percentage inscribed in the third column of Annex B of the Annex to the Doha amendment of the aggregate anthropogenic carbon dioxide equivalent emissions of greenhouse gases in the base year multiplied by eight, taking into account Article 3 (7bis) of the Kyoto Protocol.

This method of calculation is only applied to the calculation of the joint assigned amount of the European Union, its Member States and Iceland. It does not apply to the calculation of the individual assigned amounts for the Union, the Member States individually, or Iceland. Thus, the calculations of the base year emissions do not play a role in the calculation of their individual assigned amounts, which are instead determined pursuant to the joint fulfilment agreement which sets an assigned amount of 202 268 939 t of CO_2 eq. for the Slovak Republic.

12.1.4 DIFFERENCE BETWEEN THE ASSIGNED AMOUNT FOR THE SECOND COMMITMENT PERIOD AND THE AVERAGE EMISSIONS FOR THE FIRST THREE YEARS OF THE PRECEDING COMMITMENT PERIOD:

According to Article 3 (7ter) of the Doha Amendment of the Kyoto Protocol, any positive difference between the assigned amount of the second commitment period and the average annual emissions for the first three years of the preceding commitment period multiplied by eight shall be transferred to the cancellation account.

Table 12.3: *Assigned amount for the second commitment period and average emissions for the first three years of the preceding commitment period in tons of CO_2 eq.*

ASSIGNED AMOUNT FOR THE SECOND COMMITMENT PERIOD	202 268 939
AVERAGE ANNUAL EMISSIONS FOR 2008 TO 2010 MULTIPLIED BY EIGHT	380 416 187

The assigned amount for the second commitment period, is lower than average annual emissions for the period 2008 – 2010 multiplied by eight as indicated in Table 12.3. Thus, no positive difference occurs and no cancellation needs to be performed.

12.2 SUMMARY OF INFORMATION REPORTED IN THE SEF TABLES

The standard electronic format (SEF) tables are providing information on AAUs, ERUs, RMUs, CERs, lCERs and tCERs in the Slovak National Emission Registry. SEF tables covering years 2013, 2014 and 2015 are included in the submission (RREG1_SK_2013.xlsx, RREG1_SK_2014.xlsx and RREG1_SK_2015.xlsx). The tables include all required information on Kyoto units concerning second commitment period in Slovak National Emission Registry during each of the reported periods as well as information on transfers of these units during the reported periods 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_2015.xlsx, RREG3_SK_2015.xlsx, RREG4_SK_2015.xlsx and RREG5_SK_2015.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 12.4 provides a calculation using both methods to calculate the commitment period reserve. The last column presents the commitment period reserve applicable for the second commitment period for the Slovak Republic based on the lower value resulting from the two methods.

Table 12.4: Commitment period reserve of the 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	344 946 720	182 042 045

CHAPTER 13: INFORMATION ON CHANGES IN NATIONAL SYSTEM

There were no changes in the arrangement of the National Inventory System during inventory years 2015 and 2016. National Inventory System and arrangements are described in the Chapter 1.2.9 of this report.

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	The database model is provided in Annex A. Versions of the CSEUR released after 6.3.3.2 (the production version at the time of the last Chapter 14 submission) introduced minor changes in the structure of the database. These changes were limited and only affected EU ETS functionality. No change was required to the database and application backup plan. No change to the capacity of the CSEUR occurred during the reported period.

Reporting Item	Description
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Changes introduced since version 6.3.3.2 of the CSEUR were limited and mainly affected EU ETS functionalities. 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 carried out in February 2016 and the test report is provided. No other change in the CSEUR's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	No change of security measures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No change to the list of publicly available information occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change of the registry internet address occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	Changes introduced since version 6.3.3.2 of the CSEUR were limited and mainly affected EU ETS functionalities. Both regression testing and tests on the new functionality were successfully carried out prior to release of the version to Production. The site acceptance test was carried out by quality assurance consultants on behalf of and assisted by the European Commission; the report is attached as Annex B. Annex H testing was carried out in February 2016 and the test report is provided.

CHAPTER 15: INFORMATION ON MINIMIZATION OF ADVERSE IMPACTS IN ACCORDANCE WITH ARTICLE 3, PARAGRAPH 14

15.1 LEGISLATIVE BACKGROUND

- Kyoto Protocol - Article 3.14 requires Annex I countries to implement their GHG emission reduction commitments in a way to minimize the adverse social, environmental and economic impacts on developing country Parties, particularly those listed in Article 4.8 and 4.9 of the Convention.
- Decision 15/CMP.1 – paragraphs 23 – 26 in Article 3.14 and Article 7.1 provide further guidelines and focus the reporting commitments towards the following points:

a) The progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse gas emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities, in pursuit of the objective of the Convention.

b) Removing subsidies associated with the use of environmentally unsound and unsafe technologies.

c) Cooperating in the technological development of non-energy uses of fossil fuels, and supporting developing country Parties to this end.

d) Cooperating in the development, diffusion and transfer of less greenhouse-gas emitting advanced fossil-fuel technologies, and/or technologies relating to fossil fuels that capture and store greenhouse gases, and encouraging their wider use; and facilitating the participation of the least developed countries and other Parties not included in Annex I of the UNFCCC in this effort.

e) Strengthening the capacity of developing country Parties identified in Article 4, paragraphs 8 and 9, of the Convention for improving efficiency in upstream and downstream activities relating to fossil fuels, taking into consideration the need to improve the environmental efficiency of these activities.

f) Assisting developing country Parties which are highly dependent on the export and consumption of fossil fuels in diversifying their economies.

- Decision 22/CMP.1 – paragraphs 121 – 126 provides guidelines for review under Article 8 of the Kyoto Protocol, some of it relevant for Article 3.14.
- Decision 31/CMP.1 – provides a mandate to implement the commitments from the Article 3.14.

15.2 INTRODUCTION AND METHODOLOGICAL GUIDELINES

Implementation of increasingly stringent environmental regulations and economic policies which penalize further use of environmentally harmful substances, technologies and so on might be associated with a range of side effects. It is not excluded that some of possible adverse economic effects will affect some developing and least developed countries having less means for adequate remedial response measures. The magnitudes of these potential impacts are typically given by the stringency of adopted measures, selection of the particular policy instrument, size and strength of the implementing economy relative to the world markets and also the actual macroeconomic set up of the affected developing countries.

In this chapter there are identified potential channels of how domestically implemented environmental policies in the Slovak Republic might have exercised any impact on third countries. Furthermore, any existing evidence about the potential magnitudes of these effects is highlighted. Similarly, the activities in particular those related to the development aid of the Slovak Republic implemented in order to minimize the negative consequences caused by these policies are described in this chapter. The aim is to meet our commitments under the Kyoto Protocol in respect with transparent reporting on potential adverse social, environmental and economic impacts particularly on developing countries.

15.3 ADOPTED LEGISLATIVE MEASURES

15.3.1 FISCAL POLICY INSTRUMENTS

Fiscal policy instruments are increasingly being referred to as an efficient instrument to correct existing environmentally related price distortions. The Slovak Republic maintains excise taxes on fossil fuels, electricity and mineral oils. The actual fiscal policy drivers, however, still remain much more linked to the current governmental budgetary situation rather than to provide fiscal incentives for environmentally sound behaviour. Since 2009 only minor changes occurred such as a decrease of the excise tax on diesel, removal of existing exemptions of coal tax payers and increase of excise tax on LPG, CNG and electricity. No impact on any third countries is expected from already implemented fiscal policies and therefore no specific policies to offset any negative effects have been considered.

15.3.2 BIOFUELS POLICY

Biofuels policy discussed in more details in chapter 4.4.5 has been in place to meet the targets required by EU legislation. Increased demand and subsequently also the production of biofuels has not only been reflected by rising commodity prices but also induced land use changes resulting from the reduction of the supply of commodities in direct competition with those used for biofuels world-wide. Therefore, international trade represents the key channel through which the potential negative economic, social and environmental impacts[2] might be transmitted towards developing countries. Taking into account the low quantities of biofuels in use in the Slovak Republic, we do not expect any negative effects neither on forests destruction nor contribution to the rising world prices of agricultural commodities.[3] Despite its rather low contribution to these developments, the Slovak Republic actively contributes to shaping the international sustainability standards either within its own (and EU internal) legislation process or within the framework of international institutions, such as WTO, FAO, etc. Furthermore, the Slovak Republic has been actively engaged in strengthening the know-how on improving food security and agriculture, land and water management in Kenya. Moreover, scholarships for students from developing countries were offered with preference to those applying to pursue their studies in environmental sciences.

15.3.3 GHG REDUCTION POLICIES

The key policy option was a development of emerging carbon market with resulting carbon price. Among the complementary policies, targets have been adopted to increase the share of renewable energy resources, increase energy efficiency as well as the new legislation which sets more stringent quality standards for fuels and personal cars.

Adopted policies could have had some implications for third countries either through the underlying carbon market price mechanisms or requirements to comply with new and tighter environmental regulations. CO_2 emission trading (either EU ETS or Kyoto Protocol emission trading) and increasingly stringent fuel quality standards might have some impact. The major example of its direct impact on the third countries is the integration of aviation sector into the trading scheme. Among indirect effects, the major example is the concern about a possible carbon leakage. Most of the impacts of carbon leakage (shifts of industrial activity to the countries without any GHG emission reduction commitments, potential downward pressure on oil prices, etc.) on the third countries would in fact be rather positive for them.[4] Measures in place to minimize a potential carbon leakage include the provision to enlist economic sectors facing immediate threat of carbon leakage, which will under given conditions continue receiving their CO_2 allowances for free.

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[2] Implied excessive land use changes, food shortages or compromised food security.

[3] Please note that the different conclusion might be drawn when considering the implications of the overall EU biofuel policies. Similarly this would also apply in considering the existing agricultural policies within the EU Common Agricultural policy.

[4] In some specific cases, where the polluting entity seeking a location in developing country causing an increase of local pollution, increased environmental damage might outweigh economic benefits.

Furthermore, increasingly stringent fuel quality standards in Europe might in fact turn out to be positive impact because it might trigger increase of investments in the fuel processing industries in third countries. Rising fuel prices in Europe due to the carbon price (or tax) and quality increase might counter play the rising oil prices particularly due to increasing scarcity of this commodity. Such effects might on the one hand negatively affect revenues of the oil exporting countries, which can be on the other hand still balanced by rising demand from the rest of the world. The final net impact will depend on the benefits derived from expansion of industrial production and costs needed to clean up higher levels of pollution including addressing its consequences.

Apart to emission trading, no other Kyoto Protocol flexible instruments have been used to meet the GHG emission reduction targets by the Slovak Republic, therefore no impact on third countries in this respect is reported.

Activities considered within the preparation of the adaptation strategy to climate change have a local character without any implications for third countries.

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ANNEX 1: KEY CATEGORIES

Description of methodology used for identifying key categories

This Annex describes the methodology used to identify key categories. The level of disaggregation is based on the recommendation in the IPCC 2006 GL.

Key categories analysis according to Approach 1 (2006 IPCC Guidelines) is done by CRF Reporter. The results are presented in Table A1.1.1.

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 level and trend assessment in 2014*

IPCC Source Categories	Gas	Level 1990	Level 2014
4.A.1 Forest Land Remaining Forest Land	CO_2	yes	yes
1.A.3.b Road Transportation	CO_2	yes	yes
1.A.4 Other Sectors - Gaseous Fuels	CO_2	yes	yes
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO_2	yes	yes
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	yes	yes
2.C.1 Iron and Steel Production	CO_2	yes	yes
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous	CO_2	yes	yes
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	yes	yes
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	yes	yes
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO_2	yes	yes
2.A.1 Cement Production	CO_2	yes	yes
3.A Enteric Fermentation	CH_4	yes	yes
5.A Solid Waste Disposal	CH_4	yes	yes
4.B.1 Cropland Remaining Cropland	CO_2	yes	yes
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	yes	yes
2.B.1 Ammonia Production	CO_2	-	yes
2.A.2 Lime Production	CO_2	yes	yes
1.A.4 Other Sectors - Solid Fuels	CO_2	yes	yes
2.F.1 Refrigeration and Air conditioning	F-gases	-	yes
1.A.3.e Other Transportation	CO_2	yes	yes
3.B Manure Management	N_2O	yes	yes
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH_4	yes	yes
1.B.1 Fugitive emissions from Solid Fuels	CH_4	yes	yes
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	yes	yes
2.B.10 Other	CO_2	--	yes
4.A.2 Land Converted to Forest Land	CO_2	yes	yes
2.B.8 Petrochemical and Carbon Black Production	CO_2	yes	yes
2.A.4 Other Process Uses of Carbonates	CO_2	yes	yes
5.D Wastewater Treatment and Discharge	CH_4	yes	yes
4.G Harvested Wood Products	CO_2	yes	yes
2.C.3 Aluminium Production	CO_2	-	yes
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	yes	yes
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil	CO_2	-	yes
4.C.2 Land Converted to Grassland	CO_2	-	yes
2.B.2 Nitric Acid Production	N_2O	yes	-
3.B Manure Management	CH_4	yes	-
4.B.2 Land Converted to Cropland	CO_2	yes	-

Table A1.2: *Key categories identified using Approach 1 trend assessment in 2014*

IPCC Source Categories	Gas	Trend 2014
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO_2	yes
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	yes
1.A.4 Other Sectors - Solid Fuels	CO_2	yes
4.A.1 Forest Land Remaining Forest Land	CO_2	yes
1.A.3.b Road Transportation	CO_2	yes
2.C.1 Iron and Steel Production	CO_2	yes
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	yes
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO_2	yes
1.A.4 Other Sectors - Gaseous Fuels	CO_2	yes
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	yes
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	yes
3.A Enteric Fermentation	CH_4	yes
4.A.2 Land Converted to Forest Land	CO_2	yes
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	yes
1.A.3.e Other Transportation	CO_2	yes
2.A.1 Cement Production	CO_2	yes
3.B Manure Management	N_2O	yes
2.B.2 Nitric Acid Production	N_2O	yes
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	yes
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	yes
4.B.1 Cropland Remaining Cropland	CO_2	yes
2.A.2 Lime Production	CO_2	yes
1.B.1 Fugitive emissions from Solid Fuels	CH_4	yes
5.A Solid Waste Disposal	CH_4	yes
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH_4	yes
3.B Manure Management	CH_4	yes
4.G Harvested Wood Products	CO_2	yes
4.B.2 Land Converted to Cropland	CO_2	yes
5.D Wastewater Treatment and Discharge	CH_4	yes
2.A.4 Other Process Uses of Carbonates	CO_2	yes
2.B.8 Petrochemical and Carbon Black Production	CO_2	yes
1.A.4 Other Sectors - Solid Fuels	CH_4	yes
1.A.4 Other Sectors - Liquid Fuels	CO_2	yes
1.A.3.c Railways	CO_2	yes
2.B.1 Ammonia Production	CO_2	yes
2.C.3 Aluminium Production	PFCs	yes
2.C.2 Ferroalloys Production	CO_2	yes
4.F.2 Land Converted to Other Land	CO_2	yes
1.A.5 Other (Not specified elsewhere) - Solid Fuels	CO_2	yes
4.C.2 Land Converted to Grassland	CO_2	yes
2.D Non-energy Products from Fuels and Solvent Use	CO_2	yes
1.A.5 Other (Not specified elsewhere) - Gaseous Fuels	CO_2	yes
5.D Wastewater Treatment and Discharge	N_2O	yes
2.C.3 Aluminium Production	CO_2	yes
2.B.10 Other	CO_2	yes
4.E.2 Land Converted to Settlements	CO_2	yes
5.B Biological Treatment of Solid Waste	CH_4	yes
5.C Incineration and Open Burning of Waste	CO_2	yes
4(III).Direct N_2O emissions from N mineralization/immobilization	N_2O	yes
5.B Biological Treatment of Solid Waste	N_2O	yes

IPCC Source Categories	Gas	Trend 2014
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	N_2O	yes
1.A.3.b Road Transportation	N_2O	yes
1.A.3.c Railways	N_2O	yes
3.G Liming	CO_2	yes
1.A.5 Other (Not specified elsewhere) - Liquid Fuels	CO_2	yes
1.A.1 Fuel combustion - Energy Industries - Biomass	CH_4	yes
1.A.4 Other Sectors - Biomass	CH_4	yes
1.A.4 Other Sectors - Solid Fuels	N_2O	yes
1.A.3.b Road Transportation	CH_4	yes
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	N_2O	yes
1.A.1 Fuel combustion - Energy Industries - Biomass	N_2O	yes
1.B.1 Fugitive emissions from Solid Fuels	CO_2	yes
2.G Other Product Manufacture and Use	N_2O	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 (2016). 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 2016 submission for 1990 – 2014 in the IPPU. Explanation is given in the CRF Tables and also 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 2014*

IPCC category/Group	Gas	Base year emissions or removals	Year 2014 emissions or removals	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Uncertainty introduced into the trend in total national emissions
2.F.1 Refrigeration and Air conditioning	F-gases	0,00	505,15	10,00	0,40	10,01	0.0115
2.F.2 Foam Blowing Agents	F-gases	0,00	2,34	10,00	0,40	10,01	0.0000
2.F.3 Fire Protection	F-gases	0,00	18,75	10,00	0,40	10,01	0.0000
2.F.4 Aerosols	F-gases	0,00	8,90	10,00	0,40	10,01	0.0000
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO_2	3 819,21	1 246,69	5,00	3,60	6,16	0.0208
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO_2	13 060,58	4 873,86	2,50	3,60	4,38	0.0928
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	2 176,70	2 148,37	2,50	2,75	3,72	0.0142
1.A.1 Fuel combustion - Energy Industries - Other Fossil Fuels	CO_2	0,00	0,13	5,00	5,00	7,07	0.0000
1.A.1 Fuel combustion - Energy Industries - Peat	CO_2	0,00	0,00	5,00	5,00	7,07	0.0000
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	2 867,64	251,39	5,00	3,60	6,16	0.0070
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	9 028,52	4 347,02	5,00	2,80	5,73	0.2155
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	3 930,61	2 238,64	2,50	2,75	3,72	0.0142
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	0,00	232,16	5,00	5,00	7,07	0.0009
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Peat	CO_2	0,00	55,58	5,00	5,00	7,07	0.0001
1.A.3.a Domestic Aviation	CO_2	7,74	4,68	1,00	5,00	5,10	0.0000
1.A.3.b Road Transportation	CO_2	4 503,02	6 181,41	1,00	5,00	5,10	0.0854
1.A.3.c Railways	CO_2	376,77	88,28	1,00	5,00	5,10	0.0001
1.A.3.d Domestic Navigation - Liquid Fuels	CO_2	0,02	3,48	1,00	5,00	5,10	0.0000
1.A.3.e Other Transportation	CO_2	1 813,95	481,84	1,00	5,00	5,10	0.0022
1.A.4 Other Sectors - Liquid Fuels	CO_2	386,75	11,55	5,00	3,60	6,16	0.0001
1.A.4 Other Sectors - Solid Fuels	CO_2	7 171,66	616,27	5,00	4,00	6,40	0.0534
1.A.4 Other Sectors - Gaseous Fuels	CO_2	3 704,26	4 947,07	2,50	2,75	3,72	0.0817
1.A.5 Other (Not specified elsewhere) - Liquid Fuels	CO_2	41,99	4,99	5,00	3,60	6,16	0.0000
1.A.5 Other (Not specified elsewhere) - Solid Fuels	CO_2	216,08	2,53	5,00	4,00	6,40	0.0001
1.A.5 Other (Not specified elsewhere) - Gaseous Fuels	CO_2	154,75	46,45	2,50	2,75	3,72	0.0000
1.B.1 Fugitive emissions from Solid Fuels	CO_2	19,01	18,28	2,00	5,00	5,39	0.0000

IPCC category/Group	Gas	Base year emissions or removals	Year 2014 emissions or removals	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Uncertainty introduced into the trend in total national emissions
2.A.1 Cement Production	CO_2	1 464.50	1 135.27	1.50	2.80	3.18	0.0014
2.A.2 Lime Production	CO_2	794.92	662.16	1.50	2.80	3.18	0.0005
2.A.3 Glass Production	CO_2	7.88	13.22	1.50	3.00	3.35	0.0000
2.A.4 Other Process Uses of Carbonates	CO_2	446.73	321.60	2.50	4.30	4.97	0.0003
2.B.1 Ammonia Production	CO_2	331.77	674.48	5.00	5.00	7.07	0.0064
2.B.5 Carbide Production	CO_2	0.00	95.35	2.00	5.00	5.39	0.0001
2.B.8 Petrochemical and Carbon Black Production	CO_2	428.80	330.79	10.50	11.50	15.57	0.0056
2.B.10 Other	CO_2	116.99	369.29	2.00	2.00	2.83	0.0003
2.C.1 Iron and Steel Production	CO_2	4 167.97	3 763.30	2.00	5.00	5.39	0.0345
2.C.2 Ferroalloys Production	CO_2	296.74	165.00	3.00	5.00	5.83	0.0001
2.C.3 Aluminium Production	CO_2	121.32	265.24	2.00	5.00	5.39	0.0003
2.C.5 Lead Production	CO_2	0.00	0.05	1.50	20.00	20.06	0.0000
2.C.6 Zinc Production	CO_2	0.00	0.01	1.50	20.00	20.06	0.0000
2.D Non-energy Products from Fuels and Solvent Use	CO_2	162.48	100.91	5.00	50.00	50.25	0.0001
3.G Liming	CO_2	44.62	16.23	2.00	5.00	5.39	0.0000
3.H Urea Application	CO_2	15.29	51.99	2.00	5.00	5.39	0.0000
4.A.1 Forest Land Remaining Forest Land	CO_2	-6 094.07	-6 489.56	20.00	60.00	63.25	14.1323
4.A.2 Land Converted to Forest Land	CO_2	-2 211.12	-352.95	20.00	60.00	63.25	0.7961
4.B.1 Cropland Remaining Cropland	CO_2	-955.44	-873.50	75.00	100.00	125.00	2.1418
4.B.2 Land Converted to Cropland	CO_2	466.32	74.36	75.00	100.00	125.00	0.1096
4.C.2 Land Converted to Grassland	CO_2	-202.29	-204.21	75.00	100.00	125.00	0.1214
4.E.2 Land Converted to Settlements	CO_2	96.06	95.81	75.00	100.00	125.00	0.0266
4.F.2 Land Converted to Other Land	CO_2	285.40	95.25	75.00	100.00	125.00	0.0362
4.G Harvested Wood Products	CO_2	-502.44	-278.08	50.00	50.00	70.71	0.0876
4(V) Biomass Burning	CO_2	7.21	8.40	5.00	100.00	100.12	0.0000
5.C Incineration and Open Burning of Waste	CO_2	60.25	6.64	5.00	5.00	7.07	0.0000
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CH_4	3.42	1.08	3.00	50.00	50.09	0.0000
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CH_4	3.20	1.06	3.00	50.00	50.09	0.0000
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CH_4	0.98	0.99	3.00	5.00	5.83	0.0000
1.A.1 Fuel combustion - Energy Industries - Other Fossil Fuels	CH_4	0.00	0.00	5.00	50.00	50.25	0.0000
1.A.1 Fuel combustion - Energy Industries - Peat	CH_4	0.00	0.00	3.00	50.00	50.09	0.0000
1.A.1 Fuel combustion - Energy Industries - Biomass	CH_4	38.21	8.58	3.00	50.00	50.09	0.0001
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CH_4	2.79	0.19	3.00	50.00	50.09	0.0000
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CH_4	16.27	136.93	3.00	50.00	50.09	0.0092
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CH_4	1.75	25.18	3.00	5.00	5.83	0.0000

IPCC category/Group	Gas	Base year emissions or removals	Year 2014 emissions or removals	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Uncertainty introduced into the trend in total national emissions
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CH_4	0.00	49.30	5.00	50.00	50.25	0.0014
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Peat	CH_4	0.00	9.17	3.00	50.00	50.09	0.0000
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Biomass	CH_4	1.99	6.44	3.00	50.00	50.09	0.0000
1.A.3.a Domestic Aviation	CH_4	0.02	0.01	3.00	5.00	5.83	0.0000
1.A.3.b Road Transportation	CH_4	29.14	15.51	3.00	5.00	5.83	0.0000
1.A.3.c Railways	CH_4	0.74	0.13	1.00	40.00	40.01	0.0000
1.A.3.d Domestic Navigation - Liquid Fuels	CH_4	0.00	0.00	1.00	40.00	40.01	0.0000
1.A.3.e Other Transportation	CH_4	0.80	0.22	1.00	40.00	40.01	0.0000
1.A.4 Other Sectors - Liquid Fuels	CH_4	0.31	0.74	3.00	50.00	50.09	0.0000
1.A.4 Other Sectors - Solid Fuels	CH_4	416.75	17.47	3.00	50.00	50.09	0.0306
1.A.4 Other Sectors - Gaseous Fuels	CH_4	8.20	11.13	3.00	5.00	5.83	0.0000
1.A.4 Other Sectors - Biomass	CH_4	36.13	161.46	3.00	50.00	50.09	0.0111
1.A.5 Other (Not specified elsewhere) - Liquid Fuels	CH_4	0.05	0.01	3.00	50.00	50.09	0.0000
1.A.5 Other (Not specified elsewhere) - Solid Fuels	CH_4	0.05	0.01	3.00	50.00	50.09	0.0000
1.A.5 Other (Not specified elsewhere) - Gaseous Fuels	CH_4	0.34	0.10	3.00	5.00	5.83	0.0000
1.A.5 Other (Not specified elsewhere) - Biomass	CH_4	0.00	0.50	3.00	50.00	50.09	0.0000
1.B.1 Fugitive emissions from Solid Fuels	CH_4	679.94	407.77	5.00	7.00	8.60	0.0019
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4	14.79	8.24	5.00	7.00	8.60	0.0000
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	1 103.48	803.82	2.00	5.00	5.39	0.0013
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH_4	590.18	422.43	2.00	5.00	5.39	0.0003
2.B.1 Ammonia Production	CH_4	0.27	0.40	2.00	10.00	10.20	0.0000
2.B.10 Other	CH_4	0.05	0.17	2.00	10.00	10.20	0.0000
2.C.2 Ferroalloys Production	CH_4	0.00	26.58	2.00	10.00	10.20	0.0000
3.A Enteric Fermentation	CH_4	2 397.54	1 046.79	3.00	20.00	20.22	0.0184
3.B Manure Management	CH_4	561.11	179.37	3.00	45.00	45.10	0.0115
4(V) Biomass Burning	CH_4	7.44	9.02	5.00	5.00	7.07	0.0000
5.A Solid Waste Disposal	CH_4	669.50	1 032.50	5.00	100.00	100.12	0.9095
5.B Biological Treatment of Soild Waste	CH_4	64.90	75.05	5.00	50.00	50.25	0.0008
5.C Incineration and Open Burning of Waste	CH_4	0.02	0.01	5.00	5.00	7.07	0.0000
5.D Wastewater Treatment and Discharge	CH_4	466.00	316.80	5.00	50.00	50.25	0.0019
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	N_2O	7.92	2.26	3.00	50.00	50.09	0.0000
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	N_2O	57.76	16.88	3.00	50.00	50.09	0.0002
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	N_2O	1.17	1.15	3.00	5.00	5.83	0.0000
1.A.1 Fuel combustion - Energy Industries - Other Fossil Fuels	N_2O	0.00	0.00	3.00	50.00	50.09	0.0000
1.A.1 Fuel combustion - Energy Industries - Peat	N_2O	0.00	0.00	3.00	50.00	50.09	0.0000

IPCC category/Group	Gas	Base year emissions or removals	Year 2014 emissions or removals	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Uncertainty introduced into the trend in total national emissions
1.A.1 Fuel combustion - Energy Industries - Biomass	N_2O	27.35	63.85	3.00	50.00	50.09	0.0013
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	N_2O	6.81	0.46	3.00	50.00	50.09	0.0000
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	N_2O	28.72	9.56	3.00	50.00	50.09	0.0000
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	N_2O	2.09	357.71	3.00	5.00	5.83	0.0012
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	N_2O	0.00	3.13	3.00	50.00	50.09	0.0000
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Peat	N_2O	0.00	78.18	3.00	50.00	50.09	0.0035
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Biomass	N_2O	3.17	18.97	3.00	50.00	50.09	0.0002
1.A.3.a Domestic Aviation	N_2O	0.24	44.32	1.00	50.00	50.01	0.0011
1.A.3.b Road Transportation	N_2O	56.37	67.02	1.00	50.00	50.01	0.0006
1.A.3.c Railways	N_2O	48.25	3 369.10	1.00	50.00	50.01	6.3050
1.A.3.d Domestic Navigation - Liquid Fuels	N_2O	0.00	0.42	1.00	50.00	50.01	0.0000
1.A.3.e Other Transportation	N_2O	0.95	0.26	1.00	50.00	50.01	0.0000
1.A.4 Other Sectors - Liquid Fuels	N_2O	0.69	4.91	3.00	50.00	50.09	0.0000
1.A.4 Other Sectors - Solid Fuels	N_2O	29.27	2.63	3.00	50.00	50.09	0.0001
1.A.4 Other Sectors - Gaseous Fuels	N_2O	1.96	2.65	3.00	5.00	5.83	0.0000
1.A.4 Other Sectors - Peat	N_2O	0.00	0.00	3.00	50.00	50.09	0.0000
1.A.4 Other Sectors - Biomass	N_2O	6.26	25.70	3.00	50.00	50.09	0.0003
1.A.5 Other (Not specified elsewhere) - Liquid Fuels	N_2O	0.31	2.15	3.00	50.00	50.09	0.0000
1.A.5 Other (Not specified elsewhere) - Solid Fuels	N_2O	0.90	0.01	3.00	5.00	5.83	0.0000
1.A.5 Other (Not specified elsewhere) - Gaseous Fuels	N_2O	0.08	7.42	3.00	50.00	50.09	0.0000
1.A.5 Other (Not specified elsewhere) - Biomass	N_2O	0.00	0.09	1.00	50.00	50.01	0.0000
2.B.1 Ammonia Production	N_2O	0.32	0.48	2.00	10.00	10.20	0.0000
2.B.2 Nitric Acid Production	N_2O	1 141.53	129.41	2.50	7.00	7.43	0.0035
2.B.10 Other	N_2O	0.06	59.01	2.00	10.00	10.20	0.0001
2.G Other Product Manufacture and Use	N_2O	16.39	122.23	5.00	20.00	20.62	0.0013
3.B Manure Management	N_2O	1 245.86	446.61	10.00	100.00	100.50	0.2144
3.D.1 Direct N2O Emissions From Managed Soils	N_2O	2 568.68	1 425.10	25.00	100.00	103.08	0.6046
3.D.2 Indirect N2O Emissions From Managed Soils	N_2O	956.71	398.66	25.00	100.00	103.08	0.1148
4(III).Direct N2O emissions from N mineralization/immobilization	N_2O	59.89	8.21	5.00	5.00	7.07	0.0000
4(V) Biomass Burning	N_2O	4.91	5.95	5.00	5.00	7.07	0.0000
5.B Biological Treatment of Soild Waste	N_2O	58.02	67.09	5.00	50.00	50.25	0.0006
5.C Incineration and Open Burning of Waste	N_2O	5.84	2.47	1.00	5.00	5.10	0.0000
5.D Wastewater Treatment and Discharge	N_2O	138.48	49.56	5.00	50.00	50.25	0.0007
2.C.3 Aluminium Production	PFCs	314.86	9.81	7.50	11.00	13.31	0.0009
Total Uncertainties			**Uncertainty in total inventory %: 12.53**				**Trend uncertainty %: 5.13**

ANNEX 4: QUALITY ASSURANCE/QUALITY CONTROL PLAN

Table A4.1: *Quality Assurance/Quality Control Plan - Internal*

Activity		Who	Check-in	Time schedule	Record
1.	Tasks and finance plan of NIS – preparation for year 2016 (capacity building)	NIS coordinator Deputy of NIS coordinator	Ministry of Environment (NFP) Head of the SHMU	12. February 2016	Information on budget, capacity (personal, external, internal), training plan, meetings and business trips plan, plan of QA/QC activities for year 2016
2.	Sectoral contracts negotiations for year 2015	NIS coordinator Deputy of NIS coordinator	Ministry of Environment (NFP) Head of the SHMI	31. March 2016 (in conjunction with the public competition)	Frame contracts with the sectoral experts Specification of tasks for a given year (improvement plan) Nomination letters for sectoral experts
3.	Update of capacity incorporating updates for each sector	Sectoral experts (SE) Deputy of SE	NIS coordinator Deputy of NIS coordinator Ministry of Environment (NFP)	2. April 2016 (in conjunction with the contracts)	Responsibilities matrix Description of work activities
4.	Plan of QA/QC activities for the emission inventory on overall and sectoral level	Sectoral experts	NIS coordinator Deputy of NIS coordinator Quality manager	10. April 2016	Description of the sectoral QA/QC activities in the Sectoral Reports 2015 Evaluation of the QA/QC activity for the year 2015
5.	Key sources and uncertainty management for each sector for year 2014	Sectoral expert for uncertainty Sectoral experts NIS coordinator	Deputy NIS coordinator Quality manager	15. April 2016	Report on key sources and uncertainty evaluation for year 2014 Template for the key sources and uncertainty evaluation for year 2014
6.	Final evaluation of emission data 2014 on sectoral level based on the external audit of the European Commission	Sectoral experts NIS coordinator Data manager	Deputy of NIS coordinator Quality manager Ministry of Environment (NFP)	31. July 2016	Verification protocols Description of changes Updated sectoral report
7.	Improvement plans for year 2016	Sectoral experts NIS coordinator Deputy of NIS coordinator	Quality manager Ministry of Environment (NFP)	10. March 2016	Improvement plan - spreadsheets

Activity		Who	Check-in	Time schedule	Record
8.	Workshop – meeting of experts, ministries, SNE; Program: evaluation of results, findings from the reviews, proposals for improvement, proposal for the inventory plan for next year.	Sectoral experts NIS coordinator Deputy of NIS coordinator	Ministry of Environment (NFP) Quality manager	April 2016 September 2016 December 2016	Report from the meeting
9.	To check the status of completeness of emission inventory for the year 2015	Sectoral experts	NIS coordinator Deputy NIS coordinator Quality manager Ministry of Environment (NFP)	30. May 2016 30. September 2016	Report from internal audit
10.	Methodological updates, recalculations list on sectoral level, according to IPCC 2006 GL	Sectoral experts	NIS coordinator Deputy NIS coordinator Quality manager	31. October 2016	Report of emission for each sector, for year 2016
11.	Sectoral final reports delivery	Sectoral experts	NIS coordinator Deputy NIS coordinator Quality manager	30. November 2016	Delivery protocols Drafts of sectoral reports for the inventory year 2015
12.	Preparing documents for updating emission projections by sector - methodological inputs	Sectoral experts Coordinator of project	NIS coordinator Ministry of Environment (NFP)	30. November 2016	Preliminary draft of the Second biennial report
13.	Participation in individual evaluations and cooperation in preparing of view on the review assessment by the UNFCCC Secretariat	Sectoral experts	NIS coordinator Deputy NIS coordinator Quality manager	continuously	Sectoral assessment reports

__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 1990-2014 b. Preliminary National Inventory Report information for year 2016 c. Annual Report of indicators for year 2014.	NIS coordinator Deputy of NIS coordinator Sectoral experts	Ministry of Environment (NFP)	15.01.2016	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	15.01.2016	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 2014 b) National Inventory Report for year 2016 c) Key source and uncertainty analyses	NIS coordinator Deputy of NIS coordinator Sectoral experts of NIS	Quality manager Ministry of Environment (NFP)	15.03.2016	Uploaded to the CRF dbase 1990 – 2014 Uploaded to the KP CRF dbase 2008 – 2014 Annual report NIR SVK 2016 SEF 2015 Sheet of the key source and uncertainty analyses
4.	Nomination letters for the sectoral experts – update for the year 2016.	NIS coordinator Ministry of Environment - NFP	Quality manager	15.04.2016	Nomination Letters List of nominated sectoral experts for the year 2016.
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 2016.	NIS coordinator Deputy of NIS coordinator	Ministry of Environment (NFP)	15.02.2016	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 2016 The report submitted to an agenda of Government by the end of March 2016.
6.	Report of the Slovak Republic according to the Article 4, 13 a 14 of the Regulation (EU) 525/2013: - GHGs emission projections, - PAM, - Indicators and parameters for projections,	Expert for projections Ministry of Environment – NFP Sectoral experts NIS coordinator	Quality manager Ministry of Environment (NFP)	15.03.2016	KP LULUCF tables for the years 1990 and 2014 for forest management and cropland and grassland management, Tables according to the Annex XI a XII under decision (EU) 749/2014.

Activity		Who	Check-in	Time schedule	Record
	- Description of models, - Sensitivity analysis.				
7.	Draft of the Improvement Plan for the GHG emissions inventory based on the SVK ARR 2014.	NIS coordinator Deputy of NIS coordinator Ministry of Environment – NFP Sectoral experts	Independent review	15.04.2016	NIR SVK 2016 ARR 2014
8.	Submission to the secretariat UNFCCC: a) Emission GHG inventory for years 1990-2014 b) National Inventory Report for year 2016 c) KP – LULUCF for years 2008-2014 e) Information from the National Registry for year 2016	NIS coordinator Deputy of NIS coordinator Sectoral experts National Registry	Quality manager Ministry of Environment (NFP)	30.04.2016	UNFCCC submission upload: https://unfccc.int/submissionportal/webportal/SubmissionStatusComponent.jsp
9.	Publicity of the SVK NIR 2016 and emissions data on the official web of the SVK NIS	NIS coordinator Deputy of NIS coordinator	Quality manager Ministry of Environment (NFP)	30.05.2016	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	7-11.03.2016	Review report 2016
11.	Initial Assessment to the UNFCCC submission 2016	NIS coordinator Deputy of NIS coordinator Sectoral experts	Quality manager Ministry of Environment (NFP)	6 weeks after 15.04.2016	Resubmission of the GHG inventory and SVK NIR 2016 in conjustion with the upgrade of the CRF Reporter software
13.	Audit of the status of the preparation of the sectoral reports 2015.	NIS coordinator Deputy of NIS coordinator Quality manager Sectoral experts	Ministry of Environment (NFP)	30.06.2016 31.12.2016	Report from the internal audit of the delivering of the 2015 inventory data.
14.	Statistical data delivering Distribution of the SVK NIR 2016 to public institutions.	NIS coordinator Deputy of NIS coordinator Sectoral experts	Quality manager Ministry of Environment (NFP)	31.10.2016	Statistical questionnaires SVK NIR 2016
15.	Review under UNFCCC	NIS coordinator Deputy of NIS coordinator Sectoral experts Ministry of Environment – NFP Quality manager	Expert Review Team	2016	Annual Review Report for the submissions 2015 and 2016

Activity		Who	Check-in	Time schedule	Record
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 07.07.2016	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 2016.	Sectoral experts Quality manager	NIS coordinator Deputy of NIS coordinator Quality manager	30.11.2016	Report and Improvement plan for the year 2017.

Table A4.3: Plans and the implementation of the QC/QA procedures in 2016

PLANNED ACTIVITIES	PLAN - DATE	REALIZATION (Name, Date)
To clarify and explain the responsibilities of the members of the QA/QC team of NIS.	the end of February, year x	
Description of the work of the team members in a Matrix of responsibilities.	the end of February, year x	
Distribution of QA/QC forms to the members of the team of NIS.	the end of May, year x	
Ensure timely and accurate completion of the QA/QC checks and related activities, all members of the team. (1) General QC (2) Source category/specific QC (3) Cross-cutting QC	May – November, year x July – November, year x October, year x January, year x+1	
Collect completed QC checklists and forms.	September / November / December, year x	
Review completion of the QC checklists and forms for completeness and accuracy.	September / December, year x March, year x+1	
Passing the QC inspection records to the Coordinator of NIS.	December, year x	
Coordination of an external review report and the QA assessment of the report NIR.	April, year x	
External reviewers and QA assessment include: (1) Identify external reviewers (e.g. the public, universities, etc.).	the end of May, year x+1	
(2) Set up a schedule review.	the end of May, year x+1	
(3) Distribute draft report of NIR for review and QA evaluation.	July / October / December, year x+1	
(4) Collect notes and comments from the review. (5) Deliver the compiled comments and documents to the Coordinator (6) Following the decision of the Coordinator and other team members included comments in the report to the NIR. (7) Deliver the compiled comments and documents for archiving.	October / December, year x+1 November, year x+1 The end of January, year x+1 The end of March, year x+1	

__Table A4.4:__ List of provisional main findings and recommendations, and status of implementation

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION
ENERGY SECTOR			
1.AB/Reference Approach, CO_2, other, Activity data	The TERT noted that in comparing the CRF reference approach with the reference approach calculated on basis of Eurostat energy balance data we identified a notable difference of -87% for waste (CRF: 665 TJ; Eurostat: 5 255 TJ). The TERT also noted that the CRF sectoral approach in CRF Table 1.A(a)s1 includes only 2 632 TJ for 'Other fossil fuels'. In response to a question raised during the review, Slovakia replied that in the RA the consumption of the waste is estimated as a fraction of the consumption provided by EUROSTAT. This non-biomass fraction was estimated by our expert for waste. For municipal this fraction is 16.7 % (55% bio fraction, 11% non-bio fraction, 34 % inert). For industrial waste, the non-bio fraction is 10 %. In the Sector Approach a similar method is used, however the consumption, NCV, emission factor and non-bio fraction are adopted from information provided by the operators. The TERT does not think this reply explains the big differences sufficiently, since Eurostat data includes only non-renewable waste. The TERT therefore applied a technical correction to the estimates (see technical correction attached in the ESD review tool).	Trial review of the 2015 greenhouse gas inventory of Slovakia under the Effort Sharing Decision, November 2015	Implemented, see Chapter 3
1.A.3.a Fuel Combustion Activities - Transport - Civil Aviation, CH_4, CO_2, N_2O, liquid, Emission factor	For Category 1.A.3.a, the TERT noted that for gasoline and kerosene, the same CO_2 emission factor of 3 150 g/kg fuel was used (based on table 3-3 of the EMEP Corinair guidebook). It is also unclear how the 'mixed' emission factors for CH_4 and N_2O reported in table 3.38 of the NIR are calculated. In answer to a request for clarifications, Slovakia responded that they used the same EFs and other parameters as in the previous inventory for their 2015 submission. This approach used the guidance from the EMEP Corinair GB, based on type of aircraft and LTO cycles. However, this approach is now considered to be not accurate enough and Slovakia is now preparing a new estimate based on EUROCONTROL data. After approval of the Ministry of Transport, Slovakia will report this new estimate in the next submission with a recalculation for the whole time series. The TERT agrees with this approach and recommends that Slovakia include these new calculations together with a clear description in the submission of next year.	Trial review of the 2015 greenhouse gas inventory of Slovakia under the Effort Sharing Decision, November 2015	Implemented, see Chapter 3
1.A.3.a Domestic Aviation	1.A.3.a Fuel Combustion Activities - Transport - Civil Aviation, IEF CO_2, liquid 2004-2005: decrease in IEF. How do you explain the 2.2% decrease of the IEF of jet kerosene from 2004 to 2005? Please keep in mind that for the time period 1990-2004 the value of the IEF is constant to 73.05 t/TJ whereas for the time period 2005-2014 the value of the IEF has changed to 71.43 t/TJ. We should also add, that such a strong decrease can also be observed for the CO_2 IEF of aviation gasoline (from 73.6 t/TJ to 68.8 t/TJ between 2004 and 2005. Based on last year's observation "SK-1A3a-2015-0001", SK stated that a recalculation for the entire time series is planned. Could you please give us more information on this issue?	Preliminary EU ESD review 2016	Implemented, see Chapter 3
1.A.3.b Road Transportation - gasoline	1.A.3.b Fuel Combustion Activities - Transport - Road transportation, IEF CO_2 liquid in 2008 peak. How do you explain the peak value (73.86 t/TJ) of the IEF of gasoline in 2008? Could you also generally explain the trend of the IEF since there is a lot of variation over the whole time series (i.e. from 77.66 t/TJ to 71 t/TJ, then to 73.86 t/TJ and then back to 70.8 t/TJ)?	Preliminary EU ESD review 2016	Implemented, see Chapter 3

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION
1.A.3.b Road Transportation – gasoline and diesel oil	1.A.3.b Fuel Combustion Activities - Transport - Road transportation, IEF CO_2 liquid in 1990 peak. How do you explain the peak value (77.66 t/TJ) of the IEF of gasoline for the category 1.A.3.b.i-Cars in 1990? Please keep in mind that this value is also the highest among all EU MS.	Preliminary EU ESD review 2016	Implemented, see Chapter 3
1.A.3.b Road Transportation – gaseous fuels	1A3b Fuel Combustion Activities - Transport - Road transportation, gaseous fuels IEF CO_2 for 2000-2014: high values of IEF. The reported values of the IEF are in the range of 79.69 - 80.78 t/TJ, whereas for all the other MSs the reported IEF is about 55 t/TJ. Could you please explain the reason for the high values of the IEF?	Preliminary EU ESD review 2016	Implemented, see Chapter 3
1.A.3.b Road Transportation – LPG	1.A.3.b Fuel Combustion Activities - Transport - Road transportation, IEF CO_2, liquid 2002-2003: decrease in IEF. How do you explain the 2.3% decrease of the IEF of LPG from 2002 to 2003?	Preliminary EU ESD review 2016	Implemented, see Chapter 3
1.A.3.d Domestic Navigation	1A3d Fuel Combustion Activities - Transport - Water-borne Navigation: IEF for CO_2 higher in 2014 than average 1990 - 2013. For the time period 1990-2013 the value of the IEF of gas/diesel oil is constant to 75.01 t/TJ, whereas in 2014 this value has changed to 75.83 t/TJ. Could you please explain the reason for this peak value?	Preliminary EU ESD review 2016	Implemented, see Chapter 3
1.D.1.a International Aviation	1A3a Fuel Combustion Activities - Transport - Civil Aviation, IEF CH_4, N_2O 1990-2014, IEF for CH_4 and N_20 for kerosene and aviation gasoline show high jumps between the years 2004 and 2005. For aviation gasoline both IEF seem to be importantly higher compared to results from other MS (324.1 kg/TJ in 2014 in comparison to the 14.1 kg/TJ EU average for CH_4, and 33.8 kg/TJ compared to the EU average of 2.7 kg/TJ for N_2O respectively). The same goes for CH_4 for kerosene since 2005, whereas the IEF for N_2O is very high in the years 1990-2004. Could you please check these IEF? It is reminded that the default EF for CH_4 is 0.5 kg/TJ and for N_2O 2 kg/TJ following IPCC guidelines, although it is noted that both gases do not depend directly on fuel consumption so there might be quite high deviations between IEF of MS. Possibly there is a reference to SK-1A3a-2015-0002.	Preliminary EU ESD review 2016	Implemented, see Chapter 3
AGRICULTURE SECTOR			
3.A.1&2 Enteric Fermentation - cattle	3.A.1 and 3.A.2 - Gross Energy (GE). Values for Gross energy need to be reported in MJ/head/day: Values for Gross Energy need to be reported in MJ/head/day, despite the misleading unit given in the CRF tables (MJ/day). This issue was also raised and discussed in the "MS Support for KP Reporting" wiki-pages (see http://mskp-support.wikidot.com/forum/t-1170873#post-2271046). The solution was that the units for both Gross Energy (Table3.As2) and Gross Energy Intake (Table3.As1) are the same: "In the methodology, both Gross Energy and Gross Energy Intake seems to be used for the very same. In 2006 IPCC methodology, "Gross energy" is estimated using equation 10.16 (pg 10.21) which is referenced in Equation 10.21 (pg. 10.31) as "Gross Energy Intake".[1] In other context, "Gross Energy Intake" depends on diet (energy of the feed) and "Gross Energy" could be used for the needs of energy, or vice versa. Regarding the units, they seem to be different (MJ/day vs. MJ/head/day). However, all additional info in 'Enteric Fermentation' CRF Reporter table refer to the value per head. So, the units are the same. Footnote: 1. Eqn 10.16 refers to an energy requirement calculation, so gross energy (here) is what the animal needs. Eqn 10.21 refers to emission calculation where actual feed intake (as gross energy) is used.". In fact if you look in detail to Equation 10.16, you see that it depends on NEl (lactation) and NEm	Preliminary EU ESD review 2016	Implemented, see CRF tables

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION
	(maintenance) which are calculated on the basis of Milk and Weight. The units for this two variables are kg/day and kg (NOT kg/head/day and kg/head) - yet the values given are de facto corresponding to the individual animal. Using an aggregate Gross Energy for the whole population would lead to inconsistencies in Equation 10.16 and the between values reported in Table Table3.As2. Furthermore - from a pragmatic perspective - it is very important that all MS use the same unit to allow comparison between - and aggregation of - MS values; most countries already report GE in the unit MJ/head/day.		
3.A.3 Enteric Fermentation - swine	3.A.3 - Swine - all except: 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 - Implied emission factor (IEF): Data has been identified as an outlier. The value of the outlier is with 1.91 (mean of outlier years) 1.28 times the median value reported from all countries and 1.1 times the calculated upper limit. Please provide a justification for this outlier (or correct).	Preliminary EU ESD review 2016	Implemented, see Chapter 5
3.B.1.4 Manure Management - poultry	3.B.1.4.7 - Poultry - all years - Implied emission factor (IEF): Data has been identified as an outlier. The value of the outlier is with 0.29 (mean of outlier years) 9.62 times the median value reported from all countries and 1.6 times the calculated upper limit. This issue is considered a potential significant issue. In the year 2014 the value used was 0.243 - 8.1 times the median value reported from all countries over all years (0.0301). The Implied emission factor has significant impact on emissions. Please provide justification that the value used is appropriate and/or that is not linked to a potential over- or underestimation of GHG emissions. To do so, please check that the difference to emissions estimated with IPCC default methodology can be argued to be below the threshold of significance, which is 0.05% of national total GHG emissions and does not exceed 500 kt CO_2 eq. If you cannot provide a justification, this could lead to a technical correction during the ESD review. Note that the total national aggregate of estimated emissions for all gases and categories considered insignificant shall remain below 0.1 per cent of the national total GHG emissions. The value is still within the wide range given by the IPCC as default, but it needs some explanation why it is so much higher than the EU median	Preliminary EU ESD review 2016	Implemented, see Chapter 5
3.B.2.4 Manure Management - poultry	3.B.2.4.7 - Poultry - 2014 - Nitrogen excretion rate (NRATE): Data has been identified as an outlier. The value of the outlier is with 1.03 (mean of outlier years) 1.79 times the median value reported from all countries and 1.1 times the calculated upper limit. This issue is considered a potential significant issue. In the year 2014 the value used was 1.03 - 1.8 times the median value reported from all countries over all years (0.574). The Nitrogen excretion rate has significant impact on emissions. Please provide justification that the value used is appropriate and/or that is not linked to a potential over- or underestimation of GHG emissions. To do so, please check that the difference to emissions estimated with IPCC default methodology can be argued to be below the threshold of significance, which is 0.05% of national total GHG emissions and does not exceed 500 kt CO_2 eq. If you cannot provide a justification, this could lead to a technical correction during the ESD review. Note that the total national aggregate of estimated emissions for all gases and categories considered insignificant shall remain below 0.1 per cent of the national total GHG emissions. Slovakia reports for 2014 a value which is higher than the previous years (30% higher than for 2013); it might be a calculation error, it needs correction or explanation.	Preliminary EU ESD review 2016	Implemented, see Chapter 5

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION
3.B.2.4 Manure Management - horses	3.B.2.4.5 - Horses - all except: 2014 - Nitrogen excretion rate (NRATE): Data has been identified as an outlier. The value of the outlier is with 25 (mean of outlier years) 0.512 times the median value reported from all countries and 0.7 times the calculated lower limit. Please provide a justification for this outlier (or correct). Nex rate for horses reported by Slovakia seems to be the IPCC 1997 default, so it needs to be revised in agreement with the new IPCC 2006 guidelines	Preliminary EU ESD review 2016	Implemented, see Chapter 5
3.D.1.2.a Animal Manure Applied to Soils	3.D.1.2.a - Animal Manure Applied to Soils: Recalculation for the year 1990 increased total national N_2O emissions by more than 0.5% as compared to last years' submission. Emissions were checked on significant recalculations for the years 1990 and 2013. Recalculation in 1990 was 0.251 kt or 1.35% of total national N_2O emissions. Please explain the reason for this recalculation. Un-justified recalculations could be associated with over- or underestimation of emissions.	Preliminary EU ESD review 2016	Implemented, see Chapter 5
3.D.2.1 Atmospheric Deposition	3.D.2.1 - Farming - all years - Implied emission factor (IEF): Data has been identified as an outlier. The value of the outlier is with 0.00149 (mean of outlier years) 0.149 times the median value reported from all countries and 0.2 times the calculated lower limit. This issue is considered a potential significant issue. In the year 2014 the value used was 0.00132 - 0.13 times the median value reported from all countries over all years (0.01). The Implied emission factor has significant impact on emissions. Please provide justification that the value used is appropriate and/or that is not linked to a potential over- or underestimation of GHG emissions. To do so, please check that the difference to emissions estimated with IPCC default methodology can be argued to be below the threshold of significance, which is 0.05% of national total GHG emissions and does not exceed 500 kt CO_2 eq. If you cannot provide a justification, this could lead to a technical correction during the ESD review. Note that the total national aggregate of estimated emissions for all gases and categories considered insignificant shall remain below 0.1 per cent of the national total GHG emissions. IEF much lower than the IPCC default of 0.01.	Preliminary EU ESD review 2016	Implemented, see Chapter 5
3.D.2.2 N-Leaching and Run-off	3.D.2.2 - Implied emission factor (IEF): Irregularities in the time series have been identified. Years flagged: 2013 2014. Irregular time series can be caused by changes in the situation (changes in regulations or national circumstances, technology changes, environmental conditions, pests). Irregular time series can also be caused by inconsistent data sources (e.g. changes in survey data), changes in calculation methods (e.g. due to lack of data for a certain period), or mistakes. Time series inconsistencies could be linked with an over- or underestimation of emissions in part of the time series. The time series was judged to be of type 'single outlier': One or few isolated year(s) where the value is out of the general trend Note that the identified years not always correspond to the years which appear to be 'irregular'. Please provide a justification/explanation for the observed irregularities.	Preliminary EU ESD review 2016	Implemented, see Chapter 5
LULUCF SECTOR			
4.E.2.4(III) Direct N_2O Emissions from N Mineralization/Immobilization	In CRF table 4(III), direct nitrous oxide emissions from nitrogen mineralization/immobilization associated with loss/gain of soil organic matter resulting	Preliminary EU ESD review 2016	Implemented, see Chapter 6 and CRF Tables

CRF CATEGORY / ISSUE	REVIEW RECOMMENDATION	REVIEW REPORT / PARAGRAPH	MS RESPONSE / STATUS OF IMPLEMENTATION
4.F.2.4(III) Direct N_2O Emissions from N Mineralization/Immobilization	from change of land use or management of mineral soil are reported as NO under subcategories 4.C.2, 4.E.2 and 4.F.2, while losses of carbon from mineral soils are reported in table 4.C,4.E,4.F. N_2O emissions from N mineralization associated with loss	Preliminary EU ESD review 2016	Implemented, see Chapter 5 and CRF Tables
4.C.2.4.(III) Direct N_2O Emissions from N Mineralization/Immobilization	of soil organic matter resulting from change of land use or management of Mineral soils are expected when loss of carbon from mineral soils are reported in tables 4C,4E,4F. Could you please check this issue and provide a justification for the use of the notation key NO under table 4(III)? Otherwise, please consider to provide estimates of N_2O emissions using the equations 11.1, 11.2 and 11.8 of the 2006 IPCC Guidelines.	Preliminary EU ESD review 2016	Implemented, see Chapter 5 and CRF Tables
KP LULUCF			
7. 4 (KP-I) B.1-FM Land-use Matrix	Inconsistencies between total area at the end of the current inventory year reported in table NIR2 (land transition matrix) and total area subject to the activity reported in tables(4(KP-I)B.1)-FM. Having in mind that the CRF software may be responsible of some issues, please be aware that total area at the end of the current inventory year reported in table NIR2 (land transition matrix) and total area subject to the activity reported in table(4(KP-I)B.1)-FM should be consistent. In order to avoid any inconsistency in the land use matrix, could you please check this issue?	Preliminary EU ESD review 2016	Implemented, see KP LULUCF CRF Tables